Tennessee Valley Authority, P.O. Box 2000, Spring City, Tennessee 37381-2000

May 15, 2018

10 CFR 50.4

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

Watts Bar Nuclear Plant, Units 1 and 2
Facility Operating License Nos. NPF-90 and NPF-96
NRC Docket Nos. 50-390 and 50-391

Subject: **Watts Bar Nuclear Plant – Annual Radiological Environmental Operating Report - 2017**

Enclosed is the subject report for the period of January 1, 2017, through December 31, 2017. This report is being submitted as required by Watts Bar Nuclear Plant (WBN) Units 1 and 2, Technical Specification (TS) 5.9.2, "Annual Radiological Environmental Operating Report," and the WBN Offsite Dose Calculation Manual (ODCM), Administrative Control Section 5.1. This report is required to be submitted to the Nuclear Regulatory Commission (NRC) by May 15 of each year.

There are no new regulatory commitments in this letter. If you have any questions concerning this matter, please contact Kim Hulvey, WBN Licensing Manager, at (423) 365-7720.

Respectfully,

Paul Simmons
Site Vice President
Watts Bar Nuclear Plant

Enclosure:

Annual Radiological Environmental Operating Report - Watts Bar Nuclear Plant 2017

cc: See Page 2

cc (Enclosure):

NRC Regional Administrator – Region II
NRC Project Manager – Watts Bar Nuclear Plant
NRC Senior Resident Inspector - Watts Bar Nuclear Plant

ENCLOSURE

TENNESSEE VALLEY AUTHORITY
WATTS BAR NUCLEAR PLANT

Annual Radiological Environmental Operating Report
Watts Bar Nuclear Plant 2017

Annual Radiological Environmental Operating Report

Watts Bar Nuclear Plant 2017

Tennessee Valley Authority

May 2018

Chesapeake Nuclear Services

GEL Laboratories LLC

a member of The GEL Group INC

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EXECUTIVE SUMMARY

This report describes the Radiological Environmental Monitoring Program (REMP) conducted by the Tennessee Valley Authority (TVA) near the Watts Bar Nuclear Plant (WBN) during the 2017 monitoring period. The program is conducted in accordance with regulatory requirements to monitor the environment per 10 CFR 20, 10 CFR 50, and TVA procedures. The REMP includes the collection and subsequent determination of radioactive material content in environmental samples. Various types of samples are collected within the vicinity of the plant, including air, water, food crops, soil, fish and shoreline sediment, and direct radiation levels are measured. The radiation levels of these samples are measured and compared with results at control stations located outside the plant's vicinity and data collected at Watts Bar Nuclear Plant prior to operations (preoperational data). This report contains an evaluation of the potential impact of WBN operations on the environment and the general public.

Most of the radioactivity measured in environmental samples in the WBN program can be attributed to naturally occurring radioactive materials. In 2017, trace quantities of Cesium-137 (Cs-137) were measured in soil samples. The concentrations were typical of the levels expected to be present in the environment from past nuclear weapons testing. The fallout from accidents at the Chernobyl plant in the Ukraine in 1986 and the Fukushima plant in Japan in 2011 may have also contributed to the low levels of Cs-137 measured in environmental samples. Tritium (H-3) was detected in water samples collected from Washington Ferry and Breedenton Ferry and in drinking water samples from TRM 503.8 (Dayton, TN) and TRM 473 (East Side Utilities). Tritium was also detected in onsite groundwater wells. Similar levels of tritium were detected in both control and indicator locations, indicating that any plant contribution to the natural background level is small. The measured levels were a small fraction of the EPA drinking water limit These levels of radioactive elements detected do not represent a significant contribution to the radiation exposure to members of the public.

INTRODUCTION

This report describes and summarizes the results of radioactivity measurements made near WBN and laboratory analyses of samples collected in the area. The measurements are made to comply with the requirements of 10 CFR 50, Appendix A, Criterion 64 and 10 CFR 50, Appendix I, Section IV.B.2, IV.B.3 and IV.C and to determine potential effects on public health and safety. This report satisfies the annual reporting requirements of WBN Technical Specification 5.9.2 and Offsite Dose Calculation Manual (ODCM) Administrative Control 5.1. In addition to reporting the data prescribed by specific requirements, other information is included to help correlate the significance of results measured by this monitoring program to the levels of environmental radiation resulting from naturally occurring radioactive materials

Naturally Occurring and Background Radioactivity

Most materials in our world today contain trace amounts of naturally occurring radioactive materials. Potassium -40 (K-40), with a half-life of 1.3 billion years, is one of the most common radioactive materials found naturally in our environment. Approximately 0.01 percent of all potassium is radioactive K-40. Other examples of naturally occurring radioactive materials include isotopes of beryllium, bismuth, lead, thallium, thorium, uranium and radium, among others. Carbon-14 (C-14) and Hydrogen-3 (H-3, commonly called Tritium") exist in the environment naturally but also as a result of nuclear power plant operations. These naturally occurring radioactive materials are in the soil, our food, our drinking water, and our bodies. The radiation from these materials makes up a part of the low-level natural background radiation. The remainder of the natural background radiation results from cosmic rays.

It is possible to get an idea of the relative hazard of different types of radiation sources by evaluating the amount of radiation the U.S. population receives from each general type of radiation source. The information below is primarily adapted from Reference 1 and Reference 2.

Table 1 - U.S. General Population Average Dose Equivalent Estimates

Source	millirem (mrem)[i] per Year per Person
Natural Background Dose Equivalent	
Cosmic	33
Terrestrial	21
In the body	29
Radon	228
Total	311
Medical (effective dose equivalent)	300
Nuclear energy	0.28
Consumer Products	13
TOTAL	624.28

[i] One-thousandth of a Roentgen Equivalent Man (rem). By comparison, the NRC's annual radiation dose limit for the public from any licensed activity, such as a nuclear plant, is 100 mrem

As can be seen from the data presented above, natural background radiation dose equivalent to the U.S. population exceeds that normally received from nuclear plants by several hundred times. This indicates that nuclear plant operations normally result in a population radiation doses which are insignificant as compared to the dose from natural background radiation. It should be noted that the use of radiation and radioactive materials for medical uses has resulted in a similar effective dose equivalent to the U.S. population as that caused by natural background cosmic and terrestrial radiation.

Electric Power Production

Nuclear power plants are similar in many respects to conventional coal burning (or other fossil fuel) electrical generating plants. The basic process behind electrical power production in power plants is that fuel is used to heat water to produce steam which provides the force to turn turbines and generators. In a nuclear power plant, the fuel is uranium and heat is produced in the reactor through the fission of the uranium. Nuclear plants include many complex systems to control the nuclear fission process and to safeguard against the possibility of reactor malfunction. The nuclear reactions produce radionuclides commonly referred to as fission and activation products. Very small amounts of these fission and activation products are released into the plant systems. This radioactive material can be transported throughout plant systems and some of it may be released to the environment.

Paths through which radioactivity from a nuclear power plant is routinely released are monitored. Liquid and gaseous effluent monitors record the radiation levels for each release. These monitors also provide alarm mechanisms to prompt termination of any release above limits.

Releases are monitored at the onsite points of release. The radiological environmental monitoring program, which measures the environmental radiation in areas around the plant, provides a confirmation

that releases are being properly controlled and monitored in the plant and that any resulting levels in the environment are within the established regulatory limits and a small fraction of the natural background radiation levels. In this way, the release of radioactive materials from the plant is tightly controlled, and verification is provided that the public is not exposed to significant levels of radiation or radioactive materials as the result of plant operations.

The WBN ODCM, which describes the program required by the plant technical specifications, prescribes limits for the release of radioactive effluents, as well as limits for doses to the general public from the release of these effluents.

The NRC's annual dose limit to a member of the public for all licensees is 100 mrem. The NRC's regulations for nuclear power plants contain additional operational constraints, implementing the philosophy of "as low as reasonably achievable, where there the dose to a member of the general public from radioactive materials released to unrestricted areas is limited as follows:

Liquid Effluents

Total body	≤ 3 mrem/yr
Any organ	≤ 10 mrem/yr

Gaseous Effluents

Noble gases:	
Gamma radiation	≤ 10 millirad (mrad)/yr
Beta radiation	≤ 20 mrad/yr
Particulates:	
Any organ	≤ 15 mrem/yr

In addition to NRC's regulations, the EPA standard for the total dose to the public in the vicinity of a nuclear power plant, established in the Environmental Dose Standard of 40 CFR 190, are as follows:

Total body	≤ 25 mrem/yr
Thyroid	≤ 75 mrem/yr
Any other organ	≤ 25 mrem/yr

Table 6 of this report presents the compares the nominal lower limits of detection (LLD) for the WBN monitoring program with the regulatory limits for maximum annual average concentration released to unrestricted areas. The table also presents the concentrations of radioactive materials in the environment which would require a special report to the NRC and the detection limits for measured radionuclides. It should be noted that the levels of radioactive materials measured in the environment are typically below or only slightly above the lower limit of detection.

SITE AND PLANT DESCRIPTION

The WBN site is in Rhea county, Tennessee, on the west bank of the Tennessee River at Tennessee River Mile (TRM) 528. Figure 1 shows the site in relation to other TVA projects. The WBN site, containing approximately 1770 acres on Chickamauga Lake, is approximately 2 miles south of the Watts Bar Dam and approximately 31 miles north-northeast of TVA's Sequoyah Nuclear Plant (SQN) site. Also located within the reservation are the Watts Bar Dam and Hydro-Electric Plant, the Watts Bar Steam Plant (not in operation), the TVA Central Maintenance Facility, and the Watts Bar Resort Area.

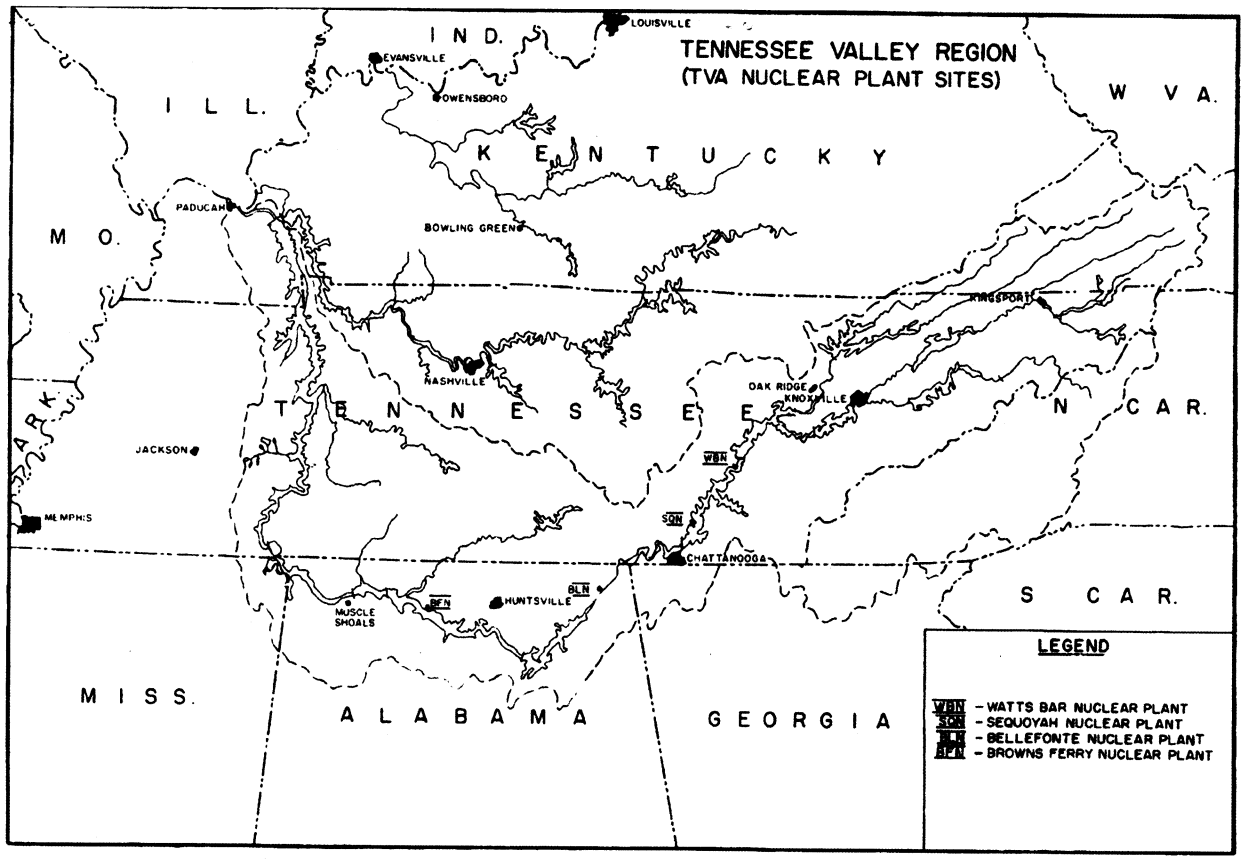
Approximately 18,500 people live within 10 miles of the WBN site. More than 80 percent of these live between 5 and 10 miles from the site. Two small towns, Spring City and Decatur, are located in this area. Spring City, with a population of approximately 2,200, is northwest and north-northwest from the site, while Decatur, with about 1,500 people, is south and south-southwest from the plant. The remainder of the area within 10 miles of the site is sparsely populated, consisting primarily of small farms and individual residences.

The area between 10 and 50 miles from the site includes portions of the cities of Chattanooga and Knoxville. The largest urban concentration in this area is the city of Chattanooga, located to the southwest and south-southwest. The city of Chattanooga has a population of about 170,000, with approximately 80 percent located between 40 and 50 miles from the site and the remainder located beyond 50 miles. The city of Knoxville is located to the east-northeast, with not more than 10 percent of its 185,000 plus people living within 50 miles of the site. Three smaller urban areas of greater than 20,000 people are located between 30 and 40 miles from the site. Oak Ridge is approximately 40 miles to the northeast, the twin cities of Alcoa and Maryville are located 45 to 50 miles to the east-northeast, and Cleveland is located about 30 miles to the south.

Chickamauga Reservoir is one of a series of highly controlled multiple-use reservoirs whose primary uses are flood control, navigation, and the generation of electric power. Secondary uses include industrial and public water supply and waste disposal, fishing, and recreation. Public access areas, boat docks, and residential subdivisions have been developed along the reservoir shoreline.

WBN consists of two pressurized water reactors. WBN Unit 1 received a low power operating license (NPF-20) on November 9, 1995 and achieved initial criticality in January 1996. The full power operating license (NPF-90) was received on February 7, 1996. Commercial operation was achieved May 25, 1996. WBN Unit 2 was deferred October 24, 2000, in accordance with the guidance in Generic Letter 87-15, "Policy Statement on Deferred Plants." On August 3, 2007, TVA provided notice of its intent to reactivate and complete construction of WBN Unit 2. WBN Unit 2 resumed construction in late 2007. October 22, 2015 the operating license was issued. Initial criticality was achieved on May 23, 2016 and commercial operation was achieved on October 19, 2016.

Figure 1 – TVA Region



RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Most of the radiation and radioactivity generated in a nuclear power reactor is contained within the reactor systems. Plant effluent radiation monitors are designed to monitor radionuclides released to the environment. Environmental monitoring is a final verification that the systems are performing as planned. The monitoring program is designed to monitor the pathways between the plant and the people in the immediate vicinity of the plant. Sample types are chosen so that the potential for detection of radioactivity in the environment will be maximized. The Radiological Environmental Monitoring Program (REMP) and sampling locations for WBN are outlined in Appendix A.

There are two primary pathways by which radioactivity can move through the environment to humans: air and water (see Figure 2). The air pathway can be separated into two components: the direct (airborne) pathway and the indirect (ground or terrestrial) pathway. The direct airborne pathway consists of direct radiation and inhalation by humans. In the terrestrial pathway, radioactive materials may be deposited on the ground or on plants and subsequently ingested by animals and/or humans. Human exposure through the liquid pathway may result from drinking water, eating fish, or by direct exposure at the shoreline. The types of samples collected in this program are designed to monitor these pathways.

Many factors were considered in determining the locations for collecting environmental samples. The locations for the atmospheric monitoring stations were determined from a critical pathway analysis based on weather patterns, dose projections, population distribution, and land use. Terrestrial sampling stations were selected after reviewing such things as the locations of dairy animals and gardens in conjunction with the air pathway analysis. Liquid pathway stations were selected based on dose projections, water use information, and availability of media such as fish and sediment. Table 4 lists the sampling stations and the types of samples collected from each. Modifications made to the WBN monitoring program in 2017 are reported in Appendix B. Deviations to the sampling program during 2017 are included in Appendix C.

To determine the amount of radioactivity in the environment prior to the operation of WBN, a preoperational radiological environmental monitoring program was initiated in December 1976 and operated through December 31, 1995. Measurements of the same types of radioactive materials that are measured currently were assessed during the preoperational phase to establish normal background levels for various radionuclides in the environment.

The preoperational monitoring program is a very important part of the overall program. During the 1950s, 1960s, and 1970s, atmospheric nuclear weapons testing released radioactive material to the environment causing fluctuations in background radiation levels. Knowledge of preexisting radionuclide patterns in the environment permits a determination, through comparison and trending analyses, of the actual environmental impact of WBN operation.

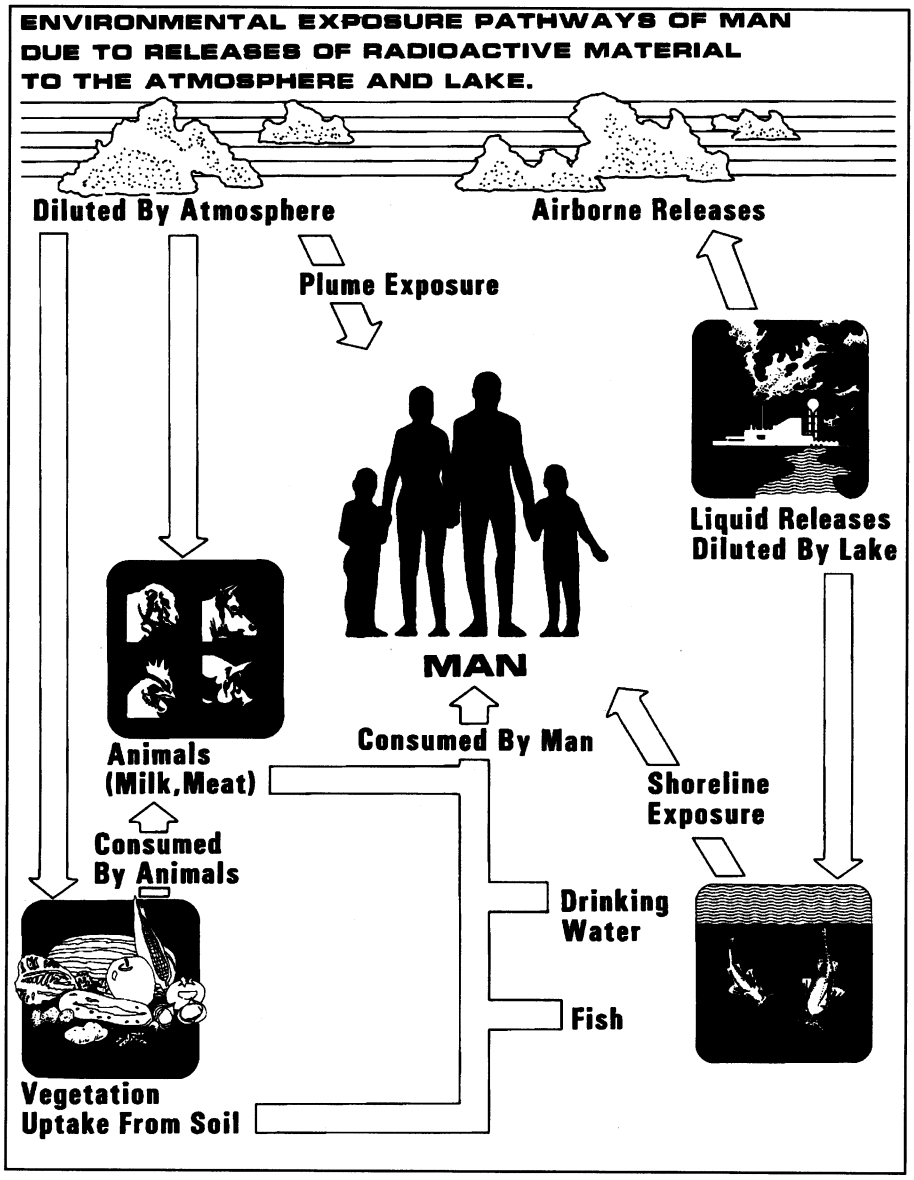
The determination of environmental impact during the operating phase also considers the presence of control stations that have been established in the environment. Results of environmental samples taken at control stations (far from the plant) are compared with those from indicator stations (near the plant) to aid in the determination of the impacts from WBN operation.

In 2017, the sample analysis was performed by two separate laboratories. Samples collected prior to June 30, 2017 were analyzed by Tennessee Valley Authority's (TVA's) Environmental Radiological Monitoring and Instrumentation (ERM&I) group located at the Western Area Radiological Laboratory (WARL) in Muscle Shoals, Alabama, except for the Strontium-89/90 (Sr-89, Sr-90) analysis of soil samples which is performed by a contract laboratory. Beginning in July 2017, GEL Laboratories, LLC, based in Charleston, SC performed all the radiochemistry analyses of the WBN REMP samples. Analyses are conducted in accordance with written and approved procedures and are based on industry established standard analytical methods. A summary of the analysis techniques and methodology is presented in Appendix D.

The radiation detection devices and analysis methods used to determine the radionuclide content of samples collected in the environment are very sensitive and capable of detecting small amounts of radioactivity. The sensitivity of the measurement process is defined in terms of the lower limit of detection (LLD). A description of the nominal LLDs for the ERM&I laboratory and GEL is presented in Appendix E.

The laboratory applies a comprehensive quality assurance/quality control program to monitor laboratory performance throughout the year. One of the key purposes of the QA/QC program is to provide early identification of any problems in the measurement process so they can be corrected in a timely manner. This program includes instrument checks, to ensure that the radiation detection instruments are working properly, and the analysis of quality control samples. As part of an interlaboratory comparison program, the laboratory participated in a blind sample program administrated by Eckert & Ziegler Analytics. A complete description of the program is presented in Appendix F. Data tables summarizing the sample analysis results are presented in Appendix H.

Figure 2 – Environmental Exposure Pathways



DIRECT RADIATION MONITORING

Direct radiation levels are measured at various monitoring points around the plant site. These measurements include contributions from cosmic radiation, radioactivity in the ground, fallout from atmospheric nuclear weapons tests conducted in the past, and any radioactivity that may be present from plant operations. Because of the relatively large variations in background radiation as compared to the small levels from the plant, contributions from the plant may be difficult to distinguish.

Measurement Techniques

The Landauer InLight environmental dosimeter is used in the radiological environmental monitoring program for the measurement of direct radiation. This dosimeter contains four elements consisting of aluminum oxide detectors with open windows as well as plastic and copper filters. The dosimeter is processed using optically stimulated luminescence (OSL) technology to determine the amount of radiation exposure.

The dosimeters are placed approximately one meter above the ground, with two at each monitoring location. Sixteen monitoring points are located around the plant near the site boundary, one location in each of the 16 compass sectors. One monitoring point is also located in each of the 16 compass sectors at a distance of approximately four to five miles from the plant.

Dosimeters are also placed at additional monitoring locations out to approximately 15 miles from the site. The dosimeters are exchanged every three months. The dosimeters are sent to Landauer InLight for processing and results reporting. The values are corrected for transit and shielded background exposure. An average of the two dosimeter results is calculated for each monitoring point. The system meets or exceeds the performance specifications outlined in American National Standards Institute (ANSI) N545-1975 and Health Physics Society (HPS) Draft Standard N13.29 for environmental applications of dosimeters.

WBN Technical Specification 5.9.2, Annual Radiological Environmental Operating Report, requires that the Annual Radiological Environmental Operating Report identify TLD results that represent collocated dosimeters in relation to the NRC TLD program and the exposure period associated with each result. The NRC collocated TLD program was terminated by the NRC at the end of 1997, therefore, there are no TLD results that represent collocated dosimeters included in this report.

Results

The results for environmental dosimeter measurements are normalized to a standard quarter (91.25 days or 2190 hours). The monitoring locations are grouped according to the distance from the plant. The first group consists of all monitoring points within 2 miles of the plant. The second group is made up of all locations greater than 2 miles from the plant. Past data have shown that the average results from the locations more than 2 miles from the plant are essentially the same. Therefore, for purposes of this report, monitoring points 2 miles or less from the plant are identified as "onsite" stations and locations greater than 2 miles are considered "offsite."

The quarterly and annual gamma radiation levels determined from the dosimeters deployed around WBN in 2017 are summarized in Table 2. For comparison purposes, the average direct radiation measurements made in the preoperational phase of the monitoring program are also shown.

Table 2 - Average External Gamma Radiation Levels at Various Distances from Watts Bar Nuclear Plant for Each Quarter – 2017

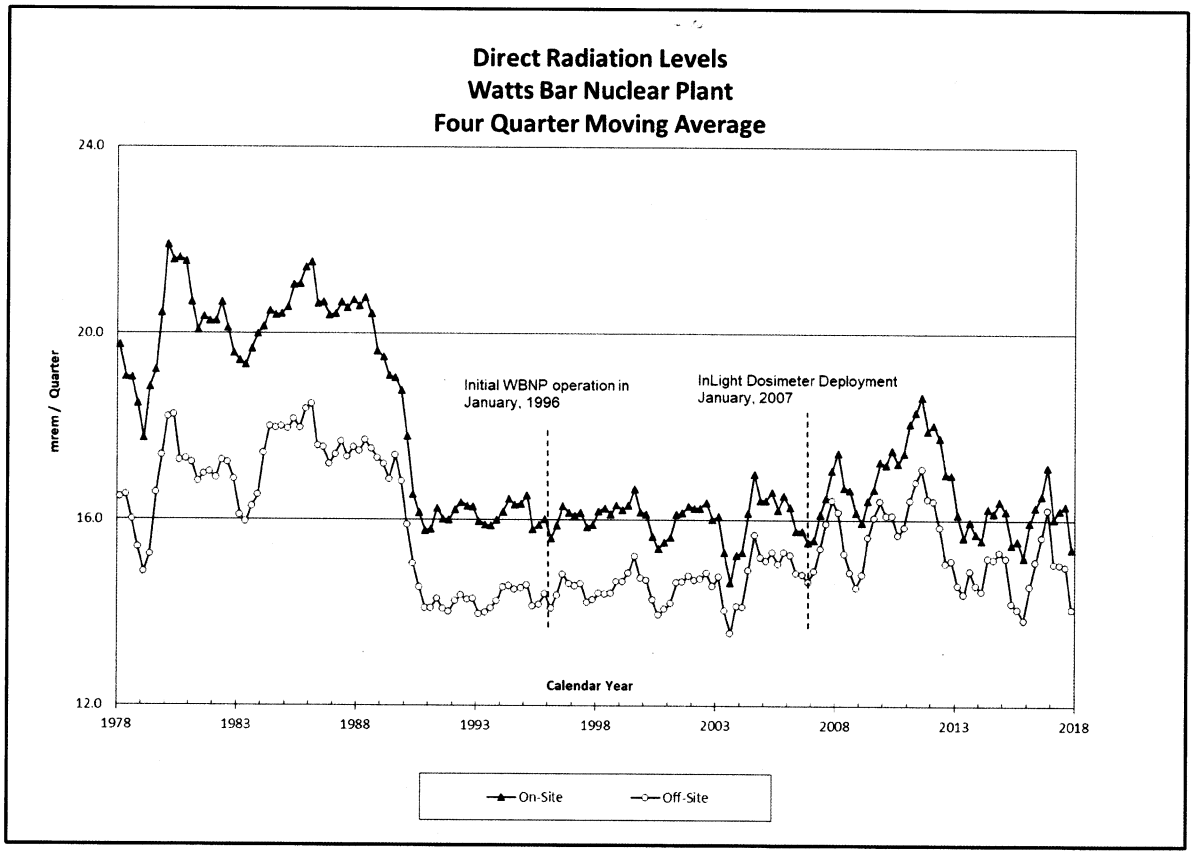
	Average External Gamma Radiation Levels					
	Q1[a] (mrem/qtr)	Q2 (mrem/qtr)	Q3 (mrem/qtr)	Q4 (mrem/qtr)	Annual (mrem/yr)	Preoperational (mR/yr)
Average 0-2 miles (onsite)[b]	12.8	17.3	17.9	13.5	61.5[c]	65
Average >2 miles (offsite)[b]	11.5	15.4	17.0	12.3	56.3	57

NOTES

a. Field periods normalized to one standard quarter (2190 hours)
b. Average of the individual measurements in the set
c. The 5.2 mrem/yr excess for onsite locations falls below the 25 mrem total body limit for 40 CFR 190.

The data in Table 2 indicates that the average quarterly direct radiation levels at the WBN onsite stations are approximately 1.3 mrem/quarter higher than levels at the offsite stations. This equates to 5.2 mrem/year detected at the onsite locations. This value falls below the EPA limit of 25 mrem/year total body. The difference in onsite and offsite averages is consistent with levels measured for the preoperational and construction phases of TVA nuclear power plant sites where the average levels onsite were slightly higher than levels offsite. Figure 3 compares plots of the data from the onsite stations with those from the offsite stations over the period from 1977 through 2017. The new Landauer InLight Optically Stimulated Luminescence (OSL) dosimeters were deployed since 2007 replacing the Panasonic UD-814 dosimeters used during the previous years.

Figure 3 – Average Direct Radiaiton Results



The data in Table 13 contains the results of the individual monitoring stations. The results reported in 2017 are consistent with historical and preoperational results, indicating that the direct radiation levels are not influenced by the operation of WBN. There is no indication that WBN activities increased the background radiation levels normally observed in the areas surrounding the plant.

ATMOSPHERIC MONITORING

The atmospheric monitoring network is divided into three groups identified as local, perimeter, and remote. Four local air monitoring stations are located on or adjacent to the plant site in the general directions of greatest wind frequency. Four perimeter air monitoring stations are located between 6 to 11 miles from the plant, and two air monitors are located out to 15 miles and used as control or baseline stations. The monitoring program and the locations of monitoring stations are identified in the tables and figures of Appendix A.

Results from the analysis of samples in the atmospheric pathway are presented in Table 14 through Table 17. Radioactivity levels identified in this reporting period are consistent with background and preoperational program data. There is no indication of an increase in atmospheric radioactivity due to WBN operations.

Sample Collection and Analysis

Air particulates are collected by continuously sampling air at a flow rate of approximately 2 cubic feet per minute (cfm) through a 2-inch glass fiber filter. The sampling system consists of a Vacuum Florescent Display (VFD), an oil-less carbon vane vacuum pump and a precision-machined mechanical differential pressure flow sensor. It is equipped with automatic flow control, on-board data storage, and alarm notifications for flow, P, T, and higher filter DP. This system is housed in a weather resistant environmental enclosure approximately 3 feet by 2 feet by 4 feet. The filter is contained in a sampling head mounted on the outside of the monitoring building. The filter is replaced weekly. Each filter is analyzed for gross beta activity about 3 days after collection to allow time for the radon daughters to decay. Every 4 weeks composites of the filters from each location are analyzed by gamma spectroscopy.

Gaseous radioiodine is sampled using a commercially available cartridge containing Triethylenediamine (TEDA)-impregnated charcoal. This system is designed to collect iodine in both the elemental form and as organic compounds. The cartridge is in the same sampling head and downstream of the air particulate filter. The cartridge is changed at the same time as the particulate filter and samples the same volume of air. Each cartridge is analyzed for I-131 by gamma spectroscopy.

Atmospheric moisture sampling is conducted by pulling air at a constant flow rate through a column loaded with approximately 400 grams of silica gel. Every two weeks, the column is exchanged on the sampler. The atmospheric moisture is removed from silica gel by heating and analyzed for tritium.

Results

The results from the analysis of air particulate samples are summarized in Table 14. Gross beta activity in 2017 was consistent with levels reported in previous years. The average gross beta activity measured for air particulate samples was 0.027 pCi/m^3. The annual averages of the gross beta activity in air particulate filters at these stations for the period 1977-2017 are presented in Figure 10. Increased levels due to fallout from atmospheric nuclear weapons testing are evident in the years prior to 1981 and a small increase from the Chernobyl accident can be seen in 1986. These patterns are consistent with data from monitoring programs conducted by TVA at other nuclear power plant construction sites. In 2017, the

annual average gross beta particulate activity has increased. However, this increase is consistent across both control and indicator locations, so is not considered a result of any WBN operational activities.

Only natural radioactive materials were identified by the monthly gamma spectral analysis of the air particulate samples. As shown in Table 15, I-131 was not detected in any charcoal cartridge samples collected in 2017.

The results for atmospheric moisture sampling are reported in Table 17. Tritium was measured, above the nominal LLD value of 3.0 pCi/m^3, in atmospheric moisture samples from both the indicator and control locations. The highest concentration from the indicator locations was 4.95 pCi/m^3 and the highest concentration from the control locations was 2.54 pCi/m^3.

TERRESTRIAL MONITORING

Terrestrial monitoring is accomplished by collecting samples of environmental media that may transport radioactive material from the atmosphere to humans. For example, radioactive material may be deposited on a vegetable garden and be ingested along with the vegetables or it may be deposited on pasture grass where dairy cattle are grazing. When the cow ingests the radioactive material, some of it may be transferred to the milk and consumed by humans who drink the milk. Therefore, samples of milk, soil, and food crops are collected and analyzed to determine potential impacts from exposure through this pathway. The results from the analysis of these samples are shown in Table 18 through Table 20.

A land use survey is conducted annually between April and October to identify the location of the nearest milk animal, the nearest residence, and the nearest garden of greater than 500 square feet producing fresh leafy vegetables in each of 16 meteorological sectors within 5 miles from the plant. This land use survey satisfies the requirements 10 CFR 50, Appendix I, Section IV.B.3. From data produced by the land use survey, radiation doses are projected for individuals living near the plant. Doses from air submersion are calculated for the nearest residence in each sector, while doses from drinking milk or eating foods produced near the plant are calculated for the areas with milk-producing animals and gardens, respectively. These dose projections are hypothetical extremes and do not represent actual doses to the general public. The results of the 2017 land use survey are presented in Appendix G.

Sample Collection and Analysis

Milk samples are collected every two weeks from two indicator dairies and from at least one control dairy. Milk samples are placed on ice for transport to the radioanalytical laboratory. A radiochemical separation analysis for I-131 and gamma spectroscopy are performed on each sample and a Sr-89 and Sr-90 analysis is performed quarterly.

The monitoring program includes a provision for sampling of vegetation from locations where milk is being produced and when milk sampling cannot be conducted. There were no periods during this year when vegetation sampling was necessary.

Soil samples are collected annually from the air monitoring locations. The samples are collected with either a "cookie cutter" or an auger type sampler. After drying and grinding, the sample is analyzed by gamma spectroscopy and for Sr-89 and Sr-90.

Samples representative of food crops raised in the area near the plant are obtained from individual gardens. Types of foods may vary from year to year due to changes in the local vegetable gardens. Samples of cabbage, corn, green beans, and tomatoes were collected from local vegetable gardens and/or farms. Samples of the same food products grown in areas that would not be affected by the plant were obtained from area produce markets as control samples. The edible portion of each sample is analyzed by gamma spectroscopy.

Results

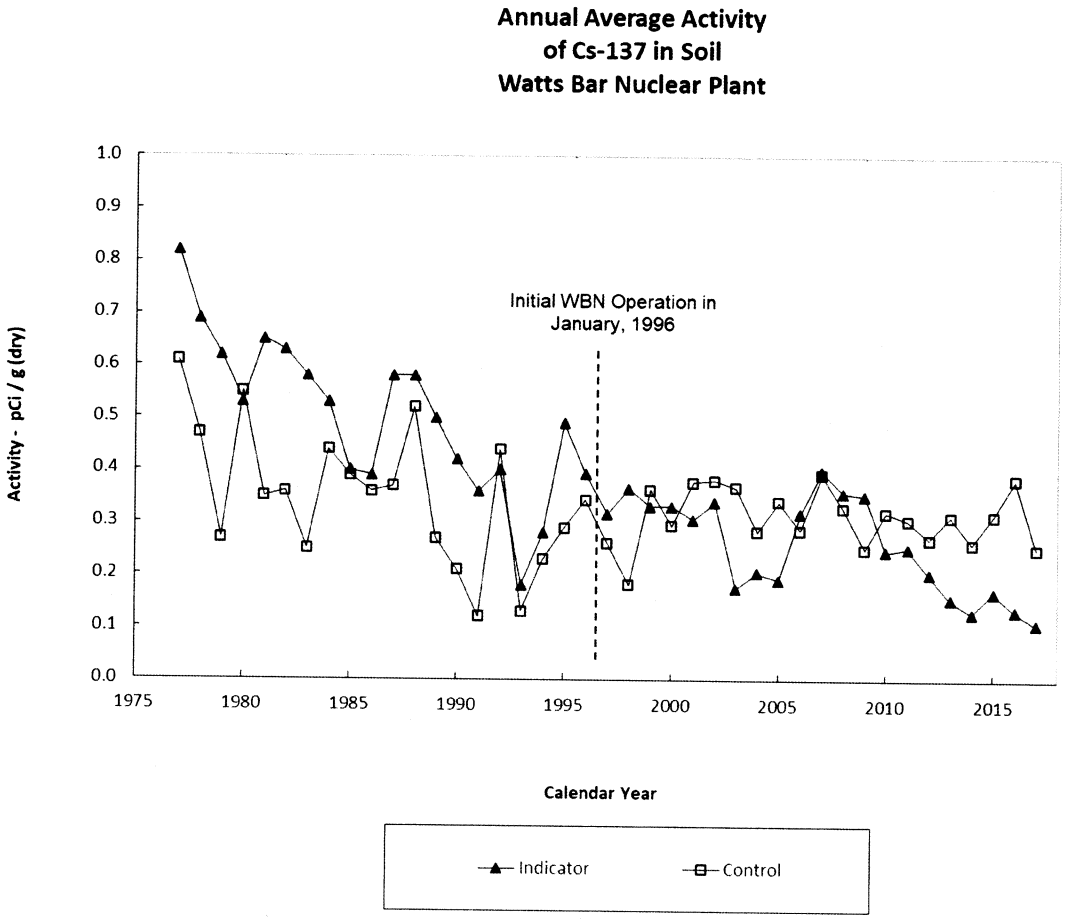
The results from the analysis of milk samples are presented in Table 18. No radioactivity attributable to WBN Plant operations was identified. All I-131 values were below the established nominal LLD of 1.0 pCi/liter. The gamma isotopic analysis detected only naturally occurring radionuclides. Milk samples are

analyzed quarterly for Sr-89 and Sr-90. No analyses identified any positive results for Sr-89 or Sr-90. However, the third quarter sample from one indicator location (Norton Farm) was not completed. The third quarter control location was analyzed for Sr-89, but the nominal LLD was not achieved.

Consistent with most of the environment, Cs-137 was detected in most of the soil samples collected in 2017. The maximum concentration of Cs-137 was 255 pCi/kg, but this was identified at a control location. The concentrations were consistent with levels previously reported from fallout. All other radionuclides reported were naturally occurring isotopes. The results of the analysis of soil samples are summarized in Table 19.

A plot of the annual average Cs-137 concentrations in soil is presented in Figure 4. Concentrations of Cs-137 in soil are steadily decreasing as a result of the cessation of weapons testing in the atmosphere, the 30-year half-life of Cs-137, and transport through the environment.

Figure 4



The radionuclides measured in food samples were naturally occurring. The results are reported in Table 20.

LIQUID PATHWAY MONITORING

Potential exposures from the liquid pathway can occur from drinking water, ingestion of fish, or from direct radiation exposure from radioactive materials deposited in the shoreline sediment. The aquatic monitoring program includes the collection of samples of river (surface) water, ground water, drinking water supplies, fish, and shoreline sediment. Indicator samples were collected downstream of the plant and control samples collected within the reservoir upstream of the plant or in the next upstream reservoir (Watts Bar Lake).

Sample Collection and Analysis

Samples of surface water are collected from the Tennessee River using automatic sampling systems from two downstream stations and one upstream station. A timer turns on the system at least once every two hours. The line is flushed and a sample is collected into a composite container. A one-gallon sample is removed from the container at 4-week intervals and the remaining water is discarded. Each sample is analyzed for gamma-emitting radionuclides and tritium.

Samples are also collected by an automatic sampling system at the first two downstream drinking water intakes. These samples are collected in the same manner as the surface water samples. These monthly samples are analyzed for gamma-emitting radionuclides, gross beta activity, and tritium. The samples collected by the automatic sampling device are taken directly from the river at the intake structure. Since these samples are untreated water collected at plant intake, the upstream surface water sample is used as a control sample for drinking water.

Ground water is sampled from one onsite well down gradient from the plant, one onsite well up gradient from the plant, and four additional onsite ground water monitoring wells located along underground discharge lines. The onsite wells are sampled with a continuous sampling system. A composite sample is collected from the onsite wells every four weeks and analyzed for gamma-emitting radionuclides, gross beta activity, and tritium content.

Samples of commercial and game fish species are collected semiannually from each of two reservoirs: the reservoir on which the plant is located (Chickamauga Reservoir) and the upstream reservoir (Watts Bar Reservoir). The samples are collected using a combination of netting techniques and electrofishing. The ODCM specifies analysis of the edible portion of the fish. To comply with this requirement, filleted portions are taken from several fish of each species. The samples are analyzed by gamma spectroscopy.

Samples of shoreline sediment are collected from recreation areas near the plant. The samples are dried, ground, and analyzed by gamma spectroscopy.

Results

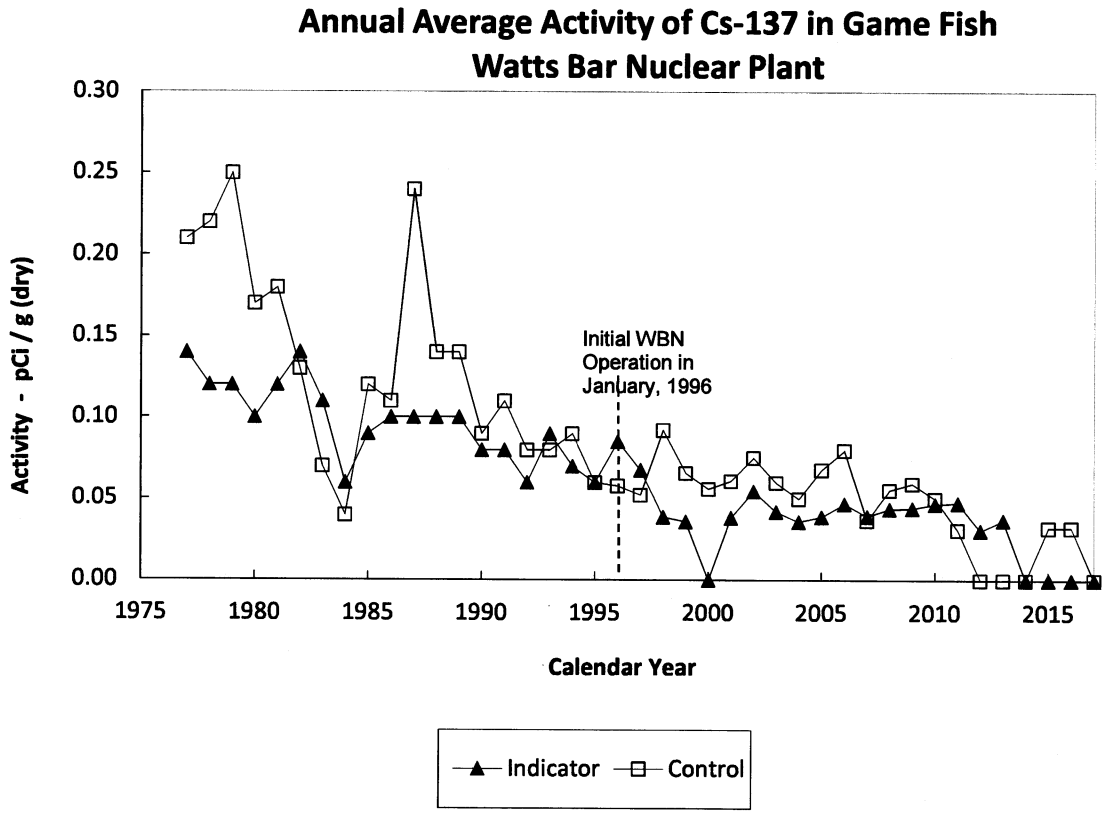
The gamma isotopic analysis of all surface water samples identified only naturally occurring radionuclides. Low levels of tritium were detected in some surface water samples. The highest tritium concentration was 846 pCi/liter at a control location. This tritium concentration is considered background and represent only a small fraction of the Environmental Protection Agency (EPA) drinking water limit of 20,000 pCi/liter. A summary table of the results for surface water samples is shown in Table 21.

No fission or activation products were identified by the gamma analysis of drinking water samples from the two downstream monitoring locations. Average gross beta activity at downstream (indicator) stations was 2.98 pCi/liter and the average for the upstream (control) station was 3.08 pCi/liter. Low levels of tritium were detected in one third of the samples collected from the two downstream public water sampling locations. The highest tritium concentration was 1,031 pCi/liter. The tritium levels were significantly below the EPA drinking water limit of 20,000 pCi/liter. The results are shown in Table 22.

The gamma isotopic analysis of ground water samples identified only naturally occurring radionuclides. Gross beta concentrations in samples from the onsite indicator locations averaged 2.2 pCi/liter. No samples from control locations identified any positive results for gross beta activity. Tritium was detected in samples from the onsite monitoring wells located near plant discharge lines. The tritium in onsite ground water was the result of previously identified leaks from plant systems. Repairs were made to resolve the leaks but the plume of contaminated ground water continues to move slowly across the site toward the river. The highest tritium concentration in samples from these monitoring locations was 498 pCi/liter. There was no tritium detected in the onsite up gradient well. The results are presented in Table 23.

Cs-137 was identified in three fish samples, two indicator and one control. The Cs-137 concentration averaged 0.021 pCi/kg measured in game fish collected at indicator locations and 0.018 pCi/kg at the control location. Other radioisotopes found in fish were naturally occurring. The results are summarized in Table 24. Trend plots of the annual average Cs-137 concentrations measured in fish samples are presented in Figure 5. The Cs-137 activities are consistent with preoperational results produced by fallout or effluents from other nuclear facilities.

Figure 5



In past years, Cs-137 activities consistent with the concentrations present in the environment as the result of past nuclear weapons testing or other nuclear operations in the area was measured in shoreline sediment samples. In 2017, no plant related nuclides were identified in shoreline sediment samples.

Consistent with previous monitoring conducted for the onsite ponds, Cs-137 was detected in the sediment samples. The average of the Cs-137 levels measured in sediment from the onsite ponds was 133 pCi/kg. This radioactivity was present in relatively low concentrations and confined to the ponds located in the owner-controlled area not open to the general public so the presence of this radioactivity does not represent an increased risk of exposure to the general public.

ASSESSMENT AND EVALUATION

Potential doses to the public are estimated from measured effluents using computer models. These models were developed by TVA and are based on guidance provided by the NRC in Regulatory Guide 1.109 for determining the potential dose to individuals and populations living near the plant. The results of the effluent dose calculations are reported in the Annual Radiological Effluent Release Report. The doses calculated are a representation of the dose to a "maximum exposed individual." Some of the factors used in these calculations (such as ingestion rates) are maximum expected values which will tend to overestimate the dose to the "hypothetical" person. The calculated maximum dose due to plant effluents are small fractions of the applicable regulatory limits. In reality, the expected dose to actual individuals is significantly lower.

Based on the very low concentrations of radionuclides present in plant effluent and radioactivity levels measured in the environment, doses as a result of plant operations are negligible. The results for the radiological environmental monitoring conducted for WBN in 2017 operations confirm this expectation.

Results

As stated earlier in this report, the estimated increase in radiation dose equivalent to the general public resulting from the operation of WBN is insignificant when compared to the dose from natural background radiation. The results from each environmental sample are compared with the concentrations from the corresponding control stations and appropriate preoperational and background data to determine influences from the plant. During this report period, Cs-137 was detected in soil, on-site pond sediment and fish collected for the WBN program. The Cs-137 concentrations were consistent with levels measured during the preoperational monitoring program. The levels of tritium measured in water samples from Chickamauga Reservoir represented concentrations that were a small fraction of the EPA drinking water limit.

The levels of tritium detected in the onsite ground water monitoring wells and the radionuclides measured in samples of sediment from the onsite ponds do not represent an increased risk of exposure to the public. These radionuclides were limited to the owner-controlled area and would not present an exposure pathway for the general public.

Conclusions

It is concluded from the above analysis of environmental samples and from the trend plots presented, that exposure to members of the general public which may have been attributable to WBN is negligible. The radioactivity reported herein is primarily the result of fallout or natural background. Any activity which may be present in the environment as a result of plant operations does not represent a significant contribution to the exposure of members of the public.

REFERENCES

1. NCRP. (March 2009). *Report No. 160, Ionizing Radiation Exposure of the Population of the United States.* NCRP, Washington, D.C.

2. USNRC. (February 1996). *Instruction Concerning Risks from Occupational Exposure.* USNRC, Washington, D.C.

APPENDIX A RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM AND SAMPLING LOCATIONS

Table 3 - Watts Bar Nuclear Power Plant Radiological Environmental Monitoring Program

Exposure Pathway and/or Sample[a]	Number of Samples and Locations[b]	Sampling and Collection Frequency	Type and Frequency of Analysis
1. AIRBORNE			
a. Particulates	4 samples from locations (in different sectors) at or near the site boundary (LM-1, 2, 3 and 4) 4 samples from communities approximately 6-10 miles from plant (PM-2, 3, 4 and 5) 2 samples from control locations > 10 miles from the plant (RM-2 and 3)	Continuous sampler operation with sample collection weekly (more frequently if required by dust loading)	Analyze for gross beta radioactivity ≥ 24 hours following filter change. Perform gamma isotopic analysis on each sample if gross beta > 10 times yearly mean of control sample. Composite at least once per 31 days (by location) for gamma spectroscopy.
b. Radioiodine	Samples from same locations as air particulates	Continuous sample operation with filter collection weekly.	I-131 at least once per 7 days. Analysis is performed by gamma spectroscopy.
c. Atmospheric Moisture	4 samples from locations (in different sectors) at or near the site boundary (LM-1, 2, 3, and 4) 2 samples from communities approximately 4-10 miles distance from the plant (PM-2, 5). 2 samples from control location greater than 10 miles from the plant (RM-2 and RM-3).	Continuous sampler operation with sample collection biweekly.	Analyze each sample for tritium.
d. Soil	Samples from same location as air particulates	Annually	Gamma spectroscopy, Sr-89, Sr-90 annually

Exposure Pathway and/or Sample[a]	Number of Samples and Locations[b]	Sampling and Collection Frequency	Type and Frequency of Analysis
2. DIRECT			
a. Dosimeters	2 or more dosimeters placed at or near the site boundary in each of the 16 sectors. 2 or more dosimeters placed at stations located approximately 5 miles from the plant in each of the 16 sectors. 2 or more dosimeters in at least 8 additional locations of special interest, including at least 2 control stations.	Quarterly (once per 92 days)	Gamma dose quarterly (at least once per 92 days)
3. WATERBORNE			
a. Surface Water	2 samples downstream from plant discharge (TRM 517.9 and TRM 523.1). 1 sample at a control location upstream from the plant discharge (TRM 529.3).	Collected by automatic sequential-type sampler[c] with composite samples collected over a period of approximately 31 days.	Gross beta, gamma spectroscopy, and tritium analysis of each sample.
b. Ground water	Five sampling locations from ground water monitoring wells adjacent to the plant (Wells No. 1, A, B, C, and F). 1 sample from ground water source up gradient (Well No. 5).	Collected by automatic sequential-type sampler[c] with composite samples collected over a period of approximately 31 days.	Gross beta, gamma spectroscopy, and tritium analysis of each sample.
c. Drinking Water	1 sample at the first two potable surface water supplies, downstream from the plant (TRM 503.8 and TRM 473.0). 1 sample at a control location (TRM 529.3)[d]	Collected by automatic sequential-type sampler[c] with composite sample collected monthly.	Gross beta, gamma scan, and tritium analysis of each sample.

Exposure Pathway and/or Sample[a]	Number of Samples and Locations[b]	Sampling and Collection Frequency	Type and Frequency of Analysis
~~d. Shoreline~~ Sediment	1 sample downstream from plant discharge (TRM 513.0) 1 sample from a control location upstream from plant discharge (TRM 530.2)	Semi-Annually (at least once per 184 days)	Gamma spectroscopy of each sample
e. Pond Sediment	1 sample from at least three locations in the Yard Holding Pond	Annually	Gamma spectroscopy of each sample
4. INGESTION			
a. Milk	1 sample from milk producing animals in each of 1-3 areas indicated by the cow census where doses are calculated to be highest. 1 or more samples from control locations	Every 2 weeks	I-131 and gamma spectroscopy on each sample. Sr-89 and Sr-90 quarterly.
b. Fish	One sample of commercially important species and one sample of recreationally important species. One sample of each species from Chickamauga and Watts Bar Reservoirs.	Semi-Annually (at least once per 184 days)	Gamma spectroscopy on edible portions
c. Vegetation[e] (Pasturage and grass)	Samples from farms producing milk but not providing a milk sample	Monthly (at least once per 31 days)	I-131 analysis and gamma spectroscopy of each sample

Exposure Pathway and/or Sample[a]	Number of Samples and Locations[b]	Sampling and Collection Frequency	Type and Frequency of Analysis
d. Food Products	1 sample each of principal food products grown at private gardens and/or farms in the vicinity of the plant. A control sample from similar food products grown 15 to 30 km distant in the least prevalent wind direction.	At least once per 365 days at the time of harvest. The types of foods will vary. Following is a list of typical foods which may be available: • Cabbage and/or lettuce • Corn • Green Beans • Potatoes • Tomatoes	Gamma scan on edible portions

[a] The sampling program outlined in this table is that which was in effect at the end of 2017.
[b] Sample locations are shown on Figure 6 through Figure 8.
[c] Samples shall be collected by collecting an aliquot at intervals not exceeding 2 hours
[d] The samples collected at TRMs 503.8 and 473.0 are taken from the raw water supply, therefore, the upstream surface water sample will be considered the control sample for drinking water.
[e] Vegetation sampling is applicable only for farms that meet the criteria for milk sampling and when milk sampling cannot be performed

Table 4 - Watts Bar Nuclear Power Plant REMP Sampling Locations

Map Location Number[a]	Station	Sector	Distance (miles)	Indicator (I) or Control (C)	Samples Collected[b]
2	PM-2	NW	7.0	I	AP, CF, S, AM
3	PM-3	NNE	10.4	I	AP, CF, S
4	PM-4	NE/ENE[c]	7.6	I	AP, CF, S
5	PM-5	S	8.0	I	AP, CF, S, AM
6	RM-2	SW	15.0	C	AP, CF, S, AM
7	RM-3	NNW	15.0	C	AP, CF, S, AM
8	LM-1	SSW	0.5	I	AP, CF, S, AM
9	LM-2	NNE	0.4	I	AP, CF, S, AM
10	LM-3	NNE	1.9	I	AP, CF, S, AM
11	LM-4	SE	0.9	I	AP, CF, S, AM
18	Well #1	S	0.6	I	W
20	Farm N	ESE	4.1	I	M
23	Well #5	N	0.5	I	W
25	TRM 517.9	--	9.9[d]	I	SW
26	TRM 523.1	--	4.7[d]	I	SW
27	TRM 529.3	--	1.5[d]	C	SW, PW[e]
31	TRM 473.0 (C. F. Industries)	--	54.8[d]	I	PW
32	TRM 513.0	--	14.8[d]	I	SS
33	TRM 530.2	--	2.4[d]	C	SS
35	TRM 503.8 (Dayton)	--	24.0[d]	I	PW
37	TRM 522.8-527.8 (downstream of WBN)	--	--	I	F
38	TRM 471-530 (Chickamauga Lake)	--	--	I	F
39	TRM 530-602 (Watts Bar Reservoir)	--	--	C	F
81	Yard Pond	SSE/S/SSW	Onsite	I	PS
82	Well A	SSE	0.6	I	W
83	Well B	SSE	0.5	I	W
84	Well C	ESE	0.3	I	W
85	Well F	SE	0.3	I	W
86	Farm HH	SSW	1.75	I	M
87	Farm BB	SW	18.6	C	M

[a] See Figure 6 through Figure 8

[b] Sample Codes:

AM = Atmospheric moisture
AP = Air particulate filter
F = Fish
M = Milk
PW = Public water
PS = Pond sediment
S = Soil
SS = Shoreline sediment
SW = Surface water
W = Well water

[c] Station located on the boundary between these two sectors.

[d] Distance from the plant discharge at Tennessee River Mile (TRM) 527.8

[e] The surface water sample is also used as a control for public water.

Table 5 - Watts Bar Nuclear Power Plant Environmental Dosimeter Locations

Map Location Number[a]	Station	Sector	Distance (miles)	Onsite or Offsite[b]
2	NW-3	NW	7.0	Off
3	NNE-3	NNE	10.4	Off
4	ENE-3	NE/ENE	7.6	Off
5	S-3	S	7.8	Off
6	SW-3	SW	15.0	Off
7	NNW-4	NNW	15.0	Off
10	NNE-1A	NNE	1.9	On
11	SE-1A	SE	0.9	On
12	SSW-2	SSW	1.3	On
14	W-2	W	4.8	Off
40	N-1	N	1.2	On
41	N-2	N	4.7	Off
42	NNE-1	NNE	1.2	On
43	NNE-2	NNE	4.1	Off
44	NE-1	NE	0.9	On
45	NE-2	NE	2.9	Off
46	NE-3	NE	6.1	Off
47	ENE-1	ENE	0.7	On
48	ENE-2	ENE	5.8	Off
49	E-1	E	1.3	On
50	E-2	E	5.0	Off
51	ESE-1	ESE	1.2	On
52	ESE-2	ESE	4.4	Off
54	SE-2	SE	5.3	Off
55	SSE-1A	SSE	0.6	On
56	SSE-2	SSE	5.8	Off
57	S-1	S	0.7	On
58	S-2	S	4.8	Off
59	SSW-1	SSW	0.8	On
60	SSW-3	SSW	5.0	Off
62	SW-1	SW	0.8	On
63	SW-2	SW	5.3	Off
64	WSW-1	WSW	0.9	On
65	WSW-2	WSW	3.9	Off
66	W-1	W	0.9	On
67	WNW-1	WNW	0.9	On
68	WNW-2	WNW	4.9	Off
69	NW-1	NW	1.1	On
70	NW-2	NW	4.7	Off
71	NNW-1	NNW	1.0	On
72	NNW-2	NNW	4.5	Off
73	NNW-3	NNW	7.0	Off
74	ENE-2A	ENE	3.5	Off
75	SE-2A	SE	3.1	Off
76	S-2A	S	2.0	Off
77	W-2A	W	3.2	Off
78	NW-2A	NW	3.0	Off
79	SSE-1	SE	0.5	On

[a] See Figure 6 through Figure 8

[b] Dosimeters designated "onsite" are located 2 miles or less from the plant; "offsite" are located more than 2 miles from the plant

Figure 6 - Radiological Environmental Sampling Locations Within 1 Mile of the Plant

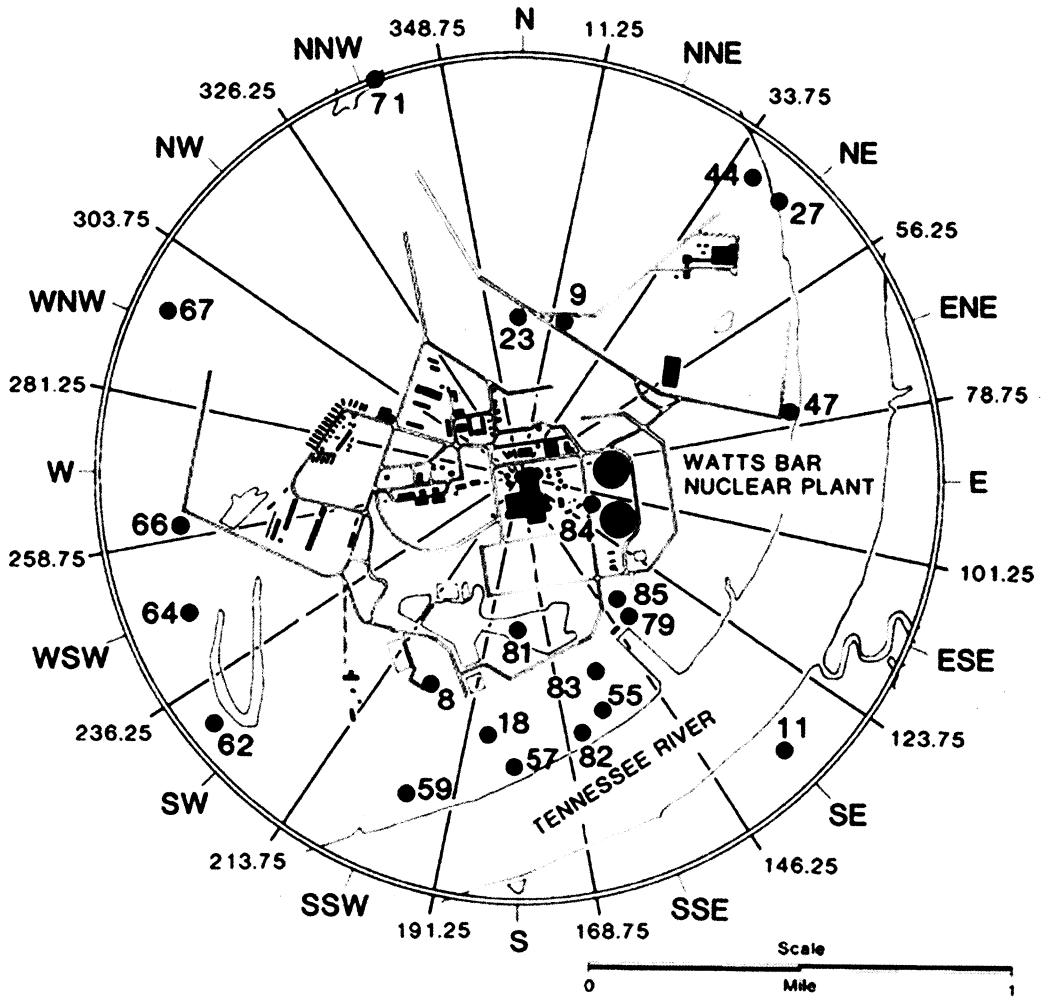


Figure 7 - Radiological Environmental Sampling Locations from 1 to 5 Miles from the Plant

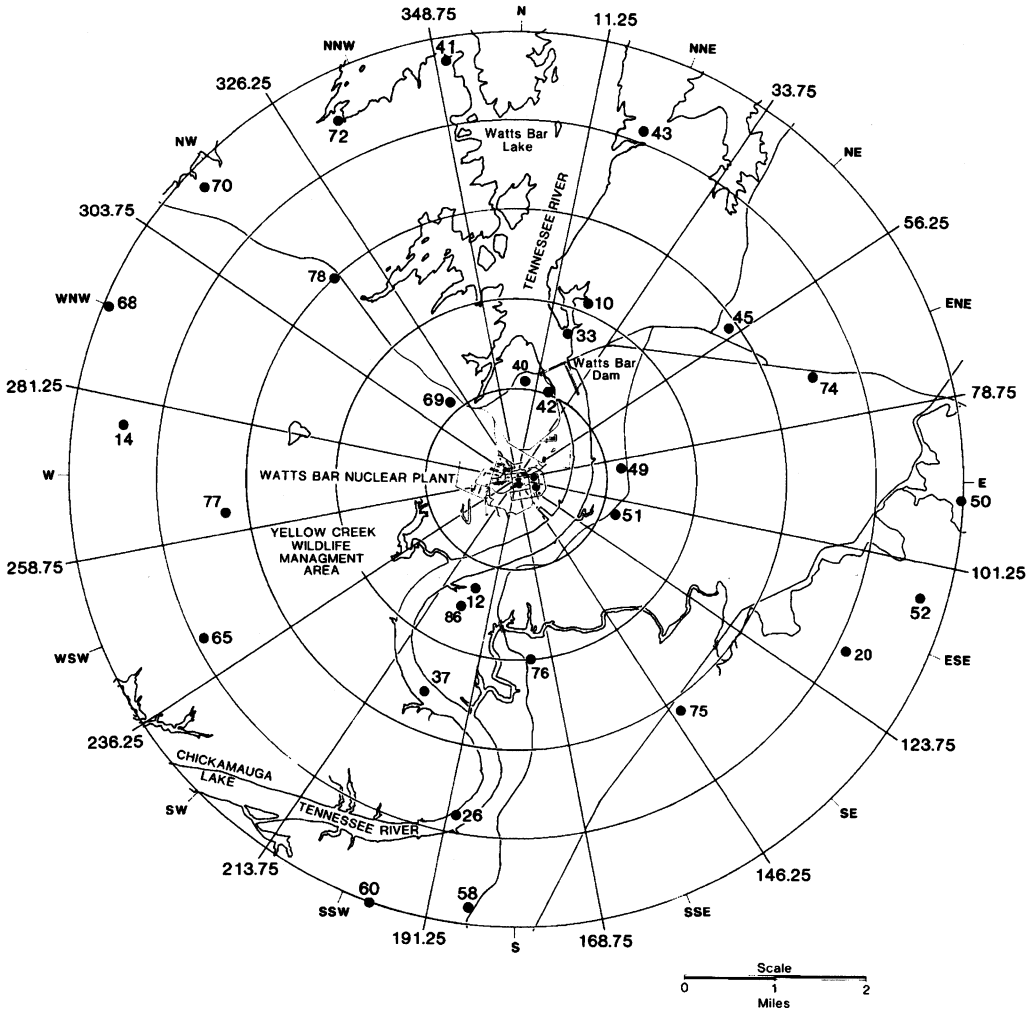
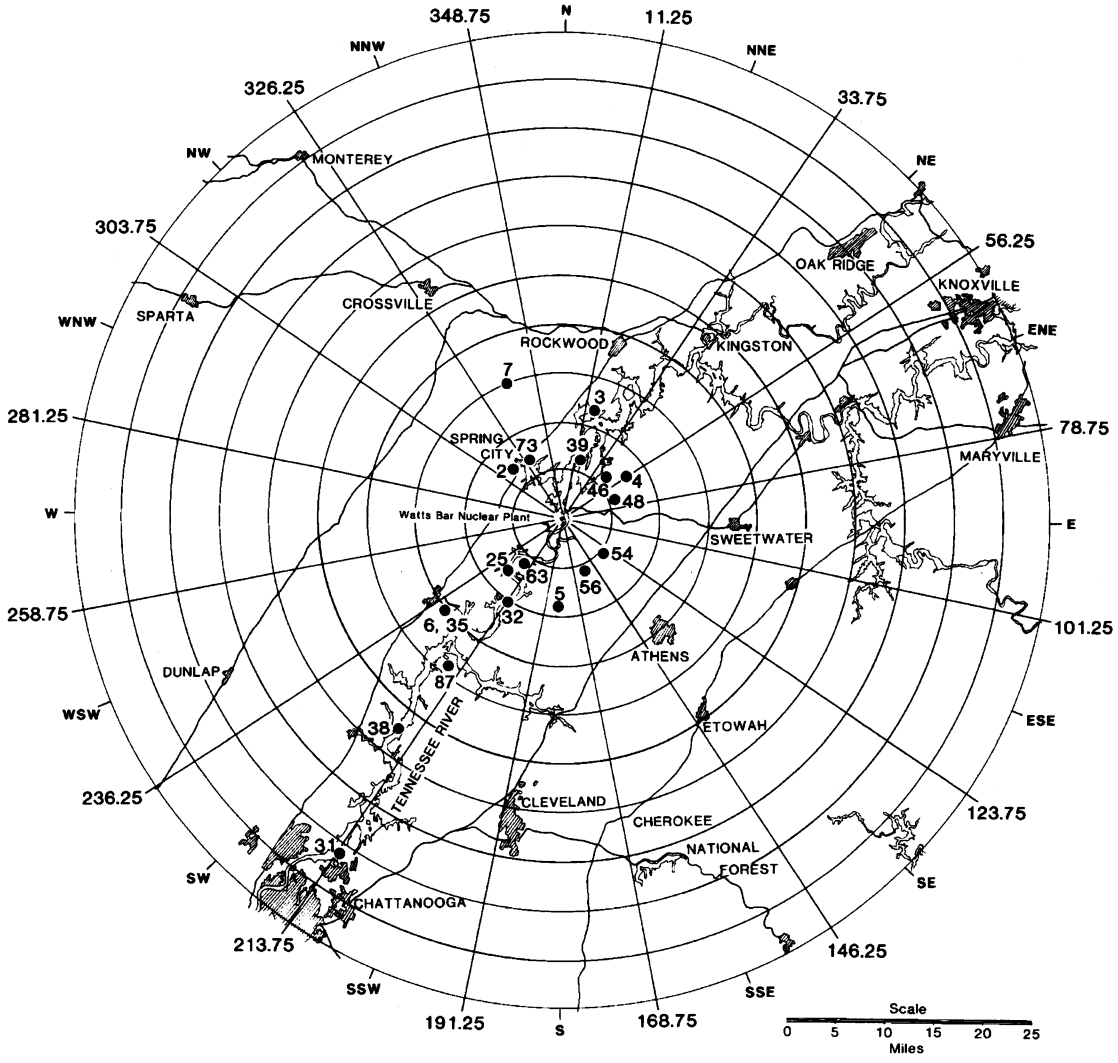


Figure 8 - Radiological Environmental Sampling Locations Greater Than 5 Miles from the Plant



APPENDIX B PROGRAM MODIFICATIONS

Radiological Environmental Monitoring Program Modifications

In June 2017, a GEL Laboratories LLC began performing all radioanalytical services in support of the Watts Bar REMP, replacing TVA's Western Areal Radiological Laboratory (WARL) based in Muscle Shoals, AL.

In 2017, there were no modification to the Radiological Environmental Monitoring Program sampling locations, analysis types or frequency.

APPENDIX C PROGRAM DEVIATIONS

Media	Location	Date	CR	Issue
Direct Radiation	Station #7	4/18/2017	1285419	While performing 0-ODI-999-02 Quarterly Direct Radiation TLD Collection, the TLDs at Deploy #7 Station WB-NNW-2 could not be located. This area had recently been disturbed by Volunteer Electric while installing a new power pole. A search of the area was performed and nothing was found. New TLDs were placed in the field.
Air Filter and Charcoal Cartridge	PM-2 3106	6/11/2017	1308950	REMP air monitoring station in 3106 PM-2, Spring City is a missed particulate/charcoal filter sample for week 24. Volume thru unit was 119.1 which is less than the required volume of 250 cubic meters. Technician noted pump flow will not maintain proper flow and unit was replaced with upgraded unit with carbon vane pump. Unit is now operating properly and maintaining flow. Known issue with units in field and are currently being replaced with new units. around 6/11/17 to 6/19/17.
	PM-3 3107	1/25/2017	1254182	While performing 0-ODI-999-05 REMP, I found the station 3107 PM-3 Cedine Bible Camp air sampler had failed. This is a missed sample. Please refer to CR1252263 (not a missed sample) for the same sampler issue from the previous week. Troubleshooting has found that when there is a power failure, the sampler does not restart as it is designed to do. Sampler will be repaired or a spare sampler will be installed in its place, when available.
	PM-3 3107	2/28/2017	1267054	While performing 0-ODI-999-05 REMP, I found the air sampler at station **3107 Cedine Bible Camp** had failed to obtain the minimum required sample volume. This is a missed sample. The sample motor runs at a slow speed and at times will accelerate only to drop back to slow. The software shows no sample being obtained. A volume of 101.9 m3 was obtained before failure and a minimum of 250 m3 is required.

Media	Location	Date	CR	Issue
	PM-3 3107	8/10/2017	1337785	WBN is in processing of swapping out faulty pumps in the REMP air monitoring stations. The pump failures of two units resulted in missed samples. Vendor has provided motor swaps which were being performed every two weeks for swapping. These were one of the last few to get replaced.
	PM-5 3109	1/19/2017	1252259	While performing 0-ODI-999-05 REMP, I found that the air sampler at station 3109 PM-5, Decatur was not operating correctly. Even though the motor was running no sample was being obtained. I could not find the source of the problem. The sampler was removed from the field and a spare put in its place. It will be sent to F&J for repair.This is a missed sample
	PM-5 3109	3/27/2017	1277588	While performing 0-ODI-999-05 REMP, the air sampler at station 3109 PM-5 Decatur TN had failed to obtain the minimum sample required. A minimum of 250 m3 needs to be sampled, the sampler was running but had drawn only 83.9 m3. This is a missed sample. Filters were changed and sent to WARL.
	PM-5 3109	6/19/2017 6/26/2017	1308965	REMP air monitoring station in **3109 PM-5, Decatur** is a missed particulate/charcoal filter sample. No volume obtained thru unit. Unit was powered on but motor was not operating. Unit was removed and shipped **6/19/17** for replacement with upgraded unit with carbon vane pump. Known issue with units in field and are currently being replaced with new units.
	LM-4 3204	8/15/2017	1337785	WBN is in processing of swapping out faulty pumps in the REMP air monitoring stations. The pump failures of two units resulted in missed samples. Vendor has provided motor swaps which were being performed every two weeks for swapping. These were one of the last few to get replaced.
Atmospheric Moisture	3106	12/19/2017		Missed sample due to not enough moisture from the samples to analyze.
	3205	10/24/2017		Missed sample due to not enough moisture from the samples to analyze.

Media	Location	Date	CR	Issue
Milk	3119	Q3		Missing Sr-89 and Sr-90 analysis. Not performed by laboratory.
	3119	7/17/2017		Missing milk sample. No analysis performed by laboratory
	3321	6/7/2017		Missing milk sample. No analysis performed by laboratory.
	3321	8/29/2017 and 12/19/2017		Sr-89 analysis was performed, but analysis resulted in an MDC above the nominal LLD of 3.5 pCi/L. Analysis did not result in any positive indication of Sr-89.
Well (Ground) Water	3121 Well #1	9/5/2017		Water bottle received by GEL was broken and empty. No gamma scan, gross beta or Tritium result.
Surface Water	3134	8/15/2017		Water bottle received by GEL was broken and empty. No gamma scan or Tritium result.

APPENDIX D ANALYTICAL PROCEDURES

Analytical Procedures

Analyses of environmental samples are performed by GEL Laboratories, LLC in Charleston, SC. Analysis procedures are based on accepted methods. A summary of the analysis techniques and methodology follows.

The gross beta measurements are made with an automatic low background counting system. Normal counting times are 50 minutes. Water samples are prepared by evaporating 400 milliliter (mL) of samples to near dryness, transferring to a stainless steel planchet, and completing the evaporation process. Air particulate filters are counted directly in a shallow planchet.

The specific analysis of I-131 in milk is performed by first isolating and purifying the iodine by radiochemical separation and then counting the final precipitate on a beta-gamma coincidence counting system. The normal count time is 480 minutes. When the I-131 counted in a gamma spectroscopy utilizing high resolution Hp-Ge detectors.

After a radiochemical separation, milk samples analyzed for Sr-89, 90 are counted on a low background beta counting system. The sample is counted a second time after a minimum ingrowth period of six days. From the two counts, the Sr-89 and Sr-90 concentrations can be determined.

Water samples are analyzed for tritium content by first distilling a portion of the sample and then counting by liquid scintillation. A commercially available scintillation cocktail is used.

Gamma analyses are performed in various counting geometries depending on the sample type and volume. All gamma counts are obtained with germanium type detectors interfaced with a high resolution gamma spectroscopy system.

The charcoal cartridges used to sample gaseous radioiodine are analyzed by gamma spectroscopy using a high resolution gamma spectroscopy system with germanium detectors.

Atmospheric moisture samples are collected on silica gel from a metered air flow. The moisture is released from the silica gel by heating and a portion of the distillate is counted by liquid scintillation for tritium using commercially available scintillation cocktail.

The necessary efficiency values, weight-efficiency curves, and geometry tables are established and maintained on each detector and counting system. A series of daily and periodic quality control checks are performed to monitor counting instrumentation. System logbooks and control charts are used to document the results of the quality control checks.

APPENDIX E LOWER LIMITS OF DETECTION

Lower Limits of Detection

A number of factors influence the Lower Limit of Detection (LLD) for a specific analysis method, including sample size, count time, counting efficiency, chemical processes, radioactive decay factors, and interfering isotopes encountered in the sample. The most probable values for these factors have been evaluated for the various analyses performed in the environmental monitoring program. The nominal LLDs are calculated from these values, in accordance with the methodology prescribed in the ODCM. The current nominal LLD values achieved by the radioanalytical lab are listed in Table 7 and Table 8. For comparison, the maximum values for the lower limits of detection specified in the ODCM are given in Table 9.

Table 6 - Comparison of Program Lower Limits of Detection with the Regulatory Limits for Maximum Annual Average Effluent Concentration Released to Unrestricted Areas and Reporting Levels

	Concentrations in Water (pCi[a]/Liter)			Concentrations in Air (pCi/m^3)		
Analysis	Effluent Concentration[b]	Reporting Level[c] [d]	Lower Limit of Detection[e]	Effluent Concentration	Reporting Level	Lower Limit of Detection
H-3	1,000,000	20,000	270	100,000	--	--
Cr-51	500,000	--	45	30,000	--	0.02
Mn-54	30,000	1000	5	1,000	--	0.005
Fe-59	10,000	400	10	500	--	0.005
Co-58	20,000	1000	5	1,000	--	0.005
Co-60	3,000	300	5	50	--	0.005
Zn-65	5,000	300	10	400	--	0.005
Sr-89	8,000	--	--	1,000	--	--
Sr-90	500	--	--	6	--	--
Nb-95	30,000	400	5	2,000	--	0.0005
Zr-95	20,000	400	10	400	--	0.005
Ru-103	30,000	--	5	900	--	0.005
Ru-106	3,000	--	40	20	--	0.02
I-131	1,000	2	0.4	200	0.9	0.03
Cs-134	900	30	5	200	10	0.005
Cs-137	1,000	50	5	200	20	0.005
Ce-144	3,000	--	30	40	--	0.01
Ba-140	8,000	200	25	2,000	--	0.015
La-140	9,000	200	10	2,000	--	0.01

[a] 1 pCi = 3.7 x10^{-2} Bq

[b] Source: Table 2 of Appendix B to 10 CFR 20.1001-20.2401

[c] For those reporting levels and lower limits of detection that are blank, no value is given in the reference

[d] Source: WBN Offsite Dose Calculation Manual, Table 2.3-2

[e] Source: Table 7 and Table 8 of this report

Table 7 – Nominal LLD Values - Radiochemical

Analysis	Airborne Particulate or Gases (pCi/m^3)	Water (pCi/L)	Milk (pCi/L)	Wet Vegetation (pCi/kg, wet)	Sediment and Soil (pCi/kg, dry)
Gross beta	0.002	1.9	--	--	--
H-3	3.0	270	--	--	--
I-131	--	0.4	0.4	6.0	--
Sr-89	--	--	3.5	--	1.6
Sr-90	--	--	2.0	--	0.4

Table 8 – Nominal LLD Values – Gamma Analysis

Analysis	Airborne Particulate (pCi/m^3)	Charcoal Filter (pCi/m^3)	Water and Milk (pCi/L)	Wet Vegetation (pCi/kg, wet)	Sediment and Soil (pCi/kg, dry)	Fish (pCi/kg, wet)	Food Products (pCi/kg, wet)
Ce-141	0.005	0.02	10	35	0.10	0.07	20
Ce-144	0.01	0.07	30	115	0.20	0.15	60
Cr-51	0.02	0.15	45	200	0.35	0.30	95
I-131	0.005	0.03	10	60	0.25	0.20	20
Ru-103	0.005	0.02	5	25	0.03	0.03	25
Ru-106	0.02	0.12	40	190	0.20	0.15	90
Cs-134	0.005	0.02	5	30	0.03	0.03	10
Cs-137	0.005	0.02	5	25	0.03	0.03	10
Zr-95	0.005	0.03	10	45	0.05	0.05	45
Nb-95	0.005	0.02	5	30	0.04	0.25	10
Co-58	0.005	0.02	5	20	0.03	0.03	10
Mn-54	0.005	0.02	5	20	0.03	0.03	10
Zn-65	0.005	0.03	10	45	0.05	0.05	45
Co-60	0.005	0.02	5	20	0.03	0.03	10
K-40	0.04	0.30	100	400	0.75	0.40	250
Ba-140	0.015	0.07	25	130	0.30	0.30	50
La-140	0.01	0.04	10	50	0.20	0.20	25
Fe-59	0.005	0.04	10	40	0.05	0.08	25
Be-7	0.02	0.15	45	200	0.25	0.25	90
Pb-212	0.005	0.03	15	40	0.10	0.04	40
Pb-214	0.005	0.07	20	80	0.15	0.10	80
Bi-214	0.005	0.05	20	55	0.15	0.10	40
Bi-212	0.02	0.20	50	250	0.45	0.25	130
Tl-208	0.002	0.02	10	30	0.06	0.03	30
Ra-224	--	--	--	--	0.75	--	--
Ra-226	--	--	--	--	0.15	--	--

Analysis	Airborne Particulate (pCi/m^3)	Charcoal Filter (pCi/m^3)	Water and Milk (pCi/L)	Wet Vegetation (pCi/kg, wet)	Sediment and Soil (pCi/kg, dry)	Fish (pCi/kg, wet)	Food Products (pCi/kg, wet)
Ac-228	0.01	0.07	20	70	0.25	0.10	50
Pa-234m	--	--	800	--	4.0	--	--

Table 9 - Maximum Values for Lower Limits of Detection (LLD)

Analysis	Water (pCi/L)	Airborne Particulate or Gases (pCi/m^3)	Fish (pCi/kg, wet)	Milk (pCi/L)	Food Products (pCi/kg, wet)	Sediment (pCi/kg, dry)
Gross beta	4	0.01	--	--	--	--
H-3	2000[a]	--	--	--	--	--
Mn-54	15	--	130	--	--	--
Fe-59	30	--	260	--	--	--
Co-58, 60	15	--	130	--	--	--
Zn-65	30	--	260	--	--	--
Zr-95	30	--	--	--	--	--
Nb-95	15	--	--	--	--	--
I-131	1[b]	0.07	--	1	60	--
Cs-134	15	0.05	130	15	60	150
Cs-137	18	0.06	150	18	80	180
Ba-140	60	--	--	60	--	--
La-140	15	--	--	15	--	--

Notes

a. If no drinking water pathway exists, a value of 3000 pCi/L may be used
b. If no drinking water pathway exists, a value of 15 pCi/L may be used.

APPENDIX F QUALITY ASSURANCE / QUALITY CONTROL PROGRAM

Quality Assurance / Quality Control Program

A quality assurance program is employed by the laboratory to ensure that the environmental monitoring data are reliable. This program includes the use of written, approved procedures in performing the work, provisions for staff training and certification, internal self-assessments of program performance, audits by various external organizations, and a laboratory quality control program

The quality control program employed by the radioanalytical laboratory is designed to ensure that the sampling and analysis process is working as intended. The program includes equipment checks and the analysis of quality control samples, along with routine field samples. Instrument quality control checks include background count rate and counts reproducibility. In addition to these two general checks, other quality control checks are performed on the variety of detectors used in the laboratory. The exact nature of these checks depends on the type of device and the method it uses to detect radiation or store the information obtained.

Quality control samples of a variety of types are used by the laboratory to verify the performance of different portions of the analytical process. These quality control samples include blanks, field duplicates, process duplicates, matrix spikes, laboratory control samples, and independent cross-checks.

Blanks are samples which contain no measurable radioactivity or no activity of the type being measured. Such samples are analyzed to determine whether there is any contamination or cross-contamination of equipment, reagents, processed samples, or interferences from isotopes other than the ones being measured.

Duplicate field samples are generated at random by the sample computer program which schedules the collection of the routine samples. For example, if the routine program calls for four milk samples every week, on a random basis each farm might provide an additional sample several times a year. These duplicate samples are analyzed along with other routine samples. They provide information about the variability of radioactive content in the various sample media. If enough sample is available for a particular analysis, the laboratory staff can split the sample taking two individual aliquots, known as process duplicates. Duplicate samples provide information about the variability of the entire sampling and analytical process.

Matrix spikes are field samples that have been spiked with known low levels of specific target isotopes. Recovery of the known amount allow the analyst to determine if any interferences are exhibited from the field sample's matrix.

Laboratory control samples are another type of quality control sample. A known amount of radioactivity is added to a sample medium are processed along with the other QC and field samples in the analytical batch. Laboratory control samples provide the assurance that all aspects of the process have been successfully completed within the criteria established by Standard Operating Procedure.

Another category of quality control samples are cross-checks. The laboratory procures single-blind performance evaluation samples from Eckert & Ziegler Analytics to verify the analysis of sample matrices processed at the laboratory. Samples are received on a quarterly basis. The laboratory's Third-Party Cross-Check Program provides environmental matrices encountered in a typical nuclear utility REMP. Once performance evaluation samples have been prepared in accordance with the instructions provided by the PT provider, samples are managed and analyzed in the same manner as environmental samples.

These samples have a known amount of radioactivity added and are presented to the lab staff labeled as cross-check samples. The laboratory does not know the true value of the amount of known added to the sample. Such samples test the best -performance of the laboratory by determining if the laboratory can find the "right answer." These samples provide information about the accuracy of the measurement process. Further information is available about the variability of the process if multiple analyses are requested on the same sample. Like matrix spikes or laboratory control samples, these samples can also be spiked with low levels of activity to test detection limits. The analysis results for internal cross-check samples met program performance goals for 2017.

The quality control data are routinely collected, examined and reported to laboratory supervisory personnel. They are checked for trends, problem areas, or other indications that a portion of the analytical process needs correction or improvement. The end result is a measurement process that provides reliable and verifiable data and is sensitive enough to measure the presence of radioactivity far below the levels which could be harmful to humans.

APPENDIX G LAND USE SURVEY

Land Use Survey

A land use survey was conducted in accordance with the provisions of ODCM Control 1.3.2 to identify the location of the nearest milk animal, the nearest residence, and the nearest garden of greater than 500 square feet producing fresh leafy vegetables in each of 16 meteorological sectors within a distance of 5 miles (8 km) from the plant.

The land use survey was conducted between April 1, 2017, and October 1, 2017, using appropriate techniques such as door-to-door survey, mail survey, telephone survey, aerial survey, or information from local agricultural authorities or other reliable sources.

There were no changes to the nearest resident or garden in 2017. The survey of milk producing locations performed in 2017 did not identify any new locations. As a result, there are no changes required to the REMP sampling or analysis program.

Table 10 - Projected Annual Air Submersion Dose to the Nearest Residence (mrem/yr)

	2016		2017	
Sector	Distance (meters)	Dose (mrem/yr)	Distance (meters)	Dose (mrem/yr)
N	4474	5.80E-02	4474	5.80E-02
NNE	3750	1.69E-01	3750	1.69E-01
NE	3399	2.14E-01	3399	2.14E-01
ENE	3072	2.27E-01	3072	2.27E-01
E	4388	1.18E-01	4388	1.18E-01
ESE	4654	1.10E-01	4654	1.10E-01
SE	1409	5.47E-01	1409	5.47E-01
SSE	1646	2.63E-01	1646	2.63E-01
S	1550	3.19E-01	1550	3.19E-01
SSW	1832	2.54E-01	1832	2.54E-01
SW	8100	2.07E-02	8100	2.07E-02
WSW	2422	1.45E-01	2422	1.45E-01
W	2901	4.01E-02	2901	4.01E-02
WNW	1448	1.44E-01	1448	1.44E-01
NW	2065	6.09E-02	2065	6.09E-02
NNW	4376	1.87E-02	4376	1.87E-02

Table 11 - Projected Annual Ingestion Dose to Child's Bone from Home-Grown Foods (mrem/yr)

	2016		2017	
Sector	Distance (meters)	Dose (mrem/yr)	Distance (meters)	Dose (mrem/yr)
N	6295	4.31E-01	6295	4.66E-01
NNE	5030	1.77E+00	5030	1.89E+00
NE	3661	2.82E+00	3661	3.09E+00
ENE	3072	3.12E+00	3072	3.48E+00
E	4656	1.49E+00	4656	1.68E+00
ESE	7297	7.58E-01	7297	8.53E-01
SE	1409	7.85E+00	1409	8.58E+00
SSE	1711	4.16E+00	1711	4.46E+00
S	2349	3.60E+00	2349	3.79E+00
SSW	2286	3.89E+00	2286	4.08E+00
SW	8100	3.64E-01	8100	3.95E-01
WSW	3080	1.58E+00	3080	1.72E+00
W	3138	5.38E-01	3138	5.89E-01
WNW	2956	6.17E-01	2956	6.76E-01
NW	2065	9.38E-01	2065	1.02E+00
NNW	4742	2.63E-01	4742	2.88E-01

Table 12 - Relative Projected Annual Dose to Receptor Thyroid from Ingestion of Milk

Cows Location	Sector	Distance (meters)	2016 Dose (mrem/yr)	2017 Dose (mrem/yr)	χ/Q (s/m^3)
Farm N	ESE	6706	7.73E-01	8.36E-01	1.35E-06
Farm HH	SSW	2826	4.13E+00	4.21E+00	1.73E-06

APPENDIX H DATA TABLES AND FIGURES

Table 13 - Individual Dosimeter Stations at Watts Bar Nuclear Plant

Map Loc. No.	Station Number	Dir. (degrees)	Distance (miles)	Q1 2017	Q2 2017	Q3 2017	Q4 2017	Annual Exposure (mrem/yr)
				(mrem/qtr)				
2	NW-3	317	7.0	14.8	17.8	19.5	15.9	67.9
3	NNE-3	17	10.4	9.2	15.0	14.8	12.9	51.8
4	ENE-3	56	7.6	7.4	13.3	15.4	9.1	45.2
5	S-3	185	7.8	10.9	12.9	10.7	8.3	42.8
6	SW-3	225	15.0	9.2	11.8	10.1	10.9	41.9
7	NNW-4	337	15.0	11.9	14.2	14.8	12.4	53.3
10	NNE-1A	22	1.9	12.5	15.6	15.9	14.3	58.4
11	SE-1A	138	0.9	14.6	18.3	20.6	14.8	68.2
12	SSW-2	200	1.3	12.6	17.1	16.8	11.9	58.5
14	W-2	277	4.8	8.7	13.2	15.5	9.6	46.9
40	N-1	10	1.2	15.6	17.8	19.9	15.2	68.5
41	N-2	350	4.7	12.6	19.4	19.5	13.8	65.1
42	NNE-1	21	1.2	12.5	19.3	17.0	15.2	64.0
43	NNE-2	20	4.1	10.4	14.6	17.0	10.5	52.5
44	NE-1	39	0.9	12.0	16.7	15.5	15.7	59.9
45	NE-2	54	2.9	14.2	15.6	16.8	13.8	60.4
46	NE-3	47	6.1	9.9	11.8	14.6	11.5	47.8
47	ENE-1	74	0.7	13.0	17.4	16.2	11.0	57.7
48	ENE-2	69	5.8	11.1	14.5	18.2	11.5	55.2
49	E-1	85	1.3	11.5	16.4	13.2	11.9	53.0
50	E-2	92	5.0	13.6	15.6	18.9	12.9	61.0
51	ESE-1	109	1.2	8.9	13.7	13.9	11.9	48.5
52	ESE-2	106	4.4	14.7	17.9	21.8	17.6	71.9
54	SE-2	128	5.3	10.0	13.3	17.3	13.3	53.9
55	SSE-1A	161	0.6	10.0	14.8	17.7	11.5	53.9
56	SSE-2	156	5.8	13.1	17.5	15.4	14.3	60.3
57	S-1	182	0.7	12.0	16.3	17.7	11.9	57.9
58	S-2	185	4.8	11.6	14.8	15.5	12.4	54.3
59	SSW-1	199	0.8	15.1	21.2	24.2	15.7	76.2
60	SSW-3	199	5.0	9.1	14.1	12.6	9.1	45.0
62	SW-1	226	0.8	12.5	19.3	23.5	16.6	71.9
63	SW-2	220	5.3	16.6	19.8	19.5	17.3	73.1
64	WSW-1	255	0.9	12.0	15.5	15.5	12.9	55.9
65	WSW-2	247	3.9	13.1	17.8	22.0	14.8	67.7
66	W-1	270	0.9	10.0	17.4	19.9	11.5	58.7
67	WNW-1	294	0.9	21.5	24.0	22.5	21.3	89.4
68	WNW-2	292	4.9	15.3	18.5	20.6	14.3	68.7
69	NW-1	320	1.1	11.5	16.8	18.2	11.5	58.0
70	NW-2	313	4.7	14.5	17.0	21.3	14.3	67.0
71	NNW-1	340	1.0	11.5	15.2	16.8	11.0	54.5
72	NNW-2	333	4.5	5.3	17.4	20.6	14.3	57.6
73	NNW-3	329	7.0	10.5	13.3	14.8	8.8	47.4

Map Loc. No.	Station Number	Dir. (degrees)	Distance (miles)	Q1 2017	Q2 2017	Q3 2017	Q4 2017	Annual Exposure (mrem/yr)
				(mrem/qtr)				
74	ENE-2A	69	3.5	9.0	13.3	12.5	9.1	43.9
75	SE-2A	144	3.1	12.1	17.1	21.8	11.9	62.9
76	S-2A	177	2.0	13.6	17.9	17.5	13.3	62.4
77	W-2A	268	3.2	13.1	15.8	16.8	9.6	55.2
78	NW-2A	321	3.0	10.9	15.3	18.4	11.0	55.6
79	SSE-1	146	0.5	12.0	16.3	16.2	11.0	55.5

Table 14 - Weekly Airborne Particulate Gross Beta

Pathway (Measurement Unit)	Type and Number of Analysis Performed	Lower Limit of Detection (LLD)	All Indicator Locations Mean (Range)	Location with Highest Annual Mean		Control Locations Mean (Range)	Non-routine Reported Measurements
				Name, Distance and Direction	Mean (Range)		
Air Filter Inhalation (pCi/m^3)	Gross Beta 512	0.01	0.027 (408/408) (0.009 – 0.075)	PM-3, 10.4 Mi. NNE	0.029 (52/52) (0.009 – 0.069)	0.027 (104/104) (0.009 – 0.070)	0

Figure 9 - Average Gross Beta in Air Filters

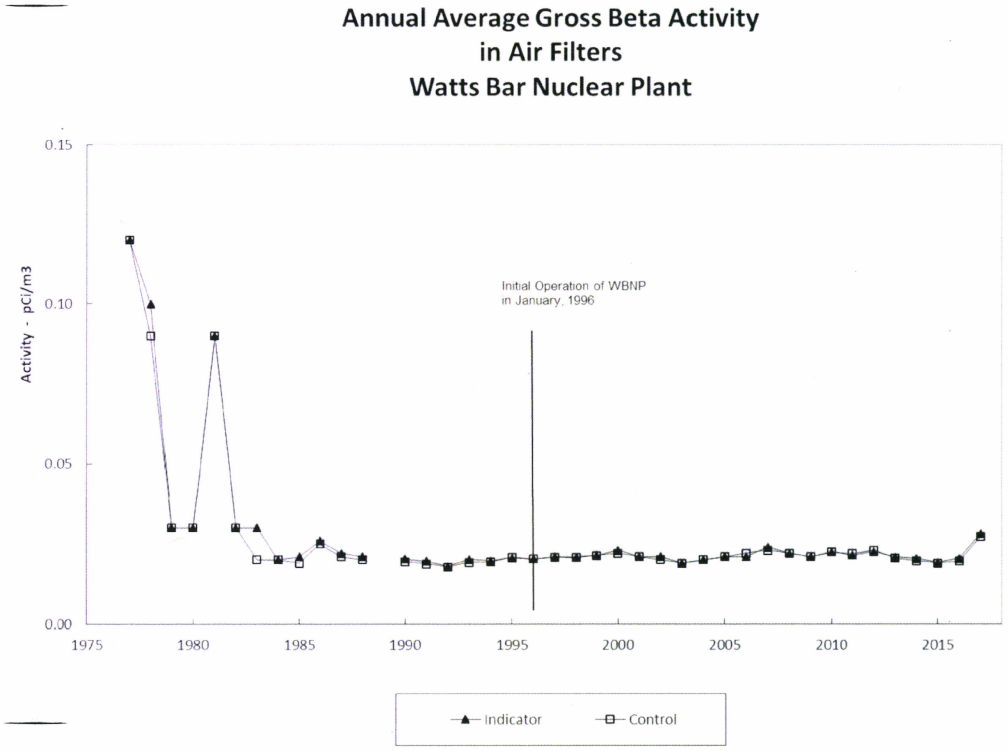


Table 15 - Weekly Radioiodine I-131 Activity

Pathway [a] (Measurement Unit)	Type and Number of Analysis Performed	Lower Limit of Detection (LLD) [b]	All Indicator Locations Mean (Range)	Location with Highest Annual Mean		Control Locations Mean (Range)	Non-routine Reported Measurements
				Name, Distance and Direction	Mean (Range)		
Activated Charcoal Inhalation (pCi/m^3)	I-131 512	0.07	< LLD [c] (0/408)	< LLD	< LLD	< LLD (0/104)	0

NOTES

a. This table summarizes the weekly air iodine-131 cartridge data above the MDC. Iodine-131 has an 8-day half-life. With reactor shutdown, it is no longer a radionuclide attributable to SONGS
b. LLD is the a priori limit as prescribed by the ODCM.
c. The Term <LLD as used means that results had no detectable activity above the minimum detectable.

Table 16 – Quarterly Composite Airborne Particulate Gamma Activity

Pathway (Measurement Unit)	Type and Number of Analysis Performed	Lower Limit of Detection (LLD)	All Indicator Locations Mean (Range)	Location with Highest Annual Mean		Control Locations Mean (Range)	Non-routine Reported Measurements
				Name, Distance and Direction	Mean (Range)		
Air Filter Inhalation (pCi/m^3)	Gamma Isotopic 129	Various	< LLD (0/104)	< LLD	< LLD	< LLD (0/25)	0

NOTES

a. Natural occurring radionuclides (Be-7, Pb-212, Bi-214 and others) were observed in quarterly composite air samples in 2017.

Table 17 – Biweekly Atmospheric Moisture Radioactivity

Pathway (Measurement Unit)	Type and Number of Analysis Performed		Lower Limit of Detection (LLD)	All Indicator Locations Mean (Range)	Location with Highest Annual Mean		Control Locations Mean (Range)	Non-routine Reported Measurements
					Name, Distance and Direction	Mean (Range)		
Atmospheric Moisture Inhalation (pCi/m³)	Tritium	206	3.0	2.70 (20/155)	LM-2, 0.4 mi NNE	3.70 (5/26) 2.47 – 4.95	1.39 (2/51) 0.24 – 2.54	0

Table 18 – Biweekly Milk Radioactivity

Pathway (Measurement Unit)	Type and Number of Analysis Performed		Lower Limit of Detection (LLD)	All Indicator Locations Mean (Range)	Location with Highest Annual Mean		Control Locations Mean (Range)	Non-routine Reported Measurements
					Name, Distance and Direction	Mean (Range)		
Milk Ingestion ~~(pCi/L)~~	Gamma Isotopic	53	Various	< LLD (0/53)	< LLD	< LLD	< LLD (0/26)	0
	Sr-89	11	3.5	< LLD (0/7)	< LLD	< LLD	< LLD (0/4)	0
	Sr-90	11	2	< LLD (0/7)	< LLD	< LLD	< LLD (0/4)	0
	I-131	76	1	< LLD (0/51)	< LLD	< LLD	< LLD (0/25)	0

NOTES

a. Natural occurring radionuclides (K-40, Pb-214, Bi-214 and others) were observed in milk samples in 2017.

Table 19 – Annual Soil Radioactivity

Pathway (Measurement Unit)	Type and Number of Analysis Performed		Lower Limit of Detection (LLD)	All Indicator Locations Mean (Range)	Location with Highest Annual Mean		Control Locations Mean (Range)	Non-routine Reported Measurements
					Name, Distance and Direction	Mean (Range)		
Soil Direct Radiation (pCi/kg)	Gamma Isotopic	10	Various	< LLD	< LLD	< LLD	< LLD	0
	Cs-137	10	180	108 (5/8) 70.7 - 173	LM-2, 0.4 mi NNE	173 (1/1) 173 – 173	252 (1/1) 248 – 255	0

Table 20 – Annual Local Crops Radioactivity

Pathway (Measurement Unit)	Type and Number of Analysis Performed		Lower Limit of Detection (LLD)	All Indicator Locations Mean (Range)	Location with Highest Annual Mean		Control Locations Mean (Range)	Non-routine Reported Measurements
					Name, Distance and Direction	Mean (Range)		
Cabbage Ingestion (pCi/g)	Gamma Isotopic	2	Various	< LLD (0/1)	< LLD	< LLD	< LLD (0/1)	0
Corn Ingestion (pCi/g)	Gamma Isotopic	2	Various	< LLD (0/1)	< LLD	< LLD	< LLD (0/1)	0
Green Beans Ingestion (pCi/g)	Gamma Isotopic	2	Various	< LLD (0/1)	< LLD	< LLD	< LLD (0/1)	0
Tomatoes Ingestion (pCi/g)	Gamma Isotopic	2	Various	< LLD (0/1)	< LLD	< LLD	< LLD (0/1)	0

Table 21 – Monthly Surface Water Radioactivity

Pathway (Measurement Unit)	Type and Number of Analysis Performed		Lower Limit of Detection (LLD)	All Indicator Locations Mean (Range)	Location with Highest Annual Mean		Control Locations Mean (Range)	Non-routine Reported Measurements
					Name, Distance and Direction	Mean (Range)		
Surface Water Direct Exposure (pCi/L)	Gamma Isotopic	38	Various	< LLD (0/25)	< LLD	< LLD	< LLD (0/13)	0
Surface Water Direct Exposure (pCi/L)	Tritium	39	2000	696 (7/25) 230 - 1710	TRM 517.9 (Washington Ferry) 9.9 miles	846 (3/12) 410 - 1710	< LLD (0/13)	0

NOTES

a. Natural occurring radionuclides (Pb-212, Bi-214 and others) were observed in surface water samples in 2017.

Table 22 – Monthly Public Drinking Water Radioactivity

Pathway (Measurement Unit)	Type and Number of Analysis Performed		Lower Limit of Detection (LLD)	All Indicator Locations Mean (Range)	Location with Highest Annual Mean		Control Locations Mean (Range)	Non-routine Reported Measurements
					Name, Distance and Direction	Mean (Range)		
Drinking Water Ingestion (pCi/L)	Gross Beta	41	4.0	2.98 (3/28) 1.91 – 6.01	TRM 503.8	4.05 (2/13) 2.10 – 6.01	3.08 (5/13) 1.92 – 5.31	0
Drinking Water Ingestion (pCi/L)	Gamma Isotopic	41	Various	< LLD (0/28)	< LLD	< LLD	< LLD (0/13)	0
Drinking Water Ingestion (pCi/L)	Tritium	46	2000	502 (11/33) 271 - 1031	TRM 473	571 (7/18) 362 - 1031	< LLD (0/13)	0

NOTES

a. Natural occurring radionuclides (Pb-212, Bi-214 and others) were observed in public drinking water samples in 2017.

Table 23 – Monthly Well (Ground) Water Radioactivity

Pathway (Measurement Unit)	Type and Number of Analysis Performed		Lower Limit of Detection (LLD)	All Indicator Locations Mean (Range)	Location with Highest Annual Mean		Control Locations Mean (Range)	Non-routine Reported Measurements
					Name, Distance and Direction	Mean (Range)		
Ground Water Ingestion (pCi/L)	Gross Beta	77	4.0	2.20 (9/64) 1.97 – 2.80	Well B 0.5 miles SSE	2.40 (4/13) 2.07 – 2.80	< LLD (0/13)	0
Ground Water Ingestion (pCi/L)	Gamma Isotopic	77	Various	(12/64)	< LLD	< LLD	< LLD (0/13)	0
Ground Water Ingestion (pCi/L)	Tritium	77	2000	498 (12/64) 255 - 834	Well B 0.5 miles SSE	715 (5/13) 562 - 834	< LLD (0/13)	0

NOTES

a. Natural occurring radionuclides (Pb-212, Bi-214 and others) were observed in surface water samples in 2017.

Table 24 – Semi-Annual Fish Radioactivity

Pathway (Measurement Unit)	Type and Number of Analysis Performed		Lower Limit of Detection (LLD)	All Indicator Locations Mean (Range)	Location with Highest Annual Mean		Control Locations Mean (Range)	Non-routine Reported Measurements
					Name, Distance and Direction	Mean (Range)		
Game Fish Ingestion (pCi/kg)	Gamma Isotopic	6	Various	< LLD (0/4)	< LLD	< LLD	< LLD (0/2)	0
	Cs-137	6	150	0.0211 (2/4) 0.019 – 0.023	TRM 522 .8 – 527.8	0.023 (1/2) 0.023 – 0.023	0.018 (1/2) 0.018 – 0.018	0
Commercial Fish Ingestion (pCi/kg)	Gamma Isotopic	8	Various	< LLD (0/5)	< LLD	< LLD	< LLD (0/3)	0

NOTES

a. Natural occurring radionuclides (Pb-212, Bi-214 and others) were observed in surface water samples in 2017.

Table 25 – Semi-Annual Shoreline Sediment Radioactivity

Pathway (Measurement Unit)	Type and Number of Analysis Performed	Lower Limit of Detection (LLD)	All Indicator Locations Mean (Range)	Location with Highest Annual Mean		Control Locations Mean (Range)	Non-routine Reported Measurements
				Name, Distance and Direction	Mean (Range)		
Shoreline Sediment Direct Radiation (pCi/kg)	Gamma Isotopic 4	Various	< LLD (0/2)	< LLD	< LLD	< LLD (0/2)	0

NOTES

a. Natural occurring radionuclides (Pb-212, Bi-214 and others) were observed in surface water samples in 2017.

APPENDIX I ERRATA TO PREVIOUS ANNUAL ENVIRONMENTAL OPERATING REPORTS

Errata to Previous AREORs

There are no identified errors in previous AREORs.