Fort Calhoun Station
Unit No. 1

CH-ODCM-0001

CHEMISTRY PROCEDURE

Title: OFF-SITE DOSE CALCULATION MANUAL (ODCM)

FC-68 Number:	44594
Reason for Change:	To incorporate Tech Spec Amendment #171 for Section 3.1 Table 3-3, Items 3a/b and 5a/b. To update/reflect the changing environmental and demographic monitoring zone and to remove redundant verbiage.
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1.0 INTRODUCTION

The OFFSITE DOSE CALCULATION MANUAL (ODCM) is the controlling document for the Fort Calhoun Station's (FCS) Radiological Effluent and Environmental Monitoring programs. The programs are necessary to ensure the requirements set forth in 10 CFR 20, 10 CFR 50.34a, 10 CFR 50.36a, and 10 CFR 50, Appendix I. The document is subdivided into four sections as outlined below:

Part I, Introduction - consists of information necessary for the effective use of the ODCM.

Part II, Radiological Effluent Controls - consists of 5 separate sections including:

Section 1 Radiological Effluent Release Limits

Section 2 Radiological Effluent Release Requirements

Section 3 Radiological Effluent Sampling and Analysis Requirements

Section 4 Radiological Effluent Reporting Requirements

Section 5 Radiological Environmental Monitoring Requirements

Together these sections provide the controls used to permit radioactive material releases from the Fort Calhoun Station.

Part III, Radiological Effluent Radiation Monitor Calculation - provides radiation monitor setpoint calculations for the liquid and airborne release pathways.

Part IV, Radiological Effluent Monitoring Calculations - provides the methodology necessary to calculate doses to individuals as a result of radioactive airborne and liquid releases from Fort Calhoun.

The ODCM has been prepared in accordance with the guidance of Nuclear Regulatory Commissions Reg. Guide 1.109, Rev. 1.

The Radiological Effluent Controls Program consists of the following sections in the Radiological Effluent Controls:

A. Radiological Effluent Release Limits - All Sections

B. Radiological Effluent Release Requirements - All Sections

C. Radiological Effluent Sampling and Analysis Requirements - All Sections

D. Radiological Effluent Reporting Requirements - Sections 4.1 and 4.4

2.0 ADMINISTRATIVE

The Radiological Environmental Monitoring Program consists of the following sections in the Radiological Effluent Controls:

A. Radiological Effluent Reporting Requirements - Sections 4.2 and 4.3

B. Radiological Environmental Monitoring Requirements - All Sections

2.1 Responsibilities

2.1.1 Nuclear Operation Division Chemistry Department is responsible for the implementation and maintenance of the ODCM.

2.1.2 Nuclear Operation Division Operation Department is responsible for the compliance with the ODCM in the operation of Fort Calhoun Station.

2.2 Change Mechanism

The ODCM 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 Review Committee and approved by the Plant Manager in accordance with Technical Specification 5.17. All changes to the ODCM will be forwarded to the Nuclear Regulatory Commission during the next reporting period for the Annual Report in accordance with the requirements of Technical Specification 5.17.

3.0 METEOROLOGICAL DATA

The Annual Average χ/Q is utilized to determine the concentrations of radionuclides at the unrestricted area boundary. This dispersion factor coincides with the highest calculated annual average value for the Fort Calhoun Station. It is based on 3 years of Onsite Meteorological data and the MESODIF II plume trajectory model. This model conforms with the Nuclear Regulatory Commissions Regulatory Guide 1.111. The model employs the sector averaged equations that are utilized for long-term releases. This type of release (long term) is not dependent solely on atmospheric conditions for complying with 10 CFR 20 concentration limits at the unrestricted area boundary.

Real time meteorological data will be utilized in the preparation of the Annual Report. This data is used to calculate the joint frequency table and 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 and LADTAP, conform with the Nuclear Regulatory Commissions Reg. Guide 1.109 and 1.21 for the reporting of doses due to routine radioactive effluent releases.

4.0 DEFINITIONS

Air Effluent Concentration (AEC)

Radionuclide limits listed in 10 CFR 20, Appendix B, Table 2, Column 1.

Channel Check

A qualitative determination of acceptable operability by observation of channel behavior during normal plant operation. This determination shall, where feasible, include comparison of the channel with other independent channels measuring the same variable.

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.

Operable - Operability

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

Purge-Purging

A means for the removal and replacement of gases within the containment building.

Source Check

Verification of channel response when the channel sensor is exposed to a radioactive source.

Venting

A means for the reduction of pressure greater than atmospheric within the containment structure.

Unrestricted Area

Means an area, access to which is neither limited or controlled by licensee.

Water Effluent Concentration (WEC)

Radionuclide limits listed in 10 CFR 20, Appendix B, Table 2, Column 2.

5.0 REFERENCES/COMMITMENT DOCUMENTS

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 50, Appendix I

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

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

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

Nureg-0472, Rev. 3 - Draft Radiological Effluent Technical Specifications for PWRs.

Regulatory Guide 1.21, Rev. 1 - Measuring, Evaluating, and Reporting Radioactivity is solid wastes and Releases of Radioactivity Materials in Liquid and Gaseous Effluents from Light-Water-Cooled Nuclear Power Plants.

Code of Federal Regulations, Title 10, Part 20

Code of Federal Regulations, Title 10, Part 50

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

Fort Calhoun Technical Specifications (Unit No. 1)

Updated Safety Analysis Report

Commitment Documents:

IMPLEMENTING STEP	COMMITMENT NUMBER (CID)	SOURCE DOCUMENT
Part II, 2.2.3.1 C.2	920102/01	FC-0133-92

PART II

RADIOLOGICAL EFFLUENT CONTROLS

1.0 RADIOACTIVE EFFLUENTS RELEASE LIMITS

The limits and conditions for the controlled release of radioactive material in liquid and airborne effluents are to ensure that these releases result in concentrations that are within the limits specified in Technical Specifications and to ensure that releases of radioactive material to the environment be as low as reasonably achievable in conformance with 10 CFR 50.34a and 50.36a. To meet these criteria, the following requirements must be met for all radioactive liquid and airborne effluents from FCS:

1.1 Liquid Effluents

1.1.1 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 20 for liquid effluents at site discharge. To support plant operations, Supervisor Radiochemistry 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 2.0 E-04 μCi/ml, total activity.

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 2.0 E-04 μCi/ml total activity.

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.

1.1.2 Annual Design Objectives

1.1.2.1 The dose or dose commitment to an individual in unrestricted areas from radioactive materials in liquid effluents during any calendar year shall not exceed 3 millirems to the total body.

1.1.2.2 The dose or dose commitment to an individual in unrestricted areas from radioactive materials in liquid effluents during any calendar year shall not exceed 10 millirems to any organ.

1.0 RADIOACTIVE EFFLUENTS RELEASE LIMITS (Continued)

1.1.2.3 The radiation dose contributions from radioactive materials in liquid effluents released at site discharge shall be determined, in accordance with Part IV, Section 2.1, on a quarterly basis. If the dose contribution, due to the cumulative release of liquid effluents averaged over a calendar quarter, exceeds one-half of the annual design objectives, the following course of actions shall be taken:

A. Make an investigation to identify the causes for such releases.

B. Define and initiate a program of action to reduce such releases to the design levels.

C. Submit a special report, pursuant to Technical Specification 5.16, within 30 days from the end of the quarter during which the release(s) occurred, identifying the causes and describing the proposed program of action to reduce such releases to the design levels.

1.2 Airborne Effluents

1.2.1 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 20 for airborne effluents at the unrestricted area boundary. To support plant operations, Supervisor Radiochemistry 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 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.

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.

1.0 RADIOACTIVE EFFLUENTS RELEASE LIMITS (Continued)

1.2.2 Annual Design Objectives

1.2.2.1 The gamma air dose in unrestricted areas due to the release of noble gases in airborne effluents shall not exceed 10 millirads during any calendar year;

1.2.2.2 The beta air dose in unrestricted areas due to the release of noble gases in airborne effluents shall not exceed 20 millirads during any calendar year; and

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

1.2.2.4 The radiation dose contributions from radioactive materials in airborne effluents shall be determined, in accordance with the Part IV, section 2.2, on a quarterly basis. If the dose contribution, due to the cumulative release of airborne effluents averaged over a calendar quarter exceeds one-half of the annual design objectives, the following course of actions shall be taken:

A. Make an investigation to identify the cause for such release rates.

B. Define and initiate a program of action to reduce such releases to design levels.

C. Submit a special report, pursuant to Technical Specification 5.16, within 30 days from the end of the quarter during which the release(s) occurred, identifying the causes and describing the proposed program of action to reduce dose contributions.

1.3 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.

2.0 RADIOACTIVE EFFLUENT RELEASE REQUIREMENTS

The requirements for the release of radioactive liquid and airborne effluents from FCS stated in this Section are to ensure that the limits of Section 1 will be met, as well as to allow for operational flexibility. When any of the requirements for release of radioactive effluents cannot be complied with, the release shall not be permitted to occur or it shall be immediately terminated, if it is in progress.

2.1 Liquid Effluent Releases

The equipment or subsystem(s) of the liquid radwaste treatment system as identified in the Part III, section 2.1, shall be operable. If the radioactive liquid effluents were discharged without treatment by one or more of the pieces of equipment or subsystem(s) identified in that section and it is confirmed that one-half of the annual dose objective will be exceeded during the calendar quarter, a special report, pursuant to Technical Specification 5.16, shall be prepared and submitted to the Nuclear Regulatory Commission within 30 days of the end of the quarter during which the equipment or subsystem(s) were inoperable. This report shall include the following information:

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

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

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

2.0 RADIOACTIVE EFFLUENT RELEASE REQUIREMENTS (Continued)

2.1.1 Monitor and Hotel Waste Tanks

During release of radioactive liquid effluents, the following conditions shall be met:

2.1.1.1 There shall be sufficient dilution flow so that, at site discharge:

$$\sum_{i=1}^{n} C_i / wec_i \leq 1$$

where:

C_i = concentration of the i^{th} radionuclide in the liquid effluent at site discharge.

wec_i = 10 CFR 20, Appendix B, Table 2, Column 2 limits.

2.1.1.2 The overboard header effluent radiation monitor shall be set in accordance with Part III to alarm and automatically close the discharge valve prior to exceeding 10 CFR 20 limits at site discharge.

NOTE: During the performance of daily 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. Effluent releases must be terminated and the actions of the ODCM carried out if the monitor fails its source check.

2.1.1.3 The liquid effluent radioactivity shall be continuously monitored during the release. If the effluent radiation monitor is inoperable, effluent releases may continue provided that: (prior to initiating a release)

A. At least two independent samples are analyzed in accordance with applicable chemistry procedures.

B. At least two qualified individuals independently verify the release rate calculations.

2.0 RADIOACTIVE EFFLUENT RELEASE REQUIREMENTS (Continued)

2.1.1.4 The liquid effluent radioactivity shall be continuously recorded during the release. If the process radiation monitor chart recorder is inoperable and the process radiation monitor is operable then effluent releases may continue provided that the radioactivity level is recorded manually at least once per four hours during actual release.

2.1.1.5 The liquid effluent flow rate shall be continuously monitored and recorded during the release. If the flow rate recorder is inoperable, effluent releases may continue provided the flow rate is determined at least once per four hours during actual release.

2.1.2 Steam Generator

During the release of steam generator blowdown to the discharge tunnel, the following conditions shall be met:

2.1.2.1 There shall be sufficient dilution flow so that, at site discharge:

$$\sum_{i=1}^{n} C_i/wec_i \le 1$$

where:

C_i = concentration of the i^{th} radionuclide in the liquid effluent at site discharge.

wec_i = 10 CFR 20, Appendix B, Table 2, Column 2 limit.

2.1.2.2 The steam generator blowdown radiation monitors shall be set in accordance with Part III to alarm and automatically close the blowdown isolation valves prior to exceeding 10 CFR 20 limits at site discharge.

2.0 RADIOACTIVE EFFLUENT RELEASE REQUIREMENTS (Continued)

NOTE: During the performance of daily 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. Effluent releases must be terminated and the actions of the ODCM carried out if the monitor fails its source check.

2.1.2.3 The radioactivity for each blowdown line shall be continuously monitored by the blowdown radiation monitors and recorded.

A. If one of the two radiation monitors is inoperable, the activity for both blowdown lines shall be monitored by the operable radiation monitor within 2 hours of the declaration, by Shift Supervisor, of inoperability.

B. If both radiation monitors are inoperable, steam generator liquid releases may continue provided grab samples are analyzed for principal gamma emitters at a sensitivity of 5.0E-07 μCi/ml and recorded at least daily when the specific activity of Steam Generator Blowdown is less than or equal to 0.01 μCi/gram dose equivalent I-131 and 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.

2.1.2.4 The radioactivity for each blowdown line shall be continuously recorded. If the process radiation monitor chart recorder is not operational, Steam Generator releases may continue provided that the radioactivity level is recorded manually at least once per four hours during actual release.

2.0 RADIOACTIVE EFFLUENT RELEASE REQUIREMENTS (Continued)

2.2 Airborne Effluent Releases

The equipment or subsystem(s) of the gaseous radwaste treatment system as identified in Part III, Section 2.2, shall be operable. If the radioactive airborne effluents were discharged without treatment by one or more of the equipment or subsystems(s) identified in that section and it is confirmed that one-half of the annual dose objective will be exceeded during the calendar quarter, a special report, pursuant to Technical Specification 5.16, shall be prepared and submitted to the Nuclear Regulatory Commission within 30 days of the end of the quarter during which the equipment or subsystem(s) were inoperable. This report shall include the following information:

A. Identification of equipment or subsystem(s) not operable and reason for inoperability.

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

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

2.2.1 Auxiliary Building Exhaust Stack

NOTE: During the performance of daily 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. Effluent releases must be terminated and the actions of the ODCM carried out if the monitor fails its source check.

2.2.1.1 During the ventilation of airborne effluents from the Auxiliary Building through the Auxiliary Building Exhaust Stack, the following conditions shall be met:

A. The Auxiliary Building Exhaust Stack Noble Gas Monitor, Iodine and Particulate Sampler, shall be operational, OR:

12/95

2.0 RADIOACTIVE EFFLUENT RELEASE REQUIREMENTS (Continued)

2.2.1.1A

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 8 hours (+25% maximum extension) and analyzed for principal gamma emitters (See Table 2). 12/95 12/95

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 using auxiliary sample collection equipment is initiated within 2 hours of the declaration of inoperability, by the Shift Supervisor, in accordance with Table 2. 12/95 /95

B. The Auxiliary Building Exhaust Stack Noble Gas Radiation Monitor shall be set in accordance with Part III to alarm and automatically terminate the release prior to exceeding 10 CFR 20 limits at the unrestricted area boundary (see Part III, Figure 1).

C. At least one Auxiliary Building Exhaust Fan shall be in operation. 12/95

D. The Auxiliary Building Exhaust Stack airborne radioactivity shall be monitored and recorded during the release. If the process radiation monitor chart recorder is inoperable and the noble gas monitor is operable then releases from the Auxiliary Building may continue provided that the radioactivity level is recorded manually at least once per four hours during the actual release.

2.0 RADIOACTIVE EFFLUENT RELEASE REQUIREMENTS (Continued)

2.2.1.1 E. The Auxiliary Building Exhaust Stack flowrate shall be monitored and recorded during ventilation of the Auxiliary Building. If the flowrate monitor or recorder is inoperable, ventilation may continue provided the flowrate is determined and recorded manually at least once per four hours.

NOTE: During the performance of daily 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. Effluent releases must be terminated and the actions of the ODCM carried out if the monitor fails its source check.

2.2.1.2 During release of airborne effluents from containment pressure relief line to the Auxiliary Building Exhaust Stack, the following conditions shall be met:

A. The conditions set forth in Section 2.2.1.1 shall be met.

B. The Containment Pressure Relief Line Flow Rate Annubar D/P shall be monitored and recorded manually at least once per four (4) hours during the release.

12/95

2.0 RADIOACTIVE EFFLUENT RELEASE REQUIREMENTS (Continued)

2.2.1.3 During release of gaseous radioactive effluent from Containment Penetration M72 or M74 (Integrated Leak Rate Test Depressurization Vent Path) to the Auxiliary Building Stack the following conditions shall be met: 12/95

A. The conditions set forth in Section 2.2.1.1 shall be met. 12/95

B. Automatic release termination capability is not required provided manual isolation can be accomplished in accordance with the requirements of SS-ST-ILRT-0001.

NOTE: During the performance of daily 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. Effluent releases must be terminated and the actions of the ODCM carried out if the monitor fails its source check.

2.2.1.4 During the release of airborne effluents from the containment purge line:

A. The conditions set forth in Section 2.2.1.1 shall be met.

B. A noble gas monitor shall monitor the containment building atmosphere.

C. The containment purgeline flow rate shall be monitored and automatically recorded during the release. If the flow rate recorder is inoperable, releases from the containment may continue provided the flow rate is recorded manually at least once per four hours during actual release.

2.0 RADIOACTIVE EFFLUENT RELEASE REQUIREMENTS (Continued)

NOTE: During the performance of daily 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. Effluent releases must be terminated and the actions of the ODCM carried out if the monitor fails its source check.

2.2.1.5 During the release of airborne effluents from the gaseous waste discharge header:

A. The conditions set forth in Section 2.2.1.1 shall be met. 12/95

B. If the Auxiliary Building Exhaust Stack noble gas monitor is inoperable, effluent releases may continue provided that (prior to release):

1) At least two independent samples are analyzed in accordance with the applicable chemistry procedure.

2) At least two qualified individuals independently verify the release rate calculations.

C. The waste gas discharge header flow rate shall be monitored and automatically recorded during releases. If the flow rate monitor or recorder is inoperable, releases may continue provided the flow rate is determined and recorded manually at least once per four hours during actual release. 12/95

2.0 RADIOACTIVE EFFLUENT RELEASE REQUIREMENTS (Continued)

2.2.2 Condenser Offgas

NOTE: During the performance of daily 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. Effluent releases must be terminated and the actions of the ODCM carried out if the monitor fails its source check.

2.2.2.1 During power operation, the condenser air ejector discharge shall be monitored for gross radioactivity. If this monitor is inoperable, grab samples shall be taken once per 24 hours (+25% maximum extension) and analyzed for principal gamma emitters. (See Table 2)

2.2.3 Laboratory and Radioactive Waste Processing Building Stack

NOTE: During the performance of daily 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. Effluent releases must be terminated and the actions of the ODCM carried out if the monitor fails its source check.

2.2.3.1 During the release of airborne effluents from the Laboratory and Radioactive Waste Processing Building (LRWPB) the following conditions shall be met:

A. The LRWPB Noble Gas Monitor, Iodine and Particulate Sampler shall be operational, OR: 12/95

2.0 RADIOACTIVE EFFLUENT RELEASE REQUIREMENTS (Continued)

2.2.3.1A 1) If the Noble Gas Monitor is inoperable, ventilation of the LRWPB may continue via the LRWPB stack provided grab samples will be taken once per 24 hours and analyzed for principal gamma emitters. 12/95

[2)] 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 Supervisor, in accordance with Table 2. 12/95 12/95

B. The LRWPB noble gas radiation monitor shall be set in accordance with Part III to alarm at its predetermined setpoints.

C. The LRWPB Stack flow rate shall be monitored and recorded during ventilation of the LRWPB. If the flow rate monitor or recorder is inoperable, ventilation may continue provided the flow rate is determined and recorded manually at least once per four hours.

3.0 RADIOLOGICAL EFFLUENT SAMPLING AND ANALYSIS REQUIREMENTS

The sampling and analysis requirements stated in this Section will provide reasonable assurance that radioactive materials present in the liquid and airborne effluents will be properly identified and accurately quantified. This information will serve as the basis for determining doses to individuals as a result of radioactive effluents from FCS.

Records shall be maintained and reports of the sampling and results of analyses shall be submitted to the Nuclear Regulatory Commission in accordance with Section 4 of these Controls. Sampling, analysis and operability testing will typically be documented on Surveillance Tests or on Release Permits or Summaries.

3.1 Liquid Effluents

3.1.1 Radioactive liquid effluent sampling and activity analyses shall be performed in accordance with Table 1. The results of these analyses shall be used with the calculational methods in Part IV of this manual to assure that the concentration at the point of release is limited to 10 CFR 20 limits for unrestricted areas.

3.1.2 Prior to release of each batch of liquid effluent, the batch shall be mixed, sampled, and analyzed for principal gamma emitters. When operational or other limitations preclude specific gamma radionuclide analysis of each batch:

3.1.2.1 Gross radioactivity measurements shall be made to estimate the quantity and concentrations of radioactive materials released in the batch.

3.1.2.2 A weekly sample composite from proportional aliquots from each batch released during the week shall be analyzed for the principal gamma-emitting radionuclides.

3.1.3 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 II, Section 4.

3.1.4 The radiation monitors for liquid effluents shall have their operability tested in accordance with the requirements in Table 3, Item A.

3.1.5 Steam Generator blowdown effluent flowrates shall have their operability tested in accordance with the requirement in Table 3, Item D.

3.0 RADIOLOGICAL EFFLUENT SAMPLING AND ANALYSIS REQUIREMENTS (Continued).

3.2 Airborne Effluents

3.2.1 Radioactive airborne effluent sampling and activity analyses shall be performed in accordance with Table 2. The results of these analyses shall be used with the calculational methods in Part IV of this manual to assure that the concentration of radioactive materials is limited to 10 CFR 20 limits at the unrestricted area boundary.

3.2.2 The radiation monitors/samplers for airborne effluents shall have their operability tested in accordance with the requirements in Table 3, Item B.

3.2.3 The Auxiliary Building Exhaust and the Laboratory Radioactive Waste Processing Building Exhaust Stack flowrates shall have their operability tested in accordance with the requirements in Table 3, Item D.

3.3 Lower Limit of Detection (LLD)

The lower limit of detection (LLD) for liquid and airborne effluent discharges, referenced in Part II, Tables 1 and 2, 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.

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

3.0 RADIOLOGICAL EFFLUENT SAMPLING AND ANALYSIS REQUIREMENTS (Continued)

3.3 Y = the fractional radiochemical yield, when applicable

λ = the radioactive decay constant for the particular radionuclide

Δt = the elapsed time for the plant effluent between the midpoint of sample collection and time of counting

Appropriate values of E, V, Y and Δt should be used in the calculation.

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.

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 by Tables 1 and 2. They will be performed with a blank (non-radioactive) sample in the same counting geometry as the actual sample.

4.0 RADIOACTIVE EFFLUENT REPORTING REQUIREMENTS

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

4.1 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 50.

The radioactive effluent release report shall include 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 1.

The radioactive effluent release report shall include a summary of the meteorological conditions concurrent with the release of airborne effluents during each quarter as outlined in Regulatory Guide 1.21, Revision 1.

4.0 RADIOACTIVE EFFLUENT REPORTING REQUIREMENTS (Continued)

4.1 The radioactive effluent release report shall include 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 1. The assessment of radiation doses shall be performed in accordance with calculational methodology of the Regulatory Guide 1.109, Revision 1.

The radioactive effluent release report shall include any 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.

4.2 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:

4.2.1 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.

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

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

4.2.4 The results of land use survey required by Part II, Section 5.4.

4.0 RADIOACTIVE EFFLUENT REPORTING REQUIREMENTS (Continued)

4.2.5 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:

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

4.2.5.2 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.

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

4.2.5.4 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

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

4.3 Non-Routine Report

If a confirmed measured radionuclide concentration in an environmental sampling medium averaged over any calendar quarter sampling period exceeds the reporting level referenced in Table 7, and if the radioactivity is attributable to plant operation, a written report shall be submitted to the Nuclear Regulatory Commission within 30 days from the end of the quarter.

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

4.0 RADIOACTIVE EFFLUENT REPORTING REQUIREMENTS (Continued)

4.4 EPA 40 CFR 190 Reporting Requirements

With the calculated dose from the release of radioactive materials in liquid or gaseous effluents exceeding twice the limits of Part II, Sections 1.1.2, 1.2.2, or 1.3, based on quarterly and annual calculations, 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 190 standard. Otherwise, obtain a variance from the Commission to permit releases which exceed the 40 CFR 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.

5.0 RADIOLOGICAL ENVIRONMENTAL MONITORING REQUIREMENTS

The requirements set forth in this Section will provide reasonable assurance that radioactive liquid and airborne effluent releases to the environment in and around Fort Calhoun Station are monitored and that any deviation of radiation levels above background will be identified.

5.1 THE RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM (REMP) shall be conducted according to Table 4. 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 (Part II, Section 4.2). 12/95

5.2 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. 12/95

5.3 If the level of radioactivity in an environmental sampling medium exceeds the reporting level specified in Table 7, a Non-routine Report shall be prepared and submitted to the Nuclear Regulatory Commission (Part II, Section 4.3). The detection capabilities of the equipment used for the analysis of environmental samples must meet the requirements of Table 6 for Lower Level of Detection (LLD). 12/95

5.4 A land use survey shall be conducted once per 24 months between the dates of June 1 and October 1. This survey shall identify the location of the nearest milk animal, nearest meat animal, nearest vegetable garden, and the nearest residence in each of the 16 cardinal sectors within a distance of five miles. The results of the land use survey shall be submitted to the Nuclear Regulatory Commission in the Annual Radiological Environmental Operating Report (Part II, Section 4.2). The survey shall be conducted under the following conditions:

5.4.1 Within a one-mile radius from the Plant site, enumeration by door-to-door or equivalent counting techniques. 12/95

5.4.2 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. 12/95

5.0 RADIOLOGICAL ENVIRONMENTAL MONITORING REQUIREMENTS

5.4.3 If it is learned from this survey that milk animals are present at a location which yields a calculated dose greater than from previously sampled location(s), the new location(s) shall be added to the monitoring program. The 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. Also, any location(s) from which milk can no longer be obtained may be dropped and replaced if practicable from the monitoring program and the Nuclear Regulatory Commission shall be notified in the Annual Radiological Environmental Operating Report (Part II, Section 4.2). 12/95

5.4.4 Radiological environmental sampling locations and the media that is utilized for analysis are presented in Table 5. Details of the emergency TLD locations are contained in the Rasiological Emergency Rerspone Plan. 12/95

5.5 Analyses shall be performed on radioactive materials as part of an Interlaboratory Comparison Program that has been approved by the Nuclear Regulatory Commission. The results of these analyses shall be included in the Annual Radiological Environmental Operating Report. 12/95

5.6 Deviations from the monitoring program, presented in this section and detailed in Table 4, 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. If the equipment malfunctions, corrective actions will be complete 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 Part II, Section 4.2. 12/95

TABLE 1

Radioactive Liquid Effluent Sampling and Analysis

Monitor & Hotel Waste Tanks Releases

Sampling Frequency	Type of Activity Analysis	Lower Limit of Detection (LLD) (μCi/ml)(1)
Each Batch	Principal Gamma Emitters(2)(3)	5.0 E-07
	I-131(2)	1.0 E-06
Monthly From One Batch	Dissolved Noble Gases(2) (Gamma Emitters)	1.0 E-05
Monthly Composite(7)	H-3	1.0 E-05
	Gross α	1.0 E-07
Quarterly Composite(7)	Sr-89, Sr-90	5.0 E-08

B. Steam Generator Blowdown

Sampling Frequency	Type of Activity Analysis	Lower Limit of Detection (LLD) (μCi/ml)(1)
Weekly Composite(7)	Principal Gamma Emitters(3)	5.0 E-07
	I-131(5)	1.0 E-06
Monthly	Dissolved Noble Gases (Gamma Emitters)	1.0 E-05
Monthly Composite(7)	H-3	1.0 E-05
	Gross α	1.0 E-07
Quarterly Composite(7)	Sr-89, Sr-90	5.0 E-08

TABLE 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)(1)
Prior to each release	Principal Gamma Emitters(4)	1.0 E-04

B. **Containment Purge Releases or Containment Pressure Relief Line Releases**

Sampling Frequency	Type of Activity Analysis	Lower Limit of Detection (LLD) (μCi/ml)(1)
Prior to each release	Principal Gamma Emitters(4)	1.0 E-04
Prior to each release	H-3	1.0 E-06

C. **Condenser Air Ejector Releases**

Sampling Frequency	Type of Activity Analysis	Lower Limit of Detection (LLD) (μCi/ml)(1)
Monthly(6)	Tritium (H-3)	1.0 E-06
Monthly	Principal Gamma Emitters(4)	1.0 E-04

TABLE 2
(Continued)

D. **Auxiliary Building Exhaust Stack and Laboratory and Radwaste Building Exhaust Stack**

Sampling Frequency	Type of Activity Analysis	Lower Limit of Detection (LLD) (μCi/ml)(1)
Weekly (Charcoal Sample)	I-131	1.0 E-12
Weekly (Particulates)	Principal Gamma Emitters(4), I-131 and Particulates with half-lives > eight days.	1.0 E-11
Weekly (Noble Gases)	Principal Gamma Emitters(4)	1.0 E-4
Monthly Composite	Gross α	1.0 E-11
Quarterly Composite (Particulates)	Sr-89, Sr-90	1.0 E-11

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12/95

TABLES 1 and 2
(Continued)

NOTES:

(1) LLD is defined in Part II, Section 3.3.

(2) Gross Radioactivity is defined as the determination of radioactivity levels without regard to specific radionuclide identification and individual isotopic quantification.

(3) The principal gamma emitters for which the LLD specification applies exclusively are the following radionuclides: Mn-54, Fe-59, Co-58, Co-60, Zn-65, Mo-99, Cs-134, Cs-137, Ce-141, and Ce-144.

(4) 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 gaseous emissions and Mn-54, Fe-59, Co-58, Co-60, Zn-65, Mo-99, Cs-134, Cs-137, Ce-141, Ce-144 for particulate emissions.

(5) 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 1.0 E-06 microCurie/milliliter.

(6) Required only when steam generator blowdown radioactivity for tritium (Table 1, Item B) exceeds 3.0 E-03 microCurie/milliliter.

(7) 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.

TABLE 3

Radiological Effluent and Environmental Instrumentation
Operability Test Requirements

A. Liquid Monitors	Daily Channel Check	Quarterly Channel Func. Test	Refueling Calibration	Source Check Prior to Release
RM-054A/054B	X(2)	X	X	-
RM-055	-	X	X	X

B. Gaseous Monitors	Daily Channel Check	Quarterly Channel Func. Test	Refueling Calibration	Source Check Prior to Release
RM-043	X	X	X	-
RM-057	X	X	X	-
RM-062	X	X	X	X
RM-052(1)	X	X	X	X
RM-043 Sampler Flow Rate	X	-	X	-
RM-062 Sampler Flow Rate	X	-	X	-
RM-052 Sampler Flow Rate(1)	X	-	X	-

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C. Envirnmntl. Monitors	Monthly Operations Check	Annual Air Flow Calibration
RM-025 → 039	X	X

D. Effluent Flowrates	Daily Channel Check	Refueling Calibration
Steam Generator Blowdown Flowrate	X	X
Auxiliary Building Exhaust Stack Flowrate	X	X
Laboratory and Radioactive Waste Processing Building Exhaust Stack Flowrate	X	X

NOTES:

(1) Required when RM-052 is sampling the Auxiliary Building Exhaust Stack.

(2) Visual flowcheck daily

TABLE 4

Radiological Environmental Monitoring Program

Exposure Pathway and/or Sample	Collection Site[1]	Types of Analysis[2]	Frequency
1. Direct Radiation	A. Ten TLD indicator stations, one control station, total of 11.	Gamma dose	Quarterly
	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.	Gamma dose during Site Area and General Emergencies only.	Replaced Annually 12/95
	C. An outer-ring of 16 stations, 1 in each cardinal sector located outside of the inner-ring, but no more distant than approximately 5 miles[5].	Gamma dose during Site Area and General Emergencies only.	Replaced Annually 12/95
2. Air Monitoring	A. Indicator Stations	1) Filter for Gross Beta[3]	Weekly
	1. 3 stations in the general area of the unrestricted area boundary	2) Charcoal for I-131	Weekly
	2. City of Blair, NE.	3) Filter for Gamma Isotopic	Quarterly composite of wkly. fltrs. 12/95
	B. One background station	Same as A. above	
3. Water	A. Missouri River at nearest downstream drinking water intake.	Gamma Isotopic, H-3	Monthly composite for Gamma Isotopic Analysis
	B. Missouri River downstream near the mixing zone.		Quarterly composite for H-3 Analysis
	C. Missouri River upstream of Plant intake (background).		
4. Milk[4]	A. Nearest family cow when available or one dairy farm within 5 miles.	Gamma Isotopic and I-131	Semimonthly grazing season (May to October) 12/95
	B. One dairy farm between 5 miles and 18.75 miles. (background)		
5. Fish	A. Four fish samples within vicinity of Plant discharge.	Gamma Isotopic	Once per season (May to October) 12/95
	B. One background sample upstream of Plant discharge.		12/95

TABLE 4
(Continued)

Radiological Environmental Monitoring Program

Fxposure Pathway and/or Sample	Collection Site(1)	Types of Analysis(2)	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)	Gamma Isotopic	Semiannually
7. Vegetables or Food Products (6)	A. One sample in the highest exposure pathway. B. One sample outside of 5 miles. (background)	Gamma Isotopic	Once per season (May to October)

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Notes:

(1) See Table 6 for required detection limits.

(2) The Lower Limit of Detection (LLD) for analysis is defined in the ODCM in accordance with the wording of NUREG - 0472, Rev. 3, Draft 7.

(3) When a gross beta count indicates radioactivity greater than 1E-12 μCi/ml or 1 pCi/m^3, a gamma spectral analysis will be performed.

(4) When milk samples are not available, a broad leaf vegetation or pasture grass sample shall be collected, when available.

(5) Details of the Emergency TLD Stations are contained in Emergency The Radiological Emergency Response Plan

(6) Samples should be collected from garden plots 500 ft^2 or more. Reference Reg. Guide 4.8 "Environmental Technical Specifications for Nuclear Power Plants", Dec. 1975.

TABLE 5

Radiological Environmental Sampling Locations and Media

Sample Station Number	Approximate Collection Sites	Approximate Distance From Containment (miles)	Approximate Direction (Degrees from north)	Air Monitoring		TLD	Water	Milk	Sediment	Fish	Vegetables and Food Products
				Airborne Particulate	Airborne Iodine						
1	Onsite Station 110-meter weather tower	0.5	293°	X	X	X	X				
2	Onsite Station adjacent to old plant access road	0.6	208°	X	X	X	X				
3	Offsite Station Intersection of Hwy. 75 and farm access road	0.8	145°	X	X	X	X				
4	Blair OPPD office	3.0	303°	X	X	X	X				
5	EOF Building, North Omaha Power Station	17.5	157°	X	X	X	X				
6	Fort Calhoun, NE City Hall	4.8	149°				X				
7	Fence around intake gate, Desoto Wildlife Refuge	2.0	101°				X				
8	Onsite Station Entrance to Plant Site From Hwy. 75	0.6	180°				X				
9	Onsite Station NW of Plant	1.0	310°				X				
10	Onsite Station WSW of Plnt	0.7	250°				X				
11	Offsite Station SE of Plnt	0.9	130°				X				
12	Met. Utilities Dist., Florence Treatment Plant North Omaha, NE	17.0	156°					X			
13	West bank Missouri River, downstream from Plant discharge	0.5	106°					X		X	
14	Upstream from intake bldg., west bank of river	0.024	345°					X		X	

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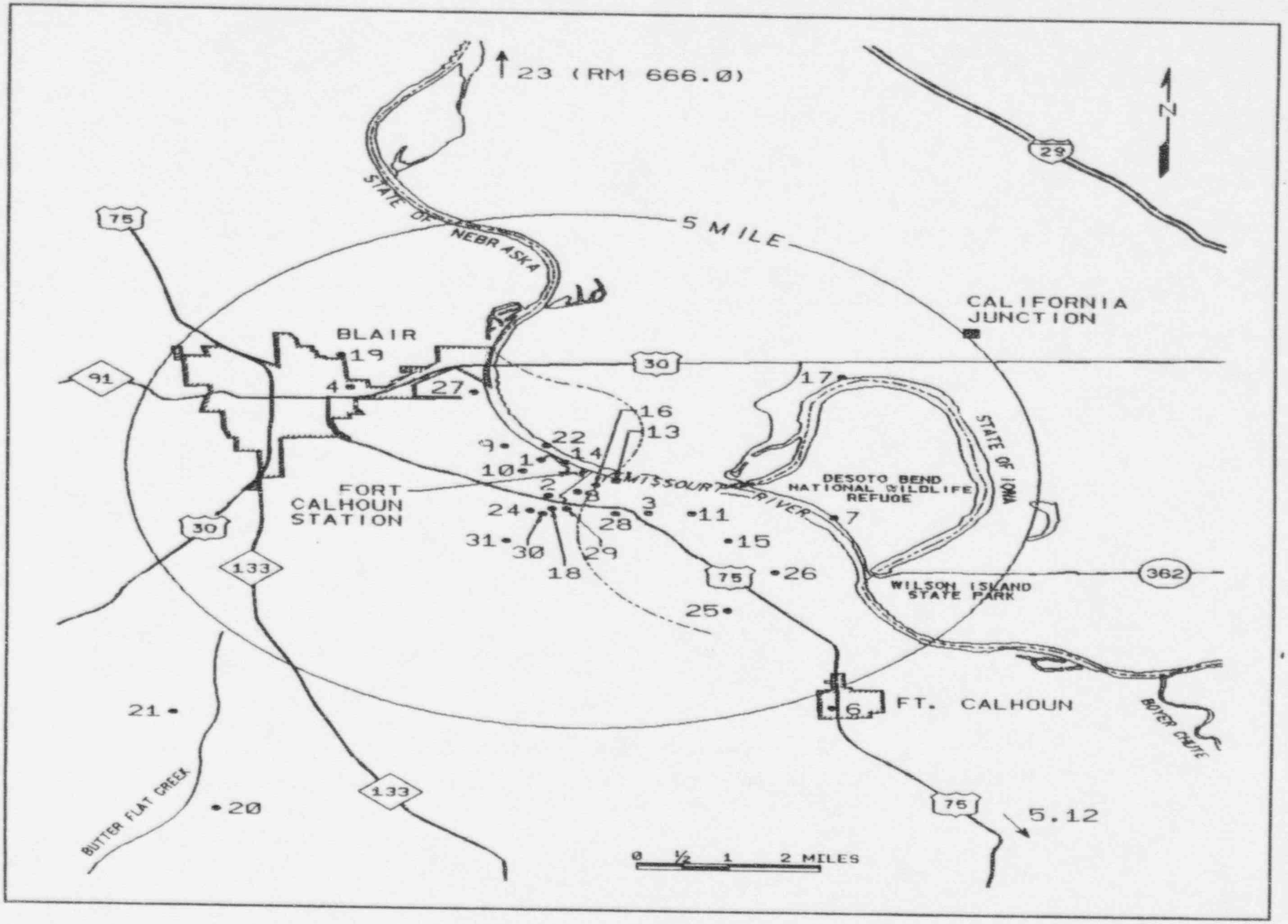
TABLE 5

Radiological Environmental Sampling Locations and Media

Sample Station Number	Approximate Collection Sites	Approximate Distance From Containment (miles)	Approximate Direction (Degrees from north)	Air Monitoring: Airborne Particulate	Air Monitoring: Airborne Iodine	TLD	Water	Milk	Sediment	Fish	Vegetables and Food Products
15	Smith Farm (1)	1.9	133°				X				
16	OPPD Onsite Well (1)	0.1	154°				X				
17	Headquarters Bldg., (1) Desoto Wildlife Refuge	3.1	53°				X				
18	Miller Farm (4)	0.8	206°					X			X
19	Flynn Dairy (4)	3.4	310°					X			
20	Mohr Dairy	7.9	187°					X(2)			X(3)
21	Japp Dairy (4)	6.3	219°					X			
22	Fish Sampling Area - Missouri River	R.M. 645.0								X	
23	Fish Sampling Area - (5) Missouri River	R.M. 666.0								X	
24	Legenhausen Farm (4)	0.7	207°					X			
25	Seltz Farm (2)	2.7	168°					X			
26	John Welchert Farm (4)	2.7	138°								X
27	Jerry Welchert Farm	2.0	296°								X
28	Alvin Pechnik Farm	0.9	164°								X
29	E Ellis Farm	0.7	180°								X
30	Axtell Acreage	0.7	207°								X
31	Hakanson Farm	1.1	205°								X

Notes:

(1) Sampling not required for pathway modeling, collections performed for additional information only.
(2) When a milk sample is not available at a location, a broad leaf vegetation sample will be collected at that location as a substitute.
(3) Vegetation sites selected based on Land Use Survey and calculated doses.
(4) Location is currently discontinued and is documented in the table for historical reference only.
(5) Location is 21.0 River miles north of plant. Exact location can not be illustrated on the map.


23 (RM 666.Ø)
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29
STATE OF NEBRASKA
5 MILE
CALIFORNIA JUNCTION
BLAIR
19
4
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91
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17
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13
9
22
14
1
10
MISSOURI RIVER
FORT CALHOUN STATION
2
8
DESOTO BEND NATIONAL WILDLIFE REFUGE
STATE OF IOWA
24
3
11
7
28
31
3Ø
29
15
18
26
362
WILSON ISLAND STATE PARK
25
21
6
FT. CALHOUN
BOYER CHUTE
133
BUTTER FLAT CREEK
20
5.12
0 ½ 1 2 MILES

TABLE 6

Detection Capabilities for Environmental Sample Analysis(1)(2)(3)
Lower Limit of Detection (LLD)

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

(1) 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 II, Section 5.1.

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

(3) The LLD is defined, for purposes of these specifications, as the smallest concentration or radioactive material in a sample that will yield a net count, above system background, that will be detected with 95% probability with only 5% probability of falsely concluding that a blank observation represents a "real" signal.

For a particular measurement system, which may include radiochemical separation:

$$LLD = \frac{4.66\ s_b}{E \cdot V \cdot 2.22E{+}06 \cdot Y \cdot \exp(-\lambda \Delta t)}$$

TABLE 7

Reporting Levels for Radioactivity Concentrations in Environmental Samples[1]

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
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	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
Air Particulate or Gases	pCi/m^3	--	--	--	--	--	--	--	--	9.0E-01	--	--	--
Grass or Broad Leaf Vegetation/ Vegetables or Food Products	pCi/kg (wet)	--	--	--	--	--	--	--	--	1.0E+02	1.0E+03	2.0E+03	--

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

$$\frac{\text{Concentration (1)}}{\text{Reporting Level (1)}} + \frac{\text{Concentration (2)}}{\text{Reporting Level (2)}} + \text{- - - - - -} \geq 1.0$$

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 II, Section 1.1 and 1.2. 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.

12/95

PART III

RADIOLOGICAL EFFLUENT RADIATION MONITOR CALCULATIONS

1.0 EFFLUENT MONITOR SETPOINTS

1.1 Liquid Effluents

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. A detailed discussion of the liquid effluent treatment system is presented in Section 2.1.

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.

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

Cs-137 is the most abundant radionuclide in liquid effluent streams and is used to calibrate the liquid effluent monitors.

1.0 EFFLUENT MONITOR SETPOINTS (Continued)

1.2 Liquid Effluent Radiation Monitors

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

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 high alarm setpoint calculations are based on controlling the discharge at 10 CFR 20 limits of 1.0E-06 μCi/ml at site discharge.

The following calculations for maximum concentration and alarm setpoints are valid when steam generator blowdown is the only liquid release pathway. For simultaneous radioactive liquid releases of steam generator blowdown and monitor tank discharge, refer to Section 1.5.1.

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

$$A_o = \frac{(1.0E\text{-}06\ \mu Ci/ml)\ (X_o)}{Y_o}$$

Where:

1.0E-06 μCi/ml = 10 CFR 20 Limit for unidentified radionuclides at site discharge (10 CFR 20, Appendix B, Note 2).

X_o = 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.)

Y_o = 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.)

A_o = Maximum allowable blowdown concentration (μCi/ml).

1.0 EFFLUENT MONITOR SETPOINTS (Continued)

1.2.1 The high alarm setpoint (CPM) =

$$.85\ [\ (S_f)\ (A_o) + B\ ]$$

Where:

.85 = Correction factor for instrument meter error.

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

A_o = Maximum allowable blowdown line activity (μCi/ml).

B = Background (CPM).

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

An alert setpoint will be chosen at a value below the alarm setpoint so that significant increases in activity will be identified prior to automatic actuation of the blowdown isolation valves.

1.2.2 Overboard Discharge Header Monitor (RM-055)

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 the 10 CFR 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.

The following calculations for maximum concentration and alarm setpoints are valid when Monitor Tank discharge is the only liquid release pathway. For simultaneous radioactive liquid releases of monitor tank discharge and steam generator blowdown, refer to Section 1.5.1.

1.0 EFFLUENT MONITOR SETPOINTS (Continued)

1.2.2 The maximum allowable concentration in the overboard discharge header is:

$$A_o = \frac{(1.0E\text{-}06\ \mu Ci/ml)\ \ (X_o)}{Y_o}$$

Where:

1.0E-06 μCi/ml	=	10 CFR 20 Limit for unidentified radionuclides at site discharge (10 CFR 20, Appendix B, Note 2).
X_o	=	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.)
Y_o	=	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.)
A_o	=	Maximum allowable activity in discharge header (μCi/ml).

1.0 EFFLUENT MONITOR SETPOINTS (Continued)

1.2.2 The high alarm setpoint (CPM) =

$.85 \; [(S_f) \; (A_o) + B]$

Where:

.85 = Correction factor for instrument meter error.

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

A_o = Maximum allowable concentration in discharge header (μCi/ml).

B = Background (CPM).

An alert setpoint will be chosen at a value below the alarm setpoint so that significant increases in activity will be identified, prior to automatic actuation of the overboard flow control valve.

1.0 EFFLUENT MONITOR SETPOINTS (Continued)

1.3 Airborne Effluents

The airborne effluent monitoring instrumentation for controlling and monitoring normal radioactive material releases in accordance with 10 CFR 20, Appendix B, Table 2, Column 1 limits at the unrestricted area boundary (see Figure 1), are summarized as follows:

A. 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.

B. 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.

C. 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.

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. A detailed discussion of the airborne effluent treatment system is presented in Section 2.2.

1.0 EFFLUENT MONITOR SETPOINTS (Continued)

1.4 Airborne Effluent Radiation Monitors

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

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 the 10 CFR 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.

The following calculations for maximum release rate and alarm setpoint are valid when Auxiliary Building Exhaust Stack is the only airborne release pathway. For simultaneous airborne releases from Auxiliary Building Exhaust Stack, Condenser Off-gas and the LRWPB Exhaust Stack, refer to Section 1.5.2.

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

$$\frac{(5.0E\text{-}07\ \mu Ci/cc)}{(5.0E\text{-}06\ \text{sec}/m^3)} \times (1.0E{+}06\ cc/m^3) = 1.0E{+}05\ \mu Ci/\text{sec}$$

Where:

5.0E-07 µCi/cc	=	10 CFR 20 Limit at the unrestricted area boundary (based upon Xe-133).
5.0E-06 sec/m³	=	Annual average dispersion factor at the unrestricted area boundary.
1.0E+06 cc/m³	=	Constant of unit conversion.

The high alarm setpoint (CPM):

$$Setpoint = .85\ [\ \frac{(1.0E{+}05)\ (S_F)\ (60)}{(F_V)\ (28317)} + B\ ]$$

1.0 EFFLUENT MONITOR SETPOINTS (Continued)

1.4.1 Where:

.85	=	Correction for instrument meter error.
S_F	=	Detector sensitivity factor (CPM/ μCi/cc). (Sensitivity based on Xe-133)
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 122500 cfm for 3 Auxiliary Building exhaust fans and 2 containment purge fans in operation. Other flow rates may be used, as required.)
B	=	Background (CPM).

An alarm setpoint will be chosen at a value below the alarm setpoint so that significant increases in activity will be identified, prior to actuation of VIAS.

1.0 EFFLUENT MONITOR SETPOINTS (Continued)

1.4.2 Condenser Air Ejector Monitor (RM-057)

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 the 10 CFR 20 limit at the unrestricted area boundary of 5.0E-07 μCi/cc, based upon Xe-133, is not exceeded.

The following calculations for maximum release rate and alarm setpoint are valid when condenser off-gas is the only airborne release pathway. For simultaneous airborne releases from condenser off-gas, Auxiliary Building Exhaust Stack, and the LRWPB Exhaust Stack, refer to Section 1.5.2.

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

$$\frac{(5.0E\text{-}07\ \mu Ci/cc)}{(5.0E\text{-}06\ \text{sec}/m^3)} \times (1.0E{+}06\ cc/m^3) = 1.0E{+}05\ \mu Ci/\text{sec}$$

Where:

5.0E-07 μCi/cc	=	10 CFR 20 Limit at the unrestricted area boundary (based upon Xe-133).
5.0E-06 sec/m³	=	Annual average dispersion factor at the unrestricted area boundary.
1.0E+06 cc/m³	=	Constant of unit conversion.

The high alarm setpoint (CPM):

$$Setpoint = .85\ [\ \frac{(1.0E{+}05)\ (S_p)\ (60)}{(F_v)\ (28317)} + B\ ]$$

1.0 EFFLUENT MONITOR SETPOINTS (Continued)

1.4.2 Where:

.85	=	Correction for instrument meter error.
S_F	=	Detector sensitivity factor (CPM/μCi/cc). (Sensitivity based on Xe-133)
60	=	Conversion (seconds to minutes).
28317	=	Conversion factor (ft^3 to cc).
F_v	=	Vent stack flow rate (SCFM). Default maximum flow rate is 4755 scfm (3 vacuum pumps in hogging mode. Other flow rates may be used, as required.)
B	=	Background (CPM).

An alert setpoint will be chosen at a value below the alarm setpoint so that significant increases in activity will be identified, allowing time for corrective actions prior to exceeding the alarm setpoint and tripping of the auxiliary steam supply valve, RCV-978.

1.0 EFFLUENT MONITOR SETPOINTS (Continued)

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

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

The following calculations for maximum release rate and alarm setpoint are valid when the LRWPB Exhaust Stack is the only airborne release pathway. For simultaneous airborne releases from condenser off-gas, Auxiliary Building Exhaust Stack, and the LRWPB Exhaust Stack, refer to Section 1.5.2.

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

$$\frac{(5.0E\text{-}07\ \mu Ci/cc)}{(5.0E\text{-}06\ \sec/m^3)} \times (1.0E{+}06\, cc/m^3) = 1.0E{+}05\ \mu Ci/\sec$$

Where:

5.0E-07 μCi/cc =	10 CFR 20 Limit at the unrestricted area boundary (based upon Xe-133).
5.0E-06 sec/m³ =	Annual average dispersion factor at the unrestricted area boundary.
1.0E+06 cc/m³ =	Constant of unit conversion.

1.0 EFFLUENT MONITOR SETPOINTS (Continued)

1.4.3 The high alarm setpoint (CPM):

$$Setpoint = .85\left[\frac{(1.0E{+}05)\ (S_F)\ (60)}{(F_v)\ (28317)} + B\right]$$

Where:

.85	=	Correction for instrument meter error.
S_F	=	Detector sensitivity factor (CPM/μCi/cc). (Sensitivity based on XE-133)
60	=	Conversion (seconds to minutes).
28317	=	Conversion factor (ft^3 to cc).
F_v	=	LRWPB Exhaust stack flow rate (SCFM). (Default flow rate is 28700 cfm. Other flow rates may be used if required.
B	=	Background (CPM).

An alert setpoint will be chosen at a value below the alarm setpoint so that significant increases in activity will be identified.

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

1.0 EFFLUENT MONITOR SETPOINTS (Continued)

1.5 Simultaneous Release Pathways

1.5.1 Liquid Release Pathways

The liquid radiation monitors (RM-054A/054B and RM-055) control liquid releases so that 10 CFR 20 limit of 1.0E-06 μCi/ml for unidentified isotopes at site discharge is not exceeded. There are two liquid release pathways that contribute to the concentration at site discharge. These are Steam Generator Blowdown and Monitor Tank Overboard Discharge Header. When more than one pathway is utilized for radioactive releases, it is necessary to adjust the alarm setpoints given in Section 1.2 so that unrestricted area concentration limits are not exceeded.

The calculations for the alarm setpoints for the liquid effluent monitors will be adjusted as follows:

$$A_T = K_o A_o + K_1 A_1$$

$$A_T = \frac{K_o\ (1.0E\text{-}06\ \mu Ci/ml)\ (X_o)}{Y_o} + \frac{K_1\ (1.0E\text{-}06\ \mu Ci/ml)\ (X_o)}{Y_1}$$

Where:

A_T = Sum of individual maximum allowable concentrations for Steam Generator and Monitor Tank prior to dilution for simultaneous liquid releases (μCi/ml)

A_o = Maximum allowable concentration in Steam Generator blowdown Line (μCi/ml)

A_1 = Maximum allowable concentration in Monitor Tank Discharge Line (μCi/ml)

K_o = Proportionality constant for Steam Generator (See Table 1)

K_1 = Proportionality constant for Monitor Tank (See Table 1)

X_o = Total dilution flow in Discharge Tunnel (GPM)

1.0 <u>EFFLUENT MONITOR SETPOINTS</u> (Continued)

1.5.1 Where:

Y_o = Steam Generator Blowdown flowrate (GPM)

Y_1 = Monitor Tank Discharge flowrate (GPM)

The High Alarm Setpoint for Steam Generator Blowdown monitors, RM-054A/054B, will then be:

$$\mathit{Alarm\ Setpoint}\ (CPM) = .85\ [K_o\ S_{Fo}\ A_o + B_o]$$

The High Alarm Setpoint for Monitor Tank Discharge Monitor, RM-055, will then be:

$$\mathit{Alarm\ Setpoint}\ (CPM) = .85\ [K_1\ S_{F1}\ A_1 + B_1]$$

Where:

S_{Fo} = Detector Sensitivity factor for RM-054A/054B, CPM/(μCi/ml), based on Cs-137.

S_{F1} = Detector Sensitivity factor for RM-055, CPM/(μCi/ml), based on Cs-137.

A_o = Maximum allowable concentration in SG Blowdown line. (μCi/ml)

A_1 = Maximum allowable concentration in MT Discharge line. (μCi/ml)

B_o = RM-054A/054B background countrate. (CPM)

B_1 = RM-055 background countrate. (CPM)

Where:

K_o, K_1 = Proportionality constants. See Table 1.

1.0 EFFLUENT MONITOR SETPOINTS (Continued)

1.5.2 Airborne Release Pathway

The noble gas radiation monitors (RM-043, RM-057, and RM-062/RM-052) control airborne releases so that 10 CFR 20 limits of 5.0E-07 μCi/cc for noble gases at the unrestricted area boundary is not exceeded. There are three pathways that contribute to the concentration at the unrestricted area boundary. These are the Auxiliary Building Exhaust Stack, Condenser Off-gas, and the LRWPB Exhaust Stack. When more than one pathway is utilized for radioactive releases, it is necessary to adjust the alarm setpoints given in Section 1.4 to ensure that unrestricted area concentration limits are not exceeded.

The calculations for the alarm setpoints for the airborne effluent monitors will be adjusted as follows:

The maximum allowable release rates for simultaneous releases is:

$$Max.\ Release\ Rate = \sum_{i=1}^{3} K_i R_i = \sum_{i=1}^{3} K_i \frac{Conc_i}{\chi/Q}$$

Where:

R_1	=	RM-062/RM-052 release rate (μCi/sec)
R_2	=	RM-057 release rate (μCi/sec)
R_3	=	RM-043 release rate (μCi/sec)
$K_1 \rightarrow K_3$	=	Proportionality constants. See Table 1.
$Conc_i$	=	Radionuclide concentration for the monitor of interest.

1.0 <u>EFFLUENT MONITOR SETPOINTS</u> (Continued)

1.5.2 The maximum release rate is then:

$$\left[\frac{K_1 (5.0E\text{-}07\ \mu Ci/cc)}{5.0E\text{-}06\ sec/m^3} + \frac{K_2 (5.0E\text{-}07\ \mu Ci/cc)}{5.0E\text{-}06\ sec/m^3} + \right.$$

$$\left. \frac{K_3 (5.0E\text{-}07\ \mu Ci/cc)}{5.0E\text{-}06\ sec/m^3} \right] 1.0E{+}06\ \frac{cc}{m^3} = Max.\ Release\ Rate$$

The alarm setpoints for the noble gas monitors will then be:

$$RM\text{-}062/052 = .85\ \left[K_1\ \frac{(1.0\ E{+}05)\ (S_F)\ (60)}{F_V\ (28317)} + B \right]$$

$$RM\text{-}057 = .85\ \left[K_2\ \frac{(1.0\ E{+}05)\ (S_F)\ (60)}{(F_V)\ (28317)} + B \right]$$

$$RM\text{-}043 = .85\ \left[K_3\ \frac{(1.0\ E{+}05)\ (S_F)\ (60)}{(F_V)\ (28317)} + B \right]$$

1.0 EFFLUENT MONITOR SETPOINTS (Continued)

1.5.2 Where:

.85	=	Correction factor for instrument meter error.
$K_1 \rightarrow K_3$	=	Proportionality constants. See Table 1.
S_F	=	Detector sensitivity factor.
F_V	=	Vent stack flowrate. (Condenser off-gas flowrate for RM-057, LRWPB Exhaust stack flow rate for RM-043, Auxiliary Building Exhaust Stack flow rate for RM-062/052).
B	=	Monitor background count rate.
60	=	Constant of unit conversion (60 sec/min).

TABLE 1

Proportionally Constants for Simultaneous Airborne Releases.

NOTE: The Fort Calhoun Station is capable of performing simultaneous airborne releases given that the sum of the Unrestricted Area Fraction Sum for all airborne releases remains less than or equal to 1.0.

1. Auxiliary Building Exhaust Stack

		Total 0.80	
K_1	Noble Gases	0.70	RM-062 or RM-052
	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/Air Ejector — Total 0.10

K_2	Noble Gases	0.05	RM-057
	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	0.05	RM-043
	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 given that the sum of the Unrestricted Area Fraction Sum for all liquid releases remains less than or equal to 1.0.

B. Proportionally Constants for Simultaneous Liquid Releases.

1.	K_0	Steam Generator Releases	0.30	RM-054A/054B
2.	K_1	Waste Liquid Releases	0.70	RM-055
		Liquid Release Total	1.00	

2.0 RADIOACTIVE WASTE TREATMENT SYSTEM

2.1 Liquid Radwaste Treatment System

The major equipment or subsystem(s) of the liquid radwaste treatment system are comprised of the waste filters, monitor tanks, and evaporator. This equipment, including associated pumps, valves and piping, is used in different combinations on an as-needed basis to process the liquid effluent to provide compliance with the as low as is reasonably achievable philosophy and the applicable section of 10 CFR Part 20. The liquid radwaste treatment system is described in Section 11.1.2 of the USAR. For effluent release points and monitor locations refer to P&ID's 11405-M-100, M-9 and M-8.

A filtration/ion exchange (FIX) system may be utilized for processing liquid radwaste in the event the waste evaporator is not in service. 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.

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 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 Part II, Section 2.1.

Every effort will be made to process all liquid waste, except from the hotel waste tanks, through the evaporator or FIX before entering the monitor tanks. If the radioactive liquid waste is discharged without processing and it appears that 1/2 of the annual objective will be exceeded during the calendar quarter, a special report shall be submitted to the Commission pursuant to Part II, Section 2.1.

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.

2.0 RADIOACTIVE WASTE TREATMENT SYSTEM

2.2 Airborne Radwaste Treatment System

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, with earlier release allowed to support plant operation only, and thus achieve decay of short half-life radioactive materials, e.g., I-131, Xe-133. If the radioactive airborne wastes from the gas decay tanks are discharged without processing in accordance with the above conditions, a special report shall be submitted to the Commission pursuant to Part II, Section 2.2.

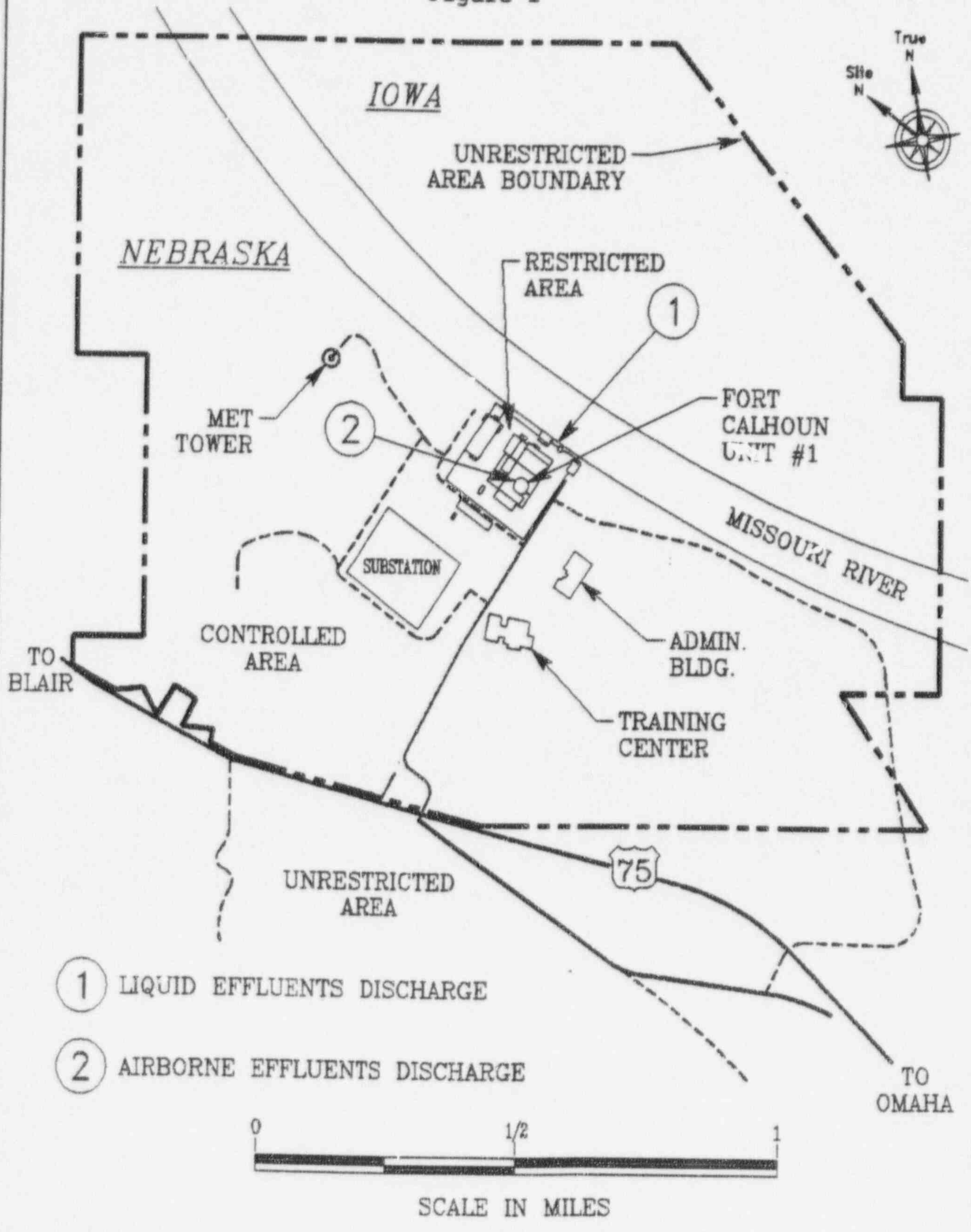
The radioactive effluents from the controlled access area of the auxiliary building are filtered by the HEPA filters in the auxiliary building ventilation system. If the radioactive effluents are discharged without the HEPA filters, a special report shall be submitted to the NRC pursuant to Part II, Section 2.2.

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 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 as per Part II, Section 2.2.

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, a special report shall be submitted to the Commission pursuant to Part II, Section 2.2.

The airborne radwaste treatment system is described in Section 11.1.3 of the USAR. For effluent release points and monitor locations refer to P&ID's 11405-M-1 and M-261.

Figure 1



EXCLUSION AND SITE BOUNDARY MAP

Figure 2

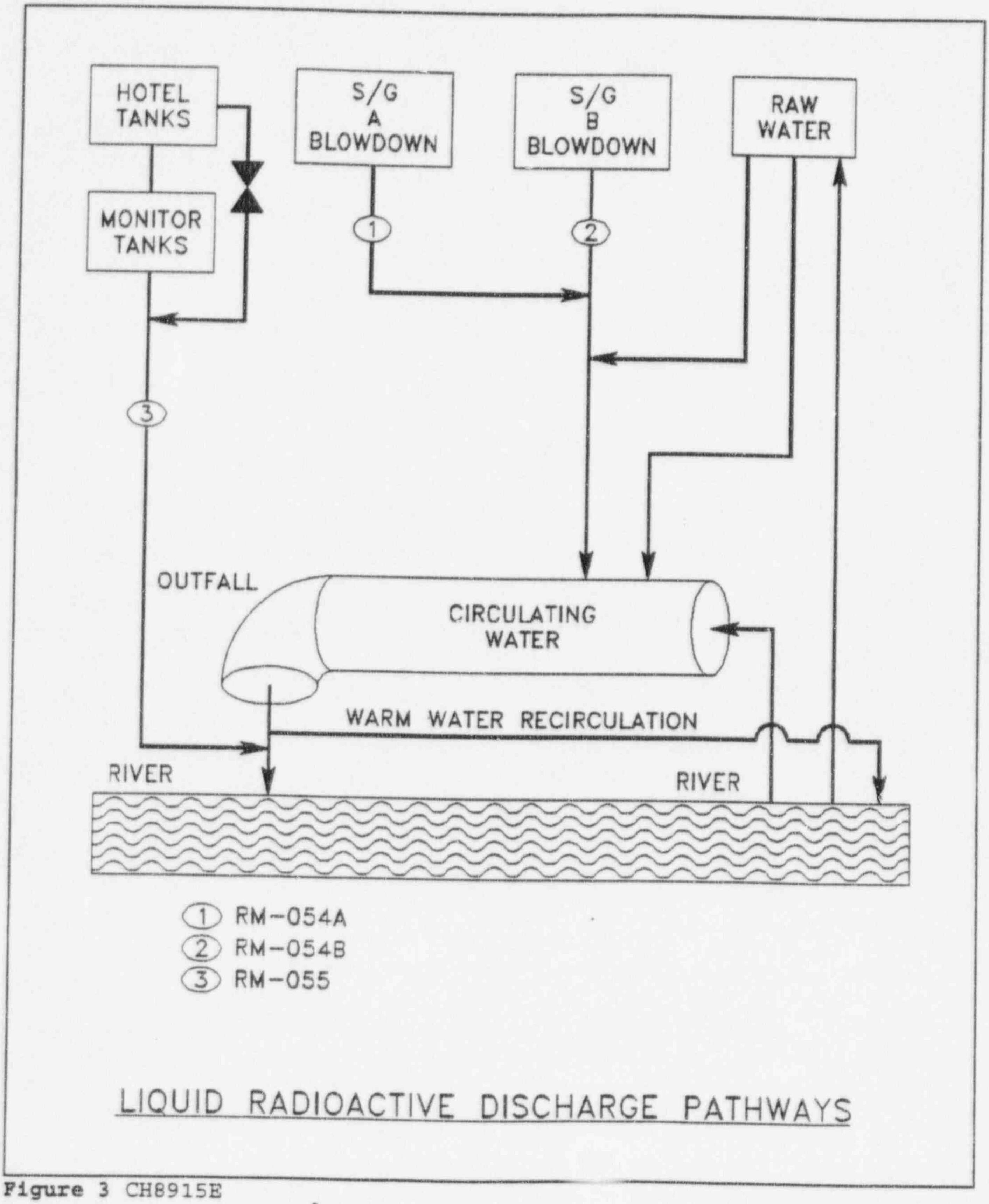
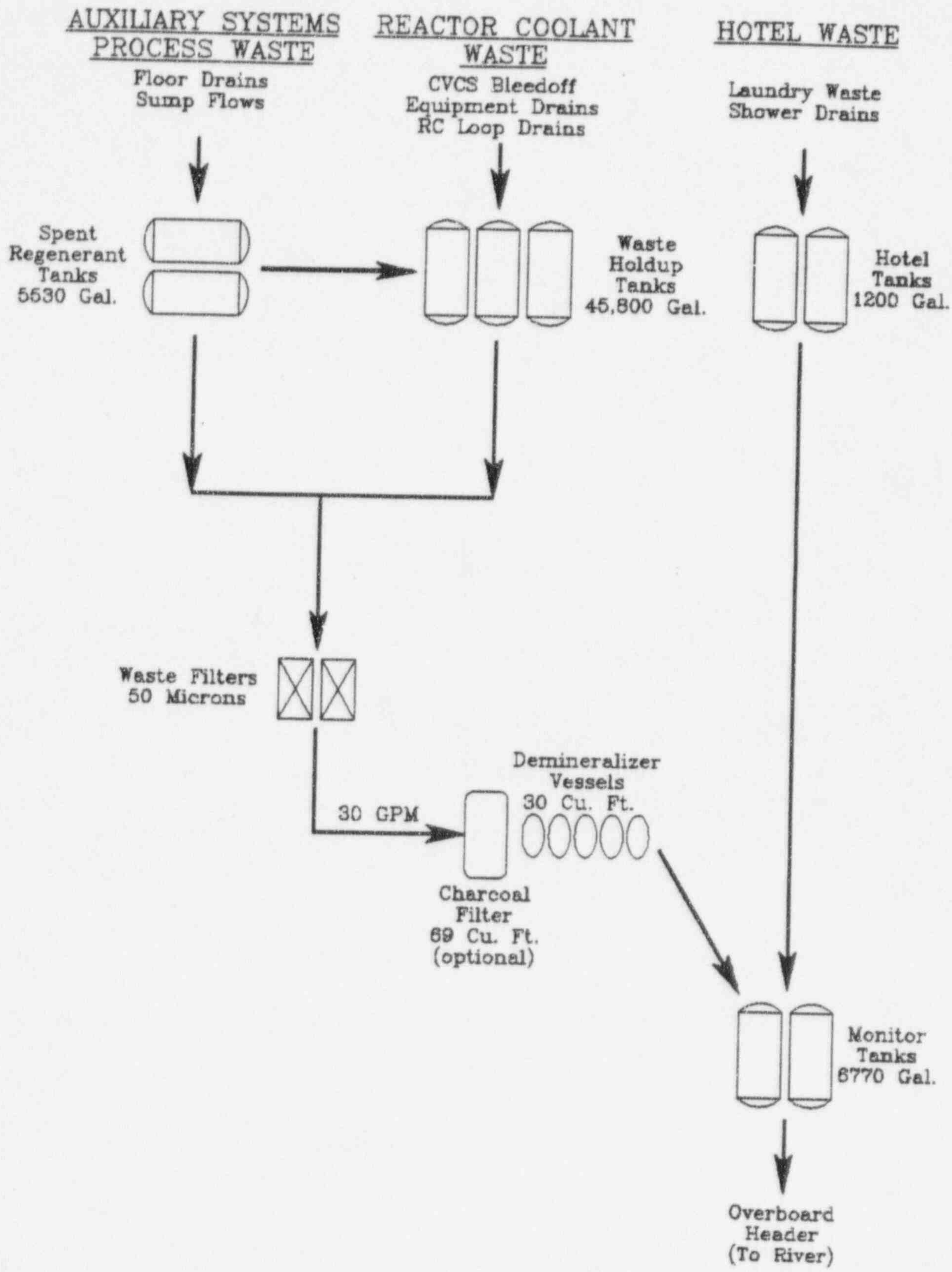


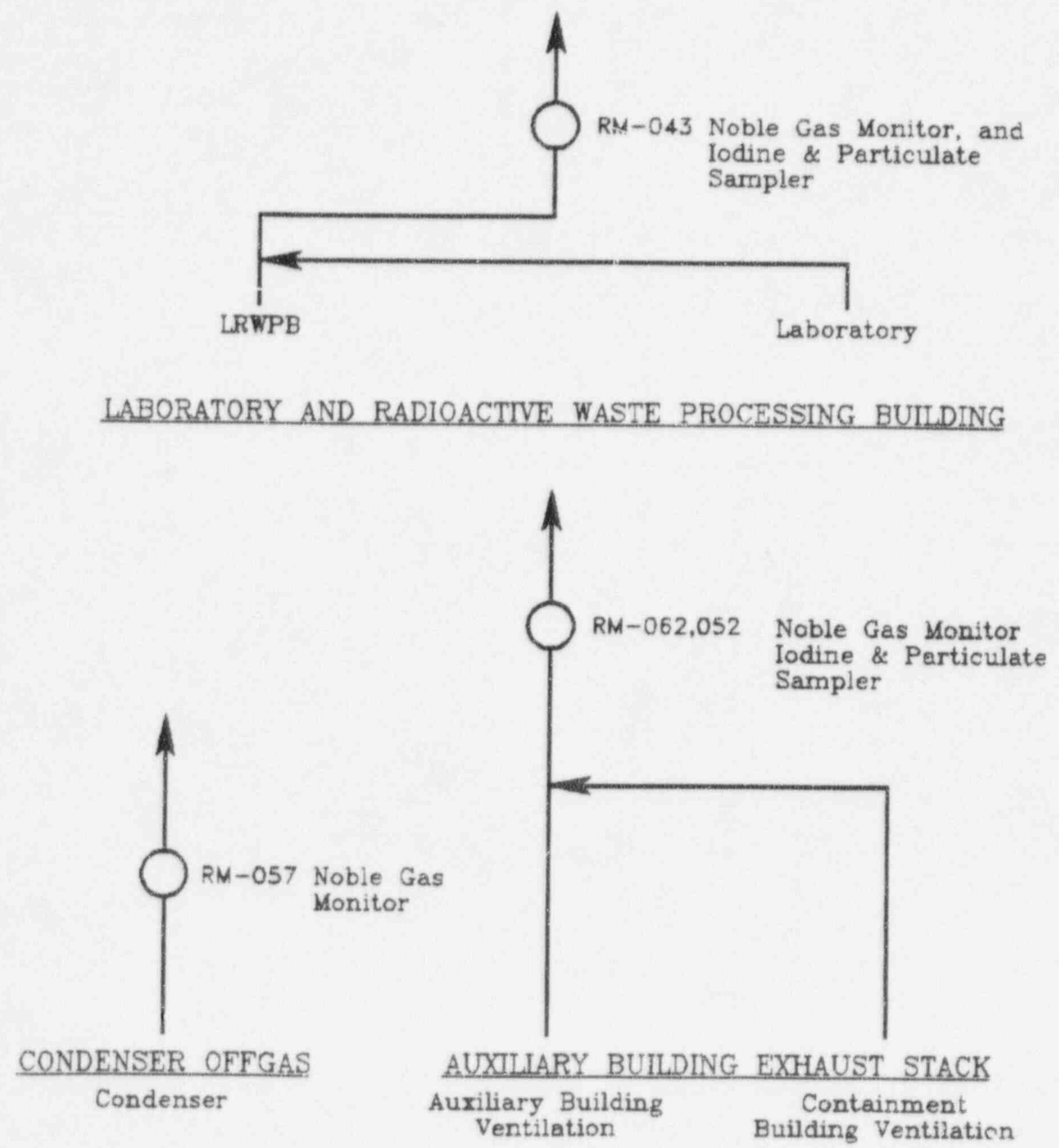
Figure 3 CH8915E

Figure 3



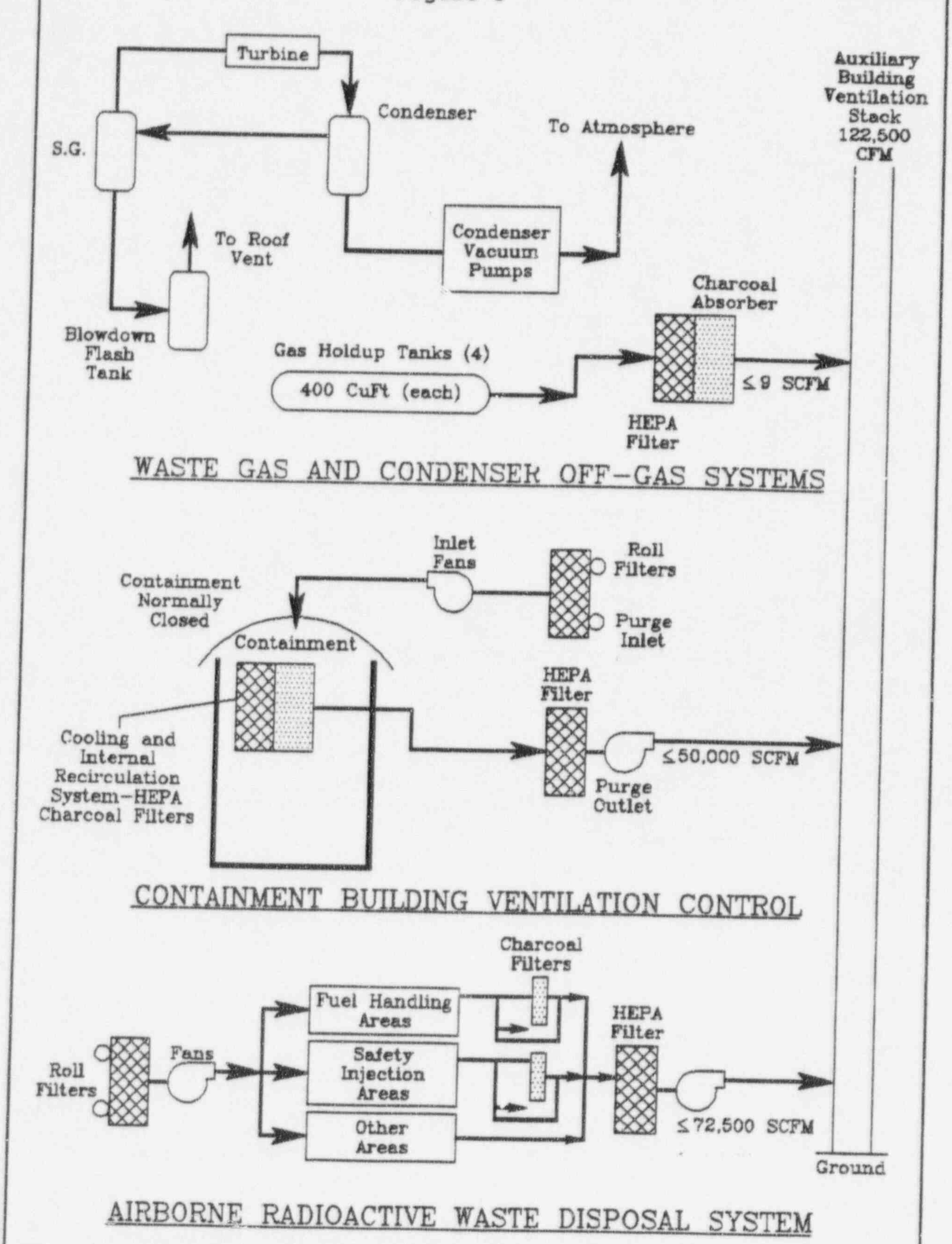
LIQUID RADIOACTIVE WASTE DISPOSAL SYSTEM

Figure 4



AIRBORNE EFFLUENT DISCHARGE PATHWAYS

Figure 5


Turbine
Condenser
S.G.
To Atmosphere
Auxiliary Building Ventilation Stack 122,500 CFM
To Roof Vent
Condenser Vacuum Pumps
Charcoal Absorber
Blowdown Flash Tank
Gas Holdup Tanks (4)
400 CuFt (each)
≤ 9 SCFM
HEPA Filter
WASTE GAS AND CONDENSER OFF-GAS SYSTEMS
Inlet Fans
Roll Filters
Containment Normally Closed
Purge Inlet
Containment
HEPA Filter
Cooling and Internal Recirculation System-HEPA Charcoal Filters
≤ 50,000 SCFM
Purge Outlet
CONTAINMENT BUILDING VENTILATION CONTROL
Charcoal Filters
Fuel Handling Areas
HEPA Filter
Roll Filters
Fans
Safety Injection Areas
Other Areas
≤ 72,500 SCFM
Ground
AIRBORNE RADIOACTIVE WASTE DISPOSAL SYSTEM

PART IV

RADIOLOGICAL EFFLUENT MONITORING CALCULATIONS

1.0 EFFLUENT CONCENTRATIONS

1.1 Liquid Effluent Concentrations

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 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 II, Table 1, and the concentration of each radionuclide at site discharge will be calculated, based on the following equation:

Radionuclide concentration at site discharge:

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

$$\text{and} \sum_{i=1}^{n} A_i \,/\, wec_i \leq 1$$

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 20, Appendix B, Table 2, Column 2.

1.0 EFFLUENT CONCENTRATIONS

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

1.2 Airborne Effluent Concentrations

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:

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

$$A_i = K_o Q_i (\chi/Q)$$

$$\text{and} \sum_{i=1}^{n} A_i/aec_i \leq 1$$

Where:

A_i = Concentration of radionuclide, i, at the unrestricted area boundary

K_o = Constant of unit conversion. ($1E\text{-}6 m^3/cc$)

aec_i = Air effluent concentration limit (10 CFR 20, Appendix B, Table 2, Column 1 value for radionuclide, i)

Q_i = The release rate of radionuclides i, in airborne effluents from all vent releases (in $\mu Ci/sec.$)

(χ/Q) = $5E\text{-}6\ sec/m^3$. For all vent releases. The highest calculated annual average relative concentration for any area at or beyond the unrestricted area boundary

1.0 EFFLUENT CONCENTRATIONS

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 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 3, may be used for evaluating the airborne effluent dose rate.

NOTE: 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 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 20.

2.0 RADIOACTIVE EFFLUENT DOSE CALCULATIONS

2.1 Liquid Effluent Dose Calculations

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.

10 CFR 50, App. 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

2.0 RADIOACTIVE EFFLUENT DOSE CALCULATIONS (Continued)

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

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 5

M_p = is the mixing ratio (reciprocal of the dilution factor) at the point of withdrawal of drinking water, dimensionless. Table 3

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 12-15

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 16

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

2.0 RADIOACTIVE EFFLUENT DOSE CALCULATIONS (Continued)

2.1 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 5

M_p = is the mixing ratio (reciprocal of the dilution factor) at the point of harvest of aquatic food, dimensionless. Table 3

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 2

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 12-15

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 16

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

2.0 RADIOACTIVE EFFLUENT DOSE CALCULATIONS (Continued)

2.1 C. SHORELINE DEPOSITS

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

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 5

M_p = is the mixing ratio (reciprocal of the dilution factor) at the point of exposure, dimensionless. Table 3

W = is the shore-width factor, dimensionless. Table 16

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 areal radionuclide concentration (in pCi/m^2). Table 7

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 16

t_b = is the period of time for which sediment or soil is exposed to the contaminated water, in hours. Table 16

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

2.0 RADIOACTIVE EFFLUENT DOSE CALCULATIONS (Continued)

2.2 Airborne Effluent Dose Calculations

2.2.1 Noble Gas

10 CFR 50, App. 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:

2.0 RADIOACTIVE EFFLUENT DOSE CALCULATIONS (Continued)

Doses from Noble Gases

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

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

Where:

$DF_i^{\gamma}, DF_i^{\beta}$ = are the gamma and beta air dose factors for a uniform semi-infinite cloud of radionuclide, i, in mrad-m^3/pCi-yr. Table 1

$D^{\gamma}(r,\Theta)$ or $D^{\beta}(r,\Theta)$ = are the annual gamma and beta air doses at distance r, in the sector at angle Θ, 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 3

3.17×10^{4} = is the number of pci per ci divided by the number of seconds per year.

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

$$D_{\infty}^{T}(r,\Theta) = S_F \sum_{i=1}^{n} \chi_i(r,\Theta) DFB_i$$

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 1

$D_{\infty}^{T}(r,\Theta)$ = 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 3

S_F = Shielding Factor. Table 16

2.0 RADIOACTIVE EFFLUENT DOSE CALCULATIONS (Continued)

2.2 C. Annual Skin Dose from All Other Noble Gas Releases

$$D_{\infty}^{T}(r,\Theta) = 1.11\ S_F \sum_{i=1}^{n} \chi_i(r,\Theta)\, DF_i^{\gamma} + \sum_{i=1}^{n} \chi_i(r,\Theta)\, DFS_i$$

Where:

$D_{\infty}^{T}(r,\Theta)$ = 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 1

1.11 = is the average ratio of tissue to air energy absorption coefficients.

2.2.2 Radioiodine, Tritium, and Particulates

10 CFR 50, App. I, restricts the dose to individuals in the unrestricted areas from radioactive materials in gaseous airborne from the Port 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 (See Part III, Figure 1) should be determined by the following expressions:

2.0 RADIOACTIVE EFFLUENT DOSE CALCULATIONS (Continued)

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

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

A.1 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 15 years (mid-point of plant operating life). Table 16
$\delta_i(r,\theta)$	=	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 3
λ_i	=	is the radiological decay constant for radionuclide, i, in yr^{-1}.
$1.0x10^{12}$	=	is the number of pCi per Ci

2.0 RADIOACTIVE EFFLUENT DOSE CALCULATIONS (Continued)

2.2 A.2 The annual organ dose is then calculated using the following equation:

$$D_j^G(r,\Theta) = 8760\ S_F \sum_{i=1}^{n} C_i^G(r,\Theta)\, DFG_{ij}$$

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 $mrem\text{-}m^2/pCi\text{-}hr$. Table 7

$D_j^G(r,\theta)$ = 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 16

8760 = is the number of hours in a year

2.0 RADIOACTIVE EFFLUENT DOSE CALCULATIONS (Continued)

2.2 B. Annual Dose from Inhalation of Radionuclides in Air

B.1 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:

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

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 R.G. 1.111). This includes depletion (for radioiodines and particulates) and radiological decay of the plume. Table 3

3.17×10^4 = is the number of pCi/Ci divided by the number of sec/yr.

B.2 The annual dose associated with inhalation of all radionuclides to organ, j, of an individual in age group, a, is then:

$$D^A_{ja}(r,\Theta) = R_a \sum_{i=1}^{n} \chi_i(r,\theta)\, DFA_{ija}$$

Where:

$D^A_{ja}(r,\theta)$ = 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 5

DFA_{ija} = is the inhalation dose factor for radionuclide, i, organ, j, and age group, a, in mrem/pCi. Tables 8-11

2.0 RADIOACTIVE EFFLUENT DOSE CALCULATIONS (Continued)

2.2 C. Concentrations of Radionuclides in Foods and Vegetation from Atmospheric Releases

C.1 Parameters for Calculating Concentrations in Forage, Produce, and Leafy Vegetables, excluding Carbon-14 and 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.

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

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

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 Regulatory Guide 1.111). Table 3

1.1×10^8 = 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.

2.0 RADIOACTIVE EFFLUENT DOSE CALCULATIONS (Continued)

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

$$d_i\ (r_1\ \theta) = 5.5 \times 10^7\ \delta_i\ (r_1\ \theta)\ Q_i$$

Where:

$d_i\ (r_1\ \theta)$ = The deposition rate of radioiodine, i.

5.5×10^7 = The number of pCi/Ci (10^{12}) divided by the number of hours per year (8760), then multiplied by the amount of radioiodine emissions considered to be nonelemental (0.5).

$\delta_i\ (r,\ \theta)$ = The relative deposition of radioiodine, i, considering depletion and decay, in m^{-2}. Table 3.

Q_i = The total (elemental and nonelemental) radioiodine, i, emission rate.

r = is the fraction of deposited activity retained on crops, dimensionless. Table 16

λ_{Ei} = is the effective removal rate constant for radionuclide, i, from crops, in hr^{-1}.

$\lambda_{Ei} = \lambda_i + \lambda_w$
$\lambda_w = 0.0021/hr$. Table 16

t_e = is the time period that crops are exposed to contamination during the growing season, in hours. Table 16

Y_v = is the agricultural productivity (yield) in kg (wet weight)/m^2. Table 16

B_{iv} = 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 4

λ_i = 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 16

P = is the effective "surface density" for soil, in kg (dry soil)/m^2. Table 16

t_h = is the holdup time that represents the time interval between harvest and consumption of the food, in hours. Table 16

2.0 RADIOACTIVE EFFLUENT DOSE CALCULATIONS (Continued)

2.2 Different values for the parameters t_e, Y_v, and t_h, 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 16

C.2 Parameters for Calculating Radionuclide Concentration in Milk, excluding Carbon-14 and Tritium

C.2.1 Parameters for Calculating the Concentration of Radionuclide, i, in the Animal's Feed (Milk Cow, Beef Cow, and Goat)

$$C_i^V(r,\Theta) = f_p f_s C_i^P(r,\Theta) + (1 - f_p) C_i^S(r,\Theta) + f_p(1 - f_s) C_i^S(r,\Theta)$$

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 C.2.1 with t_h=0), in pCi/kg.

$C_i^S(r,\theta)$ = is the concentration of radionuclide, i, in stored feeds (calculated using Equation C.2.1 with t_h=90 days), in pCi/kg.

f_p = is the fraction of the year that animals graze on pasture. Table 16

f_s = is the fraction of daily feed that is pasture grass while the animal grazes on pasture. Table 16

2.0 RADIOACTIVE EFFLUENT DOSE CALCULATIONS (Continued)

2.2 C.2.2 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 4

Q_F = is the amount of feed consumed by the animal per day, in kg/day. Table 6

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 16

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

2.0 RADIOACTIVE EFFLUENT DOSE CALCULATIONS (Continued)

2.2 C.3 Parameters for Calculating Radionuclide Concentration in Cow Meat, excluding Carbon-14 and Tritium

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

Where:

$C_i^F(r,\theta)$ = 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 4

t_s = is the average time from slaughter to consumption. Table 16

2.0 RADIOACTIVE EFFLUENT DOSE CALCULATIONS (Continued)

2.2 C.4 Parameters for Calculating the Carbon-14 Concentrations in Vegetation

Carbon-14 is assumed to be released in oxide form (CO or CO_2). The concentration of Carbon-14 in vegetation is calculated by assuming that its ratio to the natural carbon in vegetation is the same as the ratio of Carbon-14 to natural carbon in the atmosphere surrounding the vegetation. Also, in the case of intermittent releases, such as from gaseous waste decay tanks, the parameter p is employed to account for the fractional equilibrium ratio achieved. The parameter, p, is defined as the ratio of the total annual release time (for Carbon-14 atmospheric releases) to the total annual time during which photosynthesis occurs (taken to be 4400 hrs), under the condition that the value of p should never exceed unity. For continuous Carbon-14 releases, p is taken to be unity. These considerations yield the following relationship:

$$C_{14}^{V}(r,\Theta) = 3.17 \times 10^7 p Q_{14} [\chi/Q](r,\Theta)\ 0.11/0.16$$

$$= 2.2 \times 10^7 p Q_{14} [\chi/Q](r,\Theta)$$

Where:

$C_{14}^{v}(r,\theta)$ = is the concentration of Carbon-14 in vegetation grown at distance r, in the sector at angle θ, in pCi/kg.

Q_{14} = is the annual release rate of Carbon 14, in Ci/yr.

$[\chi/Q](r,\theta)$ = is the atmospheric dispersion factor, in sec/m^3. Table 3

p = is the fractional equilibrium ratio, dimensionless. P=1 (Reg. Guide 1.109, Rev. 1, pg. 26).

0.11 = is the fraction of total plant mass that is natural carbon, dimensionless.

0.16 = is equal to the concentration of natural carbon in the atmosphere, in g/m^3.

3.17×10^7 = is equal to $(1.0 \times 10^{12}$ pci/ci$)(1.0 \times 10^3$ g/kg$)$ $(3.15 \times 10^7$ sec/yr$)$.

2.0 RADIOACTIVE EFFLUENT DOSE CALCULATIONS (Continued)

2.2 C.5 Parameters for Calculating Tritium Concentrations in Vegetation

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

$$C_T^V(r,\Theta) = 3.17 \times 10^7 Q_T [\chi/Q](r,\Theta)\ (0.75)(0.5/H)$$

$$= 1.2 \times 10^7 Q_T [\chi/Q](r,\Theta)/H$$

Where:

$C_T^v(r,\theta)$ = 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.

$[\chi/Q](r,\theta)$ = is the atmospheric dispersion factor, in sec/m^3. Table 3

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.

2.0 RADIOACTIVE EFFLUENT DOSE CALCULATIONS (Continued)

2.2 D. Annual Dose from Atmospherically Released Radionuclides in Foods

D.1 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:

$$D_{ja}^{D}(r,\Theta) = \sum_{i} DFI_{ija}\left[U_a^V f_g C_i^V(r,\Theta) + U_a^m C_i^m(r,\Theta) + U_a^F C_i^F(r,\Theta) + U_a^L f_\ell C_i^L(r,\Theta)\right]$$

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 12-15.

$U_a^v, U_a^m,$ = 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 5.

Values of F_g and f_ℓ are 0.76 and 1.0, respectively.

2.0 RADIOACTIVE EFFLUENT DOSE CALCULATIONS (Continued)

2.2 D.1.1 Calculating the Ingested Dose from Leafy and Non-Leafy (produce) Vegetation for Radionuclide, i, to Each Organ, j, and Age Group, a

$$D_{ja}^{D}(r,\Theta) = DFI_{ija}\left[U_{a}^{L}f_{l}C_{i}^{L}(r,\Theta) + U_{a}^{V}f_{g}C_{i}^{V}(r,\Theta)\right]$$

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 12-15

U_{a}^{L}, U_{a}^{V} = 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 5

C_{i}^{L} = is the concentration of radionuclide, i, in and on leafy vegetation, in pCi/kg.

C_{i}^{V} = is the concentration of radionuclide, i, in and on produce, in pCi/kg.

2.0 RADIOACTIVE EFFLUENT DOSE CALCULATIONS (Continued)

2.2 D.1.2 Calculation Determining the Ingested Dose from Cow Milk for Radionuclide, i, Organ, j, and Age Group, a.

$$D_{ja}^{D}(r,\Theta) = DFI_{ija}\left[U_{a}^{M}C_{i}^{M}(r,\Theta)\right]$$

Where:

$D_{ja}^{D}(r,\theta)$ = 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 12-15

U_{a}^{M} = is the ingestion rate of cow milk for individuals in age group, a, in ℓ/yr. Table 5

C_{i}^{M} = is the radionuclide concentration in cow milk, in pCi/kg. Equation C.2.2

2.0 RADIOACTIVE EFFLUENT DOSE CALCULATIONS (Continued)

2.2 D.1.3 Calculation Determining the Ingested Dose from Meat for Radionuclide, i, to Organ, j, and Age Group, a.

$$D_{ja}^{D}(r,\Theta) = DFI_{ija}\left[U_a^F C_i^F(r,\Theta)\right]$$

Where:

$D_{ja}^{D}(r,\theta)$ = 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 12-15

U_a^F = is the ingestion rate of meat for individuals in age group, a in kg/yr. Table 5

C_i^F = is the radionuclide, i, concentration in meat, in pCi/ kg.

TABLE 1

DOSE FACTORS FOR EXPOSURE TO A SEMI-INFINITE CLOUD OF NOBLE GASES

Nuclide	β-air* (DF^{β}_{i})	β-Skin** (DFS_i)	γ-Air* (DF^{γ}_{i})	γ-Body** (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	4.76E-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

* $\frac{\text{mrad-m}^3}{\text{pCi-yr}}$

** $\frac{\text{mrem-m}^3}{\text{pCi-yr}}$

*** 2.88E-04 = 2.88×10^{-4}

TABLE 2

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 3

CONTROLLING LOCATIONS, PATHWAYS AND ATMOSPHERIC DISPERSION FOR DOSE CALCULATIONS

Location	Pathway(s)	Controlling Age Group	Atmospheric Dispersion χ/Q ($\chi/Q(r,\Theta)$) (sec/m^3)	Atmospheric Dispersion D/Q ($\delta(r,\Theta)$) (1/m^3)
Unrestricted Area Boundary	Noble Gases Direct Exposure	N/A	5.0E-06	N/A
Unrestricted Area Boundary	Inhalation	Child	5.0E-06	N/A
Unrestricted Area Boundary	Gamma-Air Beta-Air	N/A	5.0E-06	N/A
Miller Farm* 0.8 miles SSW	milk, ground plane, meat, inhalation, and vegetation	Child	5.0E-06	1.6E-08
Site Discharge	Liquid	N/A	Mixing Ratio, M_p	7.14
M.U.D. Intake	Liquid	N/A	Mixing Ratio, M_p	30.8

* Location is subject to change depending on the results of the Land Use survey performed annually in accordance with Part II, Section 5.4

TABLE 4

STABLE ELEMENT TRANSFER DATA

Element	B_{iv} Veg/Soil	F_m (Cow) Milk (d/λ)	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+01	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 5

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 (ℓ/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 (ℓ/yr)	330	510	510	730
Shoreline recreation (hr/yr)	-	14	67	12
Inhalation (m^3/yr)	1400	3700	8000	8000

TABLE 6

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 7

EXTERNAL DOSE FACTORS FOR STANDING ON CONTAMINATED GROUND
(mrem/hr per pCi/m^2)

ELEMENT	TOTAL BODY	SKIN
H-3	0.0	0.0
C-14	0.0	0.0
NA-24	2.50E-08	2.90E-08
P-32	0.0	0.0
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	0.0	0.0
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	0.0	0.0
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	0.0	0.0
Br-83	6.40E-11	9.30E-11
Br-84	1.20E-08	1.40E-08
Br-85	0.0	0.0
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
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

TABLE 7
(Continued)

EXTERNAL DOSE FACTORS FOR STANDING ON CONTAMINATED GROUND
(mrem/hr per pCi/m²)

ELEMENT	TOTAL BODY	SKIN
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	0.0	0.0
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 8
INHALATION DOSE FACTORS FOR ADULT
(mrem per pCi Inhaled)

Page 1 of 2

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
H 3	-	1.58E-07	1.58E-07	1.58E-07	1.58E-07	1.58E-07	1.58E-07
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
[illegible] 69	4.23E-12	8.14E-12	5.65E-13	-	5.27E-12	1.15E-07	2.04E-0[illegible]
BR 83	-	-	3.01E-08	-	-	-	2.90E-08
BR 84	-	-	3.91E-08	-	-	-	2.05E-13
BR 85	-	-	1.60E-09	-	-	-	LT E-24
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	1.24E-02	-	7.62E-04	-	-	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-0[illegible]
[illegible] 99	-	1.51E-08	2.87E-09	-	3.64E-08	1.14E-05	3.10E-[illegible]
[illegible] 99M	1.29E-13	3.64E-13	4.63E-12	-	5.52E-12	9.55E-08	5.20E-07

TABLE 8
INHALATION DOSE FACTORS FOR ADULT
(mrem per pCi Inhaled)

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
TC 101	5.22E-15	7.52E-15	7.38E-14	-	1.35E-13	4.99E-08	1.36E-21
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-0[illegible]
I 134	8.05E-08	2.16E-07	7.69E-08	3.73E-06	3.44E-07	-	1.26E-1[illegible]
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	-	9.75E-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
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	2.82E-09	1.55E-09	-	8.75E-09	4.70E-06	1.49E-05

TABLE 9
INHALATION DOSE FACTORS FOR TEENAGER
(mrem per pCi Inhaled)

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
H 3	-	1.59E-07	1.59E-07	1.59E-07	1.59E-07	1.59E-07	1.59E-07
C 14	3.25E-06	6.09E-07	6.09E-07	6.09E-07	6.09E-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-0[illegible]
BR 83	-	-	4.30E-08	-	-	-	LT E-24
BR 84	-	-	5.41E-08	-	-	-	LT E-24
BR 85	-	-	2.29E-09	-	-	-	LT E-24
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	1.35E-02	-	8.35E-04	-	-	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-0[illegible]
[illegible] 99	-	2.11E-08	4.03E-09	-	5.14E-08	1.92E-05	3.36E-[illegible]
[illegible] 99M	1.73E-13	4.83E-13	6.24E-12	-	7.20E-12	1.44E-07	7.66E-07

TABLE 9
INHALATION DOSE FACTORS FOR TEENAGER
(mrem per pCi Inhaled)

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
TC 101	7.40E-15	1.05E-14	1.03E-13	-	1.90E-13	8.34E-08	1.09E-16
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-0[illegible]
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
[illegible] 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	3.99E-09	2.21E-09	-	1.25E-08	8.11E-06	1.65E-05

TABLE 10
INHALATION DOSE FACTORS FOR CHILD
(mrem per pCi Inhaled)

Page 1 of 2

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
H 3	-	3.04E-07	3.04E-07	3.04E-07	3.04E-07	3.04E-07	3.04E-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
[illegible] 69	1.81E-11	2.61E-11	2.41E-12	-	1.58E-11	3.84E-07	2.75E-0[illegible]
BR 83	-	-	1.28E-07	-	-	-	LT E-24
BR 84	-	-	1.48E-07	-	-	-	LT E-24
BR 85	-	-	6.84E-09	-	-	-	LT E-24
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	2.73E-02	-	1.74E-03	-	-	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-0[illegible]
[illegible] 99	-	4.66E-08	1.15E-08	-	1.06E-07	3.66E-05	3.42E-[illegible]
[illegible] 99M	4.81E-13	9.41E-13	1.56E-11	-	1.37E-11	2.57E-07	1.30E-06

TABLE 10
INHALATION DOSE FACTORS FOR CHILD
(mrem per pCi Inhaled)

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
TC 101	2.19E-14	2.30E-14	2.91E-13	-	3.92E-13	1.58E-07	4.41E-09
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-0[illegible]
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
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	9.04E-09	6.35E-09	-	2.63E-08	1.57E-05	1.73E-05

TABLE 11
INHALATION DOSE FACTORS FOR INFANT
(mrem per pCi Inhaled)

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Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
H 3	-	4.62E-07	4.62E-07	4.62E-07	4.62E-07	4.62E-07	4.62E-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
[illegible]N 69	3.85E-11	6.91E-11	5.13E-12	-	2.87E-11	1.05E-06	9.44E-[illegible]
[illegible]R 83	-	-	2.72E-07	-	-	-	LT E-24
B[illegible] 84	-	-	2.86E-07	-	-	-	LT E-24
BR 85	-	-	1.46E-08	-	-	-	LT E-24
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	2.92E-02	-	1.85E-03	-	-	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-0[illegible]
[illegible] 99	-	1.18E-07	2.31E-08	-	1.89E-07	9.63E-05	3.48E-[illegible]
[illegible] 99M	9.98E-13	2.06E-12	2.66E-11	-	2.22E-11	5.79E-07	1.45E-06

TABLE 11
INHALATION DOSE FACTORS FOR INFANT
(mrem per pCi Inhaled)

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
TC 101	4.65E-14	5.88E-14	5.80E-13	-	6.99E-13	4.17E-07	6.03E-07
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
132	1.21E-06	2.53E-06	8.99E-07	1.21E-04	2.82E-06	-	1.36E-0[illegible]
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	1.06E-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
147	5.67E-06	5.81E-06	3.57E-07	-	2.25E-06	2.30E-04	2.23E-0[illegible]
W 187	9.26E-09	6.44E-09	2.23E-09	-	-	2.83E-05	2.54E-0[illegible]
NP 239	2.65E-07	2.37E-08	1.34E-08	-	4.73E-08	4.25E-05	1.78E-05

TABLE 12
INGESTION DOSE FACTORS FOR ADULT
(mrem per pCi Ingested)

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Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
H 3	-	1.05E-07	1.05E-07	1.05E-07	1.05E-07	1.05E-07	1.05E-07
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
[illegible]N 69	1.03E-08	1.97E-08	1.37E-09	-	1.28E-08	-	2.96E-[illegible]
BR 83	-	-	4.02E-08	-	-	-	5.79E-08
BR 84	-	-	5.21E-08	-	-	-	4.09E-13
BR 85	-	-	2.14E-09	-	-	-	LT E-24
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	7.58E-03	-	1.86E-03	-	-	-	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-[illegible]
[illegible] 99	-	4.31E-06	8.20E-07	-	9.76E-06	-	9.99E-[illegible]
[illegible] 99M	2.47E-10	6.98E-10	8.89E-09	-	1.06E-08	3.42E-10	4.13E-07

TABLE 12
INGESTION DOSE FACTORS FOR ADULT
(mrem per pCi Ingested)

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
TC 101	2.54E-10	3.66E-10	3.59E-09	-	6.59E-09	1.87E-10	1.10E-21
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.[illegible]E-04	3.48E-06	-	1.92E-06
I 131	4.16E-06	5.95E-06	3.41E-06	1.[illegible]E-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-0[illegible]
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
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 13
INGESTION DOSE FACTORS FOR TEENAGER
(mrem per pCi Inhaled)

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Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
H 3	-	1.06E-07	1.06E-07	1.06E-07	1.06E-07	1.06E-07	1.06E-07
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
[illegible]N 69	1.47E-08	2.80E-08	1.96E-09	-	1.83E-08	-	5.16E-0[illegible]
BR 83	-	-	5.74E-08	-	-	-	LT E-24
BR 84	-	-	7.22E-08	-	-	-	LT E-24
BR 85	-	-	3.05E-09	-	-	-	LT E-24
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	8.30E-03	-	2.05E-03	-	-	-	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-0[illegible]
[illegible] 99	-	6.03E-06	1.15E-06	-	1.38E-05	-	1.08E-[illegible]
TC 99M	3.32E-10	9.26E-10	1.20E-08	-	1.38E-08	5.14E-10	6.08E-07

TABLE 13
INGESTION DOSE FACTORS FOR TEENAGER
(mrem per pCi Inhaled)

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
TC 101	3.60E-10	5.12E-10	5.03E-09	-	9.26E-09	3.12E-10	8.75E-17
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
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 14
INGESTION DOSE FACTORS FOR CHILD
(mrem per pCi Ingested)

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Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
H 3	-	2.03E-07	2.03E-07	2.03E-07	2.03E-07	2.03E-07	2.03E-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
[illegible] 69	4.38E-08	6.33E-08	5.85E-09	-	3.84E-08	-	3.99E-[illegible]
BR 83	-	-	1.71E-07	-	-	-	LT E-24
BR 84	-	-	1.98E-07	-	-	-	LT E-24
BR 85	-	-	9.12E-09	-	-	-	LT E-24
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	1.70E-02	-	4.31E-03	-	-	-	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-0[illegible]
[illegible] 99	-	1.33E-05	3.29E-06	-	2.84E-05	-	1.10E-[illegible]
TC 99M	9.23E-10	1.81E-09	3.00E-08	-	2.63E-08	9.19E-10	1.03E-06

TABLE 14
INGESTION DOSE FACTORS FOR CHILD
(mrem per pCi Ingested)

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Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
TC 101	1.07E-09	1.12E-09	1.42E-08	-	1.91E-08	5.92E-10	3.56E-09
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-0[illegible]
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-0[illegible]
[illegible] 147	2.79E-08	2.26E-08	1.75E-09	-	1.24E-08	-	3.58E-0[illegible]
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 15
INGESTION DOSE FACTORS FOR INFANT
(mrem per pCi Ingested)

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
H 3	-	3.08E-07	3.08E-07	3.08E-07	3.08E-07	3.08E-07	3.08E-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
[illegible]N 69	9.33E-08	1.68E-07	1.25E-08	-	6.98E-08	-	1.37E-[illegible]
BR 83	-	-	3.63E-07	-	-	-	LT E-24
BR 84	-	-	3.82E-07	-	-	-	LT E-24
BR 85	-	-	1.94E-08	-	-	-	LT E-24
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	1.85E-02	-	4.71E-03	-	-	-	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
[illegible] 95	4.20E-08	1.73E-08	1.00E-08	-	1.24E-08	-	1.46E-[illegible]
[illegible] 99	-	3.40E-05	6.63E-06	-	5.08E-05	-	1.12E-[illegible]
TC 99M	1.92E-09	3.96E-09	5.10E-08	-	4.26E-08	2.07E-09	1.15E-06

TABLE 15
INGESTION DOSE FACTORS FOR INFANT
(mrem per pCi Ingested)

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Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
TC 101	2.27E-09	2.86E-09	2.83E-08	-	3.40E-08	1.56E-09	4.86E-07
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
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 16
RECOMMENDED VALUES FOR OTHER PARAMETERS

Page 1 of 2

Parameter Symbol	Definition	Values
f_g	Fraction of produce ingested grown in garden of interest.	0.76
f_ℓ	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 (for iodines) 0.2 (for other particulates)
S_F	Attenuation factor accounting for shielding provided by residential structures.	0.7 (for maximum individuals) 0.5 (for general population)
t_b	Period of long-term buildup for activity in sediment or soil (nominally 15 yr).	1.31 x 10^5 hr
t_e	Period of crop, leafy vegetable, or pasture grass exposure during growing season.	720 hrs (30 days, for grass-cow-milk-man pathway) 1440 hrs (60 days for crop/ vegetation-man pathway)
t_f	Transport time from animal feed-milk-man provided by residential structures.	2 days (for max. individual) 4 days (for gen. population)
t_h	Time delay between harvest of vegetation or crops and ingestion. i) For ingestion of forage by animals	Zero (for pasture grass) 2160 hr (90 days for stored feed)

TABLE 16
RECOMMENDED VALUES FOR OTHER PARAMETERS

Parameter Symbol	Definition	Values
	ii) For ingestion of crops by man	24 hr (1 day, for leafy vegetables & max. individual) feed) 1440 hr (60 days for produce & maximum individual) 336 hr (14 days for general population)
t_p	Environmental transit time, release to receptor (add time from release to exposure individual) point to minimums shown for distribution)	12 hr (for max. 24 hr (for gen. population) 24 hr (for max. individual) 168 hr (7 days for population sport fish doses) 240 hr (10 days for 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 (for grass-cow-milk man pathway) 2.0 kg/m^2 (for produce or leafy vegetables ingested by man)
W	Shore-width factor for river shoreline	0.2
λ_w	Rate constant for removal of activity on plant or leaf surfaces by weathering (corresponds to a 14-day half-life)	0.0021 hr^{-1}