your energy partner®

OPPD

Omaha Public Power District

April 26, 2017
LIC-17-0042

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

Fort Calhoun Station, Unit No. 1
Renewed Facility Operating License No. DPR-40
NRC Docket No. 50-285

Subject: Fort Calhoun Station (FCS) Radiological Effluent Release Report and Radiological Environmental Operating Report

References: FCS Technical Specifications (TS) 5.9.4a and 5.9.4b

Pursuant to Fort Calhoun Station (FCS), Unit No. 1, Technical Specifications (TS) 5.9.4a, and 5.9.4b, the Omaha Public Power District (OPPD) provides the Annual Radiological Effluent Release Report and the Annual Radiological Environmental Operating Report.

The Annual Radiological Effluent Release Report is submitted in accordance with TS 5.9.4a and encompasses the period of January 1, 2016 through December 31, 2016. The report is presented in the format outlined in Regulatory Guide 1.21, Revision 1. In addition, the report provides the results of quarterly dose calculations performed in accordance with the Offsite Dose Calculation Manual (ODCM). In accordance with TS 5.17d, Section VII of the Annual Radiological Effluent Release Report includes the revisions to the ODCM made during this period. Section VII of the Annual Radiological Effluent Release Report also includes Process Control Program changes made during this period.

The Annual Radiological Environmental Operating Report is submitted in accordance with TS 5.9.4b and encompasses the period of January 1, 2016 through December 31, 2016.

No commitments to the NRC are contained in this letter.

444 SOUTH 16TH STREET MALL • OMAHA, NE 68102-2247

Please contact Mr. Bradley H. Blome at (402) 533-7270 if you should have any questions.

Respectfully,

Bradley H. Blome
Director, Licensing and Regulatory Assurance

BHB/epm

Enclosures:

1. Annual Radiological Effluent Release Report
2. Annual Radiological Environmental Operating Report

c: K. M. Kennedy, NRC Regional Administrator, Region IV
J. S. Kim, NRC Project Manager
S. M. Schneider, NRC Senior Resident Inspector

Omaha Public Power District

MEMORANDUM

Date: April 19, 2017 FC-C-004-17

From: Plant Manager, Fort Calhoun Station

To: Distribution

Re: Annual Radiological Effluent Release Report for Technical Specification Section 5.9.4.a.
January 1, 2016 through December 31, 2016

Attached is a copy of the 2016 Annual Radiological Effluent Release Report for January 1, 2016 through December 31, 2016. This report is submitted in accordance with Section 5.9.4.a of the Technical Specifications of Fort Calhoun Station Unit No. 1, Facility Operating License DPR-40. The Effluent Report is presented in the format outlined in Regulatory Guide 1.21, Revision 2.

In addition, this report provides the results of quarterly dose calculations performed in accordance with the Offsite Dose Calculation Manual. Results are presented by quarter for the period January 1, 2016 through December 31, 2016. Any changes made during the preceding twelve months to the Offsite Dose Calculation Manual and/or the Process Control Program for the Fort Calhoun Station are described and included.

Plant Manager
Fort Calhoun Station

Distribution:

Senior Director FCS Decom
Plant Manager
Director-Nuclear Engineering
Director-Rad Prot and Chemistry
Director-Lic and Reg Assurance
Assistant Plant Manager Operations
Manager-Radiation Protection
Manager-Site Chemistry
Supervisor-RP (Chem/Environ)
Supervisor-RP (ALARA/Shipping)

Omaha Public Power District
Fort Calhoun Station Unit No. 1

Annual Report
For
Technical Specifications,
Section 5.9.4.a

January 1, 2016 to December 31, 2016

DOCKET NO. 50-285 OPERATING LICENSE DPR-40

Annual Radiological Effluent Release Report

This report is submitted in accordance with Section 5.9.4.a of the Technical Specifications of Fort Calhoun Station Unit No. 1, Facility Operating License DPR-40 for the period January 1, 2016 through December 31, 2016. The Effluent Report is presented in the format outlined in Regulatory Guide 1.21, Revision 2.

In addition, this report provides the results of quarterly dose calculations performed in accordance with the Offsite Dose Calculation Manual. Results are presented by quarter for the period January 1, 2016 through December 31, 2016.

Descriptions of any changes made during the preceding twelve months to the Offsite Dose Calculation Manual and/or the Process Control Program for the Fort Calhoun Station are presented.

Plant Manager

TABLE OF CONTENTS

TABLE OF CONTENTS

1.0 INTRODUCTION

This Annual Radiological Effluent Release Report, for Fort Calhoun Station Unit No. 1, is submitted as required by Technical Specification 5.9.4.a for the period January 1, 2016 through December 31, 2016.

1.1 Executive Summary

The Radioactive Effluent Monitoring program for the year 2016 was conducted as described in the following report. Major efforts were made to maintain the release of radioactive effluents to the environment as low as reasonably achievable.

The total airborne activity released from noble gas was 1.04 curies. This was a decrease from the 2015 activity of 1.31 curies. This decrease was due to decrease in RCS source from past fuel failures.

The total airborne activity from I-131, I-133, and particulates with half-lives > 8 days in 2016 was 0.00 curies. This a decrease from the 2015 activity of 3.70E-06 curies. Due to plant decommissioning, the scheduled outage maintenance scope was dramatically reduced.

The total airborne activity from Tritium was 2.99 curies. This was an increase from the 2015 activity of 2.88 curies. This increase was due to maintaining containment purges post defuel to assist in preparing the plant for decommissioning activities.

The total airborne activity from C-14 was 1.97 curies. This was the same as 2015. Airborne activity from C-14 is included in the 2016 annual report, per Regulatory Guide 1.21, Revision 2. This is a calculated value based on power generation and days of operation. Critical organ doses from C-14 were calculated using a ratio of 15% as CO_2. This ratio was determined during an NRC in-plant source term study conducted at the Fort Calhoun Station between 1976 and 1977, NUREG/CR-0140. The power history for the year was essentially the same as 2015.

Dose contributions from airborne effluents at the unrestricted area boundary were; 1.28 E-03 mRad gamma air dose, 5.70E-04 mRad beta air dose, 8.68E-02 mRem total body dose, and 4.20E-01 mRem critical organ dose. Gamma and beta dose showed a decrease from 2015 levels of 1.35 E-03 mRad gamma air dose and 6.66-04 mRad beta air dose, from not releasing iodines and a reduction in gas source term for Cycle 28. Whole body and critical organ doses decreased from 2015 levels of 9.97E-02 mRem total body dose and 4.83E-01 mRem critical organ dose. This decrease is attributed to the gas source term reduction previously mentioned.

Total water activity (excluding tritium, dissolved gases, and alpha) released in 2016 in liquid effluents was 4.34E-02 curies. This was an increase from the 2015 activity of 1.21E-02 curies. Outage scoping resource decisions did not allow for repairs to leakage from RCS Pressurizer Quench Tank and Safety Injection Tanks. Troubleshooting activities slowed, but did not stop SIT leakage. Processing this leakage depleted FIX processing resins. The majority (96%) of the released activity was CS-137, which has one of the lowest IX selectivity coefficients. New wastes entered the FIX system and selectively removed metallic ions, and then released CS-137 previously captured. The total activity released increased due to a decrease in rad waste processing efficiency. The FIX system, which processes liquid waste, could not have its resin sluiced due to a broken crane and a lack of available space to sluice or transfer waste resin. Resin shipping container space was limited due to failure of a lateral in one of the primary IX vessels necessitating unanticipated resin sluices so RCS chemistry could be maintained within specifications. The total water tritium activity released in 2016 in liquid effluents was 149 curies. This was a decrease from the 2015 activity of 158 curies. This decrease was due to having to increase RCS makeup water due to increased RCS Pressurizer Quench Tank and Safety Injection Tank leakage the past two cycles.

The calculated whole body dose due to liquid effluents at the site discharge from all sources in 2016 was 2.11E-01 mRem which was 7.03% of the annual dose limit. This was an increase from the 2015 dose of 3.11-02 mRem, which was 1.04% of the annual dose limit. Dose increased slightly due to an increase in released activity; station release volume and dilution flow were unchanged.

The calculated critical organ dose due to liquid effluents at the site discharge from all sources in 2016 was 3.26E-01 mRem. This was an increase from the 2015 dose of 4.40E-02 mRem. Dose increased due to an increase in released activity; station release volume and dilution flow were unchanged.

The Fort Calhoun Station meteorological system had a cumulative recovery rate of 99.46% from the station meteorological tower with the remaining 0.54% provided by the National Weather Service, for the joint frequency parameters required by Regulatory Guide 1.23 for wind speed, wind direction, and delta temperature.

There were no abnormal releases during 2016.

During 2016 there was one change to the Off-site Dose Calculations Manual (ODCM), CH-ODCM-0001 and no changes to the Process Control Program, RW-AA-100.

For 2016, the total volume of solid radwaste released from the unit was 69.04 cubic meters. This was a decrease from the 580 cubic meters of solid waste released from the unit in 2015. The decrease was attributed to only two shipments made in 2016.

The total activity released from the unit for 2016 was 2.16E-02 curies, 0.00 curies from spent resin and 2.16E-02 curies from dry compressables. This was a decrease from the 2015 value of 0.711 curies. Overall, the effluent monitoring program was conducted in a manner to ensure the activity released and dose to the public were maintained as low as reasonably achievable.

2.0 SUPPLEMENTAL INFORMATION

2.1 Regulatory Limits

The ODCM Radiological Effluent Control Specifications applicable to the release of radioactive material in liquid and gaseous effluents are described in the following sections.

2.1.1 Fission and Activation Gases (Noble Gases)

The release rate of radioactive material in airborne effluents shall be controlled such that the instantaneous concentrations of radionuclides do not exceed the values specified in 10 CFR 20 for airborne effluents at the unrestricted area boundary. To support plant operations, Supervisor - System Chemistry may increase this limit up to the limits specified in Technical Specification 5.16.1.g.

Technical Specification 5.16.1.g establishes the administrative control limit on the concentration resulting from radioactive material, other than noble gases, released in gaseous effluents to unrestricted areas conforming to ten times 10 CFR 20.1001-20.2401, Appendix B, Table 2, Column 1. For noble gases, the concentration shall be limited to five times 10 CFR 20.1001-20.2401, Appendix B, Table 2, Column 1.

The air dose due to noble gases released in gaseous effluents to areas at or beyond the unrestricted area boundary shall be limited to the following:

a. During any calendar quarter: Less than or equal to 5 mRad for gamma radiation and less than or equal to 10 mRad for beta radiation, and

b. During any calendar year: Less than or equal to 10 mRad for gamma radiation and less than or equal to 20 mRad for beta radiation.

2.1.2 Doses from I-131, I-133, C-14, Tritium, and Radioactive Material in Particulate Form with Half Lives Greater than 8 Days (Other than Noble Gases).

a. The dose to an individual or dose commitment to any organ of an individual in unrestricted areas due to the release of I-131, I-133, C-14, H-3, and radioactive material in particulate form with half-lives greater than eight days (other than noble gases) in airborne effluents shall not exceed 7.5 millirem from all exposure pathways during any calendar quarter.

b. The dose to an individual or dose commitment to any organ of an individual in unrestricted areas due to the release of I-131, I-133, C-14, H-3, and radioactive materials in particulate form with half-lives greater than eight days (other than noble gases) in airborne effluents shall not exceed 15 millirem from all exposure pathways during any calendar year.

2.1.3 Liquid Effluents

The release rate of radioactive material in liquid effluents shall be controlled such that the instantaneous concentrations for radionuclides, other than dissolved or entrained noble gases, do not exceed the values specified in 10 CFR 20 for liquid effluents at site discharge. To support plant operations, the Supervisor - System Chemistry may increase this limit up to the limit specified in Technical Specifications 5.16.1.b.

Technical Specification 5.16.1.b establishes the administrative control limit on concentration of radioactive material, other than dissolved or entrained noble gases, released in liquid effluents to unrestricted areas conforming to ten times 10 CFR 20.1001-20.2401, Appendix B, Table 2, Column 2. For dissolved or entrained noble gases, the concentration shall be limited to 2.0E-04 μCi/mL total activity.

The dose or dose commitment to a MEMBER OF THE PUBLIC from radioactive materials in liquid effluents released to unrestricted areas shall be limited to:

a. During any calendar quarter: Less than or equal to 1.5 mRem to the whole body and less than or equal to 5 mRem to any organ, and

b. During any calendar year: Less than or equal to 3 mRem to the whole body and less than or equal to 10 mRem to any organ.

2.1.4 Total Dose-Uranium Fuel Cycle

The dose to any individual from uranium fuel cycle sources shall be limited to ≤ 25 mRem to the total body or any organ (except the thyroid, which shall be limited to ≤ 75 mRem) during each calendar year.

2.2 Effluent Concentration Limits (ECL)

2.2.1 Liquid Effluents

The values specified in 10 CFR Part 20, Appendix B, Column 2 are used as the ECL for liquid radioactive effluents released to unrestricted areas. A value of 2.0E-04 µCi/mL is used as the ECL for dissolved and entrained noble gases in liquid effluents.

2.2.2 Gaseous Effluents

The values specified in 10 CFR Part 20, Appendix B, Column 1 are used as the ECL for gaseous radioactive effluents released to unrestricted areas.

2.3 Measurements and Approximations of Total Radioactivity

Measurements of total radioactivity in liquid and gaseous radioactive effluents were accomplished in accordance with the sampling and analysis requirements of Tables 3.1 and 3.2 of Part I of the ODCM.

2.3.1 Liquid Radioactive Effluents

Each batch was sampled and analyzed for gamma emitting radionuclides using gamma spectroscopy, prior to release. Composite samples were analyzed monthly and quarterly for the Monitor Tanks and Steam Generators. Composite samples were analyzed monthly in the onsite laboratory for tritium and gross alpha radioactivity, using liquid scintillation and proportional counting techniques respectively. Composite samples were analyzed quarterly for Sr-89, Sr-90, Fe-55, Ni-63, and Gross Alpha by a contract laboratory (Teledyne Brown Engineering, Inc.). A software program was used to project the total body and critical organ dose contribution at the unrestricted area boundary for each release and the percent contribution to the annual objective dose.

There were no continuous releases from the Steam Generator blowdown during the reporting period.

2.3.2 Gaseous Radioactive Effluents

Each gaseous batch release was sampled and analyzed for radioactivity prior to release. For release of Waste Gas Decay Tanks, noble gas grab samples were analyzed for gamma emitting radionuclides using gamma spectroscopy. For releases from the Containment Building, samples were taken using charcoal and particulate filters, in addition to noble gas and Tritium grab samples, and analyzed for gamma emitting radionuclides prior to each release. The results of the analysis and the total volume of effluent released were used to determine the total amount of radioactivity released in the batch mode. A software program was developed and installed that can project the total body and critical organ dose contribution at the unrestricted area boundary for each release and the percent contribution to the annual objective dose. This program also adds the projected dose to the current actual dose totals in a temporary file, until it is updated with actual release data at the completion of a purge.

Continuous release effluent pathways were continuously sampled using charcoal and particulate filters and analyzed weekly for gamma emitting radionuclides using gamma spectroscopy. Weekly particulate filters were analyzed for gross alpha radioactivity in the onsite laboratory using proportional counting techniques. Quarterly composites of particulate filters were analyzed for Sr-89, Sr-90, and Gross Alpha by a contract laboratory (Teledyne Brown Engineering, Inc.).

2.4 Estimation of Total Percent Error

The estimated total percent error is calculated as follows:

Total Percent Error = $(E_1^2 + E_2^2 + E_3^2 + ... + E_n^2)^{0.5}$
Where E_n = percent error associated with each contributing parameter.

Sample counting error is estimated by the Canberra Genie System Software for samples analyzed by gamma spectroscopy. This calculation can include the error associated with peak area determination, gamma ray abundance, efficiency and half-life. Systematic error is estimated for gaseous and liquid effluent analyses and dilution and wastewater volume.

2.5 Batch Releases

A summary of information for liquid and gaseous batch releases is included in Table III.1.

2.6 Abnormal Releases

Abnormal Releases are defined as unplanned and unmonitored releases of radioactive material from the site.

A summary of information for liquid and gaseous abnormal releases is included in Table III.2.

3.0 GASEOUS EFFLUENTS

The quantities of radioactive material released in gaseous effluents are summarized in Tables III.3, III.4 and III.5. All radioactive materials released in gaseous form are considered to be ground level releases.

4.0 LIQUID EFFLUENTS

The quantities of radioactive material released in liquid effluents are summarized in Tables III.6, III.7 and III.8.

5.0 SOLID WASTES

The quantities of radioactive material released as solid effluents are summarized in Section VI.

6.0 RELATED INFORMATION

6.1 Operability of Liquid and Gaseous Monitoring Instrumentation

During the reporting period there were 3 instruments used to monitor radioactive effluent releases that failed to meet the minimum reportable instrument operability requirements listed in the ODCM during the reporting period.

RM-054A and RM-054B, Steam Generator Blowdown Effluent Line Monitors, were inoperable for 51 days (1/11/2016-3/2/2016) for a modification to plant radiation monitors. The instrument rack design necessitated that both SG radiation monitors be removed. After install and completion of primary calibrations, the monitors were returned to service. Shiftly grab samples and analysis as required in ODCM Table 3.1.1. Note 2 were performed during this unavailability.

RM-057, Condenser Off-Gas Effluent Line Radiation Monitor, was inoperable for 82 days (1/11/2016-4/2/2016) after the cabling was damaged while moving the instrument racks for the SG radiation monitor upgrade. The unavailability of replacement parts prevented the monitor from being repaired in less than 30 days. Shiftly grab samples and analysis as required in ODCM Table 3.2.1. Note 5 were performed during this unavailability.

6.2 Changes to the Offsite Dose Calculation Manual (ODCM) and/or Process Control Program

During 2016, one revision was made to the ODCM and no changes made to the PCP. The following change was made to the ODCM:

- To remove the term Plant Review Committee and replaced with Plant Operations Review Committee

6.3 New Locations or Modifications for Dose Calculations or Environmental Monitoring

- Sample Station #75, Lomp Acreage was added.

- Sample Station #28, Alvin Pechnik Farm was removed after the 2016 samples were obtained.

6.4 Noncompliance with Radiological Effluent Control Requirements

This section provides a list of any event that did not comply with the applicable requirements of the Radiological Effluent Controls given in the Offsite Dose Calculation Manual (ODCM). Detailed documentation concerning the evaluations and corrective actions is maintained onsite.

6.4.1 Abnormal Gaseous and Liquid Releases

No abnormal releases were made during the calendar year of 2016.

6.4.2 Failure to Meet Specified Sampling Requirements

During 2016, there were no instances in which specified sampling requirements were not met.

6.5 Modifications to Liquid and Gaseous Waste Treatment and Ventilation Exhaust Systems

During the reporting period no design modifications were approved nor implemented involving major changes to the Liquid and Gaseous Waste Treatment Systems.

6.6 Meteorological Monitoring Program

A summary of hourly meteorological data, collected during 2016, is retained onsite and is maintained as documentation as required by Regulatory Guide 1.21 Rev 2. This data is available for review by the Nuclear Regulatory Commission upon request. Joint Frequency tables are included in Section VII, Attachment 2

Real time hourly meteorological data is used to calculate the annual air effluent dose to individuals. For quarterly estimates during the year an annual average X/Q is used, which is an average of the highest X/Q's calculated for each of the previous two years.

6.7 Assessment of Doses

6.7.1 Doses Due to Liquid Effluents

Total body, skin, and organ dose for liquid releases were calculated in mRem for all significant liquid pathways using the annual configuration of the LADTAP II program. The site discharge location was chosen to present a most conservative estimate of dose for an average adult, teenager, child, and infant. A conservative approach is also presented by the assumption that Omaha and Council Bluffs receive all drinking water from the Missouri River.

The LADTAP II program in its annual configuration was also used to calculate the total body and organ doses for the population of 950,006 within a 50-mile radius of the plant (based on the 2010 census). The results of the calculations are listed in Section V.

The doses due to liquid effluents for total body and critical organ are also calculated quarterly using the methods in the ODCM. The results are listed in Section II.

6.7.2 Doses Due to Gaseous Effluents

Total body, skin and organ doses from ground releases were calculated in mRem to an average adult, teenager, child, and infant in each receptor using the annual configuration of the GASPAR II program. Also, the doses to the same groups, in units of mRad due to gamma and beta radiation carried by air, were computed using GASPAR II.

The GASPAR II program in its annual configuration was also used to calculate the ALARA integrated population dose summary for the total body, skin and organ doses in person-rem for all individuals within a 50-mile radius. The results of the calculations are shown in Section IV.

The doses due to gaseous effluents for total body gamma and beta noble gas air dose are calculated quarterly using the methods in the ODCM with an annual average X/Q. The results are listed in Section II.

6.7.3 Doses Due to I-131, I-133, C-14, H-3, and Particulates with Half Lives Greater than 8 days.

The doses due to I-131, I-133, C-14, H-3, and Particulates with half-lives greater than 8 days for total body and critical organ dose are calculated quarterly using the highest of infant or child dose factors and an annual average X/Q. The results are listed in Section II for inhalation, ground and food.

6.7.4 Direct Radiation Dose to Individuals and Populations

Direct radiation doses attributed to the gamma radiation emitted from the containment structure were not observed above local background at any TLD sample locations for this annual period.

6.7.5 40 CFR 190 Dose Evaluation

ODCM Radiological Effluent Controls require dose evaluations and a special report to demonstrate compliance with 40 CFR Part 190 only if calculated yearly doses exceed two times the annual design objectives for liquid and/or gaseous effluents. At no time during 2016 were any of these limits exceeded; therefore, no special report per Tech Specification 5.16 was required.

The external Total Body Dose is comprised of:

1) Total Body Dose due to noble gas radionuclides in gaseous effluents
2) Dose due to radioactive waste and the ISFSI
3) Total Body Dose due to radioactivity deposited on the ground (this dose is accounted for in the determination of the non-noble gas dose and is not considered here)

The Total Body Dose, external is given by:
Dext = Dtb + Dosf

Where Dext is the external dose
Dtb is the total body dose
Dosf is the dose from on-site storage

The Total Dose is then given by:
Dtot = Dext + Dliq + Dnng

Where Dtot is the total dose
Dext is the external dose
Dliq is the dose from liquid effluents
Dnng is the dose from non-noble gases

<u>Dose Limits</u>

Total Body, annual	25 mrem
Thyroid, annual	75 mrem
Other Organs, annual	25 mrem

Calculation using REMP TLD Comparison

Indicating TLD station {OTD-B-(I)}, closest to on site storage, in mrem/week minus REMP environmental control {OTD-L-(C)}, in mrem/week

Dext=1.38 – 1.18 * 52 weeks =10.4 mrem

Maximum offsite doses from report

Dtbwb=0.0868 mrem, Dtbco=0.42 mrem

D liqwb=0.211mrem   Dliqco=0.326 mrem

Dtot wholebody=10.4+0.0868+0.211= 10.7 mrem

Dtot critical organ=10.4+0.42+0.326= 11.2 mrem

For cases when the general public accesses the site, see Table 18 of the ODCM, the calculated dose would be:

Dtot wholebody=10.4+5.08+0.211= 15.7 mrem

Dtot critical organ=10.4+1.20+0.326= 11.9 mrem

These reported doses are bounding cases demonstrating compliance. Actual REMP TLD readings do not show any deviation from historical averages for this location, both pre and post construction of the SG storage mausoleum and ISFSI. On-site TLD's used for dose monitoring at onsite rad storage facilities do not have identical counterparts at the site boundary or actual offsite receptors. Additionally the liquid dose pathway, since it is downstream of the indicator location and is not hydro-geologically connected, would produce very conservative results compared to calculating actual dose.

6.8 Groundwater Monitoring Program and Observations

- OPPD conducted groundwater sampling from 19 wells, 2 surface water sites, and 4 storm water headers within the site property per NEI 07-07. Additionally Nebraska requirements regarding avoidance of snow runoff were deleted, so storm water sampling is now performed quarterly, if available.

- No new monitoring wells were added to the sampling program during 2016. Additional radiological surveys were performed during decommissioning characterization, no plant related nuclides were discovered in soil. Ten sample locations in sectors experiencing significant (>10%) wind direction were established to assess potential atmospheric deposition. After an initial sampling regime in all ten sectors displayed no detectable tritium, the sampling program was switched to 2 affected sectors per rain event and an upwind background test. Four rain sampling events were conducted. No tritium activity in excess of the vendor's Minimum Detectable Activity (MDA) was reported. Fourth quarter had no rain or snow events significant enough to collect storm water samples. No tritium activity in excess of the vendor's Minimum Detectable Activity (MDA) was reported in collected storm water.

- No monitoring wells had tritium in excess of the vendor's Minimum Detectable Activity (MDA) reported in Table III.9. Some hard to detect nuclides, were reduced to an annual sample frequency (Ni-63, Fe-55, Sr-90 in deep wells) based on 2 years of quarterly sampling with no detections above MDA.

- The Fort Calhoun REMP sampling did not detect tritium in samples within the Missouri River downstream at the site boundary or at the nearest municipal drinking water facility. No groundwater drinking pathway exists on site. Groundwater monitoring of neighboring drinking wells is performed to have data, if a plume were identified on site. No state or federal drinking water limits, and no site groundwater protection program administrative limits were exceeded.

SECTION II

QUARTERLY DOSES FROM EFFLUENTS

Offsite Dose Calculation Manual

January 1, 2016 - December 31, 2016

Quarterly Dose Calculation Results

January 1, 2016 through December 31, 2016

With the implementation of the Fort Calhoun Station Radiological Effluent Technical Specifications (RETS) on October 1, 1985, radiation doses in the unrestricted area from liquid and gaseous effluents must be calculated on a quarterly basis in accordance with the Offsite Dose Calculation Manual (ODCM). These calculations are performed to ensure the annual dose limits delineated in Appendix I of 10 CFR 50 and implemented by RETS are not exceeded. If the results of the quarterly calculations exceed fifty percent (50%) of the annual limits of Appendix I, actions are taken to reduce effluents so that the resultant doses do not exceed the annual limits during the remainder of the year and a special report is submitted to the Nuclear Regulatory Commission. No special reports were required for 2016 calculated doses.

This section presents the results of the quarterly dose calculations performed during the period January 1, 2016 through December 31, 2016. Details are shown as to the types, sources and resultant doses from the effluents, the annual limits and a comparison to the annual limits.

FORT CALHOUN STATION
CHEMISTRY FORM

FC-421
R8

QUARTERLY CUMULATIVE DOSE CONTRIBUTION FROM RADIOACTIVE EFFLUENTS
FORT CALHOUN FIRST QUARTER 2016 DOSE PROJECTIONS

I. Liquid Effluents:	Total Body Dose (mrem)	Critical Organ Dose (mrem)
Batch:	1.51E-02	2.19E-02
Continuous:	0.00E+00	0.00E+00
Totals:	1.51E-02	2.19E-02
ODCM Quarterly Objective:	1.50E+00	5.00E+00
Percent of Quarterly Obj:	1.01 %	0.44 %
ODCM Annual Objective:	3.00E+00	1.00E+01
YTD Percent of Annual Obj:	0.50 %	0.22 %

II. Gaseous Effluents:	Total Body Gamma Dose (mrad)	Total Body Beta Dose (mrad)
A. Noble Gas Air Dose:	6.64E-04	2.85E-04
ODCM Quarterly Objective:	5.00E+00	1.00E+01
Percent of Quarterly Obj:	0.01 %	0.00 %
ODCM Annual Objective:	1.00E+01	2.00E+01
YTD Percent of Annual Obj:	0.01 %	0.00 %

B. I-131, I-133, Tritium, C-14, and Particulates with Half-Lives > 8 Days:	Total Body Dose (mrem)	Critical Organ Dose (mrem)
Inhalation:	2.09E-04	2.09E-04
Ground and Food:	4.91E-02	2.41E-01
Totals:	4.93E-02	2.41E-01
ODCM Quarterly Objective:	7.50E+00	7.50E+00
Percent of Quarterly Obj:	0.66 %	3.22 %
ODCM Annual Objective:	1.50E+01	1.50E+01
YTD Percent of Annual Obj:	0.33 %	1.61 %

Reviewed by: [signature]

QUARTERLY CUMULATIVE DOSE CONTRIBUTION FROM RADIOACTIVE EFFLUENTS
FORT CALHOUN SECOND QUARTER 2016 DOSE PROJECTIONS

I. Liquid Effluents:	Total Body Dose (mrem)	Critical Organ Dose (mrem)
Batch:	4.89E-02	7.54E-02
Continuous:	0.00E+00	0.00E+00
Totals:	4.89E-02	7.54E-02
ODCM Quarterly Objective:	1.50E+00	5.00E+00
Percent of Quarterly Obj:	3.26 %	1.51 %
ODCM Annual Objective:	3.00E+00	1.00E+01
YTD Percent of Annual Obj:	2.13 %	0.97 %

II. Gaseous Effluents:	Total Body Gamma Dose (mrad)	Total Body Beta Dose (mrad)
A. Noble Gas Air Dose:	6.70E-04	2.88E-04
ODCM Quarterly Objective:	5.00E+00	1.00E+01
Percent of Quarterly Obj:	0.01 %	0.00 %
ODCM Annual Objective:	1.00E+01	2.00E+01
YTD Percent of Annual Obj:	0.01 %	0.00 %

B. I-131, I-133, Tritium, C-14, and Particulates with Half-Lives > 8 Days:	Total Body Dose (mrem)	Critical Organ Dose (mrem)
Inhalation:	1.94E-04	1.94E-04
Ground and Food:	4.57E-02	2.24E-01
Totals:	4.59E-02	2.24E-01
ODCM Quarterly Objective:	7.50E+00	7.50E+00
Percent of Quarterly Obj:	0.61 %	2.99 %
ODCM Annual Objective:	1.50E+01	1.50E+01
YTD Percent of Annual Obj:	0.64 %	3.10 %

Reviewed by: JMS

FORT CALHOUN STATION
CHEMISTRY FORM

FC-421
R8

QUARTERLY CUMULATIVE DOSE CONTRIBUTION FROM RADIOACTIVE EFFLUENTS
FORT CALHOUN THIRD QUARTER 2016 DOSE PROJECTIONS

I. Liquid Effluents:	Total Body Dose (mrem)	Critical Organ Dose (mrem)
Batch:	1.02E-01	1.58E-01
Continuous:	0.00E+00	0.00E+00
Totals:	1.02E-01	1.58E-01
ODCM Quarterly Objective:	1.50E+00	5.00E+00
Percent of Quarterly Obj:	6.80 %	3.16 %
ODCM Annual Objective:	3.00E+00	1.00E+01
YTD Percent of Annual Obj:	5.53 %	2.55 %

II. Gaseous Effluents:	Total Body Gamma Dose (mrad)	Total Body Beta Dose (mrad)
A. Noble Gas Air Dose:	8.47E-04	3.62E-04
ODCM Quarterly Objective:	5.00E+00	1.00E+01
Percent of Quarterly Obj:	0.02 %	0.00 %
ODCM Annual Objective:	1.00E+01	2.00E+01
YTD Percent of Annual Obj:	0.02 %	0.00 %

B. I-131, I-133, Tritium, C-14, and Particulates with Half-Lives > 8 Days:	Total Body Dose (mrem)	Critical Organ Dose (mrem)
Inhalation:	1.32E-04	1.32E-04
Ground and Food:	4.85E-02	2.40E-01
Totals:	4.86E-02	2.40E-01
ODCM Quarterly Objective:	7.50E+00	7.50E+00
Percent of Quarterly Obj:	0.65 %	3.20 %
ODCM Annual Objective:	1.50E+01	1.50E+01
YTD Percent of Annual Obj:	0.96 %	4.70 %

Reviewed by: ____________

FORT CALHOUN STATION
CHEMISTRY FORM

FC-421
R8

QUARTERLY CUMULATIVE DOSE CONTRIBUTION FROM RADIOACTIVE EFFLUENTS
FORT CALHOUN FOURTH QUARTER 2016 DOSE PROJECTIONS

I. Liquid Effluents:	Total Body Dose (mrem)	Critical Organ Dose (mrem)
Batch:	7.87E-02	1.24E-01
Continuous:	0.00E+00	0.00E+00
Totals:	7.87E-02	1.24E-01
ODCM Quarterly Objective:	1.50E+00	5.00E+00
Percent of Quarterly Obj:	5.25 %	2.48 %
ODCM Annual Objective:	3.00E+00	1.00E+01
YTD Percent of Annual Obj:	8.17 %	3.78 %

II. Gaseous Effluents:	Total Body Gamma Dose (mrad)	Total Body Beta Dose (mrad)
A. Noble Gas Air Dose:	1.67E-04	1.10E-04
ODCM Quarterly Objective:	5.00E+00	1.00E+01
Percent of Quarterly Obj:	0.00 %	0.00 %
ODCM Annual Objective:	1.00E+01	2.00E+01
YTD Percent of Annual Obj:	0.02 %	0.01 %

B. I-131, I-133, Tritium, C-14, and Particulates with Half-Lives > 8 Days:	Total Body Dose (mrem)	Critical Organ Dose (mrem)
Inhalation:	4.49E-04	4.49E-04
Ground and Food:	1.49E-02	6.43E-02
Totals:	1.54E-02	6.47E-02
ODCM Quarterly Objective:	7.50E+00	7.50E+00
Percent of Quarterly Obj:	0.21 %	0.86 %
ODCM Annual Objective:	1.50E+01	1.50E+01
YTD Percent of Annual Obj:	1.06 %	5.13 %

Reviewed by: [signature]

SECTION III

RADIOLOGICAL EFFLUENT RELEASES

Technical Specification (5.9.4.a)

January 1, 2016 - December 31, 2016

TABLE III.1

BATCH LIQUID AND GASEOUS RELEASE SUMMARY

JANUARY THROUGH DECEMBER 2016

A. Liquid Releases All Sources	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	Year
1. Number of Batch Releases:	27	40	51	51	169
2. Total Time Period for Batch Releases(min):	3,667	5,420	6,491	7,311	22,889
3. Maximum Time Period for Batch Releases(min):	170	200	175	242	242
4. Average Time Period for Batch Releases(min):	136	136	127	143	135
5. Minimum Time Period for Batch Releases(min):	85	100	93	105	85
6. Average Dilution Stream Flow During Periods of Release into the Missouri River(mls/min):	1.363E+09	1.272E+09	1.363E+09	8.107E+08	1.175E+09

B. Gaseous Releases All Sources	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	Year
1. Number of Batch Releases:	13	15	14	37	79
2. Total Time Period for Batch Releases(min):	93,757	103,447	110,799	79,329	387,332
3. Maximum Time Period for Batch Releases(min):	8,898	8,802	8,796	9,000	9,000
4. Average Time Period for Batch Releases(min):	7,212	6,896	7,914	2,144	4,903
5. Minimum Time Period for Batch Releases(min):	94	1,473	4,636	30	30

TABLE III.2

ABNORMAL BATCH LIQUID AND GASEOUS RELEASE SUMMARY

JANUARY THROUGH DECEMBER 2016

A. Liquid Releases All Sources	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	Year
Number of Releases:	0	0	0	0	0
Total Activity Releases(Ci):	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

B. Gaseous Releases All Sources	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	Year
Number of Releases:	0	0	0	0	0
Total Activity Releases (Ci):	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

TABLE III.3

GASEOUS EFFLUENTS--SUMMATION OF ALL RELEASES

JANUARY THROUGH DECEMBER 2016

	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Year
A. Fission & Activation Gases					
Total Release (Ci):	2.70E-01	2.72E-01	3.39E-01	1.55E-01	1.04E+00
Average Release Rate (uCi/sec):	9.65E-04	7.94E-04	1.03E-03	1.16E-03	9.48E-04
Total Error (%): 25.98					
B. Iodines					
Total Release (Ci):	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Average Release Rate (uCi/sec):	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total Error (%): 21.2					
C. Particulates					
Total Release (Ci):	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Average Release Rate (uCi/sec):	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total Error (%): 20.62					
Gross Alpha:					
Total Error (%): 20.62	1.32E-06	3.35E-06	1.52E-06	3.86E-06	1.00E-05
D. Tritium					
Total Release (Ci):	6.37E-01	5.90E-01	4.01E-01	1.37E+00	2.99E+00
Average Release Rate (uCi/sec):	3.28E-03	2.71E-03	1.89E-03	3.78E-03	3.02E-03
Total Error (%): 25.08					
E. Carbon-14					
Total Release (Ci):	6.17E-01	5.75E-01	6.14E-01	1.65E-01	1.97E+00
Average Release Rate (uCi/sec):	6.11E-03	5.69E-03	6.01E-03	5.24E-03	5.83E-03
Total Error (%): 25.08					

NOTE: Values reported as zero are determined to be below the Lower Limit of Detection (LLD).

TABLE III.4
GASEOUS EFFLUENTS--GROUND LEVEL RELEASES
JANUARY THROUGH DECEMBER 2016
Batch Mode

Nuclides(Ci)	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	YEAR
Fission & Activation Gases					
XE-133	1.14E-01	1.13E-01	1.39E-01	1.18E-01	4.84E-01
XE-135	3.86E-03	4.47E-03	5.92E-03	1.66E-03	1.59E-02
AR-41	1.52E-01	1.54E-01	1.94E-01	3.49E-02	5.35E-01
Totals for Period:	2.70E-01	2.72E-01	3.39E-01	1.55E-01	1.04E+00
Iodines					
Totals for Period:	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Particulates					
Totals for Period:	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tritium and Gross Alpha					
H-3	1.42E-01	1.87E-01	1.42E-01	1.04E+00	1.51E+00

NOTE: Values reported as zero are determined to be below the Lower Limit of Detection (LLD).

TABLE III.5

GASEOUS EFFLUENTS--GROUND LEVEL RELEASES

JANUARY THROUGH DECEMBER 2016

Continuous Mode

Nuclides(Ci)	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Year
Fission & Activation Gases					
Totals for Period:	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Iodines					
Totals for Period:	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Particulates					
C-14	6.17E-01	5.75E-01	6.14E-01	1.65E-01	1.97E+00
Totals for Period:	6.17E-01	5.75E-01	6.14E-01	1.65E-01	1.97E+00
Tritium and Gross Alpha					
ALPHA	1.32E-06	3.35E-06	1.52E-06	3.86E-06	1.00E-05
H-3	4.95E-01	4.03E-01	2.59E-01	3.28E-01	1.49E+00

NOTE: Values reported as zero are determined to be below the Lower Limit of Detection (LLD).

TABLE III.6
LIQUID EFFLUENTS--SUMMATION OF ALL RELEASES
JANUARY THROUGH DECEMBER 2016

	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Year
A. Fission & Activiation Products					
Total Release (No H-3,Gas,Alpha) (Ci):	2.76E-03	8.49E-03	1.79E-02	1.42E-02	4.34E-02
Average Diluted Concentration (uCi/mL):	4.06E-10	1.58E-09	3.77E-09	7.78E-09	9.30E-09
10 CFR 20, App. B Limit 1.00E-06 (uCi/mL)					
Percent of Limit (%):	4.06E-02	1.58E-01	3.77E-01	7.78E-01	9.30E-01
Total Error (%): 24.17					
B. Tritium					
Total Release (Ci):	3.01E+01	3.12E+01	6.62E+01	2.11E+01	1.49E+02
Average Diluted Concentration (uCi/mL):	4.43E-06	5.80E-06	1.39E-05	1.16E-05	3.19E-05
10 CFR 20, App. B Limit 1.00E-03(uCi/mL)					
Percent of Limit (%):	4.43E-01	5.80E-01	1.39E+00	1.16E+00	3.19E+00
Total Error (%): 25.08					
C. Dissolved & Entrained Gases					
Total Release (Ci):	0.00E+00	7.97E-05	4.67E-04	1.93E-04	7.40E-04
Average Diluted Concentration (uCi/mL):	0.00E+00	1.48E-11	9.84E-11	1.06E-10	1.59E-10
ODCM Limit 2.00E-04 (uCi/mL):					
Percent of Limit (%):	0.00E+00	7.41E-06	4.92E-05	5.30E-05	7.94E-05
Total Error (%): 19.36					
D. Gross Alpha Radioactivity					
Total Release (Ci):	0.00E+00	0.00E+00	0.00E+00	8.72E-04	8.72E-04
Total Error (%): 25.08					
E. Volume of Waste Released Prior to Dilution (Liters):	2.99E+07	3.44E+07	3.07E+07	1.06E+07	1.06E+08
F. Volume of Dilution Water During Releases (Liters):	3.55E+11	3.48E+11	3.57E+11	1.04E+11	1.16E+12

NOTE: Values reported as zero are determined to be below the Lower Limit of Detection (LLD).

TABLE III.7

LIQUID EFFLUENTS

JANUARY THROUGH DECEMBER 2016

Batch Mode

Nuclides(Ci)	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Year
Fission & Activation Gases					
TC-99M	0.00E+00	0.00E+00	4.08E-06	0.00E+00	4.08E-06
MN-54	4.56E-06	2.02E-06	3.61E-05	1.34E-06	4.40E-05
BE-7	0.00E+00	4.15E-07	0.00E+00	0.00E+00	4.15E-07
CE-143	3.51E-07	0.00E+00	0.00E+00	0.00E+00	3.51E-07
I-133	0.00E+00	0.00E+00	9.18E-06	9.60E-07	1.01E-05
TC-101	3.51E-07	0.00E+00	0.00E+00	0.00E+00	3.51E-07
CS-137	2.29E-03	8.36E-03	1.75E-02	1.39E-02	4.20E-02
CS-134	1.59E-05	6.80E-05	1.37E-04	9.94E-05	3.20E-04
I-132	0.00E+00	0.00E+00	0.00E+00	3.08E-05	3.08E-05
CO-58	3.41E-05	6.00E-07	2.80E-06	0.00E+00	3.75E-05
MO-99	0.00E+00	0.00E+00	4.09E-06	0.00E+00	4.09E-06
I-131	2.08E-06	2.82E-05	1.59E-04	9.42E-05	2.83E-04
SB-124	0.00E+00	0.00E+00	0.00E+00	1.72E-05	1.72E-05
NI-63	3.70E-04	0.00E+00	0.00E+00	0.00E+00	3.70E-04
CO-60	4.64E-05	2.48E-05	1.13E-04	2.49E-05	2.09E-04
Totals for Period:	2.76E-03	8.49E-03	1.79E-02	1.42E-02	4.34E-02
Dissolved & Entrained Gases					
XE-133	0.00E+00	7.97E-05	4.67E-04	1.93E-04	7.40E-04
Totals for Period:	0.00E+00	7.97E-05	4.67E-04	1.93E-04	7.40E-04
Tritium and Gross Alpha					
ALPHA	0.00E+00	0.00E+00	0.00E+00	8.72E-04	8.72E-04
H-3	3.01E+01	3.12E+01	6.62E+01	2.11E+01	1.49E+02

NOTE: Values reported as zero are determined to be below the Lower Limit of Detection (LLD) values.
Reported Alpha activity was attributed to natural short-lived radionuclides. This was confirmed by quarterly offside vendor analysis.

TABLE III.8

LIQUID EFFLUENTS

JANUARY THROUGH DECEMBER 2016

Continuous Mode

Nuclides(Ci)	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Year
Fission & Activation Products					
Totals for Period:	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Dissolved & Entrained Gases					
Totals for Period:	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tritium and Gross Alpha					
ALPHA	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
H-3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

NOTE: Values reported as zero are determined to be below the Lower Limit of Detection (LLD).

TABLE III.9

GROUNDWATER ANALYSIS RESULTS

pCi/L

JANUARY THROUGH DECEMBER 2016

		1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
MW-1A					
	Tritium	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	FE-55		0.00E+00		
	NI-63		0.00E+00		
	Sr-90		0.00E+00		
	Total Gamma		0.00E+00		
MW-1B					
	Tritium	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	FE-55		0.00E+00		
	NI-63		0.00E+00		
	Sr-90		0.00E+00		
	Total Gamma	0.00E+00	0.00E+00		
MW-2					
	Tritium	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	FE-55		0.00E+00		
	NI-63		0.00E+00		
	Sr-90		0.00E+00		
	Total Gamma		0.00E+00		
MW-2A					
	Tritium	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	FE-55		0.00E+00		
	NI-63		0.00E+00		
	Sr-90		0.00E+00		
	Total Gamma		0.00E+00		
MW-2B					
	Tritium	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	FE-55		0.00E+00		
	NI-63		0.00E+00		
	Sr-90		0.00E+00		
	Total Gamma		0.00E+00		
MW-3					
	Tritium	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	FE-55		0.00E+00		
	NI-63		0.00E+00		
	Sr-90		0.00E+00		
	Total Gamma		0.00E+00		
MW-3A					
	Tritium	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	FE-55		0.00E+00	0.00E+00	0.00E+00
	NI-63		0.00E+00	0.00E+00	0.00E+00
	Sr-90		0.00E+00	0.00E+00	0.00E+00
	Total Gamma		0.00E+00	0.00E+00	0.00E+00
MW-3B					
	Tritium	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	FE-55	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	NI-63	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Sr-90	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Total Gamma		0.00E+00	0.00E+00	
MW-4A					
	Tritium	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	FE-55		0.00E+00		
	NI-63		0.00E+00		
	Sr-90		0.00E+00		
	Total Gamma		0.00E+00	0.00E+00	

TABLE III.9

GROUNDWATER ANALYSIS RESULTS

pCi/L

JANUARY THROUGH DECEMBER 2016

		1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
MW-4B					
	Tritium	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	FE-55		0.00E+00		
	NI-63		0.00E+00		
	Sr-90		0.00E+00		
	Total Gamma		0.00E+00		
MW-5A					
	Tritium	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	FE-55		0.00E+00		
	NI-63		0.00E+00		
	Sr-90		0.00E+00		
	Total Gamma	0.00E+00	0.00E+00		
MW-6					
	Tritium	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	FE-55	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	NI-63	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Sr-90	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Total Gamma		0.00E+00	0.00E+00	
MW-5B					
	Tritium	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	FE-55		0.00E+00		
	NI-63		0.00E+00		
	Sr-90		0.00E+00		
	Total Gamma		0.00E+00		
MW-7					
	Tritium	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	FE-55		0.00E+00		
	NI-63		0.00E+00		
	Sr-90		0.00E+00		
	Total Gamma		0.00E+00		
MW-9					
	Tritium	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	FE-55		0.00E+00		
	NI-63		0.00E+00		
	Sr-90		0.00E+00		
	Total Gamma		0.00E+00		
MW-10					
	Tritium	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	FE-55		0.00E+00		
	NI-63		0.00E+00		
	Sr-90		0.00E+00		
	Total Gamma		0.00E+00		
MW-11					
	Tritium	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	FE-55		0.00E+00		
	NI-63		0.00E+00		
	Sr-90		0.00E+00		
	Total Gamma		0.00E+00		
MW-12A					
	Tritium	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	FE-55		0.00E+00		
	NI-63		0.00E+00		
	Sr-90		0.00E+00		
	Total Gamma		0.00E+00		

TABLE III.9

GROUNDWATER ANALYSIS RESULTS

pCi/L

JANUARY THROUGH DECEMBER 2016

		1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
MW-12B					
	Tritium	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	FE-55		0.00E+00		
	NI-63		0.00E+00		
	Sr-90		0.00E+00		
	Total Gamma		0.00E+00		
EAST LAGOON					
	Tritium	0.00E+00	0.00E+00	0.00E+00	5.15E+02
	FE-55				
	NI-63				
	Sr-90				
	Total Gamma	0.00E+00	0.00E+00	0.00E+00	0.00E+00
WEST LAGOON					
	Tritium	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	FE-55				
	NI-63				
	Sr-90				
	Total Gamma	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NORTH STORMWATER HDR					
	Tritium	0.00E+00	0.00E+00	0.00E+00	
	FE-55				
	NI-63				
	Sr-90				
	Total Gamma		0.00E+00	0.00E+00	
SOUTH STORMWATER HDR					
	Tritium	0.00E+00	0.00E+00	0.00E+00	
	FE-55				
	NI-63				
	Sr-90				
	Total Gamma	0.00E+00	0.00E+00	0.00E+00	
SW-8 NORTH PA					
	Tritium	0.00E+00	0.00E+00	0.00E+00	
	FE-55				
	NI-63				
	Sr-90				
	Total Gamma	0.00E+00	0.00E+00	0.00E+00	
SW-6 ISFSI					
	Tritium	0.00E+00	0.00E+00	0.00E+00	
	FE-55				
	NI-63				
	Sr-90				
	Total Gamma	0.00E+00	0.00E+00	0.00E+00	

NOTE: Values reported as zero are determined to be below the Lower Limit of Detection (LLD).
Only Tritium and Gamma are required for each sampling event.
Hard to detect (HTD) nuclide sampling frequency is per station procedures.
Missed sampling events are covered in the executive summary.

SECTION IV

DOSE FROM GASEOUS EFFLUENTS

Technical Specification 5.9.4.a

GASPAR II OUTPUT

January 1, 2016 - December 31, 2016

Radioactive Effluent Releases - First, Second, Third and Fourth Quarters 2016

GASEOUS EFFLUENTS

Radioactive gaseous releases for the reporting period totaled 1.04 curies of inert gas. The gross gaseous activity release rates were 9.65E-04 μCi/sec for the first quarter, 7.94E-04 μCi/sec for the second quarter, 1.03E-03 μCi/sec for the third quarter, and 1.16E-03 μCi/sec for the fourth quarter.

Radioactive halogens releases for the reporting period totaled 0.00E+00 curies. The halogen activity release rates were 0.00E+00 μCi/sec for the first quarter, 0.00E+00 μCi/sec for the second quarter, 0.00E+00 μCi/sec for the third quarter, and 0.00E+00 μCi/sec for the fourth quarter from gaseous effluent discharges.
No radioactive particulates with half-lives greater that eight days were released during the reporting period from gaseous effluent discharges.

Radioactive tritium released during the reporting period totaled 2.99E+00 curies.

Carbon-14 released for the reporting period totaled 1.97 curies, this is a calculated value based on reactor power and days of operation. The Fort Calhoun estimate of 1.97 Ci carbon-14 with a normalized C-14 production rate and 15% carbon dioxide fraction.

Off-site vendor analysis of weekly composite samples indicated that no gross alpha radioactivity was released during the reporting period.

POTENTIAL DOSES TO INDIVIDUALS AND POPULATIONS

A. Potential Annual Doses to Individuals from Gaseous Releases

Total body, skin, and organ doses from ground releases were calculated in mRem to an average adult, teenager, child, and infant using the annual configuration of the GASPAR II program. Results to each receptor are shown in Tables IV-A-1 through IV-A-39. Also, the doses to the same groups, Table IV-B-1, in units of mRad, due to gamma and beta radiation carried by air, was computed using GASPAR II. In its annual configuration, GASPAR II assumes that all release rates are entered in curies per year (Ci/yr).

The inputs to GASPAR II for the annual period from January 1, 2016 through December 31, 2016 were as follows:

(1) All gaseous effluents

(2) Entrained gases (Ar-41, Xe-131M, Xe-133M, Xe-133, Xe-135M, Xe-135, Kr-85M, Kr-87, and Kr-88) from liquid effluents.

(3) Annual X/Q at the actual receptor locations, which are corrected for open terrain and plume depletion, are calculated according to Regulatory Guide 1.111. Also included are annual deposition rates corrected for the open terrain factor.

(4) The production, intake and grazing fractions were as follows: 1.0 for leafy vegetables grown in garden of interest, 0.76 for produce grown in garden of interest, 0.5 for the pasture grazing season of the milk animal, 1.0 for pasture grazing season of the meat animal, and 8 g/m^3 for the air water (humidity) concentrations.

(5) All dose factors, transport times from receptor to individual, and usage factors are defined by Regulatory Guide 1.109 and NUREG-0172.

(6) Site specific information, within a five-mile radius of the plant, on types of receptors located in each sector was used. That is, if a cow was not present in a sector, then the milk pathway for that sector was not considered. If it was present, then the actual sector distance was used.

(7) Using approved methodologies the C-14 doses to the site specific pathways (e.g. inhalation, milk, meat, and vegetation pathways) age group and organs are based upon airborne composition rather than ground deposition. For this reason, X/Q is utilized to calculate doses from Carbon-14 effluent releases
.
These inputs introduce a most conservative approach for the following reasons:

(1) The open terrain and deposition corrections increase annual X/Q by a factor ranging between 1.0 and 4.0

(2) The production, intake, and grazing fractions, as defined in the input definition statement, represent the environment in an extremely conservative manner.

B. Potential Semiannual Doses to Population from Gaseous Releases

The GASPAR II program in its annual configuration was also used to calculate the ALARA integrated population dose summary for the total body, skin, and organ doses in man-rem for all individuals within a 50-mile radius. The population-integrated dose is the summation of the dose received by all individuals and has units of man-thyroid-rem when applied to the summation of thyroid doses. The same inputs were used as in the individual case with the addition of the following:

(1) A total population of 950,006 (based on the 2010 census) was used to define the sector segments within a 50-mile radius of the plant.

(2) Production of milk, meat, and vegetation is based on 1973 annual data for Nebraska as recommended by the Nuclear Regulatory Commission for use in GASPAR II.

TABLE IV-A- 1

FORT CALHOUN ANNUAL 2016, DOSE PROJECTIONS

SPECIAL LOCATION NO. 1 RES
AT 4.36 MILES N

ANNUAL_BETA_AIR_DOSE = 3.84E-06 MILLRADS
ANNUAL_GAMMA_AIR_DOSE = 6.77E-06 MILLRADS

PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
PLUME	4.46E-06	4.46E-06	4.46E-06	4.46E-06	4.46E-06	4.46E-06	4.48E-06	7.58E-06
GROUND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
INHAL								
ADULT	6.68E-06	6.68E-06	0.00E+00	6.68E-06	6.68E-06	6.68E-06	6.68E-06	6.68E-06
TEEN	6.74E-06	6.74E-06	0.00E+00	6.74E-06	6.74E-06	6.74E-06	6.74E-06	6.74E-06
CHILD	5.95E-06	5.95E-06	0.00E+00	5.95E-06	5.95E-06	5.95E-06	5.95E-06	5.95E-06
INFANT	3.42E-06	3.42E-06	0.00E+00	3.42E-06	3.42E-06	3.42E-06	3.42E-06	3.42E-06

TABLE IV-A- 2

FORT CALHOUN ANNUAL 2016, DOSE PROJECTIONS

SPECIAL LOCATION NO. 2 RES

AT 1.93 MILES NNE

ANNUAL_BETA_AIR_DOSE = 2.65E-05 MILLRADS

ANNUAL_GAMMA_AIR_DOSE = 5.24E-05 MILLRADS

PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
PLUME	3.46E-05	3.46E-05	3.46E-05	3.46E-05	3.46E-05	3.46E-05	3.47E-05	5.79E-05
GROUND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
INHAL								
ADULT	3.68E-05	3.68E-05	0.00E+00	3.68E-05	3.68E-05	3.68E-05	3.68E-05	3.68E-05
TEEN	3.71E-05	3.71E-05	0.00E+00	3.71E-05	3.71E-05	3.71E-05	3.71E-05	3.71E-05
CHILD	3.28E-05	3.28E-05	0.00E+00	3.28E-05	3.28E-05	3.28E-05	3.28E-05	3.28E-05
INFANT	1.89E-05	1.89E-05	0.00E+00	1.89E-05	1.89E-05	1.89E-05	1.89E-05	1.89E-05

TABLE IV-A- 3

FORT CALHOUN ANNUAL 2016, DOSE PROJECTIONS

SPECIAL LOCATION NO. 3 RES
AT 1.52 MILES NE

ANNUAL_BETA_AIR_DOSE = 3.15E-05 MILLRADS
ANNUAL_GAMMA_AIR_DOSE = 5.79E-05 MILLRADS

PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
PLUME	3.82E-05	3.82E-05	3.82E-05	3.82E-05	3.82E-05	3.82E-05	3.83E-05	6.44E-05
GROUND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
INHAL								
ADULT	5.11E-05	5.11E-05	0.00E+00	5.11E-05	5.11E-05	5.11E-05	5.11E-05	5.11E-05
TEEN	5.16E-05	5.16E-05	0.00E+00	5.16E-05	5.16E-05	5.16E-05	5.16E-05	5.16E-05
CHILD	4.56E-05	4.56E-05	0.00E+00	4.56E-05	4.56E-05	4.56E-05	4.56E-05	4.56E-05
INFANT	2.62E-05	2.62E-05	0.00E+00	2.62E-05	2.62E-05	2.62E-05	2.62E-05	2.62E-05

TABLE IV-A- 4

FORT CALHOUN ANNUAL 2016, DOSE PROJECTIONS

SPECIAL LOCATION NO. 4 RES
AT 4.79 MILES ENE

ANNUAL_BETA_AIR_DOSE = 1.23E-06 MILLRADS
ANNUAL_GAMMA_AIR_DOSE = 1.25E-06 MILLRADS

PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
PLUME	8.10E-07	8.10E-07	8.10E-07	8.10E-07	8.10E-07	8.10E-07	8.19E-07	1.53E-06
GROUND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
INHAL								
ADULT	3.75E-06	3.75E-06	0.00E+00	3.75E-06	3.75E-06	3.75E-06	3.75E-06	3.75E-06
TEEN	3.78E-06	3.78E-06	0.00E+00	3.78E-06	3.78E-06	3.78E-06	3.78E-06	3.78E-06
CHILD	3.34E-06	3.34E-06	0.00E+00	3.34E-06	3.34E-06	3.34E-06	3.34E-06	3.34E-06
INFANT	1.92E-06	1.92E-06	0.00E+00	1.92E-06	1.92E-06	1.92E-06	1.92E-06	1.92E-06

TABLE IV-A- 5

FORT CALHOUN ANNUAL 2016, DOSE PROJECTIONS

SPECIAL LOCATION NO. 5 RES
AT 4.67 MILES E

ANNUAL_BETA_AIR_DOSE = 2.31E-06 MILLRADS
ANNUAL_GAMMA_AIR_DOSE = 3.25E-06 MILLRADS

PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
PLUME	2.13E-06	2.13E-06	2.13E-06	2.13E-06	2.13E-06	2.13E-06	2.14E-06	3.75E-06
GROUND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
INHAL								
ADULT	5.45E-06	5.45E-06	0.00E+00	5.45E-06	5.45E-06	5.45E-06	5.45E-06	5.45E-06
TEEN	5.50E-06	5.50E-06	0.00E+00	5.50E-06	5.50E-06	5.50E-06	5.50E-06	5.50E-06
CHILD	4.86E-06	4.86E-06	0.00E+00	4.86E-06	4.86E-06	4.86E-06	4.86E-06	4.86E-06
INFANT	2.80E-06	2.80E-06	0.00E+00	2.80E-06	2.80E-06	2.80E-06	2.80E-06	2.80E-06

TABLE IV-A- 6

FORT CALHOUN ANNUAL 2016, DOSE PROJECTIONS

SPECIAL LOCATION NO. 6 RES
AT 4.22 MILES ESE

ANNUAL_BETA_AIR_DOSE = 8.04E-06 MILLRADS
ANNUAL_GAMMA_AIR_DOSE = 1.81E-05 MILLRADS

PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
PLUME	1.20E-05	1.20E-05	1.20E-05	1.20E-05	1.20E-05	1.20E-05	1.20E-05	1.97E-05
GROUND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
INHAL								
ADULT	7.50E-06	7.50E-06	0.00E+00	7.50E-06	7.50E-06	7.50E-06	7.50E-06	7.50E-06
TEEN	7.57E-06	7.57E-06	0.00E+00	7.57E-06	7.57E-06	7.57E-06	7.57E-06	7.57E-06
CHILD	6.68E-06	6.68E-06	0.00E+00	6.68E-06	6.68E-06	6.68E-06	6.68E-06	6.68E-06
INFANT	3.84E-06	3.84E-06	0.00E+00	3.84E-06	3.84E-06	3.84E-06	3.84E-06	3.84E-06

TABLE IV-A- 7

FORT CALHOUN ANNUAL 2016, DOSE PROJECTIONS

SPECIAL LOCATION NO. 7 RES
AT 1.67 MILES SE

ANNUAL_BETA_AIR_DOSE = 3.06E-05 MILLRADS
ANNUAL_GAMMA_AIR_DOSE = 6.14E-05 MILLRADS

PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
PLUME	4.06E-05	4.06E-05	4.06E-05	4.06E-05	4.06E-05	4.06E-05	4.07E-05	6.77E-05
GROUND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
INHAL								
ADULT	4.09E-05	4.09E-05	0.00E+00	4.09E-05	4.09E-05	4.09E-05	4.09E-05	4.09E-05
TEEN	4.13E-05	4.13E-05	0.00E+00	4.13E-05	4.13E-05	4.13E-05	4.13E-05	4.13E-05
CHILD	3.65E-05	3.65E-05	0.00E+00	3.65E-05	3.65E-05	3.65E-05	3.65E-05	3.65E-05
INFANT	2.10E-05	2.10E-05	0.00E+00	2.10E-05	2.10E-05	2.10E-05	2.10E-05	2.10E-05

TABLE IV-A- 8

FORT CALHOUN ANNUAL 2016, DOSE PROJECTIONS

SPECIAL LOCATION NO. 8 RES
AT 0.65 MILES SSE

ANNUAL_BETA_AIR_DOSE = 4.75E-04 MILLRADS
ANNUAL_GAMMA_AIR_DOSE = 1.07E-03 MILLRADS

PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
PLUME	7.08E-04	7.08E-04	7.08E-04	7.08E-04	7.08E-04	7.08E-04	7.09E-04	1.16E-03
GROUND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
INHAL								
ADULT	4.43E-04	4.43E-04	0.00E+00	4.43E-04	4.43E-04	4.43E-04	4.43E-04	4.43E-04
TEEN	4.47E-04	4.47E-04	0.00E+00	4.47E-04	4.47E-04	4.47E-04	4.47E-04	4.47E-04
CHILD	3.95E-04	3.95E-04	0.00E+00	3.95E-04	3.95E-04	3.95E-04	3.95E-04	3.95E-04
INFANT	2.27E-04	2.27E-04	0.00E+00	2.27E-04	2.27E-04	2.27E-04	2.27E-04	2.27E-04

TABLE IV-A- 9

FORT CALHOUN ANNUAL 2016, DOSE PROJECTIONS

SPECIAL LOCATION NO. 9 RES
AT 0.73 MILES S

ANNUAL_BETA_AIR_DOSE = 1.75E-04 MILLRADS
ANNUAL_GAMMA_AIR_DOSE = 3.94E-04 MILLRADS

PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
PLUME	2.61E-04	2.61E-04	2.61E-04	2.61E-04	2.61E-04	2.61E-04	2.62E-04	4.29E-04
GROUND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
INHAL								
ADULT	1.64E-04	1.64E-04	0.00E+00	1.64E-04	1.64E-04	1.64E-04	1.64E-04	1.64E-04
TEEN	1.65E-04	1.65E-04	0.00E+00	1.65E-04	1.65E-04	1.65E-04	1.65E-04	1.65E-04
CHILD	1.46E-04	1.46E-04	0.00E+00	1.46E-04	1.46E-04	1.46E-04	1.46E-04	1.46E-04
INFANT	8.39E-05	8.39E-05	0.00E+00	8.39E-05	8.39E-05	8.39E-05	8.39E-05	8.39E-05

TABLE IV-A-10

FORT CALHOUN ANNUAL 2016, DOSE PROJECTIONS

SPECIAL LOCATION NO. 10 RES
AT 0.65 MILES SSW

ANNUAL_BETA_AIR_DOSE = 1.39E-04 MILLRADS
ANNUAL_GAMMA_AIR_DOSE = 3.12E-04 MILLRADS

PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
PLUME	2.07E-04	2.07E-04	2.07E-04	2.07E-04	2.07E-04	2.07E-04	2.07E-04	3.40E-04
GROUND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
INHAL								
ADULT	1.30E-04	1.30E-04	0.00E+00	1.30E-04	1.30E-04	1.30E-04	1.30E-04	1.30E-04
TEEN	1.31E-04	1.31E-04	0.00E+00	1.31E-04	1.31E-04	1.31E-04	1.31E-04	1.31E-04
CHILD	1.15E-04	1.15E-04	0.00E+00	1.15E-04	1.15E-04	1.15E-04	1.15E-04	1.15E-04
INFANT	6.64E-05	6.64E-05	0.00E+00	6.64E-05	6.64E-05	6.64E-05	6.64E-05	6.64E-05

TABLE IV-A-11

FORT CALHOUN ANNUAL 2016, DOSE PROJECTIONS

SPECIAL LOCATION NO. 11 RES
AT 0.73 MILES SW

ANNUAL_BETA_AIR_DOSE = 1.83E-04 MILLRADS
ANNUAL_GAMMA_AIR_DOSE = 4.11E-04 MILLRADS

PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
PLUME	2.72E-04	2.72E-04	2.72E-04	2.72E-04	2.72E-04	2.72E-04	2.73E-04	4.47E-04
GROUND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
INHAL ADULT	1.70E-04	1.70E-04	0.00E+00	1.70E-04	1.70E-04	1.70E-04	1.70E-04	1.70E-04
TEEN	1.72E-04	1.72E-04	0.00E+00	1.72E-04	1.72E-04	1.72E-04	1.72E-04	1.72E-04
CHILD	1.52E-04	1.52E-04	0.00E+00	1.52E-04	1.52E-04	1.52E-04	1.52E-04	1.52E-04
INFANT	8.74E-05	8.74E-05	0.00E+00	8.74E-05	8.74E-05	8.74E-05	8.74E-05	8.74E-05

TABLE IV-A-12

FORT CALHOUN ANNUAL 2016, DOSE PROJECTIONS

SPECIAL LOCATION NO. 12 RES
AT 1.06 MILES WSW

ANNUAL_BETA_AIR_DOSE = 8.04E-05 MILLRADS
ANNUAL_GAMMA_AIR_DOSE = 1.81E-04 MILLRADS

PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
PLUME	1.20E-04	1.20E-04	1.20E-04	1.20E-04	1.20E-04	1.20E-04	1.20E-04	1.97E-04
GROUND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
INHAL								
ADULT	7.50E-05	7.50E-05	0.00E+00	7.50E-05	7.50E-05	7.50E-05	7.50E-05	7.50E-05
TEEN	7.57E-05	7.57E-05	0.00E+00	7.57E-05	7.57E-05	7.57E-05	7.57E-05	7.57E-05
CHILD	6.68E-05	6.68E-05	0.00E+00	6.68E-05	6.68E-05	6.68E-05	6.68E-05	6.68E-05
INFANT	3.84E-05	3.84E-05	0.00E+00	3.84E-05	3.84E-05	3.84E-05	3.84E-05	3.84E-05

TABLE IV-A-13

FORT CALHOUN ANNUAL 2016, DOSE PROJECTIONS

SPECIAL LOCATION NO. 13 RES
AT 1.20 MILES W

ANNUAL_BETA_AIR_DOSE = 5.86E-05 MILLRADS
ANNUAL_GAMMA_AIR_DOSE = 1.24E-04 MILLRADS

PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
PLUME	8.18E-05	8.18E-05	8.18E-05	8.18E-05	8.18E-05	8.18E-05	8.20E-05	1.36E-04
GROUND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
INHAL								
ADULT	6.82E-05	6.82E-05	0.00E+00	6.82E-05	6.82E-05	6.82E-05	6.82E-05	6.82E-05
TEEN	6.88E-05	6.88E-05	0.00E+00	6.88E-05	6.88E-05	6.88E-05	6.88E-05	6.88E-05
CHILD	6.08E-05	6.08E-05	0.00E+00	6.08E-05	6.08E-05	6.08E-05	6.08E-05	6.08E-05
INFANT	3.49E-05	3.49E-05	0.00E+00	3.49E-05	3.49E-05	3.49E-05	3.49E-05	3.49E-05

TABLE IV-A-14

FORT CALHOUN ANNUAL 2016, DOSE PROJECTIONS

SPECIAL LOCATION NO. 14 RES
AT 2.60 MILES WNW

ANNUAL_BETA_AIR_DOSE = 1.97E-05 MILLRADS
ANNUAL_GAMMA_AIR_DOSE = 4.44E-05 MILLRADS

PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
PLUME	2.94E-05	2.94E-05	2.94E-05	2.94E-05	2.94E-05	2.94E-05	2.94E-05	4.83E-05
GROUND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
INHAL								
ADULT	1.84E-05	1.84E-05	0.00E+00	1.84E-05	1.84E-05	1.84E-05	1.84E-05	1.84E-05
TEEN	1.86E-05	1.86E-05	0.00E+00	1.86E-05	1.86E-05	1.86E-05	1.86E-05	1.86E-05
CHILD	1.64E-05	1.64E-05	0.00E+00	1.64E-05	1.64E-05	1.64E-05	1.64E-05	1.64E-05
INFANT	9.44E-06	9.44E-06	0.00E+00	9.44E-06	9.44E-06	9.44E-06	9.44E-06	9.44E-06

TABLE IV-A-15

FORT CALHOUN ANNUAL 2016, DOSE PROJECTIONS

SPECIAL LOCATION NO. 15 RES
AT 2.40 MILES NW

ANNUAL_BETA_AIR_DOSE = 2.52E-05 MILLRADS
ANNUAL_GAMMA_AIR_DOSE = 4.95E-05 MILLRADS

PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
PLUME	3.27E-05	3.27E-05	3.27E-05	3.27E-05	3.27E-05	3.27E-05	3.28E-05	5.47E-05
GROUND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
INHAL ADULT	3.55E-05	3.55E-05	0.00E+00	3.55E-05	3.55E-05	3.55E-05	3.55E-05	3.55E-05
TEEN	3.58E-05	3.58E-05	0.00E+00	3.58E-05	3.58E-05	3.58E-05	3.58E-05	3.58E-05
CHILD	3.16E-05	3.16E-05	0.00E+00	3.16E-05	3.16E-05	3.16E-05	3.16E-05	3.16E-05
INFANT	1.82E-05	1.82E-05	0.00E+00	1.82E-05	1.82E-05	1.82E-05	1.82E-05	1.82E-05

TABLE IV-A-16

FORT CALHOUN ANNUAL 2016, DOSE PROJECTIONS

SPECIAL LOCATION NO. 16 RES
AT 2.08 MILES NNW

ANNUAL_BETA_AIR_DOSE = 2.78E-05 MILLRADS
ANNUAL_GAMMA_AIR_DOSE = 4.99E-05 MILLRADS

PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
PLUME	3.29E-05	3.29E-05	3.29E-05	3.29E-05	3.29E-05	3.29E-05	3.30E-05	5.57E-05
GROUND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
INHAL								
ADULT	4.70E-05	4.70E-05	0.00E+00	4.70E-05	4.70E-05	4.70E-05	4.70E-05	4.70E-05
TEEN	4.75E-05	4.75E-05	0.00E+00	4.75E-05	4.75E-05	4.75E-05	4.75E-05	4.75E-05
CHILD	4.19E-05	4.19E-05	0.00E+00	4.19E-05	4.19E-05	4.19E-05	4.19E-05	4.19E-05
INFANT	2.41E-05	2.41E-05	0.00E+00	2.41E-05	2.41E-05	2.41E-05	2.41E-05	2.41E-05

TABLE IV-A-17

FORT CALHOUN ANNUAL 2016, DOSE PROJECTIONS

SPECIAL LOCATION NO. 17 VEG
AT 2.23 MILES NNE

ANNUAL_BETA_AIR_DOSE = 1.48E-05 MILLRADS
ANNUAL_GAMMA_AIR_DOSE = 2.69E-05 MILLRADS

PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
PLUME	1.78E-05	1.78E-05	1.78E-05	1.78E-05	1.78E-05	1.78E-05	1.78E-05	3.00E-05
GROUND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
VEGET								
ADULT	6.55E-04	6.55E-04	3.05E-03	6.55E-04	6.55E-04	6.55E-04	6.55E-04	6.55E-04
TEEN	1.04E-03	1.04E-03	4.95E-03	1.04E-03	1.04E-03	1.04E-03	1.04E-03	1.04E-03
CHILD	2.47E-03	2.47E-03	1.19E-02	2.47E-03	2.47E-03	2.47E-03	2.47E-03	2.47E-03

TABLE IV-A-18

FORT CALHOUN ANNUAL 2016, DOSE PROJECTIONS

SPECIAL LOCATION NO. 18 VEG
AT 1.52 MILES NE

ANNUAL_BETA_AIR_DOSE = 3.15E-05 MILLRADS
ANNUAL_GAMMA_AIR_DOSE = 5.79E-05 MILLRADS

PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
PLUME	3.82E-05	3.82E-05	3.82E-05	3.82E-05	3.82E-05	3.82E-05	3.83E-05	6.44E-05
GROUND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
VEGET								
ADULT	1.37E-03	1.37E-03	6.36E-03	1.37E-03	1.37E-03	1.37E-03	1.37E-03	1.37E-03
TEEN	2.17E-03	2.17E-03	1.03E-02	2.17E-03	2.17E-03	2.17E-03	2.17E-03	2.17E-03
CHILD	5.14E-03	5.14E-03	2.49E-02	5.14E-03	5.14E-03	5.14E-03	5.14E-03	5.14E-03

TABLE IV-A-19

FORT CALHOUN ANNUAL 2016, DOSE PROJECTIONS

SPECIAL LOCATION NO. 19 VEG
AT 4.79 MILES ENE

ANNUAL_BETA_AIR_DOSE = 1.23E-06 MILLRADS
ANNUAL_GAMMA_AIR_DOSE = 1.25E-06 MILLRADS

PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
PLUME	8.10E-07	8.10E-07	8.10E-07	8.10E-07	8.10E-07	8.10E-07	8.19E-07	1.53E-06
GROUND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
VEGET								
ADULT	1.00E-04	1.00E-04	4.67E-04	1.00E-04	1.00E-04	1.00E-04	1.00E-04	1.00E-04
TEEN	1.59E-04	1.59E-04	7.57E-04	1.59E-04	1.59E-04	1.59E-04	1.59E-04	1.59E-04
CHILD	3.77E-04	3.77E-04	1.82E-03	3.77E-04	3.77E-04	3.77E-04	3.77E-04	3.77E-04

TABLE IV-A-20

FORT CALHOUN ANNUAL 2016, DOSE PROJECTIONS

SPECIAL LOCATION NO. 20 VEG
AT 4.67 MILES E

ANNUAL_BETA_AIR_DOSE = 2.31E-06 MILLRADS
ANNUAL_GAMMA_AIR_DOSE = 3.25E-06 MILLRADS

PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
PLUME	2.13E-06	2.13E-06	2.13E-06	2.13E-06	2.13E-06	2.13E-06	2.14E-06	3.75E-06
GROUND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
VEGET								
ADULT	1.46E-04	1.46E-04	6.79E-04	1.46E-04	1.46E-04	1.46E-04	1.46E-04	1.46E-04
TEEN	2.31E-04	2.31E-04	1.10E-03	2.31E-04	2.31E-04	2.31E-04	2.31E-04	2.31E-04
CHILD	5.48E-04	5.48E-04	2.65E-03	5.48E-04	5.48E-04	5.48E-04	5.48E-04	5.48E-04

TABLE IV-A-21

FORT CALHOUN ANNUAL 2016, DOSE PROJECTIONS

SPECIAL LOCATION NO. 21 VEG
AT 4.22 MILES ESE

ANNUAL_BETA_AIR_DOSE = 8.04E-06 MILLRADS
ANNUAL_GAMMA_AIR_DOSE = 1.81E-05 MILLRADS

PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
PLUME	1.20E-05	1.20E-05	1.20E-05	1.20E-05	1.20E-05	1.20E-05	1.20E-05	1.97E-05
GROUND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
VEGET ADULT	2.00E-04	2.00E-04	9.33E-04	2.00E-04	2.00E-04	2.00E-04	2.00E-04	2.00E-04
TEEN	3.18E-04	3.18E-04	1.51E-03	3.18E-04	3.18E-04	3.18E-04	3.18E-04	3.18E-04
CHILD	7.54E-04	7.54E-04	3.65E-03	7.54E-04	7.54E-04	7.54E-04	7.54E-04	7.54E-04

TABLE IV-A-22

FORT CALHOUN ANNUAL 2016, DOSE PROJECTIONS

SPECIAL LOCATION NO. 22 VEG
AT 1.74 MILES SE

ANNUAL_BETA_AIR_DOSE = 4.09E-05 MILLRADS
ANNUAL_GAMMA_AIR_DOSE = 9.20E-05 MILLRADS

PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
PLUME	6.10E-05	6.10E-05	6.10E-05	6.10E-05	6.10E-05	6.10E-05	6.11E-05	1.00E-04
GROUND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
VEGET ADULT	1.02E-03	1.02E-03	4.75E-03	1.02E-03	1.02E-03	1.02E-03	1.02E-03	1.02E-03
TEEN	1.62E-03	1.62E-03	7.70E-03	1.62E-03	1.62E-03	1.62E-03	1.62E-03	1.62E-03
CHILD	3.84E-03	3.84E-03	1.86E-02	3.84E-03	3.84E-03	3.84E-03	3.84E-03	3.84E-03

TABLE IV-A-23

FORT CALHOUN ANNUAL 2016, DOSE PROJECTIONS

SPECIAL LOCATION NO. 23 VEG
AT 0.65 MILES SSE

ANNUAL_BETA_AIR_DOSE = 4.75E-04 MILLRADS
ANNUAL_GAMMA_AIR_DOSE = 1.07E-03 MILLRADS

PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
PLUME	7.08E-04	7.08E-04	7.08E-04	7.08E-04	7.08E-04	7.08E-04	7.09E-04	1.16E-03
GROUND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
VEGET								
ADULT	1.18E-02	1.18E-02	5.51E-02	1.18E-02	1.18E-02	1.18E-02	1.18E-02	1.18E-02
TEEN	1.88E-02	1.88E-02	8.94E-02	1.88E-02	1.88E-02	1.88E-02	1.88E-02	1.88E-02
CHILD	4.45E-02	4.45E-02	2.16E-01	4.45E-02	4.45E-02	4.45E-02	4.45E-02	4.45E-02

TABLE IV-A-24

FORT CALHOUN ANNUAL 2016, DOSE PROJECTIONS

SPECIAL LOCATION NO. 24 VEG
AT 0.73 MILES S

ANNUAL_BETA_AIR_DOSE = 1.75E-04 MILLRADS
ANNUAL_GAMMA_AIR_DOSE = 3.94E-04 MILLRADS

PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
PLUME	2.61E-04	2.61E-04	2.61E-04	2.61E-04	2.61E-04	2.61E-04	2.62E-04	4.29E-04
GROUND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
VEGET ADULT	4.37E-03	4.37E-03	2.04E-02	4.37E-03	4.37E-03	4.37E-03	4.37E-03	4.37E-03
TEEN	6.94E-03	6.94E-03	3.30E-02	6.94E-03	6.94E-03	6.94E-03	6.94E-03	6.94E-03
CHILD	1.64E-02	1.64E-02	7.96E-02	1.64E-02	1.64E-02	1.64E-02	1.64E-02	1.64E-02

TABLE IV-A-25

FORT CALHOUN ANNUAL 2016, DOSE PROJECTIONS

SPECIAL LOCATION NO. 25 VEG
AT 2.00 MILES SSW

ANNUAL_BETA_AIR_DOSE = 1.02E-05 MILLRADS
ANNUAL_GAMMA_AIR_DOSE = 2.30E-05 MILLRADS

PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
PLUME	1.52E-05	1.52E-05	1.52E-05	1.52E-05	1.52E-05	1.52E-05	1.53E-05	2.51E-05
GROUND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
VEGET								
ADULT	2.55E-04	2.55E-04	1.19E-03	2.55E-04	2.55E-04	2.55E-04	2.55E-04	2.55E-04
TEEN	4.05E-04	4.05E-04	1.93E-03	4.05E-04	4.05E-04	4.05E-04	4.05E-04	4.05E-04
CHILD	9.59E-04	9.59E-04	4.64E-03	9.59E-04	9.59E-04	9.59E-04	9.59E-04	9.59E-04

TABLE IV-A-26

FORT CALHOUN ANNUAL 2016, DOSE PROJECTIONS

SPECIAL LOCATION NO. 26 VEG
AT 1.43 MILES SW

ANNUAL_BETA_AIR_DOSE = 2.32E-05 MILLRADS
ANNUAL_GAMMA_AIR_DOSE = 4.51E-05 MILLRADS

PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
PLUME	2.98E-05	2.98E-05	2.98E-05	2.98E-05	2.98E-05	2.98E-05	2.99E-05	4.99E-05
GROUND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
VEGET								
ADULT	8.92E-04	8.92E-04	4.16E-03	8.92E-04	8.92E-04	8.92E-04	8.92E-04	8.92E-04
TEEN	1.42E-03	1.42E-03	6.74E-03	1.42E-03	1.42E-03	1.42E-03	1.42E-03	1.42E-03
CHILD	3.36E-03	3.36E-03	1.62E-02	3.36E-03	3.36E-03	3.36E-03	3.36E-03	3.36E-03

TABLE IV-A-27

FORT CALHOUN ANNUAL 2016, DOSE PROJECTIONS

SPECIAL LOCATION NO. 27 VEG
AT 1.13 MILES WSW

ANNUAL_BETA_AIR_DOSE = 5.29E-05 MILLRADS
ANNUAL_GAMMA_AIR_DOSE = 1.11E-04 MILLRADS

PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
PLUME	7.34E-05	7.34E-05	7.34E-05	7.34E-05	7.34E-05	7.34E-05	7.36E-05	1.22E-04
GROUND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
VEGET								
ADULT	1.67E-03	1.67E-03	7.81E-03	1.67E-03	1.67E-03	1.67E-03	1.67E-03	1.67E-03
TEEN	2.66E-03	2.66E-03	1.27E-02	2.66E-03	2.66E-03	2.66E-03	2.66E-03	2.66E-03
CHILD	6.30E-03	6.30E-03	3.05E-02	6.30E-03	6.30E-03	6.30E-03	6.30E-03	6.30E-03

TABLE IV-A-28

FORT CALHOUN ANNUAL 2016, DOSE PROJECTIONS

SPECIAL LOCATION NO. 28 VEG
AT 1.30 MILES W

ANNUAL_BETA_AIR_DOSE = 4.38E-05 MILLRADS
ANNUAL_GAMMA_AIR_DOSE = 9.05E-05 MILLRADS

PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
PLUME	5.99E-05	5.99E-05	5.99E-05	5.99E-05	5.99E-05	5.99E-05	6.00E-05	9.95E-05
GROUND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
VEGET								
ADULT	1.44E-03	1.44E-03	6.70E-03	1.44E-03	1.44E-03	1.44E-03	1.44E-03	1.44E-03
TEEN	2.28E-03	2.28E-03	1.09E-02	2.28E-03	2.28E-03	2.28E-03	2.28E-03	2.28E-03
CHILD	5.41E-03	5.41E-03	2.62E-02	5.41E-03	5.41E-03	5.41E-03	5.41E-03	5.41E-03

TABLE IV-A-29

FORT CALHOUN ANNUAL 2016, DOSE PROJECTIONS

SPECIAL LOCATION NO. 29 VEG
AT 2.65 MILES WNW

ANNUAL_BETA_AIR_DOSE = 8.92E-06 MILLRADS
ANNUAL_GAMMA_AIR_DOSE = 1.45E-05 MILLRADS

PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
PLUME	9.50E-06	9.50E-06	9.50E-06	9.50E-06	9.50E-06	9.50E-06	9.55E-06	1.63E-05
GROUND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
VEGET								
ADULT	4.73E-04	4.73E-04	2.21E-03	4.73E-04	4.73E-04	4.73E-04	4.73E-04	4.73E-04
TEEN	7.52E-04	7.52E-04	3.58E-03	7.52E-04	7.52E-04	7.52E-04	7.52E-04	7.52E-04
CHILD	1.78E-03	1.78E-03	8.62E-03	1.78E-03	1.78E-03	1.78E-03	1.78E-03	1.78E-03

TABLE IV-A-30

FORT CALHOUN ANNUAL 2016, DOSE PROJECTIONS

SPECIAL LOCATION NO. 30 VEG
AT 2.40 MILES NW

ANNUAL_BETA_AIR_DOSE = 2.52E-05 MILLRADS
ANNUAL_GAMMA_AIR_DOSE = 4.95E-05 MILLRADS

PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
PLUME	3.27E-05	3.27E-05	3.27E-05	3.27E-05	3.27E-05	3.27E-05	3.28E-05	5.47E-05
GROUND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
VEGET								
ADULT	9.47E-04	9.47E-04	4.41E-03	9.47E-04	9.47E-04	9.47E-04	9.47E-04	9.47E-04
TEEN	1.50E-03	1.50E-03	7.15E-03	1.50E-03	1.50E-03	1.50E-03	1.50E-03	1.50E-03
CHILD	3.56E-03	3.56E-03	1.72E-02	3.56E-03	3.56E-03	3.56E-03	3.56E-03	3.56E-03

TABLE IV-A-31

FORT CALHOUN ANNUAL 2016, DOSE PROJECTIONS

SPECIAL LOCATION NO. 31 VEG
AT 3.73 MILES NNW

ANNUAL_BETA_AIR_DOSE = 5.31E-06 MILLRADS
ANNUAL_GAMMA_AIR_DOSE = 7.20E-06 MILLRADS

PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
PLUME	4.71E-06	4.71E-06	4.71E-06	4.71E-06	4.71E-06	4.71E-06	4.74E-06	8.35E-06
GROUND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
VEGET								
ADULT	3.46E-04	3.46E-04	1.61E-03	3.46E-04	3.46E-04	3.46E-04	3.46E-04	3.46E-04
TEEN	5.50E-04	5.50E-04	2.61E-03	5.50E-04	5.50E-04	5.50E-04	5.50E-04	5.50E-04
CHILD	1.30E-03	1.30E-03	6.30E-03	1.30E-03	1.30E-03	1.30E-03	1.30E-03	1.30E-03

TABLE IV-A-32

FORT CALHOUN ANNUAL 2016, DOSE PROJECTIONS

SPECIAL LOCATION NO. 32 BEEF
AT 4.91 MILES E

ANNUAL_BETA_AIR_DOSE = 2.08E-06 MILLRADS
ANNUAL_GAMMA_AIR_DOSE = 2.79E-06 MILLRADS

PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
PLUME	1.82E-06	1.82E-06	1.82E-06	1.82E-06	1.82E-06	1.82E-06	1.84E-06	3.24E-06
GROUND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MEAT								
ADULT	4.86E-05	4.86E-05	2.36E-04	4.86E-05	4.86E-05	4.86E-05	4.86E-05	4.86E-05
TEEN	4.07E-05	4.07E-05	2.00E-04	4.07E-05	4.07E-05	4.07E-05	4.07E-05	4.07E-05
CHILD	7.60E-05	7.60E-05	3.75E-04	7.60E-05	7.60E-05	7.60E-05	7.60E-05	7.60E-05

TABLE IV-A-33

FORT CALHOUN ANNUAL 2016, DOSE PROJECTIONS

SPECIAL LOCATION NO. 33 BEEF
AT 1.82 MILES SSE

ANNUAL_BETA_AIR_DOSE = 3.13E-05 MILLRADS
ANNUAL_GAMMA_AIR_DOSE = 6.29E-05 MILLRADS

PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
PLUME	4.16E-05	4.16E-05	4.16E-05	4.16E-05	4.16E-05	4.16E-05	4.17E-05	6.93E-05
GROUND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MEAT								
ADULT	3.95E-04	3.95E-04	1.92E-03	3.95E-04	3.95E-04	3.95E-04	3.95E-04	3.95E-04
TEEN	3.31E-04	3.31E-04	1.62E-03	3.31E-04	3.31E-04	3.31E-04	3.31E-04	3.31E-04
CHILD	6.18E-04	6.18E-04	3.05E-03	6.18E-04	6.18E-04	6.18E-04	6.18E-04	6.18E-04

TABLE IV-A-34

FORT CALHOUN ANNUAL 2016, DOSE PROJECTIONS

SPECIAL LOCATION NO. 34 BEEF
AT 2.48 MILES S

ANNUAL_BETA_AIR_DOSE = 8.77E-06 MILLRADS
ANNUAL_GAMMA_AIR_DOSE = 1.97E-05 MILLRADS

PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
PLUME	1.31E-05	1.31E-05	1.31E-05	1.31E-05	1.31E-05	1.31E-05	1.31E-05	2.15E-05
GROUND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MEAT								
ADULT	7.77E-05	7.77E-05	3.78E-04	7.77E-05	7.77E-05	7.77E-05	7.77E-05	7.77E-05
TEEN	6.51E-05	6.51E-05	3.19E-04	6.51E-05	6.51E-05	6.51E-05	6.51E-05	6.51E-05
CHILD	1.22E-04	1.22E-04	6.00E-04	1.22E-04	1.22E-04	1.22E-04	1.22E-04	1.22E-04

TABLE IV-A-35

FORT CALHOUN ANNUAL 2016, DOSE PROJECTIONS

SPECIAL LOCATION NO. 35 BEEF
AT 0.65 MILES SSW

ANNUAL_BETA_AIR_DOSE = 1.39E-04 MILLRADS
ANNUAL_GAMMA_AIR_DOSE = 3.12E-04 MILLRADS

PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
PLUME	2.07E-04	2.07E-04	2.07E-04	2.07E-04	2.07E-04	2.07E-04	2.07E-04	3.40E-04
GROUND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MEAT								
ADULT	1.23E-03	1.23E-03	5.99E-03	1.23E-03	1.23E-03	1.23E-03	1.23E-03	1.23E-03
TEEN	1.03E-03	1.03E-03	5.06E-03	1.03E-03	1.03E-03	1.03E-03	1.03E-03	1.03E-03
CHILD	1.93E-03	1.93E-03	9.50E-03	1.93E-03	1.93E-03	1.93E-03	1.93E-03	1.93E-03

TABLE IV-A-36

FORT CALHOUN ANNUAL 2016, DOSE PROJECTIONS

SPECIAL LOCATION NO. 36 BEEF
AT 0.76 MILES SW

ANNUAL_BETA_AIR_DOSE = 1.68E-04 MILLRADS
ANNUAL_GAMMA_AIR_DOSE = 3.78E-04 MILLRADS

PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
PLUME	2.50E-04	2.50E-04	2.50E-04	2.50E-04	2.50E-04	2.50E-04	2.51E-04	4.12E-04
GROUND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MEAT ADULT	1.49E-03	1.49E-03	7.25E-03	1.49E-03	1.49E-03	1.49E-03	1.49E-03	1.49E-03
TEEN	1.25E-03	1.25E-03	6.12E-03	1.25E-03	1.25E-03	1.25E-03	1.25E-03	1.25E-03
CHILD	2.33E-03	2.33E-03	1.15E-02	2.33E-03	2.33E-03	2.33E-03	2.33E-03	2.33E-03

TABLE IV-A-37

FORT CALHOUN ANNUAL 2016, DOSE PROJECTIONS

SPECIAL LOCATION NO. 37 BEEF
AT 2.18 MILES WSW

ANNUAL_BETA_AIR_DOSE = 1.39E-05 MILLRADS
ANNUAL_GAMMA_AIR_DOSE = 3.12E-05 MILLRADS

PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
PLUME	2.07E-05	2.07E-05	2.07E-05	2.07E-05	2.07E-05	2.07E-05	2.07E-05	3.40E-05
GROUND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MEAT								
ADULT	1.23E-04	1.23E-04	5.99E-04	1.23E-04	1.23E-04	1.23E-04	1.23E-04	1.23E-04
TEEN	1.03E-04	1.03E-04	5.06E-04	1.03E-04	1.03E-04	1.03E-04	1.03E-04	1.03E-04
CHILD	1.93E-04	1.93E-04	9.50E-04	1.93E-04	1.93E-04	1.93E-04	1.93E-04	1.93E-04

TABLE IV-A-38

FORT CALHOUN ANNUAL 2016, DOSE PROJECTIONS

SPECIAL LOCATION NO. 38 BEEF
AT 2.28 MILES W

ANNUAL_BETA_AIR_DOSE = 1.61E-05 MILLRADS
ANNUAL_GAMMA_AIR_DOSE = 3.61E-05 MILLRADS

PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
PLUME	2.39E-05	2.39E-05	2.39E-05	2.39E-05	2.39E-05	2.39E-05	2.40E-05	3.94E-05
GROUND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MEAT								
ADULT	1.43E-04	1.43E-04	6.93E-04	1.43E-04	1.43E-04	1.43E-04	1.43E-04	1.43E-04
TEEN	1.19E-04	1.19E-04	5.85E-04	1.19E-04	1.19E-04	1.19E-04	1.19E-04	1.19E-04
CHILD	2.23E-04	2.23E-04	1.10E-03	2.23E-04	2.23E-04	2.23E-04	2.23E-04	2.23E-04

TABLE IV-A-39

FORT CALHOUN ANNUAL 2016, DOSE PROJECTIONS

SPECIAL LOCATION NO. 39 BEEF
AT 4.59 MILES WNW

ANNUAL_BETA_AIR_DOSE = 2.15E-06 MILLRADS
ANNUAL_GAMMA_AIR_DOSE = 1.67E-06 MILLRADS

PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
PLUME	1.06E-06	1.06E-06	1.06E-06	1.06E-06	1.06E-06	1.06E-06	1.08E-06	2.15E-06
GROUND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MEAT								
ADULT	7.13E-05	7.13E-05	3.47E-04	7.13E-05	7.13E-05	7.13E-05	7.13E-05	7.13E-05
TEEN	5.97E-05	5.97E-05	2.93E-04	5.97E-05	5.97E-05	5.97E-05	5.97E-05	5.97E-05
CHILD	1.11E-04	1.11E-04	5.50E-04	1.11E-04	1.11E-04	1.11E-04	1.11E-04	1.11E-04

TABLE IV-A-40

FORT CALHOUN ANNUAL 2016, DOSE PROJECTIONS

SPECIAL LOCATION NO. 40 GOAT
AT 3.44 MILES S

ANNUAL_BETA_AIR_DOSE = 2.93E-06 MILLRADS
ANNUAL_GAMMA_AIR_DOSE = 5.84E-06 MILLRADS

PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
PLUME	3.86E-06	3.86E-06	3.86E-06	3.86E-06	3.86E-06	3.86E-06	3.87E-06	6.44E-06
GROUND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
GOATMILK								
ADULT	4.48E-05	4.48E-05	1.99E-04	4.48E-05	4.48E-05	4.48E-05	4.48E-05	4.48E-05
TEEN	7.99E-05	7.99E-05	3.68E-04	7.99E-05	7.99E-05	7.99E-05	7.99E-05	7.99E-05
CHILD	1.91E-04	1.91E-04	9.04E-04	1.91E-04	1.91E-04	1.91E-04	1.91E-04	1.91E-04
INFANT	3.93E-04	3.93E-04	1.77E-03	3.93E-04	3.93E-04	3.93E-04	3.93E-04	3.93E-04

TABLE IV-B-1

FORT CALHOUN 1 DOSE CONTRIBUTIONS FROM GASEOUS EFFLUENTS
UNRESTRICTED AREA BOUNDARY
JANUARY 1, 2016 TO DECEMBER 31, 2016

MAXIMUM SITE BOUNDARY GAMMA AIR DOSE - 1.28E-03 MILLRADS

MAXIMUM SITE BOUNDARY BETA AIR DOSE - 5.70E-04 MILLRADS

TABLE IV-C-1

FORT CALHOUN ANNUAL 2016, DOSE PROJECTIONS
ALARA ANNUAL INTEGRATED POPULATION DOSE SUMMARY (PERSON-REM)

PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
PLUME	1.25E-04	1.25E-04	1.25E-04	1.25E-04	1.25E-04	1.25E-04	1.27E-04	2.61E-04
	0.47%	0.47%	0.10%	0.47%	0.47%	0.47%	0.48%	0.98%
INHAL	6.64E-04	6.64E-04	0.00E+00	6.64E-04	6.64E-04	6.64E-04	6.64E-04	6.64E-04
	2.51%	2.51%	0.00%	2.51%	2.51%	2.51%	2.50%	2.49%
VEGET	1.48E-02	1.48E-02	7.03E-02	1.48E-02	1.48E-02	1.48E-02	1.48E-02	1.48E-02
	55.81%	55.81%	56.93%	55.81%	55.81%	55.81%	55.81%	55.52%
COW MILK	3.73E-03	3.73E-03	1.79E-02	3.73E-03	3.73E-03	3.73E-03	3.73E-03	3.73E-03
	14.08%	14.08%	14.52%	14.08%	14.08%	14.08%	14.08%	14.01%
MEAT	7.19E-03	7.19E-03	3.52E-02	7.19E-03	7.19E-03	7.19E-03	7.19E-03	7.19E-03
	27.14%	27.14%	28.45%	27.14%	27.14%	27.14%	27.13%	27.00%
TOTAL	2.65E-02	2.65E-02	1.24E-01	2.65E-02	2.65E-02	2.65E-02	2.65E-02	2.66E-02

SECTION V

DOSE FROM LIQUID EFFLUENTS

LADTAP II OUTPUT

Technical Specification 5.9.4.a

January 1, 2016 - December 31, 2016

Radioactive Effluent Releases - First, Second, Third, and Fourth Quarters 2016

LIQUID EFFLUENTS

During the reporting period, a total of 4.34E-02 curies of radioactive liquid materials less tritium, dissolved noble gases, and alpha were released to the Missouri River at an average concentration of 9.30E-09 µCi/mL. This represents 9.30E-01 percent of the limits specified in Appendix B to 10 CFR 20 (1.0E-06 µCi/mL for unrestricted areas), 149 curies of tritium were discharged at an average diluted concentration of 3.19E-05 µCi/mL or 3.19 percent of ECL (1.0E-03 µCi/mL).

No gross alpha radioactivity was identified by Off-site vendor analysis of quarterly liquid composites for the reporting period. Ni-63 was identified in the first quarterly composite, and represented 0.85% of the total activity released.

Dilution water during the period amounted to 1.16E+12 liters, while liquid waste discharges consisted of 1.06E+08 liters of radioactive liquid waste.

A. Potential Annual Doses to Individuals from Liquid Releases

Total body, skin, and organ mRem for liquid releases were calculated for all significant liquid pathways using the annual configuration of the LADTAP II program.

The inputs to LADTAP II for the annual period from January 1, 2016 through December 31, 2016 were as follows:

(1) All liquid effluents were as described in Section IV except for entrained noble gases (Ar-41, Xe-131M, Xe-133M, Xe-133, Xe-135M, Xe-135, Kr-85M, Kr-87, and Kr-88).

(2) An average dilution stream flow during periods of release was 691.4 cubic feet per second (CFS) was utilized for 2016. The average discharge rate during releases was 725.0 cubic feet per second (CFS).

(3) Dilution factors (inverse of the mixing ratios) were computed based on Regulatory Guide 1.113 (equation 7 in Section 2.a.1 of Appendix A) for a one dimensional transport model.

(4) Drinking water transport times of 6.6 hours to the Omaha intake and 7.0 hours to the Council Bluffs intake were used for dose calculations.

(5) A shorewidth factor of 0.2 was used.

(6) All dose factors, transport times from receptor to individual, and usage factors are defined by Regulatory Guide 1.109 and NUREG-0172.

The discharge site was chosen to present the most conservative estimate of mRem dose for an average adult, teenager, child, and infant. A conservative approach is also presented by the assumption that Omaha and Council Bluffs receive all drinking water from the Missouri River.

B. Potential Annual Doses to Population from Liquid Releases

The LADTAP II program in its annual configuration was also used to calculate to total body and organ doses for the population of 950,006 within a 50-mile radius of the plant (based on the 2010 census). The same input was used as in the individual cases with the addition of the following:

(1) Dilution factors and transport times for the pathways of sport fish, commercial fish, recreation and biota were calculated based on a distance of two miles downstream as approximately the distance to the nearest recreation facility - DeSoto National Wildlife Preserve.

(2) The total fish harvest for both sport and commercial purposes was calculated using an average commercial fish catch for Nebraska.

```
****************************************************************************************
*                                                                                      *
*                                                                                      *
*                                                                                      *
*                                                                                      *
*                                                                                      *
*               L       AAA   DDDD   TTTTT   AAA   PPPP     IIIII IIIII                *
*               L      A   A  D   D    T    A   A  P   P      I     I                  *
*               L      A   A  D   D    T    A   A  P   P      I     I                  *
*               L      AAAAA  D   D    T    AAAAA  PPPP       I     I                  *
*               L      A   A  D   D    T    A   A  P          I     I                  *
*               LLLLL  A   A  DDDD     T    A   A  P        IIIII IIIII                *
*                                                                                      *
*                                                                                      *
*                                                                                      *
*                                                                                      *
*                                                                                      *
*             EVALUATION OF RADIATION DOSES FROM RELEASES OF RADIACTIVITY              *
*                                                                                      *
*                       IN NUCLEAR POWER PLANTS LIQUID EFFLUENTS                       *
*                                                                                      *
*                        REVISION DATE:  PNL VAX - OCTOBER 1985                        *
*                                                                                      *
*                                                                                      *
*        FORT CALHOUN ANNUAL 2016, DOSE PROJECTIONS                                    *
*                                                                                      *
*                                                                                      *
*                                                                                      *
*                                                                                      *
*                           RADIOLOGICAL ASSESSMENT BRANCH                             *
*                                                                                      *
*                           DIVISION OF SYSTEMS INTEGRATION                            *
*                                                                                      *
*                           U. S. NUCLEAR REGULATORY COMMISSION                        *
*                                                                                      *
*                           WASHINGTON, D. C.                                          *
*                                                                                      *
*                           DATE OF RUN:    20170308                                   *
*                                                                                      *
****************************************************************************************
```

LOCATION IS FRESHWATER INTAKE

A D U L T   D O S E S

PATHWAY	SKIN	BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI
	DOSE (MREM PER YEAR INTAKE)							
FISH		2.99E-02	4.11E-02	2.70E-02	6.94E-05	1.40E-02	4.67E-03	8.34E-04
DRINKING		1.25E-04	4.95E-04	4.37E-04	3.45E-04	3.83E-04	3.45E-04	3.29E-04
SHORELINE	4.29E-05	3.68E-05	3.68E-05	3.68E-05	3.68E-05	3.68E-05	3.68E-05	3.68E-05
SWIMMING		1.13E-07	1.13E-07	1.13E-07	1.13E-07	1.13E-07	1.13E-07	1.13E-07
BOATING		5.64E-08	5.64E-08	5.64E-08	5.64E-08	5.64E-08	5.64E-08	5.64E-08
TOTAL	4.29E-05	3.01E-02	4.17E-02	2.75E-02	4.51E-04	1.44E-02	5.05E-03	1.20E-03

	USAGE (KG/YR,HR/YR)	DILUTION	TIME(HR)
FISH	21.0	7.3	24.00
DRINKING	730.0	30.8	18.60
SHORELINE	12.0	7.3	0.00
SWIMMING	12.0	7.3	0.00
BOATING	12.0	7.3	0.00

SHOREWIDTH FACTOR=0.2

T E E N A G E R   D O S E S

PATHWAY	SKIN	BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI
	DOSE (MREM PER YEAR INTAKE)							
FISH		3.20E-02	4.28E-02	1.50E-02	5.90E-05	1.46E-02	5.68E-03	6.38E-04
DRINKING		1.23E-04	3.91E-04	2.86E-04	2.46E-04	2.85E-04	2.51E-04	2.32E-04
SHORELINE	2.40E-04	2.05E-04	2.05E-04	2.05E-04	2.05E-04	2.05E-04	2.05E-04	2.05E-04
SWIMMING		6.30E-07	6.30E-07	6.30E-07	6.30E-07	6.30E-07	6.30E-07	6.30E-07
BOATING		3.15E-07	3.15E-07	3.15E-07	3.15E-07	3.15E-07	3.15E-07	3.15E-07
TOTAL	2.40E-04	3.24E-02	4.34E-02	1.55E-02	5.11E-04	1.51E-02	6.14E-03	1.08E-03

	USAGE (KG/YR,HR/YR)	DILUTION	TIME(HR)
FISH	16.0	7.3	24.00
DRINKING	510.0	30.8	18.60
SHORELINE	67.0	7.3	0.00
SWIMMING	67.0	7.3	0.00
BOATING	67.0	7.3	0.00

SHOREWIDTH FACTOR=0.2

C H I L D   D O S E S

PATHWAY	SKIN	BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI
				DOSE (MREM PER YEAR INTAKE)				
FISH		4.03E-02	3.88E-02	5.76E-03	5.53E-05	1.26E-02	4.56E-03	2.66E-04
DRINKING		3.58E-04	7.80E-04	4.91E-04	4.80E-04	5.51E-04	4.80E-04	4.43E-04
SHORELINE	5.01E-05	4.29E-05	4.29E-05	4.29E-05	4.29E-05	4.29E-05	4.29E-05	4.29E-05
SWIMMING		1.32E-07	1.32E-07	1.32E-07	1.32E-07	1.32E-07	1.32E-07	1.32E-07
BOATING		6.58E-08	6.58E-08	6.58E-08	6.58E-08	6.58E-08	6.58E-08	6.58E-08
TOTAL	5.01E-05	4.07E-02	3.96E-02	6.30E-03	5.78E-04	1.32E-02	5.09E-03	7.52E-04

	USAGE (KG/YR,HR/YR)	DILUTION	TIME(HR)
FISH	6.9	7.3	24.00
DRINKING	510.0	30.8	18.60
SHORELINE	14.0	7.3	0.00
SWIMMING	14.0	7.3	0.00
BOATING	14.0	7.3	0.00

SHOREWIDTH FACTOR=0.2

I N F A N T   D O S E S

PATHWAY	SKIN	BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI
				DOSE (MREM PER YEAR INTAKE)				
FISH		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
DRINKING		3.69E-04	8.61E-04	4.63E-04	4.94E-04	5.48E-04	4.79E-04	4.34E-04
SHORELINE	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TOTAL	0.00E+00	3.69E-04	8.61E-04	4.63E-04	4.94E-04	5.48E-04	4.79E-04	4.34E-04

	USAGE (KG/YR,HR/YR)	DILUTION	TIME(HR)
FISH	0.0	7.3	24.00
DRINKING	330.0	30.8	18.60

SHOREWIDTH FACTOR=0.2

LOCATION IS SITE DISCHG.

A D U L T   D O S E S

PATHWAY	DOSE (MREM PER YEAR INTAKE) SKIN	BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI
FISH		2.19E-01	3.00E-01	1.97E-01	5.07E-04	1.02E-01	3.41E-02	6.09E-03
DRINKING		3.85E-03	1.53E-02	1.35E-02	1.06E-02	1.18E-02	1.06E-02	1.01E-02
SHORELINE	3.13E-04	2.69E-04	2.69E-04	2.69E-04	2.69E-04	2.69E-04	2.69E-04	2.69E-04
SWIMMING		8.24E-07	8.24E-07	8.24E-07	8.24E-07	8.24E-07	8.24E-07	8.24E-07
BOATING		4.12E-07	4.12E-07	4.12E-07	4.12E-07	4.12E-07	4.12E-07	4.12E-07
TOTAL	3.13E-04	2.23E-01	3.16E-01	2.11E-01	1.14E-02	1.14E-01	4.50E-02	1.65E-02

	USAGE (KG/YR,HR/YR)	DILUTION	TIME(HR)
FISH	21.0	1.0	24.00
DRINKING	730.0	1.0	12.00
SHORELINE	12.0	1.0	0.00
SWIMMING	12.0	1.0	0.00
BOATING	12.0	1.0	0.00

SHOREWIDTH FACTOR=0.2

T E E N A G E R   D O S E S

PATHWAY	DOSE (MREM PER YEAR INTAKE) SKIN	BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI
FISH		2.34E-01	3.13E-01	1.09E-01	4.30E-04	1.06E-01	4.15E-02	4.65E-03
DRINKING		3.78E-03	1.21E-02	8.81E-03	7.58E-03	8.76E-03	7.72E-03	7.15E-03
SHORELINE	1.75E-03	1.50E-03	1.50E-03	1.50E-03	1.50E-03	1.50E-03	1.50E-03	1.50E-03
SWIMMING		4.60E-06	4.60E-06	4.60E-06	4.60E-06	4.60E-06	4.60E-06	4.60E-06
BOATING		2.30E-06	2.30E-06	2.30E-06	2.30E-06	2.30E-06	2.30E-06	2.30E-06
TOTAL	1.75E-03	2.39E-01	3.26E-01	1.20E-01	9.52E-03	1.17E-01	5.07E-02	1.33E-02

	USAGE (KG/YR,HR/YR)	DILUTION	TIME(HR)
FISH	16.0	1.0	24.00
DRINKING	510.0	1.0	12.00
SHORELINE	67.0	1.0	0.00
SWIMMING	67.0	1.0	0.00
BOATING	67.0	1.0	0.00

SHOREWIDTH FACTOR=0.2

C H I L D   D O S E S

PATHWAY	SKIN	BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI
				DOSE (MREM PER YEAR INTAKE)				
FISH		2.94E-01	2.83E-01	4.21E-02	4.04E-04	9.23E-02	3.33E-02	1.94E-03
DRINKING		1.10E-02	2.40E-02	1.51E-02	1.48E-02	1.70E-02	1.48E-02	1.36E-02
SHORELINE	3.66E-04	3.13E-04	3.13E-04	3.13E-04	3.13E-04	3.13E-04	3.13E-04	3.13E-04
SWIMMING		9.61E-07	9.61E-07	9.61E-07	9.61E-07	9.61E-07	9.61E-07	9.61E-07
BOATING		4.81E-07	4.81E-07	4.81E-07	4.81E-07	4.81E-07	4.81E-07	4.81E-07
TOTAL	3.66E-04	3.06E-01	3.07E-01	5.75E-02	1.55E-02	1.10E-01	4.84E-02	1.59E-02

	USAGE (KG/YR,HR/YR)	DILUTION	TIME(HR)
FISH	6.9	1.0	24.00
DRINKING	510.0	1.0	12.00
SHORELINE	14.0	1.0	0.00
SWIMMING	14.0	1.0	0.00
BOATING	14.0	1.0	0.00

SHOREWIDTH FACTOR=0.2

I N F A N T   D O S E S

PATHWAY	SKIN	BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI
				DOSE (MREM PER YEAR INTAKE)				
FISH		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
DRINKING		1.14E-02	2.65E-02	1.43E-02	1.53E-02	1.69E-02	1.48E-02	1.34E-02
SHORELINE	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TOTAL	0.00E+00	1.14E-02	2.65E-02	1.43E-02	1.53E-02	1.69E-02	1.48E-02	1.34E-02

	USAGE (KG/YR,HR/YR)	DILUTION	TIME(HR)
FISH	0.0	1.0	24.00
DRINKING	330.0	1.0	12.00

SHOREWIDTH FACTOR=0.2

* * * FISH CONSUMPTION POPULATION DOSES * * *
PERSON-REM

__________SPORT HARVEST__________

PATHWAY	AGE GROUP	USAGE	DOSE (PERSON-REM) BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI
FISH	ADULT	6.10E+04	8.69E-02	1.19E-01	7.84E-02	1.61E-04	4.06E-02	1.35E-02	2.42E-03
FISH	TEENAGER	7.12E+03	1.42E-02	1.90E-02	6.66E-03	2.05E-05	6.48E-03	2.53E-03	2.84E-04
FISH	CHILD	4.93E+03	2.88E-02	2.77E-02	4.11E-03	3.00E-05	9.02E-03	3.26E-03	1.90E-04
FISH	TOTAL	7.30E+04	1.30E-01	1.66E-01	8.92E-02	2.12E-04	5.61E-02	1.93E-02	2.89E-03

LOCATION	DILUTION	CATCH	TIME(HR)-INCLUDES FOOD PROCESSING TIME OF 1.68E+02 HR	POPULATION=1.24E+04
	7.30E+00	7.30E+04	1.69E+02	

AVERAGE INDIVIDUAL CONSUMPTION (KG/YR) ADULT=6.90E+00 TEEN=5.20E+00 CHILD=2.20E+00

* * * FISH CONSUMPTION POPULATION DOSES * * *
PERSON-REM

__________COMMERCIAL HARVEST__________

PATHWAY	AGE GROUP	USAGE	DOSE (PERSON-REM) BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI
FISH	ADULT	4.18E+06	9.88E-03	1.36E-02	8.92E-03	1.69E-05	4.61E-03	1.54E-03	2.75E-04
FISH	TEENAGER	4.88E+05	1.62E-03	2.17E-03	7.58E-04	2.11E-06	7.37E-04	2.87E-04	3.22E-05
FISH	CHILD	3.38E+05	3.28E-03	3.15E-03	4.68E-04	3.05E-06	1.03E-03	3.70E-04	2.16E-05
FISH	TOTAL	5.01E+06	1.48E-02	1.89E-02	1.01E-02	2.20E-05	6.38E-03	2.20E-03	3.29E-04

LOCATION	DILUTION	CATCH	TIME(HR)-INCLUDES FOOD PROCESSING TIME OF 2.40E+02 HR	POPULATION=8.53E+05
	7.30E+00	7.30E+04	2.41E+02	

AVERAGE INDIVIDUAL CONSUMPTION (KG/YR) ADULT=6.90E+00 TEEN=5.20E+00 CHILD=2.20E+00

__________NEPA DOSES__________

NOTE--TOTAL NEPA DOSE INCLUDES SPORT CATCH

PATHWAY	AGE GROUP	USAGE	DOSE (PERSON-REM) BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI
FISH	ADULT	1.22E+05	1.74E-01	2.39E-01	1.57E-01	3.10E-04	8.11E-02	2.71E-02	4.84E-03
FISH	TEENAGER	1.42E+04	2.85E-02	3.81E-02	1.33E-02	3.91E-05	1.30E-02	5.05E-03	5.67E-04
FISH	CHILD	9.85E+03	5.76E-02	5.53E-02	8.23E-03	5.68E-05	1.80E-02	6.51E-03	3.79E-04
FISH	TOTAL	1.46E+05	2.60E-01	3.32E-01	1.78E-01	4.05E-04	1.12E-01	3.87E-02	5.78E-03

* * * POPULATION WATER CONSUMPTION DOSES * * *

SUPPLIER-OMAHA

PATHWAY	AGE GROUP	USAGE	BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI
			DOSE (PERSON-REM)						
DRINKING	ADULT	1.39E+08	2.38E-02	9.43E-02	8.32E-02	6.55E-02	7.30E-02	6.56E-02	6.27E-02
DRINKING	TEENAGER	1.51E+07	3.64E-03	1.16E-02	8.49E-03	7.27E-03	8.44E-03	7.44E-03	6.88E-03
DRINKING	CHILD	2.48E+07	1.74E-02	3.79E-02	2.38E-02	2.32E-02	2.68E-02	2.33E-02	2.15E-02
DRINKING	TOTAL	1.79E+08	4.48E-02	1.44E-01	1.16E-01	9.59E-02	1.08E-01	9.64E-02	9.11E-02

POPULATION=5.29E+05 DILUTION=3.08E+01 TRANSIT TIME=3.06E+01 HR (INCLUDING 24 HR FOR TREATMENT FACILITY)

AVERAGE INDIVIDUAL CONSUMPTION (L/YR) ADULT=3.70E+02 TEEN=2.60E+02 CHILD=2.60E+02

SUPPLIER-COUNCIL BLUFFS

PATHWAY	AGE GROUP	USAGE	BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI
			DOSE (PERSON-REM)						
DRINKING	ADULT	2.29E+07	3.85E-03	1.53E-02	1.35E-02	1.06E-02	1.18E-02	1.06E-02	1.01E-02
DRINKING	TEENAGER	2.49E+06	5.89E-04	1.88E-03	1.37E-03	1.18E-03	1.37E-03	1.20E-03	1.11E-03
DRINKING	CHILD	4.07E+06	2.81E-03	6.13E-03	3.86E-03	3.75E-03	4.33E-03	3.77E-03	3.48E-03
DRINKING	TOTAL	2.94E+07	7.25E-03	2.33E-02	1.87E-02	1.55E-02	1.75E-02	1.56E-02	1.47E-02

POPULATION=8.70E+04 DILUTION=3.13E+01 TRANSIT TIME=3.10E+01 HR (INCLUDING 24 HR FOR TREATMENT FACILITY)

AVERAGE INDIVIDUAL CONSUMPTION (L/YR) ADULT=3.70E+02 TEEN=2.60E+02 CHILD=2.60E+02

-----CUMULATIVE TOTAL-----

PATHWAY	AGE GROUP	USAGE	BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI
DRINKING	CUMUL TOTAL	2.08E+08	5.21E-02	1.67E-01	1.34E-01	1.11E-01	1.26E-01	1.12E-01	1.06E-01

__________HYDROSPHERE TRITIUM DOSE__________

AVERAGE INDIVIDUAL WATER CONSUMPTION = 3.0 L/DAY

PATHWAY	AGE GROUP	USAGE	BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI
WATER	TOTAL	2.86E+11	0.00E+00	1.13E-03	1.13E-03	1.13E-03	1.13E-03	1.13E-03	1.13E-03

* * * RECREATION POPULATION DOSES * * *

LOCATION- DOWN STREAM SWIMMING

DILUTION= 7.30E+00 TRANSIT TIME= 6.70E-01 HR SWF= 0.2

PATHWAY	AGE GROUP	USAGE	DOSE (PERSON-REM) SKIN	TOTAL BODY	THYROID
SHORELINE	TOTAL POPUL	4.10E+07	1.47E-01	1.26E-01	1.26E-01

LOCATION- DOWN STREAM SWIMMING

DILUTION= 7.30E+00 TRANSIT TIME= 6.70E-01 HR

PATHWAY	AGE GROUP	USAGE	DOSE (PERSON-REM) SKIN	TOTAL BODY	THYROID
SWIMMING	TOTAL POPUL	4.10E+07		3.85E-04	3.85E-04

LOCATION- DOWN STREAM BOATING

DILUTION= 7.30E+00 TRANSIT TIME= 6.70E-01 HR

PATHWAY	AGE GROUP	USAGE	DOSE (PERSON-REM) SKIN	TOTAL BODY	THYROID
BOATING	TOTAL POPUL	4.10E+07		1.93E-04	1.93E-04

* * * DOSE TO BIOTA * * *

MRADS PER YEAR

BIOTA DILUTION= 1.00E+00 TRANSIT TIME= 0.00E+00 HR

	INTERNAL	EXTERNAL	TOTAL
FISH	6.59E-01	9.81E-01	1.64E+00
INVERTEBRATE	3.37E-01	1.96E+00	2.30E+00
ALGAE	1.69E-01	6.01E-04	1.70E-01
MUSKRAT	3.58E+00	6.54E-01	4.24E+00
RACCOON	1.33E+00	4.90E-01	1.83E+00
HERON	2.08E+01	6.54E-01	2.15E+01
DUCK	3.27E+00	9.81E-01	4.25E+00

SECTION VI

RADIOACTIVE EFFLUENT RELEASES - SOLID RADIOACTIVE WASTE
Technical Specifications 5.9.4.a

January 1, 2016 - December 31, 2016

VI. RADIOACTIVE EFFLUENT RELEASE – SOLID RADIOACTIVE WASTE EFFLUENT AND WASTE DISPOSAL REPORT

January 1, 2016 through December 31, 2016

SOLID WASTE AND IRRADIATED FUEL SHIPMENTS

A. SOLID WASTE SHIPPED OFFSITE FOR BURIAL OR DISPOSAL (NOT IRRADIATED)

1. Type of Waste	Month Shipped	Number of Shipments	Volume Cu. Meter	Curie Content	Est. Total % Error
a. Spent resins, filter sludges, evaporator bottoms, etc.	January	0	0	0	N/A
	February	0	0	0	N/A
	March	0	0	0	N/A
	April	0	0	0	N/A
	May	0	0	0	N/A
	June	0	0	0	N/A
	July	0	0	0	N/A
	August	0	0	0	N/A
	September	0	0	0	N/A
	October	0	0	0	N/A
	November	0	0	0	N/A
	December	0	0	0	N/A
Total	(Type a)	0	0	0	N/A
b. Dry compressible, contaminated equipment, etc.	January	0	0	0	N/A
	February	0	0	0	N/A
	March	0	0	0	N/A
	April	1	32.79	1.77E-02	20
	May	0	0	0	N/A
	June	0	0	0	N/A
	July	0	0	0	N/A
	August	0	0	0	N/A
	September	0	0	0	N/A
	October	0	0	0	N/A
	November	0	0	0	N/A
	December	1	36.25	3.87E-03	20
Total	(Type b)	2	69.04	2.16E-02	20

VI. RADIOACTIVE EFFLUENT RELEASE – SOLID RADIOACTIVE WASTE EFFLUENT AND WASTE DISPOSAL REPORT

(Continued)

1. Type of Waste	Month Shipped	Number of Shipments	Volume Cu. Meter	Curie Content	Est. Total % Error
c. Irradiated components and other categories.	January	0	0	0	N/A
	February	0	0	0	N/A
	March	0	0	0	N/A
	April	0	0	0	N/A
	May	0	0	0	N/A
	June	0	0	0	N/A
	July	0	0	0	N/A
	August	0	0	0	N/A
	September	0	0	0	N/A
	October	0	0	0	N/A
	November	0	0	0	N/A
	December	0	0	0	N/A
Total	(Type c)	0	0	0	N/A
d. Other	January	0	0	0	N/A
	February	0	0	0	N/A
	March	0	0	0	N/A
	April	0	0	0	N/A
	May	0	0	0	N/A
	June	0	0	0	N/A
	July	0	0	0	N/A
	August	0	0	0	N/A
	September	0	0	0	N/A
	October	0	0	0	N/A
	November	0	0	0	N/A
	December	0	0	0	N/A
Total	(Type d)	0	0	0	N/A

III. RADIOACTIVE EFFLUENT RELEASES–SOLID RADIOACTIVE

(Continued)

B. ESTIMATE OF MAJOR NUCLIDE COMPOSITION (By Type of Waste)

1. Percentage of Curies from Represented Isotopes

	Isotope	Percent	Curies
a.	N/A	N/A	N/A
b.	Cs-137	24.6	1.33E-04
	Ni-63	17.5	9.43E-05
	Nb-95	16.5	8.93E-02
	Co-60	12.4	6.71E-05
	Zr-95	9.3	5.04E-05
	Fe-55	8.6	4.64E-02
	Cr-51	6.4	3.45E-05
	Co-58	2.6	1.40E-05

All Other Nuclides Constitute Less than 1%

	Isotope	Percent	Curies
c.	N/A	N/A	N/A
d.	N/A	N/A	N/A

C. SOLID WASTE (DISPOSITION)

Number of Shipments	Transportation Mode	Destination
2	Sole Use Vehicle	Energy Solutions, Bear Creek TN

D. IRRADIATED FUEL SHIPMENTS (DISPOSITION)

Number of Shipments	Transportation Mode	Destination
N/A	N/A	N/A

SECTION VII

ATTACHMENT 1

ODCM and PCP revisions for the period January 1, 2016 through December 31, 2016 in accordance with Technical Specification 5.17.d and 5.18.d, the radioactive effluent release report shall include any revisions to the Offsite Dose Calculation Manual (ODCM) and the Process Control Program (PCP).

____1__ revisions were made to the Offsite Dose Calculation Manual (ODCM).

____0__ revisions were made to the Process Control Program (PCP).

January 1, 2016 - December 31, 2016

CH-ODCM-0001

Off-Site Dose Calculation Manual (ODCM)

Revision 25

Safety Classification: Non-Safety

Usage Level: Reference

Change No.:	EC 68214
Reason for Change:	Removed the term Plant Review Committee and replaced with Plant Operations Review Committee
Requestor:	R. Layman
Preparer:	J. Shirah
Issued:	06-30-16 3:00 pm

Fort Calhoun Station

Table of Contents

PART I

List of Tables

PART I

List of Figures

PART I

Table of Contents

PART II

List of Tables

PART II

List of Figures

PART II

1.0 PURPOSE AND SCOPE

1.1 Purpose

1.1.1 Contains methodologies for and parameters necessary for calculating offsite doses, determination of gaseous and liquid radiation monitor set points, and administrative controls for effluent instrumentation, Radiological Effluent Tech Specs (RETS), and the Radiological Environmental Monitoring Program (REMP).

1.2 Scope

1.2.1 Radioactive effluents are generated from station operations. These controls provide methodologies ensuring these effluents are properly monitored and quantified to promote accurate dose reporting. Additional controls ensure station equipment and processes are used to minimize release to the environment. The combination of minimizing release, accurately reporting dose, and monitoring the plant environs provides the basis for ensuring that station operation is not negatively impacting public health and the environment.

2.0 DEFINITIONS

2.1 Abnormal Discharge - The unplanned or uncontrolled emission of an effluent (i.e., containing plant-related, licensed radioactive material) into the unrestricted area.

2.2 Abnormal Release - The unplanned or uncontrolled emission of an effluent (i.e., containing plant-related, licensed radioactive material).

2.3 Channel Check - A CHANNEL CHECK shall be the qualitative assessment of channel behavior during operation by observation. This determination shall include, where possible, comparison of the channel indication and/or status with other indications and/or status derived from independent instrument channels measuring the same parameter.

2.4 Channel Function Test - Injection of a simulated signal into the channel to verify that it is operable, including any alarm and/or trip initiating action.

2.5 Effluent Concentration Limit (ECL) - Radionuclide limits listed in 10 CFR Part 20, Appendix B, Table 2, Column 1.

2.6 Member(s) of the Public - Member(s) of the Public means any individual except when that individual is receiving occupational dose.

2.7 Operable-Operability - A system, subsystem, train, component or device shall be OPERABLE or have OPERABILITY when it is capable of performing its specified safety function(s) and when all necessary attendant instrumentation, controls, normal or emergency electrical power sources, cooling and seal water, lubrication, and other auxiliary equipment that are required for the system, subsystem, train, component, or device to perform its specified safety function(s) are also capable of performing their related support function(s).

2.8 Purge-Purging - PURGE or PURGING shall be any controlled process of discharging air or gas from a confinement to maintain temperature, pressure, humidity, concentration or other operating condition, in such a manner that replacement air or gas is required to purify the confinement.

2.9 Residual Radioactivity - Residual radioactivity means radioactivity in structures, materials, soils, ground water, and other media at a site resulting from activities under the licensee's control. This includes radioactivity from all licensed and unlicensed sources used by the licensee, but it excludes background radiation. It also includes radioactive materials remaining at the site as a result of routine or accidental releases of radioactive material at the site and previous burials at the site, even if those burials were made in accordance with the provisions of 10 CFR Part 20.

2.10 Site Boundary - The Site Boundary is the line beyond which the land is neither owned, or leased, nor controlled by the licensee.

2.11 Source Check - A SOURCE CHECK shall be the qualitative assessment of channel response when the channel sensor is exposed to a source of increased radioactivity.

2.12 Special Liquid - Non-routine release pathway in which normally non-radioactive liquid streams (such as Raw Water) found to contain radioactive material, are non-routine, and will be treated on a case specific basis if and when this occurs.

2.13 Unrestricted Area - An UNRESTRICTED AREA shall be any area at or beyond the SITE BOUNDARY access to which is not controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials, or any area within the SITE BOUNDARY used for residential quarters or for industrial, commercial, institutional, and/or recreational purposes.

2.14 Venting - VENTING shall be the controlled process of discharging air or gas from a confinement to maintain temperature, pressure, humidity, concentration, or other operating condition, in such a manner that replacement air or gas is not provided or required during VENTING. Vent, used in system names, does not imply a VENTING process.

2.15 Water Effluent Concentration (WEC) - Radionuclide limits listed in 10 CFR Part 20, Appendix B, Table 2, Column 2.

Table 1.2 - Frequency Notation

The surveillance intervals are defined as follows:

Notation	Title	Frequency[A]
S	Shift	At least once per 12 hours
D	Daily	At least once per 24 hours
W	Weekly	At least once per 7 days
BW	Biweekly	At least once per 14 days
M	Monthly	At least once per 31 days
Q	Quarterly	At least once per 92 days
SA	Semiannual	At least once per 184 days
A	Annually	At least once per 366 days
R	Refueling	At least once per 18 months
P	Prior to	Prior to each release (Performance within 24 hrs.)

A. Each surveillance requirement shall be performed within the specified surveillance interval with a maximum allowable extension not to exceed 25 percent of the specified surveillance interval.

Table 1.3 - Radiological Effluent Controls Program Technical Specification Implementation

Technical Specification	ODCM Implementing Step
5.16.1.a	3.1.1, 3.2.1
5.16.1.b	4.1.1
5.16.1.c	Table 4.1, Table 4.2
5.16.1.d	4.1.2
5.16.1.e	4.1.2B.1, 4.2.2B.1
5.16.1.f	4.1.3A, 4.2.4A
5.16.1.g	4.2.1
5.16.1.h	4.2.2
5.16.1.i	4.2.3
5.16.1.j	4.3.1
5.16.2.a	5.1.1
5.16.2.b	5.2.1
5.16.2.c	5.3.1
5.17	6.3, 6.2.1D
5.18	6.2.1D

3.0 INSTRUMENTATION

3.1 Radioactive Liquid Effluent Instrumentation

3.1.1 Limiting Condition for Operation

A. The radioactive liquid effluent monitoring instrumentation channels shown in Table 3.1.1 shall be OPERABLE with their alarm/trip setpoints set to ensure that the limits of Specification 3.1.1 are not exceeded. The alarm/trip setpoints of these channels shall be determined in accordance with Part II of the Off-Site Dose Calculation Manual.

APPLICABILITY: At all times

ACTION:

1. With a radioactive liquid effluent monitoring instrumentation channel alarm/trip setpoint less conservative than required by the above specification, immediately suspend the releases of radioactive liquid effluents monitored by the affected channel or declare the channel inoperable.

2. With less than the minimum number of radioactive liquid effluent monitoring instrumentation channels operable, take the action shown in Table 3.1.1. Restore inoperable effluent monitoring instrumentation to OPERABLE status within 30 days and, if unsuccessful, explain in the next Annual Radiological Effluent Release Report why this inoperability was not corrected in a timely manner. The reporting requirement is limited to the following instrumentation that monitors effluent streams: RM-055, RM-054A, and RM-054B.

3.1.2 Surveillance Requirements

A. Each radioactive liquid effluent monitoring instrumentation channel shall be demonstrated OPERABLE by performance of the CHANNEL CHECK, SOURCE CHECK, CALIBRATION, and CHANNEL FUNCTIONAL TEST at the frequencies shown in Table 3.1.2.

Table 3.1.1 - Radioactive Liquid Effluent Monitoring Instrumentation

Instrument	Minimum Channels Operable	Action
1. Radioactivity Monitors Providing Alarm and Automatic Termination of Release.		
1.1 Liquid Radwaste Effluent Line (RM-055)	1	1, 5
1.2 Steam Generator Blowdown Effluent Line (RM-054A and B)	1 [A]	2, 5
2. Flow Rate Measurement Devices		
2.1 Liquid Radwaste Effluent Line	1	3
2.2 Steam Generator Blowdown Effluent Line	1	3
3. Radioactivity Recorders		
3.1 Liquid Radwaste Effluent Line	1	4
3.2 Steam Generator Blowdown Effluent Line	1	4
A. If one of the two radiation monitors is inoperable, the activity of both blowdown lines shall be monitored by the operable monitor within 2 hours of the declaration of inoperability by the Shift Manager, or the action steps of ACTION 2, Table 3.1.1 should be performed on the Steam Generator that is not being monitored.		

Table 3.1.1 (continued)

Table Notation	
ACTION 1	With the number of channels OPERABLE less than required by the Minimum Channels OPERABLE requirement, effluent releases may continue provided that prior to initiating a release: 1. At least two independent samples are analyzed in accordance with applicable chemistry procedures. 2. At least two qualified individuals independently verify the release rate calculations.
ACTION 2	With the number of channels OPERABLE less than required by the Minimum Channels OPERABLE requirement, effluent releases may continue provided that grab samples are analyzed for principal gamma emitters at a sensitivity of 5.0E-07 μCi/gram: 1. At least once per 12 hours when the specific activity of the secondary coolant is greater than 0.01 μCi/gram dose equivalent I-131. 2. At least daily when the specific activity of the secondary coolant is less than or equal to 0.01 μCi/gram equivalent I-131. Otherwise, suspend release of radioactive effluents via this pathway.
ACTION 3	With the number of channels OPERABLE less than required by the Minimum Channels OPERABLE requirement, effluent releases may continue provided the flow rate is determined at least once per four hours during the actual release.
ACTION 4	With the number of channels OPERABLE less than required by the Minimum Channels OPERABLE requirement, effluent releases may continue provided the radioactivity is recorded manually at least once per four hours during the actual release.
ACTION 5	During the performance of source checks the effluent radiation monitor is unable to respond, hence is considered inoperable. Effluent releases may continue uninterrupted during the performance of source checks provided the operator is stationed at the monitor during the check. If the effluent radiation monitor fails the source check, carryout the action(s) of the Off-Site Dose Calculation Manual for the inoperable monitor or terminate the effluent release.

Table 3.1.2 - Radioactive Liquid Effluent Monitoring Instrumentation Surveillance Requirements

Instrument		Channel Check	Channel Calibration	Channel Function Test	Source Check
1.	Radioactivity Monitors Providing Alarm and Automatic Isolation				
	1.1 RM-054A/054B	D [A]	R	Q	M
	1.2 RM-055	----	R	Q	P
2.	Flowrate Monitors				
	2.1 Steam Generator Blowdown	D	R	Q	----

A. Visual Flowcheck Daily

3.2 Radioactive Gaseous Effluent Instrumentation

3.2.1 Limiting Condition for Operation

A. The radioactive gaseous effluent monitoring instrumentation channels shown in Table 3.2.1 shall be OPERABLE with their alarm/trip setpoints set to ensure that the limits of Specification 3.2.1 are not exceeded. The alarm/trip setpoints of these channels shall be determined in accordance with Part II of the Off-Site Dose Calculation Manual.

APPLICABILITY: At all times

ACTION:

1. With a radioactive gaseous effluent monitoring instrumentation channel alarm/trip setpoint less conservative than required by the above specification, immediately suspend the releases of radioactive gaseous effluents monitored by the affected channel or declare the channel inoperable.

2. With less than the minimum number of radioactive gaseous effluent monitoring instrumentation channels operable, take the action shown in Table 3.2.1. Restore inoperable effluent monitoring instrumentation to OPERABLE status within 30 days and, if unsuccessful, explain in the next Annual Radiological Effluent Release Report why this inoperability was not corrected in a timely manner. The reporting requirement is limited to the following instrumentation that monitors effluent streams: RM-057, RM-043, RM-062, RM-063, and RM-052.

3.2.2 Surveillance Requirements

A. Each radioactive gaseous effluent monitoring instrumentation channel shall be demonstrated OPERABLE by performance of the CHANNEL CHECK, SOURCE CHECK, CALIBRATION, and CHANNEL FUNCTIONAL TEST at the frequencies shown in Table 3.2.2.

Table 3.2.1 - Radioactive Gaseous Effluent Monitoring Instrumentation

Instrument			Minimum Channels Operable	Action
1.	Auxiliary Bldg. Exhaust Stack (RM-052, RM-062)			
	1.1	Noble Gas	1	1, 9, 11
	1.2	Iodine and Particulate	1	2, 9, 11
2.	Laboratory and Radwaste Processing Building Stack (RM-043)			
	2.1	Noble Gas	1	3, 9
	2.2	Iodine and Particulate	1	4, 9
3.	Condenser Off Gas (RM-057)			
	3.1	Noble Gas	1	5, 9
4.	Containment Purge Line (RM-051, RM-052)			
	4.1	Noble Gas	1	1, 6, 9, 11, 12
	4.2	Iodine and Particulate	1	2, 9, 11, 12
5.	Containment Pressure Relief Line (RM-051, RM-052)			
	5.1	Noble Gas	1	1, 9, 11
	5.2	Iodine and Particulate	1	2, 9, 11
6.	Containment Penetrations M72 and M74 (Integrated Leak Rate Test Depressurization Vent Path)		N/A	10
7.	Flow Rate Measurement Devices			
	7.1	Waste Gas Discharge Header	1	7

Table 3.2.1 - Radioactive Gaseous Effluent Monitoring Instrumentation

Instrument	Minimum Channels Operable	Action
7.2 Auxiliary Building Stack	1	7
7.3 Laboratory and Radwaste Processing Building Stack	1	7
7.4 Containment Purge Line	1	7
7.5 Containment Pressure Relief Line Annubar D/P	1	7
8. Radioactivity Chart Recorders		
8.1 Auxiliary Building Exhaust Stack	1	8

Table 3.2.1 Radioactive Gaseous Effluent Monitoring Instrumentation	
TABLE NOTATION	
ACTION 1	If the Auxiliary Building Exhaust Stack Noble Gas Monitor is inoperable, releases from the containment pressure relief line and the containment purge line are to be secured in the most expeditious manner. Ventilation of the auxiliary building via the Auxiliary Building Exhaust Stack may continue provided grab samples are taken once per 12 hours. (See Table 4.2)
ACTION 2	If the Auxiliary Building Exhaust Stack Iodine and Particulate Sampler is inoperable, ventilation of the Auxiliary Building and releases from the gaseous waste discharge header, containment pressure relief line or the containment purge line may continue through the Auxiliary Building Exhaust Stack provided sample collection in accordance with Table 4.2 using auxiliary sample collection equipment is initiated within 2 hours of the declaration of inoperability by the Shift Manager.
ACTION 3	If the Noble Gas Monitor is inoperable, ventilation of the LRWPB may continue via the LRWPB stack provided grab samples are taken at least once per 12 hours. (See Table 4.2)
ACTION 4	If the Iodine and Particulate Sampler is inoperable, ventilation of the LRWPB may continue via the LRWPB Stack provided sample collection using auxiliary sample collection equipment is initiated within 2 hours of the declaration of inoperability, by the Shift Manager, in accordance with Table 4.2.
ACTION 5	During power operation, when the condenser air ejector is in service, the condenser off gas discharge shall be monitored for gross radioactivity. If this monitor is inoperable, grab samples are taken at least once per 12 hours. (See Table 4.2)
ACTION 6	The release of airborne effluents from the Containment purge line will be secured if a noble gas monitor is unavailable to monitor the containment building atmosphere.
ACTION 7	With the number of channels OPERABLE less than required by the Minimum Channels OPERABLE requirement, effluent releases may continue provided the flowrate is estimated or recorded manually at least once per four hours during the actual release.
ACTION 8	With the number of channels OPERABLE less than required by the Minimum Channels OPERABLE requirement, effluent releases may continue provided the radioactivity level is recorded manually at least once per four hours during the actual release.
ACTION 9	During the performance of source checks the effluent radiation monitor is unable to respond, hence is considered inoperable. Effluent releases may continue uninterrupted during the performance of source checks provided the operator is stationed at the monitor during the check. If the effluent radiation monitor fails the source check, carryout the Action(s) of the Off-Site Dose Calculation Manual for the inoperable monitor or terminate the effluent release.

Table 3.2.1 Radioactive Gaseous Effluent Monitoring Instrumentation	
TABLE NOTATION	
ACTION 10	Automatic release termination capability is not required provided manual isolation can be accomplished in accordance with the requirements of SE-ST-ILRT-0001, Containment Integrated Leakage Rate Test (CILRT).
ACTION 11	During the ventilation of airborne effluents from the Auxiliary Building Stack at least one Auxiliary Building Exhaust fan shall be in operation.
ACTION 12	IF containment purges are made without processing through at least one of the Containment Air Cooling and Filtering Units, and it is confirmed that one half of the annual dose objective listed in Section 4.2.2 will be exceeded during the calendar quarter, a special report shall be submitted to the NRC as defined in Section 4.2.4.

Table 3.2.2 - Radioactive Gaseous Effluent Monitoring Instrumentation Surveillance Requirements

Instrument		Channel Check	Calibration	Channel Function Test	Source Check
1.	Radioactivity Monitors Providing Alarm and Automatic Isolation				
1.1	RM-043	D	R	Q	M
1.2	RM-057	D	R	Q	M
1.3	RM-062	D	R	Q	M, P
1.4	RM-052 [A]	D	R	Q	M, P[A]
2.	Flowrate Monitors				
2.1	RM-043 Sampler	D	R	Q	----
2.2	RM-062 Sampler	D	R	Q	----
2.3	RM-052 Sampler	D	R	Q	----
2.4	Auxiliary Bldg Exhaust Stack	D	R	Q	----
2.5	Laboratory and Radwaste Process Bldg Exhaust Stack	D	R	Q	----
		Operations Check		Air Flow Calibration	
3.	Environmental Monitors				
3.1	RM-023 - Sample Station #40	M		A	
3.2	RM-024 - Sample Station #41	M		A	
3.3	RM-025 - Sample Station #28	----		----	
3.4	RM-026 - Sample Station #36	----		----	
3.5	RM-027 - Sample Station #37	M		A	
3.6	RM-028 - Sample Station #38	----		----	
3.7	RM-029 - Sample Station #39	----		----	
3.8	RM-035 - Sample Station #1	----		----	
3.9	RM-036 - Sample Station #2	M		A	
3.10	RM-037 - Sample Station #3	----		----	
3.11	RM-038 - Sample Station #4	M		A	
3.12	RM-039 - Sample Station #5	----		----	
3.13	RM-040 - Sample Station #32	M		A	

A. Required when RM-052 is sampling the Auxiliary Building Exhaust Stack.

4.0 RADIOACTIVE EFFLUENTS

4.1 Radioactive Liquid Effluents

4.1.1 Concentration

A. Limiting Condition for Operation

1. The release rate of radioactive material in liquid effluents shall be controlled such that the instantaneous concentrations for radionuclides, other than dissolved or entrained noble gases, do not exceed the values specified in 10 CFR Part 20 for liquid effluents at site discharge. To support plant operations, Supervisor-System Chemistry may increase this limit up to the limit specified in Technical Specifications 5.16.1.b. For dissolved or entrained noble gases, the concentration shall be limited to 2.0E-04 µCi/ml, total activity.

2. Technical Specification 5.16.1.b establishes the administrative control limit on concentration of radioactive material, other than dissolved or entrained noble gases, released in liquid effluents to unrestricted areas conforming to ten times 10 CFR Part 20.1001-20.2401, Appendix B, Table 2, Column 2. For dissolved or entrained noble gases, the concentration shall be limited to 2.0E-04 µCi/ml total activity.

APPLICABILITY: At all times

ACTION:

a. When the concentration of radioactive material released at site discharge exceeds the above limits, appropriate corrective actions shall be taken immediately to restore concentrations within the above limits.

B. Surveillance Requirements

i	**NOTE** Radioactive liquid waste includes water used for fire suppression in areas of the plant that may contain radioactivity. These liquids are required to be monitored prior to release in accordance with SO-G-28.	i

1. Radioactive liquid waste shall be sampled and analyzed according to the sampling and analysis program in Table 4.1.

2. The results of the radioactivity analysis shall be used with the calculational methods in Part II of the Off-Site Dose Calculation Manual.

3. To assure that the concentration at the point of release is maintained within the limits of Technical Specification 5.16.1.b.

4.1.1B (continued)

4. Records shall be maintained of the radioactive concentrations and volume before dilution of each batch of liquid effluent released and of the average dilution flow and length of time over which each discharge occurred. Analytical results shall be submitted to the Commission in accordance with Part I, Section 6.0 of the Off-Site Dose Calculation Manual.

Table 4.1 - Radioactive Liquid Effluent Sampling and Analysis

A. Monitor, Hotel Waste Tanks & Special Liquid, Releases

Sampling Frequency	Type of Activity Analysis	Lower Limit of Detection (LLD) (µCi/ml) [A]
Each Batch	Principal Gamma Emitters [B]	5.0E-07
Each Batch	I-131	1.0E-06
Each Batch	Dissolved Noble Gases (Gamma Emitters) [B]	1.0E-05
Monthly Composite [D]	H-3	1.0E-05
Monthly Composite [D]	Gross Alpha	1.0E-07
Quarterly Composite [D]	Sr-89, Sr-90	5.0E-08
Quarterly Composite [D]	Fe-55	1.0E-06

B. Steam Generator Blowdown

Sampling Frequency	Type of Activity Analysis	Lower Limit of Detection (LLD) (µCi/ml) [A]
Weekly Composite [D]	Principal Gamma Emitters [B]	5.0E-07
Weekly Composite [D]	I-131 [C]	1.0E-06
Weekly Composite [D]	Dissolved Noble Gases (Gamma Emitters) [B]	1.0E-05
Monthly Composite [D]	H-3	1.0E-05
Monthly Composite [D]	Gross Alpha	1.0E-07
Quarterly Composite [D]	Sr-89, Sr-90	5.0E-08
Quarterly Composite [D]	Fe-55	1.0E-06

NOTES:

A. LLD is defined in Part II of the Off-Site Dose Calculation Manual.

B. The principal gamma emitters for which the LLD specification applies exclusively are the following radionuclides: Kr-87, Kr-88, Xe-133, Xe-133m, Xe-135, and Xe-138 for dissolved or entrained gases and Mn-54, Fe-59, Co-58, Co-60, Zn-65, Mo-99, Cs-134, Cs-137, and Ce-141 for fission and corrosion products. Ce-144 shall also be measured, but with a LLD of 5.0E-06.

C. A weekly grab sample and analyses program including gamma isotopic identification will be initiated for the turbine building sump effluent when the steam generator blowdown water composite analysis indicates the I-131 concentration is greater than 1.0E-06 µCi/ml.

D. To be representative of the average quantities and concentrations of radioactive materials in liquid effluents, samples should be collected in proportion to the rate of flow of the effluent stream. Prior to analyses, all samples taken for the composite should be mixed in order for the composite sample to be representative of the average effluent release.

4.1.2 Dose from Radioactive Liquid Effluents

A. Limiting Condition for Operation

1. The dose or dose commitment to an individual in unrestricted areas from radioactive materials in liquid effluents shall be limited to the following:

   a. During any calendar quarter: Less than or equal to 1.5 mrem to the total body and 5 mrem to any organ; and

   b. During any calendar year: Less than or equal to 3 mrem to the total body and 10 mrem to any organ.

   APPLICABILITY: At all times

   ACTION:

   a. If the dose contribution, due to the cumulative release of radioactive materials in liquid effluents, exceeds the annual or quarterly dose objectives, submit a Special Report to the NRC, per Section 6.2.3, within 30 days.

B. Surveillance Requirements

1. Cumulative dose contributions from liquid effluents for the current calendar quarter and the current calendar year shall be determined in accordance with the methodology and parameters in Part II of the Off-Site Dose Calculation Manual at least once per quarter.

4.1.3 Liquid Radwaste Treatment

A. Limiting Condition for Operation

1. The Liquid Radwaste Treatment System shall be OPERABLE, and appropriate portions of these systems shall be used to reduce releases of radioactivity when the projected doses due to the liquid effluent, from each unit, to UNRESTRICTED AREAS would exceed 0.06 mrem to the whole body or 0.2 mrem to any organ in a 31-day period.

APPLICABILITY: At all times

ACTION:

a. With radioactive liquid waste being discharged without treatment and in excess of the above limits and any portion of the Liquid Radwaste Treatment System not in operation, prepare and submit to the Nuclear Regulatory Commission within 30 days, pursuant to 10 CFR 50, Appendix I, a Special Report that includes the following information:

1) Explanation of why liquid radwaste was being discharged without treatment, identification of equipment or subsystem(s) not operable and reasons for inoperability.

2) Action(s) taken to restore the inoperable equipment to operable status.

3) Summary description of action(s) taken to prevent a recurrence.

B. Surveillance Requirements

1. Dose due to liquid releases shall be projected frequently and at least once per quarter, in accordance with the methodology and parameters in Part II of the Off-Site Dose Calculation Manual, when Liquid Radwaste Treatment Systems are not fully OPERABLE.

2. OPERABLE is defined as follows:

a. A filtration/ion exchange (FIX) system will be utilized for processing liquid radwaste. The system consists of a booster pump, charcoal pretreatment filter, and pressure vessels containing organic/inorganic resins, which can be configured for optimum performance. The effluent from the FIX system is directed to the monitor tanks for release.

4.1.3B.2 (continued)

b. Waste filters (WD-17A and WD-17B) are used only on those occasions when considered necessary, otherwise the flows from the low activity fluids may bypass the filters. No credit for decontamination factors (iodines, Cs, Rb, others) was taken for these filters during the 10 CFR Part 50 Appendix I dose design objective evaluation; therefore, the inoperability of these filters does not affect the dose contributions to any individual in the unrestricted areas via liquid pathways. The inoperability of waste filters will not be considered a reportable event in accordance with the Action listed above.

4.1.4 Liquid Holdup Tanks

Tanks included in this Specification are those outdoor tanks that are not surrounded by liners, dikes, or walls capable of holding the tanks contents and that do not have tank overflows and surrounding area drains connected to the liquid radwaste treatment system.

A. Limiting Condition for Operation

1. The quantity of radioactive material contained in each unprotected outdoor liquid holdup tank shall not exceed 10 curies, excluding tritium and dissolved or entrained noble gases.

APPLICABILITY: At all times

ACTION:

a. When the quantity of radioactive material in any unprotected outdoor liquid holdup tank exceeds 10 curies, excluding tritium and dissolved or entrained noble gasses, immediately suspend all additions of radioactive material to the tank and within 48 hours reduce the tank contents to within the limit.

B. Surveillance Requirements

1. The quantity of radioactive material contained in each outdoor liquid holdup tank shall be determined to be within the above limit by analyzing a representative sample of the tank=s contents at least once per 7 days when radioactive material is being added to the tank.

4.2 Radioactive Gaseous Effluents

4.2.1 Concentration

A. Limiting Condition for Operation

1. The release rate of radioactive material in airborne effluents shall be controlled such that the instantaneous concentrations of radionuclides does not exceed the values specified in 10 CFR Part 20 for airborne effluents at the unrestricted area boundary. To support plant operations, Supervisor-System Chemistry may increase this limit up to the limits specified in Technical Specification 5.16.1.g.

2. Technical Specification 5.16.1.g establishes the administrative control limit on the concentration resulting from radioactive material, other than noble gases, released in gaseous effluents to unrestricted areas conforming to ten times 10 CFR Part 20.1001-20.2401, Appendix B, Table 2, Column 1. For noble gases, the concentration shall be limited to five times 10 CFR Part 20.1001-20.2401, Appendix B, Table 2, Column 1.

   APPLICABILITY: At all times

   ACTION:

   a. When the concentration of radioactive material released to unrestricted areas exceeds the above limits, appropriate corrective actions shall be taken immediately to restore concentrations within the above limits.

B. Surveillance Requirements

i	**NOTE** Radioactive gaseous wastes include atmospheres in areas where gaseous fire suppression systems are utilized or where smoke is produced as a result of fire in areas of the plant that may contain radioactivity. These atmospheres are required to be monitored prior to gaseous release to unrestricted areas in accordance with SO-G-28.	i

1. Radioactive gaseous wastes shall be sampled and analyzed according to the sampling and analysis program of Table 4.2. The results of the radioactivity analysis shall be used to assure the limits in Step 4.2.1A are not exceeded.

Table 4.2 - Radioactive Airborne Effluent Sampling and Analysis

A. Gas Decay Tank Releases

Sampling Frequency	Type of Activity Analysis	Lower Limit of Detection (LLD) (µCi/ml) [A]
Prior to each release	Principal Gamma Emitters [B]	1.0E-04

B. Containment Purge Releases or Containment Pressure Relief Line Releases [E]

Sampling Frequency	Type of Activity Analysis	Lower Limit of Detection (LLD) (µCi/ml) [A]
Prior to each release	Principal Gamma Emitters [B]	1.0E-04
Prior to each release	H-3	1.0E-06

C. Condenser Off Gas Releases [E]

Sampling Frequency	Type of Activity Analysis	Lower Limit of Detection (LLD) (µCi/ml) [A]
Monthly [C]	Tritium (H-3)	1.0E-06
Monthly	Principal Gamma Emitters [B]	1.0E-04

D. Auxiliary Building Exhaust Stack [E]

Sampling Frequency	Type of Activity Analysis	Lower Limit of Detection (LLD) (µCi/ml) [A]
Weekly (Charcoal Sample)	I-131	1.0E-12
Weekly (Particulate Sample)	Principal Gamma Emitters [B]	1.0E-11
Weekly (Noble Gases)	Principal Gamma Emitters [B]	1.0E-4
Weekly	Tritium (H-3)	1.0E-06
Monthly Composite [D]	Gross Alpha	1.0E-11
Quarterly Composite (Particulate Samples)	Sr-89, Sr-90	1.0E-11

Table 4.2 - Radioactive Airborne Effluent Sampling and Analysis

E. Laboratory and Radwaste Building Exhaust Stack [E]

Sampling Frequency	Type of Activity Analysis	Lower Limit of Detection (LLD) (µCi/ml) [A]
Weekly (Charcoal Sample)	I-131	1.0E-12
Weekly (Particulate Sample)	Principal Gamma Emitters [B]	1.0E-11
Weekly (Noble Gases)	Principal Gamma Emitters [B]	1.0E-4
Monthly Composite [D]	Gross Alpha	1.0E-11
Quarterly Composite (Particulate Sample)	Sr-89, Sr-90	1.0E-11

NOTES:

A. LLD is defined in Part II of the Off-Site Dose Calculation Manual.

B. The principal gamma emitters for which the LLD specification applies exclusively are the following radionuclides: Kr-87, Kr-88, Xe-133, Xe-133m, Xe-135, and Xe-138 for noble gas releases and Mn-54, Fe-59, Co-58, Co-60, Zn-65, Mo-99, Cs-134, Cs-137, Ce-141, and Ce-144 for Iodine and particulate releases.

C. Required only when steam generator blowdown radioactivity for tritium (Table 4.1, Item B) exceeds 3.0E-03 µCi/milliliter.

D. Frequency requirement may be satisfied using weekly gross alpha results from particulate sampling media.

E. Particulate and Iodine samples shall be corrected for sampler deposition/transportation efficiency by using the approved software programs or by multiplying the activity obtained by the associated sampler multiplication factor (See Table 4.3).

Table 4.3 - Sampler Deposition/Transportation Correction Factors

Sampler	Sample	Particulate		Iodine	
		DF	**ACTMULT**	**DF**	**ACTMULT**
RM-062	AB	0.411	2.433	0.669	1.495
RM-052	AB	0.638	1.567	0.653	1.531
RM-052	CONT	0.525	1.905	0.688	1.453
RM-051	CONT	0.624	1.603	0.714	1.401
RM-043	LRWPB	0.809	1.236	0.873	1.236
PORTABLE	CONT	1.000	1.000	0.950	1.053

ACRONYM DEFINITIONS:

AB - Auxiliary Building Exhaust Stack
CONT - Containment Building
LRWPB - Laboratory and Rad Waste Processing Building
DF - Deposition Factor
ACTMULT - Activity multiplication factor to correct for sample loss.

4.2.2 Dose - Noble Gases

A. Limiting Condition for Operation

1. The dose or dose commitment to an individual at the site boundary from release of noble gases in airborne effluents shall be limited to the following:

   a. During any calendar quarter: Less than or equal to 5 mrads for gamma radiation and less than or equal to 10 mrads for beta radiation; and

   b. During any calendar year: Less than or equal to 10 mrads for gamma radiation and less than or equal to 20 mrads for beta radiation.

APPLICABILITY: At all times

ACTION:

   a. If the dose contribution, due to the cumulative release of noble gases in airborne effluents, exceeds the annual or quarterly dose objectives, submit a Special Report to the NRC, per Section 6.2.3, within 30 days.

B. Surveillance Requirements

1. The radiation dose contributions from radioactive noble gases in airborne effluents shall be determined, in accordance with the methodologies and parameters of Part II of the Off-Site Dose Calculation Manual, on a quarterly basis.

4.2.3 Dose - I-131, I-133, H-3, C-14, and Radioactive Material in Particulate Form with Half-Lives Greater than 8 Days (Other than Noble Gases)

A. Limiting Condition for Operation

1. The dose to an individual or dose commitment to any organ of an individual in unrestricted areas due to the release of I-131, I-133, H-3, C-14, and radioactive materials in particulate form with half-lives greater than eight days (excluding noble gases) in airborne effluents shall be limited to the following:

   a. During any calendar quarter: Less than or equal to 7.5 mrem to any organ; and

4.2.3A.1 (continued)

b. During any calendar year: Less than or equal to 15 mrem to any organ.

APPLICABILITY: At all times

ACTION:

a. If the dose contribution, due to the cumulative release of I-131, I-133, H-3, C-14, and radioactive materials in particulate form with half-lives greater than eight days, exceeds the annual or quarterly dose objectives, submit a Special Report to the NRC per Section 6.2.3, within 30 days.

B. Surveillance Requirements

1. The radiation dose contributions from I-131, I-133, H-3, C-14 and radioactive materials in particulate form with half-lives greater than eight days (excluding noble gases) in airborne effluents shall be determined, in accordance with the methodologies and parameters of Part II of the Off-Site Dose Calculation Manual, on a quarterly basis.

4.2.4 Gaseous Radwaste Treatment

A. Limiting Condition for Operation

1. In accordance with Technical Specification 5.16.1.f, the Waste Gas System and the Ventilation Exhaust Systems shall be OPERABLE, and appropriate portions of these systems shall be used to reduce the releases of radioactivity when the projected doses in 31 days due to gaseous effluent releases to areas at and beyond the SITE BOUNDARY would exceed:

a. 0.2 mrad to air from gamma radiation, or

b. 0.4 mrad to air from beta radiation, or

c. 0.3 mrem to any organ of a MEMBER OF THE PUBLIC

4.2.4A.1 (continued)

APPLICABILITY: At all times

ACTION:

a. With radioactive gaseous waste being discharged without treatment and in excess of the above limits, prepare and submit a report to the Nuclear Regulatory Commission within 30 days, pursuant to 10 CFR 50, Appendix I, a special report that includes the following information:

    1) Identification of equipment or subsystem(s) not operable and reasons for inoperability.

    2) Action(s) taken to restore the inoperable equipment to operable status.

    3) Summary description of action(s) taken to prevent a recurrence.

B. Surveillance Requirements

1. Dose due to gaseous releases shall be projected frequently and at least once per quarter, in accordance with the methodology and parameters in Part II of the Off-Site Dose Calculation Manual, when Waste Gas Systems and Ventilation Exhaust Systems are not fully OPERABLE.

4.2.4B (continued)

2. OPERABLE is defined as follows:

   a. Waste Gas System

      1) The waste airborne radioactive material at Fort Calhoun Station is collected in the vent header where the gas compressors take suction, compress the gas and deliver it to one of the four gas decay tanks. The waste airborne radioactive material is treated in these gas decay tanks by holding for radioactive decay prior to final controlled release to the environs. In order to provide conformance with the dose design objectives, gas decay tanks are normally stored for approximately 30 days and thus achieve decay of short half-life radioactive materials, e.g., I-131, Xe-133. Earlier release is allowed when a plant need exists and analytical results are in accordance with ALARA release objectives. If the radioactive airborne wastes from the gas decay tanks are discharged without processing in accordance with the above conditions, and it is confirmed that one half of the annual dose objective will be exceeded during the calendar quarter, a special report shall be submitted to the Commission pursuant to Section 4.2.4A.

   b. Ventilation Exhaust Systems

      1) The radioactive effluents from the controlled access area of the auxiliary building are filtered by the HEPA filters in the auxiliary building ventilation system. If the radioactive effluents are discharged without the HEPA filters, a special report shall be submitted to the NRC as defined in Action 4.2.4B.2.a above.

      2) The discharge from the gas decay tanks is routed through charcoal and HEPA filter unit VA-82. No credit was taken for the operation of hydrogen purge filters during the 10 CFR Part 50, Appendix I dose design evaluation and doses through the airborne effluent pathways were well below the design objectives. The unavailability of hydrogen purge filters will not be considered a reportable event.

4.2.4B.2.b (continued)

3) The containment air is processed through at least one of the redundant containment HEPA and charcoal filters in the Containment Air Cooling and Filtering Units prior to purging. If the containment purges are made without processing through one of the Containment Air Cooling and Filtering Units, and it is confirmed that one half of the annual dose objective will be exceeded during the calendar quarter, a special report shall be submitted to the NRC as defined in Action 4.2.4B.2.a above.

4.3 Uranium Fuel Cycle

4.3.1 Total Dose-Uranium Fuel Cycle

A. Limiting Condition for Operation

1. The dose to any real individual from uranium fuel cycle sources shall be limited to ≤ 25 mrem to the total body or any organ (except the thyroid, which shall be limited to ≤ 75 mrem) during each calendar year.

APPLICABILITY: At all times

ACTION:

a. With the calculated dose from the release of radioactive materials in liquid or gaseous effluents exceeding twice the limits of specifications 4.1.2A, 4.2.2A, or 4.2.3A, calculations shall be made including direct radiation contribution from the plant and outside storage tanks to determine whether the above limits have been exceeded. If such is the case, in lieu of any other report required by Section 6.2, prepare and submit a Special Report to the Commission pursuant to Technical Specification 5.16 that defines the corrective action to be taken to reduce subsequent releases to prevent recurrence of exceeding the above limits and includes the schedule for achieving conformance with the above limits. This Special Report , as defined in 10 CFR Part 20.2203(a)(4) and 20.2203(b), shall include an analysis that estimates the radiation exposure (dose) to a MEMBER OF THE PUBLIC from uranium fuel cycle sources, including all effluent pathways and direct radiation, for the calendar year that includes the release(s) covered by this report. It shall also describe levels of radiation and concentration of radioactive material involved, and the cause of exposure levels or concentrations. If the estimated dose(s) exceeds the above limits, and if the release condition resulting in the violation of 40 CFR Part 190 has not already been corrected, the Special Report shall include a request for a variance in accordance with the provisions of 40 CFR Part 190. Submittal of the report is considered a timely request, and a variance is granted until staff action on the request is complete.

4.3.1 (continued)

B. Surveillance Requirements

1. Cumulative dose contributions from liquid and gaseous effluents shall be determined in accordance with surveillance requirements 4.1.2B, 4.2.2B and 4.2.3B and in accordance with the methodology and parameters in Part II of the Off-Site Dose Calculation Manual.

5.0 RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM (REMP)

5.1 Monitoring Program

5.1.1 Limiting Condition for Operation

A. The Radiological Environmental Monitoring Program shall be conducted as specified in Table 5.1.

APPLICABILITY: At all times

ACTION:

1. Analytical results of this program and deviations from the sampling schedule shall be reported to the Nuclear Regulatory Commission in the Annual Radiological Environmental Operating Report (Section 6.2).

2. If the level of radioactivity from calculated doses leads to a higher exposure pathway to individuals, this pathway shall be added to the Radiological Environmental Monitoring Program. Modifications to the program shall be reported in the Annual Radiological Environmental Operating Report to the Nuclear Regulatory Commission.

3. If the level of radioactivity in an environmental sampling medium exceeds the reporting level specified in Table 5.4, and the activity is attributable to plant operation, a Special Report shall be prepared and submitted to the Nuclear Regulatory Commission within 30 days (Section 6.2.3). The detection capabilities of the equipment used for the analysis of environmental samples must meet the requirements of Table 5.3 for Lower Level of Detection (LLD).

5.1.1A (continued)

4. If the level of radioactivity in a sample from either an onsite or offsite well, performed per the Site Groundwater Protection Program, exceeds the reporting level specified in Table 5.4, and the activity is attributable to plant operation, a Special Report shall be prepared and submitted to the Nuclear Regulatory Commission within 30 days (Section 6.2.3). The detection capabilities of the equipment used for the analysis of environmental samples must meet the requirements of Table 5.3 for Lower Level of Detection (LLD). Copies of the Special Report will be forwarded to State/Local authorities. **[AR 39127]**

5. If the level of radioactivity from either an onsite or offsite well, performed per the Site Groundwater Protection Program exceeds the reporting level specified in Table 5.4, and the activity is attributable to plant operations, state and local authorities shall be notified by the end of the next business day. NRC shall be notified per SO-R-1, Reportability Determinations. **[AR 39127]**

6. Radiological environmental sampling locations and the media that is utilized for analysis are presented in Table 5.2. Sampling locations are also illustrated on the map, Figure 1. Details of the quarterly emergency TLD locations are contained in surveillance test CH-ST-RV-0003, Environmental Sample Collection – Quarterly/Environmental Dosimeters (TLDs). Each TLD sample location contains one dosimeter that is exchanged quarterly for REMP sampling and as needed for Emergency Planning Zone monitoring.

7. Deviations from the monitoring program, presented in this section and detailed in Table 5.2, are permitted if specimens are unobtainable due to mitigating circumstances such as hazardous conditions, seasonal unavailability, malfunction of equipment, or if a person discontinues participation in the program, etc. If the equipment malfunctions, corrective actions will be completed as soon as practicable. If a person no longer supplies samples, a replacement will be made if possible. All deviations from the sampling schedule will be described in the Annual Radiological Environmental Operating Report, pursuant to Section 6.2.

5.1.2 Surveillance Requirements

A. The Radiological Environmental Monitoring Program (REMP) samples shall be collected and analyzed in accordance with Tables 5.1, 5.2, and 5.3.

Table 5.1 - Radiological Environmental Monitoring Program

Exposure Pathway and/or Sample	Collection Site [A]	Type of Analysis [B]	Frequency
1. Direct Radiation	A. 14 TLD indicator stations, one background station[F], total of 15. B. An inner-ring of 16 stations, one in each cardinal sector in the general area of the unrestricted area boundary and within 2.5 miles. C. An outer-ring of 16 stations, one in each cardinal sector located outside of the inner-ring, but no more distant than approximately 5 miles.	Gamma dose Gamma dose Gamma dose	Quarterly Quarterly Quarterly
2. Air Monitoring	A. Indicator Stations 1. Three stations in the general area of the unrestricted area boundary 2. City of Blair 3. Desoto Township B. One background station [F]	Filter for Gross Beta [C] Charcoal for I-131 Filter for Gamma Isotopic	Weekly Weekly Quarterly composite of weekly filters
3. Water	A. Missouri River at nearest downstream drinking water intake. B. Missouri River downstream near the mixing zone. C. Missouri River upstream of Plant intake (background)[F].	Gamma Isotopic, H-3 I^{131} analysis on each composite when the dose calculated for the consumption of water is > 1 mrem/year[G]	Composite sample over 2 week period when I^{131} analysis is performed, monthly otherwise for Gamma isotopic analysis. Quarterly composite for H-3 Analysis
4. Milk [D]	A. Nearest milk animal (cow or goat) within 5 miles B. Milk animal (cow or goat) between 5 miles and 18.75 miles (background)[F].	Gamma Isotopic and I-131	Biweekly grazing season (May to October), monthly at other times
5. Fish	A. Four fish samples within vicinity of Plant discharge. B. One background sample upstream of Plant discharge.	Gamma Isotopic	Once per season (May to October)

Table 5.1 - Radiological Environmental Monitoring Program

Exposure Pathway and/or Sample	Collection Site [A]	Type of Analysis [B]	Frequency
6. Sediment	A. One sample from downstream area on the station side of the Missouri River. B. One sample from upstream of Plant Intake (background)[F].	Gamma Isotopic	Semiannually
7. Vegetables or Food Products [E]	A. One sample in the highest exposure pathway. B. One sample from onsite crop field C. One sample outside of 5 miles (background)[F].	Gamma Isotopic	Once per season (May to October)
8. Groundwater	A. Three samples from sources potentially affected by plant operations. B. One sample outside of 5 miles (background)[F].	H_3, Gross Beta, Gamma Isotopic, Sr-90	Quarterly
9. Vegetation in lieu of milk	A. One sample at the highest annual average D/Q offsite location. B. One sample at the second highest annual average D/Q offsite location. C. One sample outside of 5 miles (background) [F].	Gamma Isotopic	Monthly (when available)

NOTES:

A. See Table 5.3 for required detection limits.

B. The Lower Limit of Detection (LLD) for analysis is defined in the Off-Site Dose Calculation Manual in accordance with the wording of NUREG-1301.

C. When a gross beta count indicates radioactivity greater than 2.5E-13 µCi/ml or 0.25 pCi/m3, (ten times the yearly mean), a gamma spectral analysis will be performed.

D. If milk samples are temporarily not available at a sampling site due to mitigating circumstances, then vegetation (broadleaf, pasture grass, etc.) shall be collected as an alternate sample at the site. If there are no milk producers within the entire 5-mile radius of the plant, then vegetation shall be collected monthly, when available, at two offsite locations having the highest calculated annual average ground level D/Q and a background locale. (Reference Off-Site Dose Calculation Manual, Part II, Table 4 "Highest Potential Exposure Pathways for Estimating Dose")

E. Samples should be collected from garden plots of 500 ft2 or more. (Reference Reg. Guide 4.8 "Environmental Technical Specifications for Nuclear Power Plants," Dec. 1975).

F. This sample may not be located in the least prevalent wind direction. The Branch Technical Position paper, Table 1, subnote "d" says this regarding background information, or control locations. **"The purpose of this sample is to obtain background information. If it is not practical to establish control locations in accordance with the distance and wind direction criteria, other sites which provide valid background data may be substituted".**

G. The dose shall be calculated for the maximum organ and age group, using methodology and parameters in the Off-Site Dose Calculation Manual.

Table 5.2 - Radiological Environmental Sampling Locations And Media

Sample Station No.	**Approximate Collection Sites**	**Approximate Distance from Center of Containment (miles)**	**Approximate Direction (degrees from true north)**	**Sector**	**Air Monitoring**		**TLD**	**Water**	**Milk**	**Sedi-ment**	**Fish**	**Vegetables and Food Products**	**Ground-water**
					Airborne Particulate	**Airborne Iodine**							
1	Onsite Station, 110-meter weather tower	0.53	293°/WNW	P			X						
2[C,E]	Onsite Station, adjacent to old plant access road	0.59	207°/SSW	K	X	X	X						
3	Offsite Station, Intersection of Hwy. 75 and farm access road	0.94	145°/SE	G			X						
4	Blair OPPD office	2.86	305°/NW	Q	X	X	X						
5[A]													
6	Fort Calhoun, NE City Hall	5.18	150°/SSE	H			X						
7	Fence around intake gate, Desoto Wildlife Refuge	2.07	102°/ESE	F			X						
8	Onsite Station, entrance to Plant Site from Hwy. 75	0.55	191°/S	J			X						
9	Onsite Station, NW of Plant	0.68	305°/NW	Q			X						
10	Onsite Station, WSW of Plant	0.61	242°/WSW	M			X						
11	Offsite Station, SE of Plant	1.07	39°/SE	G			X						

Table 5.2 - Radiological Environmental Sampling Locations And Media

Sample Station No.	Approximate Collection Sites	Approximate Distance from Center of Containment (miles)	Approximate Direction (degrees from true north)	Sector	Air Monitoring		TLD	Water	Milk	Sedi-ment	Fish	Vegetables and Food Products	Ground-water
					Airborne Particulate	Airborne Iodine							
12	Metropolitan Utilities Dist., Florence Treatment Plant North Omaha, NE	14.3	154°/SSE	H				X					
13	West bank Missouri River, downstream from Plant discharge	0.45	108°/ESE	F				X		X			
14[D]	Upstream from Intake Bldg, west bank of river	0.09	4°/N	A				X		X			
15	Smith Farm	1.99	134°/SE	G									X
16[A]													
17[A]													
18[A]													
19[A]													
20[D]	Mohr Dairy	9.86	186°/S	J					[B]			X	X
21[A]													
22	Fish Sampling Area, Missouri River	0.08 (R.M. 645.0)	6°/N	A							X		
23[D]	Fish Sampling Area, Missouri River	17.9 (R.M. 666.0)	358°/N	A							X		
24[A]													
25[A]													
26[A]													
27[A]													

Table 5.2 - Radiological Environmental Sampling Locations And Media

Sample Station No.	Approximate Collection Sites	Approximate Distance from Center of Containment (miles)	Approximate Direction (degrees from true north)	Sector	Air Monitoring		TLD	Water	Milk	Sedi-ment	Fish	Vegetables and Food Products	Ground-water
					Airborne Particulate	Airborne Iodine							
28	Alvin Pechnik Farm	0.94	163°/SSE	H								X	
29[A]													
30[A]													
31[A]													
32[D]	Valley Substation #902	19.6	221°/SW	L	X	X	X						
33[A]													
34[A]													
35	Onsite Farm Field	0.52	118°/ESE	F								X	
36	Offsite Station Intersection Hwy 75/Co. Rd. P37	0.75	227°/SW	L			X						
37	Offsite Station Desoto Township	1.57	144°/SE	G	X	X	X						
38[A]													
39[A]													
40[A]													
41[C]	Dowler Acreage	0.73	175°/S	J	X	X	X		[B,C]				
42	Sector A-1	1.94	0°/NORTH	A			X						
43	Sector B-1	1.97	16°/NNE	B			X						
44	Sector C-1	1.56	41°/NE	C			X						
45	Sector D-1	1.34	71°/ENE	D			X						
46	Sector E-1	1.54	90°/EAST	E			X						
47	Sector F-1	0.45	108°/ESE	F			X						

Table 5.2 - Radiological Environmental Sampling Locations And Media

Sample Station No.	Approximate Collection Sites	Approximate Distance from Center of Containment (miles)	Approximate Direction (degrees from true north)	Sector	Air Monitoring		TLD	Water	Milk	Sedi-ment	Fish	Vegetables and Food Products	Ground-water
					Airborne Particulate	Airborne Iodine							
48	Sector G-1	1.99	134°/SE	G			X						
49	Sector H-1	1.04	159°/SSE	H			X						
50	Sector J-1	0.71	179°/SOUTH	J			X						
51	Sector K-1	0.61	205°/SSW	K			X						
52	Sector L-1	0.74	229°/SW	L			X						
53	Sector M-1	0.93	248°/WSW	M			X						
54	Sector N-1	1.31	266°/WEST	N			X						
55	Sector P-1	0.60	291°/WNW	P			X						
56	Sector Q-1	0.67	307°/NW	Q			X						
57	Sector R-1	2.32	328°/NNW	R			X						
58	Sector A-2	4.54	350°/NORTH	A			X						
59	Sector B-2	2.95	26°/NNE	B			X						
60	Sector C-2	3.32	50°/NE	C			X						
61	Sector D-2	3.11	75°/ENE	D			X						
62	Sector E-2	2.51	90°/EAST	E			X						
63	Sector F-2	2.91	110°/ESE	F			X						
64	Sector G-2	3.00	140°/SE	G			X						
65	Sector H-2	2.58	154°/SSE	H			X						
66	Sector J-2	3.53	181°/SOUTH	J			X						
67	Sector K-2	2.52	205°/SSW	K			X						
68	Sector L-2	2.77	214°/SW	L			X						
69	Sector M-2	2.86	243°/WSW	M			X						

Table 5.2 - Radiological Environmental Sampling Locations And Media

Sample Station No.	Approximate Collection Sites	Approximate Distance from Center of Containment (miles)	Approximate Direction (degrees from true north)	Sector	Air Monitoring		TLD	Water	Milk	Sedi-ment	Fish	Vegetables and Food Products	Ground-water
					Airborne Particulate	Airborne Iodine							
70	Sector N-2	2.54	263°/WEST	N			X						
71	Sector P-2	2.99	299°/WNW	P			X						
72	Sector Q-2	3.37	311°/NW	Q			X						
73	Sector R-2	3.81	328°/NNW	R			X						
74	D. Miller Farm	0.65	203°/SSW	K									X
75[C]	Lomp Acreage	0.65	163°/SSE	H	X	X	X		[B, C]				X
76	Stangl Farm	3.40	169°/S	J					X				

NOTES:

A. Location is either not in use or currently discontinued and is documented in the table for reference only.

B. If milk samples are temporarily not available at a sampling site due to mitigating circumstances, then vegetation (broadleaf, pasture grass, etc.) shall be collected as an alternate sample at the site. If there are no milk producers within the entire 5-mile radius of the plant, then vegetation shall be collected monthly, when available, at two offsite locations having the highest calculated annual average ground level D/Q and a background locale. (Reference Off-Site Dose Calculation Manual, Part II, Table 4 "Highest Potential Exposure Pathways for Estimating Dose")

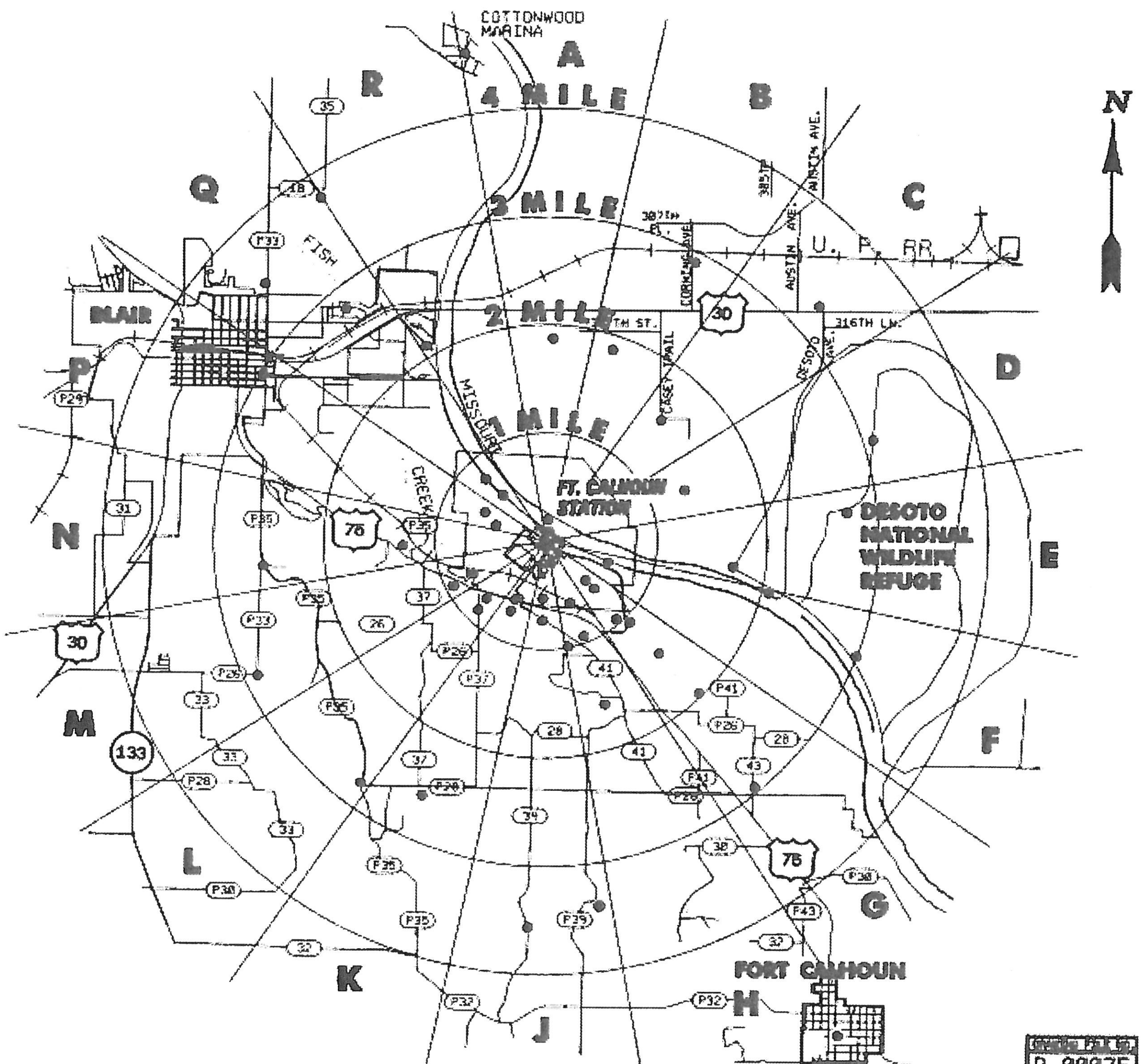
C. Locations represent highest potential exposure pathways as determined by the biennial Land Use Survey, performed in accordance with Part I, Section 7.3.2, of the Off-Site Dose Calculation Manual and are monitored as such.

D. Background location (control). All other locations are indicators.

E. Location for monitoring Sector K High Exposure Pathway Resident Receptor for inhalation.

F. When broad leaf (pasture grasses) are being collected in lieu of milk, background broad leaf samples will be collected at a background locale.

Figure 1 – Environmental Radiological Sampling Points



(*) Locations currently discontinued are not illustrated.

Table 5.3 - Detection Capabilities for Environmental Sample Analysis Lower Limit of Detection (LLD) [A, B, C]

Sample	Units	Gross Beta	H-3	Mn-54	Fe-59	Co-58, Co-60	Zn-65	Zr-95	Nb-95	I-131	Cs-134	Cs-137	Ba-140 La-140
Water	pCi/L	4	2.0E+03	1.5E+01	3.0E+01	1.5E+01	3.0E+01	1.5E+01	1.5E+01	1.0E+00[D]	1.5E+01	1.8E+01	1.5E+01
Fish	pCi/kg (wet)	---	---	1.3E+02	2.6E+02	1.3E+02	2.6E+02	---	---	---	1.3E+02	1.5E+02	---
Milk	pCi/L	---	---	---	---	---	---	---	---	1.0E+00	1.5E+01	1.8E+01	1.5E+01
Airborne Particulates or Gases	pCi/m^3	1.0E-02	---	---	---	---	---	---	---	7.0E-02	1.0E-02	1.0E-02	---
Sediment	pCi/kg (dry)	---	---	---	---	---	---	---	---	---	1.5E+02	1.8E+02	---
Grass or Broad Leaf Vegetation/ Vegetables or Food Products	pCi/kg (wet)	---	---	---	---	---	---	---	---	[E] 6.0E+01	[E] 6.0E+01	[E] 8.0E+01	---

A. This list does not mean that only these nuclides are to be considered. Other peaks that are identifiable as Plant effluents, together with those of the above nuclides, shall also be analyzed and reported in the Annual Radiological Environmental Operating Report pursuant to Part I, Section 6.2, of the Off-Site Dose Calculation Manual.

B. Required detection capabilities for thermoluminescent dosimeters used for environmental measurements shall be in accordance with the recommendations of Regulatory Guide 4.13.

C. The LLD is defined in Part II of the Off-Site Dose Calculation Manual.

D. LLD for drinking water samples. If no drinking water pathway exists, the LLD of gamma isotopic analysis may be used.

E. I-131 analysis performed on broadleaf/pasture grass samples when milk is unavailable. Gamma isotopic analysis performed on food products/vegetables.

Table 5.4 - Reporting Levels for Radioactivity Concentrations in Environmental Samples [A]

Sample	Units	H-3	Mn-54	Fe-59	Co-58	Co-60	Zn-65	Zr-95	Nb-95	I-131	Cs-134	Cs-137	Ba-140 La-140
Water	pCi/L	2.0E+04	1.0E+03	4.0E+02	1.0E+03	3.0E+02	3.0E+02	4.0E+02	4.0E+02	2.0E+00[B]	3.0E+01	5.0E+01	2.0E+02
Fish	pCi/kg (wet)	---	3.0E+04	1.0E+04	3.0E+04	1.0E+04	2.0E+04	---	---	---	1.0E+03	2.0E+03	---
Milk	pCi/L	---	---	---	---	---	---	---	---	3.0E+00	6.0E+01	7.0E+01	3.0E+02
Airborne Particulates or Gases	pCi/m^3	---	---	---	---	---	---	---	---	9.0E-01	1.0E+01	2.0E+01	---
Grass or Broad Leaf Vegetation/ Vegetables or Food Products	pCi/kg (wet)	---	---	---	---	---	---	---	---	1.0E+02	1.0E+03	2.0E+03	---

A. A Non-routine report shall be submitted when more than one of the radionuclides listed above are detected in the sampling medium and:

$$\frac{Concentration\ 1}{Reporting\ Level\ 1} + \frac{Concentration\ 2}{Reporting\ Level\ 2} + \frac{Concentration\ 3}{Reporting\ Level\ 3} + \ldots \geq 1.0$$

When radionuclides other than those listed above are detected and are the result of Plant effluents, this report shall be submitted if the potential annual dose to a member of the general public is equal to or greater than the dose objectives of Part I, Section 4.1 and 4.2, of the Off-Site Dose Calculation Manual. This report is not required if the measured level of radioactivity was not the result of Plant effluents; however, in such an event, the condition shall be reported and described in the Annual Radiological Environmental Operating Report.

B. If no drinking water pathway exists, the LLD of gamma isotopic analysis may be used.

5.2 Land Use Survey

5.2.1 Limiting Condition for Operation

A. A Land Use Survey shall identify the location of the nearest milk animal, nearest meat animal, nearest vegetable garden, nearest groundwater source and the nearest residence in each of the 16 cardinal sectors within a distance of five miles. The survey shall be conducted under the following conditions:

1. Within a one-mile radius from the Plant site, enumeration by door-to-door or equivalent counting techniques.

2. Within a Five-mile radius, enumeration may be conducted door-to-door or by using referenced information from county agricultural agents or other reliable sources.

APPLICABILITY: At all times

ACTION:

a. If it is learned from this survey that milk animals, vegetable gardens and resident receptors are present at a location which yields a calculated dose greater than 20% from previously sampled location(s), the new location(s) shall be added to the monitoring program. Milk and vegetable garden sampling location(s) having the lowest calculated dose may then be dropped from the monitoring program at the end of the grazing and/or growing season during which the survey was conducted and the new location added to the monitoring program. Groundwater monitoring is based on a determination if source(s) are potentially affected by plant operations. Modifications to the air monitoring locations, vegetable garden sampling locations, and milk sampling locations will be made as soon as practicable. The Nuclear Regulatory Commission shall be notified of modifications to the program in the Annual Radiological Environmental Operating Report (Section 6.2).

5.2.1A.2 (continued)

b. If it is learned from this survey that a pathway for dose to a MEMBER OF THE GENERAL PUBLIC no longer exists, an additional pathway has been identified or site specific factors affecting the dose calculations for a pathway have changed, then this information should be documented in the Land Use Survey, the Annual Radiological Environmental Operating Report and the Annual Radioactive Effluent Release Report. This information can be used to increase the accuracy of the dose models for the Annual Radioactive Effluent Release Report as well as dose estimates performed during the reporting period (i.e., quarterly dose estimates).

5.2.2 Surveillance Requirements

A. A land use survey shall be conducted once per 24 months between the dates of June 1 and October 1. The results of the land use survey shall be submitted to the Nuclear Regulatory Commission in the Annual Radiological Environmental Operating Report (Section 6.2) for the year it was performed.

5.3 Interlaboratory Comparison Program

5.3.1 Limiting Condition for Operation

A. Analyses shall be performed on radioactive materials as part of an Interlaboratory Comparison Program that has been approved by the Nuclear Regulatory Commission.

APPLICABILITY: At all times

ACTION:

1. With analysis not being performed as required above, report the corrective actions taken to prevent a recurrence to the Commission in the Annual Radiological Environmental Operating Report (Section 6.2).

5.3.2 Surveillance Requirements

A. The results of these analyses shall be included in the Annual Radiological Environmental Operating Report (Section 6.2).

6.0 ADMINISTRATIVE CONTROLS

6.1 Responsibilities

6.1.1 FCS Chemistry Department is responsible for the implementation and maintenance of the Off-Site Dose Calculation Manual.

6.1.2 FCS Operations Department is responsible for the compliance with the Off-Site Dose Calculation Manual in the operation of Fort Calhoun Station.

6.2 Radioactive Effluent Reporting Requirements

The reporting requirements for radioactive effluents stated in this Section are to provide assurance that the limits set forth in Part I of the Off-Site Dose Calculation Manual are complied with. These reports will meet the requirements for documentation of radioactive effluents contained in 10 CFR Part 50.36a; Reg. Guide 1.21, Rev. 2; Reg. Guide 4.8, Table 1; and Reg. Guide 1.109, Rev. 1.

6.2.1 Annual Radioactive Effluent Release Report

A report covering the operation of the Fort Calhoun Station during the previous calendar year shall be submitted prior to May 1 of each year per the requirements of Technical Specifications 5.9.4.a. and 10 CFR Part 50.

The Radioactive Effluent Release Report shall include:

A. A summary of the quantities of radioactive liquid and airborne effluents and solid waste released from the plant as outlined in Regulatory Guide 1.21, Revision 2.

B. A summary of the annual meteorological data that provides joint frequency distributions of wind direction and wind speed by atmospheric stability class will be included in the annual report. In addition, hourly meteorological data is recorded and retained on site as outlined in Regulatory Guide 1.21, Revision 2.

C. An assessment of radiation doses from the radioactive liquid and airborne effluents released from the unit during each calendar quarter as outlined in Regulatory Guide 1.21, Revision 2. The assessment of radiation doses shall be performed in accordance with calculational methodology of the Regulatory Guide 1.109, Revision 1.

D. Changes to the Process Control Program (PCP) or to the Offsite Dose Calculation Manual (ODCM) made during the reporting period. Each change shall be identified by markings in the margin of the affected pages clearly indicating the area of the page that was changed and shall indicate the date the change was implemented.

6.2.1 (continued)

E. A list and description of abnormal releases or abnormal discharges from the site to unrestricted areas of radioactive materials in gaseous and liquid effluents made during the reporting period.

F. An explanation of why instrumentation designated in Part I, Sections 3.1.1 and 3.2, of the Off-Site Dose Calculation Manual, was not restored to OPERABLE status within 30 days.

G. A description of any major design changes or modifications made to the Liquid and/or Gaseous Radwaste Treatment Systems or Ventilation Exhaust Systems during the reporting period.

H. An explanation of why the liquid and/or gaseous radwaste treatment systems were not OPERABLE, causing the limits of specifications 4.1.3A and 4.2.4A to be exceeded.

I. The results of sampling from offsite and onsite groundwater wells per the Site Groundwater Protection Plan. **[AR 39127]**

J. Non-routine planned discharges (e.g., discharges from remediation efforts like pumping contaminated groundwater from a leak).

6.2.2 Annual Radiological Environmental Operating Report

The Annual Radiological Environmental Operating Report for the previous one year of operation shall be submitted prior to May 1 of each year. This report contains the data gathered from the Radiological Environmental Monitoring Program. The content of the report shall include:

A. Summarized and tabulated results of the radiological environmental sampling/analysis activities following the format of Regulatory Guide 4.8, Table 1. In the event that some results are not available, the report shall be submitted noting and explaining the reasons for the missing results. The missing data shall be submitted as soon as possible in a supplementary report.

B. Interpretations and statistical evaluation of the results, including an assessment of the observed impacts of the plant operation and environment.

C. The results of participation in a NRC approved Interlaboratory Comparison Program.

D. The results of land use survey required by Section 5.2.

6.2.2 (continued)

E. The results of specific activity analysis in which the primary coolant exceeded the limits of Technical Specification 2.1.3. The following information shall be included:

1. Reactor power history starting 48 hours prior to the first sample in which the limit was exceeded.

2. Results of the last isotopic analysis for radioiodine performed prior to exceeding the limit, results of analysis while limit was exceeded and results of one analysis after the radioiodine activity was reduced to less than the limit. Each result should include date and time of sampling and the radioiodine concentrations.

3. Purification system flow history starting 48 hours prior to the first sample in which the limit was exceeded.

4. Graph of the I-131 concentration and one other radioiodine isotope concentration in micro-curies per gram as a function of time for the duration of the specific activity above the steadystate level, AND

5. The time duration when the specific activity of the primary coolant exceeded the radioiodine limit.

F. A map of the current environmental monitoring sample locations.

6.2.3 Special Report

If the limits or requirements of Sections 4.1.2A, 4.1.3A, 4.2.2A, 4.2.3A, 4.2.4A, 4.3.1A, and/or 5.1.1A.3 and/or 5.1.1A.4 are exceeded, a Special Report shall be issued to the Commission, pursuant to Technical Specification 5.16. This report shall include: **[AR 39127]**

A. The results of an investigation to identify the causes for exceeding the specification.

B. Define and initiate a program of action to reduce levels to within the specification limits.

C. The report shall also include an evaluation of any release conditions, environmental factors, or other aspects necessary to explain the condition.

6.2.4 EPA 40 CFR Part 190 Reporting Requirements

With the calculated dose from the release of radioactive materials in liquid or gaseous effluents exceeding twice the limits of dose from specifications 4.1.2A, 4.2.2A, or 4.2.3A, calculations shall be made including direct radiation calculations, to prepare and submit a special report to the Commission within 30 days and limit the subsequent releases such that the dose to any real individual from uranium fuel cycle sources is limited to ≤ 25 mrem to the total body or any organ (except thyroid, which is limited to ≤ 75 mrem) over the calendar year. This special report shall include an analysis which demonstrates that radiation exposures to any member of the public from uranium fuel cycle sources (including all effluent pathways and direct radiation) are less than the 40 CFR Part 190 standard. Otherwise, obtain a variance from the Commission to permit releases which exceed the 40 CFR Part 190 standard. The submittal of the report is to be considered a timely request and a variance is granted pending the final action on the variance request from the Commission.

6.3 Change Mechanism

The Off-Site Dose Calculation Manual is the controlling document for all radioactive effluent releases. It is defined as a procedure under the guidance of Technical Specification 5.8. It will be revised and reviewed by the Plant Operations Review Committee and approved by the Plant Manager in accordance with Technical Specification 5.17. All changes to the Off-Site Dose Calculation Manual will be forwarded to the Nuclear Regulatory Commission during the next reporting period for the Annual Radioactive Effluent Release Report in accordance with the requirements of Technical Specification 5.17.

6.4 Meteorological Data

The Annual Average χ/Q is utilized to determine the concentrations of radionuclides at the unrestricted area boundary. It is also the factor used in conjunction with the parameters and methodologies in Part II, of the Off-Site Dose Calculation Manual to determine unrestricted area dose on a quarterly bases or as needed. It is based on an average of the highest calculated sector χ/Q values, using all 16 sectors for each of the three previous year Annual Radioactive Effluent Release Reports, and the XOQDOQ plume trajectory model. An additional 10 percent will be added to the average for unrestricted area dose estimates performed quarterly or as needed for conservatism. When calculating χ/Q data for the Annual Radiological Effluent Release Report, if the highest calculated χ/Q for the reporting period is observed to be greater than ± 10% of the Annual Average χ/Q previously calculated, contact the Supervisor-System Chemistry for further instructions. This model conforms with the Nuclear Regulatory Commissions Regulatory Guide 1.111.

Current year meteorological data will be utilized in the preparation of the Annual Radioactive Effluent Release Report. This data is used to calculate the joint frequency table, the dispersion coefficients and deposition factors in all 16 sectors. These are used in the calculation of doses to individuals in unrestricted areas as a result of the operation of Fort Calhoun Station. The models used, GASPAR 2 and LADTAP 2, meet the intent of Nuclear Regulatory Commissions Reg. Guide 1.109 and 1.21 for the reporting of doses due to routine radioactive effluent releases.

6.5 References

6.5.1 Regulatory Guide 1.109, Rev. 1 - Calculation of Annual Dose to man from Routine Releases of Reactor Effluents for the purpose of evaluation compliance with 10 CFR Part 50, Appendix I

6.5.2 Regulatory Guide 1.111, Rev. 1 - Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors.

6.5.3 Regulatory Guide 1.113, Rev. 1 - Estimating Aquatic Dispersion of Effluents from Accidental and Routine Releases for the purpose of Implementing Appendix I.

6.5.4 Regulatory Guide 4.8, Environmental Technical Specification for Nuclear Power Plants.

6.5.5 NRC Branch Technical Position, March 1978

6.5.6 NUREG-0133 - Preparation of Radiological Effluent Technical Specifications for Nuclear Power Plants.

6.5.7 NUREG-1301 - Offsite Dose Calculation Manual Guidance.

6.5.8 Regulatory Guide 1.21, Rev. 2 - Measuring, Evaluating, and Reporting Radioactivity in solid wastes and Releases of Radioactivity Materials in Liquid and Gaseous Effluents from Light-Water-Cooled Nuclear Power Plants.

6.5.9 Code of Federal Regulations, Title 10, Part 20

6.5.10 Code of Federal Regulations, Title 10, Part 50

6.5.11 Code of Federal Regulations, Title 40, Part 190

6.5.12 Fort Calhoun Revised Environmental Report (Unit No. 1)-1972

6.5.13 Fort Calhoun Technical Specifications (Unit No. 1)

6.5.14 Updated Safety Analysis Report

6.5.15 AR 12357, Implement Recommendations of Memo FC-0133-92, Part I, Table 3.2.1 Action 4, of the Off-Site Calculation Manual

6.5.16 AR 39127, NEI Industry Initiative on Groundwater Protection

6.5.17 Regulatory Guide 4.1, Rev. 2 – Radiological Environmental Monitoring for Nuclear Power Plants

6.5.18 SO-G-28 – Station Fire Plan

7.0 BASIS

7.1 Instrumentation

7.1.1 Radioactive Liquid Effluent Instrumentation

The Radioactive liquid effluent instrumentation is provided to monitor and control, as applicable, the releases of radioactive material in liquid effluents during actual or potential releases of liquid effluents. The Alarm/Trip setpoints for these instruments shall be calculated in accordance with Part II of the Offsite Dose Calculation Manual to ensure that the alarm/trip will occur prior to exceeding the limits of 10 CFR Part 20. The OPERABILITY and use of this instrumentation is consistent with the requirements of General Design Criteria 60, 63 and 64 of Appendix A to 10 CFR Part 50.

7.1.2 Radioactive Gaseous Effluent Instrumentation

The Radioactive gaseous effluent instrumentation is provided to monitor and control, as applicable, the releases of radioactive material in gaseous effluents during actual or potential releases of gaseous effluents. The Alarm/Trip setpoints for these instruments shall be calculated in accordance with Part II of the Offsite Dose Calculation Manual to ensure that the alarm/trip will occur prior to exceeding the limits of 10 CFR Part 20. The OPERABILITY and use of this instrumentation is consistent with the requirements of General Design Criteria 60, 63 and 64 of Appendix A to 10 CFR Part 50.

7.2 Radioactive Effluents

7.2.1 Radioactive Liquid Effluents

A. Concentration

This specification is provided to ensure that the concentration of radioactive materials released in liquid waste effluents from the site to unrestricted areas will be less than 10 times the concentration levels specified in 10 CFR Part 20, Appendix B, Table II, Column 2. This limitation provides additional assurance that the levels of radioactive materials in bodies of water outside the site will result in exposures within (1) the Section II.A design objectives of Appendix I, 10 CFR Part 50, and (2) the limits of 10 CFR Part 20.1001-20.2401 to the population. The concentration limit for dissolved or entrained noble gases is based upon the assumption that Xe-133 is the controlling isotope and its effluent concentration in air (submersion) was converted to an equivalent concentration in water.

7.2.1 (continued)

B. Dose

This specification is provided to implement the requirements of Sections II.A, III.A and IV.A of Appendix I, 10 CFR Part 50. The Limiting Condition for Operation implements the guides set forth in Section II.A of Appendix I. The ACTION statements provide the required operating flexibility and at the same time implement the guides set forth in Section IV.A of Appendix I to assure that the releases of radioactive material in liquid effluents will be kept "as low as is reasonably achievable". Also, with fresh water sites with drinking water supplies which can be potentially affected by plant operations, there is reasonable assurance that the operation of the facility will not result in radionuclide concentrations in the finished drinking water that are in excess of the requirements of 40 CFR Part 141. The dose calculation methodology and parameters in Part II of the Off-Site Dose Calculation Manual, implement the requirements in Section III.A that conformance with the guides of Appendix I is to be shown by calculational procedures based on models and data such that the actual exposure of an individual through appropriate pathways is unlikely to be substantially underestimated. The equations specified in Part II of the Off-Site Dose Calculation Manual, for calculating the doses due to the actual release rates of radioactive material in liquid effluents are consistent with the methodology provided in Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," Revision 1, October 1977, and Regulatory Guide 1.113, "Estimating Aquatic Dispersion of Effluents from Accidental and Routine Reactor Releases for the Purpose of Implementing Appendix I," April 1977.

C. Liquid Waste Treatment System

The OPERABILITY of the liquid radwaste treatment system ensures that this system will be available for use whenever liquid effluents require treatment prior to release to the environment. The requirement that appropriate portions of this system be used when specified provides assurance that the releases of radioactive materials in liquid effluents will be kept "as low as is reasonably achievable". This specification implements the requirements of 10 CFR Part 50.36a, General Design Criterion 60 of Appendix I to 10 CFR Part 50 and design objective and in Section II.D of Appendix A to 10 CFR Part 50. The specified limits governing the use of appropriate portions of the liquid radwaste treatment system were specified to ensure the design objectives set forth in Section II.A of Appendix I, 10 CFR Part 50 for liquid effluents are not exceeded.

7.2.1 (continued)

D. Liquid Holdup Tanks

Restricting the quantity of radioactive material contained in the specified tanks provides assurance that in the event of an uncontrolled release of the tanks' contents, the resulting concentrations would be less than the limits of 10 CFR Part 20, Appendix B, Table II, Column 2, at the nearest potable water supply and the nearest surface water supply in an unrestricted area.

7.2.2 Radioactive Gaseous Effluents

A. Concentration

This specification, in conjunction with Steps 4.2.2A and 4.2.3A, is provided to ensure that the dose at or beyond the Site Boundary from gaseous effluents will be within the annual dose limits of 10 CFR Part 20 for MEMBERS OF THE PUBLIC. The release rate of radioactive material in airborne effluents shall be controlled such that the instantaneous concentrations for these radionuclides do not exceed the values specified in 10 CFR Part 20 for airborne effluents at the unrestricted area boundary. To support plant operations, Supervisor-System Chemistry may increase this limit up to the limits specified in Technical Specifications 5.16.1.g. Technical Specification 5.16.1.g. establishes the administrative control limit on the concentration resulting from radioactive material, other than noble gases, released in gaseous effluents to unrestricted areas conforming to ten times 10 CFR Part 20.1001-20.2401, Appendix B, Table 2, Column 1. For noble gases, the concentration shall be limited to five times 10 CFR Part 20.1001-20.2401, Appendix B, Table 2, Column 1. Because these concentrations are applied on an instantaneous basis and because of the overriding 10 CFR Part 50 Appendix I cumulative dose limitations, these limits provide reasonable assurance that radioactive material discharged in gaseous effluents will not result in the exposure of a MEMBER OF THE PUBLIC either within or outside the Site Boundary, to annual average concentrations that would result in exceeding the annual total effective dose equivalent limit specified in 10 CFR Part 20.1301(a).

7.2.2 (continued)

B. Dose - Noble Gases

This specification is provided to implement the requirements of Sections II.B, III.A and IV.A of Appendix I, 10 CFR Part 50. The Limiting Condition For Operation implements the guides set forth in Section II.B of Appendix I. The ACTION statements provide the required operating flexibility and at the same time implement the guides set forth in Section IV.A of Appendix I assure that the releases of radioactive material in gaseous effluents will be kept as low as is reasonably achievable. The surveillance requirements implement the requirements in Section III.A of Appendix I that conform with the guides of Appendix I to be shown by calculational procedures based on models and data such that the actual exposure of an individual through the appropriate pathways is unlikely to be substantially underestimated. The dose calculation methodology and parameters established in Part II of the Off-Site Dose Calculation Manual, for calculating the doses due to actual release rates of radioactive noble gases in gaseous effluents are consistent with the methodology provided in Regulatory Guide 1.109, Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I, Revision 1, October 1977 and Regulatory Guide 1.111, Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors, Revision 1, July 1977. The Off-Site Dose Calculation Manual, equations provided for determining the air doses at the site boundary are consistent with Regulatory Guides 1.109 and 1.111.

7.2.2 (continued)

C. Dose - I-131, Radioactive Material in Particulate Form with Half-Lives Greater than Eight Days (Other than Noble Gases) and Tritium

This specification is provided to implement the requirements of Sections II.C, III.A and IV.A of Appendix I, 10 CFR Part 50. The Limiting Condition For Operation implements the guides set forth in Section II.C of Appendix I. The ACTION statements provide the required operating flexibility and at the same time implement the guides set forth in Section IV.A of Appendix I assure that the releases of radioactive material in gaseous effluents will be kept as low as is reasonably achievable. The surveillance requirements implement the requirements in Section III.A of Appendix I that conform with the guides of Appendix I to be shown by calculational procedures based on models and data such that the actual exposure of an individual through the appropriate pathways is unlikely to be substantially underestimated. The dose calculation methodology and parameters established in Part II of the Off-Site Calculation Manual, for calculating the doses due to actual release rates of radioactive noble gases in gaseous effluents are consistent with the methodology provided in Regulatory Guide 1.109, Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I, Revision 1, October 1977 and Regulatory Guide 1.111, Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors, Revision 1, July 1977. The release rate specification for I-131, radioactive material in particulate form with half-lives greater than eight days (other than noble gases) and tritium are dependent on the existing radionuclide pathways to man in the areas at or beyond the site boundary. The pathways that were examined in the development of these calculations were: 1) individual inhalation of airborne radionuclides, 2) deposition of radionuclides onto green leafy vegetation with subsequent consumption by man, 3) deposition onto grassy areas where milk animals and meat producing animals graze with consumption of the milk and meat by man, and 4) deposition on the ground with subsequent exposure of man.

7.2.2 (continued)

D. Gaseous Waste Treatment

The OPERABILITY of the gaseous radwaste treatment system and the ventilation exhaust treatment systems ensures that the systems will be available for use whenever gaseous effluents require treatment prior to release to the environment. The requirement that appropriate portions of this system be used when specified provides assurance that the releases of radioactive materials in gaseous effluents will be kept as low as is reasonably achievable. This specification implements the requirements of 10 CFR Part 50.36a, General Design Criterion 60 of Appendix I to 10 CFR Part 50 and design objective and in Section II.D of Appendix A to 10 CFR Part 50. The specified limits governing the use of appropriate portions of the systems were specified to ensure the design objectives set forth in Section II.B and II.C of Appendix I, 10 CFR Part 50 for gaseous effluents are not exceeded.

7.2.2 (continued)

E. Total Dose - Uranium Fuel Cycle

This specification is provided to meet the dose limitations of 40 CFR Part 190 that have been incorporated into 10 CFR Part 20.1301(d). This requires the preparation and submittal of a Special Report whenever the calculated doses due to releases of radioactivity and to radiation from uranium fuel cycle sources exceed 25 mRems to the total body or any organ, except the thyroid, which shall be limited to less than or equal to 75 mRems. It is highly unlikely that the resultant dose to a MEMBER OF THE PUBLIC will exceed the dose limits of 40 CFR Part 190 if the plant remains within twice the dose design objectives of Appendix I, 10 CFR Part 50, and if direct radiation doses (including outside storage tanks, etc.) are kept small. The Special Report shall describe a course of action that should result in the limitation of the annual dose to a MEMBER OF THE PUBLIC to within the 40 CFR Part 190 limits. For purposes of the Special Report, it may be assumed that the dose commitment to the MEMBER OF THE PUBLIC from other uranium fuel cycle sources is negligible, with the exception that dose contributions from other nuclear fuel cycle facilities at the same site or within a radius of 8 km must be considered. If the dose to any MEMBER OF THE PUBLIC is estimated to exceed the requirements of 40 CFR Part 190, the Special Report, with a request for a variance (provided the release conditions resulting in violation of 40 CFR Part 190 have not already been corrected), in accordance with the provisions of 40 CFR Part 190.11 and 10 CFR Part 20.2203(a)(4) and 20.2203(b) is considered to be a timely request and fulfills the requirements 40 CFR Part 190 until NRC staff action is completed. The variance only relates to the limits of 40 CFR Part 190, and does not apply in any way to the other requirements for dose limitation of 10 CFR Part 20. An individual is not considered a MEMBER OF THE PUBLIC during any period in which he/she is engaged in carrying out any operation that is part of the nuclear fuel cycle. Demonstration of compliance with the limits of 40 CFR Part 190 or with the design objectives of Appendix I to 10 CFR Part 50 will be considered to demonstrate compliance with the 0.1 rem limit of 10 CFR Part 20.1301.

7.3 Radiological Environmental Monitoring

7.3.1 Monitoring Program

The radiological environmental monitoring program required by this specification provides measurements of radiation and radioactive materials in those exposure pathways and for radionuclides which lead to the highest potential radiation exposures of individuals resulting from the station operation. This monitoring program thereby supplements the radiological effluent monitoring program by verifying that the measurable concentrations of radioactive materials and levels of radiation are not higher than expected on the basis of the effluent measurements and modeling of the environmental exposure pathways. The initially specified monitoring program was effective for at least the first three years of commercial operation. Following this period, program changes are initiated based on operational experience.

7.3.2 Land Use Survey

This specification is provided to ensure that changes in the use of unrestricted areas are identified and that modifications to the monitoring program are made if required by the results of this survey. The frequency of the Land Use Survey has been reduced to a biennial requirement in site procedures because persons knowledgeable in land use census monitor usage characteristics perform routine REMP sampling. This approach allows knowledge gained during sample collection to be integrated into the program, maintaining its effectiveness. The best survey information from door to door, aerial or consulting with local agricultural authorities, or equivalent, shall be used. This survey satisfies the requirements of Section IV.B.3 of Appendix I to 10 CFR Part 50. Restricting the survey to gardens of greater than 500 square feet provides assurance that significant exposure pathways via leafy vegetables will be identified and monitored since a garden of this size is the minimum required to produce the quantity (26 kg/year) of leafy vegetables assumed in Regulatory Guide 1.109 for consumption by a child. To determine this minimum garden size, the following assumptions were used, 1) that 20% of the garden was used for growing broad leaf vegetation (i.e., similar to lettuce and cabbage), and 2) a vegetation yield of 2 kg/m^2.

For milk, the survey is restricted to only milk animals (cow or goat) producing milk for human consumption. Air monitoring stations are strategically located to monitor the resident receptors who could potentially receive the highest doses from airborne radioactive material. For groundwater, samples shall be taken when sources are determined to potentially be affected by plant operations, and when sources are tapped for drinking or irrigation purposes in areas where the hydraulic gradient or recharge properties are suitable for contamination. Guidance provided in the Branch Technical Position and Technical Specification 5.16.2 is used to meet the intent of NUREG-1301.

7.3.3 Interlaboratory Comparison Program

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

7.4 Abnormal Release or Abnormal Discharge Reporting

7.4.1 Specific information should be reported concerning abnormal (airborne and/or liquid) releases on site and abnormal discharges to the unrestricted area. The report should describe each event in a way that would enable the NRC to adequately understand how the material was released and if there was a discharge to the unrestricted area. The report should describe the potential impact on the ingestion exposure pathway involving surface water and ground water, as applicable. The report should also describe the impact (if any) on other affected exposure pathways (e.g., inhalation from pond evaporation).

7.4.2 The following are the thresholds for reporting abnormal releases and abnormal discharges in the supplemental information section:

A. Abnormal release or Abnormal Discharges that are voluntarily reported to local authorities under NEI 07-07, Industry Ground Water Protection Initiative. **[AR 39127]**

B. Abnormal release or Abnormal discharges estimated to exceed 100 gallons of radioactive liquid where the presence of licensed radioactive material is positively identified (either in the on-site environs or in the source of the leak or spill) as greater than the minimum detectable activity for the laboratory instrumentation.

C. Abnormal releases to on-site areas that result in detectable residual radioactivity after remediation.

D. Abnormal releases that result in a high effluent radiation alarm without an anticipated trip occurring.

E. Abnormal discharges to an unrestricted area.

7.4.3 Information on Abnormal releases or Abnormal discharges should include the following, as applicable:

- Date and duration
- Location
- Volume
- Estimated activity of each radionuclide
- Effluent monitoring results (if any)
- On-site monitoring results (is any)
- Depth to the local water table
- Classification(s) of subsurface aquifer(s) (e.g., drinking water, unfit for drinking water, not used for drinking water)
- Size and extent of any ground water plume
- Expected movement/mobility of any ground water plume
- Land use characteristics (e.g., water used for irrigation)
- Remedial actions considered or taken and results obtained
- Calculated member of the public dose attributable to the release
- Calculated member of the public dose attributable to the discharge
- Actions taken to prevent recurrence, as applicable
- Whether the NRC was notified, the date(s), and the contact organization

PART II

CALCULATIONS

1.0 EFFLUENT MONITOR SETPOINTS

1.1 Liquid Effluents

1.1.1 There are two liquid discharge pathways to the Missouri River. These pathways originate with the radioactive liquid waste processing system (monitor or hotel tanks) and the steam generator blowdown system. Both of these pathways empty into the circulating water system which discharges to the Missouri River (see Figure 1). Figure 2 depicts the liquid discharge pathways and associated radiation monitors. Figure 3 depicts the methods of liquid effluent treatment.

1.1.2 The flowrate for dilution water varies with the number of circulating water pumps in service, the number of raw water pumps in service, and with the operation of the warm water recirculation. Some warm water from the condenser outlet is diverted from the circulating water discharge to upstream of the intake structure to help prevent ice from forming on the circulating water pump intakes during winter months. The varying dilution flowrate and utilization of warm water recirculation is accounted for in the dilution calculations for monitor tank and stream generation releases.

1.1.3 Technical Specification 5.16.1.b establishes the administrative control limit on concentration of radioactive material, other than dissolved or entrained noble gases, released in liquid effluents to unrestricted areas conforming to ten times 10 CFR Part 20.1001-20.2401, Appendix B, Table 2, Column 2. For dissolved or entrained noble gases, the concentration shall be limited to 2.0 E-04 μCi/ml total activity.

1.1.4 The liquid effluent monitoring instrumentation ALERT setpoints shall be established low enough to ensure that the concentration of radioactive material released in liquid effluents at site discharge will be less than the concentrations specified in 10 CFR Part 20, Appendix B, Table 2, Column 2.

1.1.5 The liquid effluent monitoring instrumentation HIGH ALARM setpoints shall be established low enough to ensure that the concentration of radioactive material released in liquid effluents at site discharge will be less than 10 times the concentrations specified in 10 CFR Part 20, Appendix B, Table 2, Column 2.

1.1.6 Cs-137 is used to calibrate the liquid effluent monitors.

i	**NOTE** If the annual average χ/Q value exceeds 1.4E-04 sec/m^3, consideration should be given to basing liquid radiation monitor setpoints on an I-131 instantaneous limit of 2.0E-09 µCi/ml at the unrestricted area boundary with 10% vapor/liquid separation. Contact the Supervisor-System Chemistry for further instructions.	i

1.1.7 Liquid Effluent Radiation Monitors

A. Steam Generator Blowdown Monitors (RM-054A and B)

1. These process radiation detectors monitor the flow through the steam generator blowdown lines and automatically close the blowdown isolation valves if the monitor high alarm setpoint is reached. The monitor controls liquid effluent releases so that 10 times the 10 CFR Part 20 limit at the unrestricted area boundary of 1.0E-06 µCi/cc, is not exceeded at the site discharge.

2. The following calculations for maximum concentration and alarm setpoints are valid for simultaneous radioactive liquid releases of steam generator blowdown and monitor tank discharge.

3. The maximum allowable concentration in the blowdown line is calculated as follows:

$$C_{MAX} = \frac{(1.0E-05\,\mu Ci/ml)(F)}{f}$$

Where:

1.0E-05 µCi/ml = Ten times 10 CFR Part 20 Limit for unidentified radionuclides at site discharge (10 CFR Part 20, Appendix B, Note 2).

F = Total dilution flow in the discharge tunnel (gpm). (Normal flow is based on 1 circulating water pump at 120,000 gpm. Other flowrates may be used, as required.)

f = Blowdown flow rate (gpm). (Normal blowdown flow rate is based on 2 transfer pumps with a design flow of 135 gpm each, 270 gpm total. Other flow rates may be used, as required.)

C_{MAX} = Maximum allowable blowdown concentration (µCi/ml).

1.1.7A (continued)

	NOTE	
i	Setpoints may be recalculated based on adjusted dilution flow and adjusted blowdown flow.	i

The **High Alarm Setpoint** (CPM):

$$Setpoint = 0.75\left[\left((K_4)(S_f)(C_{MAX})\right) + B\right]$$

Where:

0.75 = An administrative correction factor which includes the following:

15% tolerance to ensure radmonitor response in accordance with License Event Report 77-17, Docket Number 050-0285 and Telecon FC-472-77.

10% tolerance to account for the difference in detector sensitivity for the range of isotopes detected.

S_f = Detector sensitivity factor (CPM/µCi/ml). (Sensitivity based on Cs-137).

K_4 = Allocation factor for Individual Steam Generator Release (See Table 1)

B = Background (CPM)

C_{MAX} = Maximum allowable blowdown line activity (µCi/ml).

The **Alert Setpoint** will be chosen less than or equal to one tenth (1/10) the value of the high alarm setpoint value so that significant increases in activity will be identified prior to exceeding an Unrestricted Area fractional sum of 1.0. It will also provide additional time for corrective actions prior to exceeding the Alarm Setpoint.

1.1.7 (continued)

B. Overboard Discharge Header Monitor (RM-055)

1. This process radiation monitor provides control of the waste monitor tank effluent by monitoring the overboard header prior to its discharge into the circulating water discharge tunnel. The concentration of activity at discharge is controlled below ten times the 10 CFR Part 20 limit of 1.0E-06 µCi/ml at site discharge for unidentified isotopes by the high alarm setpoint which closes the overboard flow control valve.

2. The following calculations for maximum concentration and alarm setpoints are valid for simultaneous radioactive liquid releases of monitor tank discharge and steam generator blowdown.

3. The maximum allowable concentration in the overboard discharge header is:

$$C_{MAX} = \frac{(1.0E-05\ \mu Ci/ml)\ (F)}{f}$$

Where:

1.0E-05 µCi/ml	=	Ten times 10 CFR Part 20 Limit for unidentified radionuclides at site discharge (10 CFR Part 20, Appendix B, Note 2).
F	=	Total dilution flow in the discharge tunnel (gpm). (Normal flow is based on 1 circulating water pump at 120,000 gpm. Other flowrates such as raw water pump(s) may be used, as required.)
f	=	Maximum monitor tank discharge flow rate (gpm). (Normal monitor tank maximum flow is 50 gpm. Other flow rates such as raw water pump(s) may be used, as required.)
C_{MAX}	=	Maximum allowable activity in discharge header (µCi/ml).

1.1.7B (continued)

The **High Alarm Setpoint** (CPM):

$$Setpoint = 0.75\ \left[\left((K_5)(S_f)(C_{MAX})\right) + B\right]$$

Where:

0.75	=	An administrative correction factor which includes the following: 15% tolerance to ensure radmonitor VIAS response in accordance with License Event Report 77-17, Docket Number 050-0285 and Telecon FC-472-77. 10% tolerance to account for the difference in detector sensitivity for the range of isotopes detected.
S_f	=	Detector sensitivity factor (CPM/µCi/ml). (Sensitivity based on Cs-137).
K_5	=	Allocation factor for Waste Liquid Releases (See Table 1)
C_{MAX}	=	Maximum allowable concentration in discharge header (µCi/ml).
B	=	Background (CPM)

The **Alert Setpoint** will be chosen less than or equal to one tenth (1/10) the value of the high alarm setpoint value so that significant increases in activity will be identified prior to exceeding an Unrestricted Area fractional sum of 1.0. It will also provide additional time for corrective actions prior to exceeding the Alarm Setpoint.

1.2 Airborne Effluents

1.2.1 There are three air effluent discharge pathways at the Fort Calhoun Station: Condenser Offgas, Laboratory and Radioactive Waste Processing Building Exhaust Stack, and the Auxiliary Building Exhaust Stack. An airborne radioactive waste flow diagram with the applicable, associated radiation monitoring instrumentation and controls is presented as Figure 4. The airborne waste disposal system is presented in Figure 5.

- Auxiliary Building - The Auxiliary Building Exhaust Stack receives discharges from the waste gas decay tanks, containment purge, containment vent systems and the auxiliary building ventilation system. Radiation Monitor RM-062 provides noble gas monitoring and iodine and particulate sampling for the Auxiliary Building Exhaust Stack. Backup noble gas monitoring and iodine and particulate sampling is provided by RM-052. Ventilation Isolation Actuation Signal (VIAS) is actuated by exceeding a monitor's alarm setpoint. Actuation of VIAS will isolate releases from containment and waste gas decay tanks. The Auxiliary Building Exhaust fans will remain in operation.

- Laboratory and Radioactive Waste Processing Building (LRWPB) - Noble gas monitoring and particulate and iodine sampling is provided by RM-043. This radiation monitor/sampler does not serve a control function.

- Condenser Off-Gas Monitors - Noble gas activity is monitored by RM-057. The condenser off-gas is discharged directly to the environment. Exceeding the high alarm setpoint on RM-057 will activate isolation of main steam to the Auxiliary Steam System.

  Technical Specification 5.16.1.g. establishes the administrative control limit on the concentration resulting from radioactive material, other than noble gases, released in gaseous effluents to unrestricted areas conforming to ten times 10 CFR Part 20.1001-20.2401, Appendix B, Table 2, Column 1. For noble gases, the concentration shall be limited to five times 10 CFR Part 20.1001-20.2401, Appendix B, Table 2, Column 1.

  The airborne effluent monitoring instrumentation ALERT setpoints shall be established low enough to ensure that the concentration of radioactive material released in air effluents at site discharge will be less than the concentrations specified in 10 CFR Part 20, Appendix B, Table 2, Column 1.

  The airborne effluent monitoring instrumentation HIGH ALARM setpoints shall be established low enough to ensure that the concentration of radioactive material released in air effluents at site discharge will be less than 5 times the concentrations specified in 10 CFR Part 20, Appendix B, Table 2, Column 1.

1.2.2 Airborne Effluent Radiation Monitors

A. Auxiliary Building Exhaust Stack Noble Gas Activity Monitor (RM-062/RM-052)

1. Either of these monitors may be used to measure the noble gas activity in the exhaust stack. The noble gas is monitored after passing through a particulate filter, and charcoal cartridge. The monitor controls airborne releases so that five times the 10 CFR Part 20 limit at the unrestricted area boundary of 5.0E-07 μCi/cc, based upon Xe-133, is not exceeded. The Ventilation Isolation Actuation Signal is initiated when the high alarm setpoint is reached.

2. The following calculations for maximum release rate and alarm setpoint are valid for simultaneous airborne releases from Auxiliary Building Exhaust Stack, Condenser Off-gas and the LRWPB Exhaust Stack.

3. The maximum allowable release rate for stack airborne activity is calculated as follows:

$$R_{MAX}\,\mu Ci/sec = \left(\frac{2.5E-06\,\mu Ci/cc}{\chi/Q\;sec/m^3}\right)1.0E+06\;cc/m^3$$

Where:

2.5E-06 μCi/cc	=	5 times the 10 CFR Part 20 Limit at the unrestricted area boundary (based upon Xe-133).
χ/Q sec/m^3	=	Annual average dispersion factor at the unrestricted area boundary from Part II Table 4, of the Off-Site Dose Calculation Manual.
1.0E+06 cc/m^3	=	Constant of unit conversion.

1.2.2A (continued)

The **High Alarm Setpoint** (CPM):

$$Setpoint = 0.75\left[K_1\left(\frac{(R_{MAX})(S_f)(60)}{(F_V)(28317)}\right) + B\right]$$

Where:

0.75	=	An administrative correction factor which includes the following: 15% tolerance to ensure radmonitor VIAS response in accordance with License Event Report 77-17, Docket Number 050-0285 and Telecon FC-472-77. 10% tolerance to allow for the contribution of noble gases other than Xe-133 towards the total ECL fraction sum.
S_f	=	Detector sensitivity factor (CPM/μCi/cc). (Sensitivity based on Xe-133)
K_1	=	Allocation factor for Auxiliary Building Exhaust Stack (See Table 1)
60	=	Conversion (seconds to minutes).
28317	=	Conversion factor (ft^3 to cc).
F_v	=	Auxiliary Building Exhaust stack flow rate (SCFM). (Default maximum flow rate is 122,500 cfm for 3 Auxiliary Building exhaust fans and 2 containment purge fans in operation. Other flow rates may be used, as required.)
R_{MAX}	=	Maximum Allowable Release Rate in μCi/sec
B	=	Background (CPM)

The **Alert Setpoint** will be chosen less than or equal to one fifth (1/5) the value of the high alarm setpoint value so that significant increases in activity will be identified, prior to exceeding an Unrestricted Area fractional sum of 1.0. It will also provide additional time for corrective actions prior to exceeding the Alarm Setpoint and VIAS actuation.

1.2.2 (continued)

B. Condenser Off Gas Monitor (RM-057)

1. This monitor is located in the turbine building and monitors the condenser off-gas. The purpose of this monitor is to monitor the condenser off-gas discharges so that five times the 10 CFR Part 20 limit at the unrestricted area boundary of 5.0E-07 μCi/cc, based upon Xe-133, is not exceeded.

2. The following calculations for maximum release rate and alarm setpoint are valid for simultaneous airborne releases from condenser off-gas, Auxiliary Building Exhaust Stack, and the LRWPB Exhaust Stack.

3. The maximum allowable release rate for condenser air ejector monitor is as follows:

$$R_{MAX}\,\mu Ci/sec = \left(\frac{2.5E-06\,\mu Ci/cc}{\chi/Q\,sec/m^3}\right) 1.0E+06\,cc/m^3$$

Where:

2.5E-06 μCi/cc	=	5 times the 10 CFR Part 20 Limit at the unrestricted area boundary (based upon Xe-133).
א/Q sec/m^3	=	Annual average dispersion factor at the unrestricted area boundary from Part II, Table 4, of the Off-Site Dose Calculation Manual.
1.0E+06 cc/m^3	=	Constant of unit conversion.

1.2.2B (continued)

The **High Alarm Setpoint** (CPM):

$$Setpoint = 0.75\left[K_2\left(\frac{(R_{MAX})(S_f)(60)}{(F_V)(28317)}\right) + B\right]$$

Where:

0.75 = An administrative correction factor which includes the following:

15% tolerance to ensure radmonitor VIAS response in accordance with License Event Report 77-17, Docket Number 050-0285 and Telecon FC-472-77.

10% tolerance to allow for the contribution of noble gases other than Xe-133 towards the total ECL fraction sum.

S_f = Detector sensitivity factor (CPM/µCi/cc). (Sensitivity based on Xe-133)

K_2 = Allocation factor for Condenser Off Gas (See Table 1)

60 = Conversion (seconds to minutes).

28317 = Conversion factor (ft; to cc).

F_v = Vent stack flow rate (SCFM). Default maximum flow rate is 4,755 scfm (3 vacuum pumps in hogging mode. Other flow rates may be used, as required.)

R_{MAX} = Maximum Allowable Release Rate in µCi/sec.

B = Background (CPM)

The **Alert Setpoint** will be chosen less than or equal to one fifth (1/5) the value of the high alarm setpoint value so that significant increases in activity will be identified, prior to exceeding an Unrestricted Area fractional sum of 1.0. It will also provide additional time for corrective actions prior to exceeding the Alarm Setpoint and tripping of the auxiliary steam supply valve, RCV-978.

1.2.2 (continued)

C. Laboratory and Radioactive Waste Processing Building Exhaust Stack Noble Gas Activity Monitor and Iodine and Particulate Sampler (RM-043)

1. RM-043 is located in the Radwaste Building and samples the LRWPB Exhaust Stack. The monitor alarm setpoint is based on five times the 10 CFR Part 20 limit for Xe-133 at the unrestricted area boundary.

2. The following calculations for maximum release rate and alarm setpoint are valid for simultaneous airborne releases from condenser off-gas, Auxiliary Building Exhaust Stack, and the LRWPB Exhaust Stack.

$$R_{MAX}\ \mu Ci/\mathrm{sec} = \left(\frac{2.5E-06\ \mu Ci/cc}{\chi/Q\ sec/m^3}\right) 1.0E+06\ cc/m^3$$

The maximum allowable release rate for RM-043 is as follows:

Where:

2.5E-06 μCi/cc	=	5 times the 10 CFR Part 20 Limit at the unrestricted area boundary (based upon Xe-133).
χ/Q	=	Annual average dispersion factor at the unrestricted area boundary from Part II of the Off-Site Dose Calculation Manual, Table 4.
1.0E+06 cc/m^3	=	Constant of unit conversion

1.2.2C (continued)

i	**NOTE** This monitor alarms in the Control Room. There are no automatic control functions associated with the actuation of the alarm.	i

The **High Alarm Setpoint** (CPM):

$$Setpoint = 0.75\left[K_3\left(\frac{(R_{MAX})(S_f)(60)}{(F_V)(28317)}\right) + B\right]$$

Where:

0.75 = An administrative correction factor which includes the following:

15% tolerance to ensure radmonitor VIAS response in accordance with License Event Report 77-17, Docket Number 050-0285 and Telecon FC-472-77.

10% tolerance to allow for the contribution of noble gases other than Xe-133 towards the total ECL fraction sum.

S_f = Detector sensitivity factor (CPM/µCi/cc). (Sensitivity based on Xe-133)

K_3 = Allocation factor for LRWPB Exhaust Stack (See Table 1)

60 = Conversion (seconds to minutes).

28317 = Conversion factor (ft^3 to cc).

F_v = LRWPB Exhaust stack flow rate (SCFM). (Default flow rate is 28,700 cfm. Other flow rates may be used if required.)

R_{MAX} = Maximum Allowable Release Rate in µCi/sec.

B = Background (CPM)

The **Alert Setpoint** will be chosen less than or equal to one fifth (1/5) the value of the high alarm setpoint value so that significant increases in activity will be identified, prior to exceeding an Unrestricted Area fractional sum of 1.0. It will also provide additional time for corrective actions prior to exceeding the Alarm Setpoint.

Table 1 - Allocation Factors for Simultaneous Releases

NOTE

The Fort Calhoun Station is capable of performing simultaneous airborne releases. The factors below may be adjusted to meet release requirements, provided that the sum of the Unrestricted Area Fraction Sum for all airborne releases remains less than or equal to 1.0.

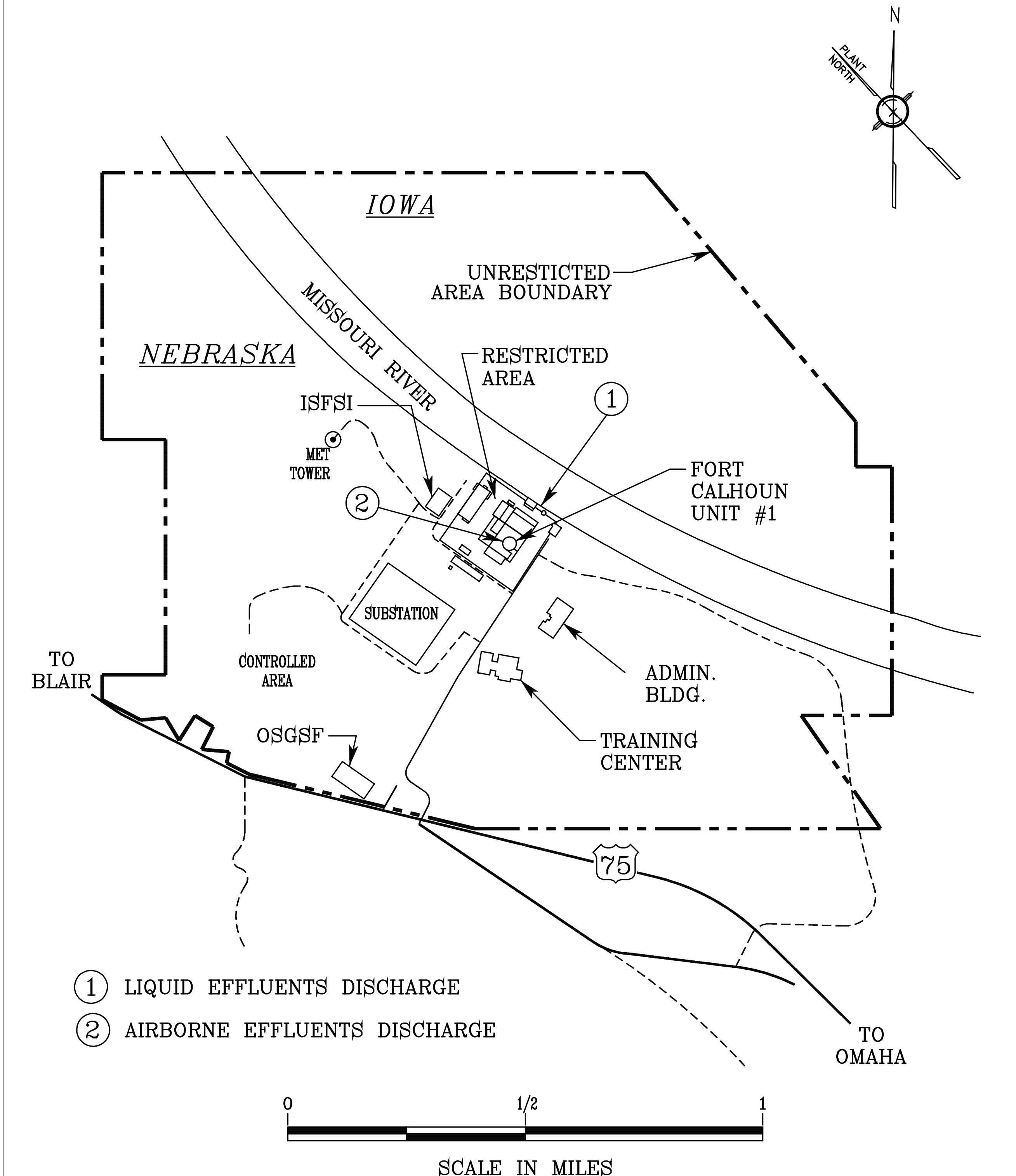
A. Allocation Factors for Simultaneous Airborne Releases		
1. Auxiliary Building Exhaust Stack		Total: 0.80
K1 Noble Gases (RM-062 or RM-052)		0.70
Iodine/Particulate/Tritium		0.10
Contributing Pathways: a) Auxiliary Building	0.10	
b) Containment Building	0.65	
c) Waste Gas Decay Tanks	0.05	
2. Condenser/Off Gas		Total: 0.10
K_2 Noble Gases (RM-057)		0.05
Tritium		0.05
Contributing Pathways:		
a) Condenser Off Gas	0.10	
3. Laboratory and Radioactive Waste Building Exhaust Stack		Total: 0.10
K_3 Noble Gases (RM-043)		0.05
Iodine/Particulate		0.05
Contributing Pathways:		
a) Laboratory and Radioactive Waste Building Exhaust Stack	0.10	
Airborne Release Total		**1.00**

NOTE

The Fort Calhoun Station is capable of performing simultaneous liquid releases. The factors below may be adjusted to meet release requirements provided that the sum of the Unrestricted Area Fraction Sum for all liquid releases remains less than or equal to 1.0.

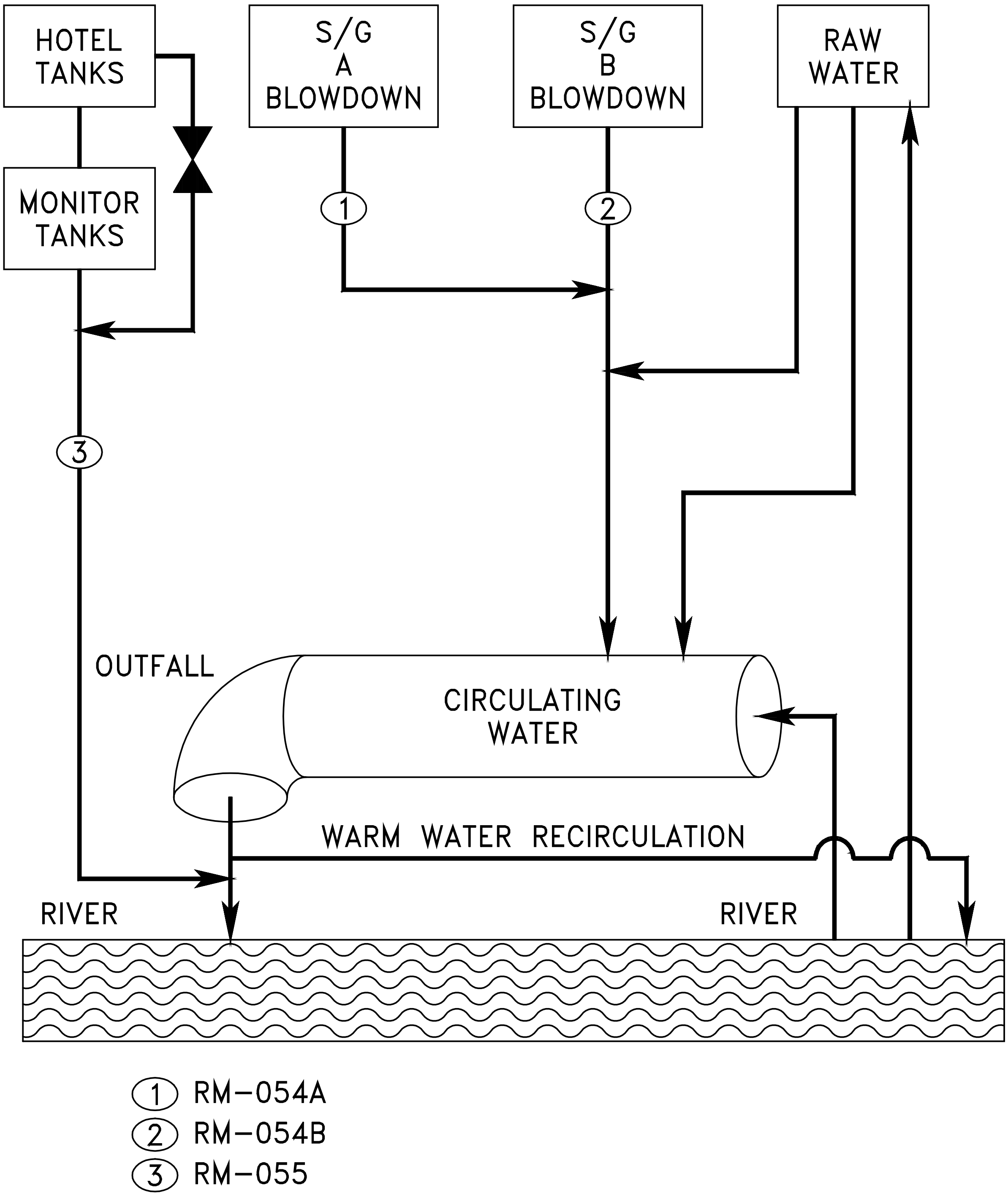
B. Allocation Factors for Simultaneous Liquid Releases		
1. K_4 Steam Generator Releases (RM-054A/054B)		Total: 0.30
Contributing Pathways: a) Alpha Steam Generator (RM-054A)	0.15	
b) Bravo Steam Generator (RM-054B)	0.15	
2. K_5 Waste Liquid Releases (RM-055)		0.70
Liquid Release Total		**1.00**

Figure 1 - Exclusion and Site Boundary Map



EXCLUSION AND SITE BOUNDARY MAP

Figure 2 - Liquid Radioactive Discharge Pathways



LIQUID RADIOACTIVE DISCHARGE PATHWAYS

Figure 3 - Liquid Radioactive Waste Disposal System

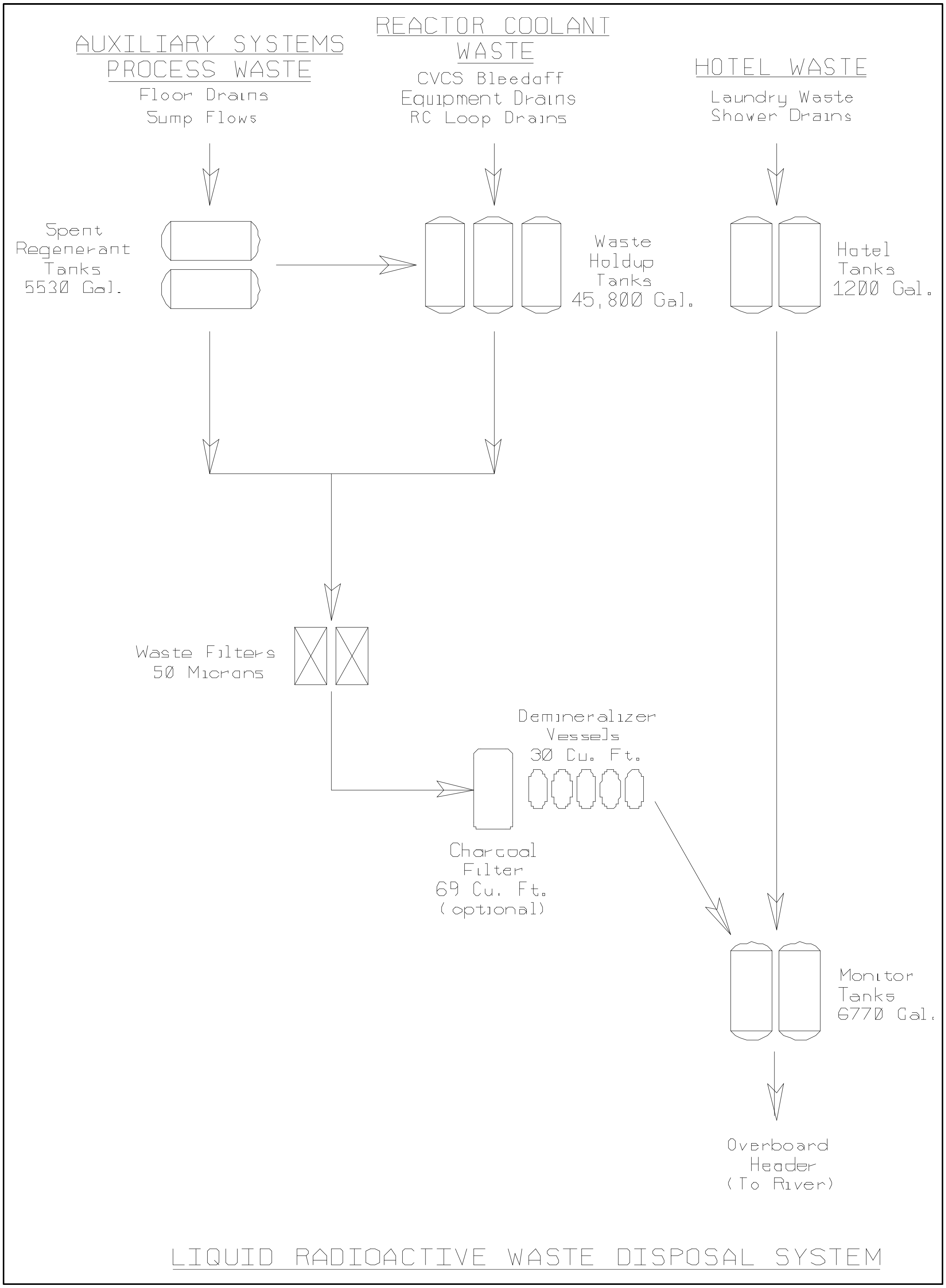


Figure 4 - Airborne Effluent Discharge Pathways

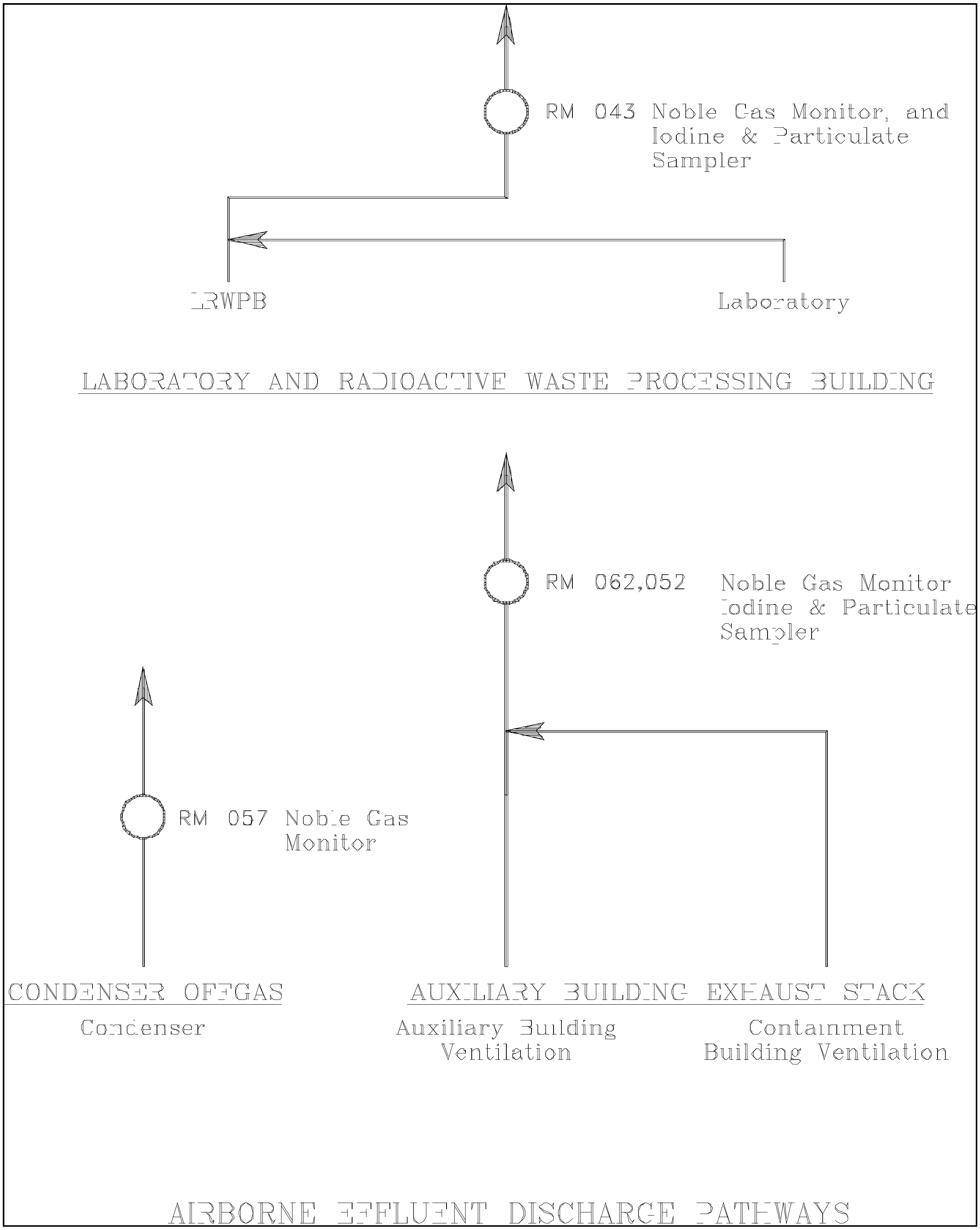
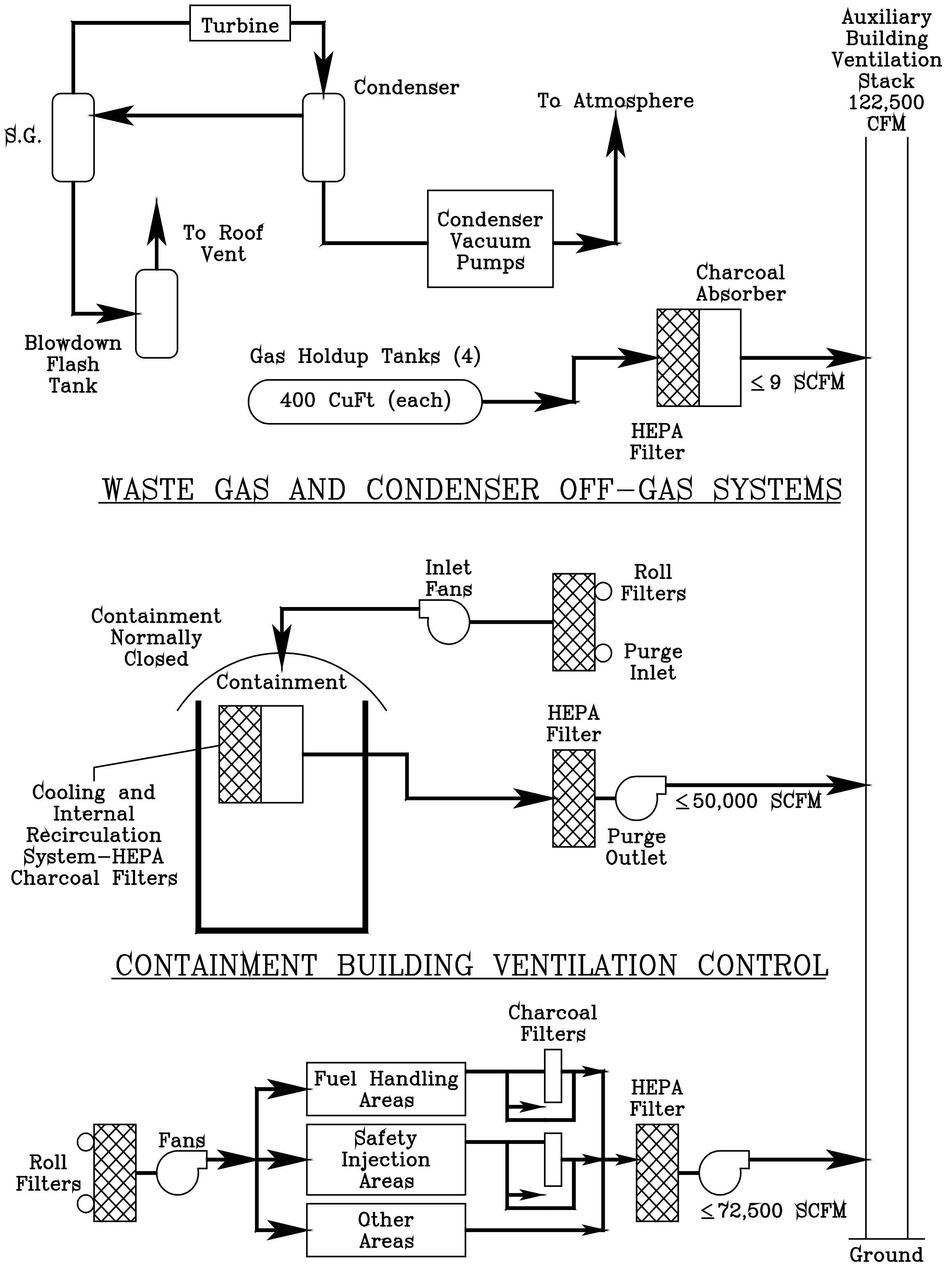


Figure 5 - Airborne Radioactive Waste Disposal System



AIRBORNE RADIOACTIVE WASTE DISPOSAL SYSTEM

2.0 EFFLUENT CONCENTRATIONS

2.1 Liquid Effluent Concentrations

2.1.1 The concentration of radioactive material in liquid effluents (after dilution in the Circulating Water System) will be limited to the concentrations as specified in 10 CFR Part 20, Appendix B, Table 2, Column 2. For batch releases (Monitor and Hotel Waste Tanks and Steam Generators) and for continuous releases (Steam Generator Blowdown), the analyses will be performed in accordance with Part I, Table 4.1, of the Off-Site Dose Calculation Manual, and the concentration of each radionuclide at site discharge will be calculated, based on the following equation:

$$A_i = \frac{a_i f}{F + f}$$

$$and \sum_{i=1}^{n} \frac{A_i}{wec_i} \leq 1$$

Radionuclide concentration at site discharge:

Where:

A_i = concentration at site discharge for radionuclide (I), in μCi/ml.

a_i = concentration of radionuclide (I) in the undiluted effluent, in μCi/ml.

f = undiluted effluent flowrate, in gpm.

F = total diluted effluent flowrate in gpm.

wec_i = water effluent concentration limit for radionuclide (I) per 10 CFR Part 20, Appendix B, Table 2, Column 2.

i	**NOTE** In addition to the above defined method, Notes 1 through 4 of 10 CFR Part 20, Appendix B, will also be applicable.	i

2.2 Airborne Effluent Concentrations

2.2.1 The concentration at the unrestricted area boundary, due to airborne effluent releases, will be limited to less than Appendix B, Table 2, Column 1, values. Radiation monitor alarm setpoints are established to ensure that these release limits are not exceeded. In the event an airborne effluent release from the station result in an alarm setpoint being exceeded, an evaluation of the unrestricted area boundary concentration resulting from the release will be performed:

2.2.2 To determine the concentration and air effluent concentration (aec) fraction summation at the unrestricted area boundary, the following equations will be used:

$$A_i = K_0\, Q_i\, (\chi/Q)$$

$$and \sum_{i=1}^{n} \frac{A_i}{ECL_i} \leq 1$$

Where:

A_i = Concentration of radionuclide (I) at the unrestricted area boundary

K_0 = Constant of unit conversion. (1.0E-6 m3/cc)

ECL_i = Effluent concentration limit (10 CFR Part 20, Appendix B, Table 2, Column 1 value for radionuclide(I))

Q_i = The release rate of radionuclide (I) in airborne effluents from all vent releases (in µCi/sec.)

(χ/Q) = Annual Average Dispersion Factor at the Unrestricted Area Boundary from Part II, Table 4, of the Off-Site Dose Calculation Manual.

2.2.3 As appropriate, simultaneous releases from the Auxiliary Building Ventilation Stack, Laboratory and Radwaste Building Stack and condenser off gas will be considered in evaluating compliance with the release rate limits of 10 CFR Part 20. Monitor indications (readings) may be averaged over a time period not to exceed 15 minutes when determining noble gas release rate based on correlation of the monitor reading and monitor sensitivity. Historical annual average dispersion parameters, as presented in Table 4, may be used for evaluating the airborne effluent dose rate.

2.2.4 For administrative purposes, more conservative alarm setpoints than those as prescribed above may be imposed. However, conditions exceeding those more limiting alarm setpoints do not necessarily indicate radioactive material release rates exceeding 10 CFR Part 20 limits. Provided actual releases do not result in radiation monitor indications exceeding alarm setpoint values based upon the above criteria, no further analyses are required for demonstrating compliance with 10 CFR Part 20.

3.0 RADIOACTIVE EFFLUENT DOSE CALCULATIONS

3.1 Liquid Effluent Dose Calculations

3.1.1 Three pathways for human exposure to liquid releases from FCS to the Missouri River exists: 1) fish, 2) drinking water, and 3) Shoreline deposition. Fish are considered to be taken from the vicinity of the plant discharge. The drinking water for Omaha is located 19 miles downstream from FCS. The dilution factors for these pathways are derived from the Revised Environmental Report for FCS, (1974), (page 4-29 and 4-31). This report states that during Low-Low river conditions, the concentration at Omaha's water intake will be ≤14% of the concentration at discharge from FCS and will average 3%. This equates to a dilution factor of 7.14, which is used to calculate the maximum dose to an individual from liquid pathways and a dilution factor of 33.33, for calculating the average dose. All pathways combine to give the dose to an individual in unrestricted areas.

3.1.2 10 CFR Part 50, Appendix I restricts the dose to individuals in the unrestricted areas from radioactive materials in liquid effluents from the Fort Calhoun Station to the following limits:

- during any calendar quarter
  ≤ 1.5 mrem to total body
  ≤ 5.0 mrem to any organ

and

- during any calendar year
  ≤ 3.0 mrem to total body
  ≤ 10.0 mrem to any organ

The following calculational methods shall be used for determining the dose or dose commitment from liquid effluents.

3.1.3 Doses from Liquid Effluent Pathways

A. Potable Water

$$R_{apj} = 1100\,\frac{U_{ap}M_p}{F}\sum_{i=1}^{n} Q_i D_{aipj}\exp(-\lambda_i t_p)$$

Where:

R_{apj} = is the total annual dose to organ(j) of individuals of age group (a) from all of the radionuclides (I) in pathway (p), in mrem/yr.

U_{ap} = is a usage factor that specifies the intake rate for an individual of age group (a) associated with pathway (p), in ℓ/yr. (Table 6)

M_p = is the mixing ratio (reciprocal of the dilution factor) at the point of withdrawal of drinking water, dimensionless. (Table 17)

F = is the flow rate of the liquid effluent, in ft^3/ sec.

Q_i = is the annual release rate of radionuclide (I), in Ci/yr.

D_{aipj} = is the dose factor specific to a given age group (a), radionuclide (I), pathway (p), and organ (j) which can be used to calculate the radiation dose from an intake of a radionuclide, in mrem/pCi. (Tables 13-16)

λ_i = is the radiological decay constant of radionuclide (I), in hr^{1}.

t_p = is the average transit time required for radionuclides to reach the point of exposure. For internal dose, t_p is the total time elapsed between release of the radionuclides and ingestion of water, in hours. (Table 17)

1100 = Constant (pCi * yr * ft^3/Ci * sec * L)

3.1.3 (continued)

B. Aquatic Foods

$$R_{apj} = 1100 \frac{U_{ap} M_p}{F} \sum_{i=1}^{n} Q_i B_{ip} D_{aipj} \exp(-\lambda_i t_p)$$

Where:

R_{apj} = is the total annual dose to organ (j) of individuals of age group (a) from all of the radionuclides (I) in pathway (p), in mrem/yr.

U_{ap} = is a usage factor that specifies the intake rate for an individual of age group (a) associated with pathway (p), in kg/yr. (Table 6)

M_p = is the mixing ratio (reciprocal of the dilution factor) at the point of harvest of aquatic food, dimensionless. (Table 17)

F = is the flow rate of the liquid effluent, in ft^3/sec.

Q_i = is the annual release rate of radionuclide (I), in Ci/yr.

B_{ip} = is the equilibrium bioaccumulation factor for radionuclide (I) in pathway (p) expressed as the ratio of the concentration in biota (in pCi/kg) to the radionuclide concentration in water (in pCi/liter), in (pCi/kg)/(pCi/liter). (Table 3)

D_{aipj} = is the dose factor specific to a given age group (a), radionuclide (I), pathway (p), and organ (j), which can be used to calculate the radiation dose from an intake of a radionuclide, in mrem/pCi. (Tables 13-16)

λ_i = is the radiological decay constant of radionuclide (I), in hr^{-1}.

t_p = is the average transit time required for radionuclides to reach the point of exposure. For internal dose, t_p is the total time elapsed between release of the radionuclides and ingestion of food, in hours. (Table 17)

1100 = Constant (pCi * yr * ft^3/Ci * sec * L)

3.1.3 (continued)

C. Shoreline Deposits

$$R_{apj} = 110{,}000\,\frac{U_{ap}M_pW}{F}\sum_{i=1}^{n} Q_iT_{ip}D_{aipj}\left[\exp(-\lambda_i t_p)\right]\left[1-\exp(-\lambda_i t_b)\right]$$

Where:

R_{apj} = is the total annual dose to organ (j) of individuals of age group (a) from all of the radionuclides (I) in pathway (p), in mrem/yr.

U_{ap} = is a usage factor that specifies the exposure time for an individual of age group (a) associated with pathway (p), in hr/yr. (Table 6)

M_p = is the mixing ratio (reciprocal of the dilution factor) at the point of exposure, dimensionless. (Table 17)

W = is the shore-width factor, dimensionless. (Table 17)

F = is the flow rate of the liquid effluent, in ft^3/sec.

Q_i = is the annual release rate of radionuclide (I), in Ci/yr.

T_{ip} = is the radioactive half life of radionuclide (I), in days.

D_{aipj} = is the dose factor specific radionuclide (I) which can be used to calculate the radiation dose from exposure to a given concentration of a radionuclide in sediment, expressed as a ratio of the dose rate (in mrem/hr) and the real radionuclide concentration (in pCi/m^2). (Table 8)

λ_i = is the radiological decay constant of radionuclide (I), in hr^{-1}.

t_p = is the average transit time required for radionuclides to reach the point of exposure, in hours. (Table 17)

t_b = is the period of time for which sediment or soil is exposed to the contaminated water, in hours. (Table 17)

110,000 = Constant [(100 * pCi * yr * ft^3)/(Ci * sec * L)]

3.2 Airborne Effluent Dose Calculations

3.2.1 Noble Gas

10 CFR Part 50, Appendix I, restricts the dose to individuals in the unrestricted areas from noble gases in airborne effluents from the Fort Calhoun Station to the following limits:

- During any calendar quarter
  ≤ 5 mrad-gamma air dose
  ≤ 10 mrad-beta air dose

and

- During any calendar year
  ≤ 10 mrad-gamma air dose
  ≤ 20 mrad-beta air dose

The following general equations shall be used to calculate the gamma-air and beta-air doses:

A. Doses from Noble Gases

1. Annual Gamma/Beta Air Dose from All Other Noble Gas Releases

$$D^{\gamma}\ (r,\theta) or\ D^{\beta}\ (r,\theta) = 3.17\ x\ 10^4 \sum_{i=1}^{n} Q_i[\chi/Q]^D\ (r,\theta)(DF_i^{\gamma}\ or\ DF_i^{\beta})$$

Where:

DF_i^{γ} or DF_i^{β}	=	are the gamma and beta air dose factors for a uniform semi-infinite cloud of radionuclide (I), in mrad-m^3/pCi-yr. (Table 2)
$D^{\gamma}(r,\theta)$ or $D^{\beta}(r,\theta)$	=	are the annual gamma and beta air doses at distance r, in the sector at angle σ, from the discharge point, in mrad/yr.
Q_i	=	is the annual release rate of radionuclide (I), in Ci/yr.
$[\chi/Q]^D(r,\theta)$	=	is the annual average gaseous dispersion factor at distance r, in the sector at angle θ, in sec/m^3. (Table 4)
$3.17x10^4$	=	is the number of pCi per Ci divided by the number of seconds per year.

3.2.1A (continued)

2. Annual Total Body Dose from All Other Noble Gas Releases

$$D_{\infty}^{T}\,(r,\theta) = \; S_f \sum_{i=1}^{n} X_i\,(r,\theta) DFB_i$$

Where:

DFB_i	=	is the total body dose factor for a semi-infinite cloud of the radionuclide (I), which includes the attenuation of 5 g/cm^2 of tissue, in mrem-m^3/pCi-yr. (Table 2)
$D^{T}_{4}\,(r,\theta)$	=	is the annual total body dose due to immersion in a semi-infinite cloud at distance r, in the sector at angle θ, in mrem/yr.
$\chi_i(r,\theta)$	=	is the annual average ground-level concentration of radionuclide (I) at distance r, in the sector at angle θ, in pCi/m^3. (Table 4)
S_f	=	Shielding Factor (Table 17)

3. Annual Skin Dose from All Other Noble Gas Releases

$$D_{\infty}^{T}\,(r,\theta) = \; 1.11\, S_f \sum_{i=1}^{n} X_i\,(r,\theta) DF_i^{\gamma} + \sum_{i=1}^{n} X_i\,(r,\theta) DFS_i$$

Where:

$D^{T}_{4}(r,\theta)$	=	is the annual skin dose due to immersion in a semi-infinite cloud at distance r, in the sector at angle θ, in mrem/yr.
DFS_i	=	is the beta skin dose factor for a semiinfinite cloud of radionuclide (I), in mrem-m^3/pCi-yr. (Table 2)
1.11	=	is the average ratio of tissue to air energy absorption coefficients.

3.2.2 Radioiodine, Tritium, and Particulates

10 CFR Part 50, Appendix I, restricts the dose to individuals in the unrestricted areas from radioactive materials in gaseous airborne from the Fort Calhoun Station to:

- During any calendar quarter
  ≤ 7.5 mrem to any organ

and

- During any calendar year
  ≤ 15 mrem to any organ

The dose to an individual from radioiodines, radioactive materials in particulate form, and radionuclides other than noble gases with half-lives greater than 8 days in airborne effluents released to unrestricted areas should be determined by the following expressions:

Radioiodine, Tritium, and Particulates (continued)

3.2.2 (continued)

i	**NOTE** In all cases, for releases of tritium, use the dispersion parameter for inhalation (χ/Q).	i

A. Annual Organ Dose from External Irradiation from Radioactivity Deposited on the Ground Plane

The ground plane concentration of radionuclide (I) at distance r, in the sector at angle θ, with respect to the release point, may be determined by:

$$C_i^G\,(r,\theta) = \frac{[1.0x10^{12}][\delta_i\,(r,\theta)Q_i]}{\lambda_i}\,[1-\exp(-\lambda_i t_b)]$$

Where:

C_i^G = is the ground plane concentration of the radionuclide (I) at distance r, in the sector at angle θ, from the release point, in pCi/m^2.

Q_i = is the annual release rate of radionuclide (I) to the atmosphere, in Ci/yr.

t_b = is the time period over which the accumulation is evaluated, which is assumed to be 20 years (mid-point of plant operating life). (Table 17)

δi(r,θ) = is the annual average relative deposition of radionuclide (I) at distance r, in the sector at angle θ, considering depletion of the plume by deposition during transport, in m-2. Table 4

λ i = is the radiological decay constant for radionuclide (I), in yr-1.

$1.0x10^{12}$ = is the number of pCi/Ci

3.2.2A (continued)

The annual organ dose is then calculated using the following equation:

$$D_i^G\ (r,\theta) = 8760\ S_f \sum_{i=1}^{n} C_i^G\ (r,\theta) DFG_{ij}$$

Where:

$C_i^G(r,\theta)$ = is the ground plane concentration of radionuclide (i) at distance r, in the sector at angle θ, in pCi/m^2.

DFG_{ij} = is the open field ground plane dose conversion factor for organ (j) from radionuclide (i), in mrem-m^2/pCi-hr. (Table 8)

$D_j^G(r,\theta)$ = is the annual dose to the organ (j) at distance r, in the sector at angle θ, in mrem/yr.

S_f = is the shielding factor that accounts for the dose reduction due to shielding provided by residential structures during occupancy, dimensionless. (Table 17)

8760 = is the number of hours in a year

B. Annual Dose from Inhalation of Radionuclides in Air

The annual average airborne concentration of radionuclide (i) at distance r, in the sector at angle θ, with respect to the release point, may be determined as:

$$X_i\ (r,\theta) = 3.17\ x\ 10^4\ Q_i\ [\chi/Q]^D\ (r,\theta)$$

Where:

Q_i = is the annual release rate of radionuclide (i) to the atmosphere, in Ci/yr.

$\chi_i(r,\theta)$ = is the annual average ground-level concentration of radionuclide (i) in air at distance r, in the sector at angle θ, in pCi/m^3.

$[\chi/Q]^D\ (r,\theta)$ = is the annual average atmosphere dispersion factor, in sec/m^3 (see Reg Guide 1.111). This includes depletion (for radioiodines and particulates) and radiological decay of the plume. (Table 4)

$3.17x10^4$ = is the number of pCi/Ci divided by the number of sec/yr.

3.2.2B (continued)

The annual dose associated with inhalation of all radionuclides to organ (j) of an individual in age group (a), is then:

$$D_{ja}^{A}\,(r,\theta) = R_a \sum_{i=1}^{n} X_i\,(r,\theta) DFA_{ija}$$

Where:

$D_{ja}^{A}(r,\theta)$ = is the annual dose to organ (j) of an individual in the age group (a) at distance r, in the sector at angle θ, due to inhalation, in mrem/yr.

R_a = is the annual air intake for individuals in the age group (a), in m^3/yr. (Table 6)

DFA_{ija} = is the inhalation dose factor for radionuclide (i), organ (j), and age group (a), in mrem/pCi. (Tables 9-12)

3.2.3 Concentrations of Radionuclides in Foods and Vegetation from Atmospheric Releases

A. Parameters for Calculating Concentrations in Forage, Produce, and Leafy Vegetables, excluding Tritium

$$C_i^V\,(r,\theta) = d_i\,(r,\theta)\left[\frac{r[1-\exp(-\lambda_{Ei}t_e)]}{Y_v\lambda_{Ei}} + \frac{B_{iv}[1-\exp(-\lambda_i t_b)]}{P\lambda_i}\right]\exp(-\lambda_i t_h)$$

Where:

$C_i^V(r,\theta)$ = is the concentration of radionuclide (i) in and on vegetation at distance r, in the sector at angle θ, in pCi/kg.

$d_i\,(r,\theta)$ = is the deposition rate of radionuclide (i) at distance r, in the sector at angle θ, in pCi/m^2 hr.

3.2.3A (continued)

The deposition rate from the plume is defined by (Reg. Guide 1.109, Rev. 1, Page 1.109-26, Equa. C-6):

$$d_i\ (r,\theta) = 1.1\ x\ 10^8\ \delta_i\ (r,\theta) Q_i$$

Where:

$d_i(r,\theta)$ = is the deposition rate of radionuclide (i).

$\delta_i(r,\theta)$ = is the relative deposition of radionuclide (i), considering depletion and decay, in m^{-2} (see Reg Guide 1.111). (Table 4)

$1.1x10^8$ = is the number of pCi/Ci (10^{12}) divided by the number of hours per year (8760).

Q_i = is the annual release rate of radionuclide (i) to the atmosphere, in Ci/yr.

3.2.3 (continued)

B. For radioiodines, the model considers only the elemental fraction of the effluent:

$$d_i\ (r,\theta) = 3.3\ x\ 10^7\ \delta_i\ (r,\theta)Q_i$$

Where:

d_i (r, θ)	=	The deposition rate of radioiodine (i).
3.3 x 10^7	=	The number of pCi/Ci (1012) divided by the number of hours per year (8760), then multiplied by the amount of radioiodine emissions considered to be elemental (0.5).
δi (r, θ)	=	The relative deposition of radioiodine (i), considering depletion and decay, in m-2. (Table 4)
Qi	=	The total (elemental and nonelemental) radioiodine (i) emission rate.
r	=	is the fraction of deposited activity retained on crops, dimensionless. (Table 17)
λEi	=	is the effective removal rate constant for radionuclide (i) from crops, in hr-1. $\lambda_{Ei} = \lambda_i + \lambda_w$ λ_w = 0.0021/hr. (Table 17)
te	=	is the time period that crops are exposed to contamination during the growing season, in hours. (Table 17)
Yv	=	is the agricultural productivity (yield) in kg (wet weight)/m2. (Table 17)
Biv	=	is the concentration factor for uptake of radionuclide (i) from soil by edible parts of crops, in pCi/ kg (wet weight) per pCi/kg dry soil. (Table 5)
λi	=	is the radiological decay constant of radionuclide (I), in hr-1
t_b	=	is the period of time for which sediment or soil is exposed to the contaminated water, in hours (mid-point of plant life). (Table 17)
P	=	is the effective "surface density" for soil, in kg (dry soil)/m2. (Table 17)
t_h	=	is the holdup time that represents the time interval between harvest and consumption of the food, in hours. (Table 17)

Different values for the parameters te, Yv, and th, may be used to allow the use of the Equation for different purposes: estimating concentrations in produce consumed by man; in leafy vegetables consumed by man; in forage consumed directly as pasture grass by dairy cows, beef cattle, or goats; and in forage consumed as stored feed by dairy cows, beef cattle or goats. See Table 17.

3.2.3 (continued)

C. Parameters for Calculating the Concentration of Radionuclide (i) in the Animal's Feed (Milk Cow, Beef Cow, and Goat)

$$C_i^V\ (r,\theta) = f_p\, f_S\, C_i^P\ (r,\theta) + \left(1 - f_p\right) C_i^S\ (r,\theta) + f_p\ (1 - f_S) C_i^S\ (r,\theta)$$

Where:

$C_i^V(r,\theta)$ = is the concentration of radionuclide (i) in the animal's feed, in pCi/kg.

$C_i^P(r,\theta)$ = is the concentration of radionuclide (i) on pasture grass (calculated using Equation 3.2.3C with t_h=0), in pCi/kg.

$C_i^S(r,\theta)$ = is the concentration of radionuclide (i) in stored feeds (calculated using Equation 3.2.3C with t_h=90 days), in pCi/kg.

f_p = is the fraction of the year that animals graze on pasture. (Table 17)

f_s = is the fraction of daily feed that is pasture grass while the animal grazes on pasture. (Table 17)

3.2.4 Parameters for Calculating Radionuclide Concentration in Cow and Goat Milk

$$C_i^M\ (r,\theta) = F_m\ C_i^V\ (r,\theta) Q_F \exp(-\lambda_i t_f)$$

Where:

$C_i^M(r,\theta)$ = is the concentration of radionuclide (i) in milk, in pCi/liter.

$C_i^V(r,\theta)$ = is the concentration of radionuclide (i) in the animal's feed, in pCi/kg.

F_m = is the average fraction of the animal's daily intake of radionuclide (i) which appears in each liter of milk, in days/liter. (Table 5)

Q_F = is the amount of feed consumed by the animal per day, in kg/day. (Table 7)

t_f = is the average transport time of the radionuclide (i) from the feed to the milk and to the receptor (a value of 2 days is assumed). (Table 17)

λ_i = is the radiological decay constant of radionuclide (i), in days^{-1}.

3.2.5 Parameters for Calculating Radionuclide Concentration in Cow Meat, excluding Tritium

$$C_i^F\ (r,\theta) = \ F_f\ C_i^V\ (r,\theta) Q_F \exp(-\lambda_i\ t_f)$$

Where:

C^F_i (r,θ) = is the concentration of radionuclide (i) in meat, in pCi/liter.

F_f = is the average fraction of the animal's daily intake of radionuclide (i) which appears in each kilogram of flesh, in days/kilogram. (Table 5)

t_s = is the average time from slaughter to consumption. (Table 17)

3.2.6 Parameters for Calculating Tritium Concentrations in Vegetation

The concentration of tritium in vegetation is calculated from its concentration in the air surrounding the vegetation.

$$C_T^V\ (r,\theta) = 3.17\ x\ 10^7\ Q_T\ \frac{[\chi/Q](r,\theta)(0.75)(0.5)}{H} = 1.2\ x\ 10^7\ Q_T\ \frac{[\chi/Q](r,\theta)}{H}$$

Where:

C^V_T(r, θ) = is the concentration of tritium in vegetation grown at distance r, in the sector at angle θ, in pCi/kg.

H = is the absolute humidity of the atmosphere at distance r, in the sector at angle θ, in g/m^3. H=8 gm/kg.

Q_T = is the annual release rate of tritium, in Ci/yr.

[χ/Q](r,θ) = is the atmospheric dispersion factor, in sec/m^3. (Table 4)

0.5 = is the ratio of tritium concentration in plant water to tritium concentration in atmospheric water, dimensionless.

0.75 = is the fraction of total plant mass that is water, dimensionless.

3.2.7 Annual Dose from Atmospherically Released Radionuclides in Foods

A. The total annual dose to organ (j) of an individual in age group (a) resulting from ingestion of all radionuclides in produce, milk, and leafy vegetables is given by:

$$D_{ja}^{D}\,(r,\theta) = \sum_{i} DFI_{ija}\,[U_{a}^{V}\,f_{g}\,C_{i}^{V}\,(r,\theta) + \,U_{a}^{M}\,C_{i}^{M}\,(r,\theta) + \,U_{a}^{F}\,C_{i}^{F}\,(r,\theta) + \,U_{a}^{L}\,f_{\ell}C_{i}^{L}\,(r,\theta)]$$

Where:

$D_{ja}^{D}(r,\theta)$ = is the annual dose to organ (j) of an individual in age group (a) from dietary intake of atmospherically released radionuclides, in mrem/yr.

DFI_{ija} = is the dose conversion factor for the ingestion of radionuclide (i), organ (j), and age group (a), in mrem/pCi. Tables 13-16.

U_{a}^{V},U_{a}^{M} = are the ingestion rates of produce (non-leafy vegetables, fruits, and grains); milk, meat, and leafy U_{a}^{F},U_{a}^{L} vegetables, respectively for individuals in age group (a). (Table 6)

f_g = Fraction of ingested produce grown in garden of interest (Table 17)

f_ℓ = Fraction of leafy vegetables grown in garden of interest (Table 17)

3.2.7 (continued)

B. Calculating the Ingested Dose from Leafy and Non-Leafy (produce) Vegetation for Radionuclide (i) to Each Organ (j) and Age Group (a)

$$D_{ja}^{D}\,(r,\theta) = \,DFI_{ja}\,[U_{a}^{L}\,f_{\ell}\,C_{i}^{L}\,(r,\theta) + \,U_{a}^{V}\,f_{g}\,C_{i}^{V}\,(r,\theta)]$$

Where:

$D_{ja}^{D}(r,\theta)$ = is the annual dose from the ingestion of radionuclide (i) to organ (j) of an individual in age group (a) from dietary intake of atmospherically released radionuclides in vegetation, in mrem/yr.

DFI_{ija} = is the dose conversion factor for the ingestion of radionuclide (i), organ (j), and age group (a), in mrem/pci. Tables 13-16

U^L_a, U^V_a = are the ingestion rates of leafy vegetables and produce (non-leafy vegetables, fruits, and grains), for individuals in age group (a), in kg/yr. (Table 6)

C^L_i = is the concentration of radionuclide (i) in and on leafy vegetation, in pCi/kg.

C^V_i = is the concentration of radionuclide (i) in and on produce, in pCi/kg.

C. Calculation Determining the Ingested Dose from Cow Milk for Radionuclide (i), Organ (j), and Age Group (a)

$$D^D_{ja}\,(r,\theta) = DFI_{ija}\,[U^M_a\; C^M_i\;(r,\theta)]$$

Where:

$D^D_{ja}(r,\theta)$ = is the annual dose from the ingestion of radionuclide (i), organ (j) of an individual in age group (a) from dietary intake of atmospherically released radionuclides in cow milk, in mrem/yr.

DFI_{ija} = is the dose conversion factor for the ingestion of radionuclide (i), organ (j), and age group (a), in mrem/pCi. (Tables 13-16)

U^M_a = is the ingestion rate of cow milk for individuals in age group (a), in ℓ/yr. (Table 6)

C^M_i = is the radionuclide concentration in cow milk, in pCi/kg. Equation 3.2.4

3.2.7 (continued)

D. Calculation Determining the Ingested Dose from Meat for Radionuclide (i) to Organ (j) and Age Group (a)

$$D^D_{ja}\,(r,\theta) = DFI_{ija}\,[U^F_a\; C^F_i\;(r,\theta)]$$

Where:

$D^{D}_{ja}(r,\theta)$ = is the annual dose from the ingestion of radionuclide (i), organ (j) of an individual in age group (a) from dietary intake of atmospherically released radionuclides in meat, in mrem/yr.

DFI_{ija} = is the dose conversion factor for the ingestion of radionuclide (i), organ (j), and age group (a), in mrem/pCi. (Tables 13-16)

U^{F}_{a} = is the ingestion rate of meat for individuals in age group (a), in kg/yr. (Table 6)

C^{F}_{i} = is the radionuclide (i) concentration in meat, in pCi/kg.

3.2.8 Annual Dose from Carbon 14

A. This is a calculated value based on power generation and days of operation. Critical organ doses from C-14 were calculated using a ratio of 15% as CO_2. This ratio was determined during an NRC in-plant source term study conducted at the Fort Calhoun Station between 1976 and 1977, NUREG/CR-0140.

4.0 LOWER LIMIT OF DETECTION (LLD)

4.1 The lower limit of detection (LLD) for liquid and airborne effluent discharges and environmental samples referenced in Part I, Tables 4.1, 4.2 and 5.3, of the Off-Site Dose Calculation Manual, is defined as the smallest concentration of radioactive material in a sample that will yield a net count, above system background, that will be detected with 95 percent probability with only 5 percent probability of falsely concluding that a blank observation represents a "real" signal.

4.2 For a particular measurement system, which may include radiochemical separation:

$$LLD = \frac{4.66 * S_b}{E * V * D * Y * \exp(-\lambda \Delta t)}$$

Where:

LLD = the lower limit of detection as defined above, in either picoCuries or microCuries, per unit mass or volume as a function of the value of D

S_b = the standard deviation of the background counting rate or of the counting rate of a blank sample, as appropriate, as counts per minute

E = the counting efficiency, as counts per disintegration

V = the sample size in units of mass or volume

D = 2.22E+06 of disintegrations per minute per microCurie or 2.22 disintegrations per minute per picoCurie

Y = the fractional radiochemical yield, when applicable

λ = the radioactive decay constant for the particular radionuclide

Δt = the elapsed time between the midpoint of sample collection and time of counting

Appropriate values of E, V, Y, and Δt should be used in the calculation.

4.3 It should be recognized that the LLD is defined as an A Priori limit representing the capability of a measurement system and not as a limit for a particular measurement.

4.4 LLD verifications will be performed on a periodic basis. This determination is to ensure that the counting system is able to detect levels of radiation at the LLD values for the specific type of analysis required. They will be performed with a blank (non-radioactive) sample in the same counting geometry as the actual sample.

Table 2 - Dose Factors for Exposure to a Semi-Infinite Cloud of Noble Gases

Nuclide	β-Air[1] (Df^{β}_i)	β-Skin[2] (DFSi)	γ-Air[1] (Df^{γ}_i)	γ-Body[2] (DFB_i)
Kr-83m	2.88E-04	---	1.93E-05	7.56E-08
Kr-85m	1.97E-03	1.46E-03	1.23E-03	1.17E-03
Kr-85	1.95E-03	1.34E-03	1.72E-05	1.61E-05
Kr-87	1.03E-02	9.73E-03	6.17E-03	5.92E-03
Kr-88	2.93E-03	2.37E-03	1.52E-02	1.47E-02
Kr-89	1.06E-02	1.01E-02	1.73E-02	1.66E-02
Kr-90	7.83E-03	7.29E-03	1.63E-02	1.56E-02
Xe-131m	1.11E-03	4.67E-04	1.56E-04	9.15E-05
Xe-133m	1.48E-03	9.94E-04	3.27E-04	2.51E-04
Xe-133	1.05E-03	3.06E-04	3.53E-04	2.94E-04
Xe-135m	7.39E-04	7.11E-04	3.36E-03	3.12E-03
Xe-135	2.46E-03	1.86E-03	1.92E-03	1.81E-03
Xe-137	1.27E-02	1.22E-02	1.51E-03	1.42E-03
Xe-138	4.75E-03	4.13E-03	9.21E-03	8.83E-03
Ar-41	3.28E-03	2.69E-03	9.30E-03	8.84E-03

1. $\frac{mrad - m^3}{pCi - yr}$

2. $\frac{mrem - m^3}{pCi - r}$

3. $2.88E - 04 = 2.88\ x\ 10^{-4}$

Table 3 - Bioaccumulation Factors
(pCi/kg per pCi/liter)

FRESHWATER

Element	Fish	Invertebrate
H	9.0E-01	9.0E-01
C	4.6E+03	9.1E+03
Na	1.0E+02	2.0E+02
P	1.0E+05	2.0E+04
Cr	2.0E+02	2.0E+03
Mn	4.0E+02	9.0E+04
Fe	1.0E+02	3.2E+03
Co	5.0E+01	2.0E+02
Ni	1.0E+02	1.0E+02
Cu	5.0E+01	4.0E+02
Zn	2.0E+03	1.0E+04
Br	4.2E+02	3.3E+02
Rb	2.0E+03	1.0E+03
Sr	3.0E+01	1.0E+02
Y	2.5E+01	1.0E+03
Zr	3.3E+00	6.7E+00
Nb	3.0E+04	1.0E+02
Mo	1.0E+01	1.0E+01
Tc	1.5E+01	5.0E+00
Ru	1.0E+01	3.0E+02
Rh	1.0E+01	3.0E+02
Te	4.0E+02	6.1E+03
I	1.5E+01	5.0E+00
Cs	2.0E+03	1.0E+03
Ba	4.0E+00	2.0E+02
La	2.5E+01	1.0E+03
Ce	1.0E+00	1.0E+03
Pr	2.5E+01	1.0E+03
Nd	2.5E+01	1.0E+03
W	1.2E+03	1.0E+01
Np	1.0E+01	4.0E+02

Table 4 - Highest Potential Exposure Pathways for Estimating Dose

i	**NOTE** The Annual Radiological Effluent Report uses the highest calculated value from real time meteorological data obtained for the entire year for calculating dose.	i

Exposure Pathway	Location [B]	Direction [B]	Distance from Containment (miles) [B]	X/Q [A] {$\chi/Q\ (r,\theta)$} (sec/m^3)	D/Q [A] {$\delta\ (r,\theta)$} (m^{-2})
Direct Exposure	Site Boundary	SSE	0.60	1.30E-05	N/A
Inhalation	Site Boundary	SSE	0.60	1.30E-05	N/A
Ingestion	Residence	SSE	0.60	N/A	7.6E-08

A. These values are used for calculating quarterly dose estimates during the annual reporting period and are based on a 2 year average, updated only upon a +10% change from the previous value. At least ten percent (10%) should be added to these values for dose estimates during the reporting periods.

B. The location is subject to change based on an annual evaluation and is utilized only for ingestion exposure pathway dose estimates. This location may differ from the highest ingestion exposure pathway for offsite air monitoring locations as determined by the Land Use Survey performed biennially in accordance with Part 1, Section 7.3.2, of the Off-Site Dose Calculation Manual.

Table 5 - Stable Element Transfer Data

Element	B_{iv} Veg./Soil	F_m (cow) Milk (d/l)	F_f Meat (d/kg)
H	4.8E+00	1.0E-02	1.2E-02
C	5.5E+00	1.2E-02	3.1E-02
Na	5.2E-02	4.0E-02	3.0E-02
P	1.1E+00	2.5E-02	4.6E-02
Cr	2.5E-04	2.2E-03	2.4E-03
Mn	2.9E-02	2.5E-04	8.0E-04
Fe	6.6E-04	1.2E-03	4.0E-02
Co	9.4E-03	1.0E-03	1.3E-02
Ni	1.9E-02	6.7E-03	5.3E-02
Cu	1.2E-01	1.4E-02	8.0E-03
Zn	4.0E-01	3.9E-02	3.0E-02
Rb	1.3E-01	3.0E-02	3.1E-02
Sr	1.7E-02	8.0E-04	6.0E-04
Y	2.6E-03	1.0E-05	4.6E-03
Zr	1.7E-04	5.0E-06	3.4E-02
Nb	9.4E-03	2.5E-03	2.8E-01
Mo	1.2E-01	7.5E-03	8.0E-03
Tc	2.5E-01	2.5E-02	4.0E-01
Ru	5.0E-02	1.0E-06	4.0E-01
Rh	1.3E+1	1.0E-02	1.5E-03
Ag	1.5E-01	5.0E-02	1.7E-02
Te	1.3E+00	1.0E-03	7.7E-02
I	2.0E-02	6.0E-03	2.9E-03
Cs	1.0E-02	1.2E-02	4.0E-03
Ba	5.0E-03	4.0E-04	3.2E-03
La	2.5E-03	5.0E-06	2.0E-04
Ce	2.5E-03	1.0E-04	1.2E-03
Pr	2.5E-03	5.0E-06	4.7E-03
Nd	2.4E-03	5.0E-06	3.3E-03
W	1.8E-02	5.0E-04	1.3E-03
Np	2.5E-03	5.0E-06	2.0E-04

Table 6 - Recommended Values for U_{ap} to Be Used for the Maximum Exposed Individual in Lieu of Site Specific Data

Pathway	**Infant**	**Child**	**Teen**	**Adult**
Fruits, vegetables, & grain (kg/yr)	---	520	630	520
Leafy vegetables (kg/yr)	---	26	42	64
Milk (P/yr)	330	330	400	310
Meat & poultry (kg/yr)	---	41	65	110
Fish (fresh or salt)(kg/yr)	---	6.9	16	21
Other Seafood (kg/yr)	---	1.7	3.8	5
Drinking water (P/yr)	330	510	510	730
Shoreline recreation (hr/yr)	---	14	67	12
Inhalation (m^3/yr)	1400	3700	8000	8000

Table 7 - Animal Consumption Rates

Animal	**Q_F Feed or Forage [Kg/day (wet weigh)]**	**Q_{AW} Water (ℓ/day)**
Milk Cow	50	60
Beef Cattle	50	50
Goats	6	8

Table 8 - External Dose Factors for Standing on Contaminated Ground
(mrem/hr per pCi/m^2)

Element	**Total Body**	**Skin**
H-3	---	---
C-14	---	---
Na-24	2.50E-08	2.90E-08
P-32	---	---
Cr-51	2.20E-10	2.60E-10
Mn-54	5.80E-09	6.80E-09
Mn-56	1.10E-08	1.30E-08
Fe-55	---	---
Fe-59	8.00E-09	9.40E-09
Co-58	7.00E-09	8.20E-09
Co-60	1.70E-08	2.00E-08
Ni-63	---	---
Nr-65	3.70E-09	4.30E-09
Cu-64	1.50E-09	1.70E-09
Zn-65	4.00E-09	4.60E-09
Zn-69	---	---
Br-83	6.40E-11	9.30E-11
Br-84	1.20E-08	1.40E-08
Br-85	---	---
Rb-86	6.30E-10	7.20E-10
Rb-88	3.50E-09	4.00E-09
Rb-89	1.50E-08	1.80E-08
Sr-89	5.60E-13	6.50E-13
Sr-91	7.10E-09	8.30E-09
Sr-92	9.00E-09	1.00E-08
Y-90	2.20E-12	2.60E-12
Y-91M	3.80E-09	4.40E-09
Y-91	2.40E-11	2.70E-11
Y-92	1.60E-09	1.90E-09
Y-93	5.70E-10	7.80E-10
Zr-95	5.00E-09	5.80E-09
Zr-97	5.50E-09	6.40E-09
Nb-95	5.10E-09	6.00E-09
Mo-99	1.90E-09	2.20E-09
Tc-99M	9.60E-10	1.10E-09
Tc-101	2.70E-09	3.00E-09
Ru-103	3.60E-09	4.20E-09

Table 8 - External Dose Factors for Standing on Contaminated Ground
(mrem/hr per pCi/m^2)

Element	Total Body	Skin
Ru-105	4.50E-09	5.10E-09
Ru-106	1.50E-09	1.80E-09
Ag-110M	1.80E-08	2.10E-08
Te-125M	3.50E-11	4.80E-11
Te-127M	1.10E-12	1.30E-12
Te-127	1.00E-11	1.10E-11
Te-129M	7.70E-10	9.00E-10
Te-129	7.10E-10	8.40E-10
Te-131M	8.40E-09	9.90E-09
Te-131	2.20E-09	2.60E-06
Te-132	1.70E-09	2.00E-09
I-130	1.40E-08	1.70E-08
I-131	2.80E-09	3.40E-09
I-132	1.70E-08	2.00E-08
I-133	3.70E-09	4.50E-09
I-134	1.60E-08	1.90E-08
I-135	1.20E-08	1.40E-08
Cs-134	1.20E-08	1.40E-08
Cs-136	1.50E-08	1.70E-08
Cs-137	4.20E-09	4.90E-09
Cs-138	2.10E-08	2.40E-08
Ba-139	2.40E-09	2.70E-09
Ba-140	2.10E-09	2.40E-09
Ba-141	4.30E-09	4.90E-09
Ba-142	7.90E-09	9.00E-09
La-140	1.50E-08	1.70E-08
La-142	1.50E-08	1.80E-08
Ce-141	5.50E-10	6.20E-10
Ce-143	2.20E-09	2.50E-09
Ce-144	3.20E-10	3.70E-10
Pr-143	---	---
Pr-144	2.00E-10	2.30E-10
Nd-147	1.00E-09	1.20E-09
W-187	3.10E-09	3.60E-09
Np-239	9.50E-10	1.10E-09

Table 9 - Inhalation Dose Factors for Adult
(mrem per pCi Inhaled)

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	---	8.98E-08	8.98E-08	8.98E-08	8.98E-08	8.98E-08	8.98E-08
C-14	2.27E-06	4.26E-07	4.26E-07	4.26E-07	4.26E-07	4.26E-07	4.26E-07
Na-24	1.28E-06	1.28E-06	1.28E-06	1.28E-06	1.28E-06	1.28E-06	1.28E-06
P-32	1.65E-04	9.64E-06	6.26E-06	---	---	---	1.08E-05
Cr-51	---	---	1.25E-08	7.44E-09	2.85E-09	1.80E-06	4.15E-07
Mn-54	---	4.95E-06	7.87E-07	---	1.23E-06	1.75E-04	9.67E-06
Mn-56	---	1.55E-10	2.29E-11	---	1.63E-10	1.18E-06	2.53E-06
Fe-55	3.07E-06	2.12E-06	4.93E-07	---	---	9.01E-06	7.54E-07
Fe-59	1.47E-06	3.47E-06	1.32E-06	---	---	1.27E-04	2.35E-05
Co-58	---	1.98E-07	2.59E-07	---	---	1.16E-04	1.33E-05
Co-60	---	1.44E-06	1.85E-06	---	---	7.46E-04	3.56E-05
Ni-63	5.40E-05	3.93E-06	1.81E-06	---	---	2.23E-05	1.67E-06
Ni-65	1.92E-10	2.62E-11	1.14E-11	---	---	7.00E-07	1.54E-06
Cu-64	---	1.83E-10	7.69E-11	---	5.78E-10	8.48E-07	6.12E-06
Zn-65	4.05E-06	1.29E-05	5.82E-06	---	8.62E-06	1.08E-04	6.68E-06
Zn-69	4.23E-12	8.14E-12	5.65E-13	---	5.27E-12	1.15E-07	2.04E-09
Br-83	---	---	3.01E-08	---	---	---	2.90E-08
Br-84	---	---	3.91E-08	---	---	---	2.05E-13
Br-85	---	---	1.60E-09	---	---	---	---
Rb-86	---	1.69E-05	7.37E-06	---	---	---	2.08E-06
Rb-88	---	4.84E-08	2.41E-08	---	---	---	4.18E-19
Rb-89	---	3.20E-08	2.12E-08	---	---	---	1.16E-21
Sr-89	3.80E-05	---	1.09E-06	---	---	1.75E-04	4.37E-05
Sr-90	3.59E-03	---	7.21E-05	---	---	1.20E-03	9.02E-05
Sr-91	7.74E-09	---	3.13E-10	---	---	4.56E-06	2.39E-05
Sr-92	8.43E-10	---	3.64E-11	---	---	2.06E-06	5.38E-06
Y-90	2.61E-07	---	7.01E-09	---	---	2.12E-05	6.32E-05
Y-91M	3.26E-11	---	1.27E-12	---	---	2.40E-07	1.66E-10
Y-91	5.78E-05	---	1.55E-06	---	---	2.13E-04	4.81E-05
Y-92	1.29E-09	---	3.77E-11	---	---	1.96E-06	9.19E-06
Y-93	1.18E-08	---	3.26E-10	---	---	6.06E-06	5.27E-05
Zr-95	1.34E-05	4.30E-06	2.91E-06	---	6.77E-06	2.21E-04	1.88E-05
Zr-97	1.21E-08	2.45E-09	1.13E-09	---	3.71E-09	9.84E-06	6.54E-05
Nb-95	1.76E-06	9.77E-07	5.26E-07	---	9.67E-07	6.31E-05	1.30E-05
Mo-99	---	1.51E-08	2.87E-09	---	3.64E-08	1.14E-05	3.10E-05
Tc-99M	1.29E-13	3.64E-13	4.63E-12	---	5.52E-12	9.55E-08	5.20E-07
Tc-101	5.22E-15	7.52E-15	7.38E-14	---	1.35E-13	4.99E-08	1.36E-21

Table 9 - Inhalation Dose Factors for Adult
(mrem per pCi Inhaled)

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
Ru-103	1.91E-07	---	8.23E-08	---	7.29E-07	6.31E-05	1.38E-05
Ru-105	9.88E-11	---	3.89E-11	---	1.27E-10	1.37E-06	6.02E-06
Ru-106	8.64E-06	---	1.09E-06	---	1.67E-05	1.17E-03	1.14E-04
Ag-110M	1.35E-06	1.25E-06	7.43E-07	---	2.46E-06	5.79E-04	3.78E-05
Te-125M	4.27E-07	1.98E-07	5.84E-08	1.31E-07	1.55E-06	3.92E-05	8.83E-06
Te-127M	1.58E-06	7.21E-07	1.96E-07	4.11E-07	5.72E-06	1.20E-04	1.87E-05
Te-127	1.75E-10	8.03E-11	3.87E-11	1.32E-10	6.37E-10	8.14E-07	7.17E-06
Te-129M	1.22E-06	5.84E-07	1.98E-07	4.30E-07	4.57E-06	1.45E-04	4.79E-05
Te-129	6.22E-12	2.99E-12	1.55E-12	4.87E-12	2.34E-11	2.42E-07	1.96E-08
Te-131M	8.74E-09	5.45E-09	3.63E-09	6.88E-09	3.86E-08	1.82E-05	6.95E-05
Te-131	1.39E-12	7.44E-13	4.49E-13	1.17E-12	5.46E-12	1.74E-07	2.30E-09
Te-132	3.25E-08	2.69E-08	2.02E-08	2.37E-08	1.82E-07	3.60E-05	6.37E-05
I-130	5.72E-07	1.68E-06	6.60E-07	1.42E-04	2.61E-06	---	9.61E-07
I-131	3.15E-06	4.47E-06	2.56E-06	1.49E-03	7.66E-06	---	7.85E-07
I-132	1.45E-07	4.07E-07	1.45E-07	1.43E-05	6.48E-07	---	5.08E-08
I-133	1.08E-06	1.85E-06	5.65E-07	2.69E-04	3.23E-06	---	1.11E-06
I-134	8.05E-08	2.16E-07	7.69E-08	3.73E-06	3.44E-07	---	1.26E-10
I-135	3.35E-07	8.73E-07	3.21E-07	5.60E-05	1.39E-06	---	6.56E-07
Cs-134	4.66E-05	1.06E-04	9.10E-05	---	3.59E-05	1.22E-05	1.30E-06
Cs-136	4.88E-06	1.83E-05	1.38E-05	---	1.07E-05	1.50E-06	1.46E-06
Cs-137	5.98E-05	7.76E-05	5.35E-05	---	2.78E-05	9.40E-06	1.05E-06
Cs-138	4.14E-08	7.76E-08	4.05E-08	---	6.00E-08	6.07E-09	2.33E-13
Ba-139	1.17E-10	8.32E-14	3.42E-12	---	7.78E-14	4.70E-07	1.12E-07
Ba-140	4.88E-06	6.13E-09	3.21E-07	---	2.09E-09	1.59E-04	2.73E-05
Ba-141	1.25E-11	9.41E-15	4.20E-13	---	8.75E-15	2.42E-07	1.45E-17
Ba-142	3.29E-12	3.38E-15	2.07E-13	---	2.86E-15	1.49E-07	1.96E-26
La-140	4.30E-08	2.17E-08	5.73E-09	---	---	1.70E-05	5.73E-05
La-142	8.54E-11	3.88E-11	9.65E-12	---	---	7.91E-07	2.64E-07
Ce-141	2.49E-06	1.69E-06	1.91E-07	---	7.83E-07	4.52E-05	1.50E-05
Ce-143	2.33E-08	1.72E-08	1.91E-09	---	7.60E-09	9.97E-06	2.83E-05
Ce-144	4.29E-04	1.79E-04	2.30E-05	---	1.06E-04	9.72E-04	1.02E-04
Pr-143	1.17E-06	4.69E-07	5.80E-08	---	2.70E-07	3.51E-05	2.50E-05
Pr-144	3.76E-12	1.56E-12	1.91E-13	---	8.81E-13	1.27E-07	2.69E-18
Nd-147	6.59E-07	7.62E-07	4.56E-08	---	4.45E-07	2.76E-05	2.16E-05
W-187	1.06E-09	8.85E-10	3.10E-10	---	---	3.63E-06	1.94E-05
Np-239	2.87E-08	2.54E-08	1.55E-09	---	8.75E-09	4.70E-06	1.49E-05

Table 10 - Inhalation Dose Factors for Teenager
(mrem per pCi Inhaled)

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	---	9.06E-08	9.06E-08	9.06E-08	9.06E-08	9.06E-08	9.06E-08
C-14	3.25E-06	6.09E-07	6.09E-07	6.09E-07	6.019E-07	6.09E-07	6.09E-07
Na-24	1.72E-06	1.72E-06	1.72E-06	1.72E-06	1.72E-06	1.72E-06	1.72E-06
P-32	2.36E-04	1.37E-05	8.95E-06	---	---	---	1.16E-05
Cr-51	---	---	1.69E-08	9.37E-09	3.84E-09	2.62E-06	3.75E-07
Mn-54	---	6.39E-06	1.05E-06	---	1.59E-06	2.48E-04	8.35E-06
Mn-56	---	2.12E-10	3.15E-11	---	2.24E-10	1.90E-06	7.18E-06
Fe-55	4.18E-06	2.98E-06	6.93E-07	---	---	1.55E-05	7.99E-07
Fe-59	1.99E-06	4.62E-06	1.79E-06	---	---	1.91E-04	2.23E-05
Co-58	---	2.59E-07	3.47E-07	---	---	1.68E-04	1.19E-05
Co-60	---	1.89E-06	2.48E-06	---	---	1.09E-03	3.24E-05
Ni-63	7.25E-05	5.43E-06	2.47E-06	---	---	3.84E-05	1.77E-06
Ni-65	2.73E-10	3.66E-11	1.59E-11	---	---	1.17E-06	4.59E-06
Cu-64	---	2.54E-10	1.06E-10	---	8.01E-10	1.39E-06	7.68E-06
Zn-65	4.82E-06	1.67E-05	7.80E-06	---	1.08E-05	1.55E-04	5.83E-06
Zn-69	6.04E-12	1.15E-11	8.07E-13	---	7.53E-12	1.98E-07	3.56E-08
Br-83	---	---	4.30E-08	---	---	---	---
Br-84	---	---	5.41E-08	---	---	---	---
Br-85	---	---	2.29E-09	---	---	---	---
Rb-86	---	2.38E-05	1.05E-05	---	---	---	2.21E-06
Rb-88	---	6.82E-08	3.40E-08	---	---	---	3.65E-15
Rb-89	---	4.40E-08	2.91E-08	---	---	---	4.22E-17
Sr-89	5.43E-05	---	1.56E-06	---	---	3.02E-04	4.64E-05
Sr-90	4.14E-03	---	8.33E-05	---	---	2.06E-03	9.56E-05
Sr-91	1.10E-08	---	4.39E-10	---	---	7.59E-06	3.24E-05
Sr-92	1.19E-09	---	5.08E-11	---	---	3.43E-06	1.49E-05
Y-90	3.73E-07	---	1.00E-08	---	---	3.66E-05	6.99E-05
Y-91M	4.63E-11	---	1.77E-12	---	---	4.00E-07	3.77E-09
Y-91	8.26E-05	---	2.21E-06	---	---	3.67E-04	5.11E-05
Y-92	1.84E-09	---	5.36E-11	---	---	3.35E-06	2.06E-05
Y-93	1.69E-08	---	4.65E-10	---	---	1.04E-05	7.24E-05
Zr-95	1.82E-05	5.73E-06	3.94E-06	---	8.42E-06	3.36E-04	1.86E-05
Zr-97	1.72E-08	3.40E-09	1.57E-09	---	5.15E-09	1.62E-05	7.88E-05
Nb-95	2.32E-06	1.29E-06	7.08E-07	---	1.25E-06	9.39E-05	1.21E-05
Mo-99	---	2.11E-08	4.03E-09	---	5.14E-08	1.92E-05	3.36E-05
Tc-99M	1.73E-13	4.83E-13	6.24E-12	---	7.20E-12	1.44E-07	7.66E-07
Tc-101	7.40E-15	1.05E-14	1.03E-13	---	1.90E-13	8.34E-08	1.09E-16

Table 10 - Inhalation Dose Factors for Teenager
(mrem per pCi Inhaled)

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
Ru-103	2.63E-07	---	1.12E-07	---	9.29E-07	9.79E-05	1.36E-05
Ru-105	1.40E-10	---	5.42E-11	---	1.76E-10	2.27E-06	1.13E-05
Ru-106	1.23E-05	---	1.55E-06	---	2.38E-05	2.01E-03	1.20E-04
Ag-110M	1.73E-06	1.64E-06	9.99E-07	---	3.13E-06	8.44E-04	3.41E-05
Te-125M	6.10E-07	2.80E-07	8.34E-08	1.75E-07	---	6.70E-05	9.38E-06
Te-127M	2.25E-06	1.02E-06	2.73E-07	5.48E-07	8.17E-06	2.07E-04	1.99E-05
Te-127	2.51E-10	1.14E-10	5.52E-11	1.77E-10	9.10E-10	1.40E-06	1.01E-05
Te-129M	1.74E-06	8.23E-07	2.81E-07	5.72E-07	6.49E-06	2.47E-04	5.06E-05
Te-129	8.87E-12	4.22E-12	2.20E-12	6.48E-12	3.32E-11	4.12E-07	2.02E-07
Te-131M	1.23E-08	7.51E-09	5.03E-09	9.06E-09	5.49E-08	2.97E-05	7.76E-05
Te-131	1.97E-12	1.04E-12	6.30E-13	1.55E-12	7.72E-12	2.92E-07	1.89E-09
Te-132	4.50E-08	3.63E-08	2.74E-08	3.07E-08	2.44E-07	5.61E-05	5.79E-05
I-130	7.80E-07	2.24E-06	8.96E-07	1.86E-04	3.44E-06	---	1.14E-06
I-131	4.43E-06	6.14E-06	3.30E-06	1.83E-03	1.05E-05	---	8.11E-07
I-132	1.99E-07	5.47E-07	1.97E-07	1.89E-05	8.65E-07	---	1.59E-07
I-133	1.52E-06	2.56E-06	7.78E-07	3.65E-04	4.49E-06	---	1.29E-06
I-134	1.11E-07	2.90E-07	1.05E-07	4.94E-06	4.58E-07	---	2.55E-09
I-135	4.62E-07	1.18E-06	4.36E-07	7.76E-05	1.86E-06	---	8.69E-07
Cs-134	6.28E-05	1.41E-04	6.86E-05	---	4.69E-05	1.83E-05	1.22E-06
Cs-136	6.44E-06	2.42E-05	1.71E-05	---	1.38E-05	2.22E-06	1.36E-06
Cs-137	8.38E-05	1.06E-04	3.89E-05	---	3.80E-05	1.51E-05	1.06E-06
Cs-138	5.82E-08	1.07E-07	5.58E-08	---	8.28E-08	9.84E-09	3.38E-11
Ba-139	1.67E-10	1.18E-13	4.87E-12	---	1.11E-13	8.08E-07	8.06E-07
Ba-140	6.84E-06	8.38E-09	4.40E-07	---	2.85E-09	2.54E-04	2.86E-05
Ba-141	1.78E-11	1.32E-14	5.93E-13	---	1.23E-14	4.11E-07	9.33E-14
Ba-142	4.62E-12	4.63E-15	2.84E-13	---	3.92E-15	2.39E-07	5.99E-20
La-140	5.99E-08	2.95E-08	7.82E-09	---	---	2.68E-05	6.09E-05
La-142	1.20E-10	5.31E-11	1.32E-11	---	---	1.27E-06	1.50E-06
Ce-141	3.55E-06	2.37E-06	2.71E-07	---	1.11E-06	7.67E-05	1.58E-05
Ce-143	3.32E-08	2.42E-08	2.70E-09	---	1.08E-08	1.63E-05	3.19E-05
Ce-144	6.11E-04	2.53E-04	3.28E-05	---	1.51E-04	1.67E-03	1.08E-04
Pr-143	1.67E-06	6.64E-07	8.28E-08	---	3.86E-07	6.04E-05	2.67E-05
Pr-144	5.37E-12	2.20E-12	2.72E-13	---	1.26E-12	2.19E-07	2.94E-14
Nd-147	9.83E-07	1.07E-06	6.41E-08	---	6.28E-07	4.65E-05	2.28E-05
W-187	1.50E-09	1.22E-09	4.29E-10	---	---	5.92E-06	2.21E-05
Np-239	4.23E-08	3.60E-08	2.21E-09	---	1.25E-08	8.11E-06	1.65E-05

Table 11 - Inhalation Dose Factors for Child
(mrem per pCi Inhaled)

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	---	1.73E-07	1.73E-07	1.73E-07	1.73E-07	1.73E-07	1.73E-07
C-14	9.70E-06	1.82E-06	1.82E-06	1.82E-06	1.82E-06	1.82E-06	1.82E-06
Na-24	4.35E-06	4.35E-06	4.35E-06	4.35E-06	4.35E-06	4.35E-06	4.35E-06
P-32	7.04E-04	3.09E-05	2.67E-05	---	---	---	1.14E-05
Cr-51	---	---	4.17E-08	2.31E-08	6.57E-09	4.59E-06	2.93E-07
Mn-54	---	1.16E-05	2.57E-06	---	2.71E-06	4.26E-04	6.19E-06
Mn-56	---	4.48E-10	8.43E-11	---	4.52E-10	3.55E-06	3.33E-05
Fe-55	1.28E-05	6.80E-06	2.10E-06	---	---	3.00E-05	7.75E-07
Fe-59	5.59E-06	9.04E-06	4.51E-06	---	---	3.43E-04	1.91E-05
Co-58	---	4.79E-07	8.55E-07	---	---	2.99E-04	9.29E-06
Co-60	---	3.55E-06	6.12E-06	---	---	1.91E-03	2.60E-05
Ni-63	2.22E-04	1.25E-05	7.56E-06	---	---	7.43E-05	1.71E-06
Ni-65	8.08E-10	7.99E-11	4.44E-11	---	---	2.21E-06	2.27E-05
Cu-64	---	5.39E-10	2.90E-10	---	1.63E-09	2.59E-06	9.92E-06
Zn-65	1.15E-05	3.06E-05	1.90E-05	---	1.93E-05	2.69E-04	4.41E-06
Zn-69	1.81E-11	2.61E-11	2.41E-12	---	1.58E-11	3.84E-07	2.75E-06
Br-83	---	---	1.28E-07	---	---	---	---
Br-84	---	---	1.48E-07	---	---	---	---
Br-85	---	---	6.84E-09	---	---	---	---
Rb-86	---	5.36E-05	3.09E-05	---	---	---	2.16E-06
Rb-88	---	1.52E-07	9.90E-08	---	---	---	4.66E-09
Rb-89	---	9.33E-08	7.85E-08	---	---	---	5.11E-10
Sr-89	1.62E-04	---	4.66E-06	---	---	5.83E-04	4.52E-05
Sr-90	1.04E-02	---	2.07E-04	---	---	3.99E-03	9.28E-05
Sr-91	3.28E-08	---	1.24E-09	---	---	1.44E-05	4.70E-05
Sr-92	3.54E-09	---	1.42E-10	---	---	6.49E-06	6.55E-05
Y-90	1.11E-06	---	2.99E-08	---	---	7.07E-05	7.24E-05
Y-91M	1.37E-10	---	4.98E-12	---	---	7.60E-07	4.64E-07
Y-91	2.47E-04	---	6.59E-06	---	---	7.10E-04	4.97E-05
Y-92	5.50E-09	---	1.57E-10	---	---	6.46E-06	6.46E-05
Y-93	5.04E-08	---	1.38E-09	---	---	2.01E-05	1.05E-04
Zr-95	5.13E-05	1.13E-05	1.00E-05	---	1.61E-05	6.03E-04	1.65E-05
Zr-97	5.07E-08	7.34E-09	4.32E-09	---	1.05E-08	3.06E-05	9.49E-05
Nb-95	6.35E-06	2.48E-06	1.77E-06	---	2.33E-06	1.66E-04	1.00E-05
Mo-99	---	4.66E-08	1.15E-08	---	1.06E-07	3.66E-05	3.42E-05
Tc-99M	4.81E-13	9.41E-13	1.56E-11	---	1.37E-11	2.57E-07	1.30E-06
Tc-101	2.19E-14	2.30E-14	2.91E-13	---	3.92E-13	1.58E-07	4.41E-09

Table 11 - Inhalation Dose Factors for Child
(mrem per pCi Inhaled)

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
Ru-103	7.55E-07	---	2.90E-07	---	1.90E-06	1.79E-04	1.21E-05
Ru-105	4.13E-10	---	1.50E-10	---	3.63E-10	4.30E-06	2.69E-05
Ru-106	3.68E-05	---	4.57E-06	---	4.97E-05	3.87E-03	1.16E-04
Ag-110M	4.56E-06	3.08E-06	2.47E-06	---	5.74E-06	1.48E-03	2.71E-05
Te-125M	1.82E-06	6.29E-07	2.47E-07	5.20E-07	---	1.29E-04	9.13E-06
Te-127M	6.72E-06	2.31E-06	8.16E-07	1.64E-06	1.72E-05	4.00E-04	1.93E-05
Te-127	7.49E-10	2.57E-10	1.65E-10	5.30E-10	1.91E-09	2.71E-06	1.52E-05
Te-129M	5.19E-06	1.85E-06	8.22E-07	1.71E-06	1.36E-05	4.76E-04	4.91E-05
Te-129	2.64E-11	9.45E-12	6.44E-12	1.93E-11	6.94E-11	7.93E-07	6.89E-06
Te-131M	3.63E-08	1.60E-08	1.37E-08	2.64E-08	1.08E-07	5.56E-05	8.32E-05
Te-131	5.87E-12	2.28E-12	1.78E-12	4.59E-12	1.59E-11	5.55E-07	3.60E-07
Te-132	1.30E-07	7.36E-08	7.12E-08	8.58E-08	4.79E-07	1.02E-04	3.72E-05
I-130	2.21E-06	4.43E-06	2.28E-06	4.99E-04	6.61E-06	---	1.38E-06
I-131	1.30E-05	1.30E-05	7.37E-06	4.39E-03	2.13E-05	---	7.68E-07
I-132	5.72E-07	1.10E-06	5.07E-07	5.23E-05	1.69E-06	---	8.65E-07
I-133	4.48E-06	5.49E-06	2.08E-06	1.04E-03	9.13E-06	---	1.48E-06
I-134	3.17E-07	5.84E-07	2.69E-07	1.37E-05	8.92E-07	---	2.58E-07
I-135	1.33E-06	2.36E-06	1.12E-06	2.14E-04	3.62E-06	---	1.20E-06
Cs-134	1.76E-04	2.74E-04	6.07E-05	---	8.93E-05	3.27E-05	1.04E-06
Cs-136	1.76E-05	4.62E-05	3.14E-05	---	2.58E-05	3.93E-06	1.13E-06
Cs-137	2.45E-04	2.23E-04	3.47E-05	---	7.63E-05	2.81E-05	9.78E-07
Cs-138	1.71E-07	2.27E-07	1.50E-07	---	1.68E-07	1.84E-08	7.29E-08
Ba-139	4.98E-10	2.66E-13	1.45E-11	---	2.33E-13	1.56E-06	1.56E-05
Ba-140	2.00E-05	1.75E-08	1.17E-06	---	5.71E-09	4.71E-04	2.75E-05
Ba-141	5.29E-11	2.95E-14	1.72E-12	---	2.56E-14	7.89E-07	7.44E-08
Ba-142	1.35E-11	9.73E-15	7.54E-13	---	7.87E-15	4.44E-07	7.41E-10
La-140	1.74E-07	6.08E-08	2.04E-08	---	---	4.94E-05	6.10E-05
La-142	3.50E-10	1.11E-10	3.49E-11	---	---	2.35E-06	2.05E-05
Ce-141	1.06E-05	5.28E-06	7.83E-07	---	2.31E-06	1.47E-04	1.53E-05
Ce-143	9.89E-08	5.37E-08	7.77E-09	---	2.26E-08	3.12E-05	3.44E-05
Ce-144	1.83E-03	5.72E-04	9.77E-05	---	3.17E-04	3.23E-03	1.05E-04
Pr-143	4.99E-06	1.50E-06	2.47E-07	---	8.11E-07	1.17E-04	2.63E-05
Pr-144	1.61E-11	4.99E-12	8.10E-13	---	2.64E-12	4.23E-07	5.32E-08
Nd-147	2.92E-06	2.36E-06	1.84E-07	---	1.30E-06	8.87E-05	2.22E-05
W-187	4.41E-09	2.61E-09	1.17E-09	---	---	1.11E-05	2.46E-05
Np-239	1.26E-07	8.14E-08	6.35E-09	---	2.63E-08	1.57E-05	1.73E-05

Table 12 - Inhalation Dose Factors for Infant
(mrem per pCi Inhaled)

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	---	2.63E-07	2.63E-07	2.63E-07	2.63E-07	2.63E-07	2.63E-07
C-14	1.89E-05	3.79E-06	3.79E-06	3.79E-06	3.79E-06	3.79E-06	3.79E-06
Na-24	7.54E-06	7.54E-06	7.54E-06	7.54E-06	7.54E-06	7.54E-06	7.54E-06
P-32	1.45E-03	8.03E-05	5.53E-05	---	---	---	1.15E-05
Cr-51	---	---	6.39E-08	4.11E-08	9.45E-09	9.17E-06	2.55E-07
Mn-54	---	1.81E-05	3.56E-06	---	3.56E-06	7.14E-04	5.04E-06
Mn-56	---	1.10E-09	1.58E-10	---	7.86E-10	8.95E-06	5.12E-05
Fe-55	1.41E-05	8.39E-06	2.38E-06	---	---	6.21E-05	7.82E-07
Fe-59	9.69E-06	1.68E-05	6.77E-06	---	---	7.25E-04	1.77E-05
Co-58	---	8.71E-07	1.30E-06	---	---	5.55E-04	7.95E-06
Co-60	---	5.73E-06	8.41E-06	---	---	3.22E-03	2.28E-05
Ni-63	2.42E-04	1.46E-05	8.29E-06	---	---	1.49E-04	1.73E-06
Ni-65	1.71E-09	2.03E-10	8.79E-11	---	---	5.80E-06	3.58E-05
Cu-64	---	1.34E-09	5.53E-10	---	2.84E-09	6.64E-06	1.07E-05
Zn-65	1.38E-05	4.47E-05	2.22E-05	---	2.32E-05	4.62E-04	3.67E-05
Zn-69	3.85E-11	6.91E-11	5.13E-12	---	2.87E-11	1.05E-06	9.44E-06
Br-83	---	---	2.72E-07	---	---	---	---
Br-84	---	---	2.86E-07	---	---	---	---
Br-85	---	---	1.46E-08	---	---	---	---
Rb-86	---	1.36E-04	6.30E-05	---	---	---	2.17E-06
Rb-88	---	3.98E-07	2.05E-07	---	---	---	2.42E-07
Rb-89	---	2.29E-07	1.47E-07	---	---	---	4.87E-08
Sr-89	2.84E-04	---	8.15E-06	---	---	1.45E-03	4.57E-05
Sr-90	1.11E-02	---	2.23E-04	---	---	8.03E-03	9.36E-05
Sr-91	6.83E-08	---	2.47E-09	---	---	3.76E-05	5.24E-05
Sr-92	7.50E-09	---	2.79E-10	---	---	1.70E-05	1.00E-04
Y-90	2.35E-06	---	6.30E-08	---	---	1.92E-04	7.43E-05
Y-91M	2.91E-10	---	9.90E-12	---	---	1.99E-06	1.68E-06
Y-91	4.20E-04	---	1.12E-05	---	---	1.75E-03	5.02E-05
Y-92	1.17E-08	---	3.29E-10	---	---	1.75E-05	9.04E-05
Y-93	1.07E-07	---	2.91E-09	---	---	5.46E-05	1.19E-04
Zr-95	8.24E-05	1.99E-05	1.45E-05	---	2.22E-05	1.25E-03	1.55E-05
Zr-97	1.07E-07	1.83E-08	8.36E-09	---	1.85E-08	7.88E-05	1.00E-04
Nb-95	1.12E-05	4.59E-06	2.70E-06	---	3.37E-06	3.42E-04	9.05E-06
Mo-99	---	1.18E-07	2.31E-08	---	1.89E-07	9.63E-05	3.48E-05
Tc-99M	9.98E-13	2.06E-12	2.66E-11	---	2.22E-11	5.79E-07	1.45E-06
Tc-101	4.65E-14	5.88E-14	5.80E-13	---	6.99E-13	4.17E-07	6.03E-07

Table 12 - Inhalation Dose Factors for Infant
(mrem per pCi Inhaled)

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
Ru-103	1.44E-06	---	4.85E-07	---	3.03E-06	3.94E-04	1.15E-05
Ru-105	8.74E-10	---	2.93E-10	---	6.42E-10	1.12E-05	3.46E-05
Ru-106	6.20E-05	---	7.77E-06	---	7.61E-05	8.26E-03	1.17E-04
Ag-110M	7.13E-06	5.16E-06	3.57E-06	---	7.80E-06	2.62E-03	2.36E-05
Te-125M	3.40E-06	1.42E-06	4.70E-07	1.16E-06	---	3.19E-04	9.22E-06
Te-127M	1.19E-05	4.93E-06	1.48E-06	3.48E-06	2.68E-05	9.37E-04	1.95E-05
Te-127	1.59E-09	6.81E-10	3.40E-10	1.32E-09	3.47E-09	7.39E-06	1.74E-05
Te-129M	1.01E-05	4.35E-06	1.59E-06	3.91E-06	2.27E-05	1.20E-03	4.93E-05
Te-129	5.63E-11	2.48E-11	1.34E-11	4.82E-11	1.25E-10	2.14E-06	1.88E-05
Te-131M	7.62E-08	3.93E-08	2.59E-08	6.38E-08	1.89E-07	1.42E-04	8.51E-05
Te-131	1.24E-11	5.87E-12	3.57E-12	1.13E-11	2.85E-11	1.47E-06	5.87E-06
Te-132	2.66E-07	1.69E-07	1.26E-07	1.99E-07	7.39E-07	2.43E-04	3.15E-05
I-130	4.54E-06	9.91E-06	3.98E-06	1.14E-03	1.09E-05	---	1.42E-06
I-131	2.71E-05	3.17E-05	1.40E-05	1.06E-02	3.70E-05	---	7.56E-07
I-132	1.21E-06	2.53E-06	8.99E-07	1.21E-04	2.82E-06	---	1.36E-06
I-133	9.46E-06	1.37E-05	4.00E-06	2.54E-03	1.60E-05	---	1.54E-06
I-134	6.58E-07	1.34E-06	4.75E-07	3.18E-05	1.49E-06	---	9.21E-07
I-135	2.76E-06	5.43E-06	1.98E-06	4.97E-04	6.05E-06	---	1.31E-06
Cs-134	2.83E-04	5.02E-04	5.32E-05	---	1.36E-04	5.69E-05	9.53E-07
Cs-136	3.45E-05	9.61E-05	3.78E-05	---	4.03E-05	8.40E-06	1.02E-06
Cs-137	3.92E-04	4.37E-04	3.25E-05	---	1.23E-04	5.09E-05	9.53E-07
Cs-138	3.61E-07	5.58E-07	2.84E-07	---	2.93E-07	4.67E-08	6.26E-07
Ba-139	119.06E-09	7.03E-13	3.07E-11	---	4.23E-13	4.25E-06	3.64E-05
Ba-140	4.00E-05	4.00E-08	2.07E-06	---	9.59E-09	1.14E-03	2.74E-05
Ba-141	1.12E-10	7.70E-14	3.55E-12	---	4.64E-14	2.12E-06	3.39E-06
Ba-142	2.84E-11	2.36E-14	1.40E-12	---	1.36E-14	1.11E-06	4.95E-07
La-140	3.61E-07	1.43E-07	3.68E-08	---	---	1.20E-04	6.06E-05
La-142	7.36E-10	2.69E-10	6.46E-11	---	---	5.87E-06	4.25E-05
Ce-141	1.98E-05	1.19E-05	1.42E-06	---	3.75E-06	3.69E-04	1.54E-05
Ce-143	2.09E-07	1.38E-07	1.58E-08	---	4.03E-08	8.30E-05	3.55E-05
Ce-144	2.28E-03	8.65E-04	1.26E-04	---	3.84E-04	7.03E-03	1.06E-04
Pr-143	1.00E-05	3.74E-06	4.99E-07	---	1.41E-06	3.09E-04	2.66E-05
Pr-144	3.42E-11	1.32E-11	1.72E-12	---	4.80E-12	1.15E-06	3.06E-06
Nd-147	5.67E-06	5.81E-06	3.57E-07	---	2.25E-06	2.30E-04	2.23E-05
W-187	9.26E-09	6.44E-09	2.23E-09	---	---	2.83E-05	2.54E-05
Np-239	2.65E-07	2.13E-07	1.34E-08	---	4.73E-08	4.25E-05	1.78E-05

Table 13 - Ingestion Dose Factors for Adult
(mrem per pCi Ingested)

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	---	5.99E-08	5.99E-08	5.99E-08	5.99E-08	5.99E-08	5.99E-08
C-14	2.84E-06	5.68E-07	5.68E-07	5.68E-07	5.68E-07	5.68E-07	5.68E-07
Na-24	1.70E-06	1.70E-06	1.70E-06	1.70E-06	1.70E-06	1.70E-06	1.70E-06
P-32	1.93E-04	1.20E-05	7.46E-06	---	---	---	2.17E-05
Cr-51	---	---	2.66E-09	1.59E-09	5.86E-10	3.53E-09	6.69E-07
Mn-54	---	4.57E-06	8.72E-07	---	1.36E-06	---	1.40E-05
Mn-56	---	1.15E-07	2.04E-08	---	1.46E-07	---	3.67E-06
Fe-55	2.75E-06	1.90E-06	4.43E-07	---	---	1.06E-06	1.09E-06
Fe-59	4.34E-06	1.02E-05	3.91E-06	---	---	2.85E-06	3.40E-05
Co-58	---	7.45E-07	1.67E-06	---	---	---	1.51E-05
Co-60	---	2.14E-06	4.72E-06	---	---	---	4.02E-05
Ni-63	1.30E-04	9.01E-06	4.36E-06	---	---	---	1.88E-06
Ni-65	5.28E-07	6.86E-08	3.13E-08	---	---	---	1.74E-06
Cu-64	---	8.33E-08	3.91E-08	---	2.10E-07	---	7.10E-06
Zn-65	4.84E-06	1.54E-05	6.96E-06	---	1.03E-05	---	9.70E-06
Zn-69	1.03E-08	1.97E-08	1.37E-09	---	1.28E-08	---	2.96E-09
Br-83	---	---	4.02E-08	---	---	---	5.79E-08
Br-84	---	---	5.21E-08	---	---	---	4.09E-13
Br-85	---	---	2.14E-09	---	---	---	---
Rb-86	---	2.11E-05	9.83E-06	---	---	---	4.16E-06
Rb-88	---	6.05E-08	3.21E-08	---	---	---	8.36E-19
Rb-89	---	4.01E-08	2.82E-08	---	---	---	2.33E-21
Sr-89	3.08E-04	---	8.84E-06	---	---	---	4.94E-05
Sr-90	8.71E-03	---	1.75E-04	---	---	---	2.19E-04
Sr-91	5.67E-06	---	2.29E-07	---	---	---	2.70E-05
Sr-92	2.15E-06	---	9.30E-08	---	---	---	4.26E-05
Y-90	9.62E-09	---	2.58E-10	---	---	---	1.02E-04
Y-91M	9.09E-11	---	3.52E-12	---	---	---	2.67E-10
Y-91	1.41E-07	---	3.77E-09	---	---	---	7.76E-05
Y-92	8.45E-10	---	2.47E-11	---	---	---	1.48E-05
Y-93	2.68E-09	---	7.40E-11	---	---	---	8.50E-05
Zr-95	3.04E-08	9.75E-09	6.60E-09	---	1.53E-08	---	3.09E-05
Zr-97	1.68E-09	3.39E-10	1.55E-10	---	5.12E-10	---	1.05E-04
Nb-95	6.22E-09	3.46E-09	1.86E-09	---	3.42E-09	---	2.10E-05
Mo-99	---	4.31E-06	8.20E-07	---	9.76E-06	---	9.99E-06
Tc-99M	2.47E-10	6.98E-10	8.89E-09	---	1.06E-08	3.42E-10	4.13E-07
Tc-101	2.54E-10	3.66E-10	3.59E-09	---	6.59E-09	1.87E-10	1.10E-21

Table 13 - Ingestion Dose Factors for Adult
(mrem per pCi Ingested)

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
Ru-103	1.85E-07	---	7.97E-08	---	7.06E-07	---	2.16E-05
Ru-105	1.54E-08	---	6.08E-09	---	1.99E-07	---	9.42E-06
Ru-106	2.75E-06	---	3.48E-07	---	5.31E-06	---	1.78E-04
Ag-110M	1.60E-07	1.48E-07	8.79E-08	---	2.91E-07	---	6.04E-05
Te-125M	2.68E-06	9.71E-07	3.59E-07	8.06E-07	1.09E-05	---	1.07E-05
Te-127M	6.77E-06	2.42E-06	8.25E-07	1.73E-06	2.75E-05	---	2.27E-05
Te-127	1.10E-07	3.95E-08	2.38E-08	8.15E-08	4.48E-07	---	8.68E-06
Te-129M	1.15E-05	4.29E-06	1.82E-06	3.95E-06	4.80E-05	---	5.79E-05
Te-129	3.14E-08	1.18E-08	7.65E-09	2.41E-08	1.32E-07	---	2.37E-08
Te-131M	1.73E-06	8.46E-07	7.05E-07	1.34E-06	8.57E-06	---	8.40E-05
Te-131	1.97E-08	8.23E-09	6.22E-09	1.62E-08	8.63E-08	---	2.79E-09
Te-132	2.52E-06	1.63E-06	1.53E-06	1.80E-06	1.57E-05	---	7.71E-05
I-130	7.56E-07	2.23E-06	8.80E-07	1.89E-04	3.48E-06	---	1.92E-06
I-131	4.16E-06	5.95E-06	3.41E-06	1.95E-03	1.02E-05	---	1.57E-06
I-132	2.03E-07	5.43E-07	1.90E-07	1.90E-05	8.65E-07	---	1.02E-07
I-133	1.42E-06	2.47E-06	7.53E-07	3.63E-04	4.31E-06	---	2.22E-06
I-134	1.06E-07	2.88E-07	1.03E-07	4.99E-06	4.58E-07	---	2.51E-10
I-135	4.43E-07	1.16E-06	4.28E-07	7.65E-05	1.86E-06	---	1.31E-06
Cs-134	6.22E-05	1.48E-04	1.21E-04	---	4.79E-05	1.59E-05	2.59E-06
Cs-136	6.51E-06	2.57E-05	1.85E-05	---	1.43E-05	1.96E-06	2.92E-06
Cs-137	7.97E-05	1.09E-04	7.14E-05	---	3.70E-05	1.23E-05	2.11E-06
Cs-138	5.52E-08	1.09E-07	5.40E-08	---	8.01E-08	7.91E-09	4.65E-13
Ba-139	9.70E-08	6.91E-11	2.84E-09	---	6.46E-11	3.92E-11	1.72E-07
Ba-140	2.03E-05	2.55E-08	1.33E-06	---	8.67E-09	1.46E-08	4.18E-05
Ba-141	4.71E-08	3.56E-11	1.59E-09	---	3.31E-11	2.02E-11	2.22E-17
Ba-142	2.13E-08	2.19E-11	1.34E-09	---	1.85E-11	1.24E-11	3.00E-26
La-140	2.50E-09	1.26E-09	3.33E-10	---	---	---	9.25E-05
La-142	1.28E-10	5.82E-11	1.45E-11	---	---	---	4.25E-07
Ce-141	9.36E-09	6.33E-09	7.18E-10	---	2.94E-09	---	2.42E-05
Ce-143	1.65E-09	1.22E-06	1.35E-10	---	5.37E-10	---	4.56E-05
Ce-144	4.88E-07	2.04E-07	2.62E-08	---	1.21E-07	---	1.65E-04
Pr-143	9.20E-09	3.69E-09	4.56E-10	---	2.13E-09	---	4.03E-05
Pr-144	3.01E-11	1.25E-11	1.53E-12	---	7.05E-12	---	4.33E-18
Nd-147	6.29E-09	7.27E-09	4.35E-10	---	4.25E-09	---	3.49E-05
W-187	1.03E-07	8.61E-08	3.01E-08	---	---	---	2.82E-05
Np-239	1.19E-09	1.17E-10	6.45E-11	---	3.65E-10	---	2.40E-05

Table 14 - Ingestion Dose Factors for Teenager
(mrem per pCi Ingested)

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	--	6.04E-08	6.04E-08	6.04E-08	6.04E-08	6.04E-08	6.04E-08
C-14	4.06E-06	8.12E-07	8.12E-07	8.12E-07	8.12E-07	8.12E-07	8.12E-07
Na-24	2.30E-06	2.30E-06	2.30E-06	2.30E-06	2.30E-06	2.30E-06	2.30E-06
P-32	2.76E-04	1.71E-05	1.07E-05	---	---	---	2.32E-05
Cr-51	---	---	3.60E-09	2.00E-09	7.89E-10	5.14E-09	6.05E-07
Mn-54	---	5.90E-06	1.17E-06	---	1.76E-06	---	1.21E-05
Mn-56	---	1.58E-07	2.81E-08	---	2.00E-07	---	1.04E-05
Fe-55	3.78E-06	2.68E-06	6.25E-07	---	---	1.70E-06	1.16E-06
Fe-59	5.87E-06	1.37E-05	5.29E-06	---	---	4.32E-06	3.24E-05
Co-58	---	9.72E-07	2.24E-06	---	---	---	1.34E-05
Co-60	---	2.81E-06	6.33E-06	---	---	---	3.66E-05
Ni-63	1.77E-04	1.25E-05	6.00E-06	---	---	---	1.99E-06
Ni-65	7.49E-07	9.57E-08	4.36E-08	---	---	---	5.19E-06
Cu-64	---	1.15E-07	5.41E-08	---	2.91E-07	---	8.92E-06
Zn-65	5.76E-06	2.00E-05	9.33E-06	---	1.28E-05	---	8.47E-06
Zn-69	1.47E-08	2.80E-08	1.96E-09	---	1.83E-08	---	5.16E-08
Br-83	---	---	5.74E-08	---	---	---	---
Br-84	---	---	7.22E-08	---	---	---	---
Br-85	---	---	3.05E-09	---	---	---	---
Rb-86	---	2.98E-05	1.40E-05	---	---	---	4.41E-06
Rb-88	---	8.52E-08	4.54E-08	---	---	---	7.30E-15
Rb-89	---	5.50E-08	3.89E-08	---	---	---	8.43E-17
Sr-89	4.40E-04	---	1.26E-05	---	---	---	5.24E-05
Sr-90	1.02E-02	---	2.04E-04	---	---	---	2.33E-04
Sr-91	8.07E-06	---	3.21E-07	---	---	---	3.66E-05
Sr-92	3.05E-06	---	1.30E-07	---	---	---	7.77E-05
Y-90	1.37E-08	---	3.69E-10	---	---	---	1.13E-04
Y-91M	1.29E-10	---	4.93E-12	---	---	---	6.09E-09
Y-91	2.01E-07	---	5.39E-09	---	---	---	8.24E-05
Y-92	1.21E-09	---	3.50E-11	---	---	---	3.32E-05
Y-93	3.83E-09	---	1.05E-10	---	---	---	1.17E-04
Zr-95	4.12E-08	1.30E-08	8.94E-09	---	1.91E-08	---	3.00E-05
Zr-97	2.37E-09	4.69E-10	2.16E-10	---	7.11E-10	---	1.27E-04
Nb-95	8.22E-09	4.56E-09	2.51E-09	---	4.42E-09	---	1.95E-05
Mo-99	---	6.03E-06	1.15E-06	---	1.38E-05	---	1.08E-05
Tc-99M	3.32E-10	9.26E-10	1.20E-08	---	1.38E-08	5.14E-10	6.08E-07
Tc-101	3.60E-10	5.12E-10	5.03E-09	---	9.26E-09	3.12E-10	8.75E-17

Table 14 - Ingestion Dose Factors for Teenager
(mrem per pCi Ingested)

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
Ru-103	2.55E-07	---	1.09E-07	---	8.99E-07	---	2.13E-05
Ru-105	2.18E-08	---	8.46E-09	---	2.75E-07	---	1.76E-05
Ru-106	3.92E-06	---	4.94E-07	---	7.56E-06	---	1.88E-04
Ag-110M	2.05E-07	1.94E-07	1.18E-07	---	3.70E-07	---	5.45E-05
Te-125M	3.83E-06	1.38E-06	5.12E-07	1.07E-06	---	---	1.13E-05
Te-127M	9.67E-06	3.43E-06	1.15E-06	2.30E-06	3.92E-05	---	2.41E-05
Te-127	1.58E-07	5.60E-08	3.40E-08	1.09E-07	6.40E-07	---	1.22E-05
Te-129M	1.63E-05	6.05E-06	2.58E-06	5.26E-06	6.82E-05	---	6.12E-05
Te-129	4.48E-08	1.67E-08	1.09E-08	3.20E-08	1.88E-07	---	2.45E-07
Te-131M	2.44E-06	1.17E-06	9.76E-07	1.76E-06	1.22E-05	---	9.39E-05
Te-131	2.79E-08	1.15E-08	8.72E-09	2.15E-08	1.22E-07	---	2.29E-09
Te-132	3.49E-06	2.21E-06	2.08E-06	2.33E-06	2.12E-05	---	7.00E-05
I-130	1.03E-06	2.98E-06	1.19E-06	2.43E-04	4.59E-06	---	2.29E-06
I-131	5.85E-06	8.19E-06	4.40E-06	2.39E-03	1.41E-05	---	1.62E-06
I-132	2.79E-07	7.30E-07	2.62E-07	2.46E-05	1.15E-06	---	3.18E-07
I-133	2.01E-06	3.41E-06	1.04E-06	4.76E-04	5.98E-06	---	2.58E-06
I-134	1.46E-07	3.87E-07	1.39E-07	6.45E-06	6.10E-07	---	5.10E-09
I-135	6.10E-07	1.57E-06	5.82E-07	1.01E-04	2.48E-06	---	1.74E-06
Cs-134	8.37E-05	1.97E-04	9.14E-05	---	6.26E-05	2.39E-05	2.45E-06
Cs-136	8.59E-06	3.38E-05	2.27E-05	---	1.84E-05	2.90E-06	2.72E-06
Cs-137	1.12E-04	1.49E-04	5.19E-05	---	5.07E-05	1.97E-05	2.12E-06
Cs-138	7.76E-08	1.49E-07	7.45E-08	---	1.10E-07	1.28E-08	4.76E-11
Ba-139	1.39E-07	9.78E-11	4.05E-09	---	9.22E-11	6.74E-11	1.24E-06
Ba-140	2.84E-05	3.48E-08	1.83E-06	---	1.18E-08	2.34E-08	4.38E-05
Ba-141	6.71E-08	5.01E-11	2.24E-09	---	4.65E-11	3.43E-11	1.43E-13
Ba-142	2.99E-08	2.99E-11	1.84E-09	---	2.53E-11	1.99E-11	9.18E-20
La-140	3.48E-09	1.71E-09	4.55E-10	---	---	---	9.28E-05
La-142	1.79E-10	7.95E-11	1.98E-11	---	---	---	2.42E-06
Ce-141	1.33E-08	8.88E-09	1.02E-09	---	4.18E-09	---	2.54E-05
Ce-143	2.35E-09	1.71E-06	1.91E-10	---	7.67E-10	---	5.14E-05
Ce-144	6.96E-07	2.88E-07	3.74E-08	---	1.72E-07	---	1.75E-04
Pr-143	1.31E-08	5.23E-09	6.52E-10	---	3.04E-09	---	4.31E-05
Pr-144	4.30E-11	1.76E-11	2.18E-12	---	1.01E-11	---	4.74E-14
Nd-147	9.38E-09	1.02E-08	6.11E-10	---	5.99E-09	---	3.68E-05
W-187	1.46E-07	1.19E-07	4.17E-08	---	---	---	3.22E-05
Np-239	1.76E-09	1.66E-10	9.22E-11	---	5.21E-10	---	2.67E-05

Table 15 - Ingestion Dose Factors for Child
(mrem per pCi Ingested)

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	---	1.16E-07	1.16E-07	1.16E-07	1.16E-07	1.16E-07	1.16E-07
C-14	1.21E-05	2.42E-06	2.42E-06	2.42E-06	2.42E-06	2.42E-06	2.42E-06
Na-24	5.80E-06	5.80E-06	5.80E-06	5.80E-06	5.80E-06	5.80E-06	5.80E-06
P-32	8.25E-04	3.86E-05	3.18E-05	---	---	---	2.28E-05
Cr-51	---	---	8.90E-09	4.94E-09	1.35E-09	9.02E-09	4.72E-07
Mn-54	---	1.07E-05	2.85E-06	---	3.00E-06	---	8.98E-06
Mn-56	---	3.34E-07	7.54E-08	---	4.04E-07	---	4.84E-05
Fe-55	1.15E-05	6.10E-06	1.89E-06	---	---	3.45E-06	1.13E-06
Fe-59	1.65E-05	2.67E-05	1.33E-05	---	---	7.74E-06	2.78E-05
Co-58	---	1.80E-06	5.51E-06	---	---	---	1.05E-05
Co-60	---	5.29E-06	1.56E-05	---	---	---	2.93E-05
Ni-63	5.38E-04	2.88E-05	1.83E-05	---	---	---	1.94E-06
Ni-65	2.22E-06	2.09E-07	1.22E-07	---	---	---	2.56E-05
Cu-64	---	2.45E-07	1.48E-07	---	5.92E-07	---	1.15E-05
Zn-65	1.37E-05	3.65E-05	2.27E-05	---	2.30E-05	---	6.41E-06
Zn-69	4.38E-08	6.33E-08	5.85E-09	---	3.84E-08	---	3.99E-06
Br-83	---	---	1.71E-07	---	---	---	---
Br-84	---	---	1.98E-07	---	---	---	---
Br-85	---	---	9.12E-09	---	---	---	---
Rb-86	---	6.70E-05	4.12E-05	---	---	---	4.31E-06
Rb-88	---	1.90E-07	1.32E-07	---	---	---	9.32E-09
Rb-89	---	1.17E-07	1.04E-07	---	---	---	1.02E-09
Sr-89	1.32E-03	---	3.77E-05	---	---	---	5.11E-05
Sr-90	2.56E-02	---	5.15E-04	---	---	---	2.29E-04
Sr-91	2.40E-05	---	9.06E-07	---	---	---	5.30E-05
Sr-92	9.03E-06	---	3.62E-07	---	---	---	1.71E-04
Y-90	4.11E-08	---	1.10E-09	---	---	---	1.17E-04
Y-91M	3.82E-10	---	1.39E-11	---	---	---	7.48E-07
Y-91	6.02E-07	---	1.61E-08	---	---	---	8.02E-05
Y-92	3.60E-09	---	1.03E-10	---	---	---	1.04E-04
Y-93	1.14E-08	---	3.13E-10	---	---	---	1.70E-04
Zr-95	1.16E-07	2.55E-08	2.27E-08	---	3.65E-08	---	2.66E-05
Zr-97	6.99E-09	1.01E-09	5.96E-10	---	1.45E-09	---	1.53E-04
Nb-95	2.25E-08	8.76E-09	6.26E-09	---	8.23E-09	---	1.62E-05
Mo-99	---	1.33E-05	3.29E-06	---	2.84E-05	---	1.10E-05
Tc-99M	9.23E-10	1.81E-09	3.00E-08	---	2.63E-08	9.19E-10	1.03E-06
Tc-101	1.07E-09	1.12E-09	1.42E-08	---	1.91E-08	5.92E-10	3.56E-09

Table 15 - Ingestion Dose Factors for Child
(mrem per pCi Ingested)

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
Ru-103	7.31E-07	---	2.81E-07	---	1.84E-06	---	1.89E-05
Ru-105	6.45E-08	---	2.34E-08	---	5.67E-07	---	4.21E-05
Ru-106	1.17E-05	---	1.46E-06	---	1.58E-05	---	1.82E-04
Ag-110M	5.39E-07	3.64E-07	2.91E-07	---	6.78E-07	---	4.33E-05
Te-125M	1.14E-05	3.09E-06	1.52E-06	3.20E-06	---	---	1.10E-05
Te-127M	2.89E-05	7.78E-06	3.43E-06	6.91E-06	8.24E-05	---	2.34E-05
Te-127	4.71E-07	1.27E-07	1.01E-07	3.26E-07	1.34E-06	---	1.84E-05
Te-129M	4.87E-05	1.36E-05	7.56E-06	1.57E-05	1.43E-04	---	5.94E-05
Te-129	1.34E-07	3.74E-08	3.18E-08	9.56E-08	3.92E-07	---	8.34E-06
Te-131M	7.20E-06	2.49E-06	2.65E-06	5.12E-06	2.41E-05	---	1.01E-04
Te-131	8.30E-08	2.53E-08	2.47E-08	6.35E-08	2.51E-07	---	4.36E-07
Te-132	1.01E-05	4.47E-06	5.40E-06	6.51E-06	4.15E-05	---	4.50E-05
I-130	2.92E-06	5.90E-06	3.04E-06	6.50E-04	8.82E-06	---	2.76E-06
I-131	1.72E-05	1.73E-05	9.83E-06	5.72E-03	2.84E-05	---	1.54E-06
I-132	8.00E-07	1.47E-06	6.76E-07	6.82E-05	2.25E-06	---	1.73E-06
I-133	5.92E-06	7.32E-06	2.77E-06	1.36E-03	1.22E-05	---	2.95E-06
I-134	4.19E-07	7.78E-07	3.58E-07	1.79E-05	1.19E-06	---	5.16E-07
I-135	1.75E-06	3.15E-06	1.49E-06	2.79E-04	4.83E-06	---	2.40E-06
Cs-134	2.34E-04	3.84E-04	8.10E-05	---	1.19E-04	4.27E-05	2.07E-06
Cs-136	2.35E-05	6.46E-05	4.18E-05	---	3.44E-05	5.13E-06	2.27E-06
Cs-137	3.27E-04	3.13E-04	4.62E-05	---	1.02E-04	3.67E-05	1.96E-06
Cs-138	2.28E-07	3.17E-07	2.01E-07	---	2.23E-07	2.40E-08	1.46E-07
Ba-139	4.14E-07	2.21E-10	1.20E-08	---	1.93E-10	1.30E-10	2.39E-05
Ba-140	8.31E-05	7.28E-08	4.85E-06	---	2.37E-08	4.34E-08	4.21E-05
Ba-141	2.00E-07	1.12E-10	6.51E-09	---	9.69E-11	6.58E-10	1.14E-07
Ba-142	8.74E-08	6.29E-11	4.88E-09	---	5.09E-11	3.70E-11	1.14E-09
La-140	1.01E-08	3.53E-09	1.19E-09	---	---	---	9.84E-05
La-142	5.24E-10	1.67E-10	5.23E-11	---	---	---	3.31E-05
Ce-141	3.97E-08	1.98E-08	2.94E-09	---	8.68E-09	---	2.47E-05
Ce-143	6.99E-09	3.79E-06	5.49E-10	---	1.59E-09	---	5.55E-05
Ce-144	2.08E-06	6.52E-07	1.11E-07	---	3.61E-07	---	1.70E-04
Pr-143	3.93E-08	1.18E-08	1.95E-09	---	6.39E-09	---	4.24E-05
Pr-144	1.29E-10	3.99E-11	6.49E-12	---	2.11E-11	---	8.59E-08
Nd-147	2.79E-08	2.26E-08	1.75E-09	---	1.24E-08	---	3.58E-05
W-187	4.29E-07	2.54E-07	1.14E-07	---	---	---	3.57E-05
Np-239	5.25E-09	3.77E-10	2.65E-10	---	1.09E-09	---	2.79E-05

Table 16 - Ingestion Dose Factors for Infant
(mrem per pCi Ingested)

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	---	1.76E-07	1.76E-07	1.76E-07	1.76E-07	1.76E-07	1.76E-07
C-14	2.37E-05	5.06E-06	5.06E-06	5.06E-06	5.06E-06	5.06E-06	5.06E-06
Na-24	1.01E-05	1.01E-05	1.01E-05	1.01E-05	1.01E-05	1.01E-05	1.01E-05
P-32	1.70E-03	1.00E-04	6.59E-05	---	---	---	2.30E-05
Cr-51	---	---	1.41E-08	9.20E-09	2.01E-09	1.79E-08	4.11E-07
Mn-54	---	1.99E-05	4.51E-06	---	4.41E-06	---	7.31E-06
Mn-56	---	8.18E-07	1.41E-07	---	7.03E-07	---	7.43E-05
Fe-55	1.39E-05	8.98E-06	2.40E-06	---	---	4.36E-06	1.14E-06
Fe-59	3.08E-05	5.38E-05	2.12E-05	---	---	1.59E-05	2.57E-05
Co-58	---	3.60E-06	8.98E-06	---	---	---	8.97E-06
Co-60	---	1.08E-05	2.55E-05	---	---	---	2.57E-05
Ni-63	6.34E-04	3.92E-05	2.20E-05	---	---	---	1.95E-06
Ni-65	4.70E-06	5.32E-07	2.42E-07	---	---	---	4.05E-05
Cu-64	---	6.09E-07	2.82E-07	---	1.03E-06	---	1.25E-05
Zn-65	1.84E-05	6.31E-05	2.91E-05	---	3.06E-05	---	5.33E-05
Zn-69	9.33E-08	1.68E-07	1.25E-08	---	6.98E-08	---	1.37E-05
Br-83	---	---	3.63E-07	---	---	---	---
Br-84	---	---	3.82E-07	---	---	---	---
Br-85	---	---	1.94E-08	---	---	---	---
Rb-86	---	1.70E-04	8.40E-05	---	---	---	4.35E-06
Rb-88	---	4.98E-07	2.73E-07	---	---	---	4.85E-07
Rb-89	---	2.86E-07	1.97E-07	---	---	---	9.74E-08
Sr-89	2.51E-03	---	7.20E-05	---	---	---	5.16E-05
Sr-90	2.83E-02	---	5.74E-04	---	---	---	2.31E-04
Sr-91	5.00E-05	---	1.81E-06	---	---	---	5.92E-05
Sr-92	1.92E-05	---	7.13E-07	---	---	---	2.07E-04
Y-90	8.69E-08	---	2.33E-09	---	---	---	1.20E-04
Y-91M	8.10E-10	---	2.76E-11	---	---	---	2.70E-06
Y-91	1.13E-06	---	3.01E-08	---	---	---	8.10E-05
Y-92	7.65E-09	---	2.15E-10	---	---	---	1.46E-04
Y-93	2.43E-08	---	6.62E-10	---	---	---	1.92E-04
Zr-95	2.06E-07	5.02E-08	3.56E-08	---	5.41E-08	---	2.50E-05
Zr-97	1.48E-08	2.54E-09	1.16E-09	---	2.56E-09	---	1.62E-04
Nb-95	4.20E-08	1.73E-08	1.00E-08	---	1.24E-08	---	1.46E-05
Mo-99	---	3.40E-05	6.63E-06	---	5.08E-05	---	1.12E-05
Tc-99M	1.92E-09	3.96E-09	5.10E-08	---	4.26E-08	2.07E-09	1.15E-06
Tc-101	2.27E-09	2.86E-09	2.83E-08	---	3.40E-08	1.56E-09	4.86E-07

Table 16 - Ingestion Dose Factors for Infant
(mrem per pCi Ingested)

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
Ru-103	1.48E-06	---	4.95E-07	---	3.08E-06	---	1.80E-05
Ru-105	1.36E-07	---	4.58E-08	---	1.00E-06	---	5.41E-05
Ru-106	2.41E-05	---	3.01E-06	---	2.85E-05	---	1.83E-04
Ag-110M	9.96E-07	7.27E-07	4.81E-07	---	1.04E-06	---	3.77E-05
Te-125M	2.33E-05	7.79E-06	3.15E-06	7.84E-06	---	---	1.11E-05
Te-127M	5.85E-05	1.94E-05	7.08E-06	1.69E-05	1.44E-04	---	2.36E-05
Te-127	1.00E-06	3.35E-07	2.15E-07	8.14E-07	2.44E-06	---	2.10E-05
Te-129M	1.00E-04	3.43E-05	1.54E-05	3.84E-05	2.50E-04	---	5.97E-05
Te-129	2.84E-07	9.79E-08	6.63E-08	2.38E-07	7.07E-07	---	2.27E-05
Te-131M	1.52E-05	6.12E-06	5.05E-06	1.24E-05	4.21E-05	---	1.03E-04
Te-131	1.76E-07	6.50E-08	4.94E-08	1.57E-07	4.50E-07	---	7.11E-06
Te-132	2.08E-05	1.03E-05	9.61E-06	1.52E-05	6.44E-05	---	3.81E-05
I-130	6.00E-06	1.32E-05	5.30E-06	1.48E-03	1.45E-05	---	2.83E-06
I-131	3.59E-05	4.23E-05	1.86E-05	1.39E-02	4.94E-05	---	1.51E-06
I-132	1.66E-06	3.37E-06	1.20E-06	1.58E-04	3.76E-06	---	2.73E-06
I-133	1.25E-05	1.82E-05	5.33E-06	3.31E-03	2.14E-05	---	3.08E-06
I-134	8.69E-07	1.78E-06	6.33E-07	4.15E-05	1.99E-06	---	1.84E-06
I-135	3.64E-06	7.24E-06	2.64E-06	6.49E-04	8.07E-06	---	2.62E-06
Cs-134	3.77E-04	7.03E-04	7.10E-05	---	1.81E-04	7.42E-05	1.91E-06
Cs-136	4.59E-05	1.35E-04	5.04E-05	---	5.38E-05	1.10E-05	2.05E-06
Cs-137	5.22E-04	6.11E-04	4.33E-05	---	1.64E-04	6.64E-05	1.91E-06
Cs-138	4.81E-07	7.82E-07	3.79E-07	---	3.90E-07	6.09E-08	1.25E-06
Ba-139	8.81E-07	5.84E-10	2.55E-08	---	3.51E-10	3.54E-10	5.58E-05
Ba-140	1.71E-04	1.71E-07	8.81E-06	---	4.06E-08	1.05E-07	4.20E-05
Ba-141	4.25E-07	2.91E-10	1.34E-08	---	1.75E-10	1.77E-10	5.19E-06
Ba-142	1.84E-07	1.53E-10	9.06E-09	---	8.81E-11	9.26E-11	7.59E-07
La-140	2.11E-08	8.32E-09	2.14E-09	---	---	---	9.77E-05
La-142	1.10E-09	4.04E-10	9.67E-11	---	---	---	6.86E-05
Ce-141	7.87E-08	4.80E-08	5.65E-09	---	1.48E-08	---	2.48E-05
Ce-143	1.48E-08	9.82E-06	1.12E-09	---	2.86E-09	---	5.73E-05
Ce-144	2.98E-06	1.22E-06	1.67E-07	---	4.93E-07	---	1.71E-04
Pr-143	8.13E-08	3.04E-08	4.03E-09	---	1.13E-08	---	4.29E-05
Pr-144	2.74E-10	1.06E-10	1.38E-11	---	3.84E-11	---	4.93E-06
Nd-147	5.53E-08	5.68E-08	3.48E-09	---	2.19E-08	---	3.60E-05
W-187	9.03E-07	6.28E-07	2.17E-07	---	---	---	3.69E-05
Np-239	1.11E-08	9.93E-10	5.61E-10	---	1.98E-09	---	2.87E-05

Table 17 - Recommended Values for Other Parameters

Parameter Symbol	Definition	Values
f_g	Fraction of ingested produce grown in garden of interest.	0.76
f_P	Fraction of leafy vegetables grown in garden of interest.	1.0
P	Effective surface density of soil (assumes a 15 cm plow layer, expressed in dry weight)	240 kg/m^2
r	Fraction of deposited activity retained on crops, leafy vegetables, or pasture grass	0.25 1.0 (iodines) 0.2 (other particulates)
S_f	Attenuation factor accounting for shielding provided by residential structures	0.7 (maximum individual) 0.5 (general population)
t_b	Period of long-term buildup for activity in sediment or soil (20 years)	1.752E5 hr
t_e	Period of crop, leafy vegetable, or pasture grass exposure during growing season	30 days (grass-cow-milk-man pathway) 60 days (crop/vegetation-man pathway)
$_f$	Transport time from animal feed-milk-man provided by residential structures	2 days (maximum individual) 4 days (general population)
t_h	Time delay between harvest of vegetation or crops and ingestion:	
	• For ingestion of forage by animals	Zero (pasture grass) 90 days (stored feed)
	• For ingestion of crops by man	1 day (leafy vegetables and max. individual feed) 60 days (produce and max. individual) 14 days (general population)
f_s	The fraction of daily feed that is pasture grass while the animals graze on pasture.	1.0
M_p	The mixing ratio at the point of withdrawal of drinking water.	Site Discharge 7.14 M.U.D. Intake 30.8
f_p	Fraction of the year that animals graze on pasture.	0.5

Table 17 - Recommended Values for Other Parameters

Parameter Symbol	Definition	Values
t_p	Environmental transit time, release to receptor (add time from release to exposure individual point to minimums shown for distribution)	12 hrs. (maximum) 1 day (maximum individual) 1 day (general population) 7 days (population--sport fish doses) 10 days (population--commercial fish doses)
t_s	Average time from slaughter of meat animal to consumption	20 days
Y_v	Agricultural productivity by unit area (measured in wet weight)	0.7 kg/m^2 (grass-cow-milk-man pathway) 2.0 kg/m^2 (produce or leafy vegetable ingested by man)
W	Shore-width factor for river shoreline	0.2
λ_w	Rate constant for removal of activity on plant or leaf structures by weathering (corresponds to a 14-day half-life)	0.0021 hr^{-1}
$\%CO_2$	Fraction of C-14 used for organ dose calculations from gaseous releases.	0.15

Table 18 - Estimated Doses Received by the General Public from On-Site Exposure

NOTE

The Dose Estimates are based on normal public activities conducted within the Fort Calhoun Station Site Boundary.

Location	**Direction**	**Distance from Containment (miles)**	**Estimated Individual Dose Rate (mR/hour)**		**Estimated Total Combined Annual Dose (mRem)[B]**	
			Direct Exposure (Total Body)	**Inhalation (Critical Organ[A])**	**Direct Exposure (Total Body)**	**Inhalation (Critical Organ[A])**
Firing Range	200°	0.24	4.08E-05	9.67E-06	5.08E+00	1.20E+00
Burn Pad	241°	0.33	1.95E-05	4.63E-06	1.41E-01	3.34E-02
On-Site Farming	118°	0.52	2.12E-05	5.03E-06	2.38E-02	5.64E-03
On-Site Farming	200°	0.51	1.03E-05	2.45E-06	2.30E-02	5.50E-03
On-Site Farming	308°	0.50	2.77E-05	6.64E-06	4.66E-02	1.12E-02
Site Maintenance Admin Bldg	145°	0.20	1.18E-04	2.84E-05	5.50E-02	1.33E-02
Site Maintenance Training Center	180°	0.20	1.45E-04	3.50E-05	6.78E-02	1.64E-02

A. Critical organ doses are based on adult thyroid.
B. Estimated totals are based on summation of all individual doses for members of the General Public while within the Fort Calhoun Station site boundary.

SECTION VII

ATTACHMENT 2

JOINT FREQUENCY DISTRIBUTION WIND DIRECTION VS. WIND SPEED
BY STABILITY CLASS AND METEOROLOGICAL DATA

(Regulatory Guide 1.21)

January 1, 2016 - December 31, 2016

JOINT FREQUENCY DISTRIBUTION WIND DIRECTION VS. WIND SPEED BY STABILITY CLASS AND METEOROLOGICAL DATA

A. Meteorological Data Recovery

Data availability from the on-site weather tower for the period January 1, 2016 through December 31, 2016 had a cumulative recovery rate of 99.46% from the meteorological tower with the remaining 0.54% provided by Eppley Airfield Weather Station, a branch of the National Weather Service. The data provided by Eppley Airfield Weather Station. The following table is a summary of the parameters and their respective recovery rates for the period.

The tabulations of the Weather Tower Data for the period January 1, 2016 through December 31, 2016 look appropriate for the season indicated. The Pasquill Classes observed for the twelve-month period are detailed below.

Pasquill Class	A	B	C	D	E	F	G	Total
% Obs.	9.50	4.69	6.25	43.37	24.88	7.77	3.55	100

On the basis of the data and its cross-checks, the weather data as amended is completely valid for use in tabulating atmospheric releases.

Omaha Public Power District
Fort Calhoun Nuclear Station
JOINT FREQUENCY DISTRIBUTION BY EVENTS
EXTREMELY UNSTABLE (delta T/ delta z <= -1.9)
PERIOD OF RECORD: JAN 2016 - DEC 2016
PASQUILL A
WIND SPEED (m/s) AT 10-m LEVEL

Wind Direct	< 0.5	0.5-1.0	1.1-1.5	1.6-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-8.0	8.1-10.0	> 10.0	Total
N	0	2	4	3	16	23	11	2	1	0	0	62
NNE	0	1	7	6	3	2	1	0	0	0	0	20
NE	0	1	5	2	7	7	2	0	0	0	0	24
ENE	0	1	2	4	4	3	4	0	1	0	0	19
E	0	0	3	5	4	1	2	1	1	0	0	17
ESE	0	0	1	2	7	8	3	2	7	1	0	31
SE	0	1	2	4	0	9	8	6	14	2	0	46
SSE	0	1	1	2	4	2	1	8	20	4	0	43
S	0	1	1	1	0	1	1	2	7	2	0	16
SSW	0	1	1	1	2	2	1	1	2	2	0	13
SW	0	0	1	2	5	5	1	5	9	7	0	35
WSW	0	0	4	1	6	2	2	1	6	0	0	22
W	0	0	1	4	9	8	8	2	3	2	0	37
WNW	0	1	2	4	19	12	11	6	4	0	0	59
NW	0	0	3	5	27	31	42	22	23	6	3	162
NNW	0	3	5	6	39	42	60	37	25	7	4	228
Total	0	13	43	52	152	158	158	95	123	33	7	834

Number of Calms 0
Number of Invalid Hours 0
Number of Valid Hours 834

Omaha Public Power District
Fort Calhoun Nuclear Station
JOINT FREQUENCY DISTRIBUTION BY EVENTS
MODERATELY UNSTABLE (-1.9 < delta T/ delta z <= -1.7)
PERIOD OF RECORD: JAN 2016 - DEC 2016
PASQUILL B
WIND SPEED (m/s) AT 10-m LEVEL

Wind Direct	< 0.5	0.5- 1.0	1.1- 1.5	1.6- 2.0	2.1- 3.0	3.1- 4.0	4.1- 5.0	5.1- 6.0	6.1- 8.0	8.1- 10.0	> 10.0	Total
N	0	1	3	4	19	11	1	0	0	0	0	39
NNE	0	0	0	3	2	0	1	0	0	0	0	6
NE	0	1	4	2	2	0	1	0	0	0	0	10
ENE	0	0	1	4	3	6	4	1	0	0	0	19
E	0	1	1	2	9	1	1	1	0	0	0	16
ESE	0	0	2	1	4	4	4	4	2	0	0	21
SE	0	0	0	1	4	13	13	13	7	1	0	52
SSE	0	1	1	0	2	1	8	6	12	2	0	33
S	0	0	0	0	2	3	2	2	10	4	1	24
SSW	0	1	0	0	1	3	1	5	5	1	0	17
SW	0	1	1	1	0	2	1	1	1	0	0	8
WSW	0	0	0	2	3	0	2	1	1	0	0	9
W	0	0	1	5	0	2	0	0	1	0	0	9
WNW	0	0	1	1	15	3	4	0	1	0	0	25
NW	0	1	1	2	7	10	7	13	5	0	1	47
NNW	0	0	3	2	14	27	18	7	6	0	0	77
Total	0	7	19	30	87	86	68	54	51	8	2	412

Number of Calms 0
Number of Invalid Hours 0
Number of Valid Hours 412

Omaha Public Power District
Fort Calhoun Nuclear Station
JOINT FREQUENCY DISTRIBUTION BY EVENTS
SLIGHTLY UNSTABLE (-1.7 < delta T/ delta z <= -1.5)
PERIOD OF RECORD: JAN 2016 - DEC 2016
PASQUILL C
WIND SPEED (m/s) AT 10-m LEVEL

Wind Direct	< 0.5	0.5-1.0	1.1-1.5	1.6-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-8.0	8.1-10.0	> 10.0	Total
N	1	1	7	3	18	7	2	0	0	0	0	39
NNE	0	0	7	1	4	4	0	0	0	0	0	16
NE	0	4	1	4	11	3	1	1	0	0	0	25
ENE	0	1	1	4	10	2	2	0	0	0	0	20
E	0	1	2	4	7	5	0	1	0	0	0	20
ESE	0	0	3	4	11	10	6	2	3	0	0	39
SE	0	0	1	2	8	14	18	21	10	2	0	76
SSE	0	0	0	0	3	5	7	12	18	5	0	50
S	0	0	1	2	3	3	11	7	9	2	1	39
SSW	0	0	1	3	3	4	8	6	11	0	0	36
SW	0	1	0	1	3	2	4	2	0	0	0	13
WSW	0	0	1	1	2	4	2	0	0	0	0	10
W	0	0	0	2	4	2	1	0	3	0	0	12
WNW	0	1	2	3	6	4	2	2	3	0	0	23
NW	0	1	1	2	12	10	12	7	5	3	0	53
NNW	0	0	4	8	13	22	10	10	6	4	1	78
Total	1	10	32	44	118	101	86	71	68	16	2	549

Number of Calms 0
Number of Invalid Hours 0
Number of Valid Hours 549

Omaha Public Power District
Fort Calhoun Nuclear Station
JOINT FREQUENCY DISTRIBUTION BY EVENTS
NEUTRAL (-1.5 < delta T/ delta z <= -0.5)
PERIOD OF RECORD: JAN 2016 - DEC 2016 PASQUILL D
WIND SPEED (m/s) AT 10-m LEVEL

Wind Direct	< 0.5	0.5- 1.0	1.1- 1.5	1.6- 2.0	2.1- 3.0	3.1- 4.0	4.1- 5.0	5.1- 6.0	6.1- 8.0	8.1- 10.0	> 10.0	Total
N	1	11	33	45	68	35	4	6	2	0	0	205
NNE	1	11	25	19	15	6	4	1	0	0	0	82
NE	1	6	16	17	18	3	2	2	3	3	0	71
ENE	0	11	27	21	16	17	5	3	7	0	0	107
E	1	5	15	26	33	18	1	0	0	0	0	99
ESE	0	8	16	29	55	45	14	10	6	0	0	183
SE	1	8	17	29	104	103	91	62	40	10	1	466
SSE	0	7	8	16	71	98	119	84	96	14	1	514
S	1	1	10	12	36	68	107	95	89	17	0	436
SSW	0	3	7	8	43	44	51	51	69	14	7	297
SW	0	6	4	8	38	22	15	10	16	7	1	127
WSW	1	5	9	9	12	11	8	6	4	0	0	65
W	1	7	7	17	22	19	9	17	11	2	0	112
WNW	0	13	18	12	43	46	28	11	16	0	0	187
NW	0	7	23	24	52	49	58	27	26	12	1	279
NNW	1	25	39	62	152	135	92	29	37	7	0	579
Total	9	134	274	354	778	719	608	414	422	86	11	3809

Number of Calms 0
Number of Invalid Hours 0
Number of Valid Hours 3809

Omaha Public Power District
Fort Calhoun Nuclear Station
JOINT FREQUENCY DISTRIBUTION BY EVENTS
SLIGHTLY STABLE (-0.5 < delta T/ delta z <= 1.5)
PERIOD OF RECORD: JAN 2016 - DEC 2016 PASQUILL E
WIND SPEED (m/s) AT 10-m LEVEL

Wind Direct	< 0.5	0.5- 1.0	1.1- 1.5	1.6- 2.0	2.1- 3.0	3.1- 4.0	4.1- 5.0	5.1- 6.0	6.1- 8.0	8.1- 10.0	> 10.0	Total
N	1	13	10	8	12	3	2	0	0	0	0	49
NNE	1	8	7	2	12	0	0	0	0	0	0	30
NE	3	13	10	5	2	2	1	0	0	0	0	36
ENE	2	14	6	4	14	5	2	0	0	0	0	47
E	2	12	12	10	8	7	3	3	1	0	0	58
ESE	2	11	27	34	37	9	5	4	5	0	0	134
SE	2	15	39	48	126	80	35	15	15	2	1	378
SSE	0	17	26	18	70	51	45	17	6	1	0	251
S	0	13	7	14	32	46	54	27	17	1	1	212
SSW	2	8	10	6	10	23	38	23	33	4	0	157
SW	6	13	5	5	9	6	6	11	22	16	4	103
WSW	3	14	10	5	8	3	10	5	2	0	1	61
W	10	34	13	16	21	16	22	5	4	1	1	143
WNW	3	69	26	23	40	29	25	4	6	2	0	227
NW	3	20	36	21	40	17	8	1	1	0	0	147
NNW	5	18	24	28	56	16	2	1	2	0	0	152
Total	45	292	268	247	497	313	258	116	114	27	8	2185

Number of Calms 0
Number of Invalid Hours 0
Number of Valid Hours 2185

Omaha Public Power District
Fort Calhoun Nuclear Station
JOINT FREQUENCY DISTRIBUTION BY EVENTS
MODERATELY STABLE (1.5 < delta T/ delta z <= 4.0)
PERIOD OF RECORD: JAN 2016 - DEC 2016 PASQUILL F
WIND SPEED (m/s) AT 10-m LEVEL

Wind Direct	< 0.5	0.5- 1.0	1.1- 1.5	1.6- 2.0	2.1- 3.0	3.1- 4.0	4.1- 5.0	5.1- 6.0	6.1- 8.0	8.1- 10.0	> 10.0	Total
N	3	2	2	2	0	0	0	0	0	0	0	9
NNE	2	5	1	1	0	0	0	0	0	0	0	9
NE	4	6	2	1	0	0	0	0	0	0	0	13
ENE	0	8	4	0	0	0	0	0	0	0	0	12
E	1	11	9	4	3	0	0	0	0	0	0	28
ESE	2	16	16	16	10	10	2	0	0	0	0	72
SE	3	20	18	18	30	16	14	3	0	0	0	122
SSE	7	21	6	4	21	7	0	1	0	0	0	67
S	4	24	5	1	10	9	3	1	0	0	0	57
SSW	11	14	4	5	6	6	1	4	0	0	0	51
SW	7	22	3	0	1	1	1	0	4	2	0	41
WSW	9	16	2	0	1	1	0	0	2	0	0	31
W	8	29	7	4	2	0	1	0	0	0	0	51
WNW	8	34	14	5	12	4	0	0	0	0	0	77
NW	4	16	7	1	0	0	0	0	0	0	0	28
NNW	2	6	3	1	1	0	0	0	1	0	0	14
Total	75	250	103	63	97	54	22	9	7	2	0	682

Number of Calms 0
Number of Invalid Hours 0
Number of Valid Hours 682

Omaha Public Power District
Fort Calhoun Nuclear Station
JOINT FREQUENCY DISTRIBUTION BY EVENTS
EXTREMELY STABLE (delta T/ delta z > 4.0)
PERIOD OF RECORD: JAN 2016 - DEC 2016 PASQUILL G
WIND SPEED (m/s) AT 10-m LEVEL

Wind Direct	< 0.5	0.5- 1.0	1.1- 1.5	1.6- 2.0	2.1- 3.0	3.1- 4.0	4.1- 5.0	5.1- 6.0	6.1- 8.0	8.1- 10.0	> 10.0	Total
N	0	2	0	0	1	0	0	0	0	0	0	3
NNE	0	1	1	1	0	0	0	0	0	0	0	3
NE	4	4	0	0	0	0	0	0	0	0	0	8
ENE	4	7	1	0	0	0	0	0	0	0	0	12
E	5	11	3	1	0	0	0	0	0	0	0	20
ESE	9	21	8	3	0	1	0	0	0	0	0	42
SE	7	26	16	6	1	2	1	0	0	0	0	59
SSE	12	26	7	2	0	0	0	0	0	0	0	47
S	3	20	2	2	1	4	1	0	0	0	0	33
SSW	6	16	2	3	3	0	0	0	0	0	0	30
SW	5	16	0	0	0	0	1	0	0	0	0	22
WSW	6	3	1	0	0	0	0	0	0	0	0	10
W	3	6	0	0	0	0	0	0	0	0	0	9
WNW	0	5	0	1	0	0	0	0	0	0	0	6
NW	1	3	0	0	1	0	0	0	0	0	0	5
NNW	1	2	0	0	0	0	0	0	0	0	0	3
Total	66	169	41	19	7	7	3	0	0	0	0	312

Number of Calms 0
Number of Invalid Hours 0
Number of Valid Hours 312
Hours Accounted For: 8783

Omaha Public Power District
Fort Calhoun Nuclear Station
JOINT FREQUENCY DISTRIBUTION BY PERCENT
EXTREMELY UNSTABLE (delta T/ delta z <= -1.9)
PERIOD OF RECORD: JAN 2016 - DEC 2016 PASQUILL A
WIND SPEED (m/s) AT 10-m LEVEL

Wind Direct	< 0.5	0.5- 1.0	1.1- 1.5	1.6- 2.0	2.1- 3.0	3.1- 4.0	4.1- 5.0	5.1- 6.0	6.1- 8.0	8.1- 10.0	> 10.0	Total
N	0.00	0.02	0.05	0.03	0.18	0.26	0.13	0.02	0.01	0.00	0.00	0.71
NNE	0.00	0.01	0.08	0.07	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.23
NE	0.00	0.01	0.06	0.02	0.08	0.08	0.02	0.00	0.00	0.00	0.00	0.27
ENE	0.00	0.01	0.02	0.05	0.05	0.03	0.05	0.00	0.01	0.00	0.00	0.22
E	0.00	0.00	0.03	0.06	0.05	0.01	0.02	0.01	0.01	0.00	0.00	0.19
ESE	0.00	0.00	0.01	0.02	0.08	0.09	0.03	0.02	0.08	0.01	0.00	0.35
SE	0.00	0.01	0.02	0.05	0.00	0.10	0.09	0.07	0.16	0.02	0.00	0.52
SSE	0.00	0.01	0.01	0.02	0.05	0.02	0.01	0.09	0.23	0.05	0.00	0.49
S	0.00	0.01	0.01	0.01	0.00	0.01	0.01	0.02	0.08	0.02	0.00	0.18
SSW	0.00	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.02	0.02	0.00	0.15
SW	0.00	0.00	0.01	0.02	0.06	0.06	0.01	0.06	0.10	0.08	0.00	0.40
WSW	0.00	0.00	0.05	0.01	0.07	0.02	0.02	0.01	0.07	0.00	0.00	0.25
W	0.00	0.00	0.01	0.05	0.10	0.09	0.09	0.02	0.03	0.02	0.00	0.42
WNW	0.00	0.01	0.02	0.05	0.22	0.14	0.13	0.07	0.05	0.00	0.00	0.67
NW	0.00	0.00	0.03	0.06	0.31	0.35	0.48	0.25	0.26	0.07	0.03	1.84
NNW	0.00	0.03	0.06	0.07	0.44	0.48	0.68	0.42	0.28	0.08	0.05	2.60
Total	0.00	0.15	0.49	0.59	1.73	1.80	1.80	1.08	1.40	0.38	0.08	9.50

Percent of Calms 0.00
Percent of Invalid Hours 0.00
Percent of Valid Hours 9.50

Omaha Public Power District
Fort Calhoun Nuclear Station
JOINT FREQUENCY DISTRIBUTION BY PERCENT
MODERATELY UNSTABLE (-1.9 < delta T/ delta z <= -1.7)
PERIOD OF RECORD: JAN 2016 - DEC 2016 PASQUILL B
WIND SPEED (m/s) AT 10-m LEVEL

Wind Direct	< 0.5	0.5- 1.0	1.1- 1.5	1.6- 2.0	2.1- 3.0	3.1- 4.0	4.1- 5.0	5.1- 6.0	6.1- 8.0	8.1- 10.0	> 10.0	Total
N	0.00	0.01	0.03	0.05	0.22	0.13	0.01	0.00	0.00	0.00	0.00	0.44
NNE	0.00	0.00	0.00	0.03	0.02	0.00	0.01	0.00	0.00	0.00	0.00	0.07
NE	0.00	0.01	0.05	0.02	0.02	0.00	0.01	0.00	0.00	0.00	0.00	0.11
ENE	0.00	0.00	0.01	0.05	0.03	0.07	0.05	0.01	0.00	0.00	0.00	0.22
E	0.00	0.01	0.01	0.02	0.10	0.01	0.01	0.01	0.00	0.00	0.00	0.18
ESE	0.00	0.00	0.02	0.01	0.05	0.05	0.05	0.05	0.02	0.00	0.00	0.24
SE	0.00	0.00	0.00	0.01	0.05	0.15	0.15	0.15	0.08	0.01	0.00	0.59
SSE	0.00	0.01	0.01	0.00	0.02	0.01	0.09	0.07	0.14	0.02	0.00	0.38
S	0.00	0.00	0.00	0.00	0.02	0.03	0.02	0.02	0.11	0.05	0.01	0.27
SSW	0.00	0.01	0.00	0.00	0.01	0.03	0.01	0.06	0.06	0.01	0.00	0.19
SW	0.00	0.01	0.01	0.01	0.00	0.02	0.01	0.01	0.01	0.00	0.00	0.09
WSW	0.00	0.00	0.00	0.02	0.03	0.00	0.02	0.01	0.01	0.00	0.00	0.10
W	0.00	0.00	0.01	0.06	0.00	0.02	0.00	0.00	0.01	0.00	0.00	0.10
WNW	0.00	0.00	0.01	0.01	0.17	0.03	0.05	0.00	0.01	0.00	0.00	0.28
NW	0.00	0.01	0.01	0.02	0.08	0.11	0.08	0.15	0.06	0.00	0.01	0.54
NNW	0.00	0.00	0.03	0.02	0.16	0.31	0.20	0.08	0.07	0.00	0.00	0.88
Total	0.00	0.08	0.22	0.34	0.99	0.98	0.77	0.61	0.58	0.09	0.02	4.69

Percent of Calms 0.00
Percent of Invalid Hours 0.00
Percent of Valid Hours 4.69

Omaha Public Power District
Fort Calhoun Nuclear Station
JOINT FREQUENCY DISTRIBUTION BY PERCENT
SLIGHTLY UNSTABLE (-1.7 < delta T/ delta z <= -1.5)
PERIOD OF RECORD: JAN 2016 - DEC 2016 PASQUILL C
WIND SPEED (m/s) AT 10-m LEVEL

Wind Direct	< 0.5	0.5- 1.0	1.1- 1.5	1.6- 2.0	2.1- 3.0	3.1- 4.0	4.1- 5.0	5.1- 6.0	6.1- 8.0	8.1- 10.0	> 10.0	Total
N	0.01	0.01	0.08	0.03	0.20	0.08	0.02	0.00	0.00	0.00	0.00	0.44
NNE	0.00	0.00	0.08	0.01	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.18
NE	0.00	0.05	0.01	0.05	0.13	0.03	0.01	0.01	0.00	0.00	0.00	0.28
ENE	0.00	0.01	0.01	0.05	0.11	0.02	0.02	0.00	0.00	0.00	0.00	0.23
E	0.00	0.01	0.02	0.05	0.08	0.06	0.00	0.01	0.00	0.00	0.00	0.23
ESE	0.00	0.00	0.03	0.05	0.13	0.11	0.07	0.02	0.03	0.00	0.00	0.44
SE	0.00	0.00	0.01	0.02	0.09	0.16	0.20	0.24	0.11	0.02	0.00	0.87
SSE	0.00	0.00	0.00	0.00	0.03	0.06	0.08	0.14	0.20	0.06	0.00	0.57
S	0.00	0.00	0.01	0.02	0.03	0.03	0.13	0.08	0.10	0.02	0.01	0.44
SSW	0.00	0.00	0.01	0.03	0.03	0.05	0.09	0.07	0.13	0.00	0.00	0.41
SW	0.00	0.01	0.00	0.01	0.03	0.02	0.05	0.02	0.00	0.00	0.00	0.15
WSW	0.00	0.00	0.01	0.01	0.02	0.05	0.02	0.00	0.00	0.00	0.00	0.11
W	0.00	0.00	0.00	0.02	0.05	0.02	0.01	0.00	0.03	0.00	0.00	0.14
WNW	0.00	0.01	0.02	0.03	0.07	0.05	0.02	0.02	0.03	0.00	0.00	0.26
NW	0.00	0.01	0.01	0.02	0.14	0.11	0.14	0.08	0.06	0.03	0.00	0.60
NNW	0.00	0.00	0.05	0.09	0.15	0.25	0.11	0.11	0.07	0.05	0.01	0.89
Total	0.01	0.11	0.36	0.50	1.34	1.15	0.98	0.81	0.77	0.18	0.02	6.25

Percent of Calms 0.00
Percent of Invalid Hours 0.00
Percent of Valid Hours 6.25

Omaha Public Power District
Fort Calhoun Nuclear Station
JOINT FREQUENCY DISTRIBUTION BY PERCENT
NEUTRAL (-1.5 < delta T/ delta z <= -0.5)
PERIOD OF RECORD: JAN 2016 - DEC 2016 PASQUILL D
WIND SPEED (m/s) AT 10-m LEVEL

Wind Direct	< 0.5	0.5- 1.0	1.1- 1.5	1.6- 2.0	2.1- 3.0	3.1- 4.0	4.1- 5.0	5.1- 6.0	6.1- 8.0	8.1- 10.0	> 10.0	Total
N	0.01	0.13	0.38	0.51	0.77	0.40	0.05	0.07	0.02	0.00	0.00	2.33
NNE	0.01	0.13	0.28	0.22	0.17	0.07	0.05	0.01	0.00	0.00	0.00	0.93
NE	0.01	0.07	0.18	0.19	0.20	0.03	0.02	0.02	0.03	0.03	0.00	0.81
ENE	0.00	0.13	0.31	0.24	0.18	0.19	0.06	0.03	0.08	0.00	0.00	1.22
E	0.01	0.06	0.17	0.30	0.38	0.20	0.01	0.00	0.00	0.00	0.00	1.13
ESE	0.00	0.09	0.18	0.33	0.63	0.51	0.16	0.11	0.07	0.00	0.00	2.08
SE	0.01	0.09	0.19	0.33	1.18	1.17	1.04	0.71	0.46	0.11	0.01	5.31
SSE	0.00	0.08	0.09	0.18	0.81	1.12	1.35	0.96	1.09	0.16	0.01	5.85
S	0.01	0.01	0.11	0.14	0.41	0.77	1.22	1.08	1.01	0.19	0.00	4.96
SSW	0.00	0.03	0.08	0.09	0.49	0.50	0.58	0.58	0.79	0.16	0.08	3.38
SW	0.00	0.07	0.05	0.09	0.43	0.25	0.17	0.11	0.18	0.08	0.01	1.45
WSW	0.01	0.06	0.10	0.10	0.14	0.13	0.09	0.07	0.05	0.00	0.00	0.74
W	0.01	0.08	0.08	0.19	0.25	0.22	0.10	0.19	0.13	0.02	0.00	1.28
WNW	0.00	0.15	0.20	0.14	0.49	0.52	0.32	0.13	0.18	0.00	0.00	2.13
NW	0.00	0.08	0.26	0.27	0.59	0.56	0.66	0.31	0.30	0.14	0.01	3.18
NNW	0.01	0.28	0.44	0.71	1.73	1.54	1.05	0.33	0.42	0.08	0.00	6.59
Total	0.10	1.53	3.12	4.03	8.86	8.19	6.92	4.71	4.80	0.98	0.13	43.37

Percent of Calms 0.00
Percent of Invalid Hours 0.00
Percent of Valid Hours 43.37

Omaha Public Power District
Fort Calhoun Nuclear Station
JOINT FREQUENCY DISTRIBUTION BY PERCENT
SLIGHTLY STABLE (-0.5 < delta T/ delta z <= 1.5)
PERIOD OF RECORD: JAN 2016 - DEC 2016 PASQUILL E
WIND SPEED (m/s) AT 10-m LEVEL

Wind Direct	< 0.5	0.5- 1.0	1.1- 1.5	1.6- 2.0	2.1- 3.0	3.1- 4.0	4.1- 5.0	5.1- 6.0	6.1- 8.0	8.1- 10.0	> 10.0	Total
N	0.01	0.15	0.11	0.09	0.14	0.03	0.02	0.00	0.00	0.00	0.00	0.56
NNE	0.01	0.09	0.08	0.02	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.34
NE	0.03	0.15	0.11	0.06	0.02	0.02	0.01	0.00	0.00	0.00	0.00	0.41
ENE	0.02	0.16	0.07	0.05	0.16	0.06	0.02	0.00	0.00	0.00	0.00	0.54
E	0.02	0.14	0.14	0.11	0.09	0.08	0.03	0.03	0.01	0.00	0.00	0.66
ESE	0.02	0.13	0.31	0.39	0.42	0.10	0.06	0.05	0.06	0.00	0.00	1.53
SE	0.02	0.17	0.44	0.55	1.43	0.91	0.40	0.17	0.17	0.02	0.01	4.30
SSE	0.00	0.19	0.30	0.20	0.80	0.58	0.51	0.19	0.07	0.01	0.00	2.86
S	0.00	0.15	0.08	0.16	0.36	0.52	0.61	0.31	0.19	0.01	0.01	2.41
SSW	0.02	0.09	0.11	0.07	0.11	0.26	0.43	0.26	0.38	0.05	0.00	1.79
SW	0.07	0.15	0.06	0.06	0.10	0.07	0.07	0.13	0.25	0.18	0.05	1.17
WSW	0.03	0.16	0.11	0.06	0.09	0.03	0.11	0.06	0.02	0.00	0.01	0.69
W	0.11	0.39	0.15	0.18	0.24	0.18	0.25	0.06	0.05	0.01	0.01	1.63
WNW	0.03	0.79	0.30	0.26	0.46	0.33	0.28	0.05	0.07	0.02	0.00	2.58
NW	0.03	0.23	0.41	0.24	0.46	0.19	0.09	0.01	0.01	0.00	0.00	1.67
NNW	0.06	0.20	0.27	0.32	0.64	0.18	0.02	0.01	0.02	0.00	0.00	1.73
Total	0.51	3.32	3.05	2.81	5.66	3.56	2.94	1.32	1.30	0.31	0.09	24.88

Percent of Calms 0.00
Percent of Invalid Hours 0.00
Percent of Valid Hours 24.88

Omaha Public Power District
Fort Calhoun Nuclear Station
JOINT FREQUENCY DISTRIBUTION BY PERCENT
MODERATELY STABLE (1.5 < delta T/ delta z <= 4.0)
PERIOD OF RECORD: JAN 2016 - DEC 2016 PASQUILL F
WIND SPEED (m/s) AT 10-m LEVEL

Wind Direct	< 0.5	0.5- 1.0	1.1- 1.5	1.6- 2.0	2.1- 3.0	3.1- 4.0	4.1- 5.0	5.1- 6.0	6.1- 8.0	8.1- 10.0	> 10.0	Total
N	0.03	0.02	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
NNE	0.02	0.06	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
NE	0.05	0.07	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15
ENE	0.00	0.09	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14
E	0.01	0.13	0.10	0.05	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.32
ESE	0.02	0.18	0.18	0.18	0.11	0.11	0.02	0.00	0.00	0.00	0.00	0.82
SE	0.03	0.23	0.20	0.20	0.34	0.18	0.16	0.03	0.00	0.00	0.00	1.39
SSE	0.08	0.24	0.07	0.05	0.24	0.08	0.00	0.01	0.00	0.00	0.00	0.76
S	0.05	0.27	0.06	0.01	0.11	0.10	0.03	0.01	0.00	0.00	0.00	0.65
SSW	0.13	0.16	0.05	0.06	0.07	0.07	0.01	0.05	0.00	0.00	0.00	0.58
SW	0.08	0.25	0.03	0.00	0.01	0.01	0.01	0.00	0.05	0.02	0.00	0.47
WSW	0.10	0.18	0.02	0.00	0.01	0.01	0.00	0.00	0.02	0.00	0.00	0.35
W	0.09	0.33	0.08	0.05	0.02	0.00	0.01	0.00	0.00	0.00	0.00	0.58
WNW	0.09	0.39	0.16	0.06	0.14	0.05	0.00	0.00	0.00	0.00	0.00	0.88
NW	0.05	0.18	0.08	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.32
NNW	0.02	0.07	0.03	0.01	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.16
Total	0.85	2.85	1.17	0.72	1.10	0.61	0.25	0.10	0.08	0.02	0.00	7.77

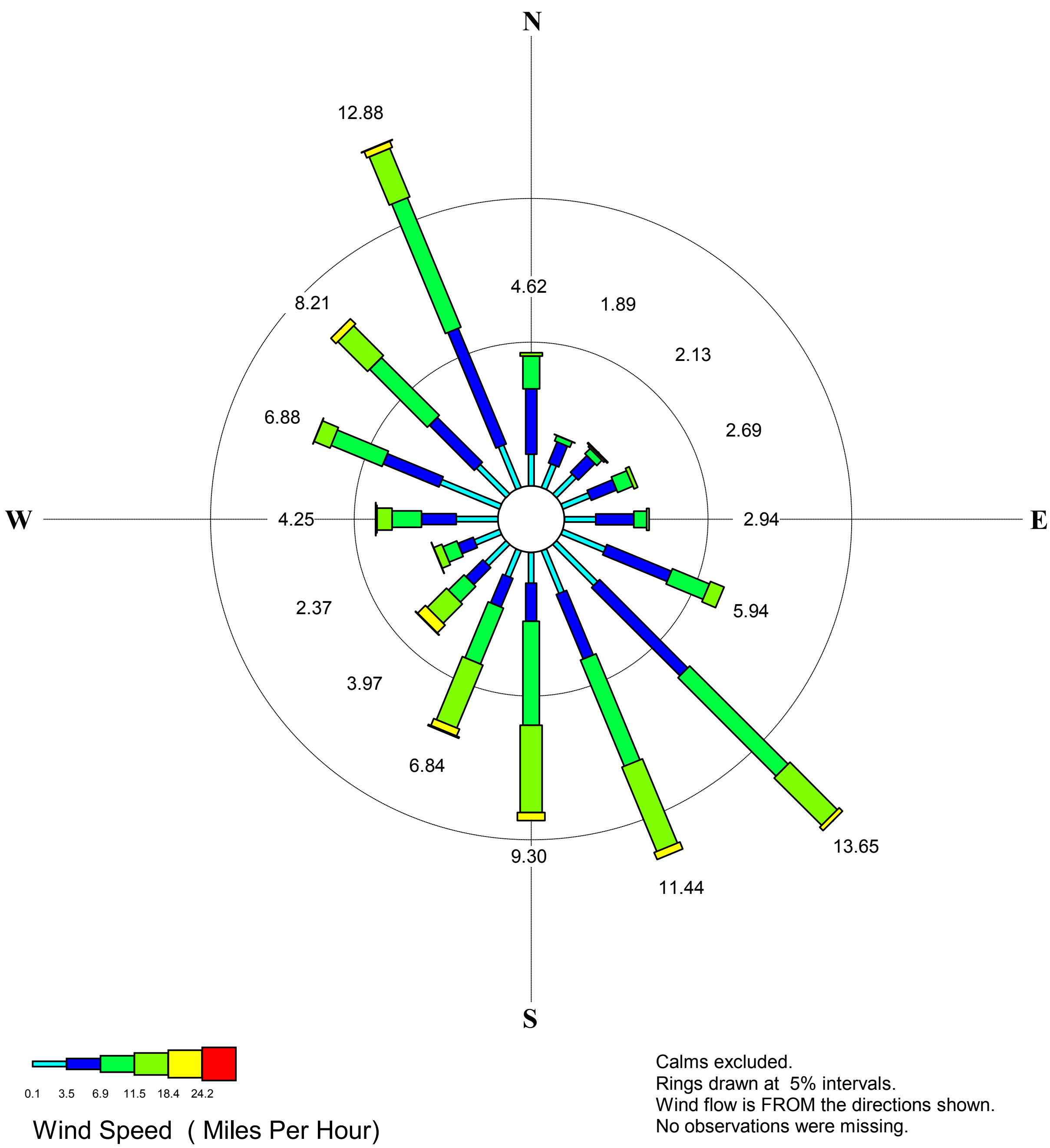
Percent of Calms 0.00
Percent of Invalid Hours 0.00
Percent of Valid Hours 7.77

Omaha Public Power District
Fort Calhoun Nuclear Station
JOINT FREQUENCY DISTRIBUTION BY PERCENT
EXTREMELY STABLE (delta T/ delta z > 4.0)
PERIOD OF RECORD: JAN 2016 - DEC 2016 PASQUILL G
WIND SPEED (m/s) AT 10-m LEVEL

Wind Direct	< 0.5	0.5- 1.0	1.1- 1.5	1.6- 2.0	2.1- 3.0	3.1- 4.0	4.1- 5.0	5.1- 6.0	6.1- 8.0	8.1- 10.0	> 10.0	Total
N	0.00	0.02	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.03
NNE	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
NE	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09
ENE	0.05	0.08	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14
E	0.06	0.13	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
ESE	0.10	0.24	0.09	0.03	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.48
SE	0.08	0.30	0.18	0.07	0.01	0.02	0.01	0.00	0.00	0.00	0.00	0.67
SSE	0.14	0.30	0.08	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.54
S	0.03	0.23	0.02	0.02	0.01	0.05	0.01	0.00	0.00	0.00	0.00	0.38
SSW	0.07	0.18	0.02	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.34
SW	0.06	0.18	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.25
WSW	0.07	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
W	0.03	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
WNW	0.00	0.06	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
NW	0.01	0.03	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.06
NNW	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
Total	0.75	1.92	0.47	0.22	0.08	0.08	0.03	0.00	0.00	0.00	0.00	3.55

Percent of Calms 0.00
Percent of Invalid Hours 0.00
Percent of Valid Hours 3.55
Percent of Hours Accounted For: 100.00

Joint Frequency Distribution
2016 FCS Meterological Tower



Calms excluded.
Rings drawn at 5% intervals.
Wind flow is FROM the directions shown.
No observations were missing.

OMAHA PUBLIC POWER DISTRICT

FORT CALHOUN STATION

RADIOLOGICAL ENVIRONMENTAL OPERATING REPORT

TECHNICAL SPECIFICATION 5.9.4.b

January 01, 2016 – December 31, 2016

Annual Radiological Environmental Operating Report

This report is submitted in accordance with Section 5.9.4.b of the Technical Specifications of Fort Calhoun Station Unit No. 1, Facility Operating License DPR-40 for the period January 01, 2016 through December 31, 2016.

In addition, this report provides any observations and anomalies that occurred during the monitoring period.

Reviewed by:

Supervisor-RadWaste/Environmental

Approved by:

Manager-Chemistry

FCS Plant Manager

Senior Director of Nuclear Decommissioning

Annual Radiological Environmental Operating Report

In accordance with Technical Specification 5.9.4.b, herein is the Fort Calhoun Station (FCS) Annual Radiological Environmental Operating Report for year 2016. The data provided is consistent with the objectives as specified in Section 5.2.2 of the Offsite Dose Calculation Manual (ODCM), "Annual Radiological Environmental Operating Report." The report is presented as follows:

1) An introductory discussion of the implementation of the Radiological Environmental Monitoring Program (REMP), including program observations and environmental impact relevant to the operation of FCS.

2) The sample class, sample collection frequency, number of sample locations, and the number of samples collected this reporting period for each parameter is delineated in Table 1.0.

3) A statistical evaluation of REMP data is summarized in Table 2.0, in accordance with Regulatory Guide 4.8, Table 1. For each type of sample media and analysis, Table 2.0 presents data separately for all **indicator** locations, all **control** (background) locations, and the location having the highest annual mean result. For each of these classes, Table 2.0 specifies the following:

    a. The total number of analyses,

    b. The fraction of analyses yielding detectable results (i.e., results above the highest Lower Limit of Detection (LLD) for this period),

    c. The maximum, minimum, and average results,

    d. Locations with the highest annual mean are specified by code, name, and by distance and direction from the center of plant reactor containment building.

4) Table 3.0 is a listing of missed samples and explanations

5) Table 4.0 is the 2016 Land Use Survey

6) Review of Environmental Inc. Quality Assurance Program

7) Appendix A describes the Interlaboratory Comparison Program

8) Appendix B describes the vendor Data Reporting Conventions utilized

9) Appendix C reports the information required when primary coolant specific activity has exceeded the limits of Technical Specification 2.1.3

10) Appendix D is the Sample Location Maps

INTRODUCTION

Radiological Environmental Monitoring Program (REMP) – 2016

This report gives the results of the Radiological Environmental Monitoring Program (REMP) for the year 2016. The REMP is a requirement of the Fort Calhoun Station (FCS) operating license. It was initiated prior to plant operation in 1973.

The main purpose of the REMP is to ensure public safety by monitoring plant discharges and assessing the effect, if any, of plant operations on the environment. Samples are collected that would account for various exposure pathways such as ingestion, inhalation, adsorption and direct exposure. Samples collected on a regular basis include: air, surface water, ground water, milk, vegetation, fish, sediment, and food crops. Direct radiation is measured by thermoluminescent dosimeters (TLDs). These samples and TLDs are sent to an independent vendor laboratory for analysis. The vendor uses analytical methods that are sensitive enough to detect a level of activity far below that which would be considered harmful. Locations for sample collection are based on radiological and meteorological data from the Annual Effluent Release Report and information obtained from the Environmental Land Use Survey.

Most samples, particularly indicator samples, are collected in a circular area within a five-mile radius of plant containment. (However, control locations are usually outside of five miles.) This circle is divided into sixteen equal sectors, each assigned an identification letter "A" through "R" (note: letters "I" and "O" are not used, as they may be mistaken for the numbers "1" and "0"). Sector "A" is centered on North or zero degrees. Sectors are also given directional labels such as "West-Southwest" ("WSW"). Sample locations are listed by number along with their respective distances and direction from plant containment, in the Offsite Dose Calculation Manual (ODCM).

When assessing sample results, data from indicator locations (those most likely to be affected by plant operations) are compared to those from control locations (those least or not likely to be affected). Results from an indicator location which were significantly higher than those from a control location could indicate a plant-attributable effect and could require additional investigation.

The results of the sample analyses, as required by the FCS Offsite Dose Calculation Manual (ODCM), are presented in the attached statistical tables in accordance with Table 1 of Regulatory Guide 4.8, "Environmental Technical Specifications for Nuclear Power Plants." Sample collection was conducted by plant chemistry/environmental staff. A contract vendor (Environmental Inc., Northbrook, Illinois) performed sample analyses, preparation of monthly reports and the statistical evaluation of sample results. All vendor analysis techniques met the sensitivity requirements as stated in the ODCM.

Results for 2016 were within expected ranges and compared closely with historical results. The result details and exceptions are listed in the following sections.

1) Ambient Gamma Radiation

Ambient gamma radiation is measured by thermoluminescent dosimeters (TLDs) provided by the vendor laboratory. These dosimeters contain calcium sulfate phosphors and are processed quarterly. Thirty-two new thermoluminescent dosimeters were added to the program during the fourth quarter of 2010.

The returned results were evaluated for their validity. The results appeared to be consistent with the results from previous quarters and to nearby TLDs, so the results were deemed to be valid.

All sample results are within the range of historical data and displayed less than 17% difference when compared to historical averages. All results were less than 3 sigma standard deviations from historical means. No discrepancy between released effluents and resultant radiation dose measured was observed. No changes in plant operation/procedures are required based upon observed impacts to the environment to date.

10-Year Trend Comparison of TLD Locations

Location	Avg. Dose (mr/week)	2016 Avg. Dose (mr/week)
A	1.32	1.10
B	1.42	1.38
C	1.38	1.25
D	1.23	1.03
F	1.36	1.23
G	1.32	1.28
H	1.39	1.18
I	1.48	1.40
J	1.53	1.40
K	1.45	1.30
N	1.43	1.50
O	1.41	1.40
P	1.47	1.53
S	1.49	1.60
L (Control)	1.26	1.18

2) **Milk/Pasture**

Milk samples or pasture grasses, if milk is temporarily unavailable, are collected every two weeks during the pasture season from the beginning of May through September, and monthly the rest of the calendar year. Indicator samples are collected from a herd of milk goats at a family farm located approximately 3.4 miles from the plant in Sector J (South). The control samples are collected from a commercial dairy cow herd located approximately 9.9 miles from the plant in Sector J (South). The indicator station and control location are unchanged from last year. No indicator milk samples were available after June due to the dairy owners suspending operations. Late fall samples were not performed due to the does drying up before birthing. Pasture grass in lieu of milk was collected at the indicator location due to unavailability.

All sample results for Cesium-134, Cesium-137 and other gammas were at the LLD for both indicator and control locations. No plant-related effects were observed.

3) **Fish**

Fish are collected on an annual basis. Control samples are collected at a location approximately twenty miles upstream of the plant (river miles 665 – 667). Indicator samples are collected in the immediate vicinity of the power plant (river miles 644 – 646). Several species of fish, important to commercial and recreational interest, representing all levels of the aquatic food chain are collected at both locations.

All sample results are within the range of historical data. Results from both control and indicator locations were less than LLD for all gamma emitters, indicating no plant-related effects.

4) **Food Crop**

Based on the results of the biennial Land Use Survey, the nearest high deposition pathway for food crops is the Alvin Pechnik Farm in Sector H (0.94 miles, 163°). Accordingly, vegetable samples were collected at Alvin Pechnik Farm for the purposes of the 2016 REMP.

Samples were comparable with historical results and within the range of results reported from the control location garden at Mohr Dairy. Additional special interest samples were obtained from on-site farm fields per plant Technical Specifications.

All results were at the LLD for all non-naturally occurring radionuclides. No plant-related effects were observed.

5) **Sediment**

River sediment samples are collected twice a year at an upstream control location and a downstream indicator location. All results were at the LLD for all non-naturally occurring radionuclides. No plant-related effects were observed.

6) Air Monitoring

Air sample results for 2016 were well within historical limits for all locations. Additionally, all indicator locations showed results very similar to the control locations.

No incidents were documented in the Corrective Action Program in 2016 related to air sampling.

All sample results are within the range of historical data. All indicator locations displayed less than 15% difference when compared to historical average. All 2016 results when compared to historical averages are within the stated vendor error acceptance tolerance.

Results from both control and indicator locations were less than LLD for gamma emitters and iodine. No changes in plant operation/procedures are required based upon observed impacts to the environment to date.

10-Year Trend Comparison of Air Sampling Locations

Location	Avg. Beta (pCi/m^3)	2016 Avg. Beta (pCi/m^3)
Sector B	0.029	0.026
Sector D	0.029	0.025
Sector I	0.025	0.022
Sector J	0.027	0.023
Sector K	0.027	0.024
Sector F (Control)	0.029	0.026

7) Surface Water

Water samples are collected upstream of the plant (control location) as well as half-mile downstream and at a municipal water treatment plant on the north edge of Omaha.

Results for Cs-134, Cs-137, and other gammas were all less than LLD. All other tritium results were less than LLD. No plant-related effects were detected.

8) Ground Water

Quarterly residential well water samples are collected at the following four locations: Station No. 15: Smith Farm, Station No. 20: Mohr Dairy, Station No. 74: D. Miller Farm and Station No. 75: Lomp Acreage. All sample results to date have been at the LLD except gross beta due to naturally occurring radionuclides. Gross beta results have ranged from a low of 2.5 pCi/liter to a high of 8.1 pCi/liter, with an average gross beta for the year of 7.2 pCi/liter for indicator locations. Strontium-90 analysis is being conducted on wells as part of the station's groundwater protection program. No plant-related effects were detected.

Table 1.0

Sample Collection Program

Sample Class	Collection Frequency	Number of Sample Locations	Samples Collected this Period
Background Radiation (TLDs)	Quarterly	47	188
Air Particulates	Weekly	6	312
Airborne Iodine	Weekly	6	312
Milk	Biweekly May thru Sept	2	38[1]
Surface Water	Monthly	3	36
Ground Water	Quarterly	4	16
Fish	Annually	2	5[2]
Sediment	Semi-annually	2	4
Food Crops	Annually	3	9[3]
		TOTAL	**920**

Note 1: Milk sample collection total includes 11 vegetation samples performed for milk unavailability. Milk samples are collected every two weeks May-Sept. and monthly the rest of the year. Three milk samples were performed in August.
Note 2: Includes one background sample.
Note 3: Variety of samples collected during period

Table 2.0 Radiological Environmental Monitoring Program Summary — Reporting Period: January-December, 2016

Name of Facility: Fort Calhoun Nuclear Power Station - Unit 1 — Docket No. 50-285

Location of Facility: Washington, Nebraska
(County, State)

Sample Type (Units)	Type and Number of Analyses[a]	LLD[b]	Indicator Locations Mean (F)[c] Range[c]	Location with Highest Annual Mean: Location[d]	Location with Highest Annual Mean: Mean (F)[c] Range[c]	Control Locations Mean (F)[c] Range[c]	Number Non-Routine Results[e]
Background Radiation (TLD) (mR/week)	Gamma 188	0.5	1.4 (184/184) (0.8-2.0)	OTD-S-(I) 0.65 @ 163°	1.6 (4/4) 1.5-1.7	1.2(4/4) (0.9-1.4)	0
Airborne Particulates (pCi/m^3)	GB 312	0.005	0.026 (260/260) (0.008-0.059)	OAP-B-(I) 0.59 mi. @207°	0.026 (52/52) (0.012-0.059)	0.026 (52/52) (0.012-0.050)	0
	GS 24						
	Cs-134	0.001	< LLD	-	-	< LLD	0
	Cs-137	0.001	< LLD	-	-	< LLD	0
	Other Gammas	0.001	< LLD	-	-	< LLD	0
Airborne Iodine (pCi/m3)	I-131 318	0.07	< LLD	-	-	< LLD	0
Milk (pCi/L)	I-131 27	0.5	< LLD	-	-	< LLD	0
	GS 27			OFM-G-(I)			
	K-40	150	1803 (8/8) (1598-2014)	Stangl Farm 3.4 mi. @ 369 °	1803 (8/8) (1598-2014)	1347 (19/19) (1189-1507)	0
	Cs-134	15	< LLD	-	-	< LLD	0
	Cs-137	15	< LLD	-	-	< LLD	0
	Other Gammas	15	< LLD	-	-	< LLD	0
Ground Water (pCi/L)	GB 16		6.2 (12/12) (2.5-8.1)	OGW-F-(I) Lomp Acreage	7.2 (4/4) (6.4-7.5)	7.0 (4/4) (6.5-7.4)	0
	H-3 16	300	< LLD	0.65 mi.@163°	-	< LLD	0
	Sr-90 16	0.7	< LLD	-	-	< LLD	0
	GS 16						
(pCi/L)	Cs-134	15	< LLD	-	-	< LLD	0
	Cs-137	18	< LLD	-	-	< LLD	0
	Other Gammas	15	< LLD	-	-	< LLD	0
Surface Water (pCi/L)	GS 36						
	Cs-134	15	< LLD	-	-	< LLD	0
	Cs-137	18	< LLD	-	-	< LLD	0
	Other Gammas	15	< LLD	-	-	< LLD	0
	H-3 12	300	< LLD	-	-	< LLD	0

Table 2.1 Radiological Environmental Monitoring Program Summary | Reporting Period | January-December, 2016

Name of Facility	Fort Calhoun Nuclear Power Station - Unit 1	Docket No.	50-285
Location of Facility	Washington, Nebraska (County, State)		

Sample Type (Units)	Type and Number of Analyses[a]	LLD[b]	Indicator Locations Mean (F)[c] Range[c]	Location with Highest Annual Mean		Control Locations Mean (F)[c] Range[c]	Number Non-Routine Results[e]
				Location[d]	Mean (F)[c] Range[c]		
Fish (pCi/g wet)	GS 5						
	Mn-54	0.026	< LLD	-	-	< LLD	0
	Co-58	0.027	< LLD	-	-	< LLD	0
	Co-60	0.023	< LLD	-	-	< LLD	0
	Fe-59	0.118	< LLD	-	-	< LLD	0
	Zn-65	0.050	< LLD	-	-	< LLD	0
	Ru-103	0.058	< LLD	-	-	< LLD	0
	Cs-134	0.026	< LLD	-	-	< LLD	0
	Cs-137	0.022	< LLD	-	-	< LLD	0
Sediment pCi/g dry	GS 4						
	Mn-54	0.040	< LLD	-	-	< LLD	0
	Co-58	0.065	< LLD	-	-	< LLD	0
	Co-60	0.026	< LLD	-	-	< LLD	0
	Fe-59	0.111	< LLD	-	-	< LLD	0
	Zn-65	0.113	< LLD	-	-	< LLD	0
	Cs-134	0.027	< LLD	-	-	< LLD	0
	Cs-137	0.044	< LLD	-	-	< LLD	0
Food Crops (pCi/g wet)	GS 9						
	Mn-54	0.011	< LLD	-	-	< LLD	0
	Co-58	0.012	< LLD	-	-	< LLD	0
	Co-60	0.011	< LLD	-	-	< LLD	0
	Fe-59	0.030	< LLD	-	-	< LLD	0
	Zn-65	0.022	< LLD	-	-	< LLD	0
	Zr-Nb-95	0.019	< LLD	-	-	< LLD	0
	Cs-134	0.014	< LLD	-	-	< LLD	0
	Cs-137	0.016	< LLD	-	-	< LLD	0
	Ba-La-140	0.024	< LLD	-	-	< LLD	0
Vegatation (pCi/g wet)	GS 11						
	Mn-54	0.036	< LLD	-	-	< LLD	0
	Co-58	0.034	< LLD	-	-	< LLD	0
Pasture grass	Co-60	0.034	< LLD	-	-	< LLD	0
in lieu of milk	Fe-59	0.062	< LLD	-	-	< LLD	0
	Zn-65	0.053	< LLD	-	-	< LLD	0
	Zr-Nb-95	0.036	< LLD	-	-	< LLD	0
	Cs-134	0.035	< LLD	-	-	< LLD	0
	Cs-137	0.036	< LLD	-	-	< LLD	0
	Ba-La-140	0.040	< LLD	-	-	< LLD	0

[a] GB = gross beta, GS = gamma scan.

[b] LLD = nominal lower limit of detection based on a 95% confidence level.

[c] Mean and range are based on detectable measurements only (i.e., >LLD) Fraction of detectable measurements at specified locations is indicated in parentheses (F).

[d] Locations are specified: (1) by code, (2) by name, and (3) by distance and direction relative to the Reactor Containment Building.

[e] Non-routine results are those which exceed ten times the control station value. If no control station value is available, the result is considered non-routine if it exceeds the typical pre-operational value for the medium or location.

Table 3.0 Listing of Missed Samples (samples scheduled but not collected)

Sample Type	Date	Location	Reason
			NONE

2016
Environmental Land Use Survey Report

Sector	Dir	Land Use	Owner	Miles	Meters	Deg	Survey Technique	Age Group: Adult	Teen	Child	Infant	XOQ	DOQ	Remarks
A	N	RESIDENCE	WRIGHT	4.36	7016.74	351	INTERVIEW	X		X		1.10E-07	4.50E-10	
		MILK ANIMAL												
		MEAT ANIMAL												
		VEGETATION												
		GROUNDWATER	WRIGHT	4.36	7016.74	351	INTERVIEW	X		X				
B	NNE	RESIDENCE	RAND,J	1.93	3106.03	12	MAIL SURVEY	X				5.60E-07	2.20E-09	
		MILK ANIMAL												
		MEAT ANIMAL												
		VEGETATION	SHEPARD	2.23	3588.84	16	INTERVIEW	X		X		3.70E-07	1.49E-09	
		GROUNDWATER	RAND,J	1.93	3106.03	12	MAIL SURVEY	X						
C	NE	RESIDENCE	HANSEN,M	1.52	2446.20	42	MAIL SURVEY	X		X		1.00E-06	2.90E-09	
		MILK ANIMAL												
		MEAT ANIMAL												
		VEGETATION	HANSEN,M	1.52	2446.20	42	MAIL SURVEY	X		X		1.00E-06	2.90E-09	
		GROUNDWATER	HANSEN,M	1.52	2446.20	42	MAIL SURVEY	X		X				
D	ENE	RESIDENCE	MEADE,G	4.79	7708.76	63	MAIL SURVEY	X				8.70E-08	1.30E-10	
		MILK ANIMAL												
		MEAT ANIMAL												
		VEGETATION	MEADE,G	4.79	7708.76	63	MAIL SURVEY	X				8.70E-08	1.30E-10	
		GROUNDWATER	MEADE,G	4.79	7708.76	63	MAIL SURVEY	X						
E	E	RESIDENCE	LOVE	4.67	7515.64	89	MAIL SURVEY	X	X			9.80E-08	1.80E-10	
		MILK ANIMAL												
		MEAT ANIMAL	BROTHERS,D	4.91	7901.88	90	INTERVIEW	X				9.20E-08	1.60E-10	
		VEGETATION	LOVE	4.67	7515.64	89	MAIL SURVEY	X	X			9.80E-08	1.80E-10	
		GROUNDWATER	LOVE	4.67	7515.64	89	MAIL SURVEY	X	X					
F	ESE	RESIDENCE	WILSON ISLAND	4.22	6791.43	121	MAIL SURVEY	X		X		1.30E-07	2.90E-10	
		MILK ANIMAL												
		MEAT ANIMAL												
		VEGETATION	WILSON ISLAND	4.22	6791.43	121	MAIL SURVEY	X		X		1.30E-07	2.90E-10	
		GROUNDWATER	WILSON ISLAND	4.22	6791.43	121	MAIL SURVEY	X		X				

2016
Environmental Land Use Survey Report

Sector	Dir	Land Use	Owner	Miles	Meters	Deg	Survey Technique	Age Group: Adult	Teen	Child	Infant	XOQ	DOQ	Remarks
G	SE	RESIDENCE	CARTER,T	1.67	2687.60	145	INTERVIEW	X				6.20E-07	3.60E-09	
		MILK ANIMAL												
		MEAT ANIMAL												
		VEGETATION	KALIN,W	1.74	2800.26	145	MAIL SURVEY	X				5.80E-07	3.30E-09	
		GROUNDWATER	KALIN,W	1.74	2800.26	145	MAIL SURVEY	X						OGW-A-(I) SMITH FARM RETAINED TO MAINTAIN HISTORICAL DATA FROM PRE-OP TO PRESENT
H	SSE	RESIDENCE	LOMP	.65	1046.07	163	MAIL SURVEY	X				6.60E-06	6.10E-08	
		MILK ANIMAL												
		MEAT ANIMAL	HINELINE,R	1.82	2929.01	148	INTERVIEW	X				6.20E-07	5.30E-09	
		VEGETATION	LOMP	.65	1046.07	163	MAIL SURVEY	X				6.60E-06	6.10E-08	
		GROUNDWATER	LOMP	.65	1046.07	163	MAIL SURVEY	X						
J	S	RESIDENCE	DOWLER	.73	1174.82	175	MAIL SURVEY	X				2.90E-06	1.90E-08	
		MILK ANIMAL	STANGL	3.44	5536.14	169	INTERVIEW	X	X	X		7.10E-08	3.80E-10	
		MEAT ANIMAL	PRATT	2.48	3991.17	170	INTERVIEW	X		X		1.41E-07	8.40E-10	
		VEGETATION	DOWLER	.73	1174.82	175	MAIL SURVEY	X				2.90E-06	1.90E-08	
		GROUNDWATER	DOWLER	.73	1174.82	175	MAIL SURVEY	X						
K	SSW	RESIDENCE	D.MILLER	.65	1046.07	203	INTERVIEW	X				2.70E-06	1.10E-08	
		MILK ANIMAL												
		MEAT ANIMAL	D.MILLER	.65	1046.07	203	INTERVIEW	X				2.70E-06	1.10E-08	
		VEGETATION	T. DEIN	2.00	3218.69	193	INTERVIEW	X		X		1.90E-07	7.30E-10	
		GROUNDWATER	D.MILLER	.65	1046.07	203	INTERVIEW	X						
L	SW	RESIDENCE	ROBERTSON,D	.73	1174.82	224	MAIL SURVEY	X				2.60E-06	8.40E-09	
		MILK ANIMAL												
		MEAT ANIMAL	RYDER	.76	1223.10	227	MAIL SURVEY	X				2.40E-06	7.70E-09	
		VEGETATION	BURGIN	1.43	2301.36	223	MAIL SURVEY	X				5.00E-07	1.50E-09	
		GROUNDWATER	ROBERTSON,D	.73	1174.82	224	MAIL SURVEY	X						
M	WSW	RESIDENCE	BENSEN,M	1.06	1705.90	257	INTERVIEW	X				1.40E-06	4.20E-09	
		MILK ANIMAL												
		MEAT ANIMAL	FREDERICK	2.18	3508.37	258	MAIL SURVEY	X				2.40E-07	6.40E-10	
		VEGETATION	THOMAS	1.13	1818.56	259	INTERVIEW	X				1.10E-06	3.40E-09	
		GROUNDWATER	BENSEN,M	1.06	1705.90	257	INTERVIEW	X						

2016
Environmental Land Use Survey Report

Sector	Dir	Land Use	Owner	Miles	Meters	Deg	Survey Technique	Age Group: Adult	Teen	Child	Infant	XOQ	DOQ	Remarks
N	W	RESIDENCE	NIELSEN	1.20	1931.21	263	INTERVIEW	X				1.30E-06	4.20E-09	
		MILK ANIMAL												
		MEAT ANIMAL	BREITHAUPT	2.28	3669.30	261	INTERVIEW	X				2.80E-07	8.10E-10	
		VEGETATION	ASMUSSEN,G	1.30	2092.15	270	MAIL SURVEY	X				1.00E-06	3.30E-09	
		GROUNDWATER	ASMUSSEN,G	1.30	2092.15	270	MAIL SURVEY	X						
P	WNW	RESIDENCE	STONE	2.60	4184.29	283	INTERVIEW	X				2.50E-07	8.50E-10	
		MILK ANIMAL												
		MEAT ANIMAL	BROWN	4.59	7386.89	288	MAIL SURVEY	X				9.60E-08	2.60E-10	
		VEGETATION	TABOR	2.65	4264.76	285	MAIL SURVEY	X	X	X		2.40E-07	8.00E-10	
		GROUNDWATER	STONE	2.60	4184.29	283	INTERVIEW	X						
Q	NW	RESIDENCE	HANSEN,R	2.40	3862.43	318	INTERVIEW	X				5.00E-07	1.90E-09	
		MILK ANIMAL												
		MEAT ANIMAL												
		VEGETATION	HANSEN,R	2.40	3862.43	318	INTERVIEW	X				5.00E-07	1.90E-09	
		GROUNDWATER	HANSEN,R	2.40	3862.43	318	INTERVIEW	X						
R	NNW	RESIDENCE	BATTIATO	2.08	3347.44	330	CITY REGISTER	X				6.40E-07	3.50E-09	
		MILK ANIMAL												
		MEAT ANIMAL												
		VEGETATION	SONDERUP	3.73	6002.85	328	INTERVIEW	X				1.70E-07	7.90E-10	
		GROUNDWATER	SONDERUP	3.73	6002.85	328	INTERVIEW	X						

Performed by__________ Reviewed by__________

Review of Environmental Inc., Quality Assurance Program

Fort Calhoun Station contracts with Environmental Inc., Midwest Laboratory (vendor lab) to perform radioanalysis of environmental samples. Environmental Inc. participates in inter-laboratory comparison (cross-check) programs as part of its quality control program. These programs are operated by such agencies as the Department of Energy, which supply blind-spike samples such as milk or water containing concentrations of radionuclides unknown to the testing laboratory. This type of program provides an independent check of the analytical laboratory's procedures and processes, and provides indication of possible weaknesses. In addition, Environmental Inc. has its own in-house QA program of blind-spike and duplicate analyses.

Vendor in-house spike sampling was performed without a failure and in-house blank analyses were performed within acceptable ranges.

DOE water sample MAW-989 dated 2/1/2016, failed for Co-57. The laboratory properly identified the Sn-75 interfering peak in the vicinity of Co-57 and stated so in the comment field. MAPEP requires results to be reported as an activity with an uncertainty. Since the calculated uncertainty was less than the activity MAPEP interpreted, they submitted result as a "false positive" resulting in a failure.

ERA water sample, ERW-1394, failed for Ba-133 on 4/4/2016. The investigation into ERW-1394 failure for Ba-133 lead to no known reason as to why the unacceptable results occurred. The reanalysis created acceptable results. The FCS REMP program does not perform Ba-133 analyses on water samples.

Three failures occurred in ERA soil sample MASO-4780 in August 2016 (Ni-63, U-233/234 and U-238). Ni-63 passed MAPEP soil testing and reanalysis with a smaller aliquot. Vendor lab is investigating improved techniques for analyzing samples with complex matrices. MAPEP states that U-233/234 & U-238 were analyzed the soluble fraction versus total and the HF acid treatment cannot assure complete dissolution. Results report for the soluble fraction only were performed correctly. The lab subsequently passed the ERA test for U-233/234 & 238.

No test results failed both the ERA and DOE methodologies for a given sample type. Reanalysis produced acceptable results. The ordering of additional tests and successful testing after corrections were applied, visibly demonstrates the vendor's commitment to reporting and resolving deficiencies.

These results indicate the vendor's ability to self-identify and correct any deviations from acceptable or expected results. The test results had no impact on Fort Calhoun samples and were documented as such by the vendor.

ATI Environmental, Inc.
Midwest Laboratory
700 Landwehr Road • Northbrook, IL 60062-2310
phone (847) 564-0700 • fax (847) 564-4517

APPENDIX A

INTERLABORATORY COMPARISON PROGRAM RESULTS

NOTE: Environmental Inc., Midwest Laboratory participates in intercomparison studies administered by Environmental Resources Associates, and serves as a replacement for studies conducted previously by the U.S. EPA Environmental Monitoring Systems Laboratory, Las Vegas, Nevada. Results are reported in Appendix A. TLD Intercomparison results, in-house spikes, blanks, duplicates and mixed analyte performance evaluation program results are also reported. Appendix A is updated four times a year; the complete Appendix is included in March, June, September and December monthly progress reports only.

January, 2016 through December, 2016

Appendix A

Interlaboratory Comparison Program Results

Environmental, Inc., Midwest Laboratory has participated in interlaboratory comparison (crosscheck) programs since the formulation of it's quality control program in December 1971. These programs are operated by agencies which supply environmental type samples containing concentrations of radionuclides known to the issuing agency but not to participant laboratories. The purpose of such a program is to provide an independent check on a laboratory's analytical procedures and to alert it of any possible problems.

Participant laboratories measure the concentration of specified radionuclides and report them to the issuing agency. Several months later, the agency reports the known values to the participant laboratories and specifies control limits. Results consistently higher or lower than the known values or outside the control limits indicate a need to check the instruments or procedures used.

Results in Table A-1 were obtained through participation in the RAD PT Study Proficiency Testing Program administered by Environmental Resources Associates, serving as a replacement for studies conducted previously by the U.S. EPA Environmental Monitoring Systems Laboratory, Las Vegas, Nevada.

Table A-2 lists results for thermoluminescent dosimeters (TLDs), via irradiation and evaluation by the University of Wisconsin-Madison Radiation Calibration Laboratory at the University of Wisconsin Medical Radiation Research Center.

Table A-3 lists results of the analyses on in-house "spiked" samples for the past twelve months. All samples are prepared using NIST traceable sources. Data for previous years available upon request.

Table A-4 lists results of the analyses on in-house "blank" samples for the past twelve months. Data for previous years available upon request.

Table A-5 lists REMP specific analytical results from the in-house "duplicate" program for the past twelve months. Acceptance is based on the difference of the results being less than the sum of the errors. Complete analytical data for duplicate analyses is available upon request.

The results in Table A-6 were obtained through participation in the Mixed Analyte Performance Evaluation Program.

Results in Table A-7 were obtained through participation in the MRAD PT Study Proficiency Testing Program administered by Environmental Resources Associates, serving as a replacement for studies conducted previously by the Environmental Measurement Laboratory Quality Assessment Program (EML).

Attachment A lists the laboratory precision at the 1 sigma level for various analyses. The acceptance criteria in Table A-3 is set at ± 2 sigma.

Out-of-limit results are explained directly below the result.

Attachment A

ACCEPTANCE CRITERIA FOR "SPIKED" SAMPLES

LABORATORY PRECISION: ONE STANDARD DEVIATION VALUES FOR VARIOUS ANALYSES[a]

Analysis	Level	One standard deviation for single determination
Gamma Emitters	5 to 100 pCi/liter or kg	5.0 pCi/liter
	> 100 pCi/liter or kg	5% of known value
Strontium-89[b]	5 to 50 pCi/liter or kg	5.0 pCi/liter
	> 50 pCi/liter or kg	10% of known value
Strontium-90[b]	2 to 30 pCi/liter or kg	5.0 pCi/liter
	> 30 pCi/liter or kg	10% of known value
Potassium-40	≥ 0.1 g/liter or kg	5% of known value
Gross alpha	≤ 20 pCi/liter	5.0 pCi/liter
	> 20 pCi/liter	25% of known value
Gross beta	≤ 100 pCi/liter	5.0 pCi/liter
	> 100 pCi/liter	5% of known value
Tritium	≤ 4,000 pCi/liter	$\pm 1\sigma = 169.85 \times (\text{known})^{0.0933}$
	> 4,000 pCi/liter	10% of known value
Radium-226,-228	≥ 0.1 pCi/liter	15% of known value
Plutonium	≥ 0.1 pCi/liter, gram, or sample	10% of known value
Iodine-131, Iodine-129[b]	≤ 55 pCi/liter	6 pCi/liter
	> 55 pCi/liter	10% of known value
Uranium-238, Nickel-63[b] Technetium-99[b]	≤ 35 pCi/liter	6 pCi/liter
	> 35 pCi/liter	15% of known value
Iron-55[b]	50 to 100 pCi/liter	10 pCi/liter
	> 100 pCi/liter	10% of known value
Other Analyses[b]	---	20% of known value

[a] From EPA publication, "Environmental Radioactivity Laboratory Intercomparison Studies Program", Fiscal Year, 1981-1982, EPA-600/4-81-004.

[b] Laboratory limit.

TABLE A-1. Interlaboratory Comparison Crosscheck program, Environmental Resource Associates (ERA)[a].

RAD study

Lab Code	Date	Concentration (pCi/L)				
		Analysis	Laboratory Result	ERA Result	Control Limits	Acceptance
ERW-1392	4/4/2016	Sr-89	43.5 ± 4.3	48.2	37.8 - 55.6	Pass
ERW-1392	4/4/2016	Sr-90	27.5 ± 1.9	28.5	20.7 - 33.1	Pass
ERW-1394 [b]	4/4/2016	Ba-133	65.2 ± 3.8	58.8	48.7 - 64.9	Fail
ERW-1394 [c]	4/4/2016	Ba-133	57.8 ± 5.3	58.8	48.7 - 64.9	Pass
ERW-1394	4/4/2016	Cs-134	43.7 ± 3.0	43.3	34.6 - 47.6	Pass
ERW-1394	4/4/2016	Cs-137	86.1 ± 5.3	78.4	70.6 - 88.9	Pass
ERW-1394	4/4/2016	Co-60	108 ± 44	102	91.8 - 114	Pass
ERW-1394	4/4/2016	Zn-65	240 ± 13	214	193 - 251	Pass
ERW-1397	4/4/2016	Gr. Alpha	52.0 ± 2.2	62.7	32.9 - 77.8	Pass
ERW-1397	4/4/2016	Gr. Beta	33.9 ± 1.2	39.2	26.0 - 46.7	Pass
ERW-1400	4/4/2016	I-131	24.7 ± 0.6	26.6	22.1 - 31.3	Pass
ERW-1402	4/4/2016	Ra-226	15.6 ± 0.5	15.2	11.3 - 17.4	Pass
ERW-1402	4/4/2016	Ra-228	5.28 ± 0.76	5.19	3.12 - 6.93	Pass
ERW-1403	4/4/2016	Uranium	4.02 ± 0.42	4.64	3.39 - 5.68	Pass
ERW-1405	4/4/2016	H-3	8,150 ± 270	7,840	6,790 - 8,620	Pass
SPW-2845	7/7/2015	Ba-133	60.3 ± 5.7	64.7	53.9 - 71.2	Pass
SPW-2845	7/7/2015	Cs-134	48.8 ± 9.3	50.1	40.3 - 55.1	Pass
SPW-2845	7/7/2015	Cs-137	101 ± 8	89.8	80.8 - 101	Pass
SPW-2845	7/7/2015	Co-60	65.1 ± 5.8	59.9	53.9 - 68.4	Pass
SPW-2845	7/7/2015	Zn-65	288 ± 29	265	238 - 310	Pass
ERW-3485	7/11/2016	Sr-89	43.3 ± 6.5	53.3	42.3 - 60.9	Pass
ERW-3485	7/11/2016	Sr-90	39.0 ± 2.8	39.2	28.8 - 45.1	Pass
ERW-3487	7/11/2016	Ba-133	83.3 ± 4.9	82.9	69.7 - 91.2	Pass
ERW-3487	7/11/2016	Cs-134	62.5 ± 4.4	65.3	53.1 - 71.8	Pass
ERW-3487	7/11/2016	Cs-137	98.1 ± 5.6	95.2	85.7 - 107	Pass
ERW-3487	7/11/2016	Co-60	122 ± 5	117	105 - 131	Pass
ERW-3487	7/11/2016	Zn-65	124 ± 9	113	102 - 134	Pass
ERW-3490	7/11/2016	Gr. Alpha	46.6 ± 2.2	48.1	25.0 - 60.5	Pass
ERW-3490	7/11/2016	Gr. Beta	26.8 ± 1.1	28.6	18.2 - 36.4	Pass
ERW-3492	7/11/2016	I-131	23.7 ± 1.0	24.9	20.7 - 29.5	Pass
ERW-3493	7/11/2016	Ra-226	12.9 ± 0.4	12.3	9.2 - 14.2	Pass
ERW-3493	7/11/2016	Ra-228	5.8 ± 0.8	5.8	3.5 - 7.6	Pass
ERW-3493	7/11/2016	Uranium	32.8 ± 0.8	25.2	28.4 - 39.3	Pass
ERW-3495	7/11/2016	H-3	12,400 ± 334	12,400	10,800 - 13,600	Pass

[a] Results obtained by Environmental, Inc., Midwest Laboratory as a participant in the crosscheck program for proficiency testing in drinking water conducted by Environmental Resources Associates (ERA).

[b] No reason determined for failure of Ba-133 result.

[c] The result of reanalysis (Compare to original result, footnoted "b" above).

TABLE A-2. Thermoluminescent Dosimetry, (TLD, $CaSO_4$: Dy Cards). [a b]

				mrem		
Lab Code	Irradiation Date	Description	Delivered Dose	Reported Dose	Performance Quotient (P) [c]	Acceptance [d]
Environmental, Inc.		Group 1				
2016-1	10/7/2016	Spike 1	135.0	148.3	0.10	
2016-1	10/7/2016	Spike 2	135.0	144.3	0.07	
2016-1	10/7/2016	Spike 3	135.0	133.2	-0.01	
2016-1	10/7/2016	Spike 4	135.0	139.6	0.03	
2016-1	10/7/2016	Spike 5	135.0	128.4	-0.05	
2016-1	10/7/2016	Spike 6	135.0	123.9	-0.08	
2016-1	10/7/2016	Spike 7	135.0	124.0	-0.08	
2016-1	10/7/2016	Spike 8	135.0	121.5	-0.10	
2016-1	10/7/2016	Spike 9	135.0	148.3	0.10	
2016-1	10/7/2016	Spike 10	135.0	126.8	-0.06	
2016-1	10/7/2016	Spike 11	135.0	123.3	-0.09	
2016-1	10/7/2016	Spike 12	135.0	137.9	0.02	
2016-1	10/7/2016	Spike 13	135.0	126.0	-0.07	
2016-1	10/7/2016	Spike 14	135.0	127.2	-0.06	
2016-1	10/7/2016	Spike 15	135.0	144.5	0.07	
2016-1	10/7/2016	Spike 16	135.0	140.5	0.04	
2016-1	10/7/2016	Spike 17	135.0	146.0	0.08	
2016-1	10/7/2016	Spike 18	135.0	127.7	-0.05	
2016-1	10/7/2016	Spike 19	135.0	146.8	0.09	
2016-1	10/7/2016	Spike 20	135.0	122.6	-0.09	
2016-1	10/7/2016	Spike 21	135.0	108.6	-0.20	
2016-1	10/7/2016	Spike 22	135.0	119.6	-0.11	
2016-1	10/7/2016	Spike 23	135.0	135.1	0.00	
2016-1	10/7/2016	Spike 24	135.0	116.2	-0.14	
2016-1	10/7/2016	Spike 25	135.0	118.9	-0.12	
2016-1	10/7/2016	Spike 26	135.0	128.5	-0.05	
2016-1	10/7/2016	Spike 27	135.0	115.6	-0.14	
2016-1	10/7/2016	Spike 28	135.0	126.4	-0.06	
2016-1	10/7/2016	Spike 29	135.0	115.0	-0.15	
2016-1	10/7/2016	Spike 30	135.0	147.3	0.09	
Mean (Spike 1-30)				130.4	0.03	Pass
Standard Deviation (Spike 1-30)				11.5	0.09	Pass

[a] Table A-2 assumes 1 roentgen = 1 rem (NRC -Health Physics Questions and Answers 10 CFR Part 20 - Question 96 - Page Last Reviewed/Updated Thursday, October 01, 2015).

[b] TLD's were irradiated by the University of Wisconsin-Madison Radiation Calibration Laboratory following ANSI N13.37 protocol from a known air kerma rate. TLD's were read and the results were submitted by Environmental Inc. to the University of Wisconsin-Madison Radiation Calibration Laboratory for comparison to the delivered dose.

[c] Performance Quotient (P) is calculated as ((reported dose - conventially true value) ÷ conventially true value) where the conventially true value is the delivered dose.

[d] Acceptance is achieved when neither the absolute value of mean of the P values, nor the standard deviation of the P values exceed 0.15.

TABLE A-2 Thermoluminescent Dosimetry, (TLD, $CaSO_4$: Dy Cards). [a b]

				mrem		
Lab Code	Irradiation Date	Description	Delivered Dose	Reported Dose	Performance [c] Quotient (P)	Acceptance [d]
Environmental, Inc.		Group 2				
2016-2	10/7/2016	Spike 31	87.0	83.0	-0.05	
2016-2	10/7/2016	Spike 32	87.0	88.3	0.01	
2016-2	10/7/2016	Spike 33	87.0	83.1	-0.04	
2016-2	10/7/2016	Spike 34	87.0	81.4	-0.06	
2016-2	10/7/2016	Spike 35	87.0	78.9	-0.09	
2016-2	10/7/2016	Spike 36	87.0	80.3	-0.08	
2016-2	10/7/2016	Spike 37	87.0	101.1	0.16	
2016-2	10/7/2016	Spike 38	87.0	78.3	-0.10	
2016-2	10/7/2016	Spike 39	87.0	86.6	0.00	
2016-2	10/7/2016	Spike 40	87.0	81.8	-0.06	
2016-2	10/7/2016	Spike 41	87.0	84.8	-0.03	
2016-2	10/7/2016	Spike 42	87.0	79.9	-0.08	
2016-2	10/7/2016	Spike 43	87.0	80.8	-0.07	
2016-2	10/7/2016	Spike 44	87.0	80.2	-0.08	
2016-2	10/7/2016	Spike 45	87.0	82.7	-0.05	
2016-2	10/7/2016	Spike 46	87.0	104.0	0.20	
2016-2	10/7/2016	Spike 47	87.0	86.1	-0.01	
2016-2	10/7/2016	Spike 48	87.0	104.0	0.20	
2016-2	10/7/2016	Spike 49	87.0	86.1	-0.01	
2016-2	10/7/2016	Spike 50	87.0	90.8	0.04	
2016-2	10/7/2016	Spike 51	87.0	85.7	-0.01	
2016-2	10/7/2016	Spike 52	87.0	86.5	-0.01	
2016-2	10/7/2016	Spike 53	87.0	86.4	-0.01	
2016-2	10/7/2016	Spike 54	87.0	92.6	0.06	
2016-2	10/7/2016	Spike 55	87.0	88.6	0.02	
2016-2	10/7/2016	Spike 56	87.0	78.9	-0.09	
2016-2	10/7/2016	Spike 57	87.0	82.6	-0.05	
2016-2	10/7/2016	Spike 58	87.0	80.6	-0.07	
2016-2	10/7/2016	Spike 59	87.0	89.9	0.03	
2016-2	10/7/2016	Spike 60	87.0	85.0	-0.02	
Mean (Spike 31-60)				86.0	0.01	Pass
Standard Deviation (Spike 31-60)				6.9	0.08	Pass

[a] Table A-2 assumes 1 roentgen = 1 rem (NRC -Health Physics Questions and Answers 10 CFR Part 20 - Question 96 - Page Last Reviewed/Updated Thursday, October 01, 2015).

[b] TLD's were irradiated by the University of Wisconsin-Madison Radiation Calibration Laboratory following ANSI N13.37 protocol from a known air kerma rate. TLD's were read and the results were submitted by Environmental Inc. to the University of Wisconsin-Madison Radiation Calibration Laboratory for comparison to the delivered dose.

[c] Performance Quotient (P) is calculated as ((reported dose - conventially true value) ÷ conventially true value) where the conventially true value is the delivered dose.

[d] Acceptance is achieved when neither the absolute value of mean of the P values, nor the standard deviation of the P values exceed 0.15.

TABLE A-3. In-House "Spiked" Samples

Lab Code [b]	Date	Analysis	Concentration [a]			
			Laboratory results 2s, n=1 [c]	Known Activity	Control Limits [d]	Acceptance
SPW-290	1/21/2016	Sr-90	38.6 ± 1.5	37.3	22.4 - 52.2	Pass
SPW-292	1/21/2016	Sr-90	35.8 ± 1.6	37.3	22.4 - 52.2	Pass
SPW-294	1/21/2016	C-14	4,689 ± 18	4,735	2,841 - 6,629	Pass
SPW-414	2/1/2016	Ra-228	18.4 ± 2.2	17.7	10.6 - 24.8	Pass
W-020416	2/4/2016	Gr. Alpha	20.8 ± 0.4	20.1	12.0 - 28.1	Pass
W-020416	2/4/2016	Gr. Beta	29.7 ± 0.3	28.9	17.3 - 40.4	Pass
W-021716	2/17/2016	Ra-226	17.9 ± 0.5	16.7	10.0 - 23.4	Pass
W-030716	3/7/2016	Gr. Alpha	16.3 ± 0.8	20.1	12.0 - 28.1	Pass
W-030716	3/7/2016	Gr. Beta	27.0 ± 0.7	28.9	17.3 - 40.4	Pass
SPDW-70046	3/29/2016	Ra-226	13.4 ± 0.4	16.7	10.0 - 23.4	Pass
SPW-1163	3/22/2016	Ra-228	4.2 ± 0.7	4.4	2.6 - 6.2	Pass
SPW-1235	3/29/2016	Gr. Alpha	21.0 ± 0.4	20.1	12.0 - 28.1	Pass
SPW-1235	3/29/2016	Gr. Beta	29.4 ± 0.3	28.9	17.3 - 40.4	Pass
SPW-1739	4/21/2016	Ra-228	16.2 ± 2.0	17.7	10.6 - 24.8	Pass
SPW-2052	4/21/2016	Ra-226	16.0 ± 0.5	16.7	10.0 - 23.4	Pass
W-042616	4/21/2016	Fe-55	1,519 ± 61	1,482	889 - 2,075	Pass
SPW-1823	4/23/2016	Gr. Alpha	21.0 ± 0.4	20.1	12.0 - 28.1	Pass
SPW-1823	4/23/2016	Gr. Beta	26.6 ± 0.3	28.9	17.3 - 40.4	Pass
SPW-1998	4/29/2016	Cs-134	35.9 ± 6.0	36.2	21.7 - 50.6	Pass
SPW-1998	4/29/2016	Cs-137	82.5 ± 7.6	71.9	43.1 - 100.6	Pass
SPW-2097	5/3/2016	H-3	3,349 ± 184	3,280	1,968 - 4,592	Pass
SPW-2132	5/4/2016	H-3	3,174 ± 178	3,280	1,968 - 4,592	Pass
SPW-2229	5/7/2016	H-3	3,182 ± 179	3,280	1,968 - 4,592	Pass
SPW-2313	5/13/2016	H-3	3,183 ± 179	3,280	1,968 - 4,592	Pass
SPW-2341	5/13/2016	H-3	3,201 ± 178	3,280	1,968 - 4,592	Pass
SPW-2374	5/14/2016	H-3	3,037 ± 175	3,280	1,968 - 4,592	Pass
SPW-2411	5/17/2016	Sr-90	37.3 ± 1.6	37.3	22.4 - 52.2	Pass
SPW-2455	5/19/2016	Gr. Alpha	19.3 ± 0.4	20.1	12.0 - 28.1	Pass
SPW-2455	5/19/2016	Gr. Beta	28.6 ± 0.3	28.9	17.3 - 40.4	Pass
SPW-2457	5/19/2016	U-238	48.2 ± 2.4	41.7	25.0 - 58.4	Pass
SPW-2504	5/20/2016	H-3	3,181 ± 178	3,280	1,968 - 4,592	Pass
SPW-2528	5/23/2016	H-3	2,998 ± 175	3,280	1,968 - 4,592	Pass
SPW-2566	5/24/2016	Gr. Alpha	19.8 ± 0.5	20.1	12.0 - 28.1	Pass
SPW-2566	5/24/2016	Gr. Beta	30.4 ± 0.3	28.9	17.3 - 40.4	Pass
W-053116	4/29/2016	Cs-134	34.0 ± 5.0	36.2	21.7 - 50.6	Pass
W-053116	4/29/2016	Cs-137	78.8 ± 7.0	71.9	43.1 - 100.6	Pass
SPW-2704	6/1/2016	Sr-90	38.0 ± 1.6	37.3	22.4 - 52.2	Pass
SPW-2719	6/2/2016	Ra-228	18.1 ± 2.1	17.7	10.6 - 24.8	Pass
SPW-2749	6/3/2016	H-3	3,197 ± 180	3,280	1,968 - 4,592	Pass
SPW-2843	6/7/2016	H-3	3,133 ± 179	3,280	1,968 - 4,592	Pass
SPW-3227	6/17/2016	Ra-226	18.6 ± 0.4	16.7	10.0 - 23.4	Pass
W-061716	4/29/2016	Cs-134	37.3 ± 8.2	36.2	21.7 - 50.6	Pass
W-061716	4/29/2016	Cs-137	79.7 ± 10.8	71.9	43.1 - 100.6	Pass
SPW-3240	6/28/2016	Gr. Alpha	25.3 ± 0.5	20.1	12.0 - 28.1	Pass
SPW-3240	6/28/2016	Gr. Beta	27.1 ± 0.3	28.9	17.3 - 40.4	Pass

TABLE A-3. In-House "Spiked" Samples

Lab Code [b]	Date	Analysis	Concentration [a] Laboratory results 2s, n=1 [c]	Known Activity	Control Limits [d]	Acceptance
SPW-3241	7/1/2016	H-3	8,821 ± 283	8,650	5,190 - 12,110	Pass
SPW-3309	7/1/2016	H-3	8,619 ± 278	8,650	5,190 - 12,110	Pass
SPW-3313	7/1/2016	Ra-228	16.6 ± 2.0	17.7	10.6 - 24.8	Pass
SPW-3328	7/6/2016	Sr-89	13.4 ± 9.2	14.8	8.9 - 20.7	Pass
SPW-3328	7/6/2016	Sr-90	12.3 ± 1.3	11.4	6.8 - 16.0	Pass
SPAP-3365	7/7/2016	Gr. Beta	39.7 ± 0.1	42.2	25.3 - 59.0	Pass
SPAP-3367	7/7/2016	Cs-134	1.2 ± 0.7	1.2	0.7 - 1.7	Pass
SPAP-3367	7/7/2016	Cs-137	94.4 ± 2.8	94.0	56.4 - 131.6	Pass
SPW-3370	7/7/2016	C-14	4,444 ± 17	4,735	2,841 - 6,629	Pass
SPW-3373	7/7/2016	Ni-63	446 ± 5	401	241 - 561	Pass
SPW-3375	7/7/2016	Tc-99	545 ± 9	539	324 - 755	Pass
SPW-3519	7/14/2016	H-3	8,621 ± 279	8650	5,190 - 12,110	Pass
SPW-3688	6/29/2016	Ra-226	17.5 ± 0.4	16.7	10.0 - 23.4	Pass
SPW-3711	7/20/2016	H-3	44,368 ± 612	43,766	26,260 - 61,273	Pass
SPW-3774	7/22/2016	H-3	45,259 ± 619	43,766	26,260 - 61,273	Pass
SPW-3776	7/22/2016	Gr. Alpha	23.3 ± 0.5	20.1	12.0 - 28.1	Pass
SPW-3776	7/22/2016	Gr. Beta	27.5 ± 0.3	28.9	17.3 - 40.4	Pass
SPW-3884	7/26/2016	H-3	45,850 ± 623	43,766	26,260 - 61,273	Pass
SPW-3950	7/28/2016	Ra-228	17.8 ± 1.8	16.7	10 - 23	Pass
SPW-3982	7/29/2016	H-3	45,273 ± 619	43,766	26,260 - 61,273	Pass
W-073016	4/29/2016	Cs-134	36.5 ± 6.1	36.2	21.7 - 50.6	Pass
W-073016	4/29/2016	Cs-137	80.6 ± 7.5	71.9	43.1 - 100.6	Pass
SPW-4134	8/4/2016	Ra-228	5.5 ± 0.8	6.7	4.0 - 9.3	Pass
SPW-4340	8/17/2016	Ra-228	19.9 ± 2.0	16.7	10.0 - 23.4	Pass
SPW-4386	7/15/2016	Ra-226	18.0 ± 0.4	16.7	10.0 - 23.4	Pass
W-082716	4/29/2016	Ra-228	32.5 ± 5.2	36.2	21.7 - 50.6	Pass
W-082716	4/29/2016	Ra-226	78.5 ± 8.3	71.9	43.1 - 100.6	Pass
SPW-4642	9/6/2016	U-238	45.8 ± 2.5	41.7	25.0 - 58.4	Pass
SPW-4999	9/26/2016	Sr-90	35.1 ± 2.2	36.8	22.1 - 51.5	Pass
SPW-5091	9/12/2016	Ra-226	18.2 ± 0.4	16.7	10.0 - 23.4	Pass
W-092716	4/29/2016	Cs-134	37.3 ± 11.8	36.2	21.7 - 50.6	Pass
W-092716	4/29/2016	Cs-137	78.3 ± 11.2	71.9	43.1 - 100.6	Pass
SPW-5165	9/30/2016	Gr. Alpha	22.2 ± 0.4	20.1	12.0 - 28.1	Pass
SPW-5165	9/30/2016	Gr. Beta	27.2 ± 0.3	28.9	17.3 - 40.4	Pass
SPW-5426	9/28/2016	Ra-226	18.2 ± 0.4	16.7	10.0 - 23.4	Pass
SPW-5510	10/18/2016	H-3	44,398 ± 618	43,766	26,260 - 61273	Pass
SPW-5553	10/19/2016	U-238	50.0 ± 2.6	41.7	25.0 - 58.4	Pass
SPW-5555	10/19/2016	Ra-228	17.4 ± 1.9	16.7	10.0 - 23.4	Pass
SPW-5612	10/20/2016	H-3	44,681 ± 622	43,766	26,260 - 61,273	Pass
SPW-5741	10/25/2016	H-3	44,946 ± 624	43,766	26,260 - 61,273	Pass
SPU-5833	10/26/2016	H-3	10,018 ± 946	8,622	5,173 - 12,071	Pass
SPW-5862	10/28/2016	H-3	18,061 ± 374	17,244	10,346 - 24,141	Pass
W-103116	4/29/2016	Cs-134	36.0 ± 4.6	36.2	21.7 - 50.6	Pass
W-103116	4/29/2016	Cs-137	81.1 ± 7.3	71.9	43.1 - 100.6	Pass

TABLE A-3. In-House "Spiked" Samples

Lab Code [b]	Date	Concentration [a]				
		Analysis	Laboratory results 2s, n=1 [c]	Known Activity	Control Limits [d]	Acceptance
SPW-5984	11/2/2016	H-3	17,727 ± 399	17,244	10,346 - 24,141	Pass
SPW-6008	11/4/2016	H-3	17,854 ± 402	17,244	10,346 - 24,141	Pass
SPW-6124	11/8/2016	Ra-228	14.4 ± 1.9	16.0	9.6 - 22.4	Pass
SPW-6132	11/9/2016	H-3	18,135 ± 374	17,243	10,346 - 24,140	Pass
SPW-6135	10/12/2016	Ra-226	18.9 ± 0.4	16.7	10.0 - 23.4	Pass
SPW-6146	11/10/2016	H-3	17,488 ± 398	17,243	10,346 - 24,140	Pass
SPW-6222	11/12/2016	H-3	17,787 ± 408	17,243	10,346 - 24,140	Pass
SPW-6318	11/16/2016	H-3	17,379 ± 408	17,243	10,346 - 24,140	Pass
SPW-6349	11/17/2016	H-3	17,893 ± 371	17,243	10,346 - 24,140	Pass
SPW-6424	11/19/2016	H-3	18,258 ± 379	17,243	10,346 - 24,140	Pass
W-112616	4/29/2016	Cs-134	35.0 ± 6.0	36.2	21.7 - 50.6	Pass
W-112616	4/29/2016	Cs-137	75.0 ± 7.1	71.9	43.1 - 100.6	Pass
SPW-6456	11/28/2016	Sr-90	41.9 ± 2.5	36.8	22.1 - 51.5	Pass
SPW-6486	11/30/2016	Sr-90	35.6 ± 2.2	36.6	21.9 - 51.2	Pass
SPW-6490	11/29/2016	Ra-226	18.8 ± 0.4	16.7	10.0 - 23.4	Pass
SPW-6519	11/30/2016	Ni-63	438 ± 4	400	240 - 560	Pass
SPW-6527	12/1/2016	U-238	49.5 ± 2.5	41.7	25.0 - 58.4	Pass
SPW-6616	12/3/2016	H-3	18,018 ± 374	17,243	10,346 - 24,140	Pass
SPW-6669	12/5/2016	H-3	18,237 ± 377	17,243	10,346 - 24,140	Pass
SPW-6735	12/9/2016	H-3	17,939 ± 396	17,243	10,346 - 24,140	Pass
SPW-6880	12/21/2016	H-3	17,835 ± 396	17,243	10,346 - 24,140	Pass
SPW-6947	12/22/2016	Ni-63	450 ± 4	400	240 - 560	Pass
W-122316	4/29/2016	Cs-134	36.0 ± 2.2	36.2	21.7 - 50.6	Pass
W-122316	4/29/2016	Cs-134	76.1 ± 2.9	71.9	43.1 - 100.6	Pass
SPW-6948	12/30/2016	H-3	17,999 ± 398	17,243	10,346 - 24,140	Pass
SPW-6974	12/29/2016	Ra-226	17.6 ± 0.4	16.7	10.0 - 23.4	Pass

[a] Liquid sample results are reported in pCi/Liter, air filters (pCi/m3), charcoal (pCi/charcoal canister), and solid samples (pCi/kg).
[b] Laboratory codes : W (Water), MI (milk), AP (air filter), SO (soil), VE (vegetation), CH (charcoal canister), F (fish), U (urine).
[c] Results are based on single determinations.
[d] Control limits are established from the precision values listed in Attachment A of this report, adjusted to ± 2s.
NOTE: For fish, gelatin is used for the spike matrix. For vegetation, cabbage is used for the spike matrix.

TABLE A-4. In-House "Blank" Samples

Lab Code	Sample Type	Date	Analysis[b]	Concentration [a] Laboratory results (4.66σ) LLD	Activity[c]	Acceptance Criteria (4.66 σ)
SPW-289	Water	1/21/2016	Sr-90	0.55	0.28 ± 0.29	1
SPW-291	Water	1/21/2016	Sr-90	0.61	0.15 ± 0.30	1
SPW-293	Water	1/21/2016	C-14	147	-12 ± 89	200
SPW-413	Water	2/1/2016	Ra-228	0.86	1.86 ± 0.60	2
W-020416	Water	2/4/2016	Gr. Alpha	0.43	-0.17 ± 0.28	2
W-020416	Water	2/4/2016	Gr. Beta	0.73	0.36 ± 0.53	4
W-020916	Water	2/9/2016	Ra-226	0.02	0.01 ± 0.01	2
W-030716	Water	3/7/2016	Gr. Alpha	0.90	-0.36 ± 0.32	2
W-030716	Water	3/7/2016	Gr. Beta	1.59	-0.62 ± 0.71	4
SPDW-70045	Water	3/29/2016	Ra-226	0.03	0.01 ± 0.02	2
SPDW-1234	Water	3/30/2016	Gr. Alpha	0.44	-0.05 ± 0.30	2
SPDW-1234	Water	3/30/2016	Gr. Beta	0.79	-0.54 ± 0.54	4
SPW-1738	Water	4/21/2016	Ra-228	1.05	0.13 ± 0.50	2
SPW-1822	Water	4/23/2016	Gr. Alpha	0.50	-0.18 ± 0.33	2
SPW-1822	Water	4/23/2016	Gr. Beta	0.08	-0.35 ± 0.51	4
SPW-2051	Water	4/12/2016	Ra-226	0.02	0.03 ± 0.02	2
SPW-2069	Water	5/3/2016	I-131	0.15	0.06 ± 0.09	1
SPW-2133	Water	5/4/2016	H-3	148	55 ± 76	200
SPW-2230	Water	5/7/2016	H-3	149	-11 ± 73	200
SPW-2314	Water	5/13/2016	H-3	150	-29 ± 72	200
SPW-2342	Water	5/13/2016	H-3	143	50 ± 74	200
SPW-2364	Water	5/13/2016	I-131	0.22	-0.03 ± 0.12	1
SPW-2375	Water	5/14/2016	H-3	146	1 ± 70	200
SPW-2410	Water	5/17/2016	Sr-90	0.59	0.10 ± 0.29	1
SPW-2454	Water	5/19/2016	Gr. Alpha	0.47	-0.21 ± 0.31	2
SPW-2454	Water	5/19/2016	Gr. Beta	0.77	-0.49 ± 0.52	4
SPW-2456	Water	5/19/2016	U-238	0.15	0.00 ± 0.09	1
SPW-2485	Water	5/20/2016	I-131	0.18	-0.01 ± 0.10	1
SPW-2505	Water	5/20/2016	H-3	144	64 ± 75	200
SPW-2529	Water	5/23/2016	H-3	152	-3 ± 75	200
SPW-2530	Water	5/23/2016	Ra-228	0.96	-0.12 ± 0.43	2
SPW-2565	Water	5/24/2016	Gr. Alpha	0.47	0.03 ± 0.33	2
SPW-2565	Water	5/24/2016	Gr. Beta	0.77	-0.23 ± 0.53	4
SPW-2703	Water	6/1/2016	Sr-89	0.68	-0.13 ± 0.50	5
SPW-2703	Water	6/1/2016	Sr-90	0.55	0.11 ± 0.27	1
SPW-2718	Water	6/2/2016	Ra-228	0.67	0.23 ± 0.34	2
SPW-2720	Water	6/2/2016	I-131	0.16	0.01 ± 0.09	1
SPW-2750	Water	6/3/2016	H-3	151	-31 ± 73	200
SPW-2844	Water	6/7/2016	H-3	148	-55 ± 75	200
SPMI-2959	Milk	6/14/2016	I-131	0.16	0.09 ± 0.10	1
SPW-3137	Water	6/23/2016	I-131	0.15	-0.03 ± 0.08	1
SPW-3226	Water	6/17/2016	Ra-226	0.02	-0.01 ± 0.04	2
SPW-3239	Water	6/28/2016	Gr. Alpha	0.40	-0.15 ± 0.26	2
SPW-3239	Water	6/28/2016	Gr. Beta	0.73	0.14 ± 0.52	4
SPW-3687	Water	6/29/2016	Ra-226	0.04	0.03 ± 0.03	2

[a] Liquid sample results are reported in pCi/Liter, air filters (pCi/m^3), charcoal (pCi/charcoal canister), and solid samples (pCi/g).

[b] I-131(G); Iodine-131 as analyzed by gamma spectroscopy.

[c] Activity reported is a net activity result.

TABLE A-4. In-House "Blank" Samples

Lab Code	Sample Type	Date	Analysis[b]	Concentration[a] Laboratory results (4.66σ) LLD	Activity[c]	Acceptance Criteria (4.66 σ)
SPW-289	Water	1/21/2016	Sr-90	0.55	0.28 ± 0.29	1
SPW-291	Water	1/21/2016	Sr-90	0.61	0.15 ± 0.30	1
SPW-293	Water	1/21/2016	C-14	147	-12 ± 89	200
SPW-413	Water	2/1/2016	Ra-228	0.86	1.86 ± 0.60	2
W-020416	Water	2/4/2016	Gr. Alpha	0.43	-0.17 ± 0.28	2
W-020416	Water	2/4/2016	Gr. Beta	0.73	0.36 ± 0.53	4
W-020916	Water	2/9/2016	Ra-226	0.02	0.01 ± 0.01	2
W-030716	Water	3/7/2016	Gr. Alpha	0.90	-0.36 ± 0.32	2
W-030716	Water	3/7/2016	Gr. Beta	1.59	-0.62 ± 0.71	4
SPDW-70045	Water	3/29/2016	Ra-226	0.03	0.01 ± 0.02	2
SPDW-1234	Water	3/30/2016	Gr. Alpha	0.44	-0.05 ± 0.30	2
SPDW-1234	Water	3/30/2016	Gr. Beta	0.79	-0.54 ± 0.54	4
SPW-1738	Water	4/21/2016	Ra-228	1.05	0.13 ± 0.50	2
SPW-1822	Water	4/23/2016	Gr. Alpha	0.50	-0.18 ± 0.33	2
SPW-1822	Water	4/23/2016	Gr. Beta	0.08	-0.35 ± 0.51	4
SPW-2051	Water	4/12/2016	Ra-226	0.02	0.03 ± 0.02	2
SPW-2069	Water	5/3/2016	I-131	0.15	0.06 ± 0.09	1
SPW-2133	Water	5/4/2016	H-3	148	55 ± 76	200
SPW-2230	Water	5/7/2016	H-3	149	-11 ± 73	200
SPW-2314	Water	5/13/2016	H-3	150	-29 ± 72	200
SPW-2342	Water	5/13/2016	H-3	143	50 ± 74	200
SPW-2364	Water	5/13/2016	I-131	0.22	-0.03 ± 0.12	1
SPW-2375	Water	5/14/2016	H-3	146	1 ± 70	200
SPW-2410	Water	5/17/2016	Sr-90	0.59	0.10 ± 0.29	1
SPW-2454	Water	5/19/2016	Gr. Alpha	0.47	-0.21 ± 0.31	2
SPW-2454	Water	5/19/2016	Gr. Beta	0.77	-0.49 ± 0.52	4
SPW-2456	Water	5/19/2016	U-238	0.15	0.00 ± 0.09	1
SPW-2485	Water	5/20/2016	I-131	0.18	-0.01 ± 0.10	1
SPW-2505	Water	5/20/2016	H-3	144	64 ± 75	200
SPW-2529	Water	5/23/2016	H-3	152	-3 ± 75	200
SPW-2530	Water	5/23/2016	Ra-228	0.96	-0.12 ± 0.43	2
SPW-2565	Water	5/24/2016	Gr. Alpha	0.47	0.03 ± 0.33	2
SPW-2565	Water	5/24/2016	Gr. Beta	0.77	-0.23 ± 0.53	4
SPW-2703	Water	6/1/2016	Sr-89	0.68	-0.13 ± 0.50	5
SPW-2703	Water	6/1/2016	Sr-90	0.55	0.11 ± 0.27	1
SPW-2718	Water	6/2/2016	Ra-228	0.67	0.23 ± 0.34	2
SPW-2720	Water	6/2/2016	I-131	0.16	0.01 ± 0.09	1
SPW-2750	Water	6/3/2016	H-3	151	-31 ± 73	200
SPW-2844	Water	6/7/2016	H-3	148	-55 ± 75	200
SPMI-2959	Milk	6/14/2016	I-131	0.16	0.09 ± 0.10	1
SPW-3137	Water	6/23/2016	I-131	0.15	-0.03 ± 0.08	1
SPW-3226	Water	6/17/2016	Ra-226	0.02	-0.01 ± 0.04	2
SPW-3239	Water	6/28/2016	Gr. Alpha	0.40	-0.15 ± 0.26	2
SPW-3239	Water	6/28/2016	Gr. Beta	0.73	0.14 ± 0.52	4
SPW-3687	Water	6/29/2016	Ra-226	0.04	0.03 ± 0.03	2

[a] Liquid sample results are reported in pCi/Liter, air filters (pCi/m^3), charcoal (pCi/charcoal canister), and solid samples (pCi/g).
[b] I-131(G); Iodine-131 as analyzed by gamma spectroscopy.
[c] Activity reported is a net activity result.

TABLE A-4. In-House "Blank" Samples

Lab Code	Sample Type	Date	Analysis[b]	Concentration [a] Laboratory results (4.66σ) LLD	Activity[c]	Acceptance Criteria (4.66 σ)
SPW-3312	Water	7/1/2016	Ra-228	0.67	0.35 ± 0.35	2
SPW-3327	Water	7/6/2016	Sr-89	0.67	0.51 ± 0.51	5
SPW-3327	Water	7/6/2016	Sr-90	0.60	-0.14 ± 0.26	1
SPAP-3364	AP	7/7/2016	Gr.Beta	0.002	0.005 ± 0.001	0.01
SPW-3370	Water	7/7/2016	C-14	115	49 ± 71	200
SPW-3372	Water	7/7/2016	Ni-63	122	115 ± 76	200
SPW-3374	Water	7/7/2016	Tc-99	6.07	1.00 ± 3.70	10
SPW-3710	Water	7/20/2016	H-3	147	35 ± 75	200
SPW-3775	Water	7/22/2016	Gr. Alpha	0.73	0.41 ± 0.53	2
SPW-3775	Water	7/22/2016	Gr. Beta	0.45	-0.14 ± 0.30	4
SPW-3884	Water	7/26/2016	H-3	151	-1 ± 73	200
SPW-3949	Water	7/28/2016	Ra-228	0.76	0.32 ± 0.39	2
SPW-3982	Water	7/29/2016	H-3	145	49 ± 75	200
SPW-4133	Water	8/4/2016	Ra-228	0.80	0.26 ± 0.40	2
SPW-4257	Water	8/11/2016	I-131	0.17	-0.01 ± 0.10	1
SPW-4339	Water	8/17/2016	Ra-228	0.73	0.36 ± 0.39	2
SPW-4385	Water	7/15/2016	Ra-226	0.09	0.75 ± 0.09	2
SPW-4641	Water	9/6/2016	U-238	0.21	0.00 ± 0.13	1
SPW-4684	Water	9/8/2016	H-3	151	48 ± 78	200
SPW-4872	Water	9/16/2016	I-131	0.21	0.05 ± 0.11	1
SPW-4998	Water	9/26/2016	Sr-89	0.54	0.06 ± 0.39	5
SPW-4998	Water	9/26/2016	Sr-90	0.53	-0.03 ± 0.24	1
SPW-5090	Water	8/19/2016	Ra-226	0.03	0.03 ± 0.02	2
SPW-5164	Water	9/30/2016	Gr. Alpha	0.46	-0.05 ± 0.32	2
SPW-5164	Water	9/30/2016	Gr. Beta	0.74	-0.02 ± 0.52	4
SPW-5425	Water	9/28/2016	Ra-226	0.02	0.07 ± 0.05	2
SPW-5323	Water	10/7/2016	H-3	157	-12 ± 75	200
SPW-5552	Water	10/19/2016	U-238	0.18	0.00 ± 0.11	1
SPW-5554	Water	10/19/2016	Ra-228	0.72	0.22 ± 0.36	2
SPW-5611	Water	10/20/2016	H-3	153	67 ± 80	200
SPW-5613	Water	10/21/2016	Gr. Alpha	0.76	-0.55 ± 0.51	2
SPW-5613	Water	10/21/2016	Gr. Beta	0.42	0.02 ± 0.29	4
SPW-5740	Water	10/25/2016	H-3	154	-2 ± 72	200
SPW-5743	Water	10/25/2016	Sr-90	1.26	0.72 ± 0.67	1
SPW-5861	Water	10/28/2016	H-3	179	129 ± 91	200
SPW-5983	Water	11/2/2016	H-3	156	8 ± 78	200
SPW-6007	Water	11/4/2016	H-3	156	-34 ± 73	200
SPW-6131	Water	11/9/2016	H-3	180	80 ± 92	200
SPW-6134	Water	10/12/2016	Ra-226	0.05	-0.02 ± 0.12	2
SPW-6145	Water	11/10/2016	H-3	171	-46 ± 80	200
SPW-6317	Water	11/16/2016	H-3	180	-43 ± 82	200
SPW-6348	Water	11/17/2016	H-3	182	-45 ± 88	200
SPW-6423	Water	11/19/2016	H-3	181	8 ± 95	200
SPW-6455	Water	11/28/2016	Sr-89	0.58	-0.15 ± 0.46	5
SPW-6455	Water	11/28/2016	Sr-90	0.67	0.09 ± 0.32	1
SPW-6489	Water	11/29/2016	Ra-226	0.03	0.03 ± 0.02	2

[a] Liquid sample results are reported in pCi/Liter, air filters (pCi/m^3), charcoal (pCi/charcoal canister), and solid samples (pCi/g).

[b] I-131(G); iodine-131 as analyzed by gamma spectroscopy.

[c] Activity reported is a net activity result.

TABLE A-4. In-House "Blank" Samples

Lab Code	Sample Type	Date	Analysis[b]	Concentration [a]		
				Laboratory results (4.66σ)		Acceptance
				LLD	Activity[c]	Criteria (4.66 σ)
SPW-6529	Water	12/1/2016	I-131	0.18	-0.03 ± 0.10	1
SPW-6616	Water	12/3/2016	H-3	180	72 ± 92	200
SPW-6670	Water	12/5/2016	H-3	174	28 ± 92	200
SPW-6735	Water	12/9/2016	H-3	152	2 ± 73	200
SPW-6792	Water	12/15/2016	I-131	0.17	0.03 ± 0.12	1
SPW-6819	Water	12/16/2016	H-3	158	14 ± 77	200
SPW-6879	Water	12/21/2016	H-3	147	80 ± 75	200
SPW-6947	Water	12/22/2016	Ni-63	93	26 ± 57	200
SPW-6973	Water	12/29/2016	Ra-226	0.03	0.03 ± 0.02	2

[a] Liquid sample results are reported in pCi/Liter, air filters (pCi/m^3), charcoal (pCi/charcoal canister), and solid samples (pCi/g).

[b] I-131(G); iodine-131 as analyzed by gamma spectroscopy.

[c] Activity reported is a net activity result.

TABLE A-5. In-House "Duplicate" Samples

			Concentration [a]			
Lab Code	Date	Analysis	First Result	Second Result	Averaged Result	Acceptance
AP-010416	1/4/2016	Gr. Beta	0.044 ± 0.006	0.051 ± 0.006	0.047 ± 0.004	Pass
SPS-62, 63	1/7/2016	K-40	21.1 ± 1.9	21.2 ± 2.1	21.2 ± 1.4	Pass
WW-125, 126	1/7/2016	H-3	659 ± 102	748 ± 106	703 ± 74	Pass
SPS-199, 200	1/7/2016	Cs-137	0.09 ± 0.02	0.08 ± 0.03	0.08 ± 0.02	Pass
SPS-199, 200	1/7/2016	K-40	7.60 ± 0.60	8.62 ± 0.62	8.11 ± 0.43	Pass
AP-011116	1/11/2016	Gr. Beta	0.024 ± 0.005	0.027 ± 0.005	0.026 ± 0.003	Pass
AP-011216	1/12/2016	Gr. Beta	0.030 ± 0.004	0.034 ± 0.004	0.032 ± 0.003	Pass
WW-262, 263	1/14/2016	H-3	153 ± 78	141 ± 78	147 ± 55	Pass
WW-346, 347	1/14/2016	H-3	1,036 ± 117	959 ± 115	997 ± 82	Pass
WW-283, 284	1/18/2016	H-3	437 ± 92	427 ± 91	432 ± 65	Pass
AP-011916	1/19/2016	Gr. Beta	0.042 ± 0.005	0.037 ± 0.004	0.040 ± 0.003	Pass
AP-012016	1/20/2016	Gr. Beta	0.023 ± 0.003	0.030 ± 0.004	0.027 ± 0.002	Pass
AP-020116	2/1/2016	Gr. Beta	0.023 ± 0.005	0.023 ± 0.005	0.023 ± 0.004	Pass
SWU-472, 473	2/2/2016	Gr. Beta	4.37 ± 0.47	4.60 ± 0.49	4.49 ± 0.34	Pass
SG-493, 494	2/6/2016	Ac-228	2.10 ± 0.20	2.13 ± 0.20	2.12 ± 0.14	Pass
SG-493, 494	2/6/2016	K-40	5.79 ± 0.57	5.50 ± 0.69	5.65 ± 0.45	Pass
SG-493, 494	2/6/2016	Pb-214	1.84 ± 0.11	1.91 ± 0.11	1.88 ± 0.08	Pass
AP-020816	2/8/2016	Gr. Beta	0.020 ± 0.004	0.019 ± 0.004	0.020 ± 0.003	Pass
AP-020916	2/9/2016	Be-7	0.032 ± 0.005	0.041 ± 0.006	0.036 ± 0.004	Pass
SPS-619, 620	2/18/2016	K-40	20.0 ± 1.8	19.1 ± 1.6	19.5 ± 1.2	Pass
WW-640, 641	2/18/2016	H-3	90.1 ± 75.0	153.6 ± 78.4	121.8 ± 54.2	Pass
AP-021916	2/19/2016	Gr. Beta	0.021 ± 0.003	0.025 ± 0.004	0.023 ± 0.002	Pass
WW-822, 823	2/26/2016	H-3	2,770 ± 173	2,974 ± 178	2,872 ± 124	Pass
DW-70010, 70011	2/29/2016	Ra-226	4.88 ± 0.29	4.93 ± 0.28	4.91 ± 0.20	Pass
DW-70010, 70011	2/29/2016	Ra-228	3.00 ± 0.77	1.90 ± 0.62	2.45 ± 0.49	Pass
SW-934, 935	3/1/2016	Gr. Beta	0.94 ± 0.52	1.36 ± 0.60	1.15 ± 0.40	Pass
SPS-913, 914	3/3/2016	Cs-137	0.08 ± 0.03	0.10 ± 0.03	0.09 ± 0.02	Pass
SPS-913, 914	3/3/2016	K-40	17.45 ± 0.94	16.83 ± 0.95	17.14 ± 0.67	Pass
SPS-913, 914	3/3/2016	Ra-226	1.02 ± 0.08	1.13 ± 0.17	1.07 ± 0.09	Pass
SPS-913, 914	3/3/2016	Ra-228	1.09 ± 0.15	1.13 ± 0.17	1.11 ± 0.11	Pass
AP-030716	3/7/2016	Gr. Beta	0.018 ± 0.005	0.021 ± 0.005	0.019 ± 0.003	Pass
F-1303,1304	3/7/2016	K-40	3.320 ± 0.475	3.508 ± 0.396	3.414 ± 0.309	Pass
SG-976, 977	3/8/2016	Ra-226	6.75 ± 0.25	6.28 ± 0.22	6.52 ± 0.17	Pass
SG-976, 977	3/8/2016	Ra-228	9.21 ± 0.49	9.09 ± 0.49	9.15 ± 0.35	Pass
PM-1094, 1095	3/9/2016	K-40	14.01 ± 0.68	14.47 ± 0.72	14.24 ± 0.49	Pass
MI-1042,1043	3/7/2016	K-40	1,684 ± 124	1,804 ± 119	1,744 ± 86	Pass
DW-70023, 70024	3/7/2016	Ra-226	3.40 ± 0.43	2.68 ± 0.35	3.04 ± 0.28	Pass
DW-70023, 70024	3/7/2016	Ra-228	4.46 ± 0.83	5.74 ± 0.94	5.10 ± 0.63	Pass
DW-70014, 70015	3/7/2016	Gr. Alpha	13.38 ± 1.58	11.40 ± 1.43	12.39 ± 1.07	Pass
DW-70026, 70027	3/7/2016	Gr. Alpha	3.46 ± 0.79	3.08 ± 0.74	3.27 ± 0.54	Pass
DW-70038, 70039	3/8/2016	Gr. Alpha	1.14 ± 0.89	1.73 ± 0.95	1.44 ± 0.65	Pass
DW-70035, 70036	3/8/2016	Ra-226	0.47 ± 0.10	0.45 ± 0.09	0.46 ± 0.07	Pass
DW-70035, 70036	3/8/2016	Ra-228	0.56 ± 0.45	0.47 ± 0.44	0.52 ± 0.31	Pass
AP-031516	3/15/2016	Gr. Beta	0.014 ± 0.003	0.016 ± 0.004	0.015 ± 0.002	Pass
AP-032116	3/21/2016	Gr. Beta	0.014 ± 0.004	0.020 ± 0.004	0.017 ± 0.003	Pass
AP-1218,1219	3/24/2016	Be-7	0.135 ± 0.065	0.167 ± 0.081	0.151 ± 0.052	Pass
AP-1719,1720	3/28/2016	Be-7	0.075 ± 0.008	0.076 ± 0.007	0.076 ± 0.005	Pass
AP-033016	3/30/2016	Gr. Beta	0.023 ± 0.004	0.025 ± 0.004	0.024 ± 0.003	Pass
SPS-1260, 1261	3/30/2016	K-40	18.00 ± 1.92	19.67 ± 1.77	18.84 ± 1.30	Pass
XW-1467, 1468	3/30/2016	H-3	310 ± 87	295 ± 86	303 ± 61	Pass
XWW-1530, 1531	3/30/2016	H-3	198 ± 84	162 ± 82	180 ± 59	Pass
AP-1827, 1828	3/30/2016	Be-7	0.069 ± 0.011	0.072 ± 0.011	0.071 ± 0.008	Pass
AP-1323,1324	3/31/2016	Be-7	0.206 ± 0.120	0.197 ± 0.091	0.202 ± 0.076	Pass
LW-1446,1447	3/31/2016	Gr. Beta	2.36 ± 0.93	2.23 ± 1.01	2.29 ± 0.69	Pass

TABLE A-5. In-House "Duplicate" Samples

			Concentration [a]			
Lab Code	Date	Analysis	First Result	Second Result	Averaged Result	Acceptance
WW-1740,1741	4/2/2016	H-3	21,162 ± 120	21,091 ± 427	21,126 ± 222	Pass
SPS-1344, 1345	4/4/2016	K-40	17.98 ± 0.93	17.14 ± 0.96	17.56 ± 0.67	Pass
SPS-1344, 1345	4/4/2016	Pb-214	1.12 ± 0.09	1.04 ± 0.08	1.08 ± 0.06	Pass
SPS-1344, 1345	4/4/2016	Ac-228	1.23 ± 0.15	1.33 ± 0.19	1.28 ± 0.12	Pass
SPS-1344, 1345	4/4/2016	Cs-137	0.13 ± 0.03	0.13 ± 0.03	0.13 ± 0.02	Pass
P-1509,1510	4/8/2016	H-3	1,084 ± 120	1,038 ± 119	1,061 ± 85	Pass
AP-041116	4/11/2016	Gr. Beta	0.020 ± 0.004	0.019 ± 0.004	0.019 ± 0.003	Pass
SS-1551,1552	4/12/2016	Gr. Beta	8.71 ± 1.11	8.88 ± 1.13	8.80 ± 0.79	Pass
SS-1551,1552	4/12/2016	K-40	3.50 ± 0.25	3.06 ± 0.28	3.28 ± 0.19	Pass
SS-1551,1552	4/12/2016	Tl-208	0.05 ± 0.02	0.05 ± 0.02	0.05 ± 0.01	Pass
SS-1551,1552	4/12/2016	Bi-214	0.10 ± 0.02	0.09 ± 0.02	0.10 ± 0.02	Pass
SS-1551,1552	4/12/2016	Pb-212	0.13 ± 0.02	0.11 ± 0.02	0.12 ± 0.01	Pass
SS-1551,1552	4/12/2016	Ra-226	0.35 ± 0.17	0.30 ± 0.17	0.32 ± 0.12	Pass
SS-1551,1552	4/12/2016	Ac-228	0.16 ± 0.05	0.17 ± 0.05	0.17 ± 0.04	Pass
SS-1593,1594	4/12/2016	K-40	14.80 ± 0.73	14.89 ± 0.78	14.85 ± 0.53	Pass
WW-1677, 1678	4/14/2016	Ra-226	0.23 ± 0.13	0.35 ± 0.15	0.29 ± 0.10	Pass
WW-1783,1784	4/14/2016	H-3	768 ± 111	632 ± 107	700 ± 77	Pass
BS-1804,1805	4/18/2016	K-40	0.79 ± 0.02	0.87 ± 0.19	0.83 ± 0.10	Pass
WW-2021,2022	4/18/2016	H-3	5,548 ± 221	5,707 ± 224	5,627 ± 157	Pass
XWW-2240, 2241	4/18/2016	H-3	638 ± 104	543 ± 101	591 ± 72	Pass
XWW-2109, 2110	4/19/2016	H-3	3461 ± 185	3250 ± 180	3356 ± 129	Pass
SPS-2130, 2131	4/25/2016	K-40	7.80 ± 0.84	6.80 ± 0.60	7.30 ± 0.52	Pass
AP-042516	4/25/2016	Gr. Beta	0.020 ± 0.004	0.023 ± 0.004	0.022 ± 0.003	Pass
BS-2065, 2066	4/25/2016	K-40	14.40 ± 1.50	14.72 ± 1.19	14.56 ± 0.96	Pass
AP-042716	4/27/2016	Gr. Beta	0.023 ± 0.003	0.019 ± 0.003	0.021 ± 0.002	Pass
SPS-1999, 2000	4/28/2016	K-40	19.84 ± 1.76	18.963 ± 2.42	19.40 ± 1.50	Pass
SO-2153,2154	5/2/2016	K-40	21.80 ± 0.81	21.17 ± 0.85	21.48 ± 0.59	Pass
SO-2153,2154	5/2/2016	Cs-137	0.11 ± 0.03	0.11 ± 0.07	0.11 ± 0.04	Pass
SO-2153,2154	5/2/2016	Ra-226	1.50 ± 0.29	1.22 ± 0.29	1.36 ± 0.21	Pass
SO-2153,2154	5/2/2016	Pb-214	0.56 ± 0.06	0.57 ± 0.06	0.57 ± 0.04	Pass
W-2394,2395	5/5/2016	H-3	736 ± 106	631 ± 102	683 ± 74	Pass
VE-2284,2285	5/9/2016	K-40	3.50 ± 0.25	3.06 ± 0.28	3.28 ± 0.19	Pass
AP-051016	5/10/2016	Gr. Beta	0.020 ± 0.005	0.018 ± 0.005	0.019 ± 0.003	Pass
SG-2261, 2262	5/10/2016	Ac-228	34.4 ± 1.2	34.4 ± 1.4	34.4 ± 0.9	Pass
SG-2261, 2262	5/10/2016	Pb-214	29.5 ± 3.0	31.9 ± 3.3	30.7 ± 2.2	Pass
BS-2439, 2440	5/12/2016	K-40	9.96 ± 0.91	10.27 ± 0.76	10.11 ± 0.59	Pass
WW-2534,2535	5/16/2016	H-3	14,342 ± 354	14,613 ± 357	14,477 ± 252	Pass
AP-051716	5/17/2016	Gr. Beta	0.014 ± 0.004	0.015 ± 0.004	0.014 ± 0.003	Pass
SPS-2945, 2946	5/19/2016	K-40	30.71 ± 0.74	31.75 ± 0.78	31.23 ± 0.54	Pass
SPS-2945, 2946	5/19/2016	Be-7	1.55 ± 0.24	1.90 ± 0.35	1.73 ± 0.21	Pass
SPS-2578, 2579	5/24/2016	Pb-214	0.96 ± 0.12	0.80 ± 0.14	0.88 ± 0.09	Pass
AP-052516	5/25/2016	Gr. Beta	0.022 ± 0.004	0.022 ± 0.004	0.022 ± 0.003	Pass
G-2642,2643	5/26/2016	Be-7	0.443 ± 0.178	0.247 ± 0.247	0.345 ± 0.152	Pass
SO-2663, 2664	5/26/2016	Cs-137	0.08 ± 0.03	0.07 ± 0.03	0.07 ± 0.02	Pass
SO-2663, 2664	5/26/2016	K-40	12.44 ± 0.68	11.64 ± 0.63	12.04 ± 0.46	Pass
SO-2663, 2664	5/26/2016	Tl-208	0.13 ± 0.02	0.14 ± 0.03	0.14 ± 0.02	Pass
SO-2663, 2664	5/26/2016	Pb-212	0.43 ± 0.04	0.41 ± 0.04	0.42 ± 0.03	Pass
SO-2663, 2664	5/26/2016	Ra-226	1.19 ± 0.34	0.87 ± 0.28	1.03 ± 0.22	Pass
SO-2663, 2664	5/26/2016	Ac-228	0.45 ± 0.09	0.53 ± 0.10	0.49 ± 0.07	Pass
SPS-2817, 2818	5/31/2016	K-40	12.10 ± 0.70	11.05 ± 0.70	11.58 ± 0.49	Pass
DW-70091, 70092	6/1/2016	Ra-226	5.61 ± 0.29	5.53 ± 0.30	5.57 ± 0.21	Pass
DW-70091, 70092	6/1/2016	Ra-228	1.45 ± 0.58	1.91 ± 0.62	1.68 ± 0.42	Pass
BS-2925,2926	6/3/2016	K-40	7.74 ± 0.44	7.86 ± 0.42	7.80 ± 0.30	Pass
SPS-2796, 2797	6/2/2016	K-40	20.91 ± 2.38	21.16 ± 1.82	21.04 ± 1.50	Pass
SPS-2882, 2883	6/7/2016	K-40	14.64 ± 0.52	14.60 ± 0.52	14.62 ± 0.37	Pass
SPS-2882, 2883	6/7/2016	Be-7	2.00 ± 0.25	1.94 ± 0.20	1.97 ± 0.16	Pass
DW-70102, 70103	6/13/2016	Ra-226	0.34 ± 0.09	0.36 ± 0.08	0.35 ± 0.06	Pass

TABLE A-5. In-House "Duplicate" Samples

			Concentration [a]			
Lab Code	Date	Analysis	First Result	Second Result	Averaged Result	Acceptance
DW-70102, 70103	6/13/2016	Ra-228	0.93 ± 0.47	1.11 ± 0.53	1.02 ± 0.35	Pass
AP-061416	6/14/2016	Gr. Beta	0.026 ± 0.004	0.023 ± 0.004	0.024 ± 0.003	Pass
SG-3144, 3145	6/17/2016	Be-7	2.23 ± 0.12	2.24 ± 0.12	2.24 ± 0.08	Pass
SG-3144, 3145	6/17/2016	K-40	7.57 ± 0.25	7.09 ± 0.23	7.33 ± 0.17	Pass
SPS-3165, 3166	6/22/2016	K-40	21.14 ± 2.27	22.88 ± 1.60	22.01 ± 1.39	Pass
SPS-3323, 3324	6/24/2016	K-40	18.67 ± 1.57	21.53 ± 1.65	20.10 ± 1.14	Pass
WW-3231, 3232	6/27/2016	H-3	414 ± 104	498 ± 108	456 ± 75	Pass
AP-3830,3831	6/29/2016	Gr. Beta	0.088 ± 0.012	0.093 ± 0.015	0.091 ± 0.010	Pass
AP-070516A	7/5/2016	Gr. Beta	0.018 ± 0.002	0.014 ± 0.002	0.016 ± 0.002	Pass
AP-070516B	7/5/2016	Gr. Beta	0.025 ± 0.005	0.026 ± 0.005	0.025 ± 0.004	Pass
XWW-3605,3606	7/7/2016	H-3	3,316 ± 186	3,316 ± 181	3,316 ± 130	Pass
DW-70135,70136	7/8/2016	Gr. Alpha	3.68 ± 1.01	2.76 ± 0.98	3.22 ± 0.70	Pass
DW-70132,70133	7/8/2016	Ra-226	1.32 ± 0.14	1.11 ± 0.15	1.22 ± 0.10	Pass
DW-70132,70133	7/8/2016	Ra-228	3.92 ± 0.94	2.94 ± 0.90	3.43 ± 0.65	Pass
AP-071216	7/12/2016	Gr. Beta	0.014 ± 0.004	0.018 ± 0.004	0.016 ± 0.003	Pass
DW-70150,70151	7/14/2016	Gr. Alpha	5.00 ± 1.06	4.43 ± 1.04	4.72 ± 0.74	Pass
SPS-3649,3650	7/15/2016	Cs-137	0.12 ± 0.03	0.12 ± 0.03	0.12 ± 0.02	Pass
SPS-3649,3650	7/15/2016	K-40	16.68 ± 0.79	16.52 ± 0.86	16.6 ± 0.58	Pass
SPS-3649,3650	7/15/2016	Pb-214	1.20 ± 0.08	1.17 ± 0.08	1.19 ± 0.06	Pass
SPS-3649,3650	7/15/2016	Ac-228	1.28 ± 0.16	1.28 ± 0.16	1.28 ± 0.11	Pass
AP-071816	7/18/2016	Gr. Beta	0.022 ± 0.005	0.024 ± 0.005	0.023 ± 0.003	Pass
DW-70163,70164	7/19/2016	Gr. Alpha	1.08 ± 0.66	1.36 ± 0.70	1.22 ± 0.48	Pass
WW-3761,3762	7/20/2016	H-3	347 ± 90	466 ± 96	407 ± 66	Pass
SPS-4003,4004	7/23/2016	K-40	7.15 ± 1.59	6.86 ± 1.21	7.00 ± 1.00	Pass
AP-072516	7/25/2016	Gr. Beta	0.023 ± 0.004	0.020 ± 0.004	0.022 ± 0.003	Pass
VE-3936,3937	7/25/2016	Sr-90	0.048 ± 0.007	0.058 ± 0.010	0.053 ± 0.006	Pass
VE-3936,3937	7/25/2016	Be-7	0.49 ± 0.15	0.51 ± 0.15	0.50 ± 0.10	Pass
VE-3936,3937	7/25/2016	K-40	4.70 ± 0.35	4.86 ± 0.37	4.78 ± 0.25	Pass
VE-3959,3960	7/27/2016	Sr-90	0.002 ± 0.002	0.003 ± 0.001	0.003 ± 0.001	Pass
VE-3959,3960	7/27/2016	Be-7	0.30 ± 0.14	0.25 ± 0.12	0.27 ± 0.09	Pass
VE-3959,3960	7/27/2016	K-40	4.01 ± 0.37	4.16 ± 0.34	4.08 ± 0.25	Pass
DW-70169,70170	7/28/2016	Ra-226	0.83 ± 0.11	0.69 ± 0.11	0.76 ± 0.08	Pass
DW-70169,70170	7/28/2016	Ra-228	1.85 ± 0.63	1.31 ± 0.84	1.58 ± 0.53	Pass
AP-080116	8/1/2016	Gr. Beta	0.029 ± 0.003	0.033 ± 0.003	0.031 ± 0.002	Pass
SS-4131,4132	8/1/2016	K-40	12.47 ± 0.71	13.24 ± 0.81	12.86 ± 0.54	Pass
SS-4131,4132	8/1/2016	Cs-137	0.10 ± 0.03	0.13 ± 0.04	0.12 ± 0.02	Pass
SPS-4087,4088	8/2/2016	K-40	17.06 ± 1.58	19.5 ± 1.97	18.28 ± 1.26	Pass
WW-4976,4977	8/4/2016	H-3	17,043 ± 390	16,821 ± 388	16,932 ± 275	Pass
SPS-4266,4267	8/10/2016	K-40	1.06 ± 0.47	1.69 ± 0.52	1.375 ± 0.35	Pass
AP-081616	8/16/2016	Gr. Beta	0.029 ± 0.005	0.025 ± 0.004	0.027 ± 0.003	Pass
VE-4399,4400	8/18/2016	K-40	3.85 ± 0.23	3.27 ± 0.41	3.56 ± 0.24	Pass
VE-4399,4400	8/18/2016	Be-7	0.30 ± 0.08	0.45 ± 0.20	0.37 ± 0.11	Pass
WW-5394,5395	8/18/2016	H-3	947 ± 122	846 ± 119	896 ± 85	Pass
SPS-4441,4442	8/22/2016	K-40	20.55 ± 2.23	19.69 ± 1.74	20.12 ± 1.41	Pass
AP-082216	8/22/2016	Gr. Beta	0.021 ± 0.005	0.015 ± 0.005	0.018 ± 0.003	Pass
VE-4462,4463	8/22/2016	Be-7	0.91 ± 0.09	0.89 ± 0.11	0.90 ± 0.07	Pass
VE-4462,4463	8/22/2016	K-40	7.48 ± 0.26	7.60 ± 0.23	7.54 ± 0.17	Pass
WW-4594,4595	8/26/2016	H-3	675 ± 107	788 ± 111	731 ± 77	Pass
WW-4663,4664	8/26/2016	H-3	607 ± 104	501 ± 100	554 ± 72	Pass
SPS-4529,4530	8/26/2016	K-40	21.98 ± 2.52	21.85 ± 1.56	21.92 ± 1.48	Pass
AP-083016A	8/30/2016	Gr. Beta	0.030 ± 0.003	0.035 ± 0.004	0.033 ± 0.002	Pass
AP-083016B	8/30/2016	Gr. Beta	0.032 ± 0.009	0.026 ± 0.004	0.029 ± 0.005	Pass
VE-4615,4616	8/31/2016	K-40	2.96 ± 0.16	3.11 ± 0.17	3.03 ± 0.11	Pass

TABLE A-5. In-House "Duplicate" Samples

Lab Code	Date	Analysis	Concentration [a] First Result	Second Result	Averaged Result	Acceptance
AP-090216	9/2/2016	Gr. Beta	0.022 ± 0.004	0.027 ± 0.004	0.024 ± 0.003	Pass
AP-090616	9/6/2016	Gr. Beta	0.023 ± 0.005	0.023 ± 0.005	0.023 ± 0.003	Pass
MI-4751,4752	9/7/2016	K-40	1,693 ± 112	1,760 ± 99	1,726 ± 75	Pass
MI-4751,4752	9/7/2016	Sr-90	1.23 ± 0.38	1.00 ± 0.33	1.11 ± 0.25	Pass
SW-4772,4773	9/8/2016	H-3	196 ± 91	236 ± 93	216 ± 65	Pass
WW-5285,5286	9/13/2016	H-3	18,010 ± 400	18,686 ± 407	18,348 ± 286	Pass
MI-4826,4827	9/14/2016	K-40	1,372.6 ± 105	1,198.1 ± 97	1,285.4 ± 71	Pass
VE-4868,4869	9/15/2016	Gr. Beta	2.50 ± 0.06	2.57 ± 0.06	2.53 ± 0.04	Pass
VE-4868,4869	9/15/2016	K-40	2.20 ± 0.17	2.30 ± 0.17	2.25 ± 0.12	Pass
CF-4934,4935	9/19/2016	K-40	11.47 ± 0.82	11.76 ± 0.50	11.61 ± 0.48	Pass
CF-4934,4935	9/19/2016	Be-7	0.43 ± 0.22	0.46 ± 0.13	0.45 ± 0.13	Pass
AP-092016	9/20/2016	Gr. Beta	0.021 ± 0.004	0.017 ± 0.004	0.019 ± 0.003	Pass
DW-70196,70197	9/20/2016	Gr. Alpha	13.8 ± 1.36	15.28 ± 1.36	14.54 ± 0.96	Pass
F-4955,4956	9/20/2016	K-40	3.40 ± 0.44	2.86 ± 0.39	3.13 ± 0.30	Pass
VE-5044,5045	9/20/2016	Be-7	0.46 ± 0.05	0.50 ± 0.11	0.48 ± 0.06	Pass
VE-5044,5045	9/20/2016	K-40	4.37 ± 0.12	4.68 ± 0.24	4.53 ± 0.13	Pass
WW-5219,5220	9/20/2016	H-3	63,744 ± 743	64,755 ± 749	64,250 ± 527	Pass
SPS-5087,5088	9/23/2016	K-40	21.04 ± 2.32	18.84 ± 1.88	19.94 ± 1.49	Pass
AP-092716	9/27/2016	Gr. Beta	0.031 ± 0.005	0.032 ± 0.005	0.031 ± 0.003	Pass
AP-5660,5661	9/28/2016	Be-7	0.093 ± 0.014	0.086 ± 0.019	0.089 ± 0.012	Pass
AP-5681,5682	9/27/2016	Be-7	0.079 ± 0.019	0.071 ± 0.015	0.075 ± 0.012	Pass
VE-5110,5111	9/28/2016	K-40	1.82 ± 0.15	2.14 ± 0.18	1.98 ± 0.12	Pass
AP-5154,5155	9/29/2016	Be-7	0.237 ± 0.116	0.195 ± 0.096	0.216 ± 0.075	Pass
AP-5702,5703	9/30/2016	Be-7	0.084 ± 0.015	0.070 ± 0.018	0.077 ± 0.012	Pass
MI-5264,5265	10/4/2016	K-40	1,636 ± 128	1,610 ± 124	1,623 ± 89	Pass
MI-5264,5265	10/4/2016	Sr-90	2.00 ± 0.44	1.28 ± 0.37	1.64 ± 0.29	Pass
SS-5547,5548	10/11/2016	Gr. Beta	11.27 ± 1.19	9.47 ± 1.20	10.37 ± 0.84	Pass
SS-5547,5548	10/11/2016	K-40	8.03 ± 0.45	7.23 ± 0.46	7.63 ± 0.32	Pass
SS-5547,5548	10/11/2016	Tl-208	0.04 ± 0.02	0.04 ± 0.02	0.04 ± 0.01	Pass
SS-5547,5548	10/11/2016	Bi-214	0.14 ± 0.03	0.12 ± 0.03	0.13 ± 0.02	Pass
SS-5547,5548	10/11/2016	Pb-212	0.12 ± 0.02	0.11 ± 0.02	0.11 ± 0.01	Pass
SS-5547,5548	10/11/2016	Ac-228	0.10 ± 0.05	0.16 ± 0.05	0.13 ± 0.04	Pass
AP-101116	10/11/2016	Gr. Beta	0.032 ± 0.004	0.028 ± 0.004	0.030 ± 0.003	Pass
WW-5526.5527	10/11/2016	H-3	18,865 ± 408	18,904 ± 408	18,884 ± 289	Pass
WW-5639,5640	10/19/2016	H-3	192 ± 103	52 ± 98	122 ± 71	Pass
WW-5723,5724	10/18/2016	H-3	36,012 ± 560	36,207 ± 561	36,110 ± 396	Pass
F-5811,5812	10/20/2016	K-40	0.91 ± 0.30	0.75 ± 0.22	0.83 ± 0.19	Pass
SO-5900,5901	10/22/2016	Cs-137	0.05 ± 0.02	0.03 ± 0.02	0.04 ± 0.02	Pass
SO-5900,5901	10/22/2016	K-40	9.82 ± 0.60	10.77 ± 0.61	10.29 ± 0.43	Pass
SO-5900,5901	10/22/2016	Tl-208	0.10 ± 0.02	0.14 ± 0.03	0.12 ± 0.02	Pass
SO-5900,5901	10/22/2016	Pb-212	0.32 ± 0.03	0.33 ± 0.03	0.32 ± 0.02	Pass
SO-5900,5901	10/22/2016	Bi-214	0.20 ± 0.04	0.27 ± 0.04	0.23 ± 0.03	Pass
SO-5900,5901	10/22/2016	Ac-228	0.41 ± 0.08	0.48 ± 0.09	0.44 ± 0.06	Pass
SO-5900,5901	10/22/2016	Ra-226	0.45 ± 0.23	0.61 ± 0.27	0.53 ± 0.18	Pass
SO-5900,5901	10/22/2016	Gr. Beta	16.49 ± 1.01	17.71 ± 1.03	17.10 ± 0.72	Pass
SS-5879,5880	10/25/2016	K-40	14.94 ± 0.83	15.26 ± 0.84	15.10 ± 0.59	Pass
SS-5879,5880	10/25/2016	Cs-137	0.06 ± 0.03	0.09 ± 0.04	0.08 ± 0.02	Pass
LW-6072,6073	10/27/2016	Gr. Beta	0.88 ± 0.49	1.53 ± 0.56	1.21 ± 0.37	Pass
BS-6009, 6010	10/27/2016	Cs-137	0.14 ± 0.08	0.13 ± 0.06	0.13 ± 0.05	Pass
BS-6009, 6010	10/27/2016	K-40	17.04 ± 1.58	18.30 ± 1.42	17.67 ± 1.06	Pass
F-6211,6212	10/28/2016	Gr. Beta	3.25 ± 0.07	3.27 ± 0.07	3.26 ± 0.05	Pass
F-6211,6212	10/28/2016	K-40	2.45 ± 0.33	2.49 ± 0.37	2.47 ± 0.25	Pass
DW-70230, 70231	10/28/2016	Ra-226	4.00 ± 0.20	4.10 ± 0.30	4.05 ± 0.18	Pass
DW-70230, 70231	10/28/2016	Ra-228	5.30 ± 0.80	5.20 ± 0.80	5.25 ± 0.57	Pass
F-6093,6094	10/31/2016	K-40	3.77 ± 0.50	3.51 ± 0.44	3.64 ± 0.33	Pass

TABLE A-5. In-House "Duplicate" Samples

			Concentration [a]			
Lab Code	Date	Analysis	First Result	Second Result	Averaged Result	Acceptance
AP-110116	11/1/2016	Gr. Beta	0.021 ± 0.004	0.024 ± 0.004	0.023 ± 0.003	Pass
S-5963, 5964	11/1/2016	K-40	20.35 ± 2.29	18.59 ± 1.90	19.47 ± 1.49	Pass
SG-6119, 6120	11/1/2016	Ac-228	5.70 ± 0.44	6.28 ± 0.57	5.99 ± 0.36	Pass
SG-6119, 6120	11/1/2016	Gr. Alpha	21.59 ± 1.88	24.35 ± 1.93	22.97 ± 1.35	Pass
SG-6119, 6120	11/1/2016	K-40	4.89 ± 1.10	5.90 ± 1.08	5.40 ± 0.77	Pass
SG-6119, 6120	11/1/2016	Pb-214	3.99 ± 0.21	4.35 ± 0.32	4.17 ± 0.19	Pass
S-6051, 6052	11/4/2016	K-40	7.05 ± 0.60	7.56 ± 0.53	7.31 ± 0.40	Pass
WW-6297, 6298	11/8/2016	H-3	207 ± 98	165 ± 97	186 ± 69	Pass
WW-6341,6342	11/8/2016	H-3	1,356 ± 140	1,404 ± 141	1,380 ± 99	Pass
SO-6406,6407	11/9/2016	Cs-137	0.36 ± 0.04	0.43 ± 0.05	0.40 ± 0.03	Pass
SO-6406,6407	11/9/2016	K-40	10.90 ± 0.68	11.29 ± 0.74	11.09 ± 0.50	Pass
AP-111416	11/14/2016	Gr. Beta	0.024 ± 0.005	0.021 ± 0.006	0.022 ± 0.004	Pass
WW-6829,6830	11/15/2016	H-3	39,982 ± 589	40,315 ± 591	40,149 ± 417	Pass
DW-70239, 70240	11/17/2016	Gr. Alpha	7.99 ± 1.15	6.41 ± 1.05	7.20 ± 0.78	Pass
AP-112216	11/22/2016	Gr. Beta	0.049 ± 0.005	0.045 ± 0.005	0.047 ± 0.003	Pass
S-6473, 6474	11/24/2016	K-40	19.37 ± 1.97	23.80 ± 3.54	21.58 ± 2.02	Pass
SG-6938, 6939	11/28/2016	Ac-228	18.99 ± 0.59	19.92 ± 0.79	19.46 ± 0.49	Pass
SG-6938, 6939	11/28/2016	Pb-214	15.28 ± 0.34	14.96 ± 0.43	15.12 ± 0.27	Pass
AP-120116	12/1/2016	Gr. Beta	0.029 ± 0.003	0.030 ± 0.003	0.030 ± 0.002	Pass
F-6567,6568	12/1/2016	K-40	3.76 ± 0.40	3.83 ± 0.46	3.80 ± 0.30	Pass
S-6522, 6523	12/1/2016	Ac-228	1.08 ± 0.13	1.29 ± 0.16	1.19 ± 0.10	Pass
S-6522, 6523	12/1/2016	Pb-214	1.00 ± 0.08	1.01 ± 0.09	1.01 ± 0.06	Pass
S-6609, 6610	12/1/2016	K-40	15.57 ± 1.01	15.99 ± 0.78	15.78 ± 0.64	Pass
S-6718, 6719	12/7/2016	K-40	18.19 ± 2.13	18.76 ± 1.80	18.48 ± 1.39	Pass
WW-6784, 6785	12/7/2016	H-3	922 ± 117	905 ± 116	914 ± 82	Pass
AP-121216	12/12/2016	Gr. Beta	0.026 ± 0.005	0.028 ± 0.005	0.027 ± 0.003	Pass
AP-7178,7179	1/3/2017	Be-7	0.047 ± 0.015	0.062 ± 0.017	0.054 ± 0.012	Pass

Note: Duplicate analyses are performed on every twentieth sample received in-house. Results are not listed for those analyses with activities that measure below the LLD.

[a] Results are reported in units of pCi/L, except for air filters (pCi/Filter or pCi/m3), food products, vegetation, soil and sediment (pCi/g).

TABLE A-6. Department of Energy's Mixed Analyte Performance Evaluation Program (MAPEP).

			Concentration [a]			
Lab Code [b]	Reference Date	Analysis	Laboratory result	Known Activity	Control Limits [c]	Acceptance
MASO-1053	2/1/2016	Ni-63	1,206 ± 20	1250	875 - 1625	Pass
MASO-1053	2/1/2016	Sr-90	0.65 ± 1.27	0.00	NA [c]	Pass
MASO-1053	2/1/2016	Tc-99	0.1 ± 5.5	0.0	NA [c]	Pass
MASO-1053	2/1/2016	Cs-134	908 ± 26	1030	721 - 1339	Pass
MASO-1053	2/1/2016	Cs-137	0.10 ± 6.20	0.00	NA [c]	Pass
MASO-1053	2/1/2016	Co-57	1058 ± 26	992	694 - 1290	Pass
MASO-1053	2/1/2016	Co-60	1229 ± 28	1190	833 - 1547	Pass
MASO-1053	2/1/2016	Mn-54	1235 ± 43	1160	812 - 1508	Pass
MASO-1053	2/1/2016	Zn-65	753 ± 64	692	484 - 900	Pass
MASO-1053	2/1/2016	K-40	753 ± 140	607	425 - 789	Pass
MASO-1053	2/1/2016	Am-241	79 ± 6	103	72 - 134	Pass
MASO-1053	2/1/2016	Pu-238	73.9 ± 9.2	63.6	44.5 - 82.7	Pass
MASO-1053	2/1/2016	Pu-239/240	0.76 ± 1.34	0.21	NA [d]	Pass
MASO-1053	2/1/2016	U-234/233	45.0 ± 5.1	45.9	32.1 - 59.7	Pass
MASO-1053	2/1/2016	U-238	129 ± 9	146	102 - 190	Pass
MAW-989	2/1/2016	Am-241	0.018 ± 0.015	0.00	NA [c]	Pass
MAW-989	2/1/2016	H-3	0.2 ± 2.8	0.0	NA [c]	Pass
MAW-989	2/1/2016	Ni-63	12.8 ± 2.7	12.3	8.6 - 16.0	Pass
MAW-989	2/1/2016	Sr-90	8.70 ± 1.20	8.74	6.12 - 11.36	Pass
MAW-989	2/1/2016	Tc-99	-1.1 ± 0.6	0.0	NA [c]	Pass
MAW-989	2/1/2016	Cs-134	15.5 ± 0.3	16.1	11.3 ± 20.9	Pass
MAW-989	2/1/2016	Cs-137	23.7 ± 0.5	21.2	14.8 - 27.6	Pass
MAW-989 [e]	2/1/2016	Co-57	1.38 ± 0.12	0.00	NA [c]	Fail
MAW-989	2/1/2016	Co-60	12.5 ± 0.3	11.8	8.3 - 15.3	Pass
MAW-989	2/1/2016	Mn-54	12.2 ± 0.4	11.1	7.8 - 14.4	Pass
MAW-989	2/1/2016	Zn-65	15.7 ± 0.7	13.6	9.5 - 17.7	Pass
MAW-989	2/1/2016	K-40	288 ± 5	251	176 - 326	Pass
MAW-989	2/1/2016	Fe-55	17.3 ± 7.0	16.2	11.3 - 21.1	Pass
MAW-989	2/1/2016	Ra-226	0.710 ± 0.070	0.718	0.503 - 0.933	Pass
MAW-989	2/1/2016	Pu-238	1.280 ± 0.110	1.244	0.871 ± 1.617	Pass
MAW-989	2/1/2016	Pu-239/240	0.640 ± 0.080	0.641	0.449 - 0.833	Pass
MAW-989	2/1/2016	U-234/233	1.39 ± 0.12	1.48	1.04 - 1.92	Pass
MAW-989	2/1/2016	U-238	1.43 ± 0.12	1.53	1.07 - 1.99	Pass
MAW-893	2/1/2016	Gross Alpha	0.600 ± 0.050	0.673	0.202 - 1.144	Pass
MAW-893	2/1/2016	Gross Beta	2.10 ± 0.06	2.15	1.08 - 3.23	Pass
MAW-896	2/1/2016	I-129	3.67 ± 0.20	3.85	2.70 - 5.01	Pass
MAAP-1056	2/1/2016	Gross Alpha	0.39 ± 0.05	1.20	0.36 - 2.04	Pass
MAAP-1056	2/1/2016	Gross Beta	1.03 ± 0.07	0.79	0.40 - 1.19	Pass

TABLE A-6. Department of Energy's Mixed Analyte Performance Evaluation Program (MAPEP).

			Concentration [a]			
Lab Code [b]	Reference Date	Analysis	Laboratory result	Known Activity	Control Limits [c]	Acceptance
MAAP-1057	2/1/2016	Sr-90	1.34 ± 0.15	1.38	0.97 ± 1.79	Pass
MAAP-1057	2/1/2016	Cs-134	-0.01 ± 0.03	0.00	NA [c]	Pass
MAAP-1057	2/1/2016	Cs-137	2.57 ± 0.10	2.30	1.61 - 2.99	Pass
MAAP-1057	2/1/2016	Co-57	3.01 ± 0.06	2.94	2.06 - 3.82	Pass
MAAP-1057	2/1/2016	Co-60	4.28 ± 0.10	4.02	2.81 - 5.23	Pass
MAAP-1057	2/1/2016	Mn-54	4.90 ± 0.13	4.53	3.17 - 5.89	Pass
MAAP-1057	2/1/2016	Zn-65	4.09 ± 0.18	3.57	2.50 - 4.64	Pass
MAAP-1057	2/1/2016	Am-241	0.059 ± 0.015	0.0805	0.0564 - 0.1047	Pass
MAAP-1057	2/1/2016	Pu-238	0.066 ± 0.020	0.0637	0.0446 - 0.0828	Pass
MAAP-1057	2/1/2016	Pu-239/240	0.074 ± 0.020	0.099	NA [d]	Pass
MAAP-1057	2/1/2016	U-234/233	0.151 ± 0.026	0.165	0.116 - 0.215	Pass
MAAP-1057	2/1/2016	U-238	0.160 ± 0.026	0.172	0.120 - 0.224	Pass
MAVE-1050	2/1/2016	Cs-134	9.83 ± 0.19	10.62	7.43 - 13.81	Pass
MAVE-1050	2/1/2016	Cs-137	6.06 ± 0.19	5.62	3.93 - 7.31	Pass
MAVE-1050	2/1/2016	Co-57	13.8 ± 0.2	11.8	8.3 - 15.3	Pass
MAVE-1050	2/1/2016	Co-60	0.022 ± 0.040	0.00	NA [c]	Pass
MAVE-1050	2/1/2016	Mn-54	0.009 ± 0.044	0.000	NA [c]	Pass
MAVE-1050	2/1/2016	Zn-65	10.67 ± 0.39	9.60	6.70 - 12.50	Pass
MASO-4780[f]	8/1/2016	Ni-63	648 ± 14	990	693 - 1287	Fail
MASO-4780[g]	8/1/2016	Ni-63	902 ± 46	990	693 - 1287	Pass
MASO-4780	8/1/2016	Sr-90	757 ± 16	894	626 - 1162	Pass
MASO-4780	8/1/2016	Tc-99	559 ± 12	556	389 - 723	Pass
MASO-4780	8/1/2016	Cs-134	0.93 ± 2.92	0.00	NA [c]	Pass
MASO-4780	8/1/2016	Cs-137	1061 ± 12	1067	747 - 1387	Pass
MASO-4780	8/1/2016	Co-57	1178 ± 8	1190	833 - 1547	Pass
MASO-4780	8/1/2016	Co-60	841 ± 9	851	596 - 1106	Pass
MASO-4780	8/1/2016	Mn-54	0.69 ± 2.53	0.00	NA [c]	Pass
MASO-4780	8/1/2016	Zn-65	724 ± 19	695	487 - 904	Pass
MASO-4780	8/1/2016	K-40	566 ± 52	588	412 - 764	Pass
MASO-4780	8/1/2016	Am-241	0.494 ± 0.698	0.000	NA [c]	Pass
MASO-4780	8/1/2016	Pu-238	69.7 ± 7.4	70.4	49.3 - 91.5	Pass
MASO-4780	8/1/2016	Pu-239/240	53.9 ± 6.3	53.8	37.7 - 69.9	Pass
MASO-4780[h]	8/1/2016	U-233/234	46.8 ± 3.9	122	85 - 159	Fail
MASO-4780[h]	8/1/2016	U-238	46.6 ± 3.9	121	85 - 157	Fail
MAW-4776	8/1/2016	I-129	4.40 ± 0.20	4.54	3.18 - 5.90	Pass
MAVE-4782	8/1/2016	Cs-134	-0.01 ± 0.05	0.00	NA [c]	Pass
MAVE-4782	8/1/2016	Cs-137	6.18 ± 0.20	5.54	3.88 - 7.20	Pass
MAVE-4782	8/1/2016	Co-57	8.13 ± 0.16	6.81	4.77 - 8.85	Pass
MAVE-4782	8/1/2016	Co-60	5.30 ± 0.15	4.86	3.40 - 6.32	Pass
MAVE-4782	8/1/2016	Mn-54	8.08 ± 0.24	7.27	5.09 - 9.45	Pass
MAVE-4782	8/1/2016	Zn-65	6.24 ± 0.36	5.40	3.78 - 7.02	Pass

TABLE A-6. Department of Energy's Mixed Analyte Performance Evaluation Program (MAPEP).

			Concentration [a]			
Lab Code [b]	Reference Date	Analysis	Laboratory result	Known Activity	NA [c] Limits [c]	Acceptance
MAAP-4784	8/1/2016	Sr-90	1.18 ± 0.10	1.03	0.72 - 1.34	Pass
MAAP-4784	8/1/2016	Cs-134	1.58 ± 0.08	2.04	1.43 - 2.65	Pass
MAAP-4784	8/1/2016	Cs-137	1.85 ± 0.09	1.78	1.25 - 2.31	Pass
MAAP-4784	8/1/2016	Co-57	2.39 ± 0.52	2.48	1.74 - 3.22	Pass
MAAP-4784	8/1/2016	Co-60	3.22 ± 0.08	3.26	2.28 - 4.24	Pass
MAAP-4784	8/1/2016	Mn-54	2.82 ± 0.12	2.75	1.93 - 3.58	Pass
MAAP-4784	8/1/2016	Zn-65	-0.015 ± 0.062	0.00	NA [c]	Pass
MAAP-4784	8/1/2016	Am-241	-0.001 ± 0.006	0.00	NA [c]	Pass
MAAP-4784	8/1/2016	Pu-238	0.075 ± 0.022	0.069	0.049 - 0.090	Pass
MAAP-4784	8/1/2016	Pu-239/240	0.048 ± 0.015	0.054	0.038 - 0.070	Pass
MAAP-4784	8/1/2016	U-234/233	0.151 ± 0.036	0.150	0.105 - 0.195	Pass
MAAP-4784	8/1/2016	U-238	0.147 ± 0.034	0.156	0.109 - 0.203	Pass
MAW-4778	8/1/2016	H-3	365 ± 11	334	234 - 434	Pass
MAW-4778	8/1/2016	Fe-55	23.6 ± 16.3	21.5	15.1 ± 28.0	Pass
MAW-4778	8/1/2016	Ni-63	17.0 ± 2.8	17.2	12.0 ± 22.4	Pass
MAW-4778	8/1/2016	Sr-90	0.17 ± 0.28	0.00	NA [c]	Pass
MAW-4778	8/1/2016	Tc-99	9.50 ± 0.41	11.60	8.10 - 15.10	Pass
MAW-4778	8/1/2016	Cs-134	22.6 ± 0.4	23.9	16.7 - 31.1	Pass
MAW-4778	8/1/2016	Cs-137	0.018 ± 0.117	0.00	NA [c]	Pass
MAW-4778	8/1/2016	Co-57	27.6 ± 0.2	27.3	19.1 ± 35.5	Pass
MAW-4778	8/1/2016	Co-60	0.018 ± 0.090	0.00	NA [c]	Pass
MAW-4778	8/1/2016	Mn-54	16.2 ± 0.4	14.8	10.4 - 19.2	Pass
MAW-4778	8/1/2016	Zn-65	19.3 ± 0.7	17.4	12.2 - 22.6	Pass
MAW-4778	8/1/2016	K-40	286 ± 6	252	176 - 328	Pass
MAW-4778	8/1/2016	Ra-226	1.48 ± 0.09	1.33	0.93 - 1.73	Pass
MAW-4778	8/1/2016	Pu-238	1.09 ± 0.13	1.13	0.79 - 1.47	Pass
MAW-4778	8/1/2016	Pu-239/240	0.003 ± 0.011	0.016	NA [d]	Pass
MAW-4778	8/1/2016	U-234/233	1.80 ± 0.13	1.86	1.30 - 2.42	Pass
MAW-4778	8/1/2016	U-238	1.77 ± 0.13	1.92	1.34 - 2.50	Pass
MAW-4778	8/1/2016	Am-241	0.678 ± 0.086	0.814	0.570 ± 1.058	Pass

[a] Results are reported in units of Bq/kg (soil), Bq/L (water) or Bq/total sample (filters, vegetation).

[b] Laboratory codes as follows: MAW (water), MAAP (air filter), MASO (soil), MAVE (vegetation).

[c] MAPEP results are presented as the known values and expected laboratory precision (1 sigma, 1 determination) and control limits as defined by the MAPEP. A known value of "zero" indicates an analysis was included in the testing series as a "false positive". MAPEP does not provide control limits.

[d] Provided in the series for "sensitivity evaluation". MAPEP does not provide control limits.

[e] The laboratory properly identified the Sn-75 interfering peak in the vicinity of Co-57 and stated so in the comment field. MAPEP requires results to be reported as an activity with an uncertainty. Since the calculated uncertainty was less than the activity MAPEP interpreted the submitted result as a "false positive" resulting in a failure.

[f] Original analysis for Ni-63 failed.

[g] Reanalysis with a smaller aliquot resulted in acceptable results. An investigation is in process to identify better techniques for analyzing samples with complex matrices.

[h] MAPEP states that samples contain two fractions of Uranium; one that is soluble in concentrated HNO^3 and HCl acid and one that is "fundamentally insoluble in these acids". They also state that HF treatment can not assure complete dissolution. Results are consistent with measuring the soluble form.

TABLE A-7. Interlaboratory Comparison Crosscheck Program, Environmental Resource Associates (ERA)[a].

MRAD Study

Lab Code [b]	Date	Analysis	Concentration [a] Laboratory Result	ERA Result	Control Limits	Acceptance
ERAP-1101	3/14/2016	Am-241	37.3	45.9	28.3 - 62.1	Pass
ERAP-1101	3/14/2016	Co-60	637	623	482 - 778	Pass
ERAP-1101	3/14/2016	Cs-134	251	304	193 - 377	Pass
ERAP-1101	3/14/2016	Cs-137	1,273	1,150	864 - 1,510	Pass
ERAP-1101	3/14/2016	Fe-55	< 162	126	39.1 - 246	Pass
ERAP-1101	3/14/2016	Mn-54	< 2.64	< 50.0	0.00 - 50.0	Pass
ERAP-1101	3/14/2016	Pu-238	68.0	70.5	48.3 - 92.7	Pass
ERAP-1101	3/14/2016	Pu-239/240	54.1	54.8	39.70 - 71.60	Pass
ERAP-1101	3/14/2016	Sr-90	139	150	73.3 - 225.0	Pass
ERAP-1101	3/14/2016	U-233/234	59.3	64.8	40.2 - 97.7	Pass
ERAP-1101	3/14/2016	U-238	55.5	64.2	41.5 - 88.8	Pass
ERAP-1101	3/14/2016	Zn-65	428	356	255 - 492	Pass
ERAP-1101	3/14/2016	Gr. Alpha	98.0	70.1	23.5 - 109	Pass
ERAP-1101	3/14/2016	Gr. Beta	78.6	54.4	34.4 - 79.3	Pass
ERSO-1105	3/14/2016	Am-241	1,030	1,360	796 - 1,770	Pass
ERSO-1105	3/14/2016	Ac-228	1,540	1,240	795 - 1,720	Pass
ERSO-1105	3/14/2016	Bi-212	1,550	1,240	330 - 1,820	Pass
ERSO-1105	3/14/2016	Bi-214	3,100	3,530	2,130 - 5,080	Pass
ERSO-1105	3/14/2016	Co-60	5,600	5,490	3,710 - 7,560	Pass
ERSO-1105	3/14/2016	Cs-134	3,030	3,450	2,260 - 4,140	Pass
ERSO-1105	3/14/2016	Cs-137	4,440	4,310	3,300 - 5,550	Pass
ERSO-1105	3/14/2016	K-40	10,300	10,600	7,740 - 14,200	Pass
ERSO-1105	3/14/2016	Mn-54	< 50.8	< 1000	0.0 - 1,000	Pass
ERSO-1105	3/14/2016	Pb-212	1,140	1,240	812 - 1,730	Pass
ERSO-1105	3/14/2016	Pb-214	3,190	3,710	2,170 - 5,530	Pass
ERSO-1105	3/14/2016	Pu-238	680	658	396 - 908	Pass
ERSO-1105	3/14/2016	Pu-239/240	460	496	324 - 0,685	Pass
ERSO-1105	3/14/2016	Sr-90	7,740	8,560	3,260 - 13,500	Pass
ERSO-1105	3/14/2016	Th-234	3,630	3,430	1,080 - 6,450	Pass
ERSO-1105	3/14/2016	U-233/234	3,090	3,460	2,110 - 4,430	Pass
ERSO-1105	3/14/2016	U-238	3,280	3,430	2,120 - 4,350	Pass
ERSO-1105	3/14/2016	Zn-65	2,940	2,450	1,950 - 3,260	Pass
ERW-1115	3/14/2016	Gr. Alpha	105.0	117.0	41.5 - 181.0	Pass
ERW-1115	3/14/2016	Gr. Beta	76.2	75.5	43.2 - 112.0	Pass
ERW-1117	3/14/2016	H-3	8,870	8,650	5,800 - 12,300	Pass

TABLE A-7. Interlaboratory Comparison Crosscheck Program, Environmental Resource Associates (ERA)[a].

MRAD Study

Lab Code [b]	Date	Analysis	Concentration [a] Laboratory Result	ERA Result	Control Limits	Acceptance
ERVE-1108	3/14/2016	Am-241	1,930	2,120	1,300 - 2,820	Pass
ERVE-1108	3/14/2016	Cm-244	1,294	1,560	764 - 2,430	Pass
ERVE-1108	3/14/2016	Co-60	1,164	1,100	759 - 1,540	Pass
ERVE-1108	3/14/2016	Cs-134	1,056	1,070	687 - 1,390	Pass
ERVE-1108	3/14/2016	Cs-137	930	838	608 - 1,170	Pass
ERVE-1108	3/14/2016	K-40	32,200	31,000	22,400 - 43,500	Pass
ERVE-1108	3/14/2016	Mn-54	< 24.5	< 300	0.00 - 300	Pass
ERVE-1108	3/14/2016	Zn-65	3,320	2,820	2,030 - 3,960	Pass
ERVE-1108	3/14/2016	Pu-238	3,410	2,810	1,680 - 3,850	Pass
ERVE-1108	3/14/2016	Pu-239/240	4,120	3,640	2,230 - 5,010	Pass
ERVE-1108	3/14/2016	Sr-90	8,120	8,710	4,960 - 11,500	Pass
ERVE-1108	3/14/2016	U-233/234	4,350	4,160	2,740 - 5,340	Pass
ERVE-1108	3/14/2016	U-238	4,220	4,120	2,750 - 5,230	Pass
ERW-1111	3/14/2016	Am-241	113	121	81.5 - 162	Pass
ERW-1111	3/14/2016	Co-60	1,120	1,050	912 - 1,230	Pass
ERW-1111	3/14/2016	Cs-134	806	842	618 - 968	Pass
ERW-1111	3/14/2016	Cs-137	1,190	1,100	934 - 1,320	Pass
ERW-1111	3/14/2016	Mn-54	< 5.89	< 100	0.00 - 100	Pass
ERW-1111	3/14/2016	Pu-238	159	138	102 - 172	Pass
ERW-1111	3/14/2016	Pu-239/240	113	98.7	76.6 - 124	Pass
ERW-1111	3/14/2016	U-233/234	46.9	52.7	39.6 - 68.0	Pass
ERW-1111	3/14/2016	U-238	50.4	52.3	39.9 - 64.2	Pass
ERW-1111	3/14/2016	Zn-65	1,160	1,010	842 - 1,270	Pass
ERW-1111	3/14/2016	Fe-55	1,600	1,650	984 - 2,240	Pass
ERW-1111	3/14/2016	Sr-90	430	434	283 - 574	Pass

[a] Results obtained by Environmental, Inc., Midwest Laboratory as a participant in the crosscheck program for proficiency testing administered by Environmental Resources Associates, serving as a replacement for studies conducted previously by the Environmental Measurements Laboratory Quality Assessment Program (EML).

[b] Laboratory codes as follows: ERW (water), ERAP (air filter), ERSO (soil), ERVE (vegetation). Results are reported in units of pCi/L, except for air filters (pCi/Filter), vegetation and soil (pCi/kg).

[c] Results are presented as the known values, expected laboratory precision (1 sigma, 1 determination) and control limits as provided by ERA.

APPENDIX B

DATA REPORTING CONVENTIONS

Data Reporting Conventions

1.0. All activities, except gross alpha and gross beta, are decay corrected to collection time or the end of the collection period.

2.0. Single Measurements

Each single measurement is reported as follows: $x \pm s$

where: x = value of the measurement;

s = 2s counting uncertainty (corresponding to the 95% confidence level).

In cases where the activity is less than the lower limit of detection L, it is reported as: <L,

where L = the lower limit of detection based on 4.66s uncertainty for a background sample.

3.0. Duplicate analyses

3.1 Individual results: For two analysis results; $x_1 \pm s_1$ and $x_2 \pm s_2$

Reported result: $x \pm s$; where $x = (1/2)(x_1 + x_2)$ and $s = (1/2)\sqrt{s_1^2 + s_2^2}$

3.2. Individual results: $<L_1$, $<L_2$ Reported result: <L, where L = lower of L_1 and L_2

3.3. Individual results: $x \pm s$, <L Reported result: $x \pm s$ if $x \geq L$; <L otherwise.

4.0. Computation of Averages and Standard Deviations

4.1 Averages and standard deviations listed in the tables are computed from all of the individual measurements over the period averaged; for example, an annual standard deviation would not be the average of quarterly standard deviations. The average $\bar{x}$ and standard deviation s of a set of n numbers $x_1, x_2 \ldots x_n$ are defined as follows:

$$\bar{x} = \frac{1}{n} \sum x \qquad s = \sqrt{\frac{\sum (x - \bar{x})^2}{n-1}}$$

4.2 Values below the highest lower limit of detection are not included in the average.

4.3 If all values in the averaging group are less than the highest LLD, the highest LLD is reported.

4.4 If all but one of the values are less than the highest LLD, the single value x and associated two sigma error is reported.

4.5 In rounding off, the following rules are followed:

4.5.1. If the figure following those to be retained is less than 5, the figure is dropped, and the retained figures are kept unchanged. As an example, 11.443 is rounded off to 11.44.

4.5.2. If the figure following those to be retained is equal to or greater than 5, the figure is dropped and the last retained figure is raised by 1. As an example, 11.445 is rounded off to 11.45.

4.6 Composite samples which overlap the next month or year are reported for the month or year in which most of the sample is collected.

APPENDIX C

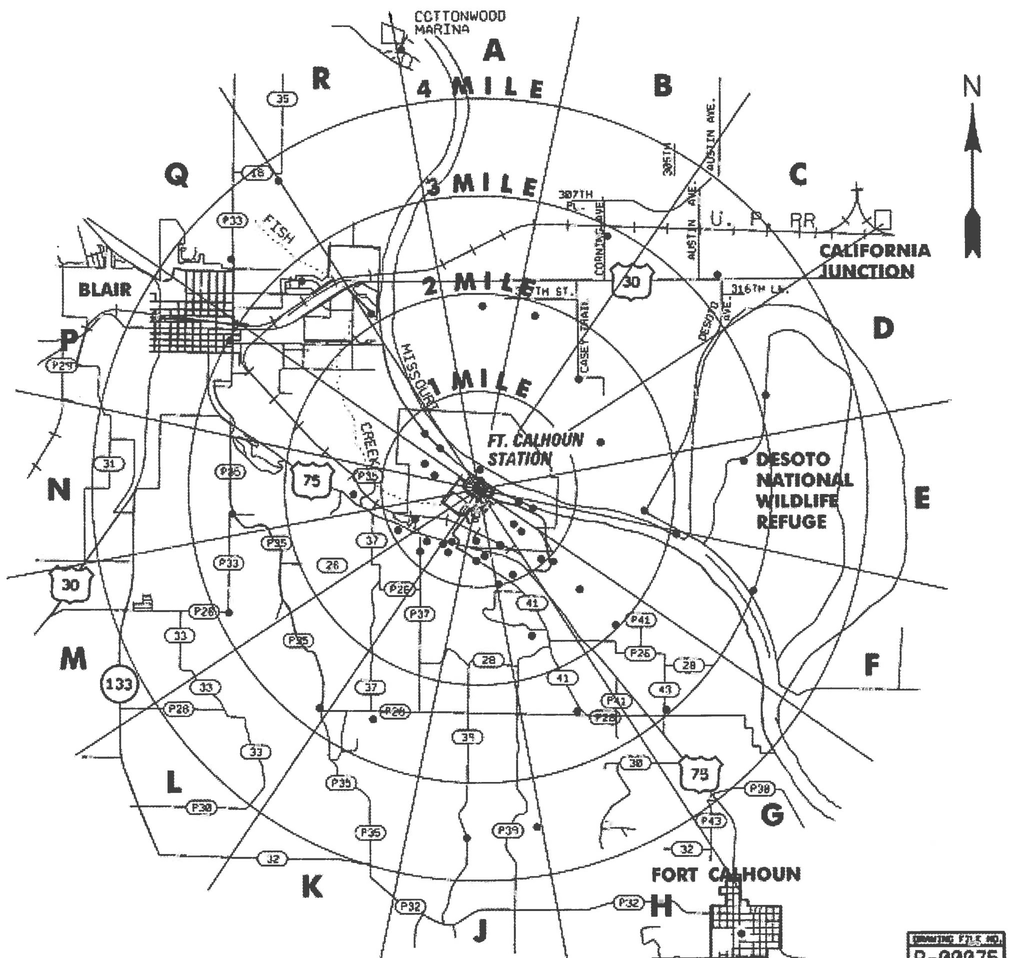
TECHNICAL SPECIFICATION 2.1.3

REACTOR COOLANT DOSE EQUIVALENT IODINE
ABOVE TECHNICAL SPECIFICATION LIMIT

During the 2016 reporting period, radioactivity of primary coolant did not exceed the limits of Technical Specification 2.1.3.

APPENDIX D

SAMPLE LOCATION MAPS


COTTONWOOD MARINA
A
B
C
D
E
F
G
H
J
K
L
M
N
P
Q
R
4 MILE
3 MILE
2 MILE
1 MILE
BLAIR
CALIFORNIA JUNCTION
FT. CALHOUN STATION
DESOTO NATIONAL WILDLIFE REFUGE
FORT CALHOUN
U. P. RR
MISSOURI
FISH
CREEK
N
P-00075

Radiological Environmental Sampling Locations and Media

Sample Station No.	Approximate Collection Sites	Approximate Distance from Center of Containment (miles)	Approximate Direction (degrees from true north)	Sector	Air Monitoring		TLD	Water	Milk	Sedi-ment	Fish	Vegetables and Food Products	Ground-water
					Airborne Particulate	Airborne Iodine							
1	Onsite Station, 110-meter weather tower	0.53	293°/WNW	P			X						
2[C,E]	Onsite Station, adjacent to old plant access road	0.59	207°/SSW	K	X	X	X						
3	Offsite Station, Intersection of Hwy. 75 and farm access road	0.94	145°/SE	G			X						
4	Blair OPPD office	2.86	305°/NW	Q	X	X	X						
5[A]													
6	Fort Calhoun, NE City Hall	5.18	150°/SSE	H			X						
7	Fence around intake gate, Desoto Wildlife Refuge	2.07	102°/ESE	F			X						

Radiological Environmental Sampling Locations and Media

Sample Station No.	Approximate Collection Sites	Approximate Distance from Center of Containment (miles)	Approximate Direction (degrees from true north)	Sector	Air Monitoring		TLD	Water	Milk	Sedi-ment	Fish	Vegetables and Food Products	Ground-water
					Airborne Particulate	Airborne Iodine							
8	Onsite Station, entrance to Plant Site from Hwy. 75	0.55	191°/S	J			X						
9	Onsite Station, NW of Plant	0.68	305°/NW	Q			X						
10	Onsite Station, WSW of Plant	0.61	242°/WSW	M			X						
11	Offsite Station, SE of Plant	1.07	39°/SE	G			X						
12	Metropolitan Utilities Dist., Florence Treatment Plant North Omaha, NE	14.3	154°/SSE	H				X					
13	West bank Missouri River, downstream from Plant discharge	0.45	108°/ESE	F				X		X			
14[D]	Upstream from Intake Bldg, west bank of river	0.09	4°/N	A				X		X			

Radiological Environmental Sampling Locations and Media

Sample Station No.	Approximate Collection Sites	Approximate Distance from Center of Containment (miles)	Approximate Direction (degrees from true north)	Sector	Air Monitoring		TLD	Water	Milk	Sedi-ment	Fish	Vegetables and Food Products	Ground-water
					Airborne Particulate	Airborne Iodine							
15	Smith Farm	1.99	134°/SE	G									X
16[A]													
17[A]													
18[A]													
19[A]													
20[D]	Mohr Dairy	9.86	186°/S	J					[B]			X	X
21[A]													
22	Fish Sampling Area, Missouri River	0.08 (R.M. 645.0)	6°/N	A							X		
23[D]	Fish Sampling Area, Missouri River	17.9 (R.M. 666.0)	358°/N	A							X		
24[A]													
25[A]													

Radiological Environmental Sampling Locations and Media

Sample Station No.	Approximate Collection Sites	Approximate Distance from Center of Containment (miles)	Approximate Direction (degrees from true north)	Sector	Air Monitoring		TLD	Water	Milk	Sedi-ment	Fish	Vegetables and Food Products	Ground-water
					Airborne Particulate	Airborne Iodine							
26[A]													
27[A]													
28[A]													
29[A]													
30[A]													
31[A]													
32[D]	Valley Substation #902	19.6	221°/SW	L	X	X	X						
33[A]													
34[A]													
35	Onsite Farm Field	0.52	118°/ESE	F								X	
36	Offsite Station Intersection Hwy 75/Co. Rd. P37	0.75	227°/SW	L			X						

Radiological Environmental Sampling Locations and Media

Sample Station No.	Approximate Collection Sites	Approximate Distance from Center of Containment (miles)	Approximate Direction (degrees from true north)	Sector	Air Monitoring		TLD	Water	Milk	Sedi-ment	Fish	Vegetables and Food Products	Ground-water
					Airborne Particulate	Airborne Iodine							
37	Offsite Station Desoto Township	1.57	144°/SE	G	X	X	X						
38[A]													
39[A]													
40[A]													
41[C]	Dowler Acreage	0.73	175°/S	J	X	X	X		[B,C]				
42	Sector A-1	1.94	0°/NORTH	A			X						
43	Sector B-1	1.97	16°/NNE	B			X						
44	Sector C-1	1.56	41°/NE	C			X						
45	Sector D-1	1.34	71°/ENE	D			X						
46	Sector E-1	1.54	90°/EAST	E			X						
47	Sector F-1	0.45	108°/ESE	F			X						
48	Sector G-1	1.99	134°/SE	G			X						

Radiological Environmental Sampling Locations and Media

Sample Station No.	Approximate Collection Sites	Approximate Distance from Center of Containment (miles)	Approximate Direction (degrees from true north)	Sector	Air Monitoring		TLD	Water	Milk	Sedi-ment	Fish	Vegetables and Food Products	Ground-water
					Airborne Particulate	Airborne Iodine							
49	Sector H-1	1.04	159°/SSE	H			X						
50	Sector J-1	0.71	179°/SOUTH	J			X						
51	Sector K-1	0.61	205°/SSW	K			X						
52	Sector L-1	0.74	229°/SW	L			X						
53	Sector M-1	0.93	248°/WSW	M			X						
54	Sector N-1	1.31	266°/WEST	N			X						
55	Sector P-1	0.60	291°/WNW	P			X						
56	Sector Q-1	0.67	307°/NW	Q			X						
57	Sector R-1	2.32	328°/NNW	R			X						
58	Sector A-2	4.54	350°/NORTH	A			X						
59	Sector B-2	2.95	26°/NNE	B			X						
60	Sector C-2	3.32	50°/NE	C			X						

Radiological Environmental Sampling Locations and Media

Sample Station No.	Approximate Collection Sites	Approximate Distance from Center of Containment (miles)	Approximate Direction (degrees from true north)	Sector	Air Monitoring		TLD	Water	Milk	Sedi-ment	Fish	Vegetables and Food Products	Ground-water
					Airborne Particulate	Airborne Iodine							
61	Sector D-2	3.11	75°/ENE	D			X						
62	Sector E-2	2.51	90°/EAST	E			X						
63	Sector F-2	2.91	110°/ESE	F			X						
64	Sector G-2	3.00	140°/SE	G			X						
65	Sector H-2	2.58	154°/SSE	H			X						
66	Sector J-2	3.53	181°/SOUTH	J			X						
67	Sector K-2	2.52	205°/SSW	K			X						
68	Sector L-2	2.77	214°/SW	L			X						
69	Sector M-2	2.86	243°/WSW	M			X						

Radiological Environmental Sampling Locations and Media

Sample Station No.	Approximate Collection Sites	Approximate Distance from Center of Containment (miles)	Approximate Direction (degrees from true north)	Sector	Air Monitoring		TLD	Water	Milk	Sedi-ment	Fish	Vegetables and Food Products	Ground-water
					Airborne Particulate	Airborne Iodine							
70	Sector N-2	2.54	263°/WEST	N			X						
71	Sector P-2	2.99	299°/WNW	P			X						
72	Sector Q-2	3.37	311°/NW	Q			X						
73	Sector R-2	3.81	328°/NNW	R			X						
74	D. Miller Farm	0.65	203°/SSW	K									X
75[C]	Lomp Acreage	0.65	163°/SSE	H	X	X	X		B, C			X	X
76	Stangl Farm	3.40	169°/S	J					X				

NOTES:

A. Location is either not in use or currently discontinued and is documented in the table for reference only.

B. If milk samples are temporarily not available at a sampling site due to mitigating circumstances, then vegetation (broadleaf, pasture grass, etc.) shall be collected as an alternate sample at the site. If there are no milk producers within the entire 5-mile radius of the plant, then vegetation shall be collected monthly, when available, at two offsite locations having the highest calculated annual average ground level D/Q and a background locale. (Reference Off-Site Dose Calculation Manual, Part II, Table 4 "Highest Potential Exposure Pathways for Estimating Dose")

C. Locations represent highest potential exposure pathways as determined by the biennial Land Use Survey

D. Background location (control). All other locations are indicators.

E. Location for monitoring Sector K High Exposure Pathway Resident Receptor for inhalation.

F. When broad leaf (pasture grasses) are being collected in lieu of milk, background broad leaf samples will be collected at a background locale.