Technical Specification 5.6.2

Palo Verde
Nuclear Generating Station
PO Box 52034
Phoenix, Arizona 85072-2034
Mail Station 7636

102-07903-MDD/MSC
May 10, 2019

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

Dear Sirs:

Subject: **Palo Verde Nuclear Generating Station**
Units 1, 2, and 3
Docket Nos. STN 50-528/529/530
Annual Radiological Environmental Operating Report 2018

In accordance with Palo Verde Nuclear Generating Station Technical Specification 5.6.2, enclosed please find the Annual Radiological Environmental Operating Report for 2018.

No new commitments are being made to the NRC by this letter. Should you need further information regarding this submittal, please contact Matthew S. Cox, Licensing Section Leader, at (623) 393-5753.

Sincerely,

Matthew S Cox
for Michael D. DiLorenzo

Michael D. DiLorenzo
Department Leader, Regulatory Affairs

MDD/TMJ/mg

Enclosure: Palo Verde Nuclear Generating Station Annual Radiological Environmental Operating Report 2018

cc:	S. A. Morris	NRC Region IV Regional Administrator
	S. P. Lingam	NRC NRR Project Manager for PVNGS
	C. A. Peabody	NRC Senior Resident Inspector for PVNGS
	B. Goretzki	Arizona Department of Health Services – Bureau of Radiation Controls (ADHS)

Enclosure

Palo Verde Nuclear Generating Station
Annual Radiological Environmental Operating Report 2018

PALO VERDE NUCLEAR GENERATING STATION ANNUAL RADIOLOGICAL ENVIRONMENTAL OPERATING REPORT 2018

(Reference: RCTSAI 1643, Legacy Item No. 036843.01)

Prepared by: Comolli, Michelle (Z09567)

Digitally signed by Comolli, Michelle (Z09567)
DN: cn=Comolli, Michelle (Z09567)
Reason: I am the author of this document
Date: 2019.04.17 12:09:25 -07'00'

Reviewed by: Grusecki, Lori J(Z39643)

Digitally signed by Grusecki, Lori J(Z39643)
DN: cn=Grusecki, Lori J(Z39643)
Reason: RP Superintendent - Technical Support
Date: 2019.04.17 14:23:21 -07'00'

Approved by: Hogue, Nathan (Z14113)

Digitally signed by Hogue, Nathan (Z14113)
DN: cn=Hogue, Nathan (Z14113)
Date: 2019.04.17 15:14:07 -07'00'

Director, Radiation Protection

1. TABLE OF CONTENTS

LIST OF TABLES

TABLE OF FIGURES

TABLE OF APPENDICIES

ABSTRACT

The Radiological Environmental Monitoring Program (REMP) is an ongoing program conducted by Arizona Public Service Company (APS) for the Palo Verde Nuclear Generating Station (PVNGS). Various types of environmental samples are collected near PVNGS and analyzed for plant-related radionuclide concentrations.

During 2018, the following categories of samples were collected by APS:

- Broadleaf vegetation
- Groundwater
- Drinking water
- Surface water
- Airborne particulate and radioiodine
- Goat milk
- Sludge and sediment

Thermoluminescent dosimeters (TLDs) were used to measure environmental gamma radiation. The Environmental TLD program is also conducted by APS.

The Arizona Department of Health Services, Bureau of Radiation Control (BRC) performs radiochemistry analyses on various duplicate samples provided to them by APS. Samples analyzed by BRC include onsite samples from the Reservoirs, Evaporation Ponds, and two (2) Deep Wells. Offsite samples analyzed by BRC include two (2) local resident wells. BRC also performs air sampling at seven (7) offsite locations identical to APS and maintains approximately fifty (50) environmental TLD monitoring locations, eighteen (18) of which are duplicates of APS locations.

A comparison of pre-operational and operational data indicates no changes to environmental radiation levels.

(NOTE: Reference to APS throughout this report refers to PVNGS personnel)

1. Introduction

This report presents the results of the operational Radiological Environmental Monitoring Program conducted by Arizona Public Service Company (APS). The Radiological Environmental Monitoring Program (REMP) was established for the Palo Verde Nuclear Generating Station (PVNGS) by APS in 1979.

This report contains the measurements and findings for 2018. All references are specifically identified in Section 12.

1.1 Overview

The Radiological Environmental Monitoring Program (REMP) provides representative measurements of radiation and radioactive materials in exposure pathways. REMP measures radionuclides that lead to the highest potential radiation exposures to members of the public resulting from station operation. This monitoring program implements Title 10 of the Code of Federal Regulations (CFR) Part 50, Appendix I, Section IV.B.2., and thereby supplements the radiological effluent monitoring program by verifying that the measurable concentrations of radioactive materials and levels of radiation are not higher than expected on the basis of the effluent measurements and the modeling of the environmental exposure pathways. Guidance for this monitoring program is provided by the US Nuclear Regulatory Commission (USNRC) in their Radiological Assessment Branch Technical Position on Environmental Monitoring, Revision 1, November 1979 (incorporated into NUREG 1301). Results from the REMP help to evaluate sources of elevated levels of radioactivity in the environment (i.e. atmospheric nuclear detonations or abnormal plant releases).

The Land Use Census ensures that changes in the use of areas at, and beyond the site boundary, are identified and that modifications to the REMP are made if required by the results of this census. This census satisfies the requirements of Section IV.B.3 of Appendix I to 10 CFR Part 50.

The Interlaboratory Comparison Program is provided to ensure that independent checks on the precision and accuracy of the measurements of radioactive material in environmental sample matrices are performed as part of the quality assurance program for environmental monitoring in order to demonstrate that the results are valid for the purposes of 10 CFR 50, Appendix I, Section IV.B.2.

Results of the PVNGS pre-operational environmental monitoring program are presented in Reference 1.

The initial criticality of Unit 1 occurred May 25, 1985. Initial criticality for Units 2 and 3 were April 18, 1986, and October 25, 1987, respectively. PVNGS operational findings (historical) are presented in Reference 2.

1.2 Radiation and Radioactivity

Atoms are the basic building blocks of matter. Unstable atoms emit radiation and material that spontaneously emits radiation is referred to as radioactive. Radioactive material is frequently categorized as either "Natural" or "Man-made"

Natural sources of radiation exist naturally in the environment and include: radon, thoron, cosmic, terrestrial, and internal. The sun and stars are a source of cosmic radiation. Atmospheric conditions, the Earth's magnetic field, and differences in elevation can affect the amount, or dose, of cosmic radiation an individual receives. The Earth is a source of terrestrial radiation. Uranium, thorium, and radium exist naturally in rock and soil. All organic matter contains carbon and potassium, and water contains small amounts of dissolved uranium and thorium. The largest contributor of dose to Americans from natural sources is attributed to radon which is found in air. All people are a source of internal radiation. Potassium-40 and carbon-14 are radioactive nuclides and inside all people from birth, making people a source of exposure.

Man-made sources of radiation include: consumer products, nuclear medicine, and medical procedures. There are a number of occupational areas which result in exposure to individuals of varying amounts of radiation such as: radiography, radiology, radiation oncology, power generation, and research laboratories. The Nuclear Regulatory Commission (NRC) requires licensees to monitor exposure to workers and limit occupational exposure to 5,000 millirem. Several consumer products contain radioactive material such as: some ceramics, thorium lantern mantles, luminous watches containing tritium, smoke detectors, and tobacco. Other consumer product sources of radiation can come from building and road construction materials, combustible fuels (i.e. gas, coal), and x-ray security systems. The most significant contributor to radiation exposure from man-made sources is medical procedures. Diagnostic x-rays and nuclear medicine procedures, such as those that use iodine-131 or cesium-137, are examples of man-made medical sources.

The average member of the public receives a total annual dose of approximately 620 millirem from ionizing radiation. Figure 1-1 illustrates the contribution of various sources of radiation to radiation exposure in the United States (NCRP Report No.160 (2009)).

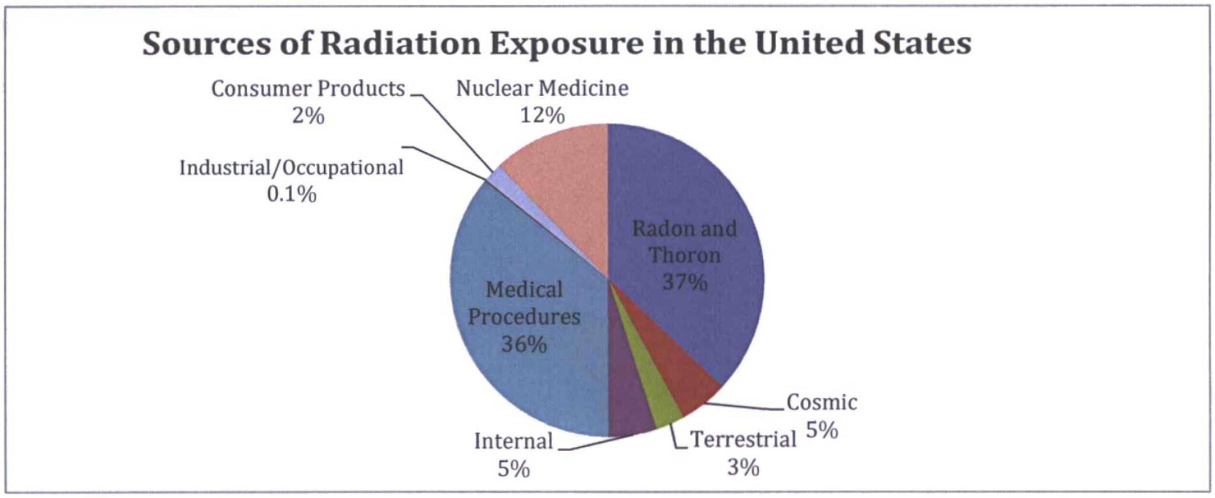


Figure 1-1 Sources of Radiation Exposure in the United States

2. Description of the Monitoring Program

APS and vendor organizations performed the pre-operational Radiological Environmental Monitoring Program between 1979 and 1985. APS and vendors continued the program into the operational phase.

2.1 Radiological Environmental Monitoring Program

The assessment program consists of routine measurements of environmental gamma radiation and of radionuclide concentrations in media such as air, groundwater, drinking water, surface water, vegetation, milk, sludge, and sediment.

Samples were collected by APS at the monitoring sites shown in Figures 2-1 and 2-2. The specific sample types, sampling locations, and sampling frequencies, as set forth in the PVNGS Offsite Dose Calculation Manual (ODCM), Reference 4, are presented in Tables 2-l, 2-2 and 9-1. Additional onsite sampling (outside the scope of the ODCM) is performed to supplement the REMP. All results are included in this report. Routine sample analyses were performed at the onsite Central Chemistry Laboratory and Operating Unit laboratories. Analyses for hard-to-detect radionuclides were performed by GEL Laboratories LLC.

Environmental gamma radiation measurements were performed by APS using TLDs at fifty (50) locations near PVNGS. The PVNGS Dosimetry Department is accredited by the National Voluntary Laboratory Accreditation Program (NVLAP) to process personnel ionizing radiation dosimeters.

In addition to monitoring environmental media, a Land Use Census is performed annually to identify the nearest milk animals, residents, and gardens. This information is used to evaluate the potential dose to members of the public for those exposure pathways that are indicated.

2.2 Radiological Environmental Monitoring Program Changes for 2018

There were no changes to the Radiological Environmental Monitoring Program that impacted the Offsite Dose Calculation Manual (ODCM) Revision 27.

2.3 REMP Deviations/Abnormal Events Summary

During calendar year 2018, there were eight (8) deviations/abnormal events with regards to the monitoring program. Refer to Table 2-3 for more detail and corrective actions taken.

There was one (1) event involving Air Sample data; the event was due to damaged sample media, resulting in an INVALID sample. Palo Verde Nuclear Generating Station has ten (10) Air Sample sites: one (1) control, four (4) ODCM required, and five (5) supplemental sites. Supplemental sampling locations were available and produced valid data for the sampling period involving an invalid sample from a required sample location.

Two (2) events involved deviation from procedural guidance. One (1) event involved the inability to preserve a milk sample according to procedural direction due to difficulty procuring the preservative from the vendor in a timely manner. No sample degradation was identified and the sample was deemed VALID. The other event was due to the use of sampling cartridges other than those specified in the procedure. The samples were capable of being analyzed in the Unit Labs, to accommodate the change in geometry. The sampling cartridges function in the same manner and the required LLDs were met; therefore, the information was deemed to be valid.

One (1) event was due to the inability to obtain a Drinking Water Sample, resulting from an inoperable well pump. The missed sample did not impact the ability to complete the monthly composite analysis.

There were four (4) events involving environmental dosimetry. One (1) event involved Site 47. Upon 2nd Quarter change-out, it was discovered that the environmental dosimetry and stanchion were missing at Site 47. The stanchion and dosimetry were replaced for the 3rd Quarter 2018 sampling period. Site 47 is a supplemental monitoring location. Two (2) events involved Site 43. Upon the 2nd and 3rd Quarter change-out, the dosimetry and stanchion were missing. The dosimetry and stanchion were replaced for the flowing sampling periods. Due to the repeated apparent tampering of this location, the stanchion was relocated, within several feet of the original monitoring location and labels were placed on the sampling container to identify the purpose and contact information for the dosimetry. These actions appear to have mitigated the apparent tampering of this location. Site 43 is also a supplemental monitoring location. The final event involved Site 10. Upon 4th Quarter change-out, it was discovered that the environmental dosimetry and stanchion were missing at Site 10. The stanchion and dosimetry were replaced for the 1st Quarter 2019 sampling period. Site 10 is a monitoring location for the Outer Ring, which is defined as 4-5 miles from Palo Verde Nuclear Generating Station. Supplemental monitoring locations were available and produced valid data during this sampling period.

2.4 Groundwater Protection

PVNGS has implemented a groundwater protection initiative developed by the Nuclear Energy Institute (NEI). The implementation of this initiative, NEI 07-07 (Industry Ground Water Protection Initiative – Final Guidance Document, August 2007), provides added assurance that groundwater will not be adversely affected by PVNGS operations.

Several monitoring wells have been installed to monitor the subsurface water and shallow aquifer at Units 1, 2, and 3. These wells are sampled monthly and quarterly for chemical and radiological parameters. The State of Arizona Aquifer Protection Permit (Area-Wide) No. P-100388 (APP) provides agreed upon monitoring parameters and reporting thresholds. Sample results for the shallow aquifer wells are reported in the PVNGS Annual Radioactive Effluent Release Report (ARERR). The State of Arizona APP provides specific regulatory criteria for groundwater protection.

Three subsurface samples were obtained, one each from Units 2 and 3 tritium monitoring wells, and one from the shallow aquifer outside of the Unit 1 Radiologically Controlled Area (RCA). These samples were analyzed for hard-to-detect radionuclides (e.g. C-14, Fe-55, Ni-63, Sr-90) as verification that there are no underground leaks from plant systems that may affect groundwater. All results were <MDA. Refer to Table 8-12 for sample results.

Table 2-1 Sample Collection Locations

SAMPLE SITE #	*SAMPLE TYPE*	*LOCATION* (a)	*LOCATION DESCRIPTION*
4	Air	E16	APS Office
6A*	Air	SSE13	Old US 80
7A	Air	ESE3	Arlington School
14A	Air	NNE2	371st Ave. and Buckeye-Salome Rd.
15	Air	NE2	NE Site Boundary
17A	Air	E3	351st Ave.
21	Air	S3	S Site Boundary
29	Air	W1	W Site Boundary
35	Air	NNW8	Tonopah
40	Air	N2	Transmission Rd
46	Drinking Water	NNW8	Local resident
47	Vegetation	N3	Local resident
48	Drinking Water	SW1	Local resident
49	Drinking Water	N2	Local resident
51	Milk	NNE3	Local resident-goats
	Vegetation	NNE3	Local resident
53*	Milk	NE30	Local resident- goats
54	Milk	NNE4	Local resident- goats
55	Drinking Water (Supplemental)	SW3	Local resident
57	Groundwater	ONSITE	Well 27ddc
58	Groundwater	ONSITE	Well 34abb
59	Surface Water	ONSITE	Evaporation Pond 1
60	Surface Water	ONSITE	85 Acre Reservoir
61	Surface Water	ONSITE	45 Acre Reservoir
62*	Vegetation	ENE26	Commercial Farm
63	Surface Water	ONSITE	Evaporation Pond 2
64	Surface Water	ONSITE	Evaporation Pond 3

NOTES:

*Designates a control site

(a) Distances and direction are from the center-line of Unit 2 containment and rounded to the nearest mile

Air sample sites designated with the letter 'A' are sites that have the same site number as a TLD location, but are not in the same location (e.g. site #**6** TLD location is different from site #**6A** air sample location; site #**4** TLD location is the same as site #**4** air sample location)

Table 2-2 Sample Collection Schedule

SAMPLE SITE #	AIRBORNE PARTICULATE	MILK	AIRBORNE RADIOIODINE	VEGETATION	GROUND WATER	DRINKING WATER	SURFACE WATER
4	W		W				
6A	W		W				
7A	W		W				
14A	W		W				
15	W		W				
17A	W		W				
21	W		W				
29	W		W				
35	W		W				
40	W		W				
46						W	
47				M/AA			
48						W	
49						W	
51			M/AA	M/AA			
53			M/AA				
54			M/AA				
55						W	
57					Q		
58					Q		
59							Q
60							Q
61							Q
62				M/AA			
63							Q
64							Q

W = WEEKLY   M/AA = MONTHLY AS AVAILABLE   Q = QUARTERLY

Table 2-3 Summaries of the REMP Deviations/Abnormal Events

Deviation/Abnormal Event	***Actions Taken***
1. Milk Sample Site 54 was not able to be preserved in accordance with procedural direction for the May sample.	A delay in receiving a broad spectrum preservative from the supplier resulted in the use of 15 tablets, versus the procedurally required 100 tablets for the May Site 54 Milk sample. Ice packs were used to compensate for the lower amount of preservatives. No sample degradation is expected to have occurred. This sample is determined to be VALAD. Event documented through CR 18-08852 (Table 8-7, Note 1).
2. Site 47 Environmental Dosimetry missing for 2nd Quarter 2018.	During the Quarterly Environmental Dosimetry change-out, it was discovered that the Site 47 dosimetry and stanchion was missing and could not be located. The stanchion and dosimetry were replaced for the 3rd Quarter 2018 sampling period. Event documented through CR 18-10649.
3. Site 43 Environmental Dosimetry missing for 2nd Quarter 2018.	During the Quarterly Environmental Dosimetry change-out, it was discovered that the Site 43 dosimetry and stanchion was missing and could not be located. The stanchion and dosimetry were replaced for the 3rd Quarter 2018 sampling period. Event documented through CR 18-10739.
4. Drinking Water Sample Site 55 was not collected, due to power outage at the well pump, for sample period 8/14/2018-8/20/2018	Drinking Water Sample Site 55 was not collected, due to power outage at the well pump, for sample period 8/14/2018-8/20/2018. This sampling location is supplemental and not a required ODCM requirement. August had 5 weekly sampling opportunities; this sample did not prevent the monthly composite analysis. Event documented through CR 18-12934.
5. Site 43 Environmental Dosimetry missing for 3rd Quarter 2018.	During the Quarterly Environmental Dosimetry change-out, it was discovered that the Site 43 dosimetry and stanchion was missing and could not be located. The stanchion and dosimetry were replaced for the 4th Quarter 2018 sampling period. Event documented through CR 18-15019.
6. All Air Sample Sites utilized cartridges different than those that are procedurally directed, during sample period 8/19/18-9/21/2018.	It was identified, during sample media change-out, that CP-100 filter cartridges were used versus the procedurally directed F&J cartridges. Samples were counted in the Unit Labs instead of the Central Lab, to accommodate the differing analytical geometry. LLDs were met and data is reported in Table 8-5. Event documented through CR 18-13499.
7. Air Sample Site 14 INVALID due to damaged cartridge for sample period 8/19/18-9/21/2018.	Damage to the radioiodine cartridge was identified for Air Sample Site 14. The sample was analyzed for information purposes; however the sample is deemed INVALID. Sample results are reported in Table 8-5 as INFO ONLY. Event documented through CR 18-13499 (Table 8-5, Note 2).
8. Site 10 Environmental Dosimetry missing for 4th Quarter 2018.	During the Quarterly Environmental Dosimetry change-out, it was discovered that the Site 10 dosimetry and stanchion was missing and could not be located. The stanchion and dosimetry were replaced for the 1st Quarter 2019 sampling period. Event documented through CR 18-20140.

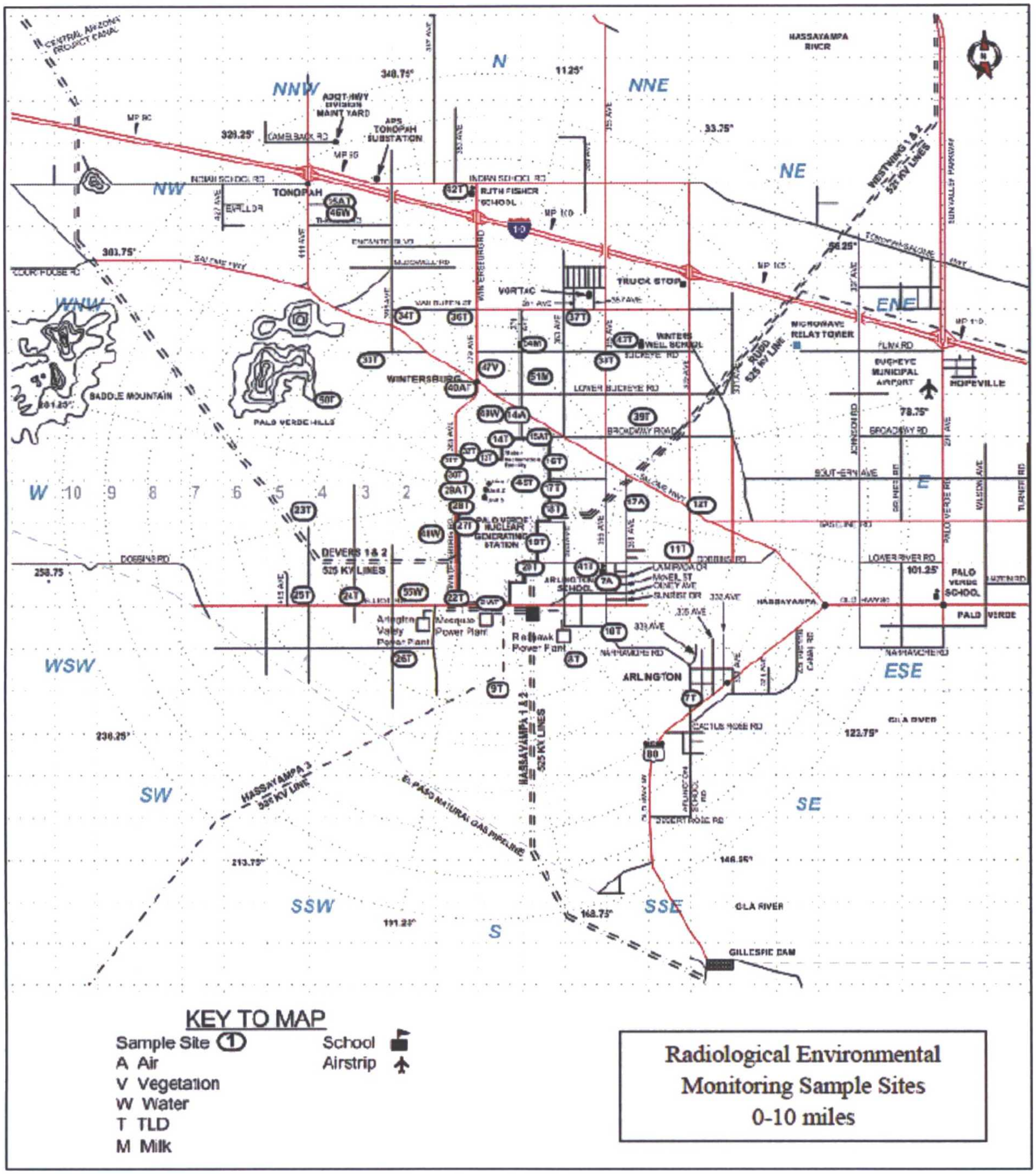


Figure 2-1 REMP Sample Sites- Map (0-10 miles)

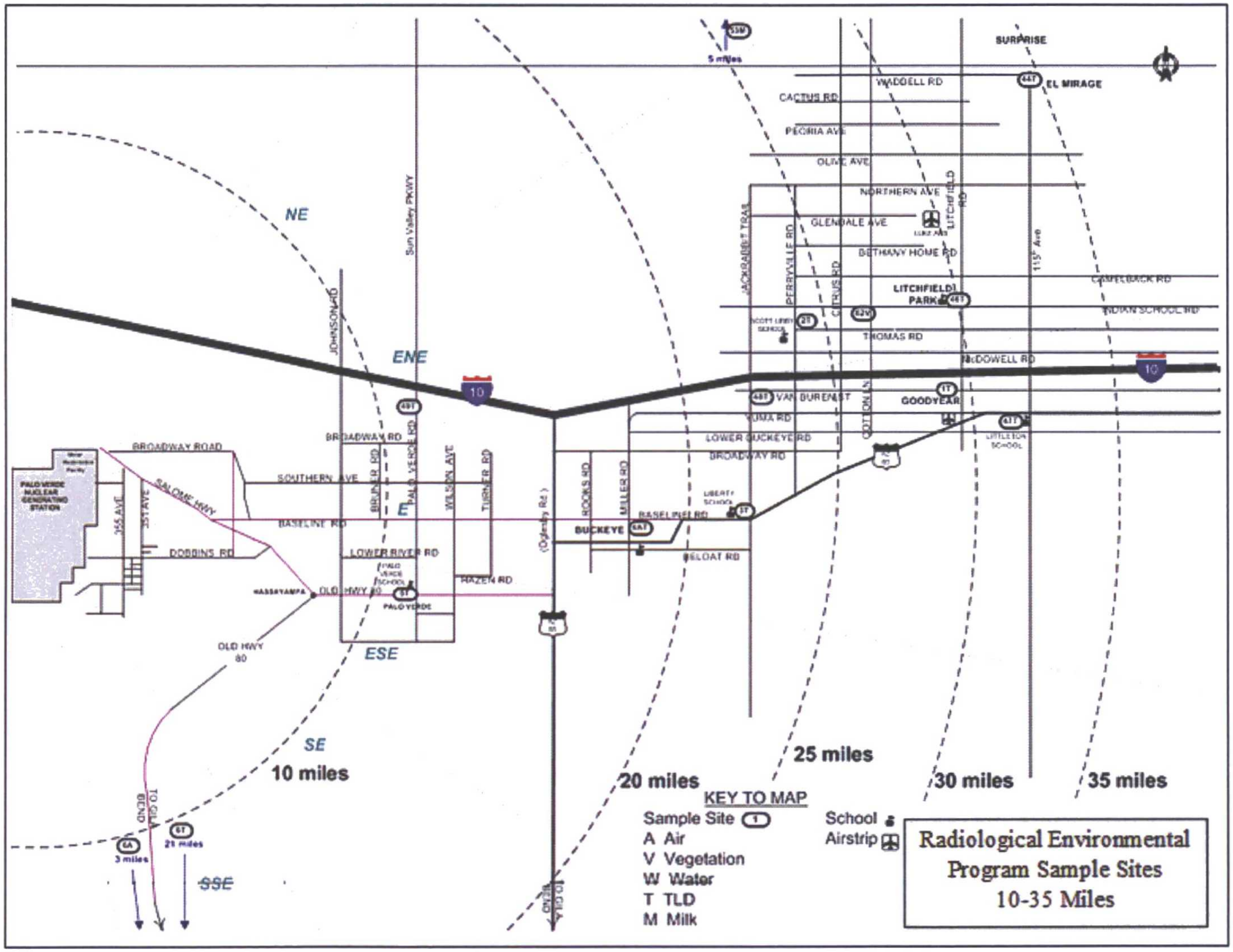


Figure 2-2 REMP Sample Sites- Map (10-35 Miles)

3. Sample Collection Program

APS Personnel, using PVNGS procedures, collected all samples.

3.1 Water

Weekly samples were collected from four (4) residence wells for monthly and quarterly composites. Samples were collected in one-gallon containers (plastic cubitainers) and 500 mL glass bottles. The samples were analyzed for gross beta, gamma-emitting radionuclides, and tritium.

Quarterly grab samples were collected from the 45 and 85 acre Reservoirs, active Evaporation Ponds 1A/B/C, 2A/B, and 3A/B, and onsite wells 34abb, 27ddc, 34aab, and 27dcb. Samples were collected in one-gallon containers (plastic cubitainers) and 500 mL glass bottles. Samples were analyzed for gamma-emitting radionuclides and tritium.

Treated sewage effluent from the City of Phoenix was sampled as a weekly composite at the onsite Water Resources (WR), and analyzed for gamma-emitting radionuclides. A monthly composite was analyzed for tritium.

3.2 Vegetation

Vegetation samples were collected monthly, as available, and were analyzed for gamma-emitting radionuclides.

3.3 Milk

Goat milk samples were collected monthly, as available, and were analyzed for gamma-emitting radionuclides, including low level I-131.

3.4 Air

Air particulate filters and charcoal cartridges were collected at ten (10) sites on a weekly basis. Particulate filters were analyzed for gross beta. Charcoal cartridges were analyzed for Iodine-131. Particulate filters were composited quarterly, by location, and analyzed for gamma-emitting radionuclides.

3.5 Soil, Sludge, and Sediment

Sludge samples were obtained weekly from the WR waste centrifuge (during operational periods) and analyzed for gamma-emitting radionuclides. Cooling tower sludge was analyzed for gamma-emitting radionuclides prior to disposal in the WR sludge landfill.

4. Analytical Procedures

The procedures described in this report are those used by APS to routinely analyze samples

4.1 Air Particulate

4.1.1 Gross Beta

A glass fiber filter sample is placed in a stainless steel planchet and counted for gross beta activity utilizing a low background gas flow proportional counter.

4.1.2 Gamma Spectroscopy

The glass fiber filters are counted on a multichannel analyzer equipped with a High-purity Germanium (HPGe) detector. The resulting spectrum is analyzed by a computer for specific radionuclides and verified by trained technicians.

4.2 Airborne Radioiodine

4.2.1 Gamma Spectroscopy

The charcoal cartridge is counted on a multichannel analyzer equipped with an HPGe detector. The resulting spectrum is analyzed by a computer for Iodine-131.

4.3 Milk

4.3.1 Gamma Spectroscopy

The sample is placed in a plastic marinelli beaker and counted on a multichannel analyzer equipped with an HPGe detector. The resulting spectrum is analyzed by a computer for specific radionuclides and verified by trained technicians.

4.3.2 Radiochemical I-131 Separation

Iodine in milk sample is reduced with sodium bisulfite and iodine is absorbed by the anion exchange resin. The iodine is eluted with NaOCl. Iodine is extracted from the sample with carbon tetrachloride. The iodine is back extracted from the organic with water containing sodium bisulfate and then precipitated as CuI. The precipitate is mounted in a planchet and counted for gross beta.

4.4 Vegetation

4.4.1 Gamma Spectroscopy

The sample is pureed in a food processor, placed in a one liter plastic marinelli beaker, weighed, and counted on a multichannel analyzer equipped with an HPGe detector. The resulting spectrum is analyzed by a computer for specific radionuclides and verified by trained technicians.

4.5 Sludge/Sediment

4.5.1 Gamma Spectroscopy

The wet/dry sample is placed in a one-liter plastic marinelli beaker, weighed, and counted on a multichannel analyzer equipped with an HPGe detector. The resulting spectrum is analyzed by a computer for specific radionuclides and verified by trained technicians.

4.6 Water

4.6.1 Gamma Spectroscopy

The sample is placed in a one-liter plastic marinelli beaker and counted on a multichannel analyzer equipped with a HPGe detector. The resulting spectrum is analyzed by a computer for specific radionuclides and verified by trained technicians.

4.6.2 Tritium

The sample is evaluated to determine the appropriate method of preparation prior to counting. If the sample contains suspended solids or is turbid, it may be filtered, distilled, and/or de-ionized, as appropriate. Eight (8) milliliters of sample are mixed with fifteen (15) milliliters of liquid scintillation cocktail. The mixture is dark adapted and counted for tritium activity using a liquid scintillation counting system.

4.6.3 Gross Beta

A 200-250 milliliter sample is placed in a beaker. Five (5) milliliters of concentrated nitric (HNO_3) acid is added and the sample is evaporated down to about twenty (20) milliliters. The remaining sample is transferred to a stainless steel planchet. The sample is heated to dryness and counted for gross beta in a gas flow proportional counter.

4.7 Soil

4.7.1 Gamma Spectroscopy

The samples are sieved, placed in a one-liter plastic marinelli beaker, and weighed. The samples are then counted on a multichannel analyzer equipped with an HPGe detector. The resulting spectrum is analyzed by a computer for specific radionuclides and verified by trained technicians.

5. Nuclear Instrumentation

5.1 Gamma Spectrometer

The Canberra Gamma Spectrometer consists of a Canberra System equipped with HPGe detectors, having resolutions of 1.73 keV and 1.88 keV (as determined by full width half max with an energy of 0.5 keV per channel) and respective efficiencies of 21.5% and 38.4% (as determined by the manufacturer with Co-60). The Canberra System is used for all gamma counting. The system uses Canberra developed software to search, identify, and quantify the peaks of interest.

5.2 Liquid Scintillation Spectrometer

A Beckman LS-6500 Liquid Scintillation Counter is used for tritium determinations. The system background averages approximately 12-16 cpm with a counting efficiency of approximately 40% using a quenched standard.

5.3 Gas Flow Proportional Counter

The Tennelec S5E is a low background gas flow proportional counter for gross beta analysis. The system contains an automatic sample changer capable of counting 50 samples in succession. Average beta background count rate is about 1-2 cpm with a beta efficiency of approximately 30% for Cs-137.

6. Isotopic Detection Limits and Reporting Criteria

6.1 Lower Limits of Detection

The lower limits of detection (LLD) and the method for calculation are specified in the PVNGS ODCM, Reference 4. The ODCM required *a priori* LLDs are presented in Table 6-1.

6.2 Data Reporting Criteria

All results that are greater than the Minimum Detectable Activity (MDA) (*a posteriori* LLD) are reported as positive activity with its associated 2σ counting error. All results that are less than the MDA are reported as less than values at the associated MDA. For example, if the MDA is 12 pCi/liter, the value is reported as <12.

Typical MDA values are presented in Table 6-3.

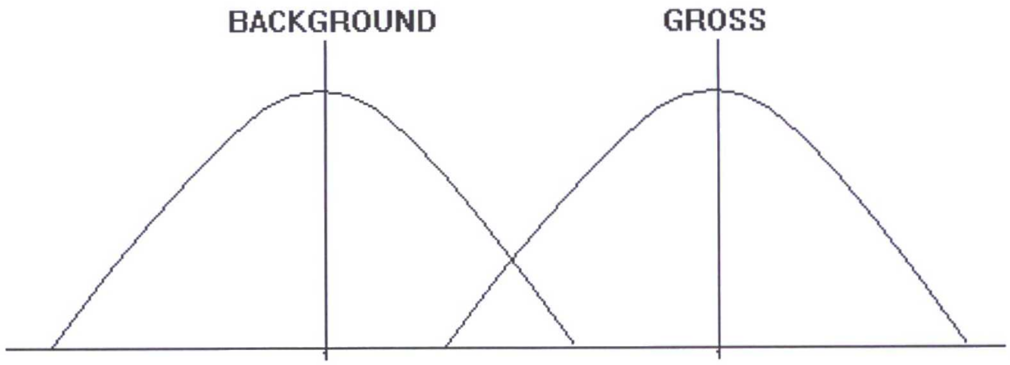
Occasionally, the PVNGS ODCM *a priori* LLDs may not be achieved as a result of:

- Background fluctuations
- Unavoidably small sample sizes
- The presence of interfering radionuclides
- Self-absorption corrections
- Decay corrections for short half-life radionuclides
- Other uncontrollable circumstances

In these instances, the contributing factors will be noted in the table where the data are presented. A summary of deviations/abnormal events is presented in Table 2-3 Summaries of the REMP Deviations/Abnormal Events and includes a description of any sample results that did not meet *a priori* LLD requirements.

6.3 LLD and Reporting Criteria Overview

Making a reasonable estimate of the limits of detection for a counting procedure or a radiochemical method is usually complicated by the presence of significant background. It must be considered that the background or blank is not a fixed value but that a series of replicates would be normally distributed. The desired net activity is the difference between the gross and background activity distributions. The interpretation of this difference becomes a problem if the two distributions intersect as indicated in the diagram.



If a sufficient number of replicate analyses are run, it is expected that the results would fall in a normal Gaussian distribution. Standard statistics allow an estimate of the probability of any particular deviation from the mean value. It is common practice to report the mean ± one or two standard deviations as the result. In routine analysis, such replication is not carried out, and it is not possible to report a Gaussian standard deviation. With counting procedures, however, it is possible to estimate a Poisson standard deviation directly from the count. Data are commonly reported as the measured value ± one or two Poisson standard deviations. The reported values are then considered to give some indication of the range in which the true value might be expected to occur.

LLD is the smallest amount of sample activity that will yield a net count for which there is confidence at a predetermined level that activity is present. LLDs are calculated values for individual radionuclides based on a number of different factors including sample size, counting efficiency and background count rate of the instrument, the background and sample counting time, the decay time, and the chemical recovery of the analytical procedures. A minimum detectable activity value (MDA) is the smallest amount of activity that can be detected in an actual sample and uses the values obtained from the instrument and outcome of the analytical process. Therefore, the MDA values may differ from the calculated LLD values if the sample size and chemical recovery, decay values, or the instrument efficiency, background, or count time differed from those used in the LLD calculation.

The factors governing the calculation of the LLD and MDA values are discussed below:

1. **Sample Size:** The number of observations included in a statistical analysis. Sample size dictates the amount of information available about a studied subject to make accurate inferences.

2. **Counting Efficiency**: The fundamental quantity in the measurement of a radioactive substance is the number of disintegrations per unit time. As with most physical measurements in analytical chemistry, an absolute measurement of the disintegration rate is seldom possible, rather it is necessary to compare the sample with one or more standards. The standards determine the counter efficiency that may then be used to convert sample counts per minute (cpm) to disintegrations per minute (dpm).

3. **Background Count Rate**: Any counter will show a certain counting rate without a sample in position. This background counting rate comes from several sources: 1) natural environmental radiation from the surrounding materials, 2) cosmic radiation, and 3) the natural radioactivity in the counter material itself. The background counting rate will depend on the amounts of these types of radiation and the sensitivity of the counter to the radiation.

4. **Background and Sample Counting Time**: The amount of time devoted to the counting of the background depends on the level of activity being measured. In general, with low level samples, this time should be about equal to that devoted to counting a sample.

5. **Time Interval between Sample Collection and Counting**: Decay measurements are useful in identifying certain short-lived nuclides. The disintegration constant is one of the basic characteristics of a specific radionuclide and is readily determined, if the half-life is sufficiently short. To ensure the required LLDs are achieved, appropriate decay correction values are used to account for radioactive decay during transit time and sample processing.

Table 6-1 ODCM Required Lower Limits of Detection (a priori)

Analysis	Water (pCi/l)	Airborne Particulate or Gas (pCi/m^3)	Fresh Milk (pCi/l)	Food Products (pCi/kg, wet)
Gross Beta	4	0.01		
H-3	2000*			
Mn-54	15			
Fe-59	30			
Co-58, -60	15			
Zn-65	30			
Zr-95	30			
Nb-95	15			
I-131	1**	0.07	1	60
Cs-134	15	0.05	15	60
Cs-137	18	0.06	18	80
Ba-140	60		60	
La-140	15		15	

* If no drinking water pathway exists, a value of 3000 pCi/liter may be used
** If no drinking water pathway exists, a value of 15 pCi/liter may be used

NOTES:
This list does not mean that only these nuclides are to be detected and reported. Other peaks that are measurable and identifiable, together with the above nuclides, shall also be identified and reported.

Table 6-2 ODCM Required Reporting Levels

Analysis	Water (pCi/l)	Airborne Particulate or Gas (pCi/m^3)	Fresh Milk (pCi/l)	Food Products (pCi/kg, wet)
H-3	20,000 *			
Mn-54	1,000			
Fe-59	400			
Co-58	1,000			
Co-60	300			
Zn-65	300			
Zr-Nb-95	400			
I-131	2 **	0.9	3	100
Cs-134	30	10	60	1,000
Cs-137	50	20	70	2,000
Ba-La-140	200		300	

* For drinking water samples. This is a 40 CFR 141 value. If no drinking water pathway exists, a value of 30,000 pCi/L may be used.

** If no drinking water pathway exists, a reporting level of 20 pCi/L may be used.

Table 6-3 Typical MDA Values

Analysis/Nuclide	Water (pCi/liter)	Milk (pCi/liter)	Airborne Particulate or Gas (pCi/m³)	Vegetation (pCi/kg, wet)
Gross Beta	2.08		0.004	
H-3	326			
Mn-54	10			
Fe-59	20			
Co-58	9			
Co-60	11			
Zn-65	22			
Zr-95	16			
Nb-95	10			
I-131	10[a]	1	0.04[b]	49
Cs-134	9	1	0.003[b]	47
Cs-137	10	1	0.003[b]	61
Ba-140	33	3		
La-140	13	1		

NOTES:

a - low level I-131 is not required since there is no drinking water pathway

b - Based on 433 m^3, the normal weekly sample volume

7. Interlaboratory Comparison Program

7.1 Quality Control Program

APS maintains an extensive QA/QC Program to provide assurance that samples are collected, handled, tracked, and analyzed to specified requirements. This program includes appropriate elements of USNRC Regulatory Guide 4.15, Quality Assurance for Radiological Monitoring Programs (Normal Operations) - Effluent Streams and the Environment, Revision 1. Included in the program are procedures for sample collection, preparation and tracking, sample analysis, equipment calibration and checks, and ongoing participation in an interlaboratory comparison program. Duplicate/replicate samples are analyzed to verify analytical precision and sample methodology. Comprehensive data reviews are performed including trending of data where appropriate.

During 2018, APS analyzed the following sample types under the interlaboratory comparison program:

- Beta/Gamma/ in Air Filter
- I-131 in Air
- Beta in Water
- Gamma in Water
- Tritium in Water
- Gamma in Milk

7.2 Intercomparison Results

APS participates in a crosscheck program using vendor supplied blind radionuclide samples. Results for the interlaboratory comparison program are presented in Table 7-1.

Table 7-1 Interlaboratory Comparison Results

Sample ID	Analysis Type	Nuclide	Units	Known Value	PVNGS Value	1 sigma Error	Resolution*	Ratio	NRC Range	Results
E12104	Beta Filter	G. Beta	pCi/ea	1.24E+02	1.26E+02	2.60E+00	48	1.02	0.75 - 1.33	Acceptable
E12105	CL Det 1 I-131 Cartridge	I-131	pCi/ea	9.57E+01	8.94E+01	1.42E+01	6	0.93	0.50 - 2.00	Acceptable
E12105	CL Det 2 I-131 Cartridge	I-131	pCi/ea	9.57E+01	9.39E+01	8.22E+00	11	0.98	0.60 - 1.66	Acceptable
E12105	CL Det 3 I-131 Cartridge	I-131	pCi/ea	9.57E+01	9.89E+01	6.69E+00	15	1.03	0.60 - 1.66	Acceptable
E12106	Gamma Filter	Ce-141	pCi/ea	8.23E+01	8.05E+01	7.68E+00	10	0.98	0.60 - 1.66	Acceptable
	CL Det 1	Co-58	pCi/ea	1.22E+02	1.29E+02	1.31E+01	10	1.06	0.60 - 1.66	Acceptable
		Co-60	pCi/ea	2.00E+02	2.01E+02	1.21E+01	17	1.01	0.75 - 1.33	Acceptable
		Cr-51	pCi/ea	3.48E+02	3.64E+02	4.72E+01	8	1.05	0.60 - 1.66	Acceptable
		Cs-134	pCi/ea	1.92E+02	1.71E+02	8.93E+00	19	0.89	0.75 - 1.33	Acceptable
		Cs-137	pCi/ea	1.84E+02	1.94E+02	2.12E+01	9	1.05	0.60 - 1.66	Acceptable
		Fe-59	pCi/ea	1.48E+02	1.65E+02	1.26E+01	13	1.11	0.60 - 1.66	Acceptable
		Mn-54	pCi/ea	1.40E+02	1.51E+02	1.45E+01	10	1.08	0.60 - 1.66	Acceptable
		Zn-65	pCi/ea	2.61E+02	2.87E+02	2.60E+01	11	1.10	0.60 - 1.66	Acceptable
E12106	Gamma Filter	Ce-141	pCi/ea	8.23E+01	8.47E+01	7.53E+00	11	1.03	0.60 - 1.66	Acceptable
	CL Det 3	Co-58	pCi/ea	1.22E+02	1.33E+02	1.45E+01	9	1.09	0.60 - 1.66	Acceptable
		Co-60	pCi/ea	2.00E+02	2.07E+02	1.23E+01	17	1.04	0.75 - 1.33	Acceptable
		Cr-51	pCi/ea	3.48E+02	3.40E+02	3.72E+01	9	0.98	0.60 - 1.66	Acceptable
		Cs-134	pCi/ea	1.92E+02	1.49E+02	8.50E+00	18	0.78	0.75 - 1.33	Acceptable
		Cs-137	pCi/ea	1.84E+02	2.01E+02	2.51E+01	8	1.09	0.60 - 1.66	Acceptable
		Fe-59	pCi/ea	1.48E+02	1.76E+02	1.26E+01	14	1.19	0.60 - 1.66	Acceptable
		Mn-54	pCi/ea	1.40E+02	1.62E+02	1.67E+01	10	1.16	0.60 - 1.66	Acceptable
		Zn-65	pCi/ea	2.61E+02	3.12E+02	2.80E+01	11	1.20	0.60 - 1.66	Acceptable
E12108	Gamma Milk	Ce-141	pCi/L	2.04E+01	1.29E+01	2.33E+00	6	0.63	0.50 - 2.00	Acceptable
	CL Det 2	Co-58	pCi/L	3.02E+01	2.60E+01	2.56E+00	10	0.86	0.60 - 1.66	Acceptable
		Co-60	pCi/L	4.95E+01	4.26E+01	2.60E+00	16	0.86	0.75 - 1.33	Acceptable
		Cr-51	pCi/L	8.61E+01	8.41E+01	9.00E+00	9	0.98	0.60 - 1.66	Acceptable
		Cs-134	pCi/L	4.75E+01	4.49E+01	2.10E+00	21	0.95	0.75 - 1.33	Acceptable
		Cs-137	pCi/L	4.55E+01	4.70E+01	4.29E+00	11	1.03	0.60 - 1.66	Acceptable
		Fe-59	pCi/L	3.67E+01	3.56E+01	3.08E+00	12	0.97	0.60 - 1.66	Acceptable
		I-131	pCi/L	1.55E+01	1.69E+01	4.38E+00	4	1.09	0.50 - 2.00	Acceptable
		Mn-54	pCi/L	3.47E+01	2.60E+01	2.54E+00	10	0.75	0.60 - 1.66	Acceptable
		Zn-65	pCi/L	6.46E+01	4.63E+01	4.07E+00	11	0.72	0.60 - 1.66	Acceptable
E12108	Gamma Milk	Ce-141	pCi/L	2.04E+01	2.11E+01	3.11E+00	7	1.03	0.50 - 2.00	Acceptable
	CL Det 3	Co-58	pCi/L	3.02E+01	3.16E+01	3.62E+00	9	1.05	0.60 - 1.66	Acceptable
		Co-60	pCi/L	4.95E+01	5.19E+01	3.39E+00	15	1.05	0.60 - 1.66	Acceptable
		Cr-51	pCi/L	8.61E+01	8.89E+01	1.63E+01	5	1.03	0.50 - 2.00	Acceptable
		Cs-134	pCi/L	4.75E+01	4.51E+01	3.18E+00	14	0.95	0.60 - 1.66	Acceptable
		Cs-137	pCi/L	4.55E+01	4.72E+01	4.51E+00	10	1.04	0.60 - 1.66	Acceptable
		Fe-59	pCi/L	3.67E+01	3.93E+01	3.74E+00	11	1.07	0.60 - 1.66	Acceptable
		I-131	pCi/L	1.55E+01	1.59E+01	3.12E+00	5	1.03	0.50 - 2.00	Acceptable
		Mn-54	pCi/L	3.47E+01	3.55E+01	4.50E+00	8	1.02	0.60 - 1.66	Acceptable
		Zn-65	pCi/L	6.46E+01	6.55E+01	7.69E+00	9	1.01	0.60 - 1.66	Acceptable
E12109	H-3 Water	H-3	pCi/L	1.37E+04	1.21E+04	3.60E+02	34	0.88	0.75 - 1.33	Acceptable

* calculated from PVNGS value/1 sigma error value

** Eckert & Ziegler Analytics, Inc. NIST-traceable known value

NRC Acceptance Criteria [1]

Resolutior	Ratio
4-7	0.5-2.0
8-15	0.6-1.66
16-50	0.75-1.33
51-200	0.80-1.25
>200	0.85-1.18

[1] From NRC Inspection Manual, procedure #84750, "Radioactive Waste Treatment, and Effluent and Environmental Monitoring"

Table 7-1 Interlaboratory Comparison Results (Continued)

Sample ID	Analysis Type	Nuclide	Units	Known Value	PVNGS Value	1 sigma Error	Resolution*	Ratio	NRC Range	Results
E12295	Gamma Water CL Det 2	Ce-141	pCi/L	1.33E+02	1.31E+02	1.16E+01	11	0.98	0.60 - 1.66	Acceptable
		Co-58	pCi/L	1.50E+02	1.45E+02	1.36E+01	11	0.97	0.60 - 1.66	Acceptable
		Co-60	pCi/L	1.98E+02	1.99E+02	1.22E+01	16	1.01	0.75 - 1.33	Acceptable
		Cr-51	pCi/L	2.75E+02	2.88E+02	4.15E+01	7	1.05	0.50 - 2.00	Acceptable
		Cs-134	pCi/L	1.28E+02	1.14E+02	7.48E+00	15	0.89	0.60 - 1.66	Acceptable
		Cs-137	pCi/L	1.54E+02	1.50E+02	1.41E+01	11	0.97	0.60 - 1.66	Acceptable
		Fe-59	pCi/L	1.24E+02	1.31E+02	1.06E+01	12	1.06	0.60 - 1.66	Acceptable
		I-131	pCi/L	6.25E+01	6.08E+01	6.54E+00	9	0.97	0.60 - 1.66	Acceptable
		Mn-54	pCi/L	1.74E+02	1.83E+02	1.66E+01	11	1.05	0.60 - 1.66	Acceptable
		Zn-65	pCi/L	2.09E+02	2.18E+02	1.96E+01	11	1.04	0.60 - 1.66	Acceptable
E12295	Gamma Water CL Det 3	Ce-141	pCi/L	1.33E+02	1.36E+02	9.17E+00	15	1.02	0.60 - 1.66	Acceptable
		Co-58	pCi/L	1.50E+02	1.49E+02	1.05E+01	14	0.99	0.60 - 1.66	Acceptable
		Co-60	pCi/L	1.98E+02	2.01E+02	8.82E+00	23	1.02	0.75 - 1.33	Acceptable
		Cr-51	pCi/L	2.75E+02	2.98E+02	3.36E+01	9	1.08	0.60 - 1.66	Acceptable
		Cs-134	pCi/L	1.28E+02	1.19E+02	5.77E+00	21	0.93	0.75 - 1.33	Acceptable
		Cs-137	pCi/L	1.54E+02	1.50E+02	1.01E+02	1	0.97	0.50 - 2.00	Acceptable
		Fe-59	pCi/L	1.24E+02	1.35E+02	9.25E+00	15	1.09	0.60 - 1.66	Acceptable
		I-131	pCi/L	6.25E+01	6.22E+01	6.12E+00	10	1.00	0.60 - 1.66	Acceptable
		Mn-54	pCi/L	1.74E+02	1.85E+02	1.28E+01	14	1.06	0.60 - 1.66	Acceptable
		Zn-65	pCi/L	2.09E+02	2.28E+02	1.50E+01	15	1.09	0.60 - 1.66	Acceptable
E12296	Beta Filter [2]	G Beta	pCi/ea	1.96E+02	1.27E+02	2.60E+00	49	0.65	0.75 - 1.33	Not Acceptable
E12297	CL Det 1 I-131 Cartridge	I-131	pCi/ea	8.20E+01	7.71E+01	7.50E+00	10	0.94	0.60 - 1.66	Acceptable
E12297	CL Det 2 I-131 Cartridge	I-131	pCi/ea	8.20E+01	8.39E+01	7.12E+00	12	1.02	0.60 - 1.66	Acceptable
E12297	CL Det 3 I-131 Cartridge	I-131	pCi/ea	8.20E+01	8.23E+01	6.25E+00	13	1.00	0.60 - 1.66	Acceptable
E12298	Gamma Filter CL Det 1	Ce-141	pCi/ea	9.78E+01	1.00E+02	8.46E+00	12	1.02	0.60 - 1.66	Acceptable
		Co-58	pCi/ea	1.10E+02	1.16E+02	1.14E+01	10	1.05	0.60 - 1.66	Acceptable
		Co-60	pCi/ea	1.45E+02	1.51E+02	9.08E+00	17	1.04	0.75 - 1.33	Acceptable
		Cr-51	pCi/ea	2.02E+02	2.16E+02	2.61E+01	8	1.07	0.60 - 1.66	Acceptable
		Cs-134	pCi/ea	9.36E+01	8.40E+01	4.57E+00	18	0.90	0.75 - 1.33	Acceptable
		Cs-137	pCi/ea	1.13E+02	1.20E+02	1.32E+01	9	1.06	0.60 - 1.66	Acceptable
		Fe-59	pCi/ea	9.11E+01	1.03E+02	7.66E+00	13	1.13	0.60 - 1.66	Acceptable
		Mn-54	pCi/ea	1.28E+02	1.41E+02	1.32E+01	11	1.10	0.60 - 1.66	Acceptable
		Zn-65	pCi/ea	1.53E+02	1.72E+02	1.56E+01	11	1.12	0.60 - 1.66	Acceptable
E12298	Gamma Filter CL Det 2	Ce-141	pCi/ea	9.78E+01	9.80E+01	7.91E+00	12	1.00	0.60 - 1.66	Acceptable
		Co-58	pCi/ea	1.10E+02	1.16E+02	1.36E+01	9	1.05	0.60 - 1.66	Acceptable
		Co-60	pCi/ea	1.45E+02	1.48E+02	8.56E+00	17	1.02	0.75 - 1.33	Acceptable
		Cr-51	pCi/ea	2.02E+02	1.96E+02	2.15E+01	9	0.97	0.60 - 1.66	Acceptable
		Cs-134	pCi/ea	9.36E+01	7.25E+01	4.71E+00	15	0.77	0.60 - 1.66	Acceptable
		Cs-137	pCi/ea	1.13E+02	1.21E+02	1.79E+01	7	1.07	0.50 - 2.00	Acceptable
		Fe-59	pCi/ea	9.11E+01	1.06E+02	7.58E+00	14	1.16	0.60 - 1.66	Acceptable
		Mn-54	pCi/ea	1.28E+02	1.46E+02	1.58E+01	9	1.14	0.60 - 1.66	Acceptable
		Zn-65	pCi/ea	1.53E+02	1.76E+02	1.58E+01	11	1.15	0.60 - 1.66	Acceptable
E12298	Gamma Filter CL Det 3	Ce-141	pCi/ea	9.78E+01	1.03E+02	9.14E+00	11	1.05	0.60 - 1.66	Acceptable
		Co-58	pCi/ea	1.10E+02	1.18E+02	1.28E+01	9	1.07	0.60 - 1.66	Acceptable
		Co-60	pCi/ea	1.45E+02	1.54E+02	9.18E+00	17	1.06	0.75 - 1.33	Acceptable
		Cr-51	pCi/ea	2.02E+02	2.06E+02	2.48E+01	8	1.02	0.60 - 1.66	Acceptable
		Cs-134	pCi/ea	9.36E+01	7.81E+01	4.68E+00	17	0.83	0.75 - 1.33	Acceptable
		Cs-137	pCi/ea	1.13E+02	1.26E+02	1.58E+01	8	1.12	0.60 - 1.66	Acceptable
		Fe-59	pCi/ea	9.11E+01	1.09E+02	8.19E+00	13	1.20	0.60 - 1.66	Acceptable
		Mn-54	pCi/ea	1.28E+02	1.47E+02	1.51E+01	10	1.15	0.60 - 1.66	Acceptable
		Zn-65	pCi/ea	1.53E+02	1.81E+02	1.67E+01	11	1.18	0.60 - 1.66	Acceptable
E12299	Beta Water	H-3	pCi/L	2.16E+02	2.47E+02	5.30E+00	47	1.14	0.75 - 1.33	Acceptable
E12300	Tech A H-3 Water	H-3	pCi/L	1.29E+04	1.25E+04	3.57E+02	35	0.97	0.75 - 1.33	Acceptable
E12300	Tech B H-3 Water	H-3	pCi/L	1.29E+04	1.25E+04	3.56E+02	35	0.97	0.75 - 1.33	Acceptable
E12300	Tech C H-3 Water	H-3	pCi/L	1.29E+04	1.21E+04	3.55E+02	34	0.94	0.75 - 1.33	Acceptable
E12300	Tech D H-3 Water	H-3	pCi/L	1.29E+04	1.23E+04	3.60E+02	34	0.95	0.75 - 1.33	Acceptable

* calculated from PVNGS value/1 sigma error value

NRC Acceptance Criteria [1]

Resolutior	Ratio
4-7	0.5-2.0
8-15	0.6-1.66
16-50	0.75-1.33
51-200	0.80-1.25
>200	0.85-1.18

[1] From NRC Inspection Manual, procedure #84750, "Radioactive Waste Systems; Water Chemistry; Confirmatory Measurements"

[2] CR 19-00619 documents the failure and proposed corrective action.

Table 7-1 Interlaboratory Comparison Results (Continued)

Sample Type	Analysis Type	ERA PT Study	Nuclide	Units	PVNGS Value	Assigned Value [1]	Acceptance Limit [2]	Results
Water	Gross Beta	RAD-114	Gross Beta	pCi/L	54	49	33.2-56.1	Acceptable
Water	Gamma	RAD-114	Ba-133	pCi/L	24.5	25.6	19.9-29.4	Acceptable
			Cs-134	pCi/L	15.2	15.7	11.4-18.2	Acceptable
			Cs-137	pCi/L	189	192	173-213	Acceptable
			Co-60	pCi/L	118	119	107-133	Acceptable
			Zn-65	pCi/L	178	177	159-208	Acceptable

[1] The ERA assigned values are established per the guidelines contained in the National Environmental Laboratory Accreditation Conference (NELAC) program criteria as applicable.

[2] "Acceptance Limits" have been calculated per ERA's Standard Operating Procedure for the Generation of Performance Acceptance Limits.

8. Data Interpretation and Conclusions

Associated with the analytical process are potential random and systematic errors. Systematic errors can be caused by instrument malfunctions, incomplete precipitation, back scattering, and self-absorption.

Efforts are made to minimize both systematic and random errors in the data reported. Systematic errors are minimized by performing reviews throughout the analysis. For example, instruments are checked routinely with radioactive sources, and recovery and self-absorption factors based on individual sample analyses are incorporated into the calculation equations where necessary. Random errors are reduced by comparing all data to historical data for the same site and performing comparisons between analytical results when available. In addition, when data do not appear to match historical results, analyses may be rerun on a separate aliquot of the sample to verify the presence of the activity. The acceptance of data is dependent upon the results of quality control samples and is part of the data review process for all analytical results.

The "plus or minus value" reported with each analytical result represents the counting error associated with the result and gives the 95% confidence (2σ) interval around the data.

Most samples contain radioactivity associated with natural background/cosmic radioactivity (e.g. K-40, Th-234, Be-7). Gross beta results for drinking water and air are due to natural background. Gamma-emitting radionuclides, which can be attributed to natural background sources, are not indicated in this report.

Results and interpretation of the data for all of the samples analyzed during 2018 are presented in the following sections.

8.1 Air Particulates

Weekly gross beta results, in quarterly format, are presented in Table 8-1 and Table 8-2. Gross beta activity at indicator locations ranged from 0.011 to 0.078 pCi/m^3. Mean quarterly activity is normally calculated using weekly activity over a thirteen (13) week period. Also presented in the tables are the weekly mean values of all the sites as well as the percent relative standard deviation (RSD %) for the data.

Table 8-3 displays the results of gamma spectroscopy on the quarterly composites of the weekly samples. No plant-related activity was identified

8.2 Airborne Radioiodine

Table 8-4 and Table 8-5 present the quarterly radioiodine results. Radioiodine was not observed in any samples.

8.3 Vegetation

Table 8-6 presents gamma isotopic data for the vegetation samples. No gamma-emitting radionuclides were observed in any of the samples.

8.4 Milk

Table 8-7 presents gamma isotopic data for the goat milk samples. No gamma-emitting radionuclides were observed in any of the samples.

8.5 Drinking Water

Samples were analyzed for gross beta, tritium, and gamma-emitting radionuclides. Results of these analyses are presented in Table 8-8. No tritium or gamma-emitting radionuclides were detected in any samples. Gross beta activity ranged from less than detectable to a high of 5.32 pCi/liter. The gross beta activity is attributable to natural (background) radioactive materials.

8.6 Groundwater

Groundwater samples were analyzed from two onsite wells (regional aquifer) for tritium and gamma-emitting radionuclides. Results obtained from the analysis of the samples are presented in Table 8-9.

No tritium or gamma-emitting radionuclides were observed in any of the samples.

8.7 Surface Water

Surface water samples from the Reservoirs and Evaporation Ponds were analyzed for tritium and gamma-emitting radionuclides. The two Reservoirs contain processed sewage water from the City of Phoenix and are approximately 45 and 85 acres in size. The three Evaporation Ponds receive mostly circulating water from main turbine condenser cooling and are about 200-250 acres each.

Sample results are presented in Table 8-10. I-131 was observed in both reservoirs and Evaporation Pond 1A. The I-131 levels ranged from 8 pCi/L – 13 pCi/L. I-131 in these surface water locations is a result of radiopharmaceutical I-131 in the Phoenix sewage effluent and is not attributable to plant effluents.

Tritium was routinely observed in the Evaporation Ponds. The highest concentration was 1146 pCi/liter. Tritium was not detected in the Reservoirs. The tritium identified in the Evaporation Ponds has been attributed to permitted plant gaseous effluent releases and secondary plant liquid discharges (e.g. condensate overboard discharge, secondary side steam generator drains, secondary plant sumps, demineralizer regeneration waste). The tritium concentrations were compared to historical values and are considered typical for the Evaporation Ponds.

8.8 Sludge and Sediment

8.8.1 WR Centrifuge Waste Sludge

Sludge samples were obtained from the WR centrifuge and analyzed by gamma spectroscopy. I-131 activity in the sludge is consistent with historical values and, as previously discussed, is due to radiopharmaceuticals in the WR Influent. The concentration of I-131 ranged from "no detectable" to 759 pCi/kg.

Results for WR centrifuge waste sludge can be found in Table 8-11.

8.8.2 Cooling Tower Sludge

Sludge/sediment originating from the Unit 2 and Unit 3 Cooling Towers and Circulating Water canals was disposed of in the WR sludge landfill during 2018. Sample results can be found in Table 8-11.

8.9 Data Trends

Figure 8-1 through Figure 8-8 present data in graphical format. Historical data are displayed for comparison where practical.

8.10 Hard-To-Detect Radionuclide Results

Table 8-12 shows the results of the three subsurface samples obtained from 3 tritium monitoring points. These samples were analyzed for hard-to-detect radionuclides (e.g. C-14, Fe-55, Ni-63, Sr-90) and all results were <MDA. These results indicate that no leaks from plant systems have affected groundwater.

Table 8-1 Particulate Gross Beta in Air 1st-2nd Quarter

PARTICULATE GROSS BETA IN AIR 1st QUARTER

ODCM required samples denoted by *

units are pCi/m^3

Week #	START DATE	STOP DATE	Site 4	(control) Site 6A*	Site 7A	Site 14A*	Site 15*	Site 17A	Site 21	Site 29*	Site 35	Site 40*	Mean	RSD (%)	Note
1	26-Dec-17	2-Jan-18	0.067	0.057	0.051	0.047	0.052	0.050	0.049	0.052	0.053	0.056	0.053	10.3	
2	2-Jan-18	9-Jan-18	0.072	0.065	0.054	0.061	0.053	0.078	0.055	0.046	0.052	0.043	0.058	19.3	
3	9-Jan-18	16-Jan-18	0.032	0.031	0.029	0.030	0.029	0.030	0.027	0.031	0.027	0.028	0.029	5.9	
4	16-Jan-18	23-Jan-18	0.041	0.035	0.039	0.036	0.042	0.041	0.041	0.040	0.039	0.041	0.039	5.8	
5	23-Jan-18	30-Jan-18	0.024	0.021	0.022	0.020	0.023	0.023	0.022	0.021	0.020	0.021	0.022	6.0	
6	30-Jan-18	6-Feb-18	0.070	0.064	0.054	0.044	0.049	0.062	0.057	0.054	0.052	0.046	0.055	14.7	
7	6-Feb-18	13-Feb-18	0.036	0.028	0.028	0.025	0.027	0.029	0.024	0.027	0.027	0.025	0.028	12.7	1
8	13-Feb-18	20-Feb-18	0.021	0.021	0.024	0.024	0.019	0.023	0.021	0.022	0.021	0.019	0.022	7.9	1
9	20-Feb-18	27-Feb-18	0.023	0.020	0.023	0.020	0.021	0.022	0.021	0.019	0.020	0.021	0.021	6.9	
10	27-Feb-18	6-Mar-18	0.019	0.019	0.020	0.017	0.017	0.021	0.021	0.019	0.019	0.018	0.019	7.6	
11	6-Mar-18	13-Mar-18	0.026	0.023	0.026	0.026	0.027	0.026	0.027	0.024	0.026	0.025	0.026	5.4	
12	13-Mar-18	20-Mar-18	0.015	0.013	0.016	0.014	0.014	0.017	0.013	0.013	0.015	0.012	0.014	10.0	
13	20-Mar-18	27-Mar-18	0.023	0.021	0.023	0.024	0.021	0.023	0.021	0.020	0.019	0.020	0.021	7.5	
	Mean		0.036	0.032	0.031	0.030	0.030	0.034	0.031	0.030	0.030	0.029	0.031	7.1	

Note 1: Site 4 blocked by road construstion on 2/13/2018. Site 4 Sample collected on 2/14/2018

PARTICULATE GROSS BETA IN AIR 2nd QUARTER

ODCM required samples denoted by *

units are pCi/m^3

Week #	START DATE	STOP DATE	Site 4	(control) Site 6A*	Site 7A	Site 14A*	Site 15*	Site 17A	Site 21	Site 29*	Site 35	Site 40*	Mean	RSD (%)	Note
14	27-Mar-18	3-Apr-18	0.027	0.021	0.025	0.027	0.025	0.029	0.024	0.026	0.025	0.022	0.025	9.8	
15	3-Apr-18	10-Apr-18	0.032	0.030	0.032	0.034	0.036	0.032	0.032	0.031	0.031	0.033	0.032	4.6	
16	10-Apr-18	17-Apr-18	0.027	0.025	0.023	0.021	0.021	0.025	0.022	0.020	0.025	0.019	0.023	11.2	
17	17-Apr-18	24-Apr-18	0.032	0.030	0.027	0.031	0.031	0.030	0.029	0.030	0.029	0.029	0.030	4.7	
18	24-Apr-18	1-May-18	0.037	0.040	0.035	0.037	0.031	0.037	0.038	0.034	0.042	0.028	0.036	11.3	
19	1-May-18	8-May-18	0.029	0.024	0.024	0.026	0.026	0.024	0.026	0.027	0.025	0.025	0.026	5.5	
20	8-May-18	15-May-18	0.024	0.027	0.026	0.027	0.024	0.024	0.022	0.024	0.025	0.019	0.024	10.0	
21	15-May-18	22-May-18	0.029	0.024	0.026	0.028	0.029	0.028	0.029	0.029	0.029	0.029	0.028	6.2	
22	22-May-18	29-May-18	0.026	0.025	0.024	0.028	0.027	0.027	0.027	0.028	0.030	0.023	0.027	7.7	
23	29-May-18	5-Jun-18	0.035	0.033	0.031	0.035	0.034	0.031	0.025	0.035	0.033	0.037	0.033	9.9	
24	5-Jun-18	12-Jun-18	0.031	0.031	0.033	0.029	0.031	0.030	0.031	0.031	0.031	0.023	0.030	8.9	
25	12-Jun-18	19-Jun-18	0.031	0.029	0.026	0.028	0.026	0.024	0.024	0.030	0.030	0.027	0.028	8.5	
26	19-Jun-18	26-Jun-18	0.035	0.032	0.032	0.036	0.035	0.037	0.028	0.031	0.037	0.029	0.033	10.0	
	Mean		0.030	0.028	0.028	0.030	0.029	0.029	0.027	0.029	0.030	0.026	0.029	4.5	

Table 8-2 Particulate Gross Beta in Air 3rd-4th Quarter

PARTICULATE GROSS BETA IN AIR 3rd QUARTER

ODCM required samples denoted by *

units are pCi/m^3

3rd Quarter

Week #	START DATE	STOP DATE	Site 4	(control) Site 6A*	Site 7A	Site 14A*	Site 15*	Site 17A	Site 21	Site 29*	Site 35	Site 40*	Mean	RSD (%)	⊥Note
27	26-Jun-18	2-Jul-18	0.031	0.029	0.037	0.033	0.033	0.031	0.026	0.030	0.034	0.023	0.030	12.8	
28	2-Jul-18	10-Jul-18	0.023	0.024	0.026	0.029	0.025	0.028	0.027	0.027	0.029	0.028	0.027	7.2	
29	10-Jul-18	17-Jul-18	0.027	0.024	0.030	0.029	0.027	0.029	0.028	0.030	0.028	0.025	0.028	7.0	
30	18-Jul-18	24-Jul-18	0.032	0.031	0.030	0.027	0.031	0.034	0.029	0.030	0.031	0.030	0.030	5.9	
31	26-Jul-18	31-Jul-18	0.033	0.033	0.033	0.035	0.035	0.037	0.035	0.032	0.040	0.034	0.035	6.2	
32	3-Aug-18	7-Aug-18	0.046	0.043	0.043	0.037	0.043	0.042	0.027	0.032	0.043	0.038	0.039	15.0	
33	11-Aug-18	14-Aug-18	0.032	0.026	0.024	0.030	0.027	0.029	0.021	0.025	0.027	0.016	0.026	17.5	
34	14-Aug-18	21-Aug-18	0.031	0.030	0.030	⊥0.030	0.031	0.034	0.028	0.029	0.032	0.026	0.030	7.3	2
35	27-Aug-18	28-Aug-18	0.029	0.023	0.022	0.026	0.023	0.025	0.021	0.024	0.027	0.024	0.024	10.4	
36	4-Sep-18	4-Sep-18	0.024	0.019	0.027	0.022	0.022	0.027	0.022	0.021	0.024	0.023	0.023	10.8	
37	12-Sep-18	11-Sep-18	0.030	0.026	0.026	0.028	0.026	0.030	0.027	0.028	0.027	0.028	0.028	5.4	
38	20-Sep-18	18-Sep-18	0.039	0.034	0.036	0.029	0.033	0.036	0.035	0.034	0.036	0.033	0.035	7.5	
39	18-Sep-18	25-Sep-18	0.031	0.030	0.027	0.026	0.029	0.030	0.028	0.029	0.029	0.021	0.028	10.4	
	Mean		0.031	0.029	0.030	0.029	0.030	0.032	0.027	0.028	0.031	0.027	0.029	5.8	

Note 2: CR 18-13499: Site 14 INVALID due to damage to Iodine sample cartridge. Data for Site 15 for INFO use only. All sample locations anaysized in Unit lab due to the use of CP 100 cartridges. Remaining samples are VALID.

PARTICULATE GROSS BETA IN AIR 4th QUARTER

ODCM required samples denoted by *

units are pCi/m^3

Week #	START DATE	STOP DATE	Site 4	(control) Site 6A*	Site 7A	Site 14A*	Site 15*	Site 17A	Site 21	Site 29*	Site 35	Site 40*	Mean	RSD (%)	⊥Note
40	25-Sep-18	2-Oct-18	0.029	0.026	0.029	0.024	0.030	0.031	0.027	0.027	0.032	0.027	0.028	8.3	
41	2-Oct-18	9-Oct-18	0.017	0.015	0.015	0.015	0.013	0.013	0.014	0.014	0.016	0.014	0.015	8.5	
42	9-Oct-18	16-Oct-18	0.019	0.016	0.020	0.020	0.018	0.022	0.018	0.017	0.021	0.018	0.019	10.7	
43	16-Oct-18	23-Oct-18	0.022	0.021	0.025	0.028	0.023	0.011	0.027	0.025	0.023	0.027	0.023	20.8	
44	23-Oct-18	30-Oct-18	0.046	0.046	0.049	0.039	0.046	0.048	0.039	0.043	0.043	0.040	0.044	8.1	
45	30-Oct-18	6-Nov-18	0.040	0.038	0.033	0.031	0.029	0.033	0.035	0.030	0.031	0.033	0.033	10.4	
46	6-Nov-18	13-Nov-18	0.038	0.035	0.038	0.039	0.036	0.041	0.041	0.035	0.036	0.035	0.037	6.2	
47	13-Nov-18	19-Nov-18	0.042	0.041	0.037	0.037	0.034	0.038	0.040	0.037	0.036	0.039	0.038	6.3	
48	19-Nov-18	27-Nov-18	0.055	0.054	0.050	0.047	0.053	0.057	0.054	0.052	0.054	0.048	0.052	6.1	
49	27-Nov-18	4-Dec-18	0.024	0.027	0.026	0.027	0.023	0.027	0.027	0.024	0.024	0.025	0.025	6.1	
50	4-Dec-18	11-Dec-18	0.032	0.033	0.031	0.030	0.032	0.026	0.034	0.029	0.029	0.028	0.030	8.4	
51	11-Dec-18	18-Dec-18	0.048	0.049	0.041	0.042	0.041	0.039	0.044	0.039	0.037	0.043	0.042	8.8	
52	18-Dec-18	24-Dec-18	0.060	0.062	0.054	0.049	0.053	0.059	0.057	0.052	0.053	0.054	0.055	7.3	
53	24-Dec-18	31-Dec-18	0.039	0.038	0.036	0.036	0.029	0.038	0.036	0.038	0.038	0.037	0.036	7.6	
	Mean		0.036	0.036	0.035	0.033	0.033	0.034	0.035	0.033	0.034	0.033	0.034	3.6	

Table 8-3 Gamma in Air Filter Composites

GAMMA IN AIR FILTER COMPOSITES

ODCM required samples denoted by *

units are pCi/m^3

QUARTER ENDPOINT	NUCLIDE	Site 4	(control) Site 6A*	Site 7A	Site 14A*	Site 15*	Site 17A	Site 21	Site 29*	Site 35	Site 40*	Note
27-Mar-18	Cs-134	<0.002	<0.002	<0.001	<0.002	<0.001	<0.002	<0.002	<0.001	<0.001	<0.002	
	Cs-137	<0.003	<0.001	<0.004	<0.001	<0.004	<0.002	<0.002	<0.003	<0.001	<0.005	
26-Jun-18	Cs-134	<0.002	<0.003	<0.002	<0.002	<0.003	<0.001	<0.001	<0.001	<0.002	<0.001	
	Cs-137	<0.002	<0.002	<0.003	<0.003	<0.004	<0.001	<0.004	<0.001	<0.003	<0.001	
25-Sep-18	Cs-134	<0.003	<0.001	<0.001	<0.002	<0.002	<0.005	<0.002	<0.001	<0.001	<0.002	
	Cs-137	<0.001	<0.002	<0.004	<0.004	<0.003	<0.005	<0.001	<0.001	<0.004	<0.003	
31-Dec-18	Cs-134	<0.002	<0.003	<0.0007	<0.003	<0.002	<0.002	<0.002	<0.0006	<0.003	<0.002	
	Cs-137	<0.0008	<0.003	<0.002	<0.003	<0.0008	<0.003	<0.003	<0.003	<0.002	<0.003	

Table 8-4 Radioiodine in Air 1st-2nd Quarter

RADIOIODINE IN AIR 1st QUARTER

ODCM required samples denoted by *

units are pCi/m^3

Week #	START DATE	STOP DATE	Site 4	(control) Site 6A*	Site 7A	Site 14A*	required LLD <0.070 Site 15*	Site 17A	Site 21	Site 29*	Site 35	Site 40*	Note
1	26-Dec-17	2-Jan-18	<0.0264	<0.0361	<0.0605	<0.0318	<0.0480	<0.0293	<0.0541	<0.0399	<0.0593	<0.0070	
2	2-Jan-18	9-Jan-18	<0.0527	<0.0520	<0.0530	<0.0524	<0.0296	<0.0534	<0.0311	<0.0589	<0.0316	<0.0352	
3	9-Jan-18	16-Jan-18	<0.0349	<0.0336	<0.0391	<0.0345	<0.0402	<0.0194	<0.0296	<0.0192	<0.0330	<0.0247	
4	16-Jan-18	23-Jan-18	<0.0359	<0.0248	<0.0407	<0.0284	<0.0463	<0.0276	<0.0317	<0.0295	<0.0216	<0.0464	
5	23-Jan-18	30-Jan-18	<0.0072	<0.0520	<0.0134	<0.0071	<0.0582	<0.0202	<0.0462	<0.0197	<0.0461	<0.0249	
6	30-Jan-18	6-Feb-18	<0.0336	<0.0415	<0.0302	<0.0421	<0.0185	<0.0125	<0.0340	<0.0667	<0.0273	<0.0345	
7	6-Feb-18	13-Feb-18	<0.0298	<0.0393	<0.0257	<0.0490	<0.0415	<0.0270	<0.0496	<0.0320	<0.0302	<0.0384	1
8	13-Feb-18	20-Feb-18	<0.0409	<0.0173	<0.0481	<0.0259	<0.0322	<0.0278	<0.0408	<0.0269	<0.0174	<0.0408	1
9	20-Feb-18	27-Feb-18	<0.0070	<0.0259	<0.0237	<0.0260	<0.0369	<0.0221	<0.0239	<0.0277	<0.0225	<0.0309	
10	27-Feb-18	6-Mar-18	<0.0381	<0.0470	<0.0121	<0.0353	<0.0323	<0.0307	<0.0541	<0.0363	<0.0331	<0.0283	
11	6-Mar-18	13-Mar-18	<0.0067	<0.0236	<0.0224	<0.0282	<0.0261	<0.0307	<0.0239	<0.0319	<0.0363	<0.0293	
12	13-Mar-18	20-Mar-18	<0.0509	<0.0440	<0.0291	<0.0200	<0.0382	<0.0200	<0.0327	<0.0200	<0.0293	<0.0253	
13	20-Mar-18	27-Mar-18	<0.0431	<0.0323	<0.0280	<0.0363	<0.0363	<0.0228	<0.0224	<0.0283	<0.0430	<0.0329	

Note 1: Site 4 blocked by road constrution on 2/13/2018. Site 4 Sample collected on 2/14/2018

RADIOIODINE IN AIR 2nd QUARTER

ODCM required samples denoted by *

units are pCi/m^3

Week #	DATE	DATE	4	(control) 6A*	7A	14A*	required LLD <0.070 15*	17A	21	29*	35	40*	Note
14	27-Mar-18	3-Apr-18	<0.0346	<0.0466	<0.0286	<0.0261	<0.0312	<0.0212	<0.0281	<0.0134	<0.0253	<0.0581	
15	3-Apr-18	10-Apr-18	<0.0273	<0.0187	<0.0391	<0.0238	<0.0369	<0.0421	<0.0242	<0.0642	<0.0241	<0.0355	
16	10-Apr-18	17-Apr-18	<0.0235	<0.0064	<0.0406	<0.0254	<0.0397	<0.0326	<0.0331	<0.0361	<0.0175	<0.0285	
17	17-Apr-18	24-Apr-18	<0.0312	<0.0288	<0.0597	<0.0289	<0.0536	<0.0381	<0.0368	<0.0264	<0.0331	<0.0380	
18	24-Apr-18	1-May-18	<0.0297	<0.0415	<0.0232	<0.0502	<0.0398	<0.0359	<0.0294	<0.0186	<0.0515	<0.0321	
19	1-May-18	8-May-18	<0.0289	<0.0383	<0.0307	<0.0179	<0.0122	<0.0189	<0.0322	<0.0123	<0.0279	<0.0228	
20	8-May-18	15-May-18	<0.0333	<0.0218	<0.0260	<0.0342	<0.0069	<0.0273	<0.0308	<0.0267	<0.0282	<0.0292	
21	15-May-18	22-May-18	<0.0261	<0.0306	<0.0348	<0.0314	<0.0570	<0.0362	<0.0451	<0.0298	<0.0243	<0.0535	
22	22-May-18	29-May-18	<0.0335	<0.0285	<0.0074	<0.0358	<0.0360	<0.0280	<0.0292	<0.0193	<0.0298	<0.0336	
23	29-May-18	5-Jun-18	<0.0329	<0.0324	<0.0224	<0.0282	<0.0238	<0.0225	<0.0278	<0.0232	<0.0251	<0.0275	
24	5-Jun-18	12-Jun-18	<0.0332	<0.0465	<0.0254	<0.0296	<0.0360	<0.0303	<0.0298	<0.0298	<0.0389	<0.0391	
25	12-Jun-18	19-Jun-18	<0.0295	<0.0357	<0.0312	<0.0173	<0.0359	<0.0308	<0.0238	<0.0317	<0.0188	<0.0318	
26	19-Jun-18	26-Jun-18	<0.0074	<0.0298	<0.0341	<0.0290	<0.0306	<0.0331	<0.0335	<0.0316	<0.0307	<0.0245	

Table 8-5 Radioiodine in Air 3rd-4th Quarter

RADIOIODINE IN AIR 3rd QUARTER
ODCM required samples denoted by *
units are pCi/m³

Week #	START DATE	STOP DATE	Site 4	Site 6A* (control)	Site 7A	Site 14A*	Site 15*	Site 17A	Site 21	Site 29*	Site 35	Site 40*	⊥Note
					required LLD <0.070								
27	26-Jun-18	2-Jul-18	<0.0368	<0.0313	<0.0219	<0.0370	<0.0284	<0.0448	<0.0362	<0.0259	<0.0324	<0.0393	
28	2-Jul-18	10-Jul-18	<0.0236	<0.0180	<0.0261	<0.0246	<0.0261	<0.0275	<0.0188	<0.0065	<0.0226	<0.0318	
29	10-Jul-18	17-Jul-18	<0.0182	<0.0300	<0.0268	<0.0278	<0.0184	<0.0219	<0.0241	<0.0174	<0.0263	<0.0220	
30	18-Jul-18	24-Jul-18	<0.0259	<0.0242	<0.0124	<0.0254	<0.0417	<0.0290	<0.0277	<0.0543	<0.0323	<0.0340	
31	26-Jul-18	31-Jul-18	<0.0329	<0.0273	<0.0438	<0.0306	<0.0429	<0.0324	<0.0585	<0.0383	<0.0316	<0.0276	
32	3-Aug-18	7-Aug-18	<0.0674	<0.0207	<0.0545	<0.0423	<0.0279	<0.0480	<0.0192	<0.0124	<0.0341	<0.0336	
33	11-Aug-18	14-Aug-18	<0.0390	<0.0275	<0.0686	<0.0244	<0.0358	<0.0391	<0.0360	<0.0293	<0.0245	<0.0320	
34	19-Aug-18	21-Aug-18	<0.0158	<0.0432	<0.0632	⊥<0.0643	<0.0563	<0.0545	<0.0438	<0.0642	<0.0440	<0.0585	2
35	27-Aug-18	28-Aug-18	<0.0396	<0.0509	<0.0357	<0.0332	<0.0131	<0.0348	<0.0129	<0.0252	<0.0536	<0.0252	
36	4-Sep-18	4-Sep-18	<0.0561	<0.0486	<0.0359	<0.0306	<0.0278	<0.0214	<0.0622	<0.0478	<0.0264	<0.0143	
37	12-Sep-18	11-Sep-18	<0.0319	<0.0223	<0.0328	<0.0289	<0.0414	<0.0187	<0.0481	<0.0382	<0.0177	<0.0599	
38	20-Sep-18	18-Sep-18	<0.0344	<0.0447	<0.0665	<0.0439	<0.0509	<0.0568	<0.0586	<0.0514	<0.0585	<0.0351	
39	18-Sep-18	25-Sep-18	<0.0130	<0.0630	<0.0435	<0.0449	<0.0361	<0.0448	<0.0257	<0.0523	<0.0333	<0.0457	

Note 2: CR 18-13499: Site 14 INVALID due to damage to Iodine sample cartridge. Data for Site 14 for INFO use only. All sample locations anaysized in Unit lab due to the use of CP 100 cartridges. Remaining samples are VALID.

RADIOIODINE IN AIR 4th QUARTER
ODCM required samples denoted by *
units are pCi/m³

Week #	START DATE	STOP DATE	Site 4	Site 6A* (control)	Site 7A	Site 14A*	Site 15*	Site 17A	Site 21	Site 29*	Site 35	Site 40*	⊥Note
					required LLD <0.070								
40	25-Sep-18	2-Oct-18	<0.0296	<0.0064	<0.0122	<0.0252	<0.0471	<0.0302	<0.0528	<0.0187	<0.0255	<0.0477	
41	2-Oct-18	9-Oct-18	<0.0437	<0.0325	<0.0240	<0.0436	<0.0279	<0.0552	<0.0250	<0.0508	<0.0323	<0.0236	
42	9-Oct-18	16-Oct-18	<0.0266	<0.0173	<0.0430	<0.0186	<0.0350	<0.0246	<0.0346	<0.0289	<0.0297	<0.0565	
43	16-Oct-18	23-Oct-18	<0.0209	<0.0244	<0.0454	<0.0276	<0.0329	<0.0527	<0.0514	<0.0247	<0.0309	<0.0352	
44	23-Oct-18	30-Oct-18	<0.0248	<0.0629	<0.0507	<0.0388	<0.0358	<0.0289	<0.0074	<0.0462	<0.0420	<0.0352	
45	30-Oct-18	6-Nov-18	<0.0281	<0.0654	<0.0350	<0.0071	<0.0500	<0.0315	<0.0434	<0.0239	<0.0454	<0.0346	
46	6-Nov-18	13-Nov-18	<0.0313	<0.0266	<0.0494	<0.0325	<0.0331	<0.0360	<0.0508	<0.0193	<0.0267	<0.0554	
47	13-Nov-18	19-Nov-18	<0.0424	<0.0327	<0.0300	<0.0355	<0.0304	<0.0222	<0.0327	<0.0421	<0.0356	<0.0310	
48	19-Nov-18	27-Nov-18	<0.0229	<0.0246	<0.0521	<0.0169	<0.0560	<0.0236	<0.0461	<0.0313	<0.0283	<0.0388	
49	27-Nov-18	4-Dec-18	<0.0300	<0.0557	<0.0213	<0.0314	<0.0318	<0.0248	<0.0481	<0.0340	<0.0470	<0.0283	
50	4-Dec-18	11-Dec-18	<0.0243	<0.0291	<0.0418	<0.0183	<0.0555	<0.0278	<0.0423	<0.0241	<0.0345	<0.0533	
51	11-Dec-18	18-Dec-18	<0.0248	<0.0210	<0.0210	<0.0279	<0.0167	<0.0063	<0.0246	<0.0419	<0.0217	<0.0542	
52	18-Dec-18	24-Dec-18	<0.0286	<0.0226	<0.0653	<0.0082	<0.0655	<0.0086	<0.0440	<0.0296	<0.0228	<0.0418	
53	24-Dec-18	31-Dec-18	<0.0298	<0.0238	<0.0310	<0.0356	<0.0261	<0.0471	<0.0214	<0.0350	<0.0213	<0.0313	

Table 8-6 Vegetation

ODCM required samples denoted by * units are pCi/kg, wet						
LOCATION	**TYPE**	**DATE COLLECTED**	**I-131**	**Cs-134**	**Cs-137**	**Note**
LOCAL RESIDENCE (Site #47)*	Lettuce	18-Jan-18	<46	<53	<39	
		No Sample Available for February				
	Lettuce	14-Mar-18	<48	<55	<74	
	Lettuce	19-Apr-18	<35	<28	<44	
	Lettuce	24-May-18	<46	<46	<78	
		No Sample Available for June				
		No Sample Available for July				
		No Sample Available for August				
		No Sample Available for September				
	Lettuce/vine leaf	18-Oct-19	<58	<47	<55	
		No Sample Available for November				
	Lettuce	20-Dec-18	<57	<51	<45	
COMMERCIAL FARM (Site #62)*	Spinach	18-Jan-18	<40	<31	<38	
	Lettuce	18-Jan-18	<45	<46	<44	
	Lettuce	16-Feb-18	<48	<30	<54	
	Spinach	16-Feb-18	<40	<45	<43	
	Lettuce	16-Mar-18	<46	<60	<69	
	Spinach	16-Mar-18	<52	<53	<66	
	Spinach	19-Apr-18	<44	<31	<11	
	Green Chard	19-Apr-18	<37	<35	<40	
	Red Chard	19-Apr-18	<24	<25	<44	
	Basil	24-May-18	<49	<58	<75	
		No Sample Available for June				
		No Sample Available for July				
		No Sample Available for August				
		No Sample Available for September				
	Lettuce	19-Oct-19	<46	<50	<67	
	Kale	19-Oct-19	<33	<36	<62	
	Tatsoi	19-Oct-19				
	Romaine	15-Nov-18	<38	<59	<56	
	Spinach	15-Nov-18	<33	<31	<33	
	Kale	15-Nov-18	<56	<44	<54	
	Spinach	20-Dec-18	<38	<49	<52	
LOCAL RESIDENCE (Site #51)		No Sample Available for January				
		No Sample Available for February				
		No Sample Available for March				
		No Sample Available for April				
		No Sample Available for May				
		No Sample Available for June				
		No Sample Available for July				
		No Sample Available for August				
		No Sample Available for September				
	Broccoli Bush Greens	18-Oct-19	<39	<39	<78	
		No Sample Available for November				
		No Sample Available for December				

Table 8-7 Milk

ODCM required samples denoted by *
units are pCi/liter

SAMPLE LOCATION	DATE COLLECTED	I-131	Cs-134	Cs-137	Ba-140	La-140	Note
Local Resident Goats (Site #51)*	No Sample Available for January						
	No Sample Available for February						
	No Sample Available for March						
	19-Apr-18	<1	<1	<1	<3	<1	
	24-May-18	<1	<1	<1	<3	<1	
	21-Jun-18	<1	<1	<1	<3	<1	
	20-Jul-18	<1	<1	<1	<3	<1	
	23-Aug-18	<1	<1	<1	<3	<2	2
	20-Sep-18	<1	<1	<1	<3	<2	2
	18-Oct-18	<1	<1	<1	<3	<1	
	16-Nov-18	<1	<1	<1	<3	<1	
	20-Dec-18	<1	<1	<1	<3	<1	
Local Resident Goats (Site #53)*	No Sample Available for January						
	No Sample Available for February						
	22-Mar-18	<1	<1	<1	<3	<1	
	26-Apr-18	<1	<1	<1	<3	<1	
	31-May-18	<1	<1	<1	<3	<1	
	28-Jun-18	<1	<1	<1	<3	<1	
	26-Jul-18	<1	<1	<1	<3	<1	
	30-Aug-18	<1	<1	<1	<3	<1	
	27-Sep-18	<1	<1	<1	<3	<1	
	No Sample for October Available						
	29-Nov-18	<1	<1	<1	<3	<1	
	27-Dec-18	<1	<1	<1	<3	<1	
Local Resident Goats (Site #54)*	11-Jan-18	<1	<1	<1	<3	<1	
	09-Feb-18	<1	<1	<1	<3	<1	
	08-Mar-18	<1	<1	<1	<3	<1	
	12-Apr-18	<1	<1	<1	<3	<1	
	17-May-18	<1	<1	<1	<3	<1	1
	14-Jun-18	<1	<1	<1	<3	<1	
	12-Jul-18	<1	<1	<1	<3	<1	
	16-Aug-18	<1	<1	<1	<3	<1	
	13-Sep-18	<1	<1	<1	<3	<1	
	11-Oct-18	<1	<1	<1	<3	<1	
	09-Nov-18	<1	<1	<1	<3	<1	
	13-Dec-18	<1	<1	<1	<3	<1	

Note 1:CR 18-08852: Sample stabilizer shortage required the use of ice to preserve milk during analysis period. No impact to analysis; sample is VALID

Note 2: Sample volume low due to atypical sample container used. Resident contacted- pet destroyed provided container, resident improvised. Resident provided with spare containers for future use. Sample VALID

Table 8-8 Drinking Water

ODCM required samples denoted by *
units are pCi/liter

SAMPLE LOCATION	MONTH ENDPOINT	Mn-54	Co-58	Fe-59	Co-60	Zn-65	Nb-95	Zr-95	I-131	Cs-134	Cs-137	Ba-140	La-140	Qtrly Tritium	Gross Beta	Note
LOCAL RESIDENCE (Site #48) *	30-Jan-18	<13	<10	<20	<8	<26	<11	<18	<9	<9	<10	<33	<13		<3.49	1
	27-Feb-18	<6	<7	<10	<5	<13	<6	<11	<6	<5	<6	<20	<10		<3.05	1
	27-Mar-18	<4	<3	<7	<3	<7	<4	<7	<4	<3	<4	<13	<11	<330	<3.85	1
	24-Apr-18	<9	<8	<15	<11	<25	<10	<18	<7	<10	<8	<29	<14		<2.92	
	29-May-18	<12	<11	<24	<9	<30	<11	<23	<9	<11	<13	<34	<10		<3.10	
	26-Jun-18	<9	<11	<19	<8	<22	<8	<19	<9	<8	<11	<28	<10	<314	<3.01	
	31-Jul-18	<10	<12	<20	<8	<23	<12	<16	<10	<9	<10	<32	<13		<2.84	
	28-Aug-18	<10	<9	<22	<9	<20	<9	<18	<9	<9	<11	<31	<12		<2.81	
	25-Sep-18	<9	<10	<21	<8	<19	<8	<15	<8	<8	<10	<31	<15	<328	3.17±1.68	
	30-Oct-18	<14	<13	<27	<12	<30	<15	<23	<11	<13	<12	<42	<14		3.92±1.78	
	27-Nov-18	<11	<12	<24	<10	<27	<13	<21	<11	<13	<12	<29	<14		3.15±1.73	
	2-Jan-19	<13	<10	<22	<13	<26	<14	<18	<10	<11	<12	<32	<12	<329	4.08±1.76	
LOCAL RESIDENCE (Site #55)	30-Jan-18	<9	<8	<16	<8	<19	<8	<15	<9	<6	<10	<28	<14		<3.31	1
	27-Feb-18	<7	<6	<15	<8	<13	<8	<11	<7	<7	<8	<23	<14		<2.96	1
	27-Mar-18	<3	<3	<6	<3	<7	<3	<6	<4	<3	<3	<13	<14	<325	<3.60	1
	24-Apr-18	<8	<8	<15	<10	<19	<9	<16	<8	<9	<9	<28	<15		2.86±1.73	
	29-May-18	<8	<9	<20	<7	<21	<9	<19	<8	<8	<11	<25	<12		<3.09	
	26-Jun-18	<10	<9	<19	<8	<22	<10	<14	<8	<7	<9	<31	<9	<316	<2.86	
	31-Jul-18	<11	<9	<13	<6	<26	<10	<15	<9	<8	<7	<34	<12		3.09±1.66	
	28-Aug-18	<13	<13	<23	<11	<25	<12	<22	<10	<11	<14	<34	<15		<2.67	
	25-Sep-18	<10	<9	<15	<9	<21	<9	<18	<10	<8	<10	<26	<15	<328	<2.52	
	30-Oct-18	<8	<9	<17	<10	<17	<11	<18	<9	<9	<11	<32	<11		3.07±1.63	
	27-Nov-18	<11	<9	<14	<10	<20	<10	<16	<8	<8	<12	<28	<9		5.31±1.73	
	2-Jan-19	<10	<10	<19	<10	<20	<10	<16	<9	<8	<9	<25	<7	<332	5.32±1.73	

Note 1: Background higher than usual but within acceptable range. Gross Beta analysis results <MDA

Table 8-8 Drinking Water (Continued)

ODCM required samples denoted by *

units are pCi/liter

SAMPLE LOCATION	MONTH ENDPOINT	Mn-54	Co-58	Fe-59	Co-60	Zn-65	Nb-95	Zr-95	I-131	Cs-134	Cs-137	Ba-140	La-140	Qtrly Tritium	Gross Beta	Note
LOCAL RESIDENCE (Site #46) *	30-Jan-18	<8	<11	<20	<12	<17	<11	<18	<10	<11	<11	<39	<14		<3.19	1
	27-Feb-18	<6	<7	<16	<7	<14	<8	<12	<6	<6	<7	<25	<14		<2.81	1
	27-Mar-18	<4	<4	<7	<3	<8	<5	<7	<4	<3	<4	<14	<14	<325	<3.51	1
	24-Apr-18	<9	<7	<19	<10	<19	<10	<18	<9	<8	<11	<30	<12		<2.68	
	29-May-18	<9	<9	<17	<11	<20	<9	<18	<8	<7	<10	<28	<10		<2.90	
	26-Jun-18	<8	<10	<11	<11	<14	<9	<16	<7	<9	<9	<34	<8	<314	<2.76	
	31-Jul-18	<11	<11	<25	<14	<26	<10	<17	<10	<9	<14	<41	<14		<2.63	
	28-Aug-18	<9	<8	<16	<9	<19	<11	<18	<10	<8	<8	<28	<13		<2.63	
	25-Sep-15	<4	<5	<9	<4	<10	<5	<10	<4	<5	<5	<16	<13	<328	3.37±1.58	
	30-Oct-18	<12	<15	<18	<12	<28	<12	<20	<9	<12	<13	<32	<12		3.50±1.65	
	27-Nov-18	<11	<11	<19	<11	<24	<11	<17	<11	<9	<12	<35	<14		2.65±1.60	
	2-Jan-19	<9	<9	<17	<9	<17	<10	<16	<8	<8	<11	<30	<9	<334	3.20±1.60	
LOCAL RESIDENCE (Site #49) *	30-Jan-18	<9	<9	<19	<7	<16	<10	<16	<8	<9	<9	<26	<15		<3.16	1
	27-Feb-18	<5	<5	<12	<6	<12	<6	<11	<7	<4	<6	<18	<15		<2.77	1
	27-Mar-18	<3	<3	<5	<3	<6	<3	<5	<3	<2	<3	<9	<13	<328	<3.47	1
	24-Apr-18	<9	<8	<21	<10	<20	<13	<21	<9	<8	<7	<28	<13		<2.64	
	29-May-18	<9	<9	<18	<9	<25	<10	<17	<9	<8	<9	<29	<15		<2.85	
	26-Jun-18	<6	<6	<12	<6	<12	<6	<10	<6	<5	<6	<19	<12	<312	<2.72	
	31-Jul-18	<9	<9	<16	<8	<17	<10	<18	<8	<7	<9	<31	<14		<2.56	
	28-Aug-18	<9	<7	<17	<8	<19	<11	<19	<8	<8	<11	<30	<11		<2.58	
	25-Sep-18	<7	<5	<13	<6	<16	<7	<11	<6	<5	<7	<23	<14	<322	<2.40	
	30-Oct-18	<10	<11	<21	<11	<29	<9	<17	<9	<11	<10	<33	<14		<2.52	
	27-Nov-18	<12	<10	<16	<10	<22	<9	<17	<9	<9	<9	<40	<14		<2.51	
	2-Jan-19	<13	<10	<23	<7	<28	<12	<21	<12	<14	<12	<43	<4	<331	<2.48	

Note 1: Background higher than usual but within acceptable range. Gross Beta analysis results <MDA

Table 8-9 Groundwater

ODCM required samples denoted by *
units are pCi/liter

SAMPLE LOCATION	DATE COLLECTED	Mn-54	Co-58	Fe-59	Co-60	Zn-65	Nb-95	Zr-95	I-131	Cs-134	Cs-137	Ba-140	La-140	Tritium	Notes
WELL 27ddc (Site #57)*	30-Jan-18	<13	<12	<19	<13	<24	<13	<19	<10	<10	<11	<38	<13	<353	
	24-Apr-18	<11	<10	<23	<11	<26	<12	<21	<11	<11	<13	<32	<12	<324	
	31-Jul-18	<10	<10	<17	<7	<18	<9	<17	<10	<8	<11	<29	<15	<324	
	30-Oct-18	<11	<10	<21	<9	<21	<12	<19	<10	<9	<12	<33	<15	<335	
WELL 34abb (Site #58)*	30-Jan-18	<10	<8	<17	<8	<20	<11	<15	<8	<9	<8	<31	<14	<352	
	24-Apr-18	<11	<10	<20	<11	<21	<10	<17	<10	<10	<11	<27	<15	<324	
		Not in Operation. No Sample Required													
		Not in Operation. No Sample Required													
Well 34aab	30-Jan-18	<10	<11	<20	<13	<28	<13	<15	<10	<9	<12	<37	<8	<352	
	24-Apr-18	<10	<12	<18	<12	<25	<13	<19	<10	<12	<13	<36	<13	<324	
	31-Jul-18	<10	<9	<17	<10	<21	<10	<18	<9	<9	<10	<30	<14	<325	
	30-Oct-18	<8	<10	<19	<9	<17	<9	<19	<9	<9	<9	<25	<14	<331	
Well 27dcb	30-Jan-18	<12	<11	<23	<12	<28	<14	<19	<11	<9	<9	<34	<13	<352	
	24-Apr-18	<9	<9	<20	<10	<22	<11	<18	<9	<8	<10	<31	<15	<324	
	31-Jul-18	<12	<13	<26	<9	<25	<13	<23	<9	<11	<13	<46	<15	<323	
	30-Oct-18	<11	<10	<17	<10	<26	<11	<14	<8	<8	<11	<31	<11	<335	

Table 8-10 Surface Water (Continued)

SURFACE WATER
ODCM required samples denoted by *
units are pCi/liter

SAMPLE LOCATION	DATE COLLECTED	Mn-54	Co-58	Fe-59	Co-60	Zn-65	Nb-95	Zr-95	I-131	Cs-134	Cs-137	Ba-140	La-140	Tritium	Notes
WRF INFLUENT	2-Jan-18	<7	<6	<15	<8	<19	<9	<15	17±9	<7	<7	<27	<14		
	9-Jan-18	<9	<9	<16	<8	<25	<9	<17	<12	<9	<9	<30	<10		
	16-Jan-18	<9	<10	<20	<10	<23	<12	<17	18±9	<7	<11	<33	<11		
	23-Jan-18	<6	<8	<15	<9	<19	<8	15.0	16±9	<7	<7	<25	<8		
	30-Jan-18	<10	<11	<20	<9	<24	<10	<17	31±11	<11	<11	<32	<9	<368	
	6-Feb-18	<10	<11	<24	<12	<21	<9	<19	<13	<10	<9	<98	<9		
	13-Feb-18	<9	<11	<16	<12	<23	<12	<20	17±10	<11	<12	<27	<14		
	20-Feb-18	<8	<8	<19	<10	<17	<12	<16	25±10	<10	<9	<30	<13		
	27-Feb-18	<13	<12	<18	<12	<27	<11	<21	31±10	<10	<11	<33	<15	<341	
	7-Mar-18	<10	<9	<15	<11	<22	<10	<16	32±9	<8	<9	<25	<8		
	13-Mar-18	<10	<12	<22	<9	<29	<8	<16	17±9	<9	<12	<35	<11		
	20-Mar-18	<9	<9	<13	<9	<17	<9	<14	16±9	<8	<8	<29	<14		
	27-Mar-18	<10	<10	<19	<7	<20	<11	<17	32±10	<7	<11	<33	<10	<343	
	3-Apr-18	<10	<9	<18	<7	<23	<9	<15	<10	<9	<11	<28	<13		
	10-Apr-18	<9	<9	<17	<12	<21	<8	<10	19±9	<9	<7	<29	<13		
	17-Apr-18	No Sample- Water Recourses Outage													
	24-Apr-18	<9	<11	<19	<12	<20	<12	<17	34±10	<8	<9	<36	<10	<338	
	1-May-18	<8	<8	<14	<5	<18	<8	<16	29±9	<7	<8	<26	<11		
	8-May-18	<11	<10	<21	<10	<15	<13	<21	<13	<11	<12	<34	<12		
	15-May-18	<9	<11	<18	<8	<25	<11	<17	9±7	<8	<9	<28	<12		
	22-May-18	<7	<9	<18	<10	<19	<9	<16	17±8	<8	<10	<28	<13		
	29-May-18	<9	<10	<15	<11	<26	<11	<17	<12	<6	<7	<26	<8	<342	
	5-Jun-18	<9	<12	<18	<11	<28	<10	<16	19±10	<8	<8	<30	<10		
	12-Jun-18	<10	<7	<15	<9	<18	<11	<15	16±9	<7	<10	<27	<12		
	19-Jun-18	<8	<8	<13	<7	<22	<9	<13	10±4	<10	<10	<26	<11		
	26-Jun-18	<9	<10	<17	<9	<19	<10	<14	<10	<7	<11	<32	<11	<324	
	3-Jul-18	<8	<8	<13	<11	<24	<10	<16	8±9	<8	<9	<34	<11		
	10-Jul-18	<10	<9	<20	<10	<17	<10	<16	<10	<9	<8	<27	<8		
	17-Jul-18	<9	<9	<18	<11	<24	<10	<14	<12	<7	<7	<27	<12		

Table 8-10 Surface Water (Continued)

SURFACE WATER
ODCM required samples denoted by *
units are pCi/liter

SAMPLE LOCATION	DATE COLLECTED	Mn-54 <15	Co-58 <15	Fe-59 <30	Co-60 <15	Zn-65 <30	Nb-95 <15	Zr-95 <30	I-131 <15	Cs-134 <15	Cs-137 <18	Ba-140 <60	La-140 <15	Tritium <3000	Note
WRF INFLUENT	24-Jul-18	<10	<9	<21	<7	<20	<8	<16	<10	<8	<9	<31	<11		
	31-Jul-18	<9	<10	<18	<9	<22	<9	<18	16±9	<7	<9	<28	<8	<334	
	7-Aug-18	<10	<9	<15	<10	<19	<10	<15	<11	<9	<10	<31	<11		
	14-Aug-18	<7	<11	<16	<9	<23	<11	<18	23±9	<8	<8	<26	<12		
	21-Aug-18	<9	<7	<19	<10	<24	<9	<16	<12	<6	<9	<26	<11		
	28-Aug-18	<12	<11	<15	<14	<24	<11	<20	10±9	<12	<14	<34	<13	<349	
	4-Sep-18	<10	<8	<17	<7	<20	<9	<16	<10	<8	<9	<30	<13		
	11-Sep-18	<11	<9	<17	<9	<20	<10	<14	6±6	<9	<10	<33	<12		
	18-Sep-18	<9	<8	<20	<9	<18	<10	<19	13±9	<8	<11	<31	<10		
	25-Sep-18	<9	<9	<21	<9	<19	<10	<16	<11	<8	<10	<27	<9	<335	
	2-Oct-18	<5	<8	<23	<8	<22	<11	<13	<10	<8	<9	<35	<12		
	9-Oct-18	No Sample- Water Recourses Outage													
	16-Oct-18	No Sample- Water Recourses Outage													
	23-Oct-18	<10	<10	<18	<10	<24	<10	<20	<10	<7	<11	<30	<7		
	30-Oct-18	<10	<10	<12	<9	<23	<11	<17	<9	<9	<9	<29	<10	<345	
	6-Nov-18	<9	<11	<19	<11	<23	<9	<16	16±9	<8	<6	<35	<13		
	13-Nov-18	<11	<10	<19	<10	<18	<9	<15	<12	<8	<10	<33	<8		
	20-Nov-18	<7	<8	<15	<9	<20	<11	<14	<12	<9	<9	<29	<11		
	27-Nov-18	<10	<9	<19	<8	<20	<9	<16	<10	<8	<9	<33	<14	<351	
	4-Dec-18	<9	<9	<15	<9	<19	<8	<15	<11	<7	<10	<28	<10		
	11-Dec-18	<8	<8	<17	<9	<17	<9	<16	25±10	<9	<9	<27	<11		
	18-Dec-18	<11	<11	<20	<10	<22	<10	<20	<13	<9	<11	<34	<14		
	24-Dec-18	<10	<11	<19	<7	<19	<10	<20	<14	<9	<10	<35	<13	<344	
	31-Dec-18	<5	<4	<8	<5	<10	<5	<8	5±5	<4	<4	<14	<12		

Table 8-10 Surface Water (Continued)

SURFACE WATER
ODCM required samples denoted by *
units are pCi/liter

SAMPLE LOCATION	DATE COLLECTED	Mn-54	Co-58	Fe-59	Co-60	Zn-65	Nb-95	Zr-95	I-131	Cs-134	Cs-137	Ba-140	La-140	Tritium	Note
SEDIMENTATION BASIN #2	2-Jan-18								EMPTY- No Sample						
	9-Jan-18								EMPTY- No Sample						
	16-Jan-18								EMPTY- No Sample						
	23-Jan-18								EMPTY- No Sample						
	30-Jan-18								EMPTY- No Sample						
	6-Feb-18								EMPTY- No Sample						
	13-Feb-18								EMPTY- No Sample						
	20-Feb-18								EMPTY- No Sample						
	27-Feb-18								EMPTY- No Sample						
	6-Mar-18								EMPTY- No Sample						
	13-Mar-18								EMPTY- No Sample						
	20-Mar-18								EMPTY- No Sample						
	27-Mar-18								EMPTY- No Sample						
	3-Apr-18								EMPTY- No Sample						
	10-Apr-18								EMPTY- No Sample						
	17-Apr-18								EMPTY- No Sample						
	24-Apr-18								EMPTY- No Sample						
	1-May-18								EMPTY- No Sample						
	8-May-18								EMPTY- No Sample						
	15-May-18								EMPTY- No Sample						
	22-May-18								EMPTY- No Sample						
	29-May-18								EMPTY- No Sample						
	5-Jun-18								EMPTY- No Sample						
	12-Jun-18								EMPTY- No Sample						
	19-Jun-18								EMPTY- No Sample						
	26-Jun-18								EMPTY- No Sample						

Table 8-10 Surface Water (Continued)

ODCM required samples denoted by *
units are pCi/liter

SAMPLE LOCATION	DATE COLLECTED	Mn-54	Co-58	Fe-59	Co-60	Zn-65	Nb-95	Zr-95	I-131	Cs-134	Cs-137	Ba-140	La-140	Tritium	Note
SEDIMENTATION BASIN #2	3-Jul-18								EMPTY- No Sample						
	10-Jul-18								EMPTY- No Sample						
	17-Jul-18								EMPTY- No Sample						
	24-Jul-18								EMPTY- No Sample						
	31-Jul-18								EMPTY- No Sample						
	7-Aug-18								EMPTY- No Sample						
	14-Aug-18								EMPTY- No Sample						
	21-Aug-18								EMPTY- No Sample						
	28-Aug-18								EMPTY- No Sample						
	4-Sep-18								EMPTY- No Sample						
	11-Sep-18								EMPTY- No Sample						
	18-Sep-18								EMPTY- No Sample						
	25-Sep-18								EMPTY- No Sample						
	2-Oct-18	<9	<9	<21	<10	<23	<10	<14	<8	<9	<12	<28	<12	445±320	
	9-Oct-18	<9	<8	<19	<9	<24	<11	<13	<9	<9	<7	<32	<10	<367	
	16-Oct-18	<10	<12	<25	<10	<25	<12	<23	<10	<10	<15	<32	<15	<334	
	23-Oct-18								EMPTY- No Sample						
	30-Oct-18								EMPTY- No Sample						
	6-Nov-18								EMPTY- No Sample						
	13-Nov-18								EMPTY- No Sample						
	20-Nov-18								EMPTY- No Sample						
	27-Nov-18								EMPTY- No Sample						
	4-Dec-18								EMPTY- No Sample						
	11-Dec-18								EMPTY- No Sample						
	18-Dec-18								EMPTY- No Sample						
	24-Dec-18								EMPTY- No Sample						
	31-Dec-18								EMPTY- No Sample						

Table 8-11 Sludge/Sediment

SAMPLE LOCATION	DATE COLLECTED	I-131	<150 Cs-134	<180 Cs-137	In-111	Notes
SLUDGE/SEDIMENT						
ODCM required samples denoted by * units are pCi/kg, wet						
WRF CENTRIFUGE WASTE SLUDGE	2-Jan-18	101±96	<128	<115		
	9-Jan-18	153±92	<64	<100		
	16-Jan-18		<92	<143		
	23-Jan-18	507±149	<67	<120		
	30-Jan-18	397±152	<26	<126		
	6-Feb-18	546±155	<110	<121		
	13-Feb-18	421±139	<75	<34		
	20-Feb-18	426±155	<102	<140		
	27-Feb-18	537±143	<37	<32		
	6-Mar-18	759±180	<106	<130		
	13-Mar-18	648±170	<113	<150		
	20-Mar-18	602±168	<92	<29		
	27-Mar-18	592±169	<95	<155		
	3-Apr-18	452±143	<138	<174		
	10-Apr-18	323±118	<113	<124		
	17-Apr-18	No Sample Water Resources Outage				
	24-Apr-18		<111	<158		
	1-May-18	276±84	<29	<97		
	8-May-18	629±157	<24	<99		
	15-May-18	476±142	<122	<99		
	22-May-18		<96	<101		
	29-May-18	401±167	<139	<132		
	5-Jun-18	347±111	<64	<151		
	12-Jun-18	169±85	<98	<120		
	19-Jun-18	355±139	<103	<178		
	26-Jun-18		<84	<133		

Table 8-11 Sludge/Sediment (Continued)

ODCM required samples denoted by *
units are pCi/kg, wet

SAMPLE LOCATION	DATE COLLECTED	I-131	Cs-134	Cs-137	In-111	Notes
WRF CENTRIFUGE WASTE SLUDGE	3-Jul-18	344±124	<90	<99		
	10-Jul-18		<124	<100		
	17-Jul-18	257±114	<37	<169		
	24-Jul-18	217±154	<150	<166		
	31-Jul-18	121±89	<65	<29		
	7-Aug-18	248±106	<33	<129		
	14-Aug-18	382±136	<134	<143		
	21-Aug-18	200±100	<90	<75		
	28-Aug-18	305±112	<108	<169		
	4-Sep-18	399±119	<25	<122		
	11-Sep-18		<23	<137		
	18-Sep-18	363±115	<134	<120		
	25-Sep-18	329±183	<61	<143		
	2-Oct-18	338±136	<131	<164		
	9-Oct-18	402±141	<92	<147		
	16-Oct-18		<69	<139		
	23-Oct-18		<109	<39		
	30-Oct-18		<97	<85		
	6-Nov-18	443±131	<71	<150		
	13-Nov-18		<124	<56		
	20-Nov-18	730±186	<116	<143		
	27-Nov-18	103±89	<88	<140		
	4-Dec-18	375±128	<107	<156		
	11-Dec-18		<139	<120		
	18-Dec-18	261±131	<24	<116		
	24-Dec-18	509±137	<99	<136		
	31-Dec-18		<63	<146		

Table 8-11 Sludge/Sediment (Continued)
Cooling Tower Sludge

Unit Cycle	Approximate Volume (yd^3)	Isotope	Activity Range (pCi/g)	Sample Type
U3R20	293	All principal gamma-emitters	<MDA	Towers/Canal Sludge
U2R21	364	All principal gamma-emitters	<MDA	Towers/Canal Sludge

Table 8-12 Hard -To-Detect Radionuclide Results

Hard-To-Detect Radionuclide (pCi/Liter)						
Sample Location	Well number	Sample Date	C-14	Fe-55	Ni-63	Sr-90
Unit 1 (outside RCA)	APP-12	11/14/2018	<46.0	<23.6	<3.75	<1.27
Unit 2 (inside RCA)	H0A	11/12/2018	<46.4	<26.1	<3.35	<1.71
Unit 3 (inside RCA)	H11	11/11/2018	<46.0	<24.9	<3.44	<1.77

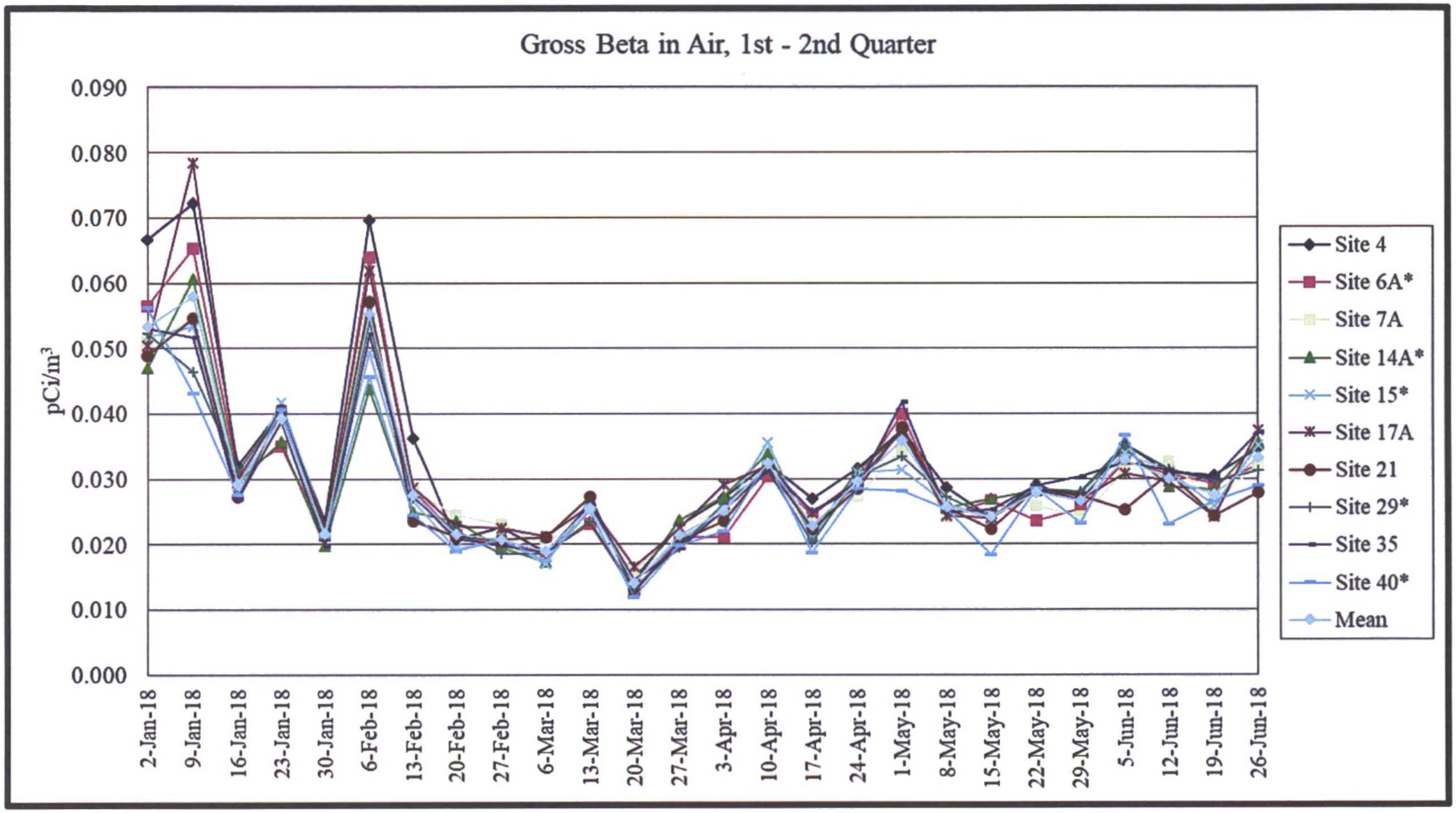


Figure 8-1 Gross Beta in Air, 1st-2nd Quarter

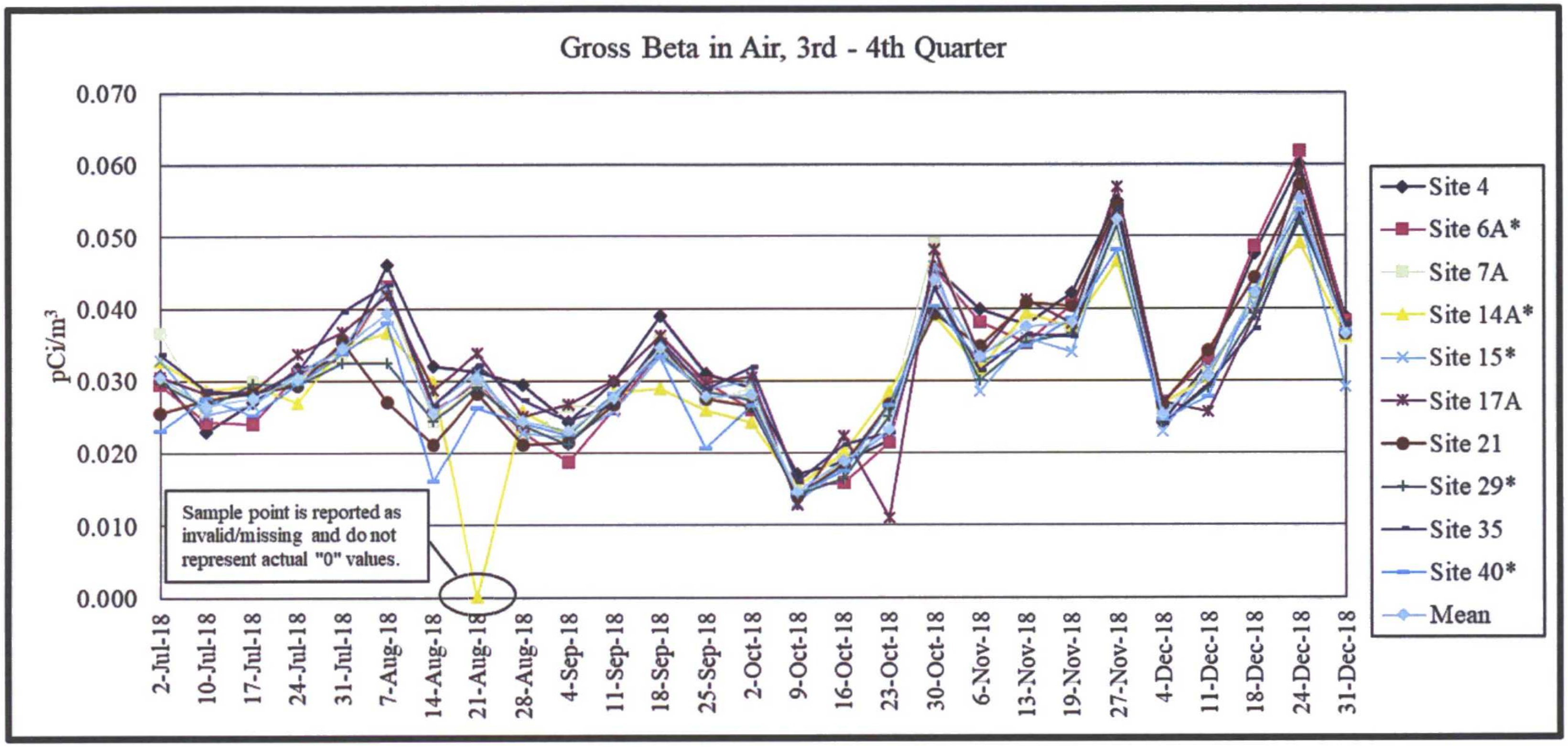


Figure 8-2 Gross Beta in Air, 3rd-4th Quarter

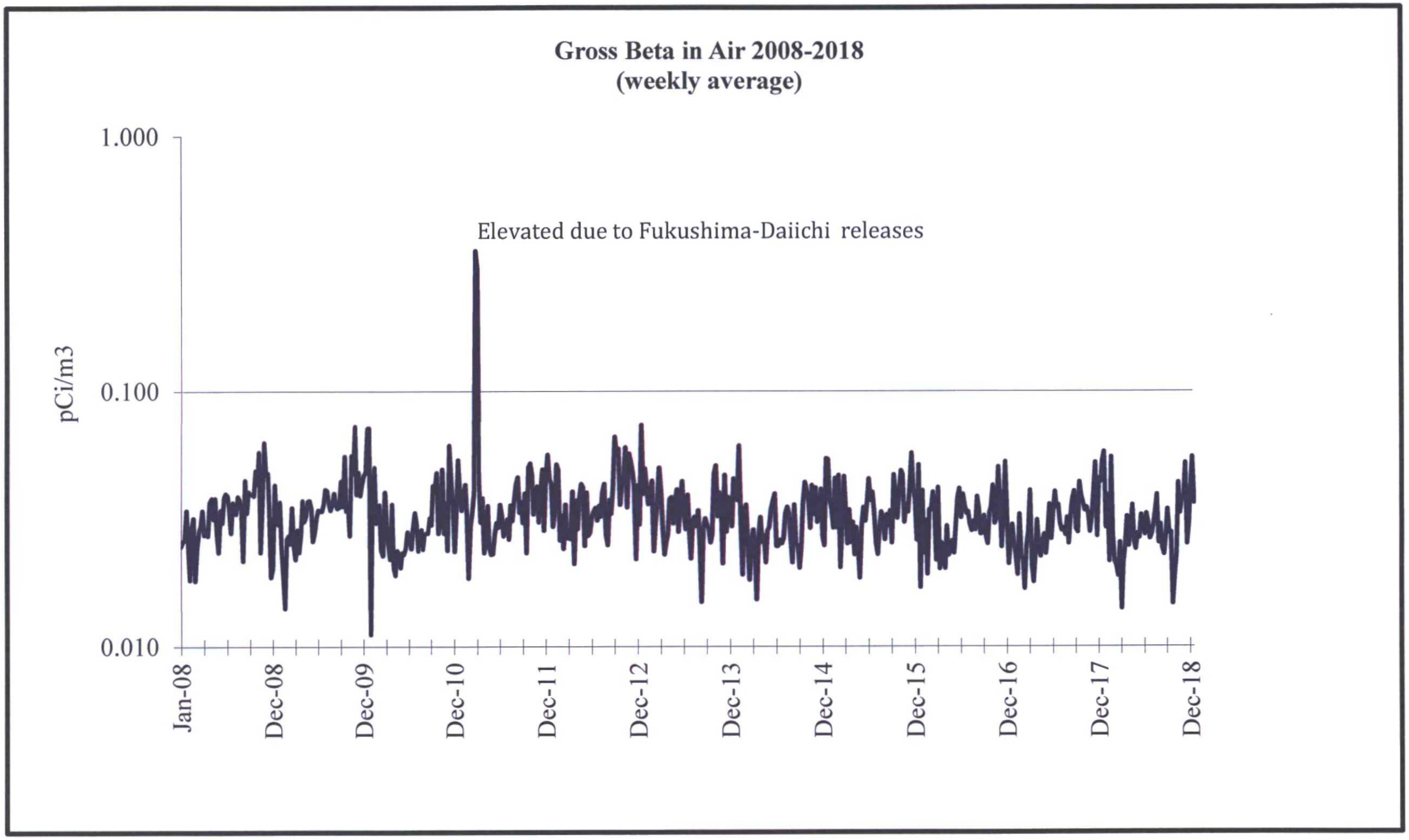


Figure 8-3 Historical Gross Beta in Air (Weekly System Average)

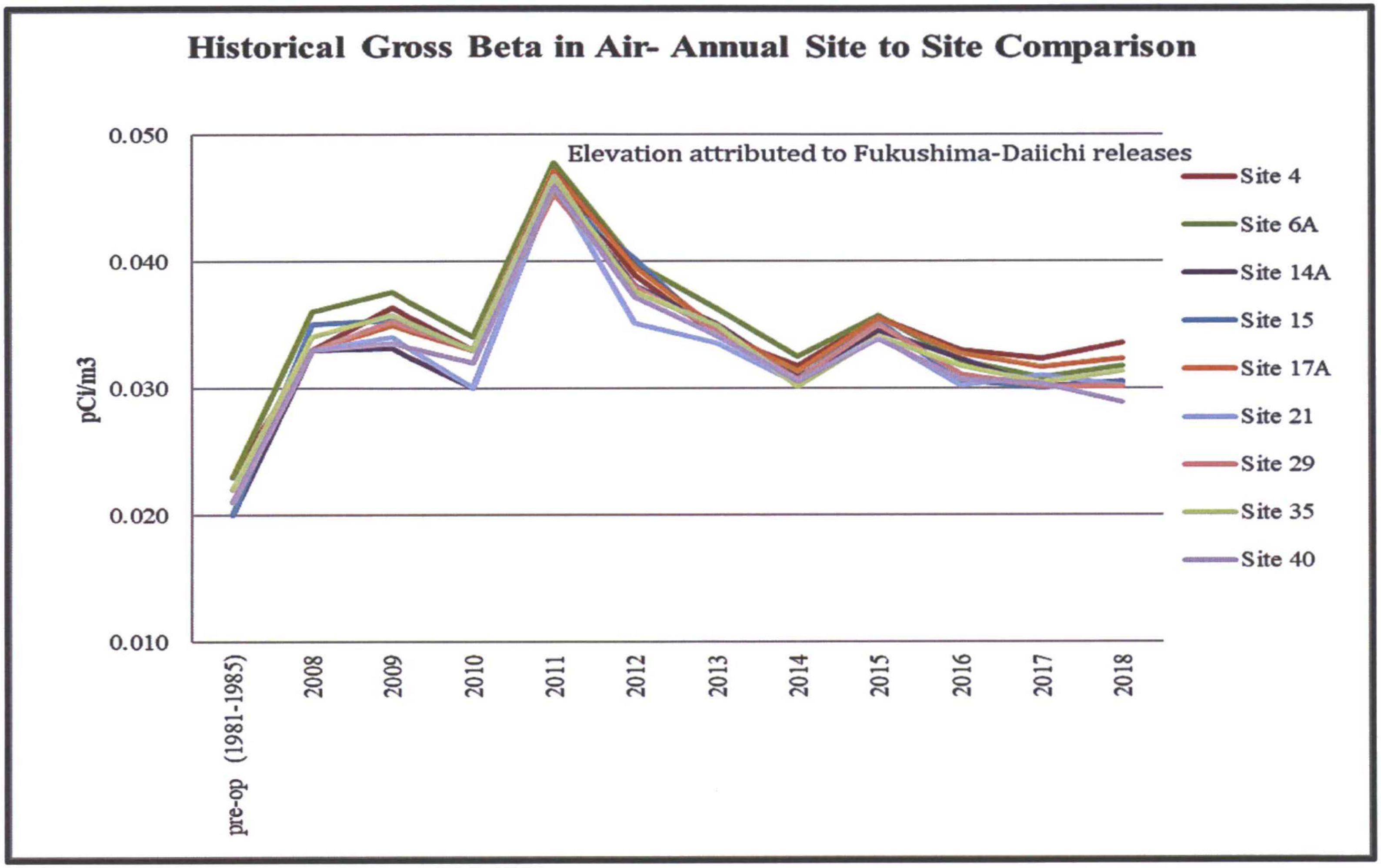


Figure 8-4 Historical Gross Beta in Air (Annual Site to Site Comparisons) Compared to Pre-Op

Note: 7A is not included due to the location change since pre-operational period. The elevated 2011 annual average values are attributed to the Fukushima-Daiichi release.

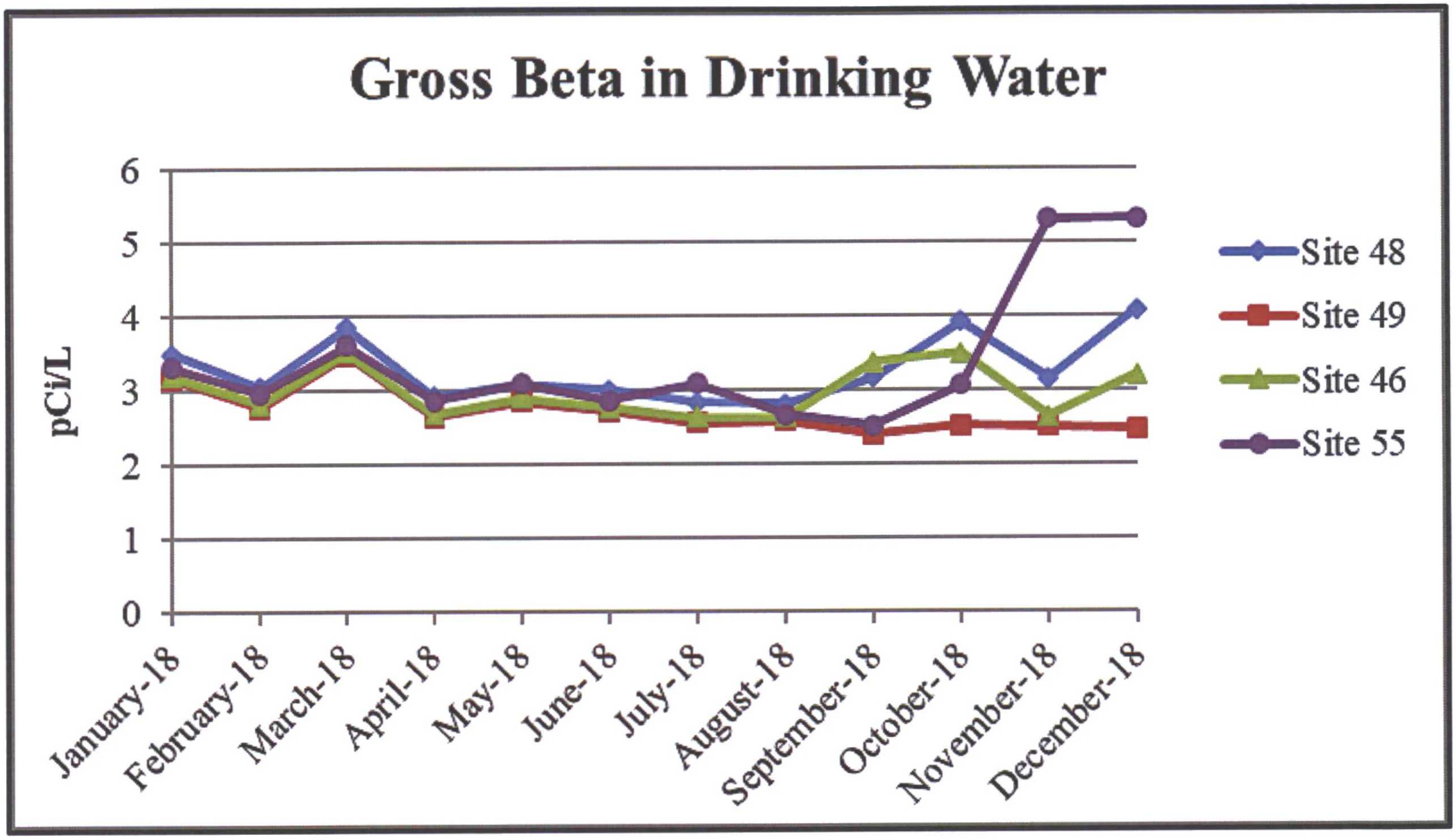


Figure 8-5 Gross Beta in Drinking Water

Notes: MDA values are plotted as activity (i.e. <2.3 is plotted as 2.3)
The action level is 30 pCi/liter

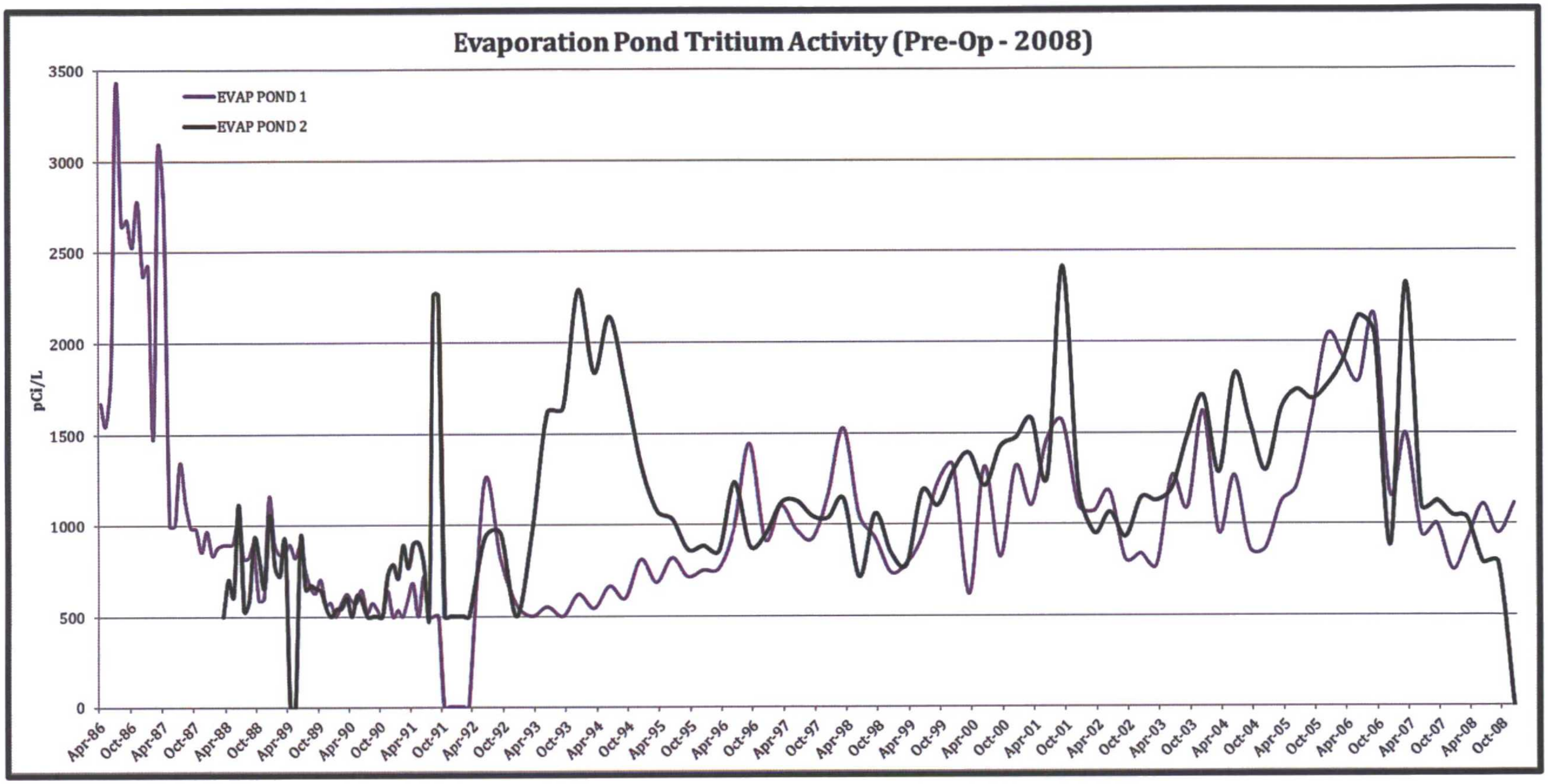


Figure 8-6 Evaporation Pond Tritium Activity (Pre-Op- 2008)

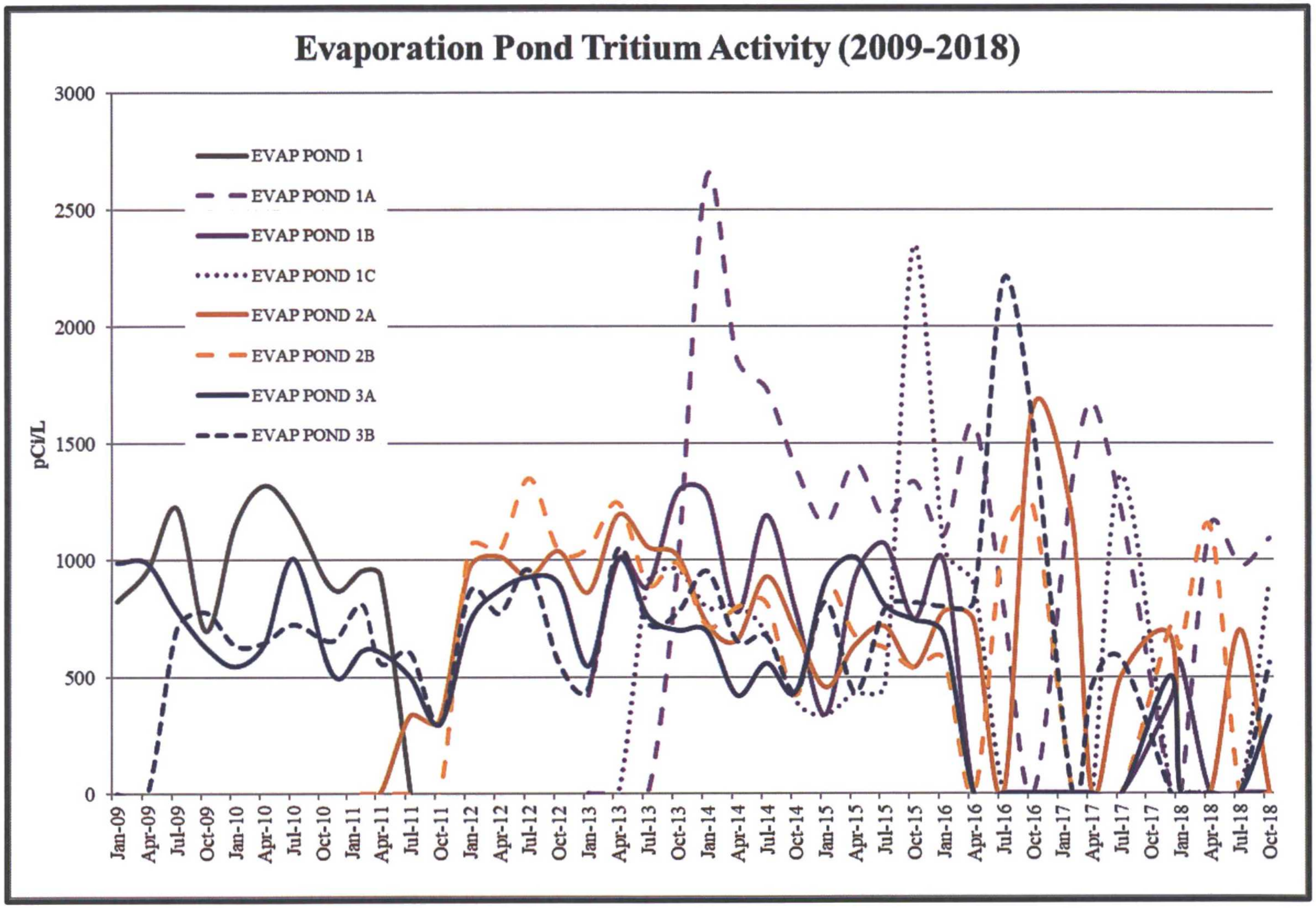


Figure 8-7 Evaporation Pond Tritium Activity (2009-2018)

Note: Zero values represent no sample taken for sampling period, per procedural guidance or lack of sample material.

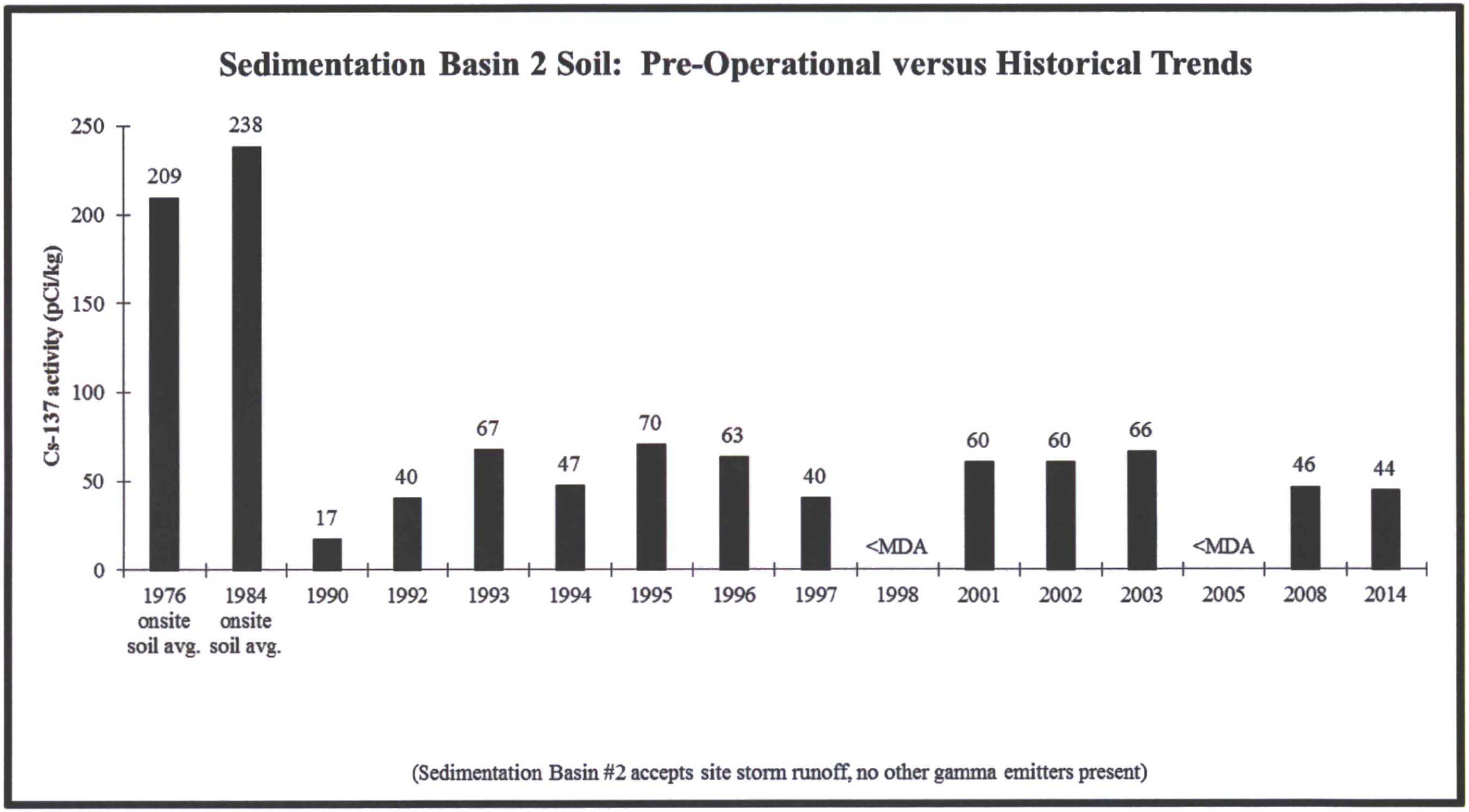


Figure 8-8 Sedimentation Basin 2 Cs-137

9. Thermoluminescent Dosimeter (TLD) Results and Data

The environmental TLD used at PVNGS is the Panasonic Model 812 Dosimeter. The Model 812 is a multi-element dosimeter combining two elements of lithium borate and two elements of calcium sulfate under various filters.

TLDs were placed in fifty locations from one to thirty-five miles from the PVNGS. TLD locations are shown in Figure 2-1 and Figure 2-2 and are described in Table 9-1. TLD results for 2018 are presented in Table 9-2. Definitions for Table 9-2 are as follows:

MDD_Q: Minimum differential dose, quarterly, 3 times 90th percentile sQ determined from analysis (mRem).

MDD_A: Minimum differential dose, annual, 3 times 90th percentile sA determined from analysis (mRem).

B_Q: Quarterly baseline (mRem) (average of previous 5 years)

M_Q: Locations 91 day standard quarter normalized dose (mRem per standard quarter)

L_Q: Quarterly investigation level dose (mRem)

B_A: Baseline background dose (mRem) (annual)

M_A: Annual monitoring data – MA determined by normalizing available quarterly data to 4 full quarters

L_A: Annual investigation level dose (mRem)

ND: Non Detectable

The baseline is calculated as the average of the previous 5 year measurements. The minimum differential dose (MDD) is calculated as 3times the 90th percentile standard deviation of the data from the previous 5 years; quarterly MDD is calculated using the quarterly data and annual MDD is calculated using the annual summation of the quarterly data. Investigation level is calculated by the difference of the data measurement and the baseline; results less than, or equal to the MDD are Non Detectable (ND) and any result exceeding the MDD meets the threshold for the investigation level. Locations exceeding the investigation level will be evaluated for cause and impact to the public and environment.

Historical environmental gamma radiation results for 1985 through 2018 are presented in graphical form on Figure 9-1 (excluding transit control TLD #45). Figure 9-2 depicts the environmental TLD results from 2018 as compared to the pre-operational TLD results (excluding sites #41 and #43, as they were deleted and later assigned to a new location, and #46-50, as they had no pre-op TLD at the location for comparison). The site to site comparisons indicate a direct correlation with respect to pre-operational results. It is indicated that the offsite dose, as measured by TLDs, has not changed since Palo Verde became operational.

Table 9-1 TLD Site Locations

(Distance and direction are relative to Unit 2 in miles)

TLD #	Location	Distance from Unit 2	TLD #	Location	Distance from Unit 2	TLD #	Location	Distance from Unit 2
1	E30	29.13	18	ESE2	1.48	35	NNW8	7.86
2	ENE24	24.18	19	SE2	1.35	36	N5	4.32
3	E21	21.87	20	SSE2	2.04	37	NNE5	4.69
4	E16	16.05	21	S3	2.68	38	NE5	4.21
5	ESE11	11.14	22	SSW3	2.74	39	ENE5	4.71
6	SSE31	31.47	23	W5	4.17	40	N2	2.37
7	SE7	6.87	24	SW4	3.75	41	ESE3	3.39
8	SSE4	4.33	25	WSW5	4.88	42	N8	7.24
9	S5	4.63	26	SSW4	4.13	43	NE5	4.60
10	SE5	3.91	27	SW1	0.93	44	ENE35	35.00
11	ESE5	5.14	28	WSW1	0.66	45	Onsite	0.18
12	E5	4.85	29	W1	0.64	46	ENE30	7.23
13	N1	0.85	30	WNW1	0.74	47	E35	32.35
14	NNE2	155	31	NW1	1.03	48	E24	22.76
15	NE2	1.63	32	NNW1	0.90	49	ENE11	11.32
16	ENE2	1.59	33	NW4	4.05	50	WNW5	4.24
17	E2	1.39	34	NNW5	4.84			

*Site #6 and site #44 are the control locations.
**Site #45 is the transit control TLD (stored in lead pig).

Table 9-2 Environmental TLD Results

Palo Verde 2018 MDD_Q: 5 mrem **Palo Verde 2018 MDD_A: 10 mrem**

Site	Quarterly (mrem)									Annual (mrem)			Note
	B_Q	M_QQ1	M_QQ2	M_QQ3	M_QQ4	L_QQ1	L_QQ2	L_QQ3	L_QQ4	B_A	M_A	L_A	
1	25.2	23.0	23.9	25.2	22.5	ND	ND	ND	ND	100.9	94.7	ND	
2	22.5	18.8	22.0	22.2	20.8	ND	ND	ND	ND	90.0	83.9	ND	
3	24.3	20.7	23.4	23.0	23.7	ND	ND	ND	ND	97.1	90.8	ND	
4	25.0	20.9	24.2	23.0	23.9	ND	ND	ND	ND	100.0	91.9	ND	
5	21.8	16.8	18.9	19.4	19.8	ND	ND	ND	ND	87.2	74.9	ND	
6	27.2	22.9	24.8	24.9	26.4	ND	ND	ND	ND	108.8	99.0	ND	
7	26.0	22.3	24.3	26.6	24.8	ND	ND	ND	ND	104.1	98.0	ND	
8	24.3	22.1	23.3	24.8	23.5	ND	ND	ND	ND	97.2	93.8	ND	
9	28.8	25.4	27.3	27.3	26.9	ND	ND	ND	ND	115.2	106.8	ND	
10	24.4	22.0	23.1	23.7	*	ND	ND	ND	*	73.1	68.9	ND	1
11	25.4	23.3	24.0	24.6	23.8	ND	ND	ND	ND	101.8	95.7	ND	
12	23.9	22.0	23.0	23.0	22.8	ND	ND	ND	ND	95.6	90.8	ND	
13	26.0	23.1	23.8	24.7	24.3	ND	ND	ND	ND	104.0	95.8	ND	
14	25.4	23.9	25.0	26.2	25.2	ND	ND	ND	ND	101.7	100.2	ND	
15	24.0	20.7	21.3	24.5	23.2	ND	ND	ND	ND	96.1	89.8	ND	
16	22.9	20.4	22.1	23.9	23.4	ND	ND	ND	ND	91.7	89.9	ND	
17	25.1	23.5	22.5	25.5	23.9	ND	ND	ND	ND	100.5	95.5	ND	
18	23.7	20.9	22.2	23.8	21.8	ND	ND	ND	ND	94.7	88.6	ND	
19	25.7	22.6	24.8	24.7	25.3	ND	ND	ND	ND	102.9	97.3	ND	
20	24.7	22.4	23.8	23.1	23.8	ND	ND	ND	ND	98.9	93.0	ND	
21	26.1	24.5	24.2	25.3	24.8	ND	ND	ND	ND	104.5	98.8	ND	
22	26.5	24.3	24.9	24.2	25.0	ND	ND	ND	ND	106.0	98.4	ND	
23	23.5	19.8	22.4	22.0	22.0	ND	ND	ND	ND	94.1	86.2	ND	
24	23.1	20.3	22.5	20.3	21.6	ND	ND	ND	ND	92.5	84.7	ND	
25	23.7	20.8	22.5	23.0	23.2	ND	ND	ND	ND	95.0	89.5	ND	
26	28.0	26.7	26.0	26.2	26.6	ND	ND	ND	ND	112.1	105.5	ND	
27	27.3	25.4	27.0	25.4	25.8	ND	ND	ND	ND	109.3	103.6	ND	
28	26.2	23.3	25.2	24.9	25.5	ND	ND	ND	ND	104.9	98.8	ND	
29	24.7	22.9	22.4	23.7	24.3	ND	ND	ND	ND	98.8	93.2	ND	
30	26.4	24.5	25.2	24.5	24.4	ND	ND	ND	ND	105.6	98.6	ND	
31	23.6	21.9	22.2	22.3	23.4	ND	ND	ND	ND	94.5	89.8	ND	
32	25.8	23.2	24.9	24.8	25.4	ND	ND	ND	ND	103.0	98.4	ND	
33	26.4	24.1	25.4	26.5	26.2	ND	ND	ND	ND	105.5	102.3	ND	
34	28.4	26.5	27.9	27.8	27.3	ND	ND	ND	ND	113.5	109.6	ND	
35	31.7	28.1	31.1	31.8	30.6	ND	ND	ND	ND	126.6	121.6	ND	
36	26.6	21.8	25.3	24.8	25.9	ND	ND	ND	ND	106.3	97.8	ND	
37	24.4	20.8	23.3	24.3	24.1	ND	ND	ND	ND	97.4	92.5	ND	
38	27.9	24.9	27.0	26.7	28.0	ND	ND	ND	ND	111.8	106.6	ND	
39	24.7	19.8	23.5	22.2	24.1	ND	ND	ND	ND	98.9	89.6	ND	
40	25.5	21.1	24.8	25.0	25.1	ND	ND	ND	ND	102.0	96.0	ND	
41	26.9	22.7	26.0	27.3	27.7	ND	ND	ND	ND	107.7	103.8	ND	
42	27.7	23.8	25.4	25.9	27.7	ND	ND	ND	ND	110.9	102.9	ND	
43	28.1	24.1	*	*	26.9	ND	*	*	ND	56.2	51.1	ND	1
44	24.4	19.1	22.8	22.7	23.9	ND	ND	ND	ND	97.7	88.6	ND	
45	5.9	2.3	5.0	5.7	3.2	ND	ND	ND	ND	23.6	16.2	ND	
46	24.1	20.4	23.4	22.1	24.4	ND	ND	ND	ND	96.4	90.4	ND	
47	24.1	20.5	*	22.9	23.7	ND	*	ND	ND	72.2	67.1	ND	1
48	24.7	20.7	24.3	23.3	22.8	ND	ND	ND	ND	98.7	91.1	ND	
49	23.1	19.1	22.0	20.1	22.4	ND	ND	ND	ND	92.5	83.6	ND	
50	20.0	17.2	18.1	19.2	19.3	ND	ND	ND	ND	79.9	73.7	ND	

Note 1: Some data unavailable due to missing dosimetry. M_A equal to the sum of data collected. B_A equal to current year average of data collected. Normalization of data indicates no notable change in sampling location results.

Figure 9-1 Network Environmental TLD Exposure Rates

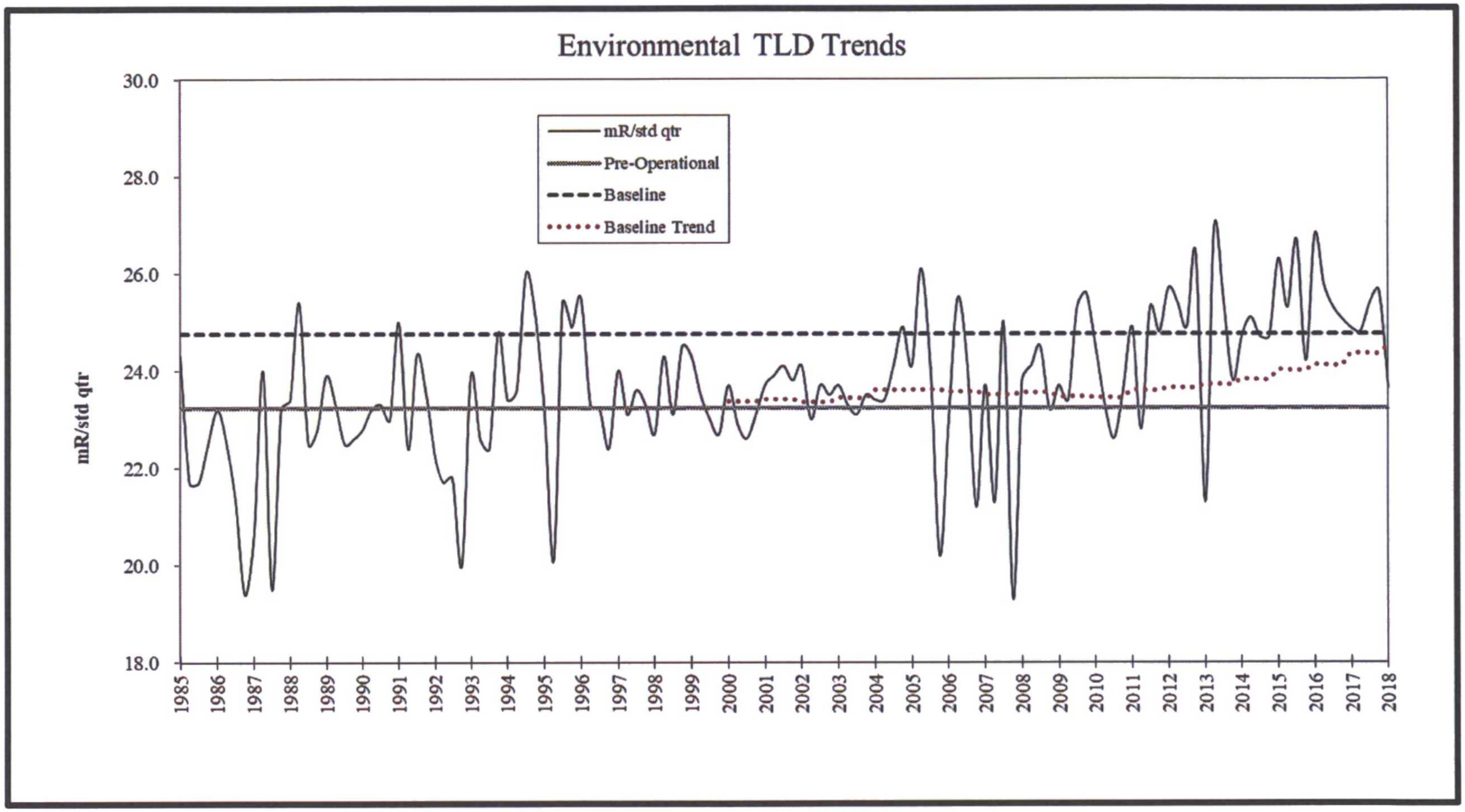
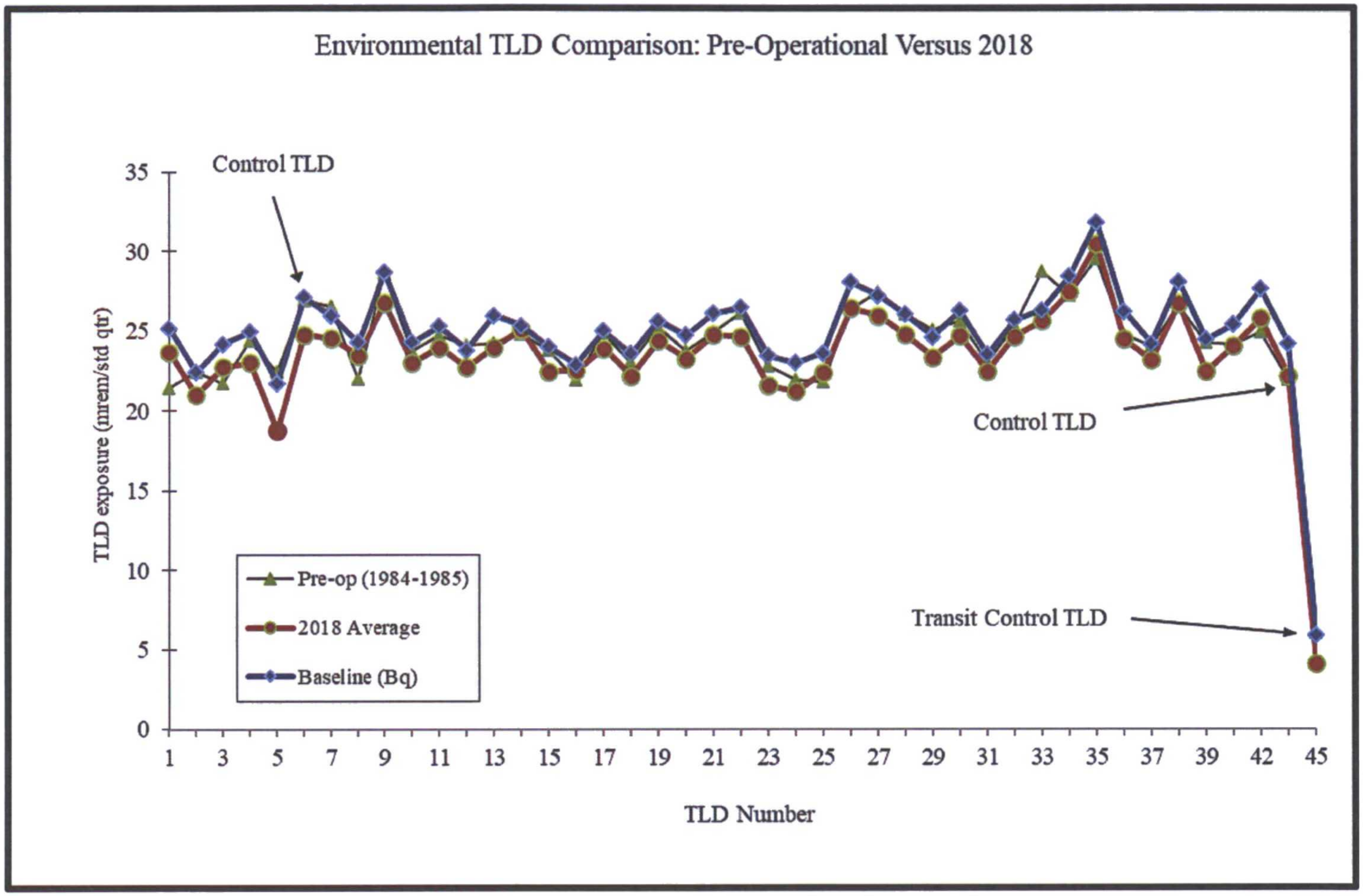


Figure 9-2 Environmental TLD Comparison: Pre-Operational versus 2018



The following TLDs are not included on this graph:
TLD #41 monitoring location was deleted in June, 2000 due to school closing (this TLD was replaced at a new school in 2004)
TLD #43 monitoring location was deleted in 1994 due to school closing (this TLD was placed at a new school in 2007)
TLDs #46-50 are not included since they were not included in the pre-op monitoring program.

10. Land Use Census

10.1 Introduction

In accordance with the PVNGS ODCM, Section 6.2, the field portion of the annual Land Use Census was performed by June 2018.

Observations were made in each of the 16 meteorological sectors to determine the nearest milking animals, residences, and gardens of greater than 500 square feet. This census was completed by driving the roads and speaking with residents.

The results of the Land Use Census are presented in Table 10-1 and discussed below. The directions and distances listed are in sectors and miles from the Unit 2 containment.

10.2 Census Results

The 2018 Land Use Census results identified new potential Radiological Effluent Release Report dose receptor location. Each location was evaluated. Below describes the changes identified and the evaluation results.

Nearest Resident

There were two (2) changes in nearest resident status from the previous year. Dose calculations indicated the highest dose to be 0.169 mrem.

Milk Animal

There were seven (7) changes in milk animal status from the previous year. Four (4) of the locations had the potential for having a dose greater than 20% that of our current sampling location with the lowest dose potential. The locations were visited by the REMP manager to evaluate program participation potential. As of December 2018, two (2) of the locations no longer had goats, and two (2) of the locations had only male goats. Dose calculations indicated the highest dose to be 0.479 mrem.

Vegetable Gardens

There were two (2) changes in nearest garden status from the previous year. Both gardens had a calculated dose lower than gardens currently in REMP. Dose calculations indicated the highest dose to be 0.296 mrem.

See Table 10-1 for a summary of the specific results and Table 2-1 for current sample locations. Figure 10-1through Figure 10-3 provide graphs depicting historical calculated doses for nearest residents, nearest milk receptor, and nearest garden receptor locations in each sector.

Differences in calculated doses are the result of many variables, including;

- Changes in receptor locations from year to year (proximity to the power plant)
- Changes in local meteorology (wind direction, wind speed, precipitation, and temperature)
- Concurrent meteorology at the time of effluent releases

- Exposure pathways

Table 10-1 Land Use Census

(Distance and direction are relative to Unit 2 in miles)

Sector	Nearest Resident	Nearest Garden	Nearest Milk Animal (Cow/Goat)	Calculated Dose (mrem)	Change from 2018
N	1.55	3.10	1.73	Resident 8.52E-2 Garden 2.12E-1 Milk 4.79E-1	Garden Milk
NNE	1.52	NONE	2.82	Resident 1.23E-1 Milk 4.09E-1	Milk
NE	2.16	NONE	4.52	Resident 1.20E-1 Milk 1.35E-1	Garden Milk
ENE	2.05	4.84	4.84	Resident 1.39E-1 Garden 2.96E-1 Milk 2.96E-1	
E	2.81	NONE	4.28	Resident 9.35E-2 Milk 2.39E-1	Milk
ESE	3.06	NONE	3.15	Resident 1.06E-1 Milk 4.22E-1	Resident Milk
SE	3.40	NONE	4.19	Resident 9.40E-2 Milk 4.65E-1	Milk
SSE	NONE	NONE	NONE	NA	
S	4.67	NONE	NONE	Resident 1.69E-1	Resident
SSW	NONE	NONE	NONE	NA	
SW	1.39	NONE	NONE	Resident 1.60E-1	
WSW	0.75	NONE	NONE	Resident 1.44E-1	
W	0.70	NONE	NONE	Resident 1.03E-1	
WNW	NONE	NONE	NONE	NA	
NW	0.93	NONE	NONE	Resident 9.14E-2	
NNW	1.30	4.34	1.59	Resident 7.53E-2 Garden 1.32E-1 Milk 4.10E-1	Milk

Comments:

Dose calculations were performed using GASPAR code and 2017 meteorological data and source term. Dose reported for each location is the total for all three PVNGS Units and is the highest individual critical organ dose identified.

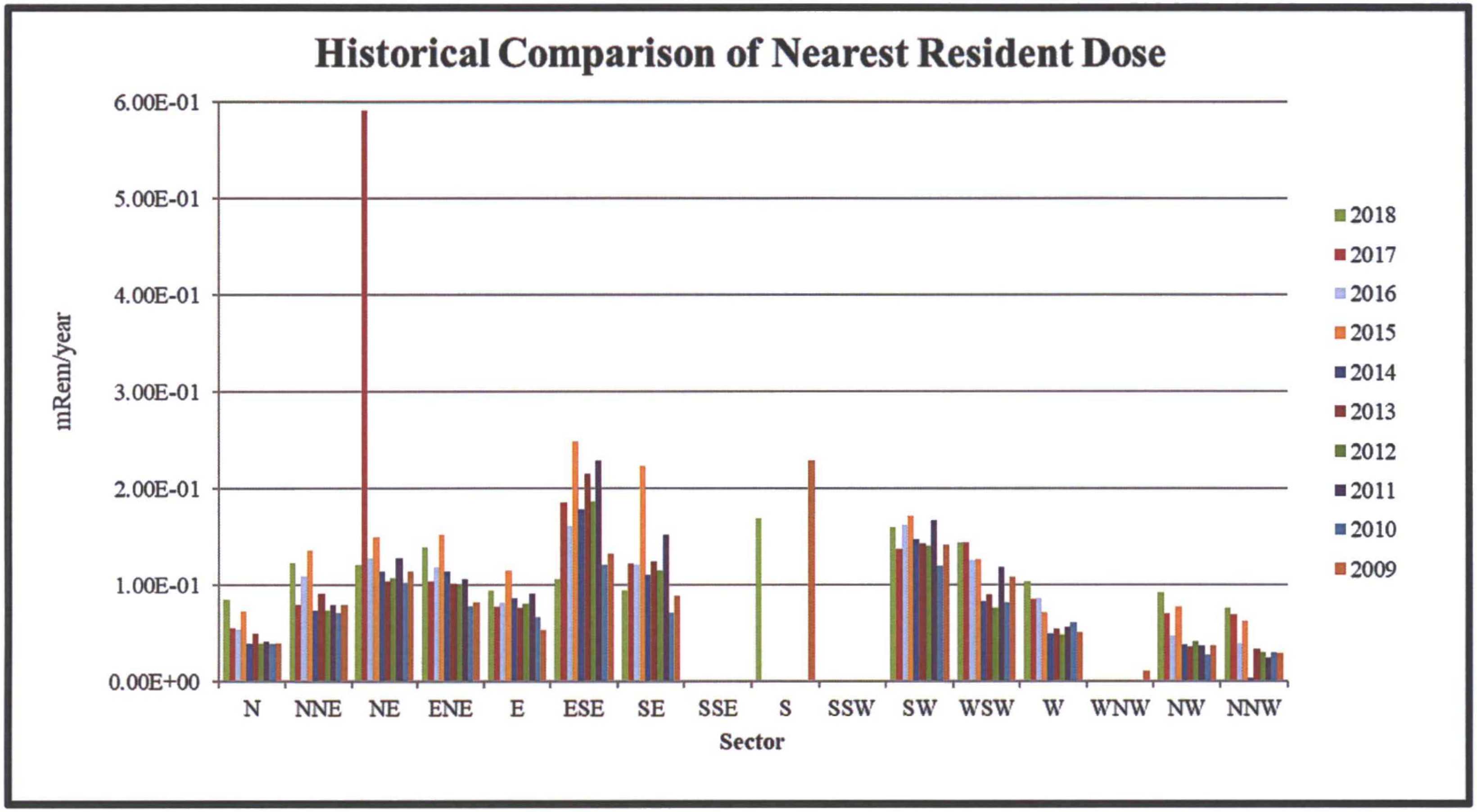


Figure 10-1 Historical Comparison of Nearest Resident Dose

Historical annual average most prevalent wind direction is from the SW; the next highest is from the N. This attributes to the higher doses assigned to residents in the S sector. The 2018 Land Use Census identified potential garden pathway for the nearest resident in the NE Sector; dose is reflective of the assumption of direct radiation and ingestion pathway.

Historical annual average least prevalent wind direction is from the SE; the second least prevalent is from the ESE. This attributes to the lower doses assigned to the residents in the WNW, NW, and NNW sectors.

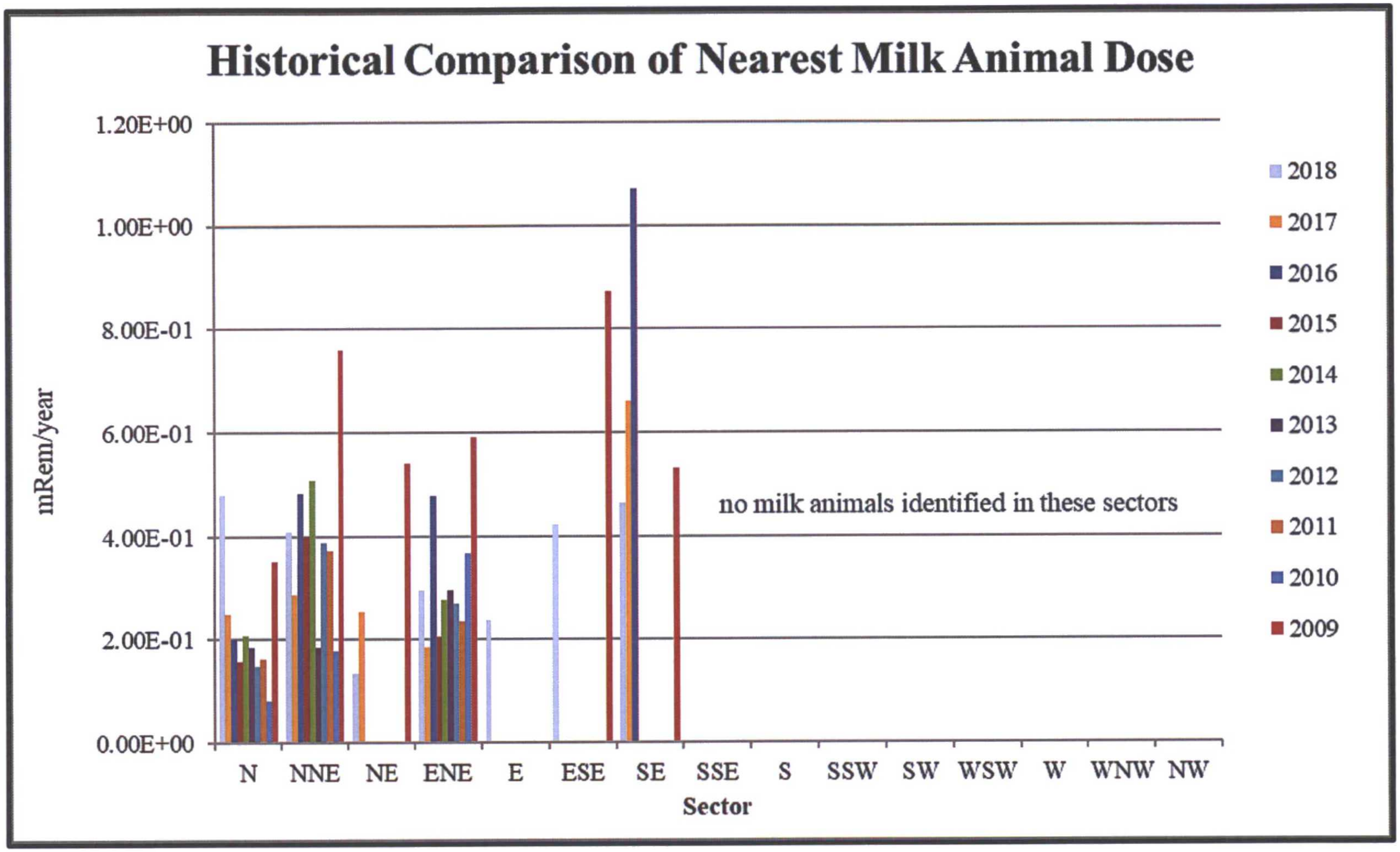


Figure 10-2 Historical Comparison of Nearest Milk Animal Dose

Milk animals include goats and/or cows. Several new milk animals were identified in 2009 that were closer to the power plant than in the past, resulting in generally higher calculated doses in that calendar year.

No milk samples have indicated any plant-related radionuclides. Additionally, milk animals in the desert environment are normally fed stored feed and are not on pasture. The calculated does are conservative due to the inclusion of pastured feed as part of the calculation.

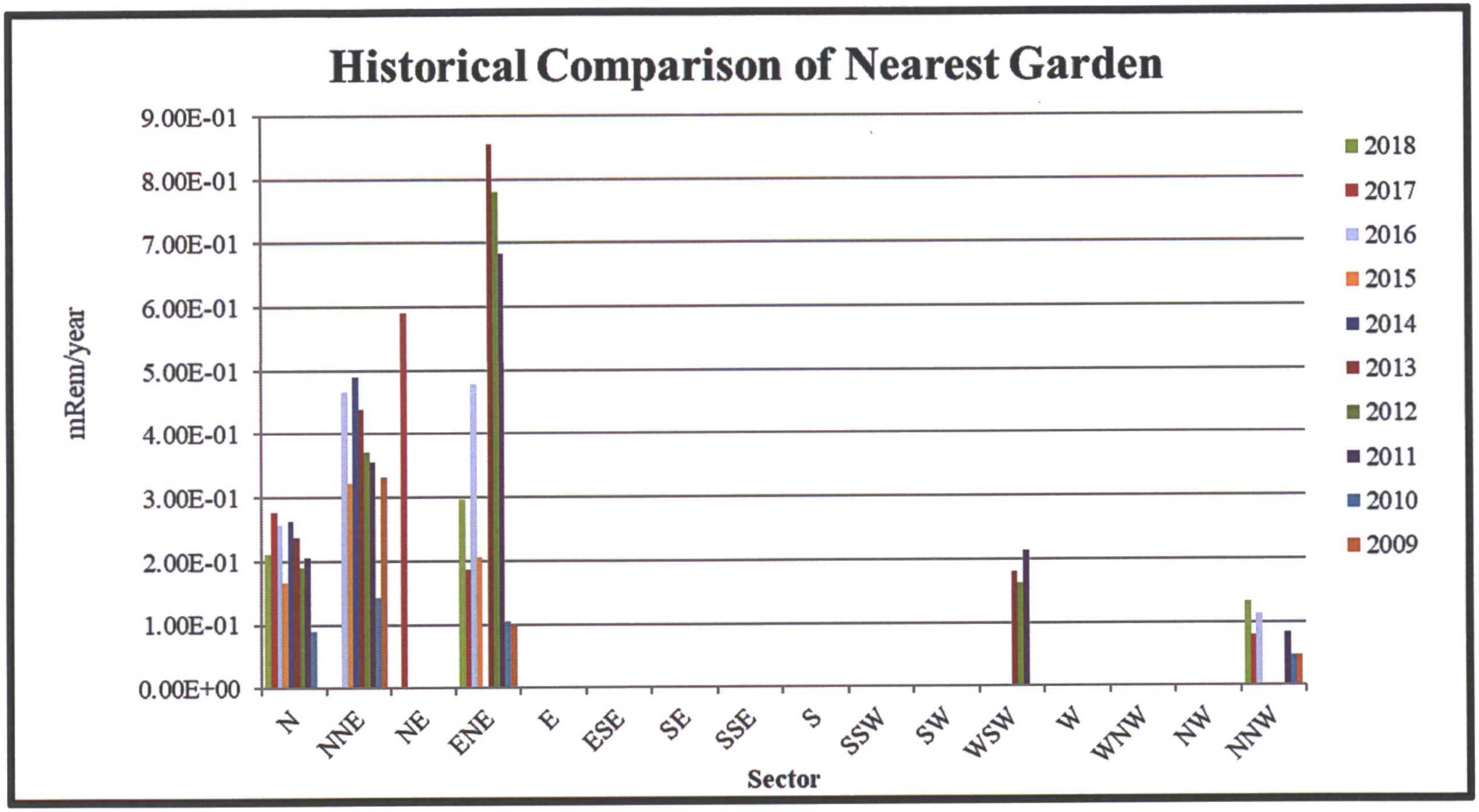


Figure 10-3 Historical Comparison of Nearest Garden Dose

Gardens have been sporadically identified from year to year. Gardening is not prevalent in the desert environment.

11. Summary and Conclusions

Summary

The conclusions are based on a review of the radioassay results and environmental gamma radiation measurements for the 2018 calendar year. Where possible, the data were compared to pre-operational sample data.

All sample results for 2018 are presented in Table 8-1 through Table 8-12 and do not include observations of naturally occurring radionuclides, with the exception of gross beta in air and gross beta in drinking water. Table 11-1 summarizes the ODCM required samples and is in the format required by the NRC BTP on Environmental Monitoring.

I-131 identified in the evaporation ponds, Water Resources influent, Water Resources centrifuge sludge, and reservoirs is the result of offsite sources and appears in the effluent sewage from Phoenix. The levels of I-131 detected in these locations are consistent with levels identified in previous years.

Cs-137 was detected in one Evaporation Pond 3A sample. Two samples were collected and the average of the results was reported in Table 8-10. The first sample was 15 pCi/L +/- 10 pCi/L; the second sample was 21 pCi/L +/- 10 pCi/L. The required lower limit of detection for Cs-137 in water is 18 pCi/L; the action level for Cs-137 in water is 50 pCi/L. Evaporation Pond 3A has not received any influent during 2018 and is being drained to another evaporation pond to make repairs to the top liner. The water level in Evaporation Pond 3A is low, such that sediment that has collected in the pond was unavoidably collected in the sample. Cs-137 is known to bind to sediment, and the levels detected is consistent with what was found in the preoperational soils in the surrounding area as a result of atmospheric bomb testing. Additionally, one of the samples was below the required lower limit of detection and both samples, were well below the action level for Cs-137 in water.

Tritium concentrations identified in surface water onsite have been attributed to PVNGS permitted gaseous effluent releases and secondary plant releases. These concentrations are consistent with historical values.

Environmental radiation levels are consistent with measurements reported in previous Pre-operational and Operational Radiological Environmental annual reports, References 1 and 2.

Conclusion

There was no measurable radiological impact on the environment in 2018 resulting from the operation of PVNGS.

Table 11-1 Environmental Radiological Monitoring Program Annual Summary

TABLE 11.1 ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM ANNUAL SUMMARY

Palo Verde Nuclear Generating Station — Docket Nos. STN 50-528/529/530
Maricopa County, Arizona — Calendar Year 2018

Medium or Pathway Sampled (Unit of Measurement)	Type and Total Number of Analyses Performed	Lower Limit of Detection (LLD) (from Table 6.1)	All Indicator Locations Mean (f)[a] Range	Location with Highest Annual Mean: Name Distance and Direction	Location with Highest Annual Mean: Mean (f)[a] Range	Control Locations Mean (f)[a] Range	Number of Nonroutine Reported Measurements
Direct Radiation (mrem/std. qtr.)	TLD - 199	NA	24.9 (184/188) 16.8 – 31.8	Site #35 8 miles 330°	30.4 (4/4) 28.1 – 31.8	23.4 (8/8) 19.1 – 26.4	4
Air Particulates (pCi/m^3)	Gross Beta - 530	0.01	0.031 (467/468) 0.011 - 0.078	Site # 4 16 miles 92°	0.034 (53/53) 0.015 - 0.072	0.032 (53/53) 0.013 - 0.065	1
	Gamma Spec Composite - 40						
	Cs-134 (quarterly)	0.05	<LLD <LLD	NA NA	<LLD <LLD	<LLD <LLD	0
	Cs-137 (quarterly)	0.06	<LLD <LLD	NA NA	<LLD <LLD	<LLD <LLD	0
Air Radioiodine (pCi/m^3)	Gamma Spec. - 530						
	I-131	0.07	<LLD <LLD	NA NA	<LLD <LLD	<LLD <LLD	1
Broadleaf Vegetation (pCi/Kg-wet)	Gamma Spec. - 24						
	I-131	60	<LLD	NA	<LLD	<LLD	0
	Cs-134	60	<LLD	NA	<LLD	<LLD	0
	Cs-137	80	<LLD	NA	<LLD	<LLD	0

Groundwater (pCi/liter)	H-3 – 12	2000	<LLD	NA	<LLD	NA	0
	Gamma Spec. - 14						
	Mn-54	15	<LLD	NA	<LLD	NA	0
	Fe-59	30	<LLD	NA	<LLD	NA	0
	Co-58	15	<LLD	NA	<LLD	NA	0
	Co-60	15	<LLD	NA	<LLD	NA	0
	Zn-65	30	<LLD	NA	<LLD	NA	0
	Zr-95	30	<LLD	NA	<LLD	NA	0
	Nb-95	15	<LLD	NA	<LLD	NA	0
	I-131	15	<LLD	NA	<LLD	NA	0
	Cs-134	15	<LLD	NA	<LLD	NA	0
	Cs-137	18	<LLD	NA	<LLD	NA	0
	Ba-140	60	<LLD	NA	<LLD	NA	0
	La-140	15	<LLD	NA	<LLD	NA	0
Drinking Water (pCi/liter)	Gross Beta – 48	4	3.09 (48/48) 2.40 – 5.32	Site #55 3 miles 214°	3.39 (12/12) 2.52 -5.32	NA	0
	H-3 – 16	2000	<LLD	NA	<LLD	NA	0
	Gamma Spec. – 48						
	Mn-54	15	<LLD	NA	<LLD	NA	0
	Fe-59	30	<LLD	NA	<LLD	NA	0
	Co-58	15	<LLD	NA	<LLD	NA	0
	Co-60	15	<LLD	NA	<LLD	NA	0
	Zn-65	30	<LLD	NA	<LLD	NA	0
	Zr-95	30	<LLD	NA	<LLD	NA	0
	Nb-95	15	<LLD	NA	<LLD	NA	0
	I-131	15	<LLD	NA	<LLD	NA	3
	Cs-134	15	<LLD	NA	<LLD	NA	0
	Cs-137	18	<LLD	NA	<LLD	NA	0
	Ba-140	60	<LLD	NA	<LLD	NA	0
	La-140	15	<LLD	NA	<LLD	NA	0

	Gamma Spec. – 30						
Milk	I-131	1	<LLD	NA	<LLD	<LLD	0
(pCi/liter)			<LLD	NA	<LLD	<LLD	
	Cs-134	15	<LLD	NA	<LLD	<LLD	0
			<LLD	NA	<LLD	<LLD	
	Cs-137	18	<LLD	NA	<LLD	<LLD	0
			<LLD	NA	<LLD	<LLD	
	Ba-140	60	<LLD	NA	<LLD	<LLD	0
	La-140	15	<LLD	NA	<LLD	<LLD	0
	Gamma Spec. - 18						
	Mn-54	15	<LLD	NA	<LLD	NA	0
	Fe-59	30	<LLD	NA	<LLD	NA	0
	Co-58	15	<LLD	NA	<LLD	NA	0
	Co-60	15	<LLD	NA	<LLD	NA	0
	Zn-65	30	<LLD	NA	<LLD	NA	0
	Zr-95	30	<LLD	NA	<LLD	NA	0
	Nb-95	15	<LLD	NA	<LLD	NA	0
Surface Water (pCi/liter)	I-131	15	11 (1/18)	Site #63	11 (1/3)	NA	0
			11-11	Onsite 180°	11-11		
	Cs-134	15	<LLD	NA	<LLD	NA	0
	Cs-137	18	<LLD	Site #64	18 (1/3)	NA	0
				Onsite 190°	15-21		
	Ba-140	60	<LLD	NA	<LLD	NA	0
	La-140	15	<LLD	NA	<LLD	NA	0
	H-3 - 25	3000	597 (10/18)	Site #59	937 (5/5)	NA	0
			323-1146	Onsite 180°	559-1146		

(a) Mean and range based upon detectable measurements only. Fraction of detectable measurements at specified locations is indicated in parentheses. (f)

NOTE: Miscellaneous samples that are not listed on Tables 2.1 and 9.1 (not ODCM required) are not included on this table.

12. References

1. Pre-Operational Radiological Monitoring Program, Summary Report 1979-1985

2. 1985-2016 Annual Radiological Environmental Operating Reports, Palo Verde Nuclear Generating Station

3. Palo Verde Nuclear Generating Station Technical Specifications and Technical Reference Manual

4. Offsite Dose Calculation Manual, Revision 27, PVNGS Units 1, 2, and 3

5. Regulatory Guide 4.1, Programs for Monitoring Radioactivity in the Environs of Nuclear Power Plants

6. Regulatory Guide 4.8, Environmental Technical Specifications for Nuclear Power Plants

7. NRC Radiological Assessment Branch Technical Position on Environmental Monitoring, Revision 1, November 1979 (Incorporated into NUREG-1301)

8. NEI 07-07, Nuclear Energy Institute, Industry Ground Water Protection Initiative – Final Guidance Document, August 2007

9. "Sources of Radiation." *NRC: Sources of Radiation*. Nuclear Regulatory Commission, 2 Oct. 2017. Web. 18 Feb. 2019.

10. "NCRP Report No. 160: Ionizing Radiation Exposure of the Population of the United States." *Journal of Radiological Protection J. Radiol. Prot.* 29.3 (2009): 465. Web.

Appendix A

One abnormal event was omitted from the 2017 Annual Radiological Environmental Operating Report (AREOR), Table 2-3: Summaries of the REMP Deviation/Abnormal Events. Condition Report (CR) 17-07102 was generated to document the inability to collect a resident well sample from Site #46 due to the closure of the main water valve to the home. Samples for the sampling periods 25 April to 2 May, 2017 and 2 May to 9 May, 2017, were missed. May 2017 had five (5) sampling opportunities. Three (3) samples were collected, and as such, the monthly composite analysis for Site #46 was still performed. The results of that analysis were reported in Table 8-8: Drinking Water, of the 2017 AREOR.