Tennessee Valley Authority, Post Office Box 2000, Decatur, Alabama 35609-2000

May 15, 2018

10 CFR 50.4

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

Browns Ferry Nuclear Plant, Units 1, 2, and 3
Renewed Facility Operating License Nos. DPR-33, DPR-52, and DPR-68
NRC Docket Nos. 50-259, 50-260, and 50-296

Subject: **2017 Annual Radiological Environmental Operating Report**

In accordance with the Browns Ferry Nuclear Plant Technical Specification 5.6.2 and Offsite Dose Calculation Manual Administrative Control Section 5.1, the Tennessee Valley Authority is submitting the 2017 Annual Radiological Environmental Operating Report for Browns Ferry Nuclear Plant, Units 1, 2, and 3. Enclosed is the subject report for the period of January 1, 2017, through December 31, 2017.

There are no new regulatory commitments contained within this letter. If you have any questions, please contact J. L. Paul at (256) 729-2636.

Respectfully,

(FOR)

D. L. Hughes
Site Vice President

Enclosure: 2017 Annual Radiological Environmental Operating Report

cc (w/Enclosure):

NRC Regional Administrator – Region II
NRC Senior Resident Inspector – Browns Ferry Nuclear Plant
NRC Project Manager – Browns Ferry Nuclear Plant

Enclosure

Browns Ferry Nuclear Plant
Units 1, 2, and 3

2017 Annual Radiological Environmental Operating Report

See Enclosed

Annual Radiological Environmental Operating Report

Browns Ferry Nuclear Plant 2017

Tennessee Valley Authority

May 2018

TABLE OF CONTENTS

EXECUTIVE SUMMARY

This report describes the Radiological Environmental Monitoring Program (REMP) conducted by the Tennessee Valley Authority (TVA) near the Browns Ferry Nuclear Plant (BFN) 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 Browns Ferry Nuclear Plant prior to operations (preoperational data). This report contains an evaluation of the potential impact of BFN operations on the environment and the general public.

Most of the radioactivity measured in environmental samples in the BFN program can be attributed to naturally occurring radioactive materials. In 2017, trace quantities of Cesium-137 (Cs-137) were measured in soil, shoreline sediment and fish samples. The concentrations were typical of the levels expected to be present in the environment from past nuclear weapons. 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 some surface water, public drinking water and well water samples in 2017. 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 in the vicinity of BFN 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 BFN Technical Specification 5.6.2 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 (K)-40, with a half-life of 1.3 billion years, is one of the major types of radioactive materials found naturally in our environment. Approximately 0.01 percent of all potassium is radioactive potassium-40. Other examples of naturally occurring radioactive materials are beryllium (Be)-7, bismuth (Bi)-212 and 214, lead (Pb)-212 and 214, thallium (Tl)-208, actinium (Ac)-228, uranium (U)-238 and 235, thorium (Th)-234, radium (Ra)-226, radon (Rn)-222 and 220, carbon (C)-14, and hydrogen (H)-3 (generally called tritium). 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 BFN 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

Appendix E Table 6 of this report presents and compares the nominal lower limits of detection (LLD) for the BFN 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

BFN is located on the north shore of Wheeler Reservoir at Tennessee River Mile 294 in Limestone County in north Alabama (see Figure 1). Wheeler Reservoir averages 1 to 1-1/2 miles in width in the vicinity of the plant. The BFN site contains approximately 840 acres. The dominant character of land use is small, scattered villages and homes in an agricultural area. A number of relatively large farming operations occupy much of the land on the north side of the river immediately surrounding the plant. The principal crop grown in the area is cotton.

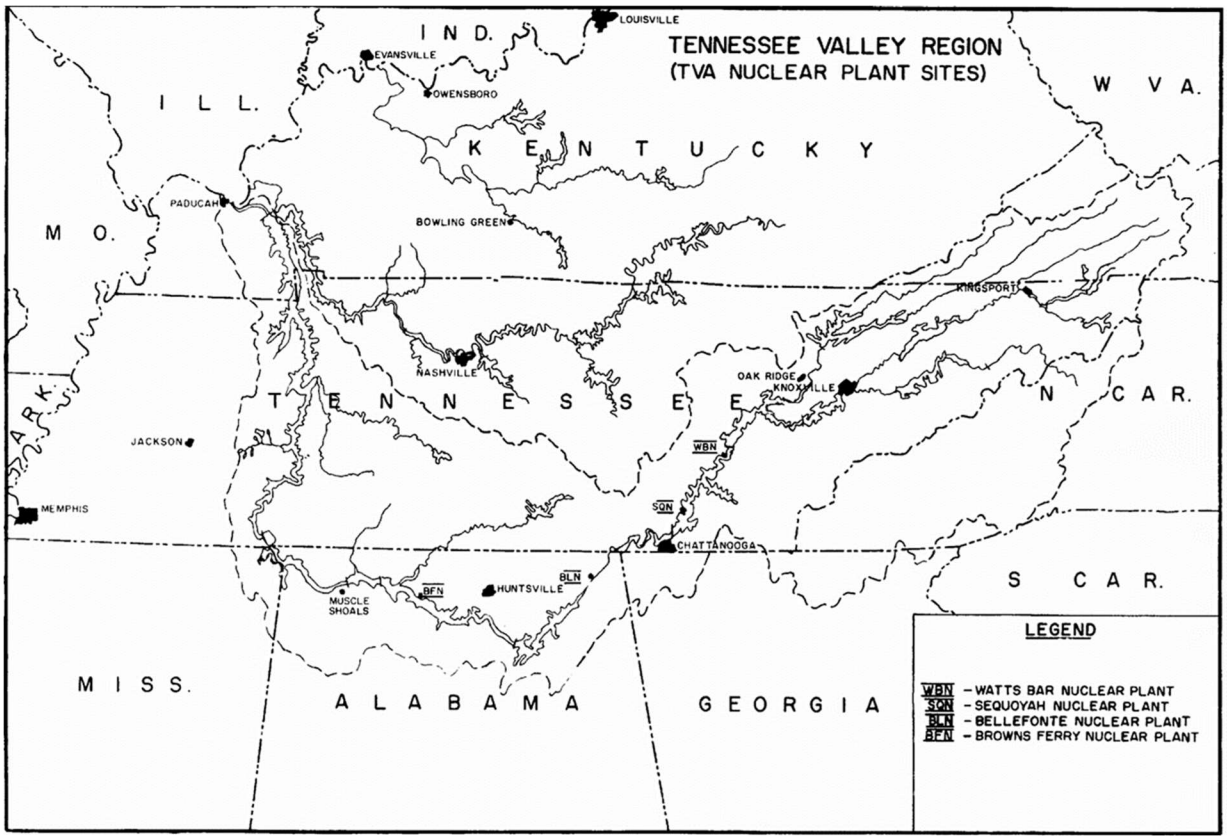
Approximately 1,397 people live within a 5-mile radius of the plant. The town of Athens has a population of about 29,500 and is approximately 10 miles northeast of BFN. Approximately 52,250 people live in the city of Decatur 10 miles southeast. The cities of Madison and Huntsville have a combined population of approximately 227,000 starting 20 miles east of the site.

Area recreation facilities are developed along the Tennessee River. The nearest facilities are public use areas located 2 to 3 miles from the site. The city of Decatur has a large municipal recreation area, Point Mallard Park, approximately 15 miles upstream of the site. The Tennessee River is also a popular sport fishing area.

BFN consists of three boiling water reactors. Unit 1 achieved criticality on August 17, 1973 and began commercial operation on August 1, 1974. Unit 2 began commercial operation on March 1, 1975. However, a fire in the cable trays on March 22, 1975, forced the shutdown of both reactors. Units 1 and 2 resumed operation and Unit 3 began testing in August 1976. Unit 3 began commercial operation on March 1, 1977.

All three units were shut down from March 1985 to May 1991. Unit 2 was restarted May 24, 1991 and Unit 3 restarted on November 19, 1995. Recovery work for Unit 1 was completed and the unit was restarted on May 22, 2007.

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 BFN 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.

A number of 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. Appendix A Table 4 lists the sampling stations and the types of samples collected from each. Modifications made to the BFN 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 BFN, a preoperational REMP was initiated in 1968 and conducted until the plant began operation in 1973. Sampling and analyses conducted during the preoperational phase has provided data that can be used 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 increases 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 BFN 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 BFN operation.

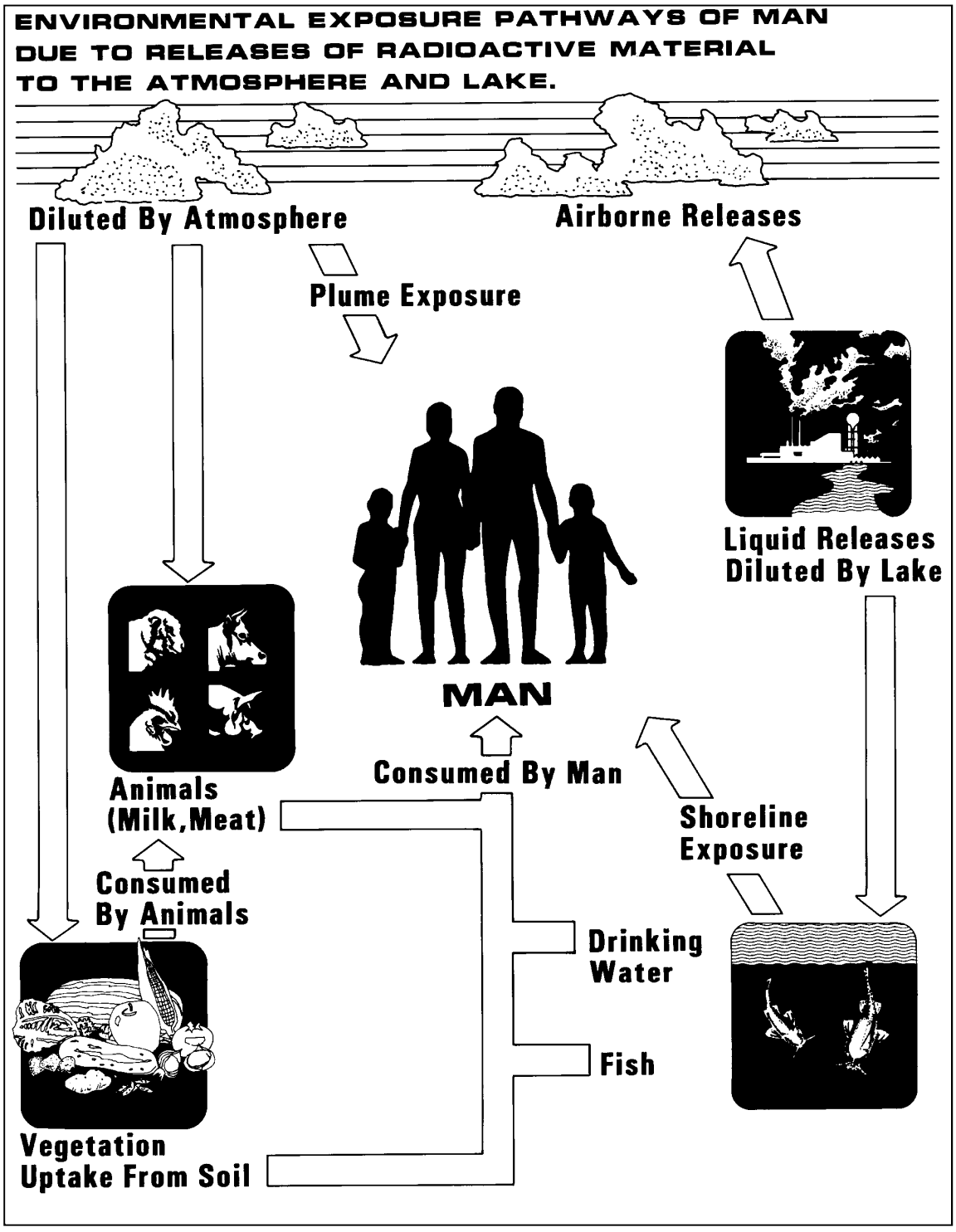
Until June 2017, the sample analyses were performed by the Tennessee Valley Authority (TVA) Environmental Radiological Monitoring and Instrumentation (ERM&I) group located at the Western Area

Radiological Laboratory in Muscle Shoals, Alabama. Beginning in June 2017, the sample analyses were performed by a contracted laboratory, GEL Laboratories, LLC, based in Charleston, SC. 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 Radioanalytical Laboratory 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 quality control 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 32 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.

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 BFN 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 Browns Ferry Nuclear Plant for Each Quarter – 2017[a]

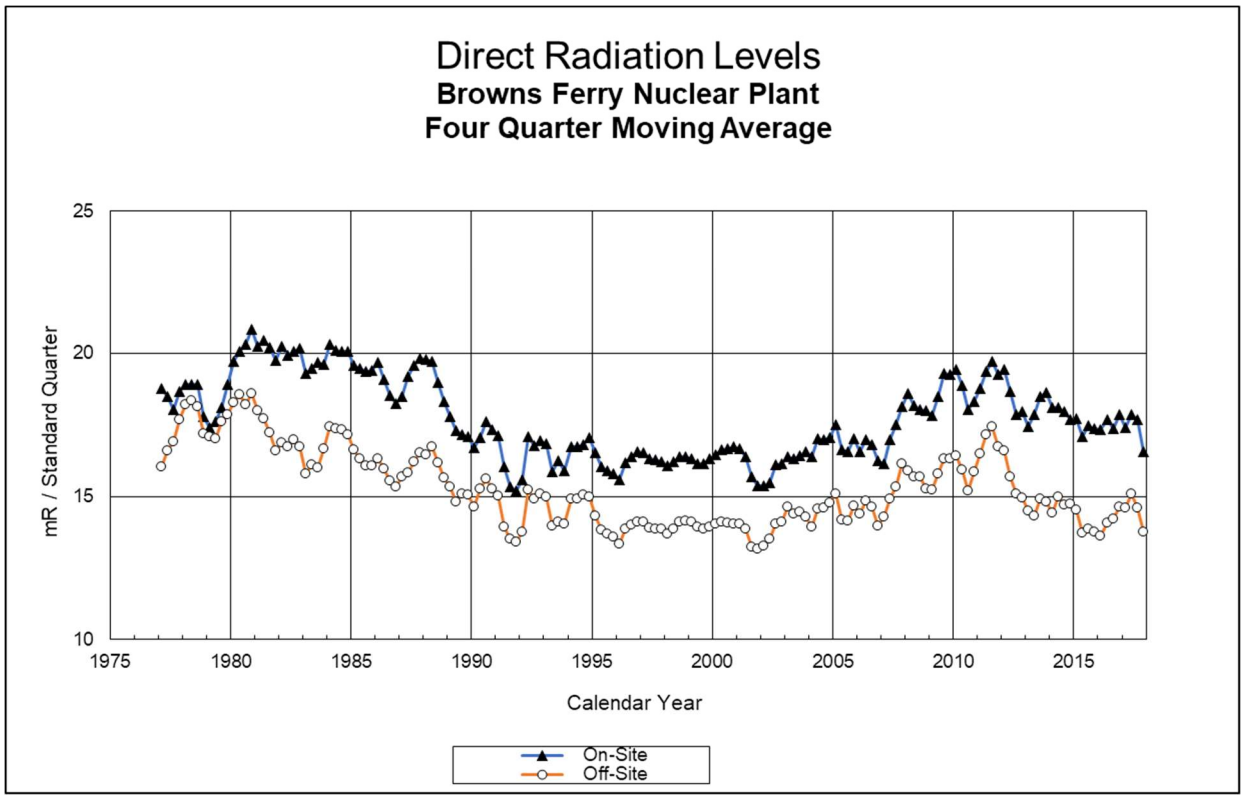
	Average External Gamma Radiation Levels					
	Q1[b] (mrem/qtr)	Q2[b] (mrem/qtr)	Q3[b] (mrem/qtr)	Q4[b] (mrem/qtr)	Annual[C] (mrem/yr)	Preoperational (mR/yr)
Average 0-2 miles (onsite)	14.2	19.6	18.1	14.3	66.3	71
Average >2 miles (offsite)	12.0	17.0	14.1	11.9	55.0	59

NOTES

a. Field periods normalized to one standard quarter (2190 hours)
b. Average of the individual measurements in the set
c. The 11.3 mrem/yr excess for onsite locations falls below the 25 mrem total body limit for 40 CFR 190. It is also similar to the preoperational results.

The data in Table 2 indicates that the average quarterly direct radiation levels at the BFN onsite stations are approximately 2.8 mrem/quarter higher than levels at the offsite stations. This equates to 11.3 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 at BFN where the average levels onsite were 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 Radiation Levels



The data in Appendix H Table 12 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 BFN. There is no indication that BFN 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. In the current program, five local air monitoring stations are located on or adjacent to the plant site in the general direction of greatest wind frequency. Three of these stations (LM-1, LM-2, and LM-3) are located on the plant side of the Tennessee River and two stations (LM-6 and LM-7) are located immediately across the river from the plant site. One additional station (station LM-4) is located at the point of maximum predicted offsite concentration of radionuclides based on meteorological data. Three perimeter air monitoring stations are located in communities out to about 13 miles from the plant, and two monitors used as controls are located out to 32 miles. 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 Appendix H Table 13 through Table 15. Radioactivity levels identified in this reporting period are consistent with background radioactivity levels.

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 pump, a magnehelic gauge for measuring the drop in pressure across the system, and a dry gas meter. This allows an accurate determination of the volume of air passing through the filter. The sampling system is housed in a metal building. 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 collected 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 located in the same sampling head as the air particulate filter and is downstream of the 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 iodine (I)-131 by gamma spectroscopy analysis.

Results

The results from the analysis of air particulate samples are summarized in Appendix H Table 13. Gross beta activity in 2017 was consistent with levels reported in previous years. The annual average gross beta concentrations was 0.026 pCi/m^3. The annual averages of the gross beta activity in air particulate filters for the years 1968-2017 are presented in Appendix H Figure 7. Increased levels due to fallout from atmospheric nuclear weapons testing are evident, especially in 1969, 1970, 1971, 1977, 1978, and 1981. Evidence of a small increase resulting from the Chernobyl accident can also be seen in 1986. These patterns are consistent with data from monitoring programs conducted by TVA at other nuclear power plant sites during construction and preoperational stages.

Only naturally occurring radionuclides were identified by the monthly gamma spectral analysis of the air particulate samples.

There was no I-131 detected in any charcoal cartridge samples collected during 2017. The results for the analysis of charcoal cartridges are reported in Appendix H Table 14.

TERRESTRIAL MONITORING

Terrestrial monitoring is accomplished by collecting samples of environmental media that may transport radioactive material from the atmosphere to humans. Samples of soil and food crops are collected and analyzed to determine the potential impacts from exposure to this pathway. The results from the analysis of these samples are shown in Appendix H Table 16 and Table 17.

A land use survey is conducted annually to locate milk producing animals and gardens within a 5-mile radius of the plant. No milk-producing animals were identified within 5 miles of the plant. The results of the 2017 land use survey are presented in Appendix G.

Sample Collection and Analysis

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. When the gamma analysis is complete, the sample is analyzed 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 as a result of changes in the local vegetable gardens. Samples of apples, cabbage, corn, green beans, potatoes, and tomatoes were collected from local gardens in 2017. Samples of these same food crops were purchased from area produce markets or private gardens to serve as control samples. The edible portion of each sample is analyzed by gamma spectroscopy.

Results

The only fission or activation product identified, above nominal LLD, in soil samples was Cs-137. The average concentration measured in samples from indicator locations was 198 pCi/kg. The average concentration for control locations was 266 pCi/kg. These concentrations are consistent with levels previously reported from fallout. All other radionuclides reported were naturally occurring isotopes.

The results of the analysis of the soil samples are reported in Appendix H Table 16. A plot of the annual average Cs-137 concentrations in soil is presented in Appendix H Figure 8. The concentration of Cs-137 in soil is steadily decreasing due to the cessation of weapons testing in the atmosphere, the 30-year half-life of Cs-137 and transport through the environment.

Analyses of food samples indicated no contribution from plant activities. The results are reported in Appendix H Table 17.

LIQUID PATHWAY MONITORING

Potential exposures from the liquid pathway can occur from drinking water, ingestion of fish, and from direct radiation exposure to radioactive materials deposited in the river shoreline sediment. The liquid pathway monitoring program conducted during 2017 included the collection of samples of surface (river/reservoir) water, groundwater, drinking water supplies, fish, and shoreline sediment. Samples from the reservoir are collected both upstream and downstream from the plant. Results from the analysis of aquatic samples are presented in Appendix H Table 18 through Table 22.

Sample Collection and Analysis

Samples of surface water are collected from the Tennessee River using automatic sampling systems from one downstream station and one upstream station. The upstream sample is collected from the raw water intake at the Decatur, Alabama water plant and is utilized as a control sampling location for both surface and drinking water. A timer turns on the system at least once every two hours. The line is flushed and a sample collected into a collection container. A one-gallon sample is removed from the container every 4 weeks and the remaining water in the jug is discarded. The 4-week composite sample is analyzed for gamma isotopic and gross beta activity. A quarterly composite sample is analyzed for tritium.

Samples are also collected by an automatic sampling system at the first downstream drinking water intake, West Morgan - East Lawrence Water Authority. This sample of raw untreated water is collected at the intake from the water plant. These samples are collected in the same manner as the surface water samples. These monthly samples are analyzed for gamma isotopic and gross beta activity. A quarterly composite is analyzed for tritium.

At other selected locations, grab samples are collected from drinking water systems which use the Tennessee River as their source. These samples are analyzed every 4 weeks for gamma isotopic and gross beta activity. A quarterly composite sample from each station is analyzed for tritium.

A groundwater well onsite is equipped with an automatic water sampler. Water is also collected from a private well in an area unaffected by BFN. Samples from the wells are collected every 4 weeks and analyzed by gamma spectroscopy. A quarterly composite sample is analyzed for tritium.

Samples of commercial and game fish species are collected semiannually from each of the two reservoirs: the reservoir on which the plant is located (Wheeler Reservoir) and the upstream reservoir (Guntersville Reservoir). The samples are collected using a combination of netting techniques and electrofishing. To sample edible portions of the fish, the fish are filleted. After drying and grinding, the samples are analyzed by gamma spectroscopy.

Shoreline sediment is collected from two downstream recreational use areas and one upstream location. The samples were collected at the normal water level shoreline and analyzed by gamma spectroscopy.

Results

Only naturally occurring isotopes were identified by gamma spectral analysis of surface water. Tritium was detected in one downstream (indicator) sample and one upstream (control) sample. Tritium was measured at a concentration of 284 pCi/liter in the indicator sample and 241 pCi/liter for the control

sample. These tritium concentrations are considered background and represent only a small fraction of the Environmental Protection Agency (EPA) drinking water limit of 20,000 pCi/liter. The gross beta activity for surface water samples was consistent with the results from previous years. The average gross beta concentration measured in surface water samples was 2.5 pCi/liter. A summary table of the results for this reporting period is shown in Appendix H Table 18.

No fission or activation products were detected by the gamma analysis of drinking water. Gross beta activity averaged 2.9 pCi/liter at the downstream stations and 2.6 pCi/liter at upstream stations. These results are consistent with previous monitoring results. Tritium was measured in drinking water samples at an average concentration of 286 pCi/liter in the indicator sample and 241 pCi/liter for the control sample. This tritium concentration represented only a small fraction of the EPA drinking water limit of 20,000 pCi/liter. The results are shown in Appendix H Table 19.

No fission or activation products were detected in groundwater samples from BFN REMP monitoring locations by gamma analysis. Gross beta activity averaged 9.58 pCi/L at the indicator locations, and 5.42 pCi/L at the control location. Tritium was detected in samples collected from the indicator location at a maximum concentration of 360 pCi/liter. Results from the analysis of groundwater samples are presented in Appendix H Table 20.

In 2017, one sample of game fish from the control location positively identified Cs-137, at a concentration of 0.022 pCi/kg. No other sample, including all those from the indicator location, identified any fission or activation products. The concentration of radioactivity in this fish sample is consistent with previous years. The results are summarized in Appendix H Table 21.

Only naturally occurring radionuclides were identified above the nominal LLD in shoreline sediment samples from the indicator locations. In one sample from the control location, Cs-137 was identified at 0.27 pCi/kg, which is consistent with previous years' results. The results of the analysis of shoreline sediment are provided in Appendix H Table 22.

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 methodology provided by the NRC in Regulatory Guide 1.109 for determining the potential dose to individuals and populations living near a nuclear power plant. The results of the effluent dose calculations are reported in the Annual Radioactive Effluent Release Report. The calculated doses 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 this "hypothetical" person. The calculated maximum dose due to plant effluents are small fractions of the applicable regulatory limits. The expected dose to actual individuals is significantly lower.

Based on the very low concentrations of radionuclides present in the plant effluents, radioactivity levels measured in the environment, due to plant operations, are expected to be negligible. The results for the radiological environmental monitoring conducted for BFN 2017 operations confirm this expectation.

Results

As stated earlier in the report, the estimated increase in radiation dose equivalent to the public resulting from the operation of BFN is negligible 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 identified, above the nominal LLD, in soil samples. The Cs-137 detected in these samples was consistent with levels generally found in the environment as the result of past nuclear weapons testing. The low levels of tritium measured in water samples from Wheeler Reservoir, Guntersville Reservoir and the onsite well represented concentrations that were significantly lower than the EPA drinking water limit.

Conclusions

It is concluded from the above analysis of the environmental sampling results and from the trend plots presented in Appendix H that the exposure to members of the public which may have been attributable to BFN is negligible. The radioactivity reported herein is primarily the result of fallout or natural background radiation. Any activity which may be present due to 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 - Browns Ferry 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	6 samples from locations (in different sectors) at or near the site boundary (LM-1, 2, 3, 4, 6 and 7) 3 samples from communities approximately 10 miles from plant (PM-1, 2 and 3) 2 samples from control locations > 10 miles from the plant (RM-1 and 6)	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 at least once per 7 days.	I-131 by gamma scan on each sample.
c. Soil	Samples from same location as air particulates	Once every year	Gamma scan, Sr-89, Sr-90 once per year
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.	At least once per 92 days	Gamma dose once per 92 days

Exposure Pathway and/or Sample[a]	Number of Samples and Locations[b]	Sampling and Collection Frequency	Type and Frequency of Analysis
3. WATERBORNE			
a. Surface Water	1 sample downstream from plant discharge (TRM 293.5). 1 sample at a control location upstream from the plant discharge (TRM 306.0).	Collected by automatic sequential-type sampler[c] with composite samples collected over a period of approximately 31 days.	Gamma scan at least once per 31 days. Composite for tritium at least once per 92 days.
b. Drinking Water	1 sample at the first potable surface water supply downstream from the plant (TRM 286.5). 1 sample at a control location (TRM 306)	Collected by automatic sequential-type sampler [c] with composite sample collected at least once per 31 days.	Gross beta and gamma scan on 4-week composite. Composite for tritium analysis at least once per 92 days.
	3 additional samples of potable surface water downstream from the plant (TRM 274.9, TRM 259.8 and TRM 259.6)	Grab sample taken from the water supply at a facility using water from the public supply being monitored. Sample collected at least once per 31 days.	
c. Ground water	1 sample adjacent to the plant (Well #6R)	Collected by automatic sequential-type sampler [c] with composite samples collected over a period of approximately 31 days.	Composite for gamma scan and tritium at least once per 92 days.
	1 sample at a control location up gradient from the plant (Farm B)	Grab sample taken at least once per 31 days.	

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 from each of at least two downstream locations with recreational use. (TRM 293 and TRM 279.5) 1 sample from a control location upstream from plant discharge (TRM 305)	At least once per 184 days	Gamma scan of each sample
4. INGESTION			
a. Fish	2 samples representing commercial and game species in Guntersville Reservoir above the plant. 2 samples representing commercial and game species in Wheeler Reservoir near the plant.	Semi-Annually (at least once per 184 days)	Gamma spectroscopy on edible portions
b. Food Products	Samples of food crops such as greens, corn, green beans, tomatoes and potatoes grown at private gardens and/or farms in the immediate vicinity of the plant. 1 sample of each of the same foods grown at greater than 10 miles from the plant.	At least once per year at time of harvest.	Gamma spectroscopy 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 4 through Figure 6.
[c] Samples shall be collected by collecting an aliquot at intervals not exceeding 2 hours

Table 4 - Browns Ferry Nuclear Power Plant REMP Sampling Locations

Map Station Number[a]	Station	Sector	Approximate Distance (miles)	Indicator (I) or Control (C)	Samples Collected[b]
1	PM-1	NW	13.8	I	AP,CF,S
2	PM-2	NE	10.9	I	AP,CF,S
3	PM-3	SSE	7.5	I	AP,CF,S
4	LM-7	W	2.1	I	AP,CF,S
5	RM-1	W	31.0	C	AP,CF,S
6	RM-6	E	23.4	C	AP,CF,S
7	LM-1	NNW	1.0	I	AP,CF,S
8	LM-2	NNE	0.9	I	AP,CF,S
9	LM-3	ENE	0.9	I	AP,CF,S
10	LM-4	NNW	1.7	I	AP,CF,S
11	LM-6	SSW	3.0	I	AP,CF,S
12	Farm B	NNW	6.8	C	W
24	TRM 306.0	-	12.0[c]	C	PW, SW
25	TRM 259.6	-	34.4[c]	I	PW
26	TRM 274.9	-	19.1[c]	I	PW
28	TRM 293.5	-	0.5[c]	I	SW
70	TRM 259.8	-	34.2[c]	I	PW
71	TRM 286.5	-	7.5[c]	I	PW
72	TRM 305	-	11.0[c]	C	SS
73	TRM 293	-	1.0[c]	I	SS
74	TRM 279.5	-	14.5[c]	I	SS
76	Well 6R	NW	0.1	I	W
	Wheeler Reservoir (TRM 275 – 349)	-	-	I	F
	Guntersville Reservoir (TRM 349 – 424)	-	-	C	F

[a] See Figure 4 through Figure 6

[b] Sample Codes:

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

[c] Distance from plant discharge at Tennessee River Mile (TRM) 294

[d] TRM = Tennessee River Mile

Table 5 – Browns Ferry Nuclear Power Plant Environmental Dosimeter Locations

	Station	Sector	Distance (miles)	Onsite or Offsite[a]
1	NW-3	NW	13.8	Off
2	NE-3	NE	10.9	Off
3	SSE-2	SSE	7.5	Off
5	W-3	W	31.0	Off
6	E-3	E	23.1	Off
7	N-1	NNW	1.0	On
8	NNE-1	NNE	0.9	On
9	ENE-1	ENE	0.9	On
10	NNW-2	NNW	1.7	On
38	N-2	N	5.0	Off
39	NNE-2	NNE	0.7	On
40	NNE-3	NNE	5.2	Off
41	NE-1	NE	0.8	On
42	NE-2	NE	5.0	Off
43	ENE-2	ENE	6.2	Off
44	E-1	E	0.8	On
45	E-2	E	5.2	Off
46	ESE-1	ESE	0.9	On
47	ESE-2	ESE	3.0	Off
48	SE-1	SE	0.5	On
49	SE-2	SE	5.4	Off
50	SSE-1	SSE	5.1	Off
51	S-1	S	3.1	Off
52	S-2	S	4.8	Off
53	SSW-1	SSW	3.0	Off
54	SSW-2	SSW	4.4	Off
55	SW-1	SW	1.9	On
56	SW-2	SW	4.7	Off
58	WSW-1	WSW	2.7	Off
59	WSW-2	WSW	5.1	Off
60	WSW-3	WSW	10.5	Off
61	W-1	W	1.9	On
62	W-2	W	4.7	Off
64	WNW-1	WNW	3.3	Off
65	WNW-2	WNW	4.4	Off
66	NW-1	NW	2.2	Off
67	NW-2	NW	5.3	Off
68	NNW-1	NNW	1.0	On
69	NNW-3	NNW	5.2	Off
75	N-1A	N	1.0	On

[a] Dosimeters designated “onsite” are located 2 miles or less from the plant; “offsite” are located more than 2 miles from the plant. See Figure 4 through Figure 6.

Figure 4 – Radiological Environmental Monitoring Locations within 1 mile of the plant

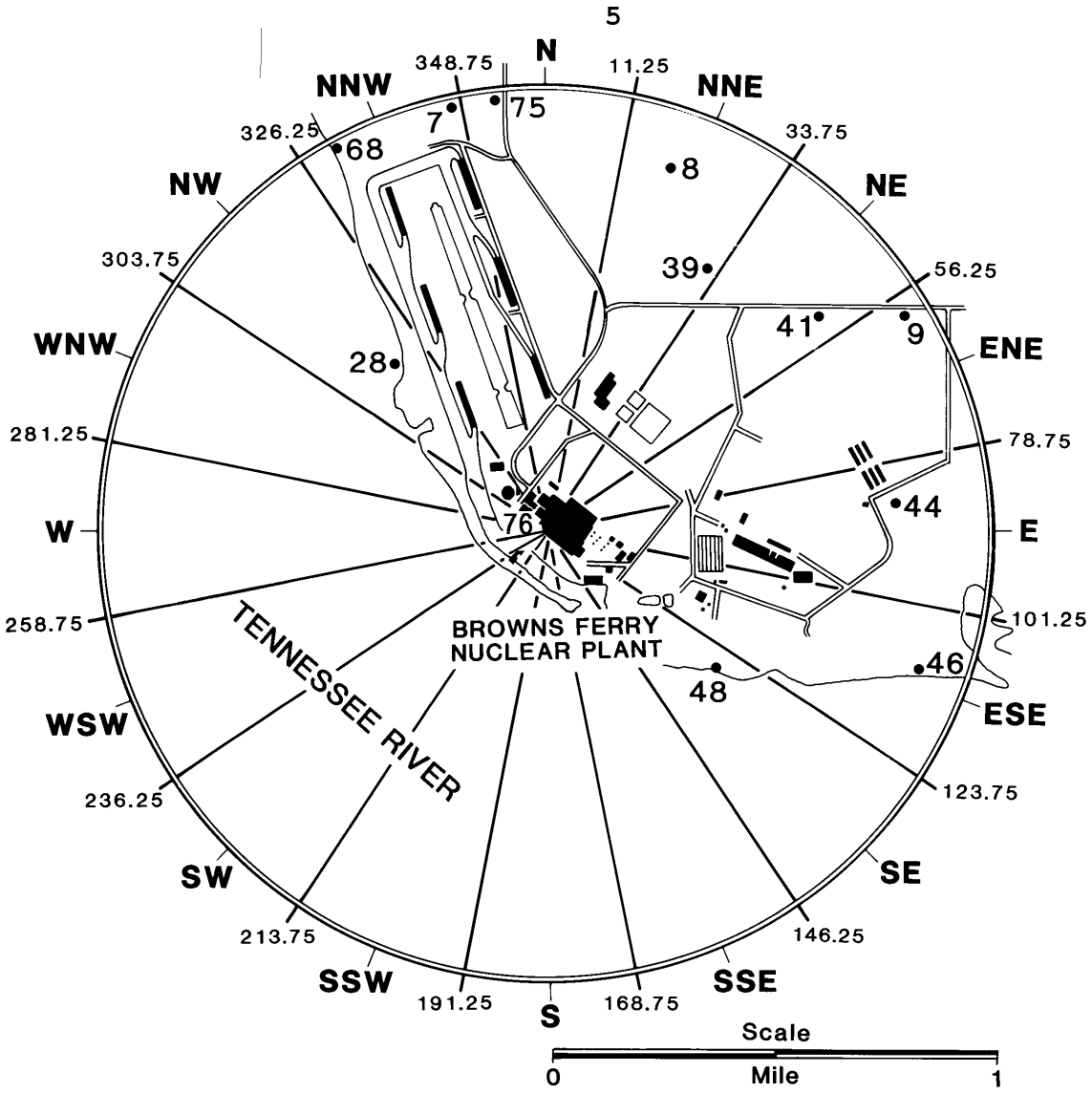


Figure 5 - Radiological Environmental Monitoring Locations 1 - 5 miles from the Plant

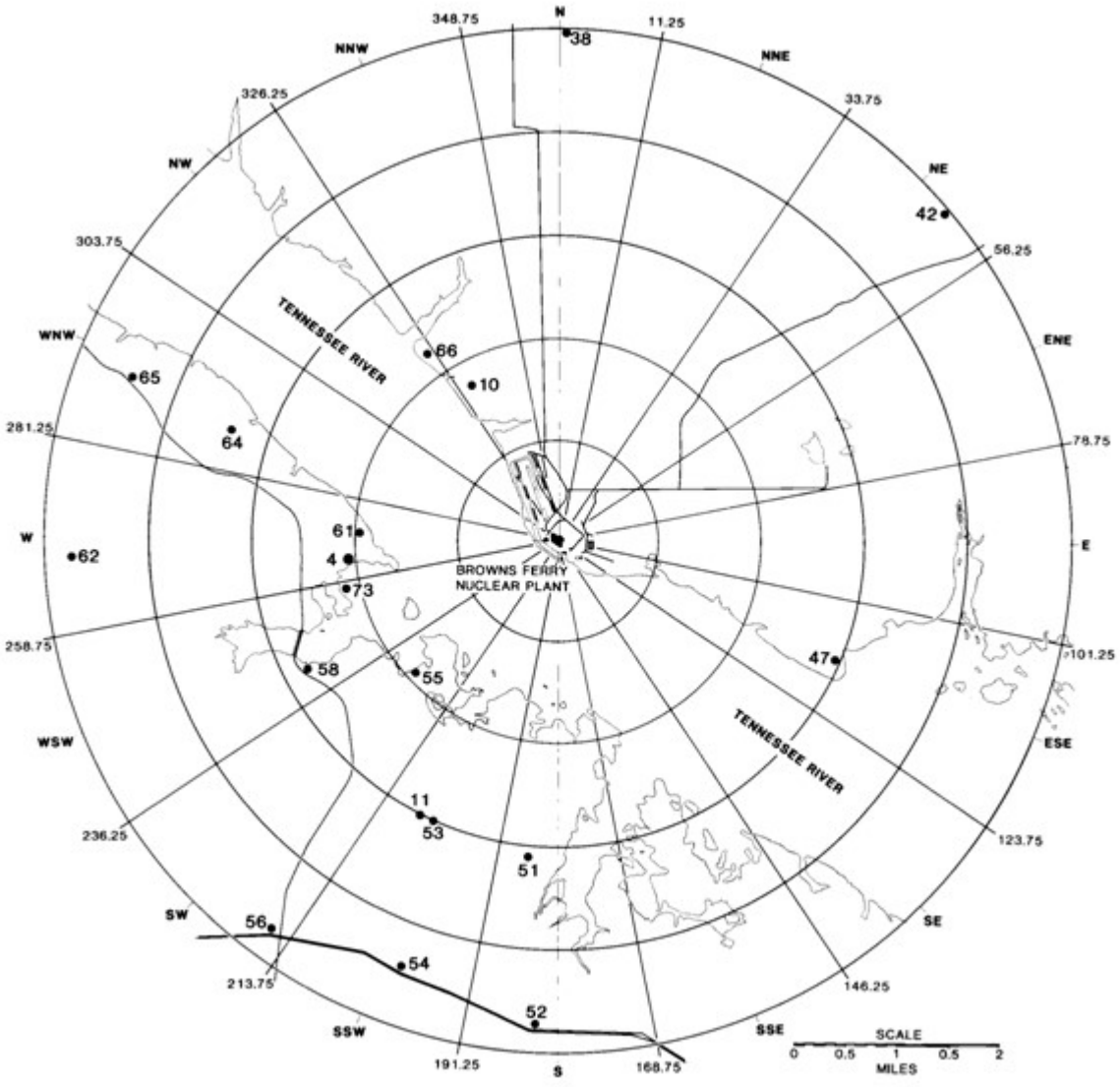
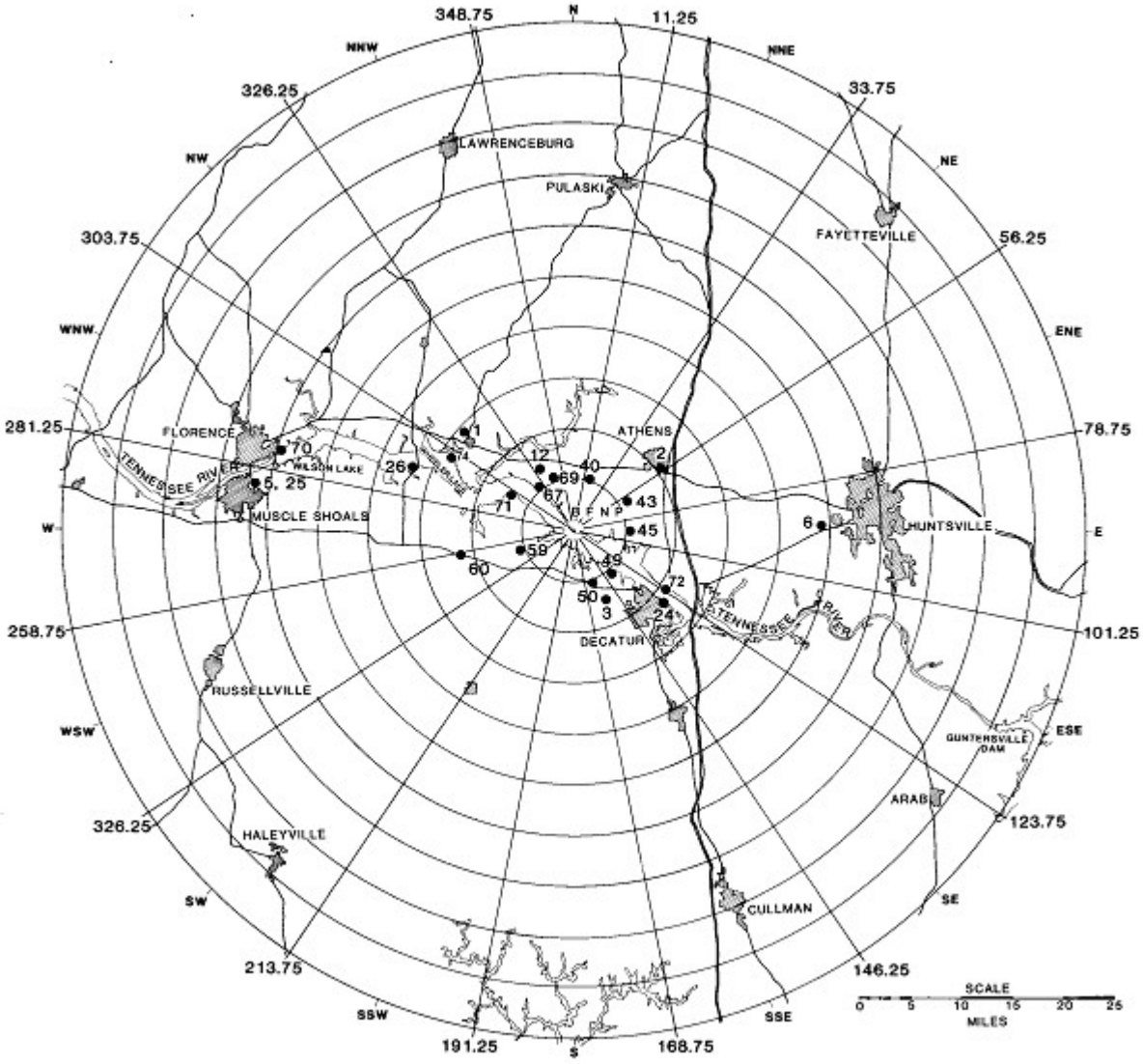


Figure 6 - Radiological Environmental Sampling Locations Greater than 5 miles from the Plant



APPENDIX B PROGRAM MODIFICATIONS

Radiological Environmental Monitoring Program Modifications

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

In 2017, there were no modifications to the Browns Ferry Nuclear Power Plant Radiological Environmental Monitoring Program sampling locations, analysis types, or frequency.

APPENDIX C PROGRAM DEVIATIONS

Program Deviations

Media	Location	Date	CR	Issue
Air Particulate and Charcoal Filter	LM-2 (1102)	8/28/2017	1333805	During weekly REMP sampling week 35, field technicians found BFN air monitor LM-2 not working. EPFS personnel and cognizant chemist were notified. EPFS personnel responded to the air monitor the same day and replaced a failed GFI outlet; EPFS reported back that the air sampler has been returned to service. Calculation of the true volume was 117.9 cubic meters, which is below the acceptance criteria of 250 cubic meters; this will be a missed sample which is required to be reported in the 2017 AREOR.

APPENDIX D ANALYTICAL PROCEDURES

Analytical Procedures

Analyses of environmental samples were performed by TVA - WARL Laboratory in Muscle Shoals AL and 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. Then the I-131 is counted in a gamma spectroscopy utilizing high resolution Hp-Ge detectors.

After a radiochemical separation, milk samples analyzed for Sr-89 and Sr-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.

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

Many 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]	Nominal Lower Limit of Detection[e]	Effluent Concentration	Reporting Level	Nominal Lower Limit of Detection [e]
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	0.005
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: BFN Offsite Dose Calculation Manual, Table 2.3-3

[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

Table 8 – Nominal LLD Values – Gamma Analysis (cont'd)

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)
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	--	--
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.

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 from the performance evaluator 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 also identifies all gardens of greater than 500 square feet producing fresh leafy vegetables within a distance of 3 miles (5 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.

Using the survey data, relative radiation doses were projected for individuals near the plant. Doses from air submersion were calculated for the nearest resident in each sector. Doses from milk ingestion or vegetable ingestion were calculated for the areas with milk producing animals and gardens, respectively. These doses were calculated using historical meteorological data. They also assume that the effluent releases are equivalent to the design basis source terms. The calculated doses are relative in nature and do not reflect actual exposures received by individuals living near BFN.

There were no changes in the location of the nearest resident identified in 2017 as compared to 2016, in any of the 16 directional sectors. The location of the nearest garden changed in 3 sectors. The distance to the nearest garden increased in sector ENE, decreased in sector E and a garden has been identified in sector W where there was not one in the past. In 2017, no milk locations were identified within an 8-km radius of the plant site. Browns Ferry gaseous effluents are characterized as an elevated release. As a result, BFN is required to identify all qualifying gardens out to a distance of 3 miles, in accordance with regulatory requirements and the Browns Ferry ODCM. The 2017 land use survey identified a total of nine additional gardens within 3 miles that are not the nearest gardens to the site, in their particular sector. Of these nine, two were new in 2017.

Table 10 and Table 11 compare the results of the relative projected annual dose calculations for 2016 and 2017.

Table 10 - Relative Projected Annual Air Submersion Dose to the Nearest Residence

	2016		2017	
Sector	Distance (meters)	Dose	Distance (meters)	Dose
N	2,440	0.34	2,440	0.34
NNE	2,620	0.14	2,620	0.14
NE	2,020	0.17	2,020	0.17
ENE	2,460	0.17	2,460	0.17
E	1,410	0.40	1,410	0.40
ESE	1,750	0.24	1,750	0.24
SE	[a]	--	[a]	--
SSE	[a]	--	[a]	--
S	4,540	0.15	4,540	0.15
SSW	4,610	0.16	4,610	0.16
SW	4,650	0.10	4,650	0.10
WSW	4,200	0.07	4,200	0.07
W	2,660	0.17	2,660	0.17
WNW	5,280	0.10	5,280	0.10
NW	3,150	0.33	3,150	0.33
NNW	1,650	0.75	1,650	0.75

Notes

a. There is no residence within the 8 km radius for this sector

Table 11 - Relative Projected Annual Ingestion Dose to Child's Bone from Home-Grown Foods

Sector	2016 Distance (meters)	2016 Dose	2017 Distance (meters)	2017 Dose	Number of Gardens within 5 km for 2017
N	2,540	5.99	2,540	5.99	1
NNE	5,980	0.88	5,980	0.88	1
NE	3,790	1.50	3,790	1.50	2
ENE	5,070	1.06	5,180	1.03	1
E	4,240	1.81	1,530	6.21	3
ESE	1,830	6.10	1,830	6.10	4
SE	[a]	--	[a]	--	0
SSE	[a]	--	[a]	--	0
S	4,540	2.24	4,540	2.24	1
SSW	4,880	2.14	4,880	2.14	2
SW	4,940	1.00	4,940	1.00	1
WSW	4,330	0.60	4,330	0.60	1
W	[a]	--	3,070	1.10	1
WNW	[a]	--	[a]	--	0
NW	[a]	--	[a]	--	0
NNW	2,290	7.30	2,290	7.30	3

Notes

a. There is no garden within the 8 km radius for this sector

APPENDIX H DATA TABLES AND FIGURES

Table 12 - Individual Dosimeter Stations at Browns Ferry 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)				
1	NW-3	310	13.8	9.3	15.2	13.5	10.9	49.0
2	NE-3	56	10.9	11.3	17.1	12.4	11.9	52.7
3	SSE-2	165	7.5	10.3	16.6	13.5	11.9	52.3
5	W-3	275	31.0	12.3	18.1	12.4	12.8	55.6
6	E-3	90	23.1	13.8	19.9	15.1	10.9	59.8
7	N-1	348	1.0	16.8	20.4	19.5	15.6	72.2
8	NNE-1	12	0.9	14.8	21.8	17.3	13.7	67.6
9	ENE-1	61	0.9	15.3	18.5	16.8	15.1	65.7
10	NNW-2	331	1.7	17.3	18.5	18.9	13.7	68.4
38	N-2	1	5.0	11.3	16.2	14.0	11.4	52.9
39	NNE-2	31	0.7	11.8	19.9	19.5	15.6	66.8
40	NNE-3	19	5.2	12.3	16.2	15.1	12.3	55.9
41	NE-1	51	0.8	15.8	20.4	20.0	12.3	68.5
42	NE-2	49	5.0	13.3	18.5	15.1	13.3	60.2
43	ENE-2	62	6.2	11.8	16.6	17.3	13.7	59.5
44	E-1	85	0.8	14.3	21.3	20.6	19.3	75.5
45	E-2	91	5.2	13.3	17.6	15.1	13.7	59.7
46	ESE-1	110	0.9	12.3	17.6	16.8	11.4	58.0
47	ESE-2	112	3.0	14.3	19.5	16.2	16.5	66.5
48	SE-1	130	0.5	12.3	21.3	16.8	16.5	66.9
49	SE-2	135	5.4	13.8	17.1	12.4	14.2	57.5
50	SSE-1	163	5.1	15.3	19.0	13.0	11.9	59.1
51	S-1	185	3.1	11.3	15.2	17.9	13.2	57.6
52	S-2	182	4.8	11.3	16.2	14.0	11.4	52.9
53	SSW-1	203	3.0	9.3	16.2	10.8	10.0	46.2
54	SSW-2	199	4.4	11.8	15.7	15.1	11.8	54.4
55	SW-1	228	1.9	13.3	17.6	16.2	15.5	62.6
56	SW-2	219	4.7	14.3	15.2	14.0	11.3	54.9
58	WSW-1	244	2.7	9.8	14.8	11.9	10.0	46.4
59	WSW-2	251	5.1	13.3	17.6	15.7	11.8	58.3
60	WSW-3	257	10.5	11.8	15.7	15.7	9.5	52.7
61	W-1	275	1.9	12.8	17.6	17.9	11.3	59.6
62	W-2	268	4.7	12.3	17.6	10.8	11.3	52.0
64	WNW-1	291	3.3	13.3	17.6	14.6	10.0	55.4
65	WNW-2	293	4.4	10.3	18.5	14.6	10.0	53.4
66	NW-1	326	2.2	9.8	15.7	11.9	9.5	46.9
67	NW-2	321	5.3	12.8	17.6	13.5	12.8	56.7
68	NNW-1	331	1.0	13.3	18.5	16.8	11.9	60.4
69	NNW-3	339	5.2	10.8	17.6	14.6	13.7	56.7
75	N-1A	355	1.0	15.3	21.3	18.9	14.2	69.7

Table 13 - 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/m³)	Gross Beta 572	0.01	0.026 (468/468) (0.009 – 0.069)	PM-3, 7.5 Mi. SSE	0.027 (52/52) (0.011 – 0.069)	0.025 (104/104) (0.009 – 0.062)	0

NOTES

a LLD is the a priori limit as prescribed by the ODCM.

b The Term <LLD as used means that results had no detectable activity above the minimum detectable.

Figure 7

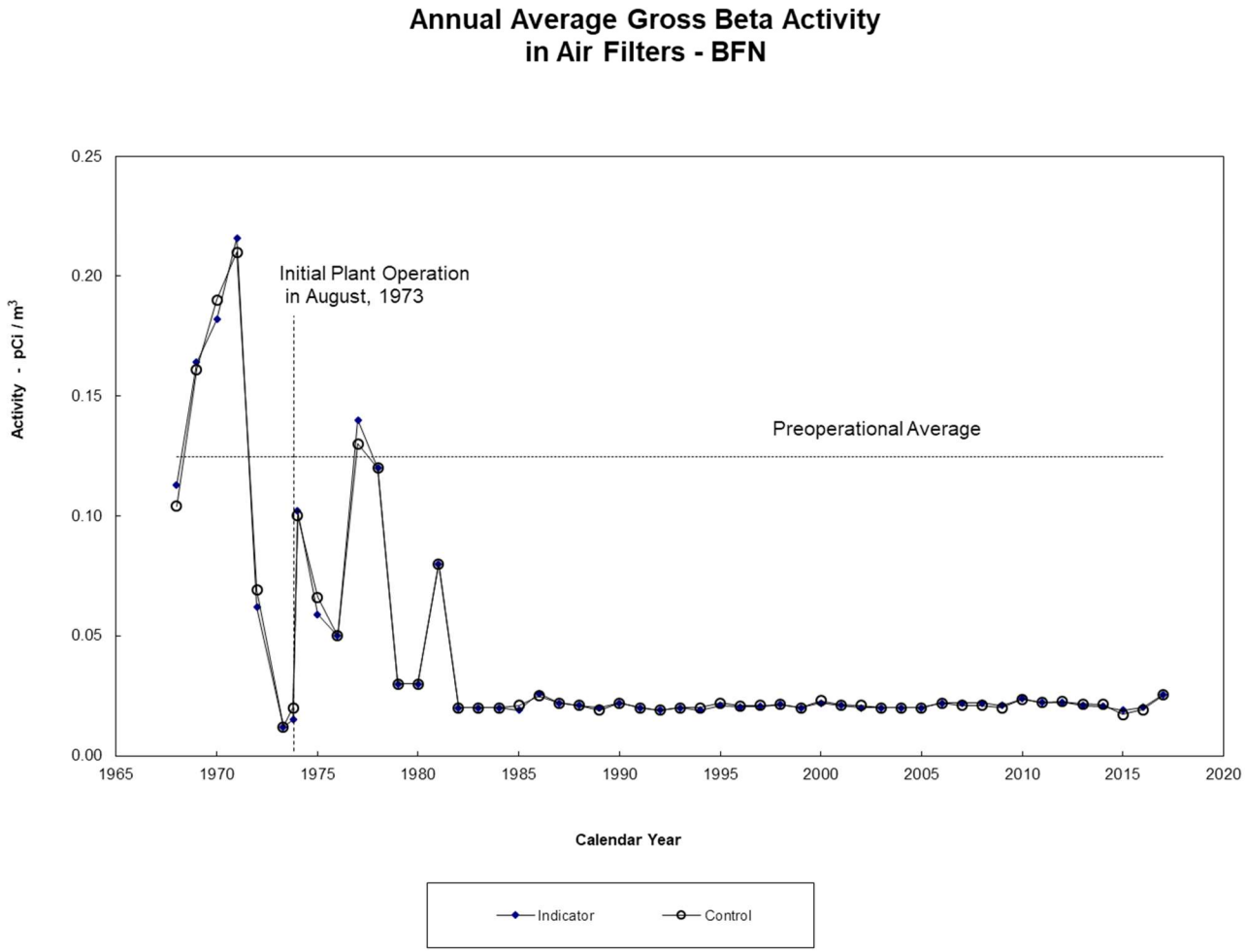

Annual Average Gross Beta Activity
in Air Filters - BFN
Activity - pCi / m3
0.25
0.20
0.15
0.10
0.05
0.00
Initial Plant Operation
in August, 1973
Preoperational Average
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Calendar Year
Indicator
Control

Table 14 - 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/m³)	I-131 572	0.07	< LLD (0/468)	< LLD	< LLD	< LLD (0/104)	0

Table 15 – 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/m³)	Gamma Isotopic 143	Various [b]	< LLD (0/117)	< LLD	< LLD	< LLD (0/26)	0

NOTES

a. Natural occurring radionuclides (Pb-212, Bi-214 and others) were observed in quarterly composite air samples in 2017.
b. See Appendix E Table 6 and Table 8 for the required and nominal LLDs for individual radionuclides via gamma isotopic analysis.

Table 16 – 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	11	Various [a]	< LLD (0/9)	< LLD	< LLD	< LLD (0/2)	0
	Cs-137	11	180	198 (6/9) 148 - 266	LM-6, 3 Mi.SSW	266 (1/1) 266 - 266	144 (2/2) 134 - 153	0
	Sr-89	11	1.6	< LLD (0/9)	< LLD	< LLD	< LLD (0/2)	0
	Sr-90	11	0.4	< LLD (0/9)	< LLD	< LLD	< LLD (0/2)	0

NOTES

a. See Appendix E Table 6 and Table 8 for the required and nominal LLDs for individual radionuclides via gamma isotopic analysis.

Figure 8

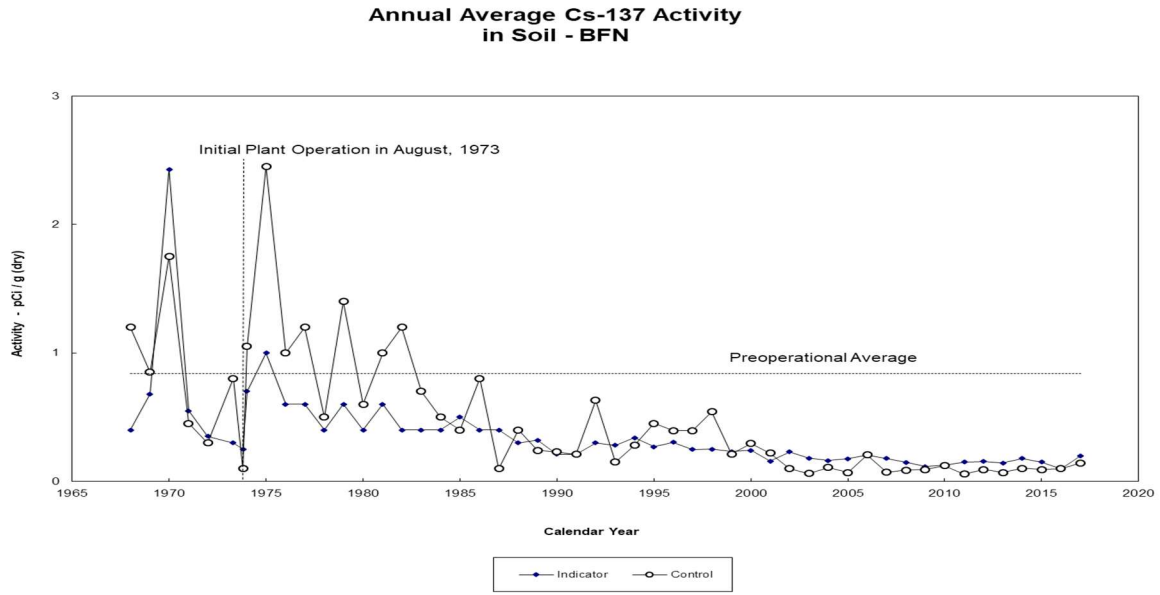


Table 17 – Annual Local Crops Radioactivity

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)		
Apples Ingestion (pCi/kg)	Gamma Isotopic	2	Various [a]	< LLD (0/1)	< LLD	< LLD	< LLD (0/1)	0
Cabbage Ingestion (pCi/kg)	Gamma Isotopic	2	Various [a]	< LLD (0/1)	< LLD	< LLD	< LLD (0/1)	0
Corn Ingestion (pCi/kg)	Gamma Isotopic	2	Various [a]	< LLD (0/1)	< LLD	< LLD	< LLD (0/1)	0
Potatoes Ingestion (pCi/kg)	Gamma Isotopic	2	Various [a]	< LLD (0/1)	< LLD	< LLD	< LLD (0/1)	0
Green Beans Ingestion (pCi/kg)	Gamma Isotopic	2	Various [a]	< LLD (0/1)	< LLD	< LLD	< LLD (0/1)	0
Tomatoes Ingestion (pCi/kg)	Gamma Isotopic	2	Various [a]	< LLD (0/1)	< LLD	< LLD	< LLD (0/1)	0

NOTES

a. See Appendix E Table 6 and Table 8 for the required and nominal LLDs for individual radionuclides via gamma isotopic analysis.

Table 18 – 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)	Gross Beta [b]	26	4.0	2.38 (6/13) 1.48 – 3.24	TRM 306 [d]	2.55 (6/13) 1.78 – 3.21	2.55 (6/13) 1.78 – 3.21	0
Surface Water Direct Exposure (pCi/L)	Gamma Isotopic	26	Various [e]	< LLD (0/13)	< LLD	< LLD	< LLD (0/13)	0
Surface Water Direct Exposure (pCi/L)	Tritium [c]	8	2000	284 (2/4) 238 - 330	TRM 293.5	284 (2/4) 238 - 330	241 (2/4) 215 - 266	0

NOTES

a. Natural occurring radionuclides (Pb-212, Bi-214 and others) were observed in surface water samples in 2017.
b. Gross beta samples are not required by BFN ODCM for surface water samples
c. BFN ODCM only requires quarterly tritium samples on surface water samples
d. The location with the highest annual mean is a control location.
e. See Appendix E Table 6 and Table 8 for the required and nominal LLDs for individual radionuclides via gamma isotopic analysis.

Table 19 – 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	65	4.0	2.89 (18/52)	TRM 259.6	3.42 (5/13) 2.20 – 7.04	2.55 (2/13) 1.78 – 3.21	0
Drinking Water Ingestion (pCi/L)	Gamma Isotopic	65	Various [b]	< LLD (0/52)	< LLD	< LLD	< LLD (0/13)	0
Drinking Water Ingestion (pCi/L)	Tritium	20	2000	286 (4/16) 233 - 368	TRM 274.9	368 (1/4) 368 - 368	241 (2/4) 215 - 266	0

NOTES

a. Natural occurring radionuclides (Pb-212, Bi-214 and others) were observed in surface water samples in 2017.
b. See Appendix E Table 6 and Table 8 for the required and nominal LLDs for individual radionuclides via gamma isotopic analysis.

Table 20 – Quarterly 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 [b]	10	4.0	9.58 (5/5) 3.54 – 19.7	Well #6R, 0.12 Mi., NW	9.58 (5/5) 3.54 – 19.7	5.42 (1/5) 5.42 – 5.42	0
Ground Water Ingestion (pCi/L)	Gamma Isotopic	26	Various [c]	< LLD (0/13)	< LLD	< LLD	< LLD (0/13)	0
Ground Water Ingestion (pCi/L)	Tritium	8	2000	300 (2/4) 240 - 360	Well #6R, 0.12 Mi., NW	300 (2/4) 240 - 360	49.3 (2/4) 46.5 – 52.1	0

NOTES

a. Natural occurring radionuclides (Pb-212, Bi-214 and others) were observed in ground water samples in 2017.
b. Gross beta analysis is not required by the BFN ODCM.
c. See Appendix E Table 6 and Table 8 for the required and nominal LLDs for individual radionuclides via gamma isotopic analysis.

Table 21 – 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	4	Various [c]	< LLD (0/2)	< LLD	< LLD	< LLD (0/2)	0
	Cs-137	4	150	< LLD (0/2)	Guntersville Reservoir [b]	.022 (1/2) 0.022 – 0.022	.022 (1/2) 0.022 – 0.022	0
Commercial Fish Ingestion (pCi/kg)	Gamma Isotopic	5	Various [c]	< LLD (0/3)	< 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.
b. The location with the highest annual mean for Cs-137 in game fish is the control location.
c. See Appendix E Table 6 and Table 8 for the required and nominal LLDs for individual radionuclides via gamma isotopic analysis.

Table 22 – 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	6	Various[c]	< LLD (0/4)	< LLD	< LLD	< LLD (0/2)	0
	Cs-137	6	180	0.01 (1/4) 0.01 -0.01	TRM 305 [b]	0.27 (1/2) 0.27 – 0.27	0.27 (1/2) 0.27 – 0.27	0

NOTES

a. Natural occurring radionuclides (Pb-212, Bi-214 and others) were observed in surface water samples in 2017.
b. The location with the highest annual mean for Cs-137 in shoreline sediment is a control location.
c. See Appendix E Table 6 and Table 8 for the required and nominal LLDs for individual radionuclides via gamma isotopic analysis.

APPENDIX I ERRATA TO PREVIOUS ANNUAL ENVIRONMENTAL OPERATING REPORTS

Errata to Previous AREORs

There are no identified errors in previous AREORs.