

OFFSITE DOSE CALCULATION MANUAL FOR BYRON STATION
UNITS 1 AND 2

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Part 1 - RADIOLOGICAL EFFLUENTS

1. DEFINITIONS

- 1.1. **ACTIONS** shall be that part of a Requirement that prescribes Required Actions to be taken under designated Conditions within specified Completion Times.
- 1.2. **CHANNEL CALIBRATION** shall be the adjustment, as necessary, of the channel so that it responds within the required range and accuracy to known inputs. The CHANNEL CALIBRATION shall encompass the entire channel, including the required sensor, alarm, interlock, display, and trip functions. Calibration of instrument channels with Resistance Temperature Detector (RTD) or thermocouple sensors may consist of an in place qualitative assessment of sensor behavior and normal calibration of the remaining adjustable devices in the channel. The CHANNEL CALIBRATION may be performed by means of any series of sequential, overlapping calibrations or total channel steps so that the entire channel is calibrated.
- 1.3. **CHANNEL CHECK** shall be the qualitative assessment, by observation, of channel behavior during operation. This determination shall include, where possible, comparison of the channel indication and status to other indications or status derived from independent instrument channels measuring the same parameter.
- 1.4. **CHANNEL OPERATIONAL TEST (COT)** shall be the injection of a simulated or actual signal into the channel as close to the sensor as practicable to verify the OPERABILITY of required alarm, interlock, display and trip functions. The COT shall include adjustments, as necessary, of the required alarm, interlock, and trip setpoints so that the setpoints are within the required range and accuracy.
- 1.5. **DOSE EQUIVALENT I-131** shall be that concentration of I-131 (microcurie/gram) that alone would produce the same dose when inhaled as the combined activities of iodine isotopes I-131, I-132, I-133, I-134, and I-135 actually present. The determination of DOSE EQUIVALENT I-131 shall be performed using the committed Effective Dose Equivalent (CEDE) dose conversion factors from Table 2.1 of EPA Federal Guidance Report No. 11, 1988, "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion".

- 1.6. **FREQUENCY** - Table 1-a provides the definitions of various frequencies for which surveillances, sampling, etc., are performed unless defined otherwise. The 25% variance shall not be applied to Operability Action statements. The bases to Surveillance Requirement 3.0.2 provide clarifications to this requirement.
- 1.7. **IMMEDIATELY** – When “immediately” is used as a completion time the Required Action should be pursued without delay and in a controlled manner.
- 1.8. **MEMBER(S) OF THE PUBLIC** shall include all persons who are not occupationally associated with the plant. This category does not include employees of the licensee, its contractors or vendors and persons who enter the site to service equipment or to make deliveries. This category does include persons who use portions of the site for recreational, occupational, or other purposes not associated with the plant.
- 1.9. **MODE** shall correspond to any one inclusive combination of core reactivity condition, power level, average reactor coolant temperature, and reactor vessel head closure bolt tensioning specified in TRM Table T1.1-1 with fuel in the reactor vessel.
- 1.10. **OCCUPATIONAL DOSE** means the dose received by an individual in the course of employment in which the individual's assigned duties involve exposure to radiation and/or to radioactive material from licensed and unlicensed sources of radiation, whether in the possession of the licensee or other person. Occupational dose does not include dose from background radiation, as a patient from medical practices, from voluntary participation in medical research programs, or as a member of the public.
- 1.11. A system, subsystem, train, component, or device shall be **OPERABLE** or have **OPERABILITY** when it is capable of performing its specified safety function(s) and when all necessary attendant instrumentation, controls, normal or emergency electrical power, cooling and seal water, lubrication, and other auxiliary equipment that are required for the system, subsystem, train, component, or device to perform its specified safety function(s) are also capable of performing their related support function(s).
- 1.12. **PROCESS CONTROL PROGRAM (PCP)** shall contain the current formulas, sampling, analyses, tests, and determinations to be made to ensure that processing and packaging of solid radioactive wastes based on demonstrated processing of actual or simulated wet solid wastes will be accomplished in such a way as to assure compliance with 10 CFR Parts 20, 61, and 71, State regulations, burial ground requirements and other requirements governing the disposal of solid radioactive waste.

- 1.13. **PURGE/PURGING** shall be any controlled process of discharging air or gas from a confinement to maintain temperature, pressure, humidity, concentration or other operating condition, in such a manner that replacement air or gas is required to purify the confinement.
- 1.14. **RATED THERMAL POWER** shall be a total reactor core heat transfer rate to the reactor coolant of 3645MWt.
- 1.15. **RADIOLOGICAL EFFLUENTS (RE)** are in accordance with Byron Technical Requirements Manual (TRM) and the Code of Federal Regulations.
- 1.16. **RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM (REMP)** are in accordance with Byron Technical Requirements Manual (TRM) and the Code of Federal Regulations.
- 1.17. **SITE BOUNDARY** shall be that line beyond which the land is neither owned, nor leased, nor otherwise controlled by the licensee.
- 1.18. **SOLIDIFICATION** shall be the conversion of wet wastes into a form that meets shipping and burial ground requirements.
- 1.19. **SOURCE CHECK** shall be the qualitative assessment of channel response when the channel sensor is exposed to a source of increased radioactivity.
- 1.20. **THERMAL POWER** shall be the total reactor core heat transfer rate to the reactor coolant.
- 1.21. **TLCO-TECHNICAL LIMITING CONDITION FOR OPERATION** Limiting Condition for Operation as listed in the TRM.
- 1.22. **TECHNICAL REQUIREMENTS MANUAL (TRM)** Chapter 3.11 contains the Radiological Effluents (RE). Chapter 3.12 contains the Radiological Environmental Monitoring Program (REMP).
- 1.23. **UNRESTRICTED AREA** shall be any area at or beyond the SITE BOUNDARY access to which is not controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials, or any area within the SITE BOUNDARY used for residential quarters or for industrial, commercial, institutional, and/or recreational purposes.

- 1.24. **VENTILATION EXHAUST TREATMENT SYSTEM** shall be any system designed and installed to reduce gaseous radioiodine or radioactive material in particulate form in effluents by passing ventilation or vent exhaust gases through charcoal adsorbers (as required) and/or HEPA filters for the purpose of removing iodines or particulates from the gaseous exhaust stream prior to the release to the environment. Such a system is not considered to have any effect on noble gas effluents. Engineered Safety Features Atmospheric Cleanup Systems are not considered to be VENTILATION EXHAUST TREATMENT SYSTEM components.
- 1.25. **WASTE GAS HOLDUP SYSTEM** shall be any system designed and installed to reduce radioactive gaseous effluents by collecting Reactor Coolant System off-gases from the Reactor Coolant System and providing for delay or holdup for the purpose of reducing the total radioactivity prior to release to the environment.
- 1.26. Definitions Peculiar to Estimating Dose to Members of the Public using the OFFSITE DOSE CALCULATION MANUAL (ODCM) Computer Program.
- A. **ACTUAL** - ACTUAL refers to using known release data to project the dose to members of the public for the previous time period. This data is stored in the database and used to demonstrate compliance with the reporting requirements of the ODCM.
 - B. **PROJECTED** - PROJECTED refers to using known release data from the previous time period or estimated release data to forecast a future dose to members of the public. This data is not incorporated into the database.

Table 1-a**FREQUENCY NOTATIONS***

<u>Notation</u>	<u>Frequency</u>
S - Shiftly	At least once per 12 hours
D - Daily	At least once per 24 hours
W - Weekly	At least once per 7 days
B- Biweekly	At least once every 14 days
M - Monthly	At least once per 31 days
Q - Quarterly	At least once per 92 days
SA - Semiannually	At least once per 184 days
A - Annually	At least once per 366 days
R - Refuel Cycle	At least once per 18 months
S/U - Startup	Prior to each reactor startup
N.A.	Not applicable
P - Prior	Prior to each radioactive release

*Each frequency requirement shall be performed within the specified time interval with the maximum allowable extension not to exceed 25% of the frequency interval. The 25% variance shall not be applied to Operability Action statements. The bases to TSR 3.0.b provide clarifications to this requirement. These frequency notations do not apply to the Radiological Environmental Monitoring Program as described in TRM 3.12.

Table 1-b
COMPLIANCE MATRIX

Regulation	Dose Component Limit	ODCM Equation	TRM	Technical Specification
10 CFR 50 Appendix I	1. Gamma air dose and beta air dose due to airborne radioactivity in effluent plume.	4-4 4-5	3.11.g	5.5.4.h
	a. Total body and skin dose due to airborne radioactivity in effluent plume are reported only if certain gamma and beta air dose criteria are exceeded.	4-6 4-7	N/A	N/A
	2. Dose for all organs and all four age groups due to iodines and particulates in effluent plume. All pathways are considered.	4-8	3.11.h	5.5.4.i
	3. Dose for all organs and all four age groups due to radioactivity in liquid effluents.	3-3	3.11.d	5.5.4.d
10 CFR 20	1. Total Dose, totaling all external dose components (direct, ground and plume shine) and internal dose (all pathways, both airborne and liquid-borne).	5-2	N/A	5.5.4.c
40 CFR 190 (now by reference, also part of 10 CFR 20)	1. Total body dose due to direct dose, ground and plume shine from all sources at a station.	5-1	3.11.k	5.5.4.j
	2. Organ doses to an adult due to all pathways.	3-3 4-8		
Technical Specifications	1. "Instantaneous" total body, skin and organ dose rates to a child due to radioactivity in airborne effluents. For the organ dose, only inhalation is considered.	4-1 4-2 4-3	3.11.f	5.5.4.g
	2. "Instantaneous" concentration limits for liquid effluents.	3-1	3.11.c	5.5.4.b
Technical Specifications	1. Radioactive Effluent Release Report	N/A	N/A	5.6.3
10CFR50 Appendix I Section IV.B.2	1. Implement Environmental Monitoring Program.	N/A	3.12.a	N/A
10CFR50 Appendix I Section IV.B.3	1. Land Use Census	N/A	3.12.b	N/A
10CFR50 Appendix I Section IV.B.2	1. Interlaboratory Comparison Program	N/A	3.12.c	N/A
10CFR50 Appendix I Section IV.B.2 and Technical Specifications	1. Annual Radiological Environmental Operating Report	N/A	N/A	5.6.2

NOTE: 2.0 through 3.10 are not used.

3.11. Radiological Effluents and Radiological Environmental Monitoring Program

NOTE: SEE TRM Chapter 3.11 for Radiological Effluents (RE) and TRM Chapter 3.12 for Radiological Environmental Monitoring Program (REMP).

3.13. METEOROLOGICAL MONITORING PROGRAM

3.13.1. METEOROLOGICAL MONITORING

1. Meteorological parameters are measured in the vicinity of each nuclear power station in order to provide data for calculating radiation doses due to airborne effluent radioactivity. Some nuclear power stations' Technical Specifications state applicable requirements (typically under the subheading, "Meteorological Instrumentation," in the instrumentation section). Regulatory guidance is given in Regulatory Guide 1.23 (Reference 5). Wind speed, wind direction and the temperature gradient are measured using instruments at two or more elevations on a meteorological tower at each Exelon Nuclear station. The elevations are chosen to provide meteorological data representative of the elevations of the airborne releases from the station. The Annual Radiological Environmental Operating Report includes a summary of meteorological data collected over the reporting year.

3.13.2. METEOROLOGICAL CONTRACTOR

1. The meteorological contractor operates and maintains the meteorological tower instrumentation at each nuclear power station. The contractor collects and analyzes the data and issues periodic reports. The contractor prepares the meteorological data summary required for the Annual Radiological Environmental Operating Report (AREOR).

4. **BASES**

4.1. RADIOACTIVE LIQUID EFFLUENT MONITORING INSTRUMENTATION (TRM 3.11.a)

1. The radioactive liquid effluent instrumentation is provided to monitor and control, as applicable, the releases of radioactive materials in liquid effluents during actual or potential releases of liquid effluents. The alarm/trip setpoints for these instruments shall be calculated and adjusted in accordance with the methodology and parameters in the ODCM to ensure that the alarm/trip will occur prior to exceeding 10 times the EFFLUENT CONCENTRATION values specified in Appendix B, Table 2, Column 2 to 10 CFR 20. The OPERABILITY and use of this instrumentation is consistent with the requirements of General Design Criteria 60, 63 and 64 of Appendix A to 10 CFR Part 50. The purpose of tank level indicating devices is to assure the detection and control of leaks that if not

controlled could potentially result in the transport of radioactive materials to UNRESTRICTED AREAS.

4.2. RADIOACTIVE GASEOUS EFFLUENT MONITORING INSTRUMENTATION (TRM 3.11.b)

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

4.3. CONCENTRATION LIMITS FOR EFFLUENTS (TRM 3.11.c)

1. This Control is provided to ensure that the concentration of radioactive materials released in liquid waste effluents to UNRESTRICTED AREAS will be less than 10 times the EFFLUENT CONCENTRATION values specified in Appendix B, Table 2, Column 2 to 10 CFR 20. The Control provides operational flexibility for releasing liquid effluents in concentrations to follow the Section II.A and II.C design objectives of Appendix I to 10 CFR Part 50. This limitation provides reasonable assurance that the levels of radioactive materials in bodies of water in UNRESTRICTED AREAS will result in exposures within (1) the Section II.A design objectives of Appendix I, 10 CFR Part 50, to a MEMBER OF THE PUBLIC and (2) the restrictions authorized by 10 CFR Part 20.1301(e). The concentration limit for the dissolved or entrained noble gases is based upon the assumption that Xe-133 is the controlling radionuclide and its EFFLUENT CONCENTRATION in air (submersion) was converted to an equivalent concentration in water. This control does not affect the requirement to comply with the annual limitations of 10 CFR Part 20.1301(a).
2. This Control applies to the release of radioactive materials in liquid effluents from all units at the site.
3. The required detection capabilities for radioactive materials in liquid waste samples are tabulated in terms of the lower limits of detection (LLDs). Detailed discussion of the LLD and other detection limits can be found in Currie, L.A., "Lower Limit of Detection: Definition and Elaboration of a Proposed Position for Radiological Effluent and Environmental Measurements," NUREG/CR-4007 (September 1984), and in the HASL Procedures Manual, HASL-300 (revised annually).

4.4. DOSE FROM LIQUID EFFLUENTS (TRM 3.11.d)

1. This Control is provided to implement the requirements of Sections II.A, III.A and IV.A of Appendix I, 10 CFR Part 50. The Control statement implements the guides set forth in Section II.A of Appendix I. The Action statements provide the required operating flexibility and at the same time implement the guides set forth

in Section IV.A of Appendix I to assure that the releases of radioactive material in liquid effluents will be kept "as low as is reasonably achievable." Also, for fresh water sites with drinking water supplies that can be potentially affected by plant operations, there is reasonable assurance that the operation of the facility will not result in radionuclide concentrations in the finished drinking water that are in excess of the requirements of 40 CFR Part 141. The dose calculation methodology and parameters in the ODCM implement the requirements in Section III.A of Appendix I that conformance with the guides of Appendix I be shown by calculational procedures based on models and data, such that the actual exposure of a MEMBER OF THE PUBLIC through appropriate pathways is unlikely to be substantially underestimated. The equations specified in the ODCM for calculating the doses due to the actual release rates of radioactive materials in liquid effluents are consistent with the methodology provided in Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," Revision 1, October 1977 and Regulatory Guide 1.113, "Estimating Aquatic Dispersion of Effluents from Accidental and Routine Reactor Releases for the Purpose of Implementing Appendix I," April 1977.

2. This Control applies to the release of liquid effluents from each reactor at the site. For units with shared radwaste treatment systems, the liquid effluents from the shared system are proportioned among the units sharing that system.

4.5. LIQUID RADWASTE TREATMENT SYSTEM (TRM 3.11.e)

1. The OPERABILITY of the Liquid Radwaste Treatment System ensures that this system will be available for use whenever liquid effluents require treatment prior to release to the environment. The requirement that the appropriate portions of this system be used, when specified, provides assurance that the releases of radioactive materials in liquid effluents will be kept "as low as is reasonably achievable". This Control implements the requirements of 10 CFR Part 50.36a, General Design Criterion 60 of Appendix A to 10 CFR Part 50 and the design objective given in Section II.D of Appendix I to 10 CFR part 50. The specified limits governing the use of appropriate portions of the liquid radwaste treatment system were specified as a suitable fraction of the dose design objectives set forth in Section II.A of Appendix I, 10 CFR Part 50, for liquid effluents.
2. This Control applies to the release of liquid effluents from each reactor at the site. For units with shared radwaste treatment systems, the liquid effluents from the shared system are proportioned among the units sharing that system.

4.6. DOSE RATE FOR GASEOUS EFFLUENT (TRM 3.11.f)

1. This Control provides reasonable assurance that radioactive material discharged in gaseous effluents will not result in the exposure of a MEMBER OF THE PUBLIC in an UNRESTRICTED AREA, either at or beyond the SITE BOUNDARY in excess of the design objectives of Appendix I to 10 CFR Part 50. This Control is provided to ensure that gaseous effluents from all units on the site will be appropriately controlled. It provides operational flexibility for releasing gaseous effluents to satisfy the Section II.A and II.C design objectives of Appendix I to 10 CFR Part 50. For MEMBERS OF THE PUBLIC who may at times be within the SITE BOUNDARY, the occupancy of that MEMBER OF THE PUBLIC will usually be sufficiently low to compensate for the reduced atmospheric dispersion of gaseous effluents relative to that for the SITE BOUNDARY. Examples of calculations for such MEMBERS OF THE PUBLIC, with the appropriate occupancy factors, shall be given in the ODCM. The specified release rate limits restrict, at all times, the corresponding dose rates above background to a MEMBER OF THE PUBLIC at or beyond the SITE BOUNDARY to less than or equal to 500 mrem/year to the total body or to less than or equal to 3000 mrem/year to the skin. These release rate limits also restrict, at all times, the corresponding thyroid dose rate above background to a child via the inhalation pathway to less than or equal to 1500 mrem/year. This Control does not affect the requirement to comply with the annual limitations of 10 CFR 20.1301(a).
2. This Control applies to the release of gaseous effluents from all units at the site.

3. The required detection capabilities for radioactive materials in gaseous waste samples are tabulated in terms of the lower limits of detection (LLDs). Detailed discussion of the LLD and other detection limits can be found in Currie, L.A., "Lower Limit of Detection: Definition and Elaboration of a Proposed Position for Radiological Effluent and Environmental Measurements," NUREG/CR-4007 (September 1984), and in the HASL Procedures Manual, HASL-300 (revised annually).
- 4.7. DOSE - NOBLE GASES (TRM 3.11.g)
1. This Control is provided to implement the requirements of Sections II.B, III.A and IV.A of Appendix I, 10 CFR Part 50. The Control statements implement the guides set forth in Section II.B of Appendix I. The Action statements provide the required operating flexibility and at the same time implement the guides set forth in Section IV.A of Appendix I to assure that the releases of radioactive material in gaseous effluents will be kept "as low as is reasonably achievable." The Surveillance Requirements implement the requirements in Section III.A of Appendix I that conformance with the guides of Appendix I be shown by calculational procedures based on models and data such that the actual exposure of a MEMBER OF THE PUBLIC through appropriate pathways is unlikely to be substantially underestimated.
 2. The dose calculation methodology and parameters established in the ODCM for calculating the doses due to the actual release rates of radioactive noble gases in gaseous effluents are consistent with the methodology provided in Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," Revision 1, October 1977 and Regulatory Guide 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water Cooled Reactors," Revision 1, July 1977. The ODCM equations provided for determining the air doses at and beyond the SITE BOUNDARY are based upon the historical average atmospheric conditions.
 3. This Control applies to the release of gaseous effluents from each reactor at the site. For units with shared radwaste treatment systems, the gaseous effluents from the shared system are proportioned among the units sharing that system.

4.8. DOSE - IODINE-131, TRITIUM, AND RADIOACTIVE MATERIAL IN PARTICULATE FORM (TRM 3.11.h)

1. This Control is provided to implement the requirements of Sections II.C, III.A and IV.A of Appendix I, 10 CFR Part 50. The Controls are the guides set forth in Section II.C of Appendix I. The Action statements provide the required operating flexibility and at the same time implement the guides set forth in Section IV.A of Appendix I to assure that the releases of radioactive materials in gaseous effluents will be kept "as low as is reasonably achievable." The ODCM calculational methods specified in the Surveillance Requirements implement the requirements in Section III.A of Appendix I that conformance with the guides of Appendix I be shown by calculational procedures based on models and data, such that the actual exposure of a MEMBER OF THE PUBLIC through appropriate pathways is unlikely to be substantially underestimated.
2. The ODCM calculational methodology and parameters for calculating the doses due to the actual release rates of the subject materials are consistent with the methodology provided in Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," Revision 1, October 1977 and Regulatory Guide 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors," Revision 1, July 1977. These equations also provide for determining the actual doses based upon the historical average atmospheric conditions. The release rate controls for Iodine-131, Tritium, and radionuclides in particulate form with half-lives greater than 8 days are dependent upon the existing radionuclide pathways to man, in the areas at and beyond the SITE BOUNDARY. The pathways that were examined in the development of these calculations were: 1) individual inhalation of airborne radionuclides, 2) deposition of radionuclides onto green leafy vegetation with subsequent consumption by man, 3) deposition onto grassy areas where milk animals and meat producing animals graze with consumption of the milk and meat by man, and 4) deposition on the ground with subsequent exposure of man.
3. This Control applies to the release of gaseous effluents from each reactor at the site. For units with shared radwaste treatment systems, the gaseous effluents from the shared systems are proportioned among the units sharing that system.

4.9. GASEOUS RADWASTE TREATMENT SYSTEM (TRM 3.11.i)

1. The OPERABILITY of the Gaseous Radwaste Treatment System ensures that the system will be available for use whenever gaseous effluents require treatment prior to release of the environment. The requirement that the appropriate portions of these systems be used, when specified, provides reasonable assurance that the release of radioactive materials in gaseous effluents will be kept "as low as is reasonably achievable." This Control implements the requirements of 10 CFR Part 50.36a, General Design Criterion 60 of Appendix A to 10 CFR Part 50, and the design objectives given in Section II.D of Appendix I to 10 CFR Part 50.
2. The specified limits governing the use of appropriate portions of the systems were specified as a suitable fraction of the dose design objectives set forth in Sections II.B and II.C of Appendix I, 10 CFR Part 50, for gaseous effluents.
3. This Control applies to the release of gaseous effluents from each reactor at the site. For units with shared radwaste treatment systems, the gaseous effluents from the shared systems are proportioned among the units sharing that system.

4.10. TOTAL DOSE (TRM 3.11.k)

1. This Control is provided to meet the dose limitations of 40 CFR Part 190 that have been incorporated into 10 CFR Part 20.1301(d). The Control requires the preparation and submittal of a Special Report whenever the calculated doses due to releases of radioactivity and to radiation from uranium fuel cycle sources exceed 25 mremS to the total body or any organ, except the thyroid, which shall be limited to less than or equal to 75 mremS.
2. For sites containing up to 4 reactors, it is highly unlikely that the resultant dose to a MEMBER OF THE PUBLIC will exceed the dose limits of 40 CFR Part 190 if the individual reactors remain within twice the dose design objectives of Appendix I, and if direct radiation doses from the reactor units and outside storage tanks, etc., are kept small. The Special Report will describe a course of action that should result in the limitation of the annual dose to a MEMBER OF THE PUBLIC to within the 40 CFR Part 190 limits. For the purposes of the Special Report, it may be assumed that the dose commitment to the MEMBER OF THE PUBLIC from other uranium fuel cycle sources is negligible, with the exception that dose contributions from other nuclear fuel cycle facilities at the same site or within a radius of 8 km must be considered. If the dose to any MEMBER OF THE PUBLIC is estimated to exceed the requirements of 40 CFR Part 190, submittal of the Special Report within 30 days with a request for a variance (provided the release conditions resulting in violation of 40 CFR Part 190 have not already been corrected), in accordance with the provisions of 40 CFR Part 190.11 and 10 CFR Part 20.2203(a)(4), is considered to be a timely request and fulfills the requirements of 40 CFR Part 190 until NRC staff action is completed.

3. Demonstration of compliance with the limits of 40 CFR Part 190 or with the design objectives of Appendix I to 10 CFR Part 50 will be considered to demonstrate compliance with the 0.1 rem limit of 10 CFR Part 20.1301.
- 4.11. RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM (TRM 3.12)
1. The Radiological Environmental Monitoring Program required by this Control provides representative measurements of radiation and of radioactive materials in those exposure pathways and for those radionuclides that lead to the highest potential radiation exposures of MEMBERS OF THE PUBLIC resulting from the station operation.
 2. This monitoring program implements Section IV.B.2 of Appendix I to 10 CFR Part 50 and thereby supplements the Radiological Effluent Monitoring Program by verifying that the measurable concentrations of radioactive materials and levels of radiation are not higher than expected on the basis of the effluent measurements and the modeling of the environmental exposure pathways. Isotopes identified in REMP are compared to those identified in the applicable Annual Effluent Report. Program changes may be initiated based on these operational experiences.
 3. The required detection capabilities for environmental sample analyses are tabulated in terms of the lower limits of detection (LLDs). The LLDs required by Table T3.12.a-3 are considered optimum for routine environmental measurements in industrial laboratories. It should be recognized that the LLD is defined as an a priori (before the fact) limit representing the capability of a measurement system and not as an a posteriori (after the fact) limit for a particular measurement.
 4. Detailed discussion of the LLD and other detection limits can be found in Currie, L.A., "Lower Limit of Detection: Definition and Elaboration of a Proposed Position for Radiological Effluent and Environmental Measurements," NUREG/CR-4007 (September 1984), and in the HASL Procedures Manual, HASL-300 (revised annually).

4.12. LAND USE CENSUS (TRM 3.12.b)

1. This Control is provided to ensure that changes in the use of areas at and beyond the SITE BOUNDARY are identified and that modifications to the Radiological Environmental Monitoring Program are made if required by the results of this census. The best information from the door-to-door survey, from aerial survey or from consulting with local agricultural authorities shall be used. This census satisfies the requirements of Section IV.B.3 of Appendix I to 10 CFR Part 50. Restricting the census to gardens of greater than 50 m² provides assurance that significant exposure pathways via leafy vegetables will be identified and monitored since a garden of this size is the minimum required to produce the quantity (26 kg/year) of leafy vegetables assumed in Regulatory Guide 1.109 for consumption by a child. To determine this minimum garden size, the following assumptions were made: 1) 20% of the garden was used for growing broad leaf vegetation (i.e., similar to lettuce and cabbage), and 2) a vegetation yield of 2 kg/m².

4.13. INTERLABORATORY COMPARISON PROGRAM (TRM 3.12.c)

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

5. **ADMINISTRATIVE REQUIREMENTS**

5.1. Annual Radiological Environmental Operating Report*

1. Routine Annual Radiological Environmental Operating Report covering the operation of the Unit(s) during the previous calendar year shall be submitted prior to May 15 of each year.
2. The Annual Radiological Environmental Operating Report shall include summaries, interpretations, and an analysis of trends of the results of the radiological environmental surveillance activities for the report period, including a comparison with operational controls as appropriate, and with previous environmental surveillance reports, and an assessment of the observed impacts of the plant operation on the environment.
3. The Annual Radiological Environmental Operating Report shall include the results of all radiological environmental samples and of all environmental radiation measurements taken during the period pursuant to the locations specified in the tables and figures in Part 2 Section 6 of the ODCM, as well as summarized and tabulated results of these analyses and measurements in the format of the table in the Radiological Assessment Branch Technical Position, Revision 1, November 1979.
4. In the event that some individual results are not available for inclusion with the report, 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.
5. The reports shall also include the following: a summary description of the Radiological Environmental Monitoring Program; legible maps covering all sampling locations keyed to a table giving distances and directions from the midpoint between the two units; reasons for not conducting the Radiological Environmental Monitoring Program as required by TLCO 3.12.a, a Table of Missed Samples and a Table of Sample Anomalies for all deviations from the sampling schedule of TRM Table T3.12.a-1; discussion of environmental sample measurements that exceed the reporting levels of TRM Table T3.12.a-2 but are not the result of plant effluents, discussion of all analyses in which the LLD required by TRM Table T3.12.a-3 was not achievable; result of the Land Use Census required by TRM TLCO 3.12.b; and the results of the licensee participation in an Interlaboratory Comparison Program and the corrective actions being taken if the specified program is not being performed as required by TRM TLCO 3.12.c.

6. The Annual Radiological Environmental Operating Report shall also include an annual summary of hourly meteorological data collected over the applicable year. This annual summary may be either in the form of an hour-by-hour listing on magnetic tape of wind speed, wind direction, atmospheric stability, and precipitation (if measured), or in the form of joint frequency distributions of wind speed, wind direction, and atmospheric stability. In lieu of submission with the Annual Radiological Environmental Operating Report, the licensee has the option of retaining this summary of required meteorological data on site in a file that shall be provided to the NRC upon request.
7. The Annual Radiological Environmental Operating Report shall also include an assessment of the radiation doses due to the radioactive liquid and gaseous effluents released from the Unit or Station during the previous calendar year. This report shall also include an assessment of the radiation doses to the most likely exposed MEMBER OF THE PUBLIC from reactor releases and other near-by uranium fuel cycle sources including doses from primary effluent pathways and direct radiation, for the previous calendar year. The assessment of radiation doses shall be performed in accordance with the methodology and parameters in the ODCM, and in compliance with 10CFR20 and 40 CFR Part 190, "Environmental Radiation Protection Standards for Nuclear Power Operation."

*A single submittal may be made for a multiple unit station.

5.2. Annual Radioactive Effluent Release Report**

1. Routine Annual Radioactive Effluent Release Reports covering the operation of the unit during the previous calendar year of operation shall be submitted prior to May 1 of the following year.
2. The Annual Radioactive Effluent Release Reports shall include a summary of the quantities of radioactive liquid and gaseous effluents and solid waste released from the unit as outlined in Regulatory Guide 1.21, "Measuring Evaluating, and Reporting Radioactivity in Solid Wastes and Releases of Radioactive Materials in Liquid and Gaseous Effluents from Light-Water-Cooled Nuclear Power Plants," Revision 1, June 1974, with data summarized on a quarterly basis following the format of Appendix B thereof.
3. For solid wastes, the format for Table 3 in Appendix B of the report shall be supplemented with three additional categories: class of solid wastes (as defined by 10 CFR Part 61), type of container (e.g., LSA, Type A, Type B, Large Quantity), and SOLIDIFICATION agent or absorbent (e.g., cement, urea formaldehyde).
The Annual Radioactive Effluent Release Reports shall include a list and description of unplanned releases from the site to UNRESTRICTED AREAS of radioactive materials in gaseous and liquid effluents made during the reporting period.
4. The Annual Radioactive Effluent Release Reports shall include any changes made during the reporting period to the PCP as well as any major changes to Liquid, Gaseous or Solid Radwaste Treatment Systems, pursuant to Part 1 Section 5.4.
5. The Annual Radioactive Effluent Release Reports shall also include the following: an explanation as to why the inoperability of liquid or gaseous effluent monitoring instrumentation was not corrected within the time specified in TRM TLCO 3.11.a or TLCO 3.11.b, respectively; and description of the events leading to liquid holdup tanks or gas storage tanks exceeding the limits of TS 5.5.12.

** A single submittal may be made for a multiple unit station. The submittal should combine those sections that are common to all units at the station; however, for units with separate radwaste systems, the submittal shall specify the releases of radioactive material from each unit.

5.3. ODCM

5.3.1. The ODCM shall be submitted to the Commission following proper approval through station processes.

5.3.2. Licensee-initiated changes to the ODCM:

1. Shall be documented and records of reviews performed shall be retained as required by UFSAR Chapter 17. This documentation shall contain:
 - A. Sufficient information to support the change together with the appropriate analyses or evaluations justifying the changes(s); and
 - B. A determination that the change will maintain the level of radioactive effluent control required by 10 CFR Part 20, 40 CFR Part 190, 10 CFR 50.36a, and Appendix I to 10 CFR Part 50 and not adversely impact the accuracy or reliability of effluent, dose, or setpoint calculations.
2. Shall become effective after review and acceptance by the Independent Technical Review and PORC and the approval of the Plant Manager on the date specified by the Independent Technical Review and PORC.
3. Shall be submitted to the Commission in the form of the complete, legible copy of the entire ODCM, or updated pages if the Commission retains a controlled copy. If an entire copy of the ODCM is submitted, it shall be submitted as a part of or concurrent with the Annual Radioactive Effluent Release Report for the period of the report in which any change to the ODCM was made effective. 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 (eg. month/year) the change was implemented.

- 5.4. Major Changes to Liquid and Gaseous Radwaste Treatment Systems***
- 5.4.1. Licensee-initiated major changes to the Radwaste Treatment Systems (liquid and gaseous):
1. Shall be reported to the Commission in the Annual Radioactive Effluent Release Report for the period in which the evaluation was reviewed by the Independent Technical Review and PORC. The discussion of each change shall contain:
 - A. A summary of the evaluation that led to the determination that the change could be made in accordance with 10 CFR 50.59;
 - B. Sufficient detailed information to totally support the reason for the change without benefit of additional and supplemental information;
 - C. A detailed description of the equipment, components, and processes involved and the interfaces with other plant systems.
 - D. An evaluation of the change which shows the predicted releases of radioactive materials in liquid and gaseous effluents that differ from those previously predicted in the License application and amendments thereto;
 - E. An evaluation of the change, which shows the expected maximum exposures to a MEMBER OF THE PUBLIC in the UNRESTRICTED AREA and to the general population that differ from those previously estimated in the License application and amendments thereto;
 - F. A comparison of the predicted releases of radioactive materials, in liquid and gaseous effluents, to the actual releases for the period prior to when the changes are to be made;
 - G. An estimate of the exposure to plant operating personnel as a result of the change; and
 - H. Documentation of the fact that the change was reviewed and found acceptable by the Independent Technical Review and PORC.
 2. Shall become effective upon review and acceptance by the Independent Technical Review and PORC.

***Licensees may choose to submit the information called for in this standard as part of the bi-annual FSAR update.

Part 2 – ODCM

1. INTRODUCTION - ODCM GENERAL INFORMATION

1. The Offsite Dose Calculation Manual (ODCM) presents a discussion of the following:
 - A. The basic concepts applied in calculating offsite doses from plant effluents.
 - B. The regulations and requirements for the ODCM and related programs.
 - C. The methodology and parameters for the offsite dose calculations to assess impact on the environment and compliance with regulations.
2. The methodology detailed in this manual is intended for the calculation of radiation doses during routine (i.e., non-accident) conditions. The calculations are normally performed using a computer program. Manual calculations may be performed in lieu of the computer program.
3. The dose effects of airborne radioactivity releases predominately depend on meteorological conditions (wind speed, wind direction, and atmospheric stability). For airborne effluents, the dose calculations prescribed in this manual are based on historical average atmospheric conditions. This methodology is appropriate for estimating annual average dose effects and is stipulated in the Bases Section of the Radiological Effluents (RE).
- 1.1. Structure of the ODCM
 - 1.1.1. Part 1 of the ODCM is considered to be the Radiological Effluents (RE), and contains the former Radiological Effluent Technical Specifications that have been removed from the Technical Specifications. Part 1 is organized as follows:
 1. Definitions
 2. Radiological Effluents and Radiological Environmental Monitoring Program
 3. Meteorological Monitoring Program
 4. Bases
 5. Administrative Requirements

1.1.2. Part 2 of the ODCM is considered to be the Offsite Dose Calculation Manual (ODCM), and contains methods, equations, assumptions, and parameters for calculation of radiation doses from plant effluents. Part 2 is organized as follows:

1. Introduction
2. Instrumentation and Systems
3. Liquid Effluents
4. Gaseous Effluents
5. Total Dose
6. Radiological Environmental Monitoring Program

1.2. Regulations

1. This section serves to illustrate the regulations and requirements that define and are applicable to the ODCM. Any information provided in the ODCM concerning specific regulations are not a substitute for the regulations as found in the Code of Federal Regulations (CFR) or Technical Specifications.

1.2.1. Code of Federal Regulations

1. Various sections of the Code of Federal Regulations (CFR) require nuclear power stations to be designed and operated in a manner that limits the radiation exposure to members of the public. These sections specify limits on offsite radiation doses and on effluent radioactivity concentrations and they also require releases of radioactivity to be "As Low As Reasonably Achievable". These requirements are contained in 10CFR20, 10CFR50 and 40CFR190. In addition, 40CFR141 imposes limits on the concentration of radioactivity in drinking water provided by the operators of public water systems.

A. 10CFR20, Standards for Protection Against Radiation

1. This revision of the ODCM addresses the requirements of 10CFR20. The 10CFR20 dose limits are summarized in Table 1-1.

B. Design Criteria (Appendix A of 10CFR50)

1. Section 50.36 of 10CFR50 requires that an application for an operating license include proposed Technical Specifications. Final Technical Specifications for each station are developed through negotiation between the applicant and the NRC. The Technical Specifications are then issued as a part of the operating license, and the licensee is required to operate the facility in accordance with them.
2. Section 50.34 of 10CFR50 states that an application for a license must state the principal design criteria of the facility. Minimum requirements are contained in Appendix A of 10CFR50.

C. ALARA Provisions (Appendix I of 10CFR50)

1. Sections 50.34a and 50.36a of 10CFR50 require that the nuclear plant design and the station RE have provisions to keep levels of radioactive materials in effluents to unrestricted areas "As Low As Reasonably Achievable" (ALARA). Although 10CFR50 does not impose specific limits on releases, Appendix I of 10CFR50 does provide numerical design objectives and suggested limiting conditions for operation. According to Section I of Appendix I of 10CFR50, design objectives and limiting conditions for operation, conforming to the guidelines of Appendix I "shall be deemed a conclusive showing of compliance with the "As Low As Reasonably Achievable" requirements of 10CFR50.34a and 50.36a."

An applicant must use calculations to demonstrate conformance with the design objective dose limits of Appendix I. The calculations are to be based on models and data such that the actual radiation exposure of an individual is "unlikely to be substantially underestimated" (see 10CFR50 Appendix I, Section III.A.1).

The guidelines in Appendix I call for an investigation, corrective action and a report to the NRC whenever the calculated dose due to the radioactivity released in a calendar quarter exceeds one-half of an annual design objective. The guidelines also require a surveillance program to monitor releases, monitor the environment and identify changes in land use.

D. 40CFR190, Environmental Radiation Protection Standards for Nuclear Power Operations

1. Under an agreement between the NRC and the EPA, the NRC stipulated to its licensees in Generic Letter 79-041 that "Compliance with Radiological Effluent Technical Specifications (RETS), NUREG-0472 (Rev.2) for PWR's, implements the LWR provisions to meet 40CFR190". (See References 49 and 103.)
2. The regulations of 40CFR190 limit radiation doses received by members of the public as a result of operations that are part of the uranium fuel cycle. Operations must be conducted in such a manner as to provide reasonable assurance that the annual dose equivalent to any member of the public due to radiation and to planned discharges of radioactive materials does not exceed the following limits:
 - 25 mrem to the total body
 - 75 mrem to the thyroid
 - 25 mrem to any other organ
3. An important difference between the design objectives of 10CFR50 and the limits of 40CFR190 is that 10CFR50 addresses only doses due to radioactive effluents. 40CFR190 limits doses due to effluents and to radiation sources maintained on site. See Section 1.2.4 for further discussion of the differences between the requirements of 10CFR50 Appendix I and 40CFR190.

E. 40CFR141, National Primary Drinking Water Regulations

1. The following radioactivity limits for community water systems were established in the July, 1976 Edition of 40CFR141:
 - Combined Ra-226 and Ra-228: ≤ 5 pCi/L.
 - Gross alpha (particle activity including Ra-226 but excluding radon and uranium): ≤ 15 pCi/L.
 - The average annual concentration of beta particle and photon radioactivity from man-made radionuclides in drinking water shall not produce an annual dose equivalent to the total body or any internal organ greater than 4 mrem/yr.

2. The regulations specify procedures for determining the values of annual average radionuclide concentration that produce an annual dose equivalent of 4 mrem. Radiochemical analysis methods are also specified. The responsibility for monitoring radioactivity in a community water system falls on the supplier of the water. The Byron Station has requirements related to 40CFR141 in the RECS.

- F. 10CFR72.104 states that annual dose to any real individual located beyond the controlled area must not exceed the following:

- 25 mrem to the total body
- 75 mrem to the thyroid
- 25 mrem to any other critical organ

1. as a result of planned discharges of radioactive material to the environment, direct radiation from ISFSI operation, and other radiation from uranium fuel cycle operation (40CFR190). These requirements are consistent with the requirements of 40CFR190.

1.2.2. Radiological Effluent Technical Standards

1. The Radiological Effluent Technical Standards (RETS) were formerly a subset of the Technical Specifications. They implement provisions of the Code of Federal Regulations aimed at limiting offsite radiation dose. The NRC published Standard RETS for PWRs (Reference 2) as guidance to assist in the development of technical specifications. These documents have undergone frequent minor revisions to reflect changes in plant design and evolving regulatory concerns. The RETS have been removed from the Technical Specifications and placed in the TRM as the Radiological Effluents (RE) (see Reference 90). The RE are similar but not identical to the guidance of the Standard Radiological Effluent Technical Specifications.

1.2.3. Offsite Dose Calculation Manual

1. The NRC in Generic Letter 89-01 defines the ODCM as follows (not verbatim) (see Reference 90):
 - A. The Offsite Dose Calculation Manual (ODCM) shall contain the methodology and parameters used in the calculation of offsite doses resulting from radioactive gaseous and liquid effluents, in the calculation of gaseous and liquid effluent monitoring Alarm/Trip Setpoints, and in the conduct of the Radiological Environmental Monitoring Program. The ODCM shall also contain (1) the Radioactive Effluent Controls and Radiological Environmental Monitoring Programs and (2) descriptions of the Information that should be included in the Annual Radiological Environmental Operating and Annual Radioactive Effluent Release Reports.
2. Additional requirements for the content of the ODCM are contained throughout the text of the RECS.

1.2.4. Overlapping Requirements

1. In 10CFR20, 10CFR50 and 40CFR190, there are overlapping requirements regarding offsite radiation dose and dose commitment to the total body. In 10CFR20.1301, the total effective dose equivalent (TEDE) to a member of the public is limited to 100 mrem per calendar year. In addition, Appendix I to 10CFR50 establishes design objectives on annual total body dose or dose commitment of 3 mrem per reactor for liquid effluents and 5 mrem per reactor for gaseous effluents (see 10CFR50 Appendix I, Sections II.A and II.B.2(a)). Finally, 40CFR190 limits annual total body dose or dose commitment to a member of the public to 25 mrem due to all uranium fuel cycle operations.
2. While these dose limits/design objectives appear to overlap, they are different and each is addressed separately by the RE. Calculations are made and reports are generated to demonstrate compliance to all regulations. Refer to Table 1-1 and Table 1-2 for additional information regarding instantaneous effluent limits, design objectives and regulatory compliance.

1.2.5. Dose Receiver Methodology

1. Table 1-2 lists the location of the dose recipient and occupancy factors, if applicable. Dose is assessed at the location in the unrestricted area where the combination of existing pathways and receptor age groups indicates the maximum potential exposures. The dose calculation methodology is consistent with the methodology of Regulatory Guide 1.109 (Reference 6) and NUREG 0133 (Reference 14). Dose is therefore calculated to a maximum individual. The maximum individual is characterized as "maximum" with regard to food consumption, occupancy and other usage of the area in the vicinity of the plant site. Such a "maximum individual" represents reasonable deviation from the average for the population in general. In all physiological and metabolic respects, the maximum individual is assumed to have those characteristics that represent averages for their corresponding age group. Thus, the dose calculated is very conservative compared to the "average" (or typical) dose recipient who does not go out of the way to maximize radioactivity uptakes and exposure.

Table 1 - 1
Regulatory Dose Limit Matrix

REGULATION	DOSE TYPE		DOSE LIMIT(s)		TRM Section
Airborne Releases:			(quarterly)	(annual)	
10CFR50 App. I ³	Gamma Dose to Air due to Noble Gas Radionuclides (per reactor unit)		5 mrad	10 mrad	3.11.g
	Beta Dose to Air Due to Noble Gas Radionuclides (per reactor unit)		10 mrad	20 mrad	3.11.g
	Organ Dose Due to Specified Non-Noble Gas Radionuclides (per reactor unit)		7.5 mrem	15 mrem	3.11.h
	Total Body and Skin Dose (if air dose is exceeded)	Total Body	2.5 mrem	5 mrem	N/A
		Skin	7.5 mrem	15 mrem	N/A
Technical Specifications	Total Body Dose Rate Due to Noble Gas Radionuclides (instantaneous limit, per site)		500 mrem/yr		3.11.f
	Skin Dose Rate Due to Noble Gas Radionuclides (instantaneous limit, per site)		3,000 mrem/yr		3.11.f
	Organ Dose Rate Due to Specified Non-Noble Gas Radionuclides (instantaneous limit, per site)		1,500 mrem/yr		3.11.f
Liquid Releases:			(quarterly)	(annual)	
10CFR50 App. I ³	Whole (Total) Body Dose (per reactor unit)		1.5 mrem	3 mrem	3.11.d
	Organ Dose (per reactor unit)		5 mrem	10 mrem	3.11.d
Technical Specifications	The concentration of radioactivity in liquid effluents released to unrestricted areas		Ten times the values listed in 10CFR20 Appendix B; Table 2, Column 2, and note 5 below for Noble Gases		3.11.c
Total Doses ¹ :					ODCM PART 2
10 CFR 20.1301 (a)(1)	Total Effective Dose Equivalent ⁴		100 mrem/yr		5.5
10CFR20.1301 (d) And 40CFR190	Total Body Dose		25 mrem/yr		5.5
	Thyroid Dose		75 mrem/yr		5.5
	Other Organ Dose		25 mrem/yr		5.5
Other Limits ² :					
40CFR141	Total Body Dose Due to Drinking Water From Public Water Systems		4 mrem/yr		3.4
	Organ Dose Due to Drinking Water From Public Water Systems		4 mrem/yr		3.4

¹ These doses are calculated considering all sources of radiation and radioactivity in effluents.

² These limits are not directly applicable to nuclear power stations. They are applicable to the owners or operators of public water systems. However, the Byron RECS requires assessment of compliance with these limits.

³ Note that 10CFR50 provides design objectives, not limits.

⁴ Compliance with 10CFR20.1301(a)(1) is demonstrated by compliance with 40CFR190. Note that it may be necessary to address dose from on-site activity by members of the public as well.

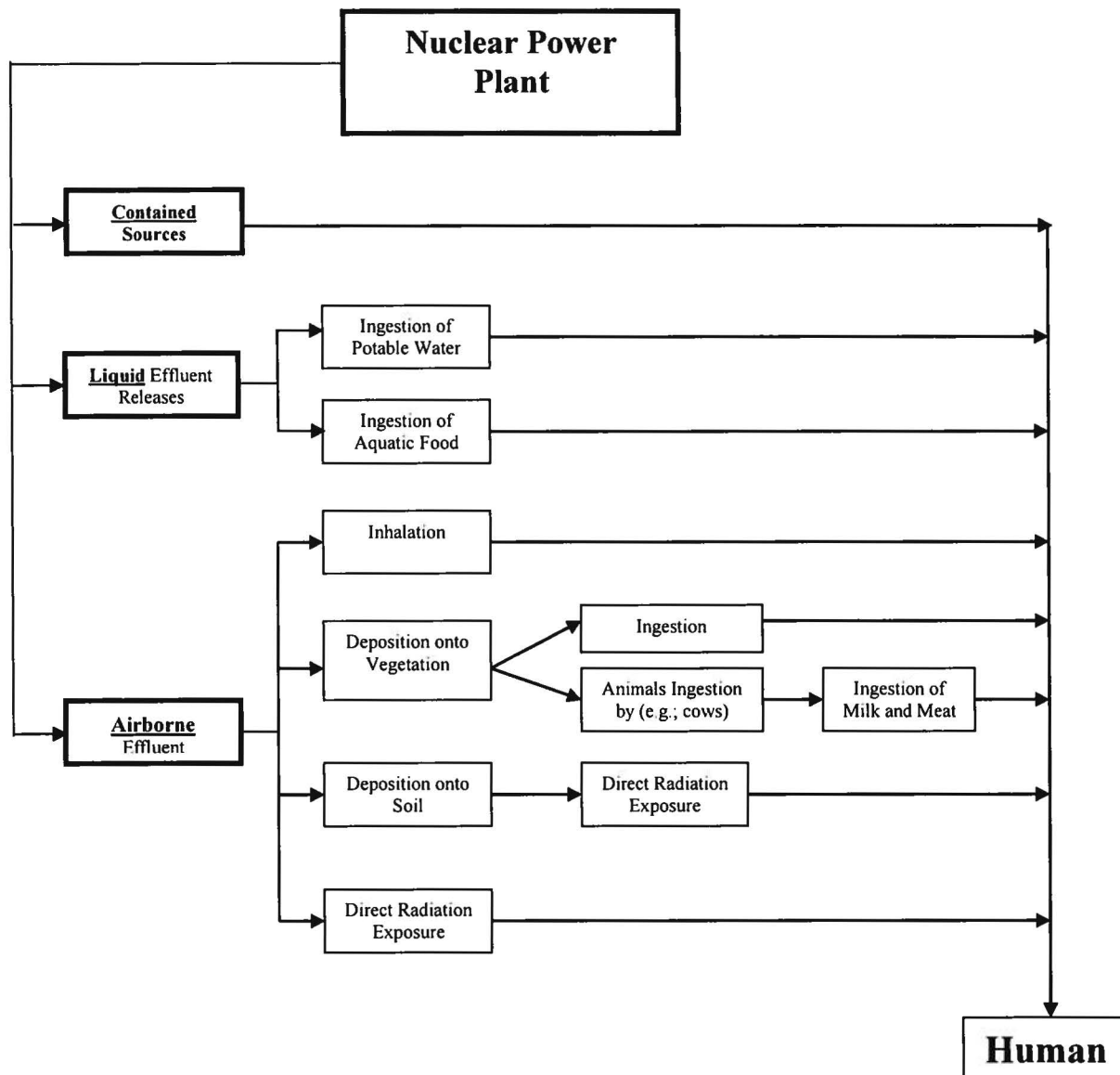
⁵ Kr-85m, Kr-85, Kr-87, Kr-88, Ar-41, Xe-131m, Xe-133m, Xe-133, Xe-135m and Xe-135 allowable concentration is 2E-4 $\mu\text{Ci/ml}$ computed from Equation 17 of ICRP Publication 2 adjusted for infinite cloud submersion in water, and $R = 0.01 \text{ rem/wk}$, $\rho_w = 1.0 \text{ g/cm}^3$, and $P_w/P_t = 1.0$.

Table 1 - 2
Dose Assessment Receivers

Dose Component or Pathway	Location; Occupancy if Different than 100%
"Instantaneous" dose rates from airborne radioactivity	Unrestricted area boundary location that results in the maximum dose rate
"Instantaneous" concentration limits in liquid effluents	Point where liquid effluents enter the unrestricted area
Annual average concentration limits for liquid effluents	Point where liquid effluents enter the unrestricted area
Direct dose from contained sources	Receiver spends part of this time in the controlled area and the remainder at his residence or fishing nearby; occupancy factor is considered and is site-specific.
Direct dose from airborne plume	Receiver is at the unrestricted area boundary location that results in the maximum dose.
Dose due to radioiodines, tritium and particulates with half-lives greater than 8 days for inhalation, ingestion of vegetation, milk and meat, and ground plane exposure pathways.	Receiver is at the location in the unrestricted area where the combination of existing pathways and receptor age groups indicates the highest potential exposures.
Ingestion dose from drinking water	The drinking water pathway is considered as an additive dose component in this assessment only if the public water supply serves the community immediately adjacent to the plant.
Ingestion dose from eating fish	The receiver eats fish from the receiving body of water
Total Organ Doses	Summation of ingestion/inhalation doses
Total Dose	Summation of above data (Note it may also be necessary to address dose from on-site activity by members of the public.)

Figure 1-1 illustrates some of the potential radiation exposure pathways to humans due to routine operation of a nuclear power station.

Figure 1 - 1
Radiation Exposure Pathways to Humans



1.3. Offsite Dose Calculation Parameters

1. This section contains offsite dose calculation parameter factors, or values not specific only to one of the gas, liquid, or total dose chapters. Additional parameters are provided in the Sections 2, 4 and 5 of the ODCM.
2. 10CFR50 Dose Commitment Factors
 - A. With the exception of H-3, the dose commitment factors for 10CFR50 related calculations are exactly those provided in Regulatory Guide 1.109 (Reference 6). The following table lists the parameters and the corresponding data tables in the RG 1.109:

<u>PATHWAY</u>	<u>ADULT</u>	<u>TEENAGER</u>	<u>CHILD</u>	<u>INFANT</u>
Inhalation	RG 1.109: Table E-7	RG 1.109: Table E-8	RG 1.109: Table E-9	RG 1.109: Table E-10
Ingestion	RG 1.109: Table E-11	RG 1.109: Table E-12	RG 1.109: Table E-13	RG 1.109: Table E-14

- B. These tables are contained in Regulatory Guide 1.109 (Reference 6). Each table (E-7 through E-14) provides dose factors for seven organs for each of 73 radionuclides, and Table E-5 lists Miscellaneous Dose Assessment Factors - Consumption Parameters. For radionuclides not found in these tables, dose factors will be derived from ICRP 2 (Reference 50) or NUREG-0172 (Reference 51). The values for H-3 are taken from NUREG-4013 (Reference 107).

1.4. References

2. U.S. Nuclear Regulatory Commission, Standard Radiological Effluent Technical Specifications for Pressurized Water Reactors, NUREG-0472, Rev. 3, Draft, January 1983 (frequently revised).
4. U.S. Nuclear Regulatory Commission, Measuring, Evaluating, and Reporting Radioactivity in Solid Wastes and Releases of Radioactive Materials in Liquid and Gaseous Effluents from Light-Water-Cooled Nuclear Power Plants, Regulatory Guide 1.21. Revision 1, June 1974.
5. U.S. Nuclear Regulatory Commission, Meteorological Monitoring Programs for Nuclear Power Plants, Regulatory Guide 1.23, Rev. 1, March 2007.

6. U.S. Nuclear Regulatory Commission, Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50 Appendix I, Regulatory Guide 1.109, Rev. 1, October 1977.
7. U.S. Nuclear Regulatory Commission, Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors, Regulatory Guide 1.111, Rev. 1, July 1977.
8. U.S. Nuclear Regulatory Commission, Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Light-Water-Cooled Power Reactors, Regulatory Guide 1.112, Rev. 0-R, April 1976; reissued May 1977.
9. U.S. Nuclear Regulatory Commission, Estimating Aquatic Dispersion of Effluents from Accidental and Routine Reactor Releases for the Purpose of Implementing Appendix I, Regulatory Guide 1.113, Rev. 1, April 1977.
10. U.S. Nuclear Regulatory Commission, Programs for Monitoring Radioactivity in the Environs of Nuclear Power Plants, Regulatory Guide 4.1, Rev. 1, April 1975.
11. U.S. Nuclear Regulatory Commission, Preparation of Environmental Reports for Nuclear Power Stations, Regulatory Guide 4.2, Rev. 2, July 1976.
12. U.S. Nuclear Regulatory Commission, Environmental Technical Specifications for Nuclear Power Plants, Regulatory Guide 4.8, Rev. 1, December 1975. (See also the related Radiological Assessment Branch Technical Position, Rev. 1, November 1979.)
13. U.S. Nuclear Regulatory Commission, Quality Assurance for Radiological Monitoring Programs (Normal Operations)--Effluent Streams and the Environment, Regulatory Guide 4.15, Rev. 1, February 1979.
14. U.S. Nuclear Regulatory Commission, Preparation of Radiological Effluent Technical Specifications for Nuclear Power Plants, edited by J. S. Boegli et al. NUREG-0133, October 1978.
15. U.S. Nuclear Regulatory Commission, XOQDOQ: Computer Program for the Meteorological Evaluation of Routine Effluent Releases at Nuclear Power Stations, J. F. Sagendorf et al. NUREG/CR-2919, PNL-4380, September 1982.
16. U.S. Nuclear Regulatory Commission, Radiological Assessment, edited by J. E. Till and H. R. Meyer, NUREG/CR-3332, ORNL-5968, September 1983.
17. U.S. Nuclear Regulatory Commission, Standard Review Plan, NUREG-0800, July 1981.
18. U.S. Atomic Energy Commission, Meteorology and Atomic Energy 1968, edited by D. H. Slade, TID-21940, July 1968.
19. U.S. Atomic Energy Commission, Plume Rise, G. A. Briggs, TID-25075, 1969.

20. U.S. Atomic Energy Commission, The Potential Radiological Implications of Nuclear Facilities in the Upper Mississippi River Basin in the Year 2000, WASH 1209, January 1973.
21. U.S. Atomic Energy Commission, HASL Procedures Manual, Health and Safety Laboratory, HASL-300 (revised annually).
22. U.S. Department of Energy, Models and Parameters for Environmental Radiological Assessments, edited by C. W. Miller, DOE/TIC-11468, 1984.
23. U.S. Department of Energy, Atmospheric Science and Power Production, edited by D. Randerson, DOE/TIC-27601, 1984.
24. U.S. Environmental Protection Agency, Workbook of Atmospheric Dispersion Estimates, D. B. Turner, Office of Air Programs Publication No. AP-26, 1970.
25. U.S. Environmental Protection Agency, 40CFR190 Environmental Radiation Protection Requirements for Normal Operations of Activities in the Uranium Fuel Cycle, Final Environmental Statement, EPA 520/4-76-016, November 1, 1976.
26. U.S. Environmental Protection Agency, Environmental Analysis of the Uranium Fuel Cycle, EPA-520/9-73-003-C, November 1973.
27. American Society of Mechanical Engineers, Recommended Guide for the Prediction of the Dispersion of Airborne Effluents, 1973.
28. Eisenbud, M., Environmental Radioactivity, 3rd Edition, (Academic Press, Orlando, FL, 1987).
29. Glasstone, S., and Jordan, W. H., Nuclear Power and Its Environmental Effects (American Nuclear Society, LaGrange Park, IL, 1980).
30. International Atomic Energy Agency, Generic Models and Parameters for Assessing the Environmental Transfer of Radionuclides from Routine Releases, Safety Series, No. 57, 1982.
31. National Council on Radiation Protection and Measurements, Radiological Assessment: Predicting the Transport, Bioaccumulation, and Uptake by Man of Radionuclides Released to the Environment, NCRP Report No. 76, March 15, 1984.
32. American National Standards Institute, Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities, ANSI N13.1-1969, February 19, 1969.
33. Institute of Electrical and Electronics Engineers, Specification and Performance of On-Site Instrumentation for Continuously Monitoring Radioactivity in Effluents, ANSI N13.10-1974, September 19, 1974.

34. American National Standards Institute, Testing and Procedural Specifications for Thermoluminescence Dosimetry (Environmental Applications), ANSI N545-1975, August 20, 1975.
35. American Nuclear Insurers, Effluent Monitoring, ANI/MAELU Engineering Inspection Criteria for Nuclear Liability Insurance, Section 5.1, Rev. 2, October 24, 1986.
36. American Nuclear Insurers, Environmental Monitoring, ANI/MAELU Engineering Inspection Criteria for Nuclear Liability Insurance, Section 5.2, Rev. 1, March 23, 1987.
37. American Nuclear Insurers, Environmental Monitoring Programs, ANI/MAELU Information Bulletin 86-1, June 9, 1986.
38. Cember, H., Introduction to Health Physics, 2nd Edition (Pergamon Press, Elmsford, NY 1983).
41. U.S. Nuclear Regulatory Commission, Branch Technical Position, Radiological Assessment Branch, Revision 1, November 1979. (This is a branch position on Regulatory Guide 4.8.)
43. U.S. Nuclear Regulatory Commission, Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Pressurized Water Reactors (PWR-GALE Code), NUREG-0017, April 1976.
49. U.S. Nuclear Regulatory Commission, Methods for Demonstrating LWR Compliance with the EPA Uranium Fuel Cycle Standard (40 CFR Part 190), NUREG-0543, February 1980.
50. International Commission on Radiological Protection, Report of Committee Two on Permissible Dose for Internal Radiation, Recommendations of the International Commission on Radiological Protection, ICRP Publication 2, 1959.
51. U.S. Nuclear Regulatory Commission, Age-Specific Radiation Dose Commitment Factors for a One-Year Chronic Intake, Battelle Pacific Northwest Laboratories, NUREG-0172, 1977.
52. W. C. Ng, Transfer Coefficients for Prediction of the Dose to Man via the Forage-Cow-Milk Pathway from Radionuclides Released to the Biosphere, UCRL-51939.
53. E. C. Eimutis and M. G. Konicek, Derivations of Continuous Functions for the Lateral and Vertical Atmospheric Dispersion Coefficients, Atmospheric Environment 6, 859 (1972).

54. D. C. Kocher, Editor, Nuclear Decay Data for Radionuclides Occurring in Routine Releases from Nuclear Fuel Cycle Facilities, ORNL/NUREG/TM-102, August 1977.
55. R. L. Heath, Gamma-Ray Spectrum Catalog, Aerojet Nuclear Co., ANCR-1000-2, third or subsequent edition.
56. S. E. Thompson, Concentration Factors of Chemical Elements in Edible Aquatic Organisms, UCRL-50564, Rev. 1, 1972.
57. U.S. Nuclear Regulatory Commission, Instruction Concerning Risks from Occupational Radiation Exposure, Regulatory Guide 8.29, July 1981.
58. Dresden Nuclear Power Station, Radioactive Waste and Environmental Monitoring, Annual Report 1987, March 1988.
59. Reserved reference number
70. D. C. Kocher, Radioactivity Decay Data Tables, DOE/TIC-11026, 1981.
71. J. C. Courtney, A Handbook of Radiation Shielding Data, ANS/SD-76/14, July 1976.
75. Sargent & Lundy, METWRSUM, S&L Program Number 09.5.187-1.0.
76. Sargent & Lundy, Comments on CEC Co ODCM and List of S&L Calculations, Internal Office Memorandum, P. N. Derezotes to G. R. Davidson, November 23, 1988.
77. Sargent & Lundy, AZAP, A Computer Program to Calculate Annual Average Offsite Doses from Routine Releases of Radionuclides in Gaseous Effluents and Postaccident X/Q Values, S&L Program Number 09.8.054-1.7.
78. National Oceanic and Atmospheric Administration, A Program for Evaluating Atmospheric Dispersion from a Nuclear Power Station, J. F. Sagendorf, NOAA Technical Memorandum ERL ARL-42, Air Resources Laboratory, Idaho Falls, Idaho, May 1974.
79. G. P. Lahti, R. S. Hubner, and J. C. Golden, Assessment of Gamma-Ray Exposures Due to Finite Plumes, Health Physics 41, 319 (1981).
80. National Council of Radiation Protection and Measurements, Ionizing Radiation Exposure of the Population of the United States, NCRP Report No. 93, September 1, 1987.
82. W. R. Van Pelt (Environmental Analysts, Inc.), Letter to J. Golden (ComEd) dated January 3, 1972.
84. U.S. Nuclear Regulatory Commission, Draft Generic Environmental Impact Statement on Uranium Milling, NUREG-0511, April 1979.

85. U.S. Environmental Protection Agency, Environmental Analysis of the Uranium Fuel Cycle, Part I - Fuel Supply, EPA-520/9-73-003-B, October 1973.
86. U.S. Nuclear Regulatory Commission, Final Generic Environmental Statement on the Use of Recycle Plutonium in Mixed Oxide Fuel in Light Water Cooled Reactors, NUREG-0002, August 1976.
87. U.S. Nuclear Regulatory Commission, Demographic Statistics Pertaining to Nuclear Power Reactor Sites, NUREG-0348, Draft, December 1977.
88. Nuclear News 31, Number 10, Page 69 (August 1988).
89. General Electric Company, Irradiated Fuel Storage at Morris Operation, Operating Experience Report, January 1972 through December 1982, K. J. Eger, NEDO-20969B.
90. U.S. Nuclear Regulatory Commission, Generic Letter 89-01, "Guidance For The Implementation of Programmatic Controls For RETS In The Administrative Controls Section of Technical Specifications and the Relocation of Procedural Details of Current RETS to the Offsite Dose Calculation Manual or Process Control Program", January 1989.
92. NRC Safety Evaluation Report (SER)/Idaho National Engineering Laboratory Technical Evaluation Report (TER) of the Commonwealth Edison Offsite Dose Calculation Manual (ODCM), Revision O.A, December 2, 1991.
95. U.S. Nuclear Regulatory Commission, Standards for Protection Against Radiation (10CFR20).
96. U.S. Nuclear Regulatory Commission, Licensing of Production and Utilization Facilities (10CFR50).
97. Federal Register, Vol. 57, No. 169, Monday, August 31, 1992, page 39358.
98. Miller, Charles W., Models and Parameters for Environmental Radiological Assessments, U.S. Dept. of Energy, DE8102754, 1984, pages 32, 33, 48, and 49.
99. Kocher, D. C., "Dose-Rate Conversion Factors For External Exposure To Photons and Electrons", Health Physics Vol. 45, No. 3 (September), pp. 665-686, 1983.
100. U.S. Department of Health, Education and Welfare Public Health Service, Radiological Health Handbook, January 1970.

101. ODCM Bases and Reference Document, rev.0, November, 1998.
103. U.S. Nuclear Regulatory Commission, Generic Letter 79-041, September 17, 1979.
104. Federal Register, Vol. 56, No. 98, Tuesday, May 21, 1991, page 23374, column 3.
105. U.S. Nuclear Regulatory Commission, Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Pressurized Water Reactors, NUREG-1301, April 1991.
107. U.S. Nuclear Regulatory Commission, LADTAP II - Technical Reference and Users Guide, NUREG-4013, April 1986.
108. Holtec Report No. HI-2146048, Dose Versus Distance from a HI-STORM 100S Version B Containing the MPC-32 for Byron/Braidwood, Holtec International, 8/14/08.
109. Exelon Letter RS-11-099, Request For License Amendment Regarding Measurement Uncertainty Recapture (MUR) Power Uprate, June 23, 2011.
110. Engineering Change (EC) # 405541, Partial Abandonment of the Containment Charcoal Filter Units (Byron Unit 2)
111. Engineering Change (EC) #402667, Unit 1 OG Vent Stack Isolation Valve Single Point Vulnerability Elimination – Install Valve Block on 1OG035
112. Engineering Change (EC) #402668, Unit 2 OG Vent Stack Isolation Valve Single Point Vulnerability Elimination – Install Valve Block on 2OG035
113. Engineering Change (EC) #624333, SGBD Overboard and Reduction

Table 1 - 3
Miscellaneous Dose Assessment Factors: Environmental Parameters

Parameter	Value	Comment	Equation	Basis ^a
f_g	0.76		4-11, 4-12	A
f_L	1.0		4-11, 4-12	A
f_p	1.0		4-13, 4-15	A
f_s	1.0		4-13, 4-15	A
t_b	262,800 hrs	30 years	4-9	C
t_f	48 hrs	Cow Milk Pathway	4-13	A
t_f	480 hrs	Cow Meat Pathway	4-15	A
t_h	1440 hrs	60 days for produce	4-11	A
t_h	2160 hrs	90 days for produce	4-13, 4-15	A
t_L	24 hrs	1 day for leafy vegetables	4-11	A
Q_F	50 Kg/day		4-13, 4-14, 4-15, 4-16	B
r	1.0	For Iodines	4-11, 4-13, 4-15	A
r	0.2	For Particulates	4-11, 4-13, 4-15	A
Y_p	0.7 Kg/m ²		4-13, 4-15	A
Y_s	2.0 Kg/m ²		4-13, 4-15	A
Y_v	2.0 Kg/m ²		4-11	A
λ_w	0.0021 hr ⁻¹		4-11, 4-13, 4-15	A
H	8 gm/m ³	Absolute Atmospheric Humidity	4-12, 4-14, 4-16	D
p	1.0	Fractional Equilibrium Ratio	4-12a, 4-14a, 4-16a	E

^aBasis key:

- A: Reference 6, Table E-15.
- B: Reference 6, Table E-3.
- C: The parameter t_b is taken as the midpoint of plant operating life (based upon an assumed 60 year plant operating lifetime).
- D: Reference 14, Section 5.3.1.3.
- E: Reference 6, Appendix C

Table 1 - 4
Stable Element Transfer Data

Element	F_f Meat (d/kg)	F_M (Cow) Milk (d/L)	Reference
H	1.2E-02	1.0E-02	6
Be	1.5E-03	3.2E-03	Footnote 1
C	3.1E-02	1.2E-02	6
F	2.9E-03	1.4E-02	Footnote 2
Na	3.0E-02	4.0E-02	6
Mg	1.5E-03	3.2E-03	Footnote 1
Al	1.5E-02	1.3E-03	Footnote 3
P	4.6E-02	2.5E-02	6
Cl	2.9E-03	1.4E-02	Footnote 2
Ar	NA	NA	NA
K	1.8E-02	7.2E-03	16
Ca	1.6E-03	1.1E-02	16
Sc	2.4E-03	7.5E-06	Footnote 4
Ti	3.4E-02	5.0E-06	Footnote 5
V	2.8E-01	1.3E-03	Footnote 6
Cr	2.4E-03	2.2E-03	6
Mn	8.0E-04	2.5E-04	6
Fe	4.0E-02	1.2E-03	6
Co	1.3E-02	1.0E-03	6
Ni	5.3E-02	6.7E-03	6
Cu	8.0E-03	1.4E-02	6
Zn	3.0E-02	3.9E-02	6
Ga	1.5E-02	1.3E-03	Footnote 3
Ge	9.1E-04	9.9E-05	Footnote 7
As	1.7E-02	5.0E-04	Footnote 8
Se	7.7E-02	1.0E-03	Footnote 9
Br	2.9E-03	2.2E-02	F_f Footnote 2; F_M from Ref. 16
Kr	NA	NA	NA
Rb	3.1E-02	3.0E-02	6
Sr	6.0E-04	8.0E-04	6
Y	4.6E-03	1.0E-05	6
Zr	3.4E-02	5.0E-06	6
Nb	2.8E-01	2.5E-03	6
Mo	8.0E-03	7.5E-03	6
Tc	4.0E-01	2.5E-02	6
Ru	4.0E-01	1.0E-06	6
Rh	1.5E-03	1.0E-02	6
Pd	5.3E-02	6.7E-03	Footnote 10
Cd	3.0E-02	2.0E-02	Footnote 11
In	1.5E-02	1.3E-03	Footnote 3
Sn	9.1E-04	9.9E-05	Footnote 7
Sb	5.0E-03	2.0E-05	98
Ag	1.7E-02	5.0E-02	6
Te	7.7E-02	1.0E-03	6
I	2.9E-03	6.0E-03	6
Xe	NA	NA	NA
Cs	4.0E-03	1.2E-02	6
Ba	3.2E-03	4.0E-04	6
La	2.0E-04	5.0E-06	6
Ce	1.2E-03	1.0E-04	6
Pr	4.7E-03	5.0E-06	6
Nd	3.3E-03	5.0E-06	6

Table 1-4 (Cont'd)
Stable Element Transfer Data

Element	F _f Meat (d/kg)	F _M (Cow) Milk (d/L)	Reference
Pm	2.9E-04	2.0E-05	16
Sm	2.9E-04	2.0E-05	16
Eu	2.9E-04	2.0E-05	16
Gd	2.9E-04	2.0E-05	16
Dy	2.9E-04	2.0E-05	16
Er	2.9E-04	2.0E-05	16
Tm	2.9E-04	2.0E-05	16
Yb	2.9E-04	2.0E-05	16
Lu	2.9E-04	2.0E-05	16
Hf	3.4E-02	5.0E-06	Footnote 5
Ta	2.8E-01	1.3E-03	F _M - Ref.16; F _f -Footnote 6
W	1.3E-03	5.0E-04	6
Re	1.0E-01	1.3E-03	F _M - Ref.16; F _f -Footnote 12
Os	2.2E-01	6.0E-04	Footnote 13
Ir	7.3E-03	5.5E-03	Footnote 14
Pt	5.3E-02	6.7E-03	Footnote 10
Au	1.3E-02	3.2E-02	Footnote 15
Hg	3.0E-02	9.7E-06	F _M - Ref.16; F _f -Footnote 11
Tl	1.5E-02	1.3E-03	F _M - Ref.16; F _f -Footnote 3
Pb	9.1E-04	9.9E-05	98
Bi	1.7E-02	5.0E-04	98
Ra	5.5E-04	5.9E-04	98
Th	1.6E-06	5.0E-06	98
U	1.6E-06	1.2E-04	98
Np	2.0E-04	5.0E-06	6
Am	1.6E-06	2.0E-05	98

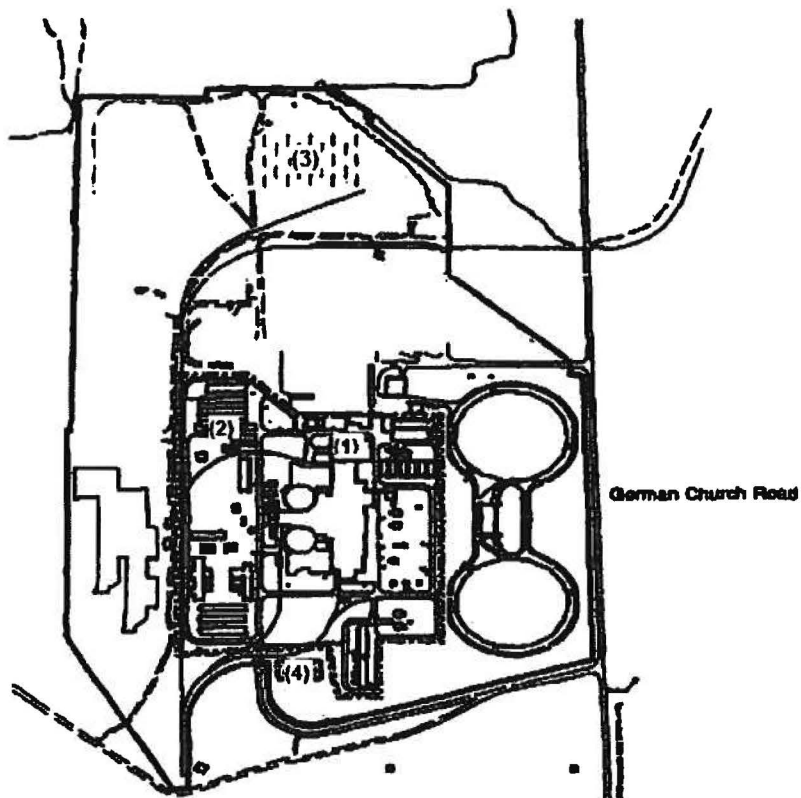
Notes:

1. NA = It is assumed that noble gases are not deposited on the ground.
2. Elements listed are those considered for 10CFR20 assessment and compliance.

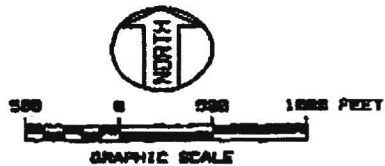
Footnotes:

There are numerous F_f and F_M values that were not found in published literature. In these cases, the periodic table was used in conjunction with published values. The periodic table was used based on a general assumption that elements have similar characteristics when in the same column of the periodic table. The values of elements in the same column of the periodic table, excluding atomic numbers 58-71 and 90-103, were averaged then assigned to elements missing values located in the same column of the periodic table. This method was used for all columns where there were missing values except column 3A, where there was no data, hence, the average of column 2B and 4A were used.

1. Values obtained by averaging Reference 6 values of Ca, Sr, Ba and Ra.
2. F_f value obtained by assigning the Reference 6 value for I. F_M value obtained by averaging I (Ref. 6) and Br (Ref.16).
3. F_f values obtained by averaging Zn (Ref.6) and Pb (Ref. 98); there were no values for elements in the same column; an average is taken between values of columns 2B and 4A on the periodic table. F_M values obtained by using the value for Tl from Reference 16.
4. Values obtained by averaging Reference 6 values of Y and La.
5. Values obtained by assigning the Reference 6 value for Zr.
6. F_f values obtained from Ref. 6 value for Nb. F_M values obtained by averaging values for Nb (Ref.6) and Ta (Ref. 16).
7. Values obtained from the Reference 6 values for Pb.
8. Values obtained from the Reference 6 values for Bi.
9. Values obtained from the Reference 6 values for Te.
10. Values obtained from the Reference 6 values for Ni.
11. F_f values obtained from Ref. 6 values for Zn. F_M values obtained by averaging the Reference 6 values for Zn and Hg.
12. Values obtained by averaging Reference 6 values for Mn, Tc, Nd and Reference 98 value for U.
13. Values obtained by averaging Reference 6 values from Fe and Ru.
14. Values obtained by averaging Reference 6 values from Co and Rh.
15. Values obtained by averaging Reference 6 values from Cu and Ag.



- (1) Process Radwaste Storage Building
- (2) DAW Building (Warehouse #3)
- (3) Future DAW & 48 Pack Locations
- (4) ISFSI Pad
- Restricted Area Boundary



OFFSITE DOSE CALCULATION MANUAL
BYRON STATION

FIGURE 1-3
RESTRICTED AREA BOUNDARY

2. **INSTRUMENTATION AND SYSTEMS**

2.1. Liquid Effluents System Description

1. A simplified liquid release flowpath diagram is provided in Figure 2-3. A simplified liquid radwaste processing diagram is provided in Figure 2-2.
2. The liquid radwaste treatment system is designed and installed to reduce radioactive liquid effluents by collecting the liquids, providing for retention or holdup, and providing for treatment by demineralizer for the purpose of reducing the total radioactivity prior to release to the environment. The system is described in Chapter 11 of the Byron Updated Final Safety Analysis Report.

2.1.1. Release Tanks

1. There are two radwaste release tanks (0WX0IT and 0WX26T 30,000-gallon capacity each) that receive liquid waste before discharge to the Rock River.

2.1.2. Turbine Building Fire and Oil Sump

1. The turbine building fire and oil sump receives water from selected turbine building sumps, the tendon tunnel sumps, and the diesel fuel oil storage sumps, all of which are normally non-radioactive but potentially contaminated. The effluent from this sump is monitored, and if radioactive contamination exceeds a predetermined level pump operation is automatically terminated. The water may then be sent to the liquid radwaste treatment system.

2.1.3. Condensate Polisher Sump

1. The condensate polisher sump receives wastewater from the condensate polisher system and secondary process water, which is normally non-radioactive but potentially contaminated. The effluent from this sump is monitored and if radioactive contamination exceeds a predetermined level sump discharge is terminated and major condensate polisher inputs to the sump are automatically isolated. The water may then be sent to the liquid radwaste treatment system.

2.2. Liquid Effluent Radiation Monitors

Pertinent information on the Liquid Radioactive Effluent Monitors and associated control devices are shown in Table 2-1; additional information is provided in the Byron UFSAR Chapter 11.

2.2.1. Liquid Radwaste Effluent Monitor

1. Monitor 0RE-PR001 is used to monitor all releases from the release tanks. On high alarm, the monitor automatically initiates closure of valves 0WX-353 and 0WX-869 to terminate the release.

2.2.2. Station Blowdown Monitor

1. Monitor 0RE-PR010 continuously monitors the circulating water blowdown. No control device is initiated by this channel.

2.2.3. Reactor Containment Fan Cooler (RCFC) and Essential Service Water (SX) Outlet Line Monitors.

1. Monitors 1RE-PR002, 2RE-PR002, 1RE-PR003, and 2RE-PR003 continuously monitor the RCFC and SX outlet lines. No control device is initiated by these channels.

2.2.4. Turbine Building Fire and Oil Sump Monitor

1. Monitor 0RE-PR005 continuously monitors the fire and oil sump discharge. On high alarm the monitor automatically initiates an interlock to trip the discharge pumps, close valve 0OD030, and terminate the release.

2.2.5. Condensate Polisher Sump Monitor

1. Monitor 0RE-PR041 continuously monitors the condensate polisher sump discharge. On high alarm, the monitor automatically initiates an interlock to trip the discharge pumps and terminate the release.

2.2.6. Component Cooling Water Monitors

1. Monitors 0RE-PR009 (common), 1RE-PR009 (Unit 1), and 2RE-PR009 (Unit 2) continuously monitor the component cooling water heat exchanger outlets. On high alarm 0RE-PR009 initiates closure of both component cooling water surge tank (CCWST) vents, 1RE-PR009 initiates closure of the Unit 1 CCWST vent, and 2RE-PR009 initiates closure of the Unit 2 CCWST vent.

2.3. Liquid Radiation Effluent Monitors Alarm and Trip Setpoints

1. Alarm and trip setpoints of liquid effluent monitors at the principal release points are established to ensure that the limits of TRM Section 3.11.a are not exceeded in the unrestricted area.
2. Setpoint calculations normally consist of identified release mixtures, dilution factors, conversion factors (detector sensitivity), maximum release flow rates, and conservatism factors.

2.3.1. Station Blowdown Monitor

During release, the monitor setpoint is found by solving equation 2-1

$$P \leq C^{CW} + (1.50 \times C^T) \times (F_{max}^r / (F^{CW} + F_{max}^r)) \quad (2-1)$$

P Release Setpoint [μCi/ml]

1.50 Factor to account for minor fluctuations in count rate

C^{CW} Concentration of activity in the circulating water blowdown at the time of discharge ("Background reading") [μCi/ml]

C^T Analyzed activity in the release tank (excluding tritium)[μCi/ml]

F^{CW} Circulating Water Blowdown Rate [gpm]

F_{max}^r Maximum Release Tank Discharge Flow Rate [gpm]
The flow rate from the radwaste discharge tank

1. The release mixture used for the setpoint determination is the radionuclide mix identified in the release tank grab sample isotopic analysis.

2.3.2. Liquid Radwaste Effluent Monitor

1. During release, the setpoint is established at 1.5 times the analyzed tank activity plus the background reading. However, per procedure, the maximum discharge flow rate is limited to a value that will result in less than 50% of 10*ECL at the discharge point. (See Section 1)

2.3.2.1 Radwaste Tank Discharge Flow Rate

1. Prior to each batch release, a grab sample is obtained.
2. The results of the analysis of the waste sample determine the discharge rate of each batch as follows:

$$F_{\max}^r = 0.5(F_{act}^d / \sum(C_i / 10 * ECL_i)) \quad (2-2)$$

The summation is over radionuclides i.

F_{\max}^r Maximum Permitted Discharge Flow Rate [gpm]

The maximum permitted flow rate from the radwaste discharge tank based on radiological limits (not chemistry limits which may be more restrictive)

F_{act}^d Circulating Water Blowdown Rate [gpm]

C_i Concentration of Radionuclide i in the Release Tank [μ Ci/ml]

The concentration of radioactivity in the radwaste discharge tank based on measurements of a sample drawn from the tank.

ECL_i Effluent Concentration Limit [μ Ci/ml]

The concentration of radionuclide i given in Appendix B, Table 2, Column 2 to 10CFR20.1001 - 20.2402.

10 Multiplier

2.3.2.2 Release Mixture

1. The release mixture used for the setpoint determination is the radionuclide mix identified in the release tank grab sample isotopic analysis.

2.3.2.3 Liquid Dilution Flow Rates

1. Dilution flow rates are obtained from the main control board in the control room. If this information is unavailable, releases may continue for up to 30 days provided the dilution flow rates are estimated every 4 hours during the release, in accordance with TRM Table T 3.11.a-1.

2.3.2.4 Projected Concentrations for Releases

1. After determining F_{\max}^r from Equation 2-2, RE compliance is verified using Equations 2-3 and 2-4.

$$C_i^a = C_i^T [F_{\max}^r / (F_{\max}^r + F_{act}^d)] \quad (2-3)$$

$$\sum \{ C_i^a / 10 * ECL_i \} \leq 1 \quad (2-4)$$

The summation is over radionuclides i.

C_i^a Concentration of Radionuclide i in the Unrestricted Area [$\mu\text{Ci/mL}$]

The calculated concentration of radionuclide i in the unrestricted area as determined by Equation 2-3.

C_i^T Concentration of Radionuclide i in the Release Tank [$\mu\text{Ci/mL}$]

The concentration of radioactivity in the radwaste discharge tank based on measurements of a sample drawn from the tank.

ECL_i Effluent Concentration Limit [$\mu\text{Ci/ml}$]

The concentration of radionuclide i given in Appendix B, Table 2, Column 2 to 10CFR20.1001 - 20.2402.

10 Multiplier

F_{\max}^r Maximum Release Tank Discharge Flow Rate [gpm]

F_{act}^d Circulating Water Blowdown Rate [gpm]

2.3.3. Other Liquid Effluent Monitors

1. For all other liquid effluent monitors, including 0RE-PR001 and 0RE-PR010 when not batch releasing, setpoints are determined such that the concentration limits do not exceed 10 times the ECL value given in Appendix B, Table 2, Column 2 to 10CFR20.1001 - 20.2402 in the unrestricted area. Release mixtures are based on a representative isotopic mixture of the waste stream or inputs to the waste stream, or defaulted to the mix listed in Table 2-4.

2.3.4. Conversion Factors

1. The readouts for the liquid effluent monitors are in $\mu\text{Ci/ml}$. The cpm to $\mu\text{Ci/ml}$ conversion is determined for each monitor.

2.3.5. Allocation of Effluents from Common Release Points

1. Radioactive liquid effluents released from either release tank (0WX01T or 0WX26T) are comprised of contributions from both units. Under normal operating conditions, it is difficult to apportion the radioactivity between the units. Consequently, allocation is made evenly between units.

2.3.6. Solidification of Waste/Process Control Program

1. The process control program (PCP) contains the sampling, analysis, and formulation determination by which solidification of radioactive wastes from liquid systems is ensured.

2.4. Gaseous Effluents System Description

1. A simplified HVAC and gaseous effluent flow diagram is provided in Figure 2-1. The principal release points for potentially radioactive airborne effluents are the two auxiliary building vent stacks (designated Stack 1 and Stack 2 in Figure 2-1). In the classification scheme of Section 4.1.4, each is classified as a vent release point. Engineered safety features atmospheric cleanup systems are not considered to be ventilation exhaust treatment system components.

2.4.1. Waste Gas Holdup System

1. The waste gas holdup system is designed and installed to reduce radioactive gaseous effluents by collecting reactor coolant system off-gases from the reactor coolant system and providing for delay or holdup to reduce the total radioactivity by radioactive decay prior to release to the environment.

2.4.2. Ventilation Exhaust Treatment System

1. Ventilation exhaust treatment systems are designed and installed to reduce gaseous radioiodine or radioactive material in particulate form in gaseous effluents by passing ventilation or vent exhaust gases through charcoal adsorbers (as required) and/or HEPA filters prior to release to the environment. Such a system is not considered to have any effect on noble gas effluents. The ventilation exhaust treatment systems are shown in Figure 2-1.
2. Engineered safety features atmospheric cleanup systems are not considered to be ventilation exhaust treatment system components.

2.5. Gaseous Effluent Radiation Monitors

1. Pertinent information on the Gaseous Effluent Radiation Monitors and associated control devices are shown in Table 2-2, additional information is provided in Byron UFSAR Chapter 11.

2.5.1. Auxiliary Building Vent Effluent Monitors

1. Monitors 1RE-PR028 (Unit 1) and 2RE-PR028 (Unit 2) continuously monitor the final effluent from the auxiliary building vent stacks.
2. Both vent stack monitors feature automatic noble gas monitoring, isokinetic sampling, grab sampling, and sampling for iodine, particulate, and tritium.
3. These monitors perform no automatic isolation or control functions.

2.5.2. Containment Purge Effluent Monitors

1. Monitors 1RE-PR001 (Unit 1) and 2RE-PR001 (Unit 2) continuously monitor the effluent from the Unit 1 and Unit 2 containments, respectively. When airborne radioactivity in the containment purge effluent stream exceeds a specified level station personnel will follow established procedures to terminate the release by manually activating the containment purge valves. Additionally, the auxiliary building vent effluent monitors provide an independent, redundant means of monitoring the containment purge effluent.
2. These monitors perform no automatic isolation or control functions.
3. Monitors 1RE-AR011, 2RE-AR011, 1RE-AR012 and 2RE-AR012 continuously monitor the containment atmosphere for radioactive gas and particulates. On high alarm during a containment purge, these monitors will automatically terminate the purge.

2.5.3. Waste Gas Decay Tank Monitors

1. Monitors 0RE-PR002A and 0RE-PR002B continuously monitor the noble gas activity released from the gas decay tanks.
2. On high alarm, the monitors automatically initiate closure of the valve 0GW104 thus terminating the release.

2.5.4. Gland Steam and Condenser Air Ejector Monitors

1. Monitors 1RE-PR027 and 2RE-PR027 continuously monitor the condenser air ejector gas from Units 1 and 2, respectively. This monitor performs no automatic isolation or control functions.

2.5.5. Radwaste Building Ventilation Monitor

1. Monitor 0RE-PR026 continuously monitors radioactivity in the radwaste building ventilation system. On high alarm, 0RE-PR026 initiates isolation of the radwaste building ventilation system.

2.5.5.1 Miscellaneous Ventilation Monitors

1. Monitor 0RE-PR003 continuously monitors radioactivity in the ventilation exhaust from the laboratory fume hoods. This monitor performs no automatic isolation or control functions.

2.6. Gaseous Effluent Monitor Alarm and Trip Setpoints

2.6.1. Auxiliary Building Vent Effluent Monitors

1. The setpoints for the low range noble gas channel are conservatively established at 2.5% of the maximum permissible release rate for the high alarm and 0.25% of the maximum release rate for the alert alarm.
2. The setpoints for the high range noble gas channel are conservatively established at 50% of the maximum permissible release rate for the high alarm and 5% of the maximum release rate for the alert alarm.
3. The setpoint methodology must ensure simultaneous releases do not exceed the off-site dose rate limits set forth in TRM3.11. Setpoints can be adjusted based upon operational requirements with the restriction that the sum of the percentages between the Unit 1 and Unit 2 noble gas channels does not exceed 90% of the maximum permissible release rate.

2.6.2. Containment Purge Effluent Monitors

1. Under normal conditions when the containment atmosphere monitor gas detector is operational, the setpoints are established at 1.25 times the containment noble gas activity during purge based on a grab sample obtained from the rad monitor.
2. When the containment atmosphere monitor gas detector is not operational, the setpoints are established at 1.5 times the containment noble gas activity during purge to prevent a spurious alarm based on a grab sample that may not be as representative of the containment atmosphere as monitored by the containment purge rad monitor during non-release periods.

2.6.3. Waste Gas Decay Tank Effluent Monitors

1. The setpoints are established at 1.25 times the analyzed waste gas tank activity during release.

2.6.4. Gaseous Effluent Release Limits

1. Alarm and trip setpoints of gaseous effluent monitors are established to ensure that the dose rate limits of TRM Section 3.11.f are not exceeded. The release limits are found by solving Equations 2-5 and 2-6 for the total allowed release rate of vent releases, Q_{tv} .

$$(\chi/Q)_v Q_{tv} \sum_i K_i f_i < 500 \text{ mrem / yr} \quad (2-5)$$

$$Q_{tv} \sum_i f_i \{ L_i (\chi/Q)_v + (1.11) M_i (\chi/Q)_v \} < 3000 \text{ mrem / yr} \quad (2-6)$$

The summations are over noble gas radionuclides i .

f_i Fractional Radionuclide Composition

The release rate of noble gas radionuclide i divided by the total release rate of all noble gas radionuclides.

Q_{tv} Total Allowed Release Rate, Vent Release [μ Ci/sec]

The total allowed release rate of all noble gas radionuclides released as vent releases.

2. The remaining parameters in Equation 2-5 have the same definitions as in Equation 4-1 of Part 2 Section 4. The remaining parameters in Equation 2-6 have the same definition as in Equation 4-2 of Part 2 Section 4.
3. Equation 2-5 is based on Equation 4-1 of Section 4 and the RE restriction on whole body dose rate (500 mrem/yr) due to noble gases released in gaseous effluents (see Part 2 Section 4.2.1.1). Equation 2-6 is based on Equation 4-2 of Section 4 and the RE restriction on skin dose rate (3000 mrem/yr) due to noble gases released in gaseous effluents (see Part 2 Section 4.2.1.2).
4. Since the solution to Equation 2-6 is more conservative than the solution to Equation 2-5, the value of Equation 2-6 (1.02×10^7 $\mu\text{Ci/sec}$) is used as the limiting noble gas release rate. During evolutions involving releases from the containment or waste gas decay tanks, the total station release rate is procedurally limited such that the maximum permissible release rate is not exceeded.

2.6.5. Release Mixture

1. In the determination of alarm and trip setpoints, the radioactivity mixture in exhaust air is assumed to have the radionuclide composition of Table 2-3.

2.6.6. Conversion Factors.

1. The response curves used to determine the monitor count rates are based on the sensitivity to Xe-133 for conservatism.

2.6.7. HVAC Dilution Flow Rates

1. The plant vent stack flow rates are obtained from the RMS (or equivalent) console in the control room. If the values cannot be obtained from RMS (or equivalent), flow rates can be estimated from the operating fan combinations.

2.6.8. Allocation of Effluents from Common Release Points

1. Radioactive gaseous effluents released from the auxiliary building, miscellaneous ventilation systems and the gas decay tanks are comprised of contributions from both units. Consequently, allocation is made evenly between units.

2.6.9. Dose Projections for Batch Releases

1. The 10CFR20 dose limits have been converted into a station administrative release rate limit using the methodology in the ODCM. Compliance is verified prior to each release. Doses are calculated after purging the containment or venting the waste gas decay tanks. Per procedure, representative samples are obtained and analyzed, and the doses calculated on a monthly basis to verify compliance with 10CFR50.

Table 2-1 Liquid Radioactive Effluent Monitors

Channel	Monitor Description	Sampling Locations	Effluent Control Functions	Alarm Setpoint Used
0RE-PR001	Radwaste Release Tank Monitor	Common release point from Radwaste Release Tanks 0WX01T, 0WX26T	Radwaste release termination	Yes
0RE-PR010	Station Blowdown Monitor	Circulating Water Blowdown	None	No
1RE-PR002 2RE-PR002 1RE-PR003 2RE-PR003	Reactor Containment Fan Cooler and Essential Service Water Outlet Line Monitors	RCFC and SX outlet lines	None	No
0RE-PR005	Turbine Building Fire and Oil Sump Monitor	Fire and Oil Sump discharge	Terminates release from Fire and Oil Sump	Yes
0RE-PR041	Condensate Polisher Sump Monitor	Condensate Polisher Sump discharge	Terminates release from Condensate Polisher Sump	Yes
0RE-PR009 1RE-PR009 2RE-PR009	Component Cooling Water (CCW) Monitors	0RE-PR009: CCW Heat Exchangers, common discharge 1RE-PR009: Unit 1 CCW Heat Exchanger discharge 2RE-PR009: Unit 2 CCW Heat Exchanger discharge	0RE-PR009: Closes both CCW surge tank vents 1RE-PR009: Closes Unit 1 CCW surge tank vent 2RE-PR009: Closes Unit 2 CCW surge tank vent	Yes

Table 2-2 Gaseous Radioactive Effluent Monitors

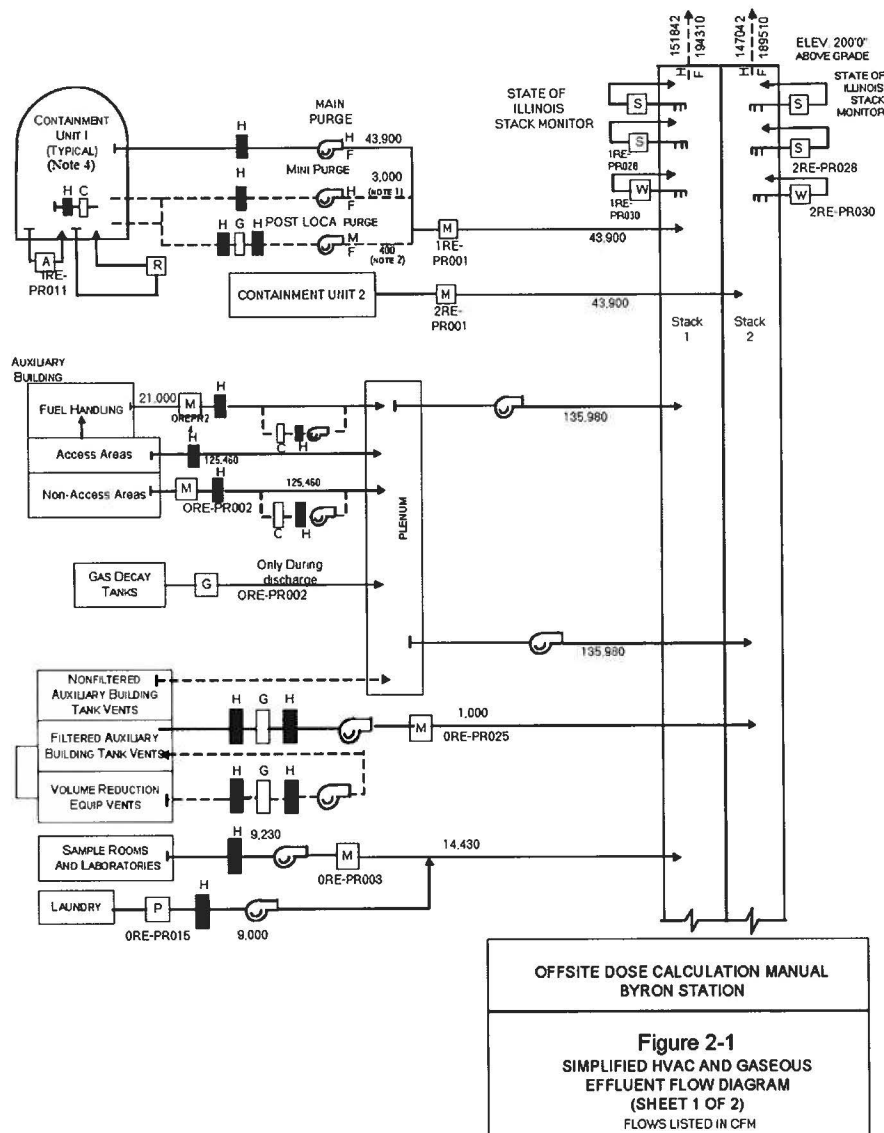
Channel	Monitor Description	Sampling Locations	Effluent Control Functions	Alarm Setpoint Used
1RE-PR028 2RE-PR028	Auxiliary Building Vent Effluent Monitors	Final effluent from auxiliary building vent stack from Unit 1 (1RE-PR028) and from Unit 2 (2RE-PR028)	None	Yes
1RE-PR001 2RE-PR001	Containment Purge Effluent Monitors	Effluent from Unit 1 Containment (1RE-PR001) Effluent from Unit 2 Containment (2RE-PR001)	None	Yes
1RE-AR011 2RE-AR011 1RE-AR012 2RE-AR012	Reactor Containment Particulate and Gas Monitors	Unit 1 Containment (1RE-AR011, 1RE-AR012) Unit 2 Containment (2RE-AR011, 2RE-AR012) <i>Note: not effluent monitors, but have effluent control functions</i>	Terminate containment purge	Yes
0RE-PR002A 0RE-PR002B	Waste Gas Decay Tank Monitors	Release line from Waste Gas Decay Tanks	Closes valve 0GW104, terminates release	Yes
1RE-PR027 2RE-PR027	Gland Steam and Condenser Air Ejector Monitors	Condenser Air Ejector (CAE) gas from Unit 1 (1RE-PR027) and CAE gas from Unit 2 (2RE-PR027)	None	No
0RE-PR026	Radwaste Building Ventilation	Radwaste Building Ventilation System	Isolates Radwaste Building ventilation system	Yes
0RE-PR003	Laboratory Fume Hood Exhaust Monitor	Common line from laboratory fume hoods	None	No

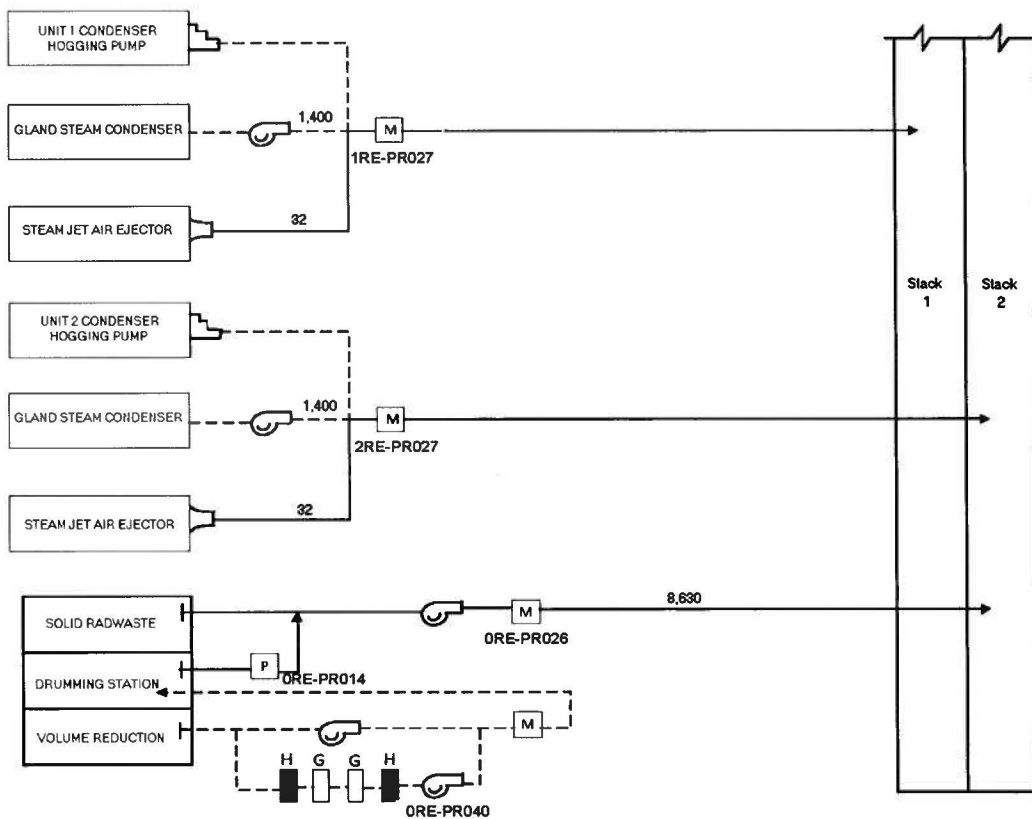
Table 2-3 Assumed Composition of the Byron Station Noble Gas Effluent

<u>Isotope</u>	<u>Percent of Effluent</u>
Ar-41	0.89
Kr-85m	0.18
Kr-85	24.9
Kr-87	0.04
Kr-88	0.28
Xe-131m	1.42
Xe-133m	0.57
Xe-133	71.1
Xe-135	0.53
Xe-138	0.04

Table 2-4 Assumed Composition of the Byron Station Liquid Effluent

Isotope	Concentration (uCi/ml)	Isotope	Concentration (uCi/ml)
H-3	1.16E-05	Ag-110m	1.70E-11
Cr-51	2.39E-12	Te-127	5.40E-13
Mn-54	3.86E-11	Te-129m	1.78E-12
Fe-55	2.08E-12	Te-129	1.16E-12
Fe-59	1.35E-12	Te-131m	1.27E-12
Co-58	1.74E-10	Te-132	2.39E-11
Co-60	3.40E-10	I-130	4.24E-12
Br-83	6.59E-13	I-131	3.09E-09
Rb-86	1.81E-12	I-132	6.95E-11
Sr-89	5.02E-13	I-133	1.43E-09
Zr-95	5.40E-11	I-135	1.66E-10
Nb-95	7.72E-11	Cs-134	1.08E-09
Mo-99	7.72E-11	Cs-136	2.66E-10
Tc-99m	8.88E-11	Cs-137	1.35E-09
Ru-103	5.40E-12	Ce-144	2.01E-10
Ru-106	9.26E-11	Np-239	8.88E-13





LEGEND

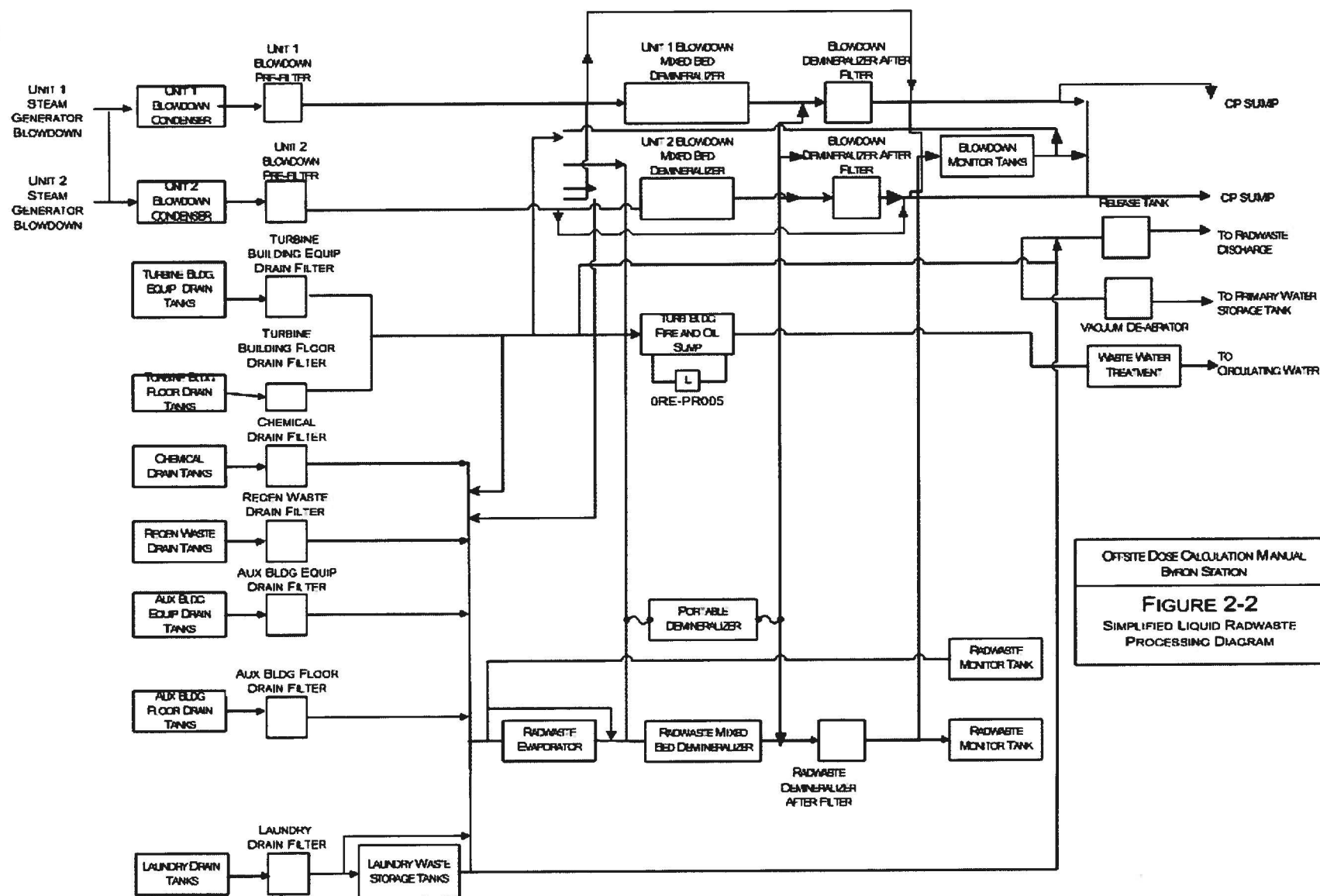
- NORMAL OR FREQUENT FLOW PATH
 - - - OCCASIONAL FLOW PATH
- A CONTAINMENT ATMOSPHERE RADIATION MONITOR
 C CHARCOAL FILTER
- G NOBLE GAS RADIATION MONITOR
 H HEPA FILTER
 M THREE-CHANNEL RADIATION MONITOR FOR PARTICULATE, IODINE, AND NOBLE GAS (OffLine)
- P PARTICULATE MONITOR (OffLine)
 R HYDROGEN RECOMBINER
 S NORMAL RANGE STACK RADIATION MONITOR (PARTICULATE, IODINE, AND NOBLE GAS)
 W WIDE-RANGE STACK NOBLE GAS RADIATION MONITOR

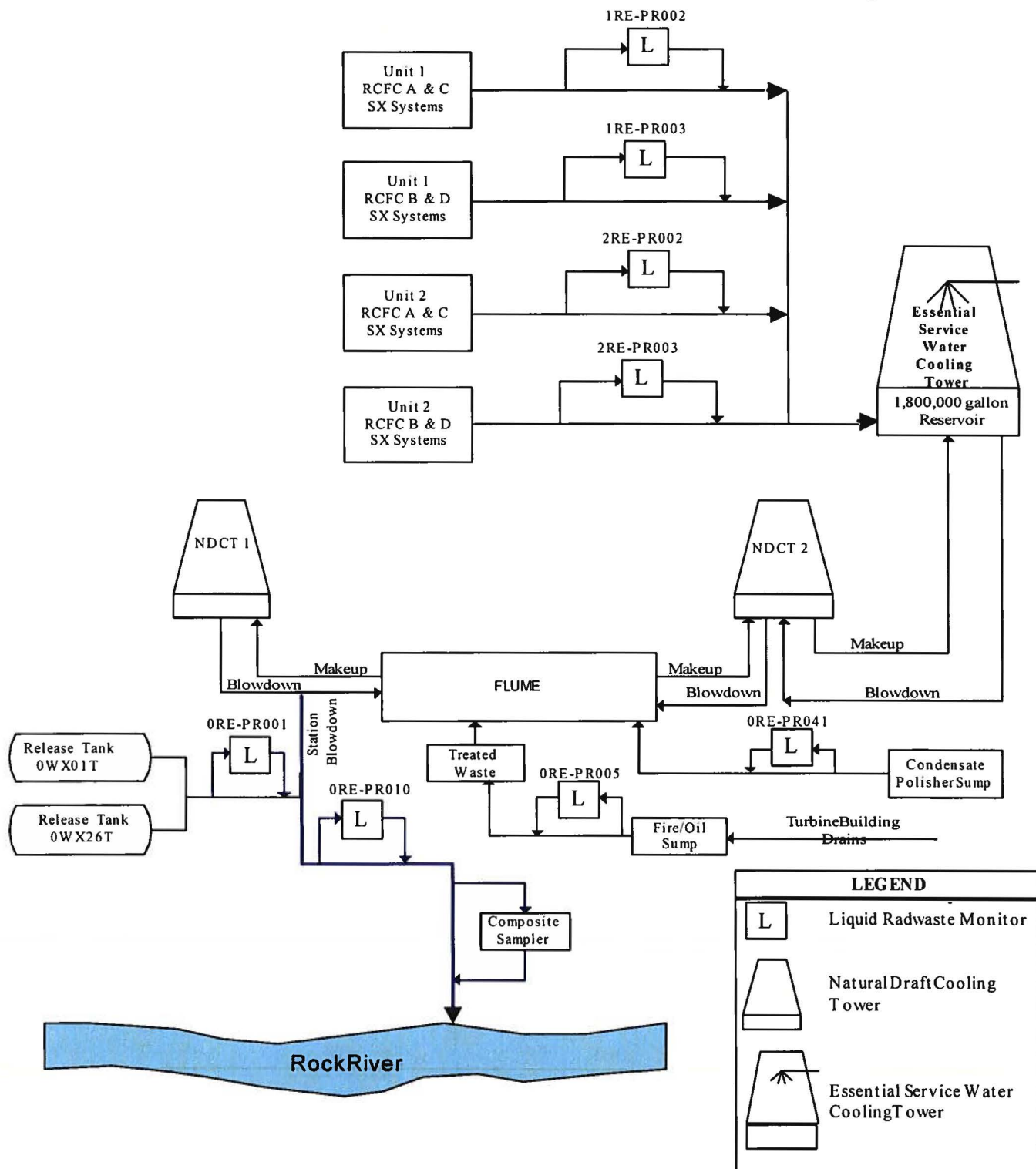
NOTES

1. USED INTERMITTENTLY TO VENT CONTAINMENT DURING NORMAL OPERATION
2. USED ONLY DURING POST ACCIDENT OPERATION
3. NOTE REMOVED
4. CHARCOAL FILTRATION REMOVED FROM UNIT 2 CONTAINMENT UNDER EC 406541

OFFSITE DOSE CALCULATION MANUAL
 BYRON STATION

Figure 2-1
 SIMPLIFIED HVAC AND GASEOUS
 EFFLUENT FLOW DIAGRAM
 (SHEET 2 OF 2)
 FLOWS LISTED IN CFM



**Figure 2-3 Liquid Release Flow Path**

3. **LIQUID EFFLUENTS**

3.1. Liquid Effluent Releases – General Information

- 3.1.1. The design objectives of 10CFR50, Appendix I and RE provide the following limits on the dose to a member of the public from radioactive materials in liquid effluents released from each reactor unit to restricted area boundaries:
1. During any calendar quarter, less than or equal to 1.5 mrem to the total body and less than or equal to 5 mrem to any organ.
 2. During any calendar year, less than or equal to 3 mrem to the total body and less than or equal to 10 mrem to any organ.
- 3.1.2. The organ doses due to radioactivity in liquid effluents are also used as part of the 40CFR190 compliance and are included in the combination of doses to determine the total dose used to demonstrate 10CFR20 compliance. (See Section 5.0, Total Dose)
- 3.1.3. Dose assessments for 10CFR50 Appendix I compliance are made for four age groups (adult, teenager, child, infant) using NUREG 0133 (Reference 14) methodology and Regulatory Guide 1.109 (Reference 6) dose conversion factors.
- 3.1.4. To limit the consequences of tank overflow, Technical Specification 5.5.12 limits the quantity of radioactivity that may be stored in unprotected outdoor tanks to 10 Curies.
1. Unprotected tanks are tanks that are not surrounded by liners, dikes, or walls capable of holding the tank contents and that do not have tank overflows and surrounding area drains connected to the liquid radwaste treatment system.
 2. The specific objective is to provide assurance that in the event of an uncontrolled release of a tank's contents, the resulting radioactivity concentrations beyond the unrestricted area boundary, at the nearest potable water supply and at the nearest surface water supply, will be less than the limits of 10CFR20 Appendix B, Table 2; Column 2.
- 3.1.5. Cases in which normally non-radioactive liquid streams (such as the Service Water) are found to contain radioactive material are non-routine and will be treated on a case specific basis if and when this occurs. Since the station has sufficient capacity to delay a liquid release for reasonable periods of time, it is expected that planned releases will not take place under these circumstances. Therefore, the liquid release setpoint calculations need not and do not contain provisions for treating multiple simultaneous release pathways.

- 3.1.6. Radioactive liquid effluents released from either release tank (0WX01T or 0WX26T) are comprised of contributions from both units. Under normal operating conditions, it is difficult to apportion the radioactivity between the units. Consequently, allocation is made evenly between units.

3.2. Liquid Effluent Concentrations

- 3.2.1. One method of demonstrating compliance to the requirements of 10CFR20.1301 is to demonstrate that the annual average concentrations of radioactive material released in gaseous and liquid effluents do not exceed the values specified in 10CFR20 Appendix B, Table 2, Column 2. (See 10CFR 20.1302(b)(2).) However, as noted in Section 5.5, this mode of 10CFR20.1301 compliance has not been elected.

1. As a means of assuring that annual concentration limits will not be exceeded, and as a matter of policy assuring that doses by the liquid pathway will be ALARA; RE provides the following restriction:

- A. "The concentration of radioactive material released in liquid effluents to unrestricted areas shall be limited to ten times the concentration values in Appendix B, Table 2, Column 2 to 10CFR20.1001-20.2402."

2. This also meets the requirement of Station Technical Specifications and RE.

- 3.2.2. According to the footnotes to 10CFR20 Appendix B, Table 2, Column 2, if a radionuclide mix of known composition is released, the concentrations must be such that

$$\sum_i \left(\frac{C_i}{10 ECL_i} \right) \leq 1 \quad (3-1)$$

where the summation is over radionuclide *i*.

C_i Radioactivity Concentration in Liquid Effluents to the Unrestricted Area [μ Ci/ml]

Concentration of radionuclide *i* in liquid released to the unrestricted area.

ECL_i Effluent Concentration Limit in Liquid Effluents Released to the Unrestricted Area [μ Ci/ml]

1. The allowable annual average concentration of radionuclide *i* in liquid effluents released to the unrestricted area. This concentration is specified in 10CFR20 Appendix B, Table 2, Column 2. Concentrations for noble gases are different and are specified in the stations' Technical Specifications and RE.

10 Multiplier to meet the requirements of Technical Specifications.

2. If either the identity or concentration of any radionuclide in the mixture is not known, special rules apply. These are given in the footnotes in 10CFR20 Appendix B, Table 2, Column 2.

- 3.2.3. When radioactivity is released to the unrestricted area with liquid discharge from a tank (e.g., a radwaste discharge tank), the concentration of a radionuclide in the effluent is calculated as follows:

$$C_i = C_i^t \frac{\text{Waste Flow}}{\text{Dilution Flow}} \quad (3-2)$$

C_i Concentration of radionuclide *i* in liquid released to the unrestricted area. [$\mu\text{Ci/ml}$]

C_i^t Concentration in the Discharge Tank [$\mu\text{Ci/ml}$]

Measured concentration of radionuclide *i* in the discharge tank.

1. The RE and Technical Specifications require a specified sampling and analysis program to assure that liquid radioactivity concentrations at the point of release are maintained within the required limits. To comply with this provision, samples are analyzed in accordance with the radioactive liquid waste (or effluent) sampling and analysis program in the TRM 3.11.c. Radioactivity concentrations in tank effluents are determined in accordance with Equation 3-2. Comparison with the Effluent Concentration Limit is made using Equation 3-1.

3.3. Liquid Effluent Dose Calculation Requirements

3.3.1. RE require determination of cumulative and projected dose contributions from liquid effluents for the current calendar quarter and the current calendar year at least once per 31 days. (See TRM Chapter 3.11.)

- 1. For a release attributable to a processing or effluent system shared by more than one reactor unit, the dose due to an individual unit is obtained by proportioning the effluents among the units sharing the system. The allocation procedure is specified in section 3.1.6.**

3.3.2. Operability and Use of the Liquid Radwaste Treatment System

- 1. The design objectives of 10CFR50, Appendix I, RE and Technical Specifications require that the liquid radwaste treatment system be operable and that appropriate portions be used to reduce releases of radioactivity when projected doses due to the liquid effluent from each reactor unit to restricted area boundaries exceed either of the following (see TRM Chapter 3.11, RE);**

- 0.06 mrem to the total body in a 31-day period.**
- 0.2 mrem to any organ in a 31-day period.**

3.4. Dose Methodology

3.4.1. Liquid Effluent Dose Method: General

1. The dose from radioactive materials in liquid effluents considers the contributions for consumption of fish and potable water. All of these pathways are considered in the dose assessment unless demonstrated not to be present. While the adult is normally considered the maximum individual, the methodology provides for dose to be calculated for all four age groups. The dose to each organ (and to the total body) is calculated by the following expression:

$$D_{aj}^{Liq} = F \Delta t \sum_p \sum_i A_{aipj} C_i \quad (3-3)$$

The summation is over exposure pathways p and radionuclides i .

D_{aj}^{Liq} Organ and Total Body Dose Due to Liquid Effluents [mrem]

Dose to organ j (including total body) of age group a due to radioactivity in liquid effluents.

F Near Field Average Dilution Factor [dimensionless]
Dilution in the near field averaged over the period of interest.

Defined as:

$$F = \frac{\text{Waste Flow}}{\text{Dilution Flow} \times Z} \quad (3-4)$$

Waste Flow Liquid Radioactive Waste Flow [gpm]

The average flow during disposal from the discharge structure release point into the receiving water body.

Dilution Flow Dilution Water Flow During Period of Interest [gpm]

Z Discharge Structure Mixing Factor [dimensionless]

2. Site-specific factor to account for the mixing effect of the discharge structure. The factor addresses the dilution that occurs in the near field between the discharge structure and the body of water containing the fish in the liquid ingestion pathway (See Section 3.5).

Δt Duration of Release [hrs]

C_i Average Radionuclide Concentration [$\mu\text{Ci/ml}$]

Average concentration of radionuclide i , in the undiluted liquid effluent during time period Δt .

A_{aipj} Site-Specific Liquid Dose Factor [(mrem/hr)/($\mu\text{Ci/ml}$)]

3. Site-specific dose factor for age group a , nuclide i , liquid pathway p and organ j . The pathways included are potable water and fish ingestion. A_{aipj} is defined for these pathways in the following sections. Values for A_{aipj} are provided in Part 2 Section 3.5 of this ODCM.

3.4.2. Potable Water Pathway

1. The site-specific potable water pathway dose factor is calculated by the following expression:

$$A_{ai(PW)j} = k_o \left\{ \frac{U_a^w}{D^w} \right\} DFL_{aij} \quad (3-5)$$

Where:

$A_{ai(PW)j}$ Site-Specific Dose Factor for Potable Water Pathway
[(mrem/hr)/(μCi/ml)]

Site-specific potable water ingestion dose factor for age group **a**, nuclide **i** and organ **j**.

k_o Conversion Constant (1.14E05) [(yr-pCi-ml)/(hr-μCi-l)]

Units constant to convert years to hours, pCi to μCi and liters to ml.

U_a^w Potable Water Consumption Rate [l/yr]

Potable water consumption rate for age group **a**. Taken from Table E-5 of Regulatory Guide 1.109.

D^w Potable Water Dilution Factor [dimensionless]

Dilution factor from the near field area within one-quarter mile of the release point to the potable water intake (See section 3.5).

DFL_{aij} Ingestion Dose Conversion Factor [mrem/pCi]

Ingestion dose conversion factor for age group **a**, nuclide **i** and organ **j**. Converts pCi ingested to mrem. Taken from Tables E-11 through E-14 of Regulatory Guide 1.109. The values for H-3 and Sr-90 are taken from NUREG 4013 (Reference 107).

3.4.3. Fish Ingestion Pathway

1. The site-specific fish ingestion pathway dose factor is calculated by the following expression:

$$A_{al(Fish)j} = k_o U_a^F B F_i D F L_{alj} \quad (3-6)$$

Where:

$A_{al(Fish)j}$ Site-Specific Dose Factor for Fish Ingestion Pathway
[(mrem/hr)/(μCi/ml)]

Site-specific fish ingestion dose factor for age group a, nuclide i and organ j.

U_a^F Fish Consumption Rate [kg/yr]

Fish consumption rate for age group a. Taken from Table E-5 of Regulatory Guide 1.109.

$B F_i$ Bioaccumulation Factor [(pCi/kg)/(pCi/l)]

Bioaccumulation factor for nuclide i in fresh water fish. Taken from Table 3-8.

All other terms have been previously defined.

- 3.4.4. Offsite doses due to projected releases of radioactive materials in liquid effluents are calculated using Equation 3-3. Projected radionuclide release concentrations are used in place of measured concentrations, C_i .

3.5. Site Specific Dose Factors and Bioaccumulation Factors

- 3.5.1. There are no public potable water intakes on the Rock River downstream of the station.
- 3.5.2. There is no irrigation occurring on the Rock River downstream of the station.
- 3.5.3. Recreation includes one or more of the following: boating, water-skiing, swimming, and sport fishing.

- 3.5.4. According to Section 2.4.1.2 and Figure 2.4-5 of the Byron Environmental Report, there are four downstream dams on the Rock River within approximately 50 miles of the station one at Oregon, one at Dixon and two at Sterling.
- 3.5.5. Water and Fish Ingestion Parameters
 - 3.5.5.1 $D^w = 10$ (potable water dilution factor, dimensionless)
 - 3.5.5.2 $Z = 32$ (discharge structure mixing factor, dimensionless)
- 3.5.6. Site-specific dose factors for potable water consumption are shown in Table 3-1 for adult, Table 3-2 for teen, Table 3-3 for child, and Table 3-4 for infant age groups. These tables include dose factors for the bone, liver, total body, thyroid, kidney, lung, and GI (lower large intestines).
- 3.5.7. Site-specific dose factors for fish ingestion are shown in Table 3-5 for adult, Table 3-6 for teen, and Table 3-7 for child age groups. These tables include dose factors for the bone, liver, total body, thyroid, kidney, lung, and GI (lower large intestines).

Table 3-1
Site Specific Potable Water Dose Factors for Adult Age Group

Nuclide	Bone	Liver	T Body	Thyroid	Kidney	Lung	GI-LLI
H-3	0.00E+00	4.98E-01	4.98E-01	4.98E-01	4.98E-01	4.98E-01	4.98E-01
Na-24	1.41E+01	1.41E+01	1.41E+01	1.41E+01	1.41E+01	1.41E+01	1.41E+01
Cr-51	0.00E+00	0.00E+00	2.21E-02	1.32E-02	4.88E-03	2.94E-02	5.57E+00
Mn-54	0.00E+00	3.80E+01	7.26E+00	0.00E+00	1.13E+01	0.00E+00	1.17E+02
Mn-56	0.00E+00	9.57E-01	1.70E-01	0.00E+00	1.22E+00	0.00E+00	3.05E+01
Fe-55	2.29E+01	1.58E+01	3.69E+00	0.00E+00	0.00E+00	8.82E+00	9.07E+00
Fe-59	3.61E+01	8.49E+01	3.25E+01	0.00E+00	0.00E+00	2.37E+01	2.83E+02
Co-58	0.00E+00	6.20E+00	1.39E+01	0.00E+00	0.00E+00	0.00E+00	1.26E+02
Co-60	0.00E+00	1.78E+01	3.93E+01	0.00E+00	0.00E+00	0.00E+00	3.35E+02
Ni-63	1.08E+03	7.50E+01	3.63E+01	0.00E+00	0.00E+00	0.00E+00	1.56E+01
Ni-65	4.39E+00	5.71E-01	2.60E-01	0.00E+00	0.00E+00	0.00E+00	1.45E+01
Cu-64	0.00E+00	6.93E-01	3.25E-01	0.00E+00	1.75E+00	0.00E+00	5.91E+01
Zn-65	4.03E+01	1.28E+02	5.79E+01	0.00E+00	8.57E+01	0.00E+00	8.07E+01
Zn-69	8.57E-02	1.64E-01	1.14E-02	0.00E+00	1.07E-01	0.00E+00	2.46E-02
Br-83	0.00E+00	0.00E+00	3.35E-01	0.00E+00	0.00E+00	0.00E+00	4.82E-01
Br-84	0.00E+00	0.00E+00	4.34E-01	0.00E+00	0.00E+00	0.00E+00	3.40E-06
Br-85	0.00E+00	0.00E+00	1.78E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	1.76E+02	8.18E+01	0.00E+00	0.00E+00	0.00E+00	3.46E+01
Rb-88	0.00E+00	5.03E-01	2.67E-01	0.00E+00	0.00E+00	0.00E+00	6.96E-12
Rb-89	0.00E+00	3.34E-01	2.35E-01	0.00E+00	0.00E+00	0.00E+00	1.94E-14
Sr-89	2.56E+03	0.00E+00	7.36E+01	0.00E+00	0.00E+00	0.00E+00	4.11E+02
Sr-90	7.25E+04	0.00E+00	1.46E+03	0.00E+00	0.00E+00	0.00E+00	1.82E+03
Sr-91	4.72E+01	0.00E+00	1.91E+00	0.00E+00	0.00E+00	0.00E+00	2.25E+02
Sr-92	1.79E+01	0.00E+00	7.74E-01	0.00E+00	0.00E+00	0.00E+00	3.55E+02
Y-90	8.01E-02	0.00E+00	2.15E-03	0.00E+00	0.00E+00	0.00E+00	8.49E+02
Y-91M	7.56E-04	0.00E+00	2.93E-05	0.00E+00	0.00E+00	0.00E+00	2.22E-03
Y-91	1.17E+00	0.00E+00	3.14E-02	0.00E+00	0.00E+00	0.00E+00	6.46E+02
Y-92	7.03E-03	0.00E+00	2.06E-04	0.00E+00	0.00E+00	0.00E+00	1.23E+02
Y-93	2.23E-02	0.00E+00	6.16E-04	0.00E+00	0.00E+00	0.00E+00	7.07E+02
Zr-95	2.53E-01	8.11E-02	5.49E-02	0.00E+00	1.27E-01	0.00E+00	2.57E+02
Zr-97	1.40E-02	2.82E-03	1.29E-03	0.00E+00	4.26E-03	0.00E+00	8.74E+02
Nb-95	5.18E-02	2.88E-02	1.55E-02	0.00E+00	2.85E-02	0.00E+00	1.75E+02
Nb-97	4.35E-04	1.10E-04	4.02E-05	0.00E+00	1.28E-04	0.00E+00	4.06E-01
Mo-99	0.00E+00	3.59E+01	6.82E+00	0.00E+00	8.12E+01	0.00E+00	8.31E+01
Tc- 99M	2.06E-03	5.81E-03	7.40E-02	0.00E+00	8.82E-02	2.85E-03	3.44E+00
Tc-101	2.11E-03	3.05E-03	2.99E-02	0.00E+00	5.48E-02	1.56E-03	9.15E-15
Ru-103	1.54E+00	0.00E+00	6.63E-01	0.00E+00	5.88E+00	0.00E+00	1.80E+02
Ru-105	1.28E-01	0.00E+00	5.06E-02	0.00E+00	1.66E+00	0.00E+00	7.84E+01
Ru-106	2.29E+01	0.00E+00	2.90E+00	0.00E+00	4.42E+01	0.00E+00	1.48E+03
Ag-110M	1.33E+00	1.23E+00	7.32E-01	0.00E+00	2.42E+00	0.00E+00	5.03E+02
Sb-124	2.33E+01	4.41E-01	9.25E+00	5.66E-02	0.00E+00	1.82E+01	6.63E+02
Sb-125	1.49E+01	1.67E-01	3.55E+00	1.52E-02	0.00E+00	1.15E+01	1.64E+02
Te-125M	2.23E+01	8.08E+00	2.99E+00	6.71E+00	9.07E+01	0.00E+00	8.90E+01
Sb-126	9.58E+00	1.95E-01	3.46E+00	5.87E-02	0.00E+00	5.88E+00	7.83E+02

Table 3-1 (continued)
Site Specific Potable Water Dose Factors for Adult Age Group

Nuclide	Bone	Liver	T Body	Thyroid	Kidney	Lung	GI-LLI
Te-127M	5.63E+01	2.01E+01	6.87E+00	1.44E+01	2.29E+02	0.00E+00	1.89E+02
Te-127	9.15E-01	3.29E-01	1.98E-01	6.78E-01	3.73E+00	0.00E+00	7.22E+01
Te-129M	9.57E+01	3.57E+01	1.51E+01	3.29E+01	3.99E+02	0.00E+00	4.82E+02
Te-129	2.61E-01	9.82E-02	6.37E-02	2.01E-01	1.10E+00	0.00E+00	1.97E-01
Te-131M	1.44E+01	7.04E+00	5.87E+00	1.12E+01	7.13E+01	0.00E+00	6.99E+02
Te-131	1.64E-01	6.85E-02	5.18E-02	1.35E-01	7.18E-01	0.00E+00	2.32E-02
Te-132	2.10E+01	1.36E+01	1.27E+01	1.50E+01	1.31E+02	0.00E+00	6.42E+02
I-130	6.29E+00	1.86E+01	7.32E+00	1.57E+03	2.90E+01	0.00E+00	1.60E+01
I-131	3.46E+01	4.95E+01	2.84E+01	1.62E+04	8.49E+01	0.00E+00	1.31E+01
I-132	1.69E+00	4.52E+00	1.58E+00	1.58E+02	7.20E+00	0.00E+00	8.49E-01
I-133	1.18E+01	2.06E+01	6.27E+00	3.02E+03	3.59E+01	0.00E+00	1.85E+01
I-134	8.82E-01	2.40E+00	8.57E-01	4.15E+01	3.81E+00	0.00E+00	2.09E-03
I-135	3.69E+00	9.65E+00	3.56E+00	6.37E+02	1.55E+01	0.00E+00	1.09E+01
Cs-134	5.18E+02	1.23E+03	1.01E+03	0.00E+00	3.99E+02	1.32E+02	2.16E+01
Cs-136	5.42E+01	2.14E+02	1.54E+02	0.00E+00	1.19E+02	1.63E+01	2.43E+01
Cs-137	6.63E+02	9.07E+02	5.94E+02	0.00E+00	3.08E+02	1.02E+02	1.76E+01
Cs-138	4.59E-01	9.07E-01	4.49E-01	0.00E+00	6.67E-01	6.58E-02	3.87E-06
Ba-139	8.07E-01	5.75E-04	2.36E-02	0.00E+00	5.38E-04	3.26E-04	1.43E+00
Ba-140	1.69E+02	2.12E-01	1.11E+01	0.00E+00	7.22E-02	1.22E-01	3.48E+02
Ba-141	3.92E-01	2.96E-04	1.32E-02	0.00E+00	2.75E-04	1.68E-04	1.85E-10
Ba-142	1.77E-01	1.82E-04	1.12E-02	0.00E+00	1.54E-04	1.03E-04	2.50E-19
La-140	2.08E-02	1.05E-02	2.77E-03	0.00E+00	0.00E+00	0.00E+00	7.70E+02
La-142	1.07E-03	4.84E-04	1.21E-04	0.00E+00	0.00E+00	0.00E+00	3.54E+00
Ce-141	7.79E-02	5.27E-02	5.98E-03	0.00E+00	2.45E-02	0.00E+00	2.01E+02
Ce-143	1.37E-02	1.02E+01	1.12E-03	0.00E+00	4.47E-03	0.00E+00	3.79E+02
Ce-144	4.06E+00	1.70E+00	2.18E-01	0.00E+00	1.01E+00	0.00E+00	1.37E+03
Pr-143	7.66E-02	3.07E-02	3.79E-03	0.00E+00	1.77E-02	0.00E+00	3.35E+02
Pr-144	2.50E-04	1.04E-04	1.27E-05	0.00E+00	5.87E-05	0.00E+00	3.60E-11
Nd-147	5.23E-02	6.05E-02	3.62E-03	0.00E+00	3.54E-02	0.00E+00	2.90E+02
W-187	8.57E-01	7.17E-01	2.50E-01	0.00E+00	0.00E+00	0.00E+00	2.35E+02
Np-239	9.90E-03	9.74E-04	5.37E-04	0.00E+00	3.04E-03	0.00E+00	2.00E+02

Notes:

- 1) Units are mrem/hr per $\mu\text{Ci/ml}$.

Table 3-2
Site Specific Potable Water Dose Factors for Teen Age Group

Nuclide	Bone	Liver	T Body	Thyroid	Kidney	Lung	GI-LLI
H-3	0.00E+00	3.51E-01	3.51E-01	3.51E-01	3.51E-01	3.51E-01	3.51E-01
Na-24	1.34E+01	1.34E+01	1.34E+01	1.34E+01	1.34E+01	1.34E+01	1.34E+01
Cr-51	0.00E+00	0.00E+00	2.09E-02	1.16E-02	4.59E-03	2.99E-02	3.52E+00
Mn-54	0.00E+00	3.43E+01	6.80E+00	0.00E+00	1.02E+01	0.00E+00	7.03E+01
Mn-56	0.00E+00	9.19E-01	1.63E-01	0.00E+00	1.16E+00	0.00E+00	6.05E+01
Fe-55	2.20E+01	1.56E+01	3.63E+00	0.00E+00	0.00E+00	9.88E+00	6.74E+00
Fe-59	3.41E+01	7.97E+01	3.08E+01	0.00E+00	0.00E+00	2.51E+01	1.88E+02
Co-58	0.00E+00	5.65E+00	1.30E+01	0.00E+00	0.00E+00	0.00E+00	7.79E+01
Co-60	0.00E+00	1.63E+01	3.68E+01	0.00E+00	0.00E+00	0.00E+00	2.13E+02
Ni-63	1.03E+03	7.27E+01	3.49E+01	0.00E+00	0.00E+00	0.00E+00	1.16E+01
Ni-65	4.35E+00	5.56E-01	2.53E-01	0.00E+00	0.00E+00	0.00E+00	3.02E+01
Cu-64	0.00E+00	6.69E-01	3.15E-01	0.00E+00	1.69E+00	0.00E+00	5.19E+01
Zn-65	3.35E+01	1.16E+02	5.42E+01	0.00E+00	7.44E+01	0.00E+00	4.92E+01
Zn-69	8.55E-02	1.63E-01	1.14E-02	0.00E+00	1.06E-01	0.00E+00	3.00E-01
Br-83	0.00E+00	0.00E+00	3.34E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-84	0.00E+00	0.00E+00	4.20E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-85	0.00E+00	0.00E+00	1.77E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	1.73E+02	8.14E+01	0.00E+00	0.00E+00	0.00E+00	2.56E+01
Rb-88	0.00E+00	4.95E-01	2.64E-01	0.00E+00	0.00E+00	0.00E+00	4.24E-08
Rb-89	0.00E+00	3.20E-01	2.26E-01	0.00E+00	0.00E+00	0.00E+00	4.90E-10
Sr-89	2.56E+03	0.00E+00	7.33E+01	0.00E+00	0.00E+00	0.00E+00	3.05E+02
Sr-90	5.93E+04	0.00E+00	1.19E+03	0.00E+00	0.00E+00	0.00E+00	1.35E+03
Sr-91	4.69E+01	0.00E+00	1.87E+00	0.00E+00	0.00E+00	0.00E+00	2.13E+02
Sr-92	1.77E+01	0.00E+00	7.56E-01	0.00E+00	0.00E+00	0.00E+00	4.52E+02
Y-90	7.97E-02	0.00E+00	2.15E-03	0.00E+00	0.00E+00	0.00E+00	6.57E+02
Y-91M	7.50E-04	0.00E+00	2.87E-05	0.00E+00	0.00E+00	0.00E+00	3.54E-02
Y-91	1.17E+00	0.00E+00	3.13E-02	0.00E+00	0.00E+00	0.00E+00	4.79E+02
Y-92	7.03E-03	0.00E+00	2.03E-04	0.00E+00	0.00E+00	0.00E+00	1.93E+02
Y-93	2.23E-02	0.00E+00	6.10E-04	0.00E+00	0.00E+00	0.00E+00	6.80E+02
Zr-95	2.40E-01	7.56E-02	5.20E-02	0.00E+00	1.11E-01	0.00E+00	1.74E+02
Zr-97	1.38E-02	2.73E-03	1.26E-03	0.00E+00	4.13E-03	0.00E+00	7.38E+02
Nb-95	4.78E-02	2.65E-02	1.46E-02	0.00E+00	2.57E-02	0.00E+00	1.13E+02
Nb-97	4.29E-04	1.07E-04	3.89E-05	0.00E+00	1.25E-04	0.00E+00	2.54E+00
Mo-99	0.00E+00	3.51E+01	6.69E+00	0.00E+00	8.02E+01	0.00E+00	6.28E+01
Tc- 99M	1.93E-03	5.38E-03	6.98E-02	0.00E+00	8.02E-02	2.99E-03	3.53E+00
Tc-101	2.09E-03	2.98E-03	2.92E-02	0.00E+00	5.38E-02	1.81E-03	5.09E-10
Ru-103	1.48E+00	0.00E+00	6.34E-01	0.00E+00	5.23E+00	0.00E+00	1.24E+02
Ru-105	1.27E-01	0.00E+00	4.92E-02	0.00E+00	1.60E+00	0.00E+00	1.02E+02
Ru-106	2.28E+01	0.00E+00	2.87E+00	0.00E+00	4.40E+01	0.00E+00	1.09E+03
Ag-110M	1.19E+00	1.13E+00	6.86E-01	0.00E+00	2.15E+00	0.00E+00	3.17E+02
Sb-124	2.25E+01	4.15E-01	8.79E+00	5.11E-02	0.00E+00	1.97E+01	4.54E+02
Sb-125	1.44E+01	1.58E-01	3.38E+00	1.38E-02	0.00E+00	1.27E+01	1.12E+02
Te-125M	2.23E+01	8.02E+00	2.98E+00	6.22E+00	0.00E+00	0.00E+00	6.57E+01
Sb-126	9.26E+00	1.89E-01	3.32E+00	5.23E-02	0.00E+00	6.64E+00	5.48E+02

Table 3-2 (continued)
Site Specific Potable Water Dose Factors for Teen Age Group

Nuclide	Bone	Liver	T Body	Thyroid	Kidney	Lung	GI-LLI
Te-127M	5.62E+01	1.99E+01	6.69E+00	1.34E+01	2.28E+02	0.00E+00	1.40E+02
Te-127	9.19E-01	3.26E-01	1.98E-01	6.34E-01	3.72E+00	0.00E+00	7.09E+01
Te-129M	9.48E+01	3.52E+01	1.50E+01	3.06E+01	3.97E+02	0.00E+00	3.56E+02
Te-129	2.60E-01	9.71E-02	6.34E-02	1.86E-01	1.09E+00	0.00E+00	1.42E+00
Te-131M	1.42E+01	6.80E+00	5.67E+00	1.02E+01	7.09E+01	0.00E+00	5.46E+02
Te-131	1.62E-01	6.69E-02	5.07E-02	1.25E-01	7.09E-01	0.00E+00	1.33E-02
Te-132	2.03E+01	1.28E+01	1.21E+01	1.35E+01	1.23E+02	0.00E+00	4.07E+02
I-130	5.99E+00	1.73E+01	6.92E+00	1.41E+03	2.67E+01	0.00E+00	1.33E+01
I-131	3.40E+01	4.76E+01	2.56E+01	1.39E+04	8.20E+01	0.00E+00	9.42E+00
I-132	1.62E+00	4.24E+00	1.52E+00	1.43E+02	6.69E+00	0.00E+00	1.85E+00
I-133	1.17E+01	1.98E+01	6.05E+00	2.77E+03	3.48E+01	0.00E+00	1.50E+01
I-134	8.49E-01	2.25E+00	8.08E-01	3.75E+01	3.55E+00	0.00E+00	2.97E-02
I-135	3.55E+00	9.13E+00	3.38E+00	5.87E+02	1.44E+01	0.00E+00	1.01E+01
Cs-134	4.87E+02	1.15E+03	5.31E+02	0.00E+00	3.64E+02	1.39E+02	1.42E+01
Cs-136	4.99E+01	1.97E+02	1.32E+02	0.00E+00	1.07E+02	1.69E+01	1.58E+01
Cs-137	6.51E+02	8.66E+02	3.02E+02	0.00E+00	2.95E+02	1.15E+02	1.23E+01
Cs-138	4.51E-01	8.66E-01	4.33E-01	0.00E+00	6.40E-01	7.44E-02	3.93E-04
Ba-139	8.08E-01	5.69E-04	2.35E-02	0.00E+00	5.36E-04	3.92E-04	7.21E+00
Ba-140	1.65E+02	2.02E-01	1.06E+01	0.00E+00	6.86E-02	1.36E-01	2.55E+02
Ba-141	3.90E-01	2.91E-04	1.30E-02	0.00E+00	2.70E-04	1.99E-04	8.31E-07
Ba-142	1.74E-01	1.74E-04	1.07E-02	0.00E+00	1.47E-04	1.16E-04	5.34E-13
La-140	2.02E-02	9.94E-03	2.65E-03	0.00E+00	0.00E+00	0.00E+00	5.71E+02
La-142	1.04E-03	4.62E-04	1.15E-04	0.00E+00	0.00E+00	0.00E+00	1.41E+01
Ce-141	7.73E-02	5.16E-02	5.93E-03	0.00E+00	2.43E-02	0.00E+00	1.48E+02
Ce-143	1.37E-02	9.94E+00	1.11E-03	0.00E+00	4.46E-03	0.00E+00	2.99E+02
Ce-144	4.05E+00	1.67E+00	2.17E-01	0.00E+00	1.00E+00	0.00E+00	1.02E+03
Pr-143	7.62E-02	3.04E-02	3.79E-03	0.00E+00	1.77E-02	0.00E+00	2.51E+02
Pr-144	2.50E-04	1.02E-04	1.27E-05	0.00E+00	5.87E-05	0.00E+00	2.76E-07
Nd-147	5.45E-02	5.93E-02	3.55E-03	0.00E+00	3.48E-02	0.00E+00	2.14E+02
W-187	8.49E-01	6.92E-01	2.42E-01	0.00E+00	0.00E+00	0.00E+00	1.87E+02
Np-239	1.02E-02	9.65E-04	5.36E-04	0.00E+00	3.03E-03	0.00E+00	1.55E+02

Notes:

- 1) Units are mrem/hr per $\mu\text{Ci/ml}$.

Table 3-3
Site Specific Potable Water Dose Factors for Child Age Group

Nuclide	Bone	Liver	T Body	Thyroid	Kidney	Lung	GI-LLI
H-3	0.00E+00	6.74E-01	6.74E-01	6.74E-01	6.74E-01	6.74E-01	6.74E-01
Na-24	3.37E+01	3.37E+01	3.37E+01	3.37E+01	3.37E+01	3.37E+01	3.37E+01
Cr-51	0.00E+00	0.00E+00	5.17E-02	2.87E-02	7.85E-03	5.24E-02	2.74E+00
Mn-54	0.00E+00	6.22E+01	1.66E+01	0.00E+00	1.74E+01	0.00E+00	5.22E+01
Mn-56	0.00E+00	1.94E+00	4.38E-01	0.00E+00	2.35E+00	0.00E+00	2.81E+02
Fe-55	6.69E+01	3.55E+01	1.10E+01	0.00E+00	0.00E+00	2.01E+01	6.57E+00
Fe-59	9.59E+01	1.55E+02	7.73E+01	0.00E+00	0.00E+00	4.50E+01	1.62E+02
Co-58	0.00E+00	1.05E+01	3.20E+01	0.00E+00	0.00E+00	0.00E+00	6.10E+01
Co-60	0.00E+00	3.08E+01	9.07E+01	0.00E+00	0.00E+00	0.00E+00	1.70E+02
Ni-63	3.13E+03	1.67E+02	1.06E+02	0.00E+00	0.00E+00	0.00E+00	1.13E+01
Ni-65	1.29E+01	1.22E+00	7.09E-01	0.00E+00	0.00E+00	0.00E+00	1.49E+02
Cu-64	0.00E+00	1.42E+00	8.60E-01	0.00E+00	3.44E+00	0.00E+00	6.69E+01
Zn-65	7.97E+01	2.12E+02	1.32E+02	0.00E+00	1.34E+02	0.00E+00	3.73E+01
Zn-69	2.55E-01	3.68E-01	3.40E-02	0.00E+00	2.23E-01	0.00E+00	2.32E+01
Br-83	0.00E+00	0.00E+00	9.94E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-84	0.00E+00	0.00E+00	1.15E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-85	0.00E+00	0.00E+00	5.30E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	3.90E+02	2.40E+02	0.00E+00	0.00E+00	0.00E+00	2.51E+01
Rb-88	0.00E+00	1.10E+00	7.67E-01	0.00E+00	0.00E+00	0.00E+00	5.42E-02
Rb-89	0.00E+00	6.80E-01	6.05E-01	0.00E+00	0.00E+00	0.00E+00	5.93E-03
Sr-89	7.67E+03	0.00E+00	2.19E+02	0.00E+00	0.00E+00	0.00E+00	2.97E+02
Sr-90	1.49E+05	0.00E+00	2.99E+03	0.00E+00	0.00E+00	0.00E+00	1.33E+03
Sr-91	1.40E+02	0.00E+00	5.27E+00	0.00E+00	0.00E+00	0.00E+00	3.08E+02
Sr-92	5.25E+01	0.00E+00	2.10E+00	0.00E+00	0.00E+00	0.00E+00	9.94E+02
Y-90	2.39E-01	0.00E+00	6.40E-03	0.00E+00	0.00E+00	0.00E+00	6.80E+02
Y-91M	2.22E-03	0.00E+00	8.08E-05	0.00E+00	0.00E+00	0.00E+00	4.35E+00
Y-91	3.50E+00	0.00E+00	9.36E-02	0.00E+00	0.00E+00	0.00E+00	4.66E+02
Y-92	2.09E-02	0.00E+00	5.99E-04	0.00E+00	0.00E+00	0.00E+00	6.05E+02
Y-93	6.63E-02	0.00E+00	1.82E-03	0.00E+00	0.00E+00	0.00E+00	9.88E+02
Zr-95	6.74E-01	1.48E-01	1.32E-01	0.00E+00	2.12E-01	0.00E+00	1.55E+02
Zr-97	4.06E-02	5.87E-03	3.47E-03	0.00E+00	8.43E-03	0.00E+00	8.90E+02
Nb-95	1.31E-01	5.09E-02	3.64E-02	0.00E+00	4.78E-02	0.00E+00	9.42E+01
Nb-97	1.26E-03	2.28E-04	1.07E-04	0.00E+00	2.53E-04	0.00E+00	7.04E+01
Mo-99	0.00E+00	7.73E+01	1.91E+01	0.00E+00	1.65E+02	0.00E+00	6.40E+01
Tc- 99M	5.37E-03	1.05E-02	1.74E-01	0.00E+00	1.53E-01	5.34E-03	5.99E+00
Tc-101	6.22E-03	6.51E-03	8.26E-02	0.00E+00	1.11E-01	3.44E-03	2.07E-02
Ru-103	4.25E+00	0.00E+00	1.63E+00	0.00E+00	1.07E+01	0.00E+00	1.10E+02
Ru-105	3.75E-01	0.00E+00	1.36E-01	0.00E+00	3.30E+00	0.00E+00	2.45E+02
Ru-106	6.80E+01	0.00E+00	8.49E+00	0.00E+00	9.19E+01	0.00E+00	1.06E+03
Ag-110M	3.13E+00	2.12E+00	1.69E+00	0.00E+00	3.94E+00	0.00E+00	2.52E+02
Sb-124	6.46E+01	8.38E-01	2.26E+01	1.43E-01	0.00E+00	3.59E+01	4.04E+02
Sb-125	4.17E+01	3.21E-01	8.73E+00	3.86E-02	0.00E+00	2.32E+01	9.96E+01
Te-125M	6.63E+01	1.80E+01	8.84E+00	1.86E+01	0.00E+00	0.00E+00	6.40E+01
Sb-126	2.56E+01	3.92E-01	9.20E+00	1.50E-01	0.00E+00	1.22E+01	5.16E+02

Table 3-3 (continued)
Site Specific Potable Water Dose Factors for Child Age Group

Nuclide	Bone	Liver	T Body	Thyroid	Kidney	Lung	GI-LLI
Te-127M	1.68E+02	4.52E+01	1.99E+01	4.02E+01	4.79E+02	0.00E+00	1.36E+02
Te-127	2.74E+00	7.38E-01	5.87E-01	1.90E+00	7.79E+00	0.00E+00	1.07E+02
Te-129M	2.83E+02	7.91E+01	4.40E+01	9.13E+01	8.31E+02	0.00E+00	3.45E+02
Te-129	7.79E-01	2.17E-01	1.85E-01	5.56E-01	2.28E+00	0.00E+00	4.85E+01
Te-131M	4.19E+01	1.45E+01	1.54E+01	2.98E+01	1.40E+02	0.00E+00	5.87E+02
Te-131	4.83E-01	1.47E-01	1.44E-01	3.69E-01	1.46E+00	0.00E+00	2.53E+00
Te-132	5.87E+01	2.60E+01	3.14E+01	3.78E+01	2.41E+02	0.00E+00	2.62E+02
I-130	1.70E+01	3.43E+01	1.77E+01	3.78E+03	5.13E+01	0.00E+00	1.60E+01
I-131	1.00E+02	1.01E+02	5.72E+01	3.33E+04	1.65E+02	0.00E+00	8.95E+00
I-132	4.65E+00	8.55E+00	3.93E+00	3.97E+02	1.31E+01	0.00E+00	1.01E+01
I-133	3.44E+01	4.26E+01	1.61E+01	7.91E+03	7.09E+01	0.00E+00	1.72E+01
I-134	2.44E+00	4.52E+00	2.08E+00	1.04E+02	6.92E+00	0.00E+00	3.00E+00
I-135	1.02E+01	1.83E+01	8.66E+00	1.62E+03	2.81E+01	0.00E+00	1.40E+01
Cs-134	1.36E+03	2.23E+03	4.71E+02	0.00E+00	6.92E+02	2.48E+02	1.20E+01
Cs-136	1.37E+02	3.76E+02	2.43E+02	0.00E+00	2.00E+02	2.98E+01	1.32E+01
Cs-137	1.90E+03	1.82E+03	2.69E+02	0.00E+00	5.93E+02	2.13E+02	1.14E+01
Cs-138	1.33E+00	1.84E+00	1.17E+00	0.00E+00	1.30E+00	1.40E-01	8.49E-01
Ba-139	2.41E+00	1.28E-03	6.98E-02	0.00E+00	1.12E-03	7.56E-04	1.39E+02
Ba-140	4.83E+02	4.23E-01	2.82E+01	0.00E+00	1.38E-01	2.52E-01	2.45E+02
Ba-141	1.16E+00	6.51E-04	3.78E-02	0.00E+00	5.63E-04	3.83E-03	6.63E-01
Ba-142	5.08E-01	3.66E-04	2.84E-02	0.00E+00	2.96E-04	2.15E-04	6.63E-03
La-140	5.87E-02	2.05E-02	6.92E-03	0.00E+00	0.00E+00	0.00E+00	5.72E+02
La-142	3.05E-03	9.71E-04	3.04E-04	0.00E+00	0.00E+00	0.00E+00	1.92E+02
Ce-141	2.31E-01	1.15E-01	1.71E-02	0.00E+00	5.05E-02	0.00E+00	1.44E+02
Ce-143	4.06E-02	2.20E+01	3.19E-03	0.00E+00	9.24E-03	0.00E+00	3.23E+02
Ce-144	1.21E+01	3.79E+00	6.45E-01	0.00E+00	2.10E+00	0.00E+00	9.88E+02
Pr-143	2.28E-01	6.86E-02	1.13E-02	0.00E+00	3.72E-02	0.00E+00	2.47E+02
Pr-144	7.50E-04	2.32E-04	3.77E-05	0.00E+00	1.23E-04	0.00E+00	4.99E-01
Nd-147	1.62E-01	1.31E-01	1.02E-02	0.00E+00	7.21E-02	0.00E+00	2.08E+02
W-187	2.49E+00	1.48E+00	6.63E-01	0.00E+00	0.00E+00	0.00E+00	2.08E+02
Np-239	3.05E-02	2.19E-03	1.54E-03	0.00E+00	6.34E-03	0.00E+00	1.62E+02

Notes:

- 1) Units are mrem/hr per $\mu\text{Ci/ml}$.

Table 3-4
Site Specific Potable Water Dose Factors for Infant Age Group

Nuclide	Bone	Liver	T Body	Thyroid	Kidney	Lung	GI-LLI
H-3	0.00E+00	6.62E-01	6.62E-01	6.62E-01	6.62E-01	6.62E-01	6.62E-01
Na-24	3.80E+01	3.80E+01	3.80E+01	3.80E+01	3.80E+01	3.80E+01	3.80E+01
Cr-51	0.00E+00	0.00E+00	5.30E-02	3.46E-02	7.56E-03	6.73E-02	1.55E+00
Mn-54	0.00E+00	7.49E+01	1.70E+01	0.00E+00	1.66E+01	0.00E+00	2.75E+01
Mn-56	0.00E+00	3.08E+00	5.30E-01	0.00E+00	2.64E+00	0.00E+00	2.80E+02
Fe-55	5.23E+01	3.38E+01	9.03E+00	0.00E+00	0.00E+00	1.65E+01	4.29E+00
Fe-59	1.16E+02	2.02E+02	7.98E+01	0.00E+00	0.00E+00	5.98E+01	9.67E+01
Co-58	0.00E+00	1.35E+01	3.38E+01	0.00E+00	0.00E+00	0.00E+00	3.37E+01
Co-60	0.00E+00	4.06E+01	9.59E+01	0.00E+00	0.00E+00	0.00E+00	9.67E+01
Ni-63	2.39E+03	1.47E+02	8.28E+01	0.00E+00	0.00E+00	0.00E+00	7.34E+00
Ni-65	1.77E+01	2.00E+00	9.10E-01	0.00E+00	0.00E+00	0.00E+00	1.52E+02
Cu-64	0.00E+00	2.29E+00	1.06E+00	0.00E+00	3.87E+00	0.00E+00	4.70E+01
Zn-65	6.92E+01	2.37E+02	1.09E+02	0.00E+00	1.15E+02	0.00E+00	2.01E+02
Zn-69	3.51E-01	6.32E-01	4.70E-02	0.00E+00	2.63E-01	0.00E+00	5.15E+01
Br-83	0.00E+00	0.00E+00	1.37E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-84	0.00E+00	0.00E+00	1.44E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-85	0.00E+00	0.00E+00	7.30E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	6.40E+02	3.16E+02	0.00E+00	0.00E+00	0.00E+00	1.64E+01
Rb-88	0.00E+00	1.87E+00	1.03E+00	0.00E+00	0.00E+00	0.00E+00	1.82E+00
Rb-89	0.00E+00	1.08E+00	7.41E-01	0.00E+00	0.00E+00	0.00E+00	3.66E-01
Sr-89	9.44E+03	0.00E+00	2.71E+02	0.00E+00	0.00E+00	0.00E+00	1.94E+02
Sr-90	1.06E+05	0.00E+00	2.16E+03	0.00E+00	0.00E+00	0.00E+00	8.69E+02
Sr-91	1.88E+02	0.00E+00	6.81E+00	0.00E+00	0.00E+00	0.00E+00	2.23E+02
Sr-92	7.22E+01	0.00E+00	2.68E+00	0.00E+00	0.00E+00	0.00E+00	7.79E+02
Y-90	3.27E-01	0.00E+00	8.77E-03	0.00E+00	0.00E+00	0.00E+00	4.51E+02
Y-91M	3.05E-03	0.00E+00	1.04E-04	0.00E+00	0.00E+00	0.00E+00	1.02E+01
Y-91	4.25E+00	0.00E+00	1.13E-01	0.00E+00	0.00E+00	0.00E+00	3.05E+02
Y-92	2.88E-02	0.00E+00	8.09E-04	0.00E+00	0.00E+00	0.00E+00	5.49E+02
Y-93	9.14E-02	0.00E+00	2.49E-03	0.00E+00	0.00E+00	0.00E+00	7.22E+02
Zr-95	7.75E-01	1.89E-01	1.34E-01	0.00E+00	2.04E-01	0.00E+00	9.41E+01
Zr-97	5.57E-02	9.56E-03	4.36E-03	0.00E+00	9.63E-03	0.00E+00	6.09E+02
Nb-95	1.58E-01	6.51E-02	3.76E-02	0.00E+00	4.66E-02	0.00E+00	5.49E+01
Nb-97	1.73E-03	3.69E-04	1.33E-04	0.00E+00	2.88E-04	0.00E+00	1.16E+02
Mo-99	0.00E+00	1.28E+02	2.49E+01	0.00E+00	1.91E+02	0.00E+00	4.21E+01
Tc- 99M	7.22E-03	1.49E-02	1.92E-01	0.00E+00	1.60E-01	7.79E-03	4.33E+00
Tc-101	8.54E-03	1.08E-02	1.06E-01	0.00E+00	1.28E-01	5.87E-03	1.83E+00
Ru-103	5.57E+00	0.00E+00	1.86E+00	0.00E+00	1.16E+01	0.00E+00	6.77E+01
Ru-105	5.12E-01	0.00E+00	1.72E-01	0.00E+00	3.76E+00	0.00E+00	2.04E+02
Ru-106	9.07E+01	0.00E+00	1.13E+01	0.00E+00	1.07E+02	0.00E+00	6.88E+02
Ag-110M	3.75E+00	2.73E+00	1.81E+00	0.00E+00	3.91E+00	0.00E+00	1.42E+02
Sb-124	8.06E+01	1.19E+00	2.50E+01	2.14E-01	0.00E+00	5.05E+01	2.49E+02
Sb-125	4.63E+01	4.48E-01	9.53E+00	5.80E-02	0.00E+00	2.68E+01	6.18E+01
Te-125M	8.77E+01	2.93E+01	1.19E+01	2.95E+01	0.00E+00	0.00E+00	4.18E+01
Sb-126	3.04E+01	5.95E-01	1.10E+01	2.33E-01	0.00E+00	1.91E+01	3.15E+02

Table 3-4 (continued)
Site Specific Potable Water Dose Factors for Infant Age Group

Nuclide	Bone	Liver	T Body	Thyroid	Kidney	Lung	GI-LLI
Te-127M	2.20E+02	7.30E+01	2.66E+01	6.36E+01	5.42E+02	0.00E+00	8.88E+01
Te-127	3.76E+00	1.26E+00	8.09E-01	3.06E+00	9.18E+00	0.00E+00	7.90E+01
Te-129M	3.76E+02	1.29E+02	5.79E+01	1.44E+02	9.41E+02	0.00E+00	2.25E+02
Te-129	1.07E+00	3.68E-01	2.49E-01	8.95E-01	2.66E+00	0.00E+00	8.54E+01
Te-131M	5.72E+01	2.30E+01	1.90E+01	4.66E+01	1.58E+02	0.00E+00	3.87E+02
Te-131	6.62E-01	2.45E-01	1.86E-01	5.91E-01	1.69E+00	0.00E+00	2.67E+01
Te-132	7.82E+01	3.87E+01	3.62E+01	5.72E+01	2.42E+02	0.00E+00	1.43E+02
I-130	2.26E+01	4.97E+01	1.99E+01	5.57E+03	5.45E+01	0.00E+00	1.06E+01
I-131	1.35E+02	1.59E+02	7.00E+01	5.23E+04	1.86E+02	0.00E+00	5.68E+00
I-132	6.24E+00	1.27E+01	4.51E+00	5.94E+02	1.41E+01	0.00E+00	1.03E+01
I-133	4.70E+01	6.85E+01	2.01E+01	1.25E+04	8.05E+01	0.00E+00	1.16E+01
I-134	3.27E+00	6.70E+00	2.38E+00	1.56E+02	7.49E+00	0.00E+00	6.92E+00
I-135	1.37E+01	2.72E+01	9.93E+00	2.44E+03	3.04E+01	0.00E+00	9.86E+00
Cs-134	1.42E+03	2.64E+03	2.67E+02	0.00E+00	6.81E+02	2.79E+02	7.19E+00
Cs-136	1.73E+02	5.08E+02	1.90E+02	0.00E+00	2.02E+02	4.14E+01	7.71E+00
Cs-137	1.96E+03	2.30E+03	1.63E+02	0.00E+00	6.17E+02	2.50E+02	7.19E+00
Cs-138	1.81E+00	2.94E+00	1.43E+00	0.00E+00	1.47E+00	2.29E-01	4.70E+00
Ba-139	3.31E+00	2.20E-03	9.59E-02	0.00E+00	1.32E-03	1.33E-03	2.10E+02
Ba-140	6.43E+02	6.43E-01	3.31E+01	0.00E+00	1.53E-01	3.95E-01	1.58E+02
Ba-141	1.60E+00	1.09E-03	5.04E-02	0.00E+00	6.58E-04	6.66E-04	1.95E+01
Ba-142	6.92E-01	5.76E-04	3.41E-02	0.00E+00	3.31E-04	3.48E-04	2.86E+00
La-140	7.94E-02	3.13E-02	8.05E-03	0.00E+00	0.00E+00	0.00E+00	3.68E+02
La-142	4.14E-03	1.52E-03	3.64E-04	0.00E+00	0.00E+00	0.00E+00	2.58E+02
Ce-141	2.96E-01	1.81E-01	2.13E-02	0.00E+00	5.57E-02	0.00E+00	9.33E+01
Ce-143	5.57E-02	3.69E+01	4.21E-03	0.00E+00	1.08E-02	0.00E+00	2.16E+02
Ce-144	1.12E+01	4.59E+00	6.28E-01	0.00E+00	1.85E+00	0.00E+00	6.43E+02
Pr-143	3.06E-01	1.14E-01	1.52E-02	0.00E+00	4.25E-02	0.00E+00	1.61E+02
Pr-144	1.03E-03	3.99E-04	5.19E-05	0.00E+00	1.44E-04	0.00E+00	1.85E+01
Nd-147	2.08E-01	2.14E-01	1.31E-02	0.00E+00	8.24E-02	0.00E+00	1.35E+02
W-187	3.40E+00	2.36E+00	8.16E-01	0.00E+00	0.00E+00	0.00E+00	1.39E+02
Np-239	4.18E-02	3.74E-03	2.11E-03	0.00E+00	7.45E-03	0.00E+00	1.08E+02

Notes:

- 1) Units are mrem/hr per $\mu\text{Ci/ml}$.

Table 3-5
Site Specific Fish Ingestion Dose Factors for Adult Age Group

Nuclide	Bone	Liver	T Body	Thyroid	Kidney	Lung	GI-LLI
H-3	0.00E+00	1.29E-01	1.29E-01	1.29E-01	1.29E-01	1.29E-01	1.29E-01
Na-24	4.07E+02	4.07E+02	4.07E+02	4.07E+02	4.07E+02	4.07E+02	4.07E+02
Cr-51	0.00E+00	0.00E+00	1.27E+00	7.61E-01	2.81E-01	1.69E+00	3.20E+02
Mn-54	0.00E+00	4.38E+03	8.35E+02	0.00E+00	1.30E+03	0.00E+00	1.34E+04
Mn-56	0.00E+00	1.10E+02	1.95E+01	0.00E+00	1.40E+02	0.00E+00	3.51E+03
Fe-55	6.58E+02	4.55E+02	1.06E+02	0.00E+00	0.00E+00	2.54E+02	2.61E+02
Fe-59	1.04E+03	2.44E+03	9.36E+02	0.00E+00	0.00E+00	6.82E+02	8.14E+03
Co-58	0.00E+00	8.92E+01	2.00E+02	0.00E+00	0.00E+00	0.00E+00	1.81E+03
Co-60	0.00E+00	2.56E+02	5.65E+02	0.00E+00	0.00E+00	0.00E+00	4.81E+03
Ni-63	3.11E+04	2.16E+03	1.04E+03	0.00E+00	0.00E+00	0.00E+00	4.50E+02
Ni-65	1.26E+02	1.64E+01	7.49E+00	0.00E+00	0.00E+00	0.00E+00	4.17E+02
Cu-64	0.00E+00	9.97E+00	4.68E+00	0.00E+00	2.51E+01	0.00E+00	8.50E+02
Zn-65	2.32E+04	7.37E+04	3.33E+04	0.00E+00	4.93E+04	0.00E+00	4.64E+04
Zn-69	4.93E+01	9.43E+01	6.56E+00	0.00E+00	6.13E+01	0.00E+00	1.42E+01
Br-83	0.00E+00	0.00E+00	4.04E+01	0.00E+00	0.00E+00	0.00E+00	5.82E+01
Br-84	0.00E+00	0.00E+00	5.24E+01	0.00E+00	0.00E+00	0.00E+00	4.11E-04
Br-85	0.00E+00	0.00E+00	2.15E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	1.01E+05	4.71E+04	0.00E+00	0.00E+00	0.00E+00	1.99E+04
Rb-88	0.00E+00	2.90E+02	1.54E+02	0.00E+00	0.00E+00	0.00E+00	4.00E-09
Rb-89	0.00E+00	1.92E+02	1.35E+02	0.00E+00	0.00E+00	0.00E+00	1.12E-11
Sr-89	2.21E+04	0.00E+00	6.35E+02	0.00E+00	0.00E+00	0.00E+00	3.55E+03
Sr-90	6.26E+05	0.00E+00	1.26E+04	0.00E+00	0.00E+00	0.00E+00	1.57E+04
Sr-91	4.07E+02	0.00E+00	1.64E+01	0.00E+00	0.00E+00	0.00E+00	1.94E+03
Sr-92	1.54E+02	0.00E+00	6.68E+00	0.00E+00	0.00E+00	0.00E+00	3.06E+03
Y-90	5.76E-01	0.00E+00	1.54E-02	0.00E+00	0.00E+00	0.00E+00	6.10E+03
Y-91M	5.44E-03	0.00E+00	2.11E-04	0.00E+00	0.00E+00	0.00E+00	1.60E-02
Y-91	8.44E+00	0.00E+00	2.26E-01	0.00E+00	0.00E+00	0.00E+00	4.64E+03
Y-92	5.06E-02	0.00E+00	1.48E-03	0.00E+00	0.00E+00	0.00E+00	8.86E+02
Y-93	1.60E-01	0.00E+00	4.43E-03	0.00E+00	0.00E+00	0.00E+00	5.09E+03
Zr-95	2.40E-01	7.70E-02	5.21E-02	0.00E+00	1.21E-01	0.00E+00	2.44E+02
Zr-97	1.33E-02	2.68E-03	1.22E-03	0.00E+00	4.04E-03	0.00E+00	8.30E+02
Nb-95	4.47E+02	2.48E+02	1.34E+02	0.00E+00	2.46E+02	0.00E+00	1.51E+06
Nb-97	3.75E+00	9.49E-01	3.47E-01	0.00E+00	1.11E+00	0.00E+00	3.50E+03
Mo-99	0.00E+00	1.03E+02	1.96E+01	0.00E+00	2.34E+02	0.00E+00	2.39E+02
Tc- 99M	8.87E-03	2.51E-02	3.19E-01	0.00E+00	3.81E-01	1.23E-02	1.48E+01
Tc-101	9.12E-03	1.31E-02	1.29E-01	0.00E+00	2.37E-01	6.72E-03	3.95E-14
Ru-103	4.43E+00	0.00E+00	1.91E+00	0.00E+00	1.69E+01	0.00E+00	5.17E+02
Ru-105	3.69E-01	0.00E+00	1.46E-01	0.00E+00	4.76E+00	0.00E+00	2.26E+02
Ru-106	6.58E+01	0.00E+00	8.33E+00	0.00E+00	1.27E+02	0.00E+00	4.26E+03
Ag-110M	8.81E-01	8.15E-01	4.84E-01	0.00E+00	1.60E+00	0.00E+00	3.33E+02
Sb-124	6.71E+00	1.27E-01	2.66E+00	1.63E-02	0.00E+00	5.23E+00	1.91E+02
Sb-125	4.29E+00	4.80E-02	1.02E+00	4.36E-03	0.00E+00	3.31E+00	4.72E+01
Te-125M	2.57E+03	9.30E+02	3.44E+02	7.72E+02	1.04E+04	0.00E+00	1.02E+04
Sb-126	2.76E+00	5.61E-02	9.95E-01	1.69E-02	0.00E+00	1.69E+00	2.25E+02

Table 3-5 (continued)
Site Specific Fish Ingestion Dose Factors for Adult Age Group

Nuclide	Bone	Liver	T Body	Thyroid	Kidney	Lung	GI-LLI
Te-127M	6.48E+03	2.32E+03	7.90E+02	1.66E+03	2.63E+04	0.00E+00	2.17E+04
Te-127	1.05E+02	3.78E+01	2.28E+01	7.80E+01	4.29E+02	0.00E+00	8.31E+03
Te-129M	1.10E+04	4.11E+03	1.74E+03	3.78E+03	4.60E+04	0.00E+00	5.54E+04
Te-129	3.01E+01	1.13E+01	7.33E+00	2.31E+01	1.26E+02	0.00E+00	2.27E+01
Te-131M	1.66E+03	8.10E+02	6.75E+02	1.28E+03	8.21E+03	0.00E+00	8.04E+04
Te-131	1.89E+01	7.88E+00	5.96E+00	1.55E+01	8.26E+01	0.00E+00	2.67E+00
Te-132	2.41E+03	1.56E+03	1.47E+03	1.72E+03	1.50E+04	0.00E+00	7.38E+04
I-130	2.71E+01	8.01E+01	3.16E+01	6.79E+03	1.25E+02	0.00E+00	6.89E+01
I-131	1.49E+02	2.14E+02	1.22E+02	7.00E+04	3.66E+02	0.00E+00	5.64E+01
I-132	7.29E+00	1.95E+01	6.82E+00	6.82E+02	3.11E+01	0.00E+00	3.66E+00
I-133	5.10E+01	8.87E+01	2.70E+01	1.30E+04	1.55E+02	0.00E+00	7.97E+01
I-134	3.81E+00	1.03E+01	3.70E+00	1.79E+02	1.64E+01	0.00E+00	9.01E-03
I-135	1.59E+01	4.17E+01	1.54E+01	2.75E+03	6.68E+01	0.00E+00	4.70E+01
Cs-134	2.98E+05	7.09E+05	5.79E+05	0.00E+00	2.29E+05	7.61E+04	1.24E+04
Cs-136	3.12E+04	1.23E+05	8.86E+04	0.00E+00	6.85E+04	9.38E+03	1.40E+04
Cs-137	3.82E+05	5.22E+05	3.42E+05	0.00E+00	1.77E+05	5.89E+04	1.01E+04
Cs-138	2.64E+02	5.22E+02	2.59E+02	0.00E+00	3.84E+02	3.79E+01	2.23E-03
Ba-139	9.29E-01	6.62E-04	2.72E-02	0.00E+00	6.19E-04	3.75E-04	1.65E+00
Ba-140	1.94E+02	2.44E-01	1.27E+01	0.00E+00	8.30E-02	1.40E-01	4.00E+02
Ba-141	4.51E-01	3.41E-04	1.52E-02	0.00E+00	3.17E-04	1.93E-04	2.13E-10
Ba-142	2.04E-01	2.10E-04	1.28E-02	0.00E+00	1.77E-04	1.19E-04	2.87E-19
La-140	1.50E-01	7.54E-02	1.99E-02	0.00E+00	0.00E+00	0.00E+00	5.54E+03
La-142	7.66E-03	3.48E-03	8.68E-04	0.00E+00	0.00E+00	0.00E+00	2.54E+01
Ce-141	2.24E-02	1.52E-02	1.72E-03	0.00E+00	7.04E-03	0.00E+00	5.79E+01
Ce-143	3.95E-03	2.92E+00	3.23E-04	0.00E+00	1.29E-03	0.00E+00	1.09E+02
Ce-144	1.17E+00	4.88E-01	6.27E-02	0.00E+00	2.90E-01	0.00E+00	3.95E+02
Pr-143	5.51E-01	2.21E-01	2.73E-02	0.00E+00	1.27E-01	0.00E+00	2.41E+03
Pr-144	1.80E-03	7.48E-04	9.16E-05	0.00E+00	4.22E-04	0.00E+00	2.59E-10
Nd-147	3.76E-01	4.35E-01	2.60E-02	0.00E+00	2.54E-01	0.00E+00	2.09E+03
W-187	2.96E+02	2.47E+02	8.65E+01	0.00E+00	0.00E+00	0.00E+00	8.10E+04
Np-239	2.85E-02	2.80E-03	1.54E-03	0.00E+00	8.74E-03	0.00E+00	5.75E+02

Notes:

- 1) Units are mrem/hr per $\mu\text{Ci/ml}$.

Table 3-6
Site Specific Fish Ingestion Dose Factors for Teen Age Group

Nuclide	Bone	Liver	T Body	Thyroid	Kidney	Lung	GI-LLI
H-3	0.00E+00	9.92E-02	9.92E-02	9.92E-02	9.92E-02	9.92E-02	9.92E-02
Na-24	4.20E+02	4.20E+02	4.20E+02	4.20E+02	4.20E+02	4.20E+02	4.20E+02
Cr-51	0.00E+00	0.00E+00	1.31E+00	7.30E-01	2.88E-01	1.88E+00	2.21E+02
Mn-54	0.00E+00	4.30E+03	8.54E+02	0.00E+00	1.28E+03	0.00E+00	8.83E+03
Mn-56	0.00E+00	1.15E+02	2.05E+01	0.00E+00	1.46E+02	0.00E+00	7.59E+03
Fe-55	6.89E+02	4.89E+02	1.14E+02	0.00E+00	0.00E+00	3.10E+02	2.12E+02
Fe-59	1.07E+03	2.50E+03	9.65E+02	0.00E+00	0.00E+00	7.88E+02	5.91E+03
Co-58	0.00E+00	8.86E+01	2.04E+02	0.00E+00	0.00E+00	0.00E+00	1.22E+03
Co-60	0.00E+00	2.56E+02	5.77E+02	0.00E+00	0.00E+00	0.00E+00	3.34E+03
Ni-63	3.23E+04	2.28E+03	1.09E+03	0.00E+00	0.00E+00	0.00E+00	3.63E+02
Ni-65	1.37E+02	1.75E+01	7.95E+00	0.00E+00	0.00E+00	0.00E+00	9.47E+02
Cu-64	0.00E+00	1.05E+01	4.93E+00	0.00E+00	2.65E+01	0.00E+00	8.14E+02
Zn-65	2.10E+04	7.30E+04	3.40E+04	0.00E+00	4.67E+04	0.00E+00	3.09E+04
Zn-69	5.36E+01	1.02E+02	7.15E+00	0.00E+00	6.68E+01	0.00E+00	1.88E+02
Br-83	0.00E+00	0.00E+00	4.40E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-84	0.00E+00	0.00E+00	5.53E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-85	0.00E+00	0.00E+00	2.34E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	1.09E+05	5.11E+04	0.00E+00	0.00E+00	0.00E+00	1.61E+04
Rb-88	0.00E+00	3.11E+02	1.66E+02	0.00E+00	0.00E+00	0.00E+00	2.66E-05
Rb-89	0.00E+00	2.01E+02	1.42E+02	0.00E+00	0.00E+00	0.00E+00	3.08E-07
Sr-89	2.41E+04	0.00E+00	6.89E+02	0.00E+00	0.00E+00	0.00E+00	2.87E+03
Sr-90	5.58E+05	0.00E+00	1.12E+04	0.00E+00	0.00E+00	0.00E+00	1.27E+04
Sr-91	4.42E+02	0.00E+00	1.76E+01	0.00E+00	0.00E+00	0.00E+00	2.00E+03
Sr-92	1.67E+02	0.00E+00	7.11E+00	0.00E+00	0.00E+00	0.00E+00	4.25E+03
Y-90	6.25E-01	0.00E+00	1.68E-02	0.00E+00	0.00E+00	0.00E+00	5.15E+03
Y-91M	5.88E-03	0.00E+00	2.25E-04	0.00E+00	0.00E+00	0.00E+00	2.78E-01
Y-91	9.17E+00	0.00E+00	2.46E-01	0.00E+00	0.00E+00	0.00E+00	3.76E+03
Y-92	5.52E-02	0.00E+00	1.60E-03	0.00E+00	0.00E+00	0.00E+00	1.51E+03
Y-93	1.75E-01	0.00E+00	4.79E-03	0.00E+00	0.00E+00	0.00E+00	5.34E+03
Zr-95	2.48E-01	7.82E-02	5.38E-02	0.00E+00	1.15E-01	0.00E+00	1.81E+02
Zr-97	1.43E-02	2.82E-03	1.30E-03	0.00E+00	4.28E-03	0.00E+00	7.64E+02
Nb-95	4.50E+02	2.50E+02	1.37E+02	0.00E+00	2.42E+02	0.00E+00	1.07E+06
Nb-97	4.04E+00	1.00E+00	3.66E-01	0.00E+00	1.17E+00	0.00E+00	2.40E+04
Mo-99	0.00E+00	1.10E+02	2.10E+01	0.00E+00	2.52E+02	0.00E+00	1.97E+02
Tc- 99M	9.08E-03	2.53E-02	3.28E-01	0.00E+00	3.78E-01	1.41E-02	1.66E+01
Tc-101	9.85E-03	1.40E-02	1.38E-01	0.00E+00	2.53E-01	8.54E-03	2.39E-09
Ru-103	4.65E+00	0.00E+00	1.99E+00	0.00E+00	1.64E+01	0.00E+00	3.89E+02
Ru-105	3.98E-01	0.00E+00	1.54E-01	0.00E+00	5.02E+00	0.00E+00	3.21E+02
Ru-106	7.15E+01	0.00E+00	9.01E+00	0.00E+00	1.38E+02	0.00E+00	3.43E+03
Ag-110M	8.60E-01	8.14E-01	4.95E-01	0.00E+00	1.55E+00	0.00E+00	2.29E+02
Sb-124	7.07E+00	1.30E-01	2.76E+00	1.60E-02	0.00E+00	6.17E+00	1.43E+02
Sb-125	4.53E+00	4.95E-02	1.06E+00	4.33E-03	0.00E+00	3.98E+00	3.53E+01
Te-125M	2.79E+03	1.01E+03	3.74E+02	7.81E+02	0.00E+00	0.00E+00	8.24E+03
Sb-126	2.90E+00	5.94E-02	1.04E+00	1.64E-02	0.00E+00	2.08E+00	1.72E+02

Table 3-6 (continued)
Site Specific Fish Ingestion Dose Factors for Teen Age Group

Nuclide	Bone	Liver	T Body	Thyroid	Kidney	Lung	GI-LLI
Te-127M	7.06E+03	2.50E+03	8.39E+02	1.68E+03	2.86E+04	0.00E+00	1.76E+04
Te-127	1.15E+02	4.09E+01	2.48E+01	7.95E+01	4.67E+02	0.00E+00	8.90E+03
Te-129M	1.19E+04	4.41E+03	1.88E+03	3.84E+03	4.98E+04	0.00E+00	4.47E+04
Te-129	3.27E+01	1.22E+01	7.95E+00	2.33E+01	1.37E+02	0.00E+00	1.79E+02
Te-131M	1.78E+03	8.54E+02	7.12E+02	1.28E+03	8.90E+03	0.00E+00	6.85E+04
Te-131	2.04E+01	8.39E+00	6.36E+00	1.57E+01	8.90E+01	0.00E+00	1.67E+00
Te-132	2.55E+03	1.61E+03	1.52E+03	1.70E+03	1.55E+04	0.00E+00	5.11E+04
I-130	2.82E+01	8.15E+01	3.26E+01	6.65E+03	1.26E+02	0.00E+00	6.27E+01
I-131	1.60E+02	2.24E+02	1.20E+02	6.54E+04	3.86E+02	0.00E+00	4.43E+01
I-132	7.63E+00	2.00E+01	7.17E+00	6.73E+02	3.15E+01	0.00E+00	8.70E+00
I-133	5.50E+01	9.33E+01	2.85E+01	1.30E+04	1.64E+02	0.00E+00	7.06E+01
I-134	3.99E+00	1.06E+01	3.80E+00	1.76E+02	1.67E+01	0.00E+00	1.40E-01
I-135	1.67E+01	4.30E+01	1.59E+01	2.76E+03	6.79E+01	0.00E+00	4.76E+01
Cs-134	3.05E+05	7.19E+05	3.33E+05	0.00E+00	2.28E+05	8.72E+04	8.94E+03
Cs-136	3.13E+04	1.23E+05	8.28E+04	0.00E+00	6.71E+04	1.06E+04	9.92E+03
Cs-137	4.09E+05	5.44E+05	1.89E+05	0.00E+00	1.85E+05	7.19E+04	7.73E+03
Cs-138	2.83E+02	5.44E+02	2.72E+02	0.00E+00	4.01E+02	4.67E+01	2.47E-01
Ba-139	1.01E+00	7.14E-04	2.95E-02	0.00E+00	6.73E-04	4.92E-04	9.05E+00
Ba-140	2.07E+02	2.54E-01	1.34E+01	0.00E+00	8.61E-02	1.71E-01	3.20E+02
Ba-141	4.90E-01	3.66E-04	1.63E-02	0.00E+00	3.39E-04	2.50E-04	1.04E-06
Ba-142	2.18E-01	2.18E-04	1.34E-02	0.00E+00	1.85E-04	1.45E-04	6.70E-13
La-140	1.59E-01	7.80E-02	2.07E-02	0.00E+00	0.00E+00	0.00E+00	4.48E+03
La-142	8.16E-03	3.63E-03	9.03E-04	0.00E+00	0.00E+00	0.00E+00	1.10E+02
Ce-141	2.43E-02	1.62E-02	1.86E-03	0.00E+00	7.62E-03	0.00E+00	4.63E+01
Ce-143	4.29E-03	3.12E+00	3.48E-04	0.00E+00	1.40E-03	0.00E+00	9.38E+01
Ce-144	1.27E+00	5.25E-01	6.82E-02	0.00E+00	3.14E-01	0.00E+00	3.19E+02
Pr-143	5.97E-01	2.38E-01	2.97E-02	0.00E+00	1.39E-01	0.00E+00	1.97E+03
Pr-144	1.96E-03	8.03E-04	9.94E-05	0.00E+00	4.61E-04	0.00E+00	2.16E-06
Nd-147	4.28E-01	4.65E-01	2.79E-02	0.00E+00	2.73E-01	0.00E+00	1.68E+03
W-187	3.20E+02	2.60E+02	9.13E+01	0.00E+00	0.00E+00	0.00E+00	7.05E+04
Np-239	3.21E-02	3.03E-03	1.68E-03	0.00E+00	9.50E-03	0.00E+00	4.87E+02

Notes:

- 1) Units are mrem/hr per $\mu\text{Ci/ml}$.

Table 3-7
Site Specific Fish Ingestion Dose Factors for Child Age Group

Nuclide	Bone	Liver	T Body	Thyroid	Kidney	Lung	GI-LLI
H-3	0.00E+00	8.21E-02	8.21E-02	8.21E-02	8.21E-02	8.21E-02	8.21E-02
Na-24	4.56E+02	4.56E+02	4.56E+02	4.56E+02	4.56E+02	4.56E+02	4.56E+02
Cr-51	0.00E+00	0.00E+00	1.40E+00	7.77E-01	2.12E-01	1.42E+00	7.43E+01
Mn-54	0.00E+00	3.37E+03	8.97E+02	0.00E+00	9.44E+02	0.00E+00	2.83E+03
Mn-56	0.00E+00	1.05E+02	2.37E+01	0.00E+00	1.27E+02	0.00E+00	1.52E+04
Fe-55	9.05E+02	4.80E+02	1.49E+02	0.00E+00	0.00E+00	2.71E+02	8.89E+01
Fe-59	1.30E+03	2.10E+03	1.05E+03	0.00E+00	0.00E+00	6.09E+02	2.19E+03
Co-58	0.00E+00	7.08E+01	2.17E+02	0.00E+00	0.00E+00	0.00E+00	4.13E+02
Co-60	0.00E+00	2.08E+02	6.14E+02	0.00E+00	0.00E+00	0.00E+00	1.15E+03
Ni-63	4.23E+04	2.27E+03	1.44E+03	0.00E+00	0.00E+00	0.00E+00	1.53E+02
Ni-65	1.75E+02	1.64E+01	9.60E+00	0.00E+00	0.00E+00	0.00E+00	2.01E+03
Cu-64	0.00E+00	9.64E+00	5.82E+00	0.00E+00	2.33E+01	0.00E+00	4.52E+02
Zn-65	2.16E+04	5.74E+04	3.57E+04	0.00E+00	3.62E+04	0.00E+00	1.01E+04
Zn-69	6.89E+01	9.96E+01	9.20E+00	0.00E+00	6.04E+01	0.00E+00	6.28E+03
Br-83	0.00E+00	0.00E+00	5.65E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-84	0.00E+00	0.00E+00	6.54E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-85	0.00E+00	0.00E+00	3.01E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	1.05E+05	6.48E+04	0.00E+00	0.00E+00	0.00E+00	6.78E+03
Rb-88	0.00E+00	2.99E+02	2.08E+02	0.00E+00	0.00E+00	0.00E+00	1.47E+01
Rb-89	0.00E+00	1.84E+02	1.64E+02	0.00E+00	0.00E+00	0.00E+00	1.60E+00
Sr-89	3.11E+04	0.00E+00	8.90E+02	0.00E+00	0.00E+00	0.00E+00	1.21E+03
Sr-90	6.04E+05	0.00E+00	1.22E+04	0.00E+00	0.00E+00	0.00E+00	5.40E+03
Sr-91	5.66E+02	0.00E+00	2.14E+01	0.00E+00	0.00E+00	0.00E+00	1.25E+03
Sr-92	2.13E+02	0.00E+00	8.54E+00	0.00E+00	0.00E+00	0.00E+00	4.04E+03
Y-90	8.08E-01	0.00E+00	2.16E-02	0.00E+00	0.00E+00	0.00E+00	2.30E+03
Y-91M	7.51E-03	0.00E+00	2.73E-04	0.00E+00	0.00E+00	0.00E+00	1.47E+01
Y-91	1.18E+01	0.00E+00	3.17E-01	0.00E+00	0.00E+00	0.00E+00	1.58E+03
Y-92	7.08E-02	0.00E+00	2.03E-03	0.00E+00	0.00E+00	0.00E+00	2.05E+03
Y-93	2.24E-01	0.00E+00	6.16E-03	0.00E+00	0.00E+00	0.00E+00	3.34E+03
Zr-95	3.01E-01	6.62E-02	5.89E-02	0.00E+00	9.47E-02	0.00E+00	6.90E+01
Zr-97	1.81E-02	2.62E-03	1.55E-03	0.00E+00	3.76E-03	0.00E+00	3.97E+02
Nb-95	5.31E+02	2.07E+02	1.48E+02	0.00E+00	1.94E+02	0.00E+00	3.82E+05
Nb-97	5.13E+00	9.26E-01	4.32E-01	0.00E+00	1.03E+00	0.00E+00	2.86E+05
Mo-99	0.00E+00	1.05E+02	2.59E+01	0.00E+00	2.23E+02	0.00E+00	8.65E+01
Tc- 99M	1.09E-02	2.14E-02	3.54E-01	0.00E+00	3.10E-01	1.08E-02	1.22E+01
Tc-101	1.26E-02	1.32E-02	1.68E-01	0.00E+00	2.25E-01	6.99E-03	4.20E-02
Ru-103	5.75E+00	0.00E+00	2.21E+00	0.00E+00	1.45E+01	0.00E+00	1.49E+02
Ru-105	5.07E-01	0.00E+00	1.84E-01	0.00E+00	4.46E+00	0.00E+00	3.31E+02
Ru-106	9.20E+01	0.00E+00	1.15E+01	0.00E+00	1.24E+02	0.00E+00	1.43E+03
Ag-110M	9.75E-01	6.59E-01	5.26E-01	0.00E+00	1.23E+00	0.00E+00	7.83E+01
Sb-124	8.74E+00	1.13E-01	3.06E+00	1.93E-02	0.00E+00	4.85E+00	5.47E+01
Sb-125	5.64E+00	4.35E-02	1.18E+00	5.22E-03	0.00E+00	3.14E+00	1.35E+01
Te-125M	3.59E+03	9.72E+02	4.78E+02	1.01E+03	0.00E+00	0.00E+00	3.46E+03
Sb-126	3.47E+00	5.30E-02	1.25E+00	2.03E-02	0.00E+00	1.65E+00	6.99E+01

Table 3-7 (continued)
Site Specific Fish Ingestion Dose Factors for Child Age Group

Nuclide	Bone	Liver	T Body	Thyroid	Kidney	Lung	GI-LLI
Te-127M	9.09E+03	2.45E+03	1.08E+03	2.17E+03	2.59E+04	0.00E+00	7.36E+03
Te-127	1.48E+02	4.00E+01	3.18E+01	1.03E+02	4.22E+02	0.00E+00	5.79E+03
Te-129M	1.53E+04	4.28E+03	2.38E+03	4.94E+03	4.50E+04	0.00E+00	1.87E+04
Te-129	4.22E+01	1.18E+01	1.00E+01	3.01E+01	1.23E+02	0.00E+00	2.62E+03
Te-131M	2.27E+03	7.83E+02	8.34E+02	1.61E+03	7.58E+03	0.00E+00	3.18E+04
Te-131	2.61E+01	7.96E+00	7.77E+00	2.00E+01	7.90E+01	0.00E+00	1.37E+02
Te-132	3.18E+03	1.41E+03	1.70E+03	2.05E+03	1.31E+04	0.00E+00	1.42E+04
I-130	3.45E+01	6.96E+01	3.59E+01	7.67E+03	1.04E+02	0.00E+00	3.26E+01
I-131	2.03E+02	2.04E+02	1.16E+02	6.75E+04	3.35E+02	0.00E+00	1.82E+01
I-132	9.44E+00	1.73E+01	7.98E+00	8.05E+02	2.65E+01	0.00E+00	2.04E+01
I-133	6.99E+01	8.64E+01	3.27E+01	1.60E+04	1.44E+02	0.00E+00	3.48E+01
I-134	4.94E+00	9.18E+00	4.22E+00	2.11E+02	1.40E+01	0.00E+00	6.09E+00
I-135	2.06E+01	3.72E+01	1.76E+01	3.29E+03	5.70E+01	0.00E+00	2.83E+01
Cs-134	3.68E+05	6.04E+05	1.27E+05	0.00E+00	1.87E+05	6.72E+04	3.26E+03
Cs-136	3.70E+04	1.02E+05	6.58E+04	0.00E+00	5.41E+04	8.07E+03	3.57E+03
Cs-137	5.14E+05	4.92E+05	7.27E+04	0.00E+00	1.60E+05	5.77E+04	3.08E+03
Cs-138	3.59E+02	4.99E+02	3.16E+02	0.00E+00	3.51E+02	3.78E+01	2.30E+02
Ba-139	1.30E+00	6.95E-04	3.78E-02	0.00E+00	6.07E-04	4.09E-04	7.52E+01
Ba-140	2.61E+02	2.29E-01	1.53E+01	0.00E+00	7.46E-02	1.37E-01	1.32E+02
Ba-141	6.29E-01	3.52E-04	2.05E-02	0.00E+00	3.05E-04	2.07E-03	3.59E-01
Ba-142	2.75E-01	1.98E-04	1.54E-02	0.00E+00	1.60E-04	1.16E-04	3.59E-03
La-140	1.99E-01	6.94E-02	2.34E-02	0.00E+00	0.00E+00	0.00E+00	1.94E+03
La-142	1.03E-02	3.28E-03	1.03E-03	0.00E+00	0.00E+00	0.00E+00	6.51E+02
Ce-141	3.12E-02	1.56E-02	2.31E-03	0.00E+00	6.83E-03	0.00E+00	1.94E+01
Ce-143	5.50E-03	2.98E+00	4.32E-04	0.00E+00	1.25E-03	0.00E+00	4.37E+01
Ce-144	1.64E+00	5.13E-01	8.73E-02	0.00E+00	2.84E-01	0.00E+00	1.34E+02
Pr-143	7.73E-01	2.32E-01	3.83E-02	0.00E+00	1.26E-01	0.00E+00	8.34E+02
Pr-144	2.54E-03	7.85E-04	1.28E-04	0.00E+00	4.15E-04	0.00E+00	1.69E+00
Nd-147	5.49E-01	4.44E-01	3.44E-02	0.00E+00	2.44E-01	0.00E+00	7.04E+02
W-187	4.05E+02	2.40E+02	1.08E+02	0.00E+00	0.00E+00	0.00E+00	3.37E+04
Np-239	4.13E-02	2.97E-03	2.08E-03	0.00E+00	8.57E-03	0.00E+00	2.19E+02

Notes:

- 1) Units are mrem/hr per $\mu\text{Ci/ml}$.
- 2) The infant age group is assumed to receive no dose through the fish ingestion pathway; therefore, no dose factors are supplied.

Table 3-8
Bioaccumulation Factors (BF_f) to be Used in the Absence of
Site-Specific Data

Element	BF _f for Freshwater Fish (pCi/kg per pCi/L)	Reference
H	9.0E-01	6
Be	2.8E+01	Footnote 2
C	4.6E+03	6
F	2.2E+02	Footnote 16
Na	1.0E+02	6
Mg	2.8E+01	Footnote 2
Al	2.2E+03	Footnote 13
P	1.0E+05	6
Cl	2.2E+02	Footnote 16
Ar	NA	NA
K	1.0E+03	Footnote 1
Ca	2.8E+01	Footnote 2
Sc	2.5E+01	Footnote 3
Ti	3.3E+00	Footnote 4
V	3.0E+04	Footnote 5
Cr	2.0E+02	6
Mn	4.0E+02	6
Fe	1.0E+02	6
Co	5.0E+01	6
Ni	1.0E+02	6
Cu	5.0E+01	6
Zn	2.0E+03	6
Ga	2.2E+03	Footnote 13
Ge	2.4E+03	Footnote 12
As	3.3E+04	Footnote 14
Se	4.0E+02	Footnote 15
Br	4.2E+02	6
Kr	NA	NA
Rb	2.0E+03	6
Sr	3.0E+01	6
Y	2.5E+01	6
Zr	3.3E+00	6
Nb	3.0E+04	6
Mo	1.0E+01	6
Tc	1.5E+01	6
Ru	1.0E+01	6
Rh	1.0E+01	6
Pd	1.0E+02	Footnote 9

**Table 3-8 (cont.)
Bioaccumulation Factors (BF_i) to be Used in the Absence of
Site-Specific Data**

Cd	2.0E+03	Footnote 11
In	2.2E+03	Footnote 13
Sn	2.4E+03	Footnote 12
Sb	1.0E+00	98
Ag	2.3E+00	56
Te	4.0E+02	6
I	1.5E+01	6
Xe	NA	NA
Cs	2.0E+03	6
Ba	4.0E+00	6
La	2.5E+01	6
Ce	1.0E+00	6
Pr	2.5E+01	6
Nd	2.5E+01	6
Pm	3.0E+01	98
Sm	3.0E+01	Footnote 3
Eu	1.0E+02	Footnote 3
Gd	2.6E+01	Footnote 3
Dy	2.2E+03	Footnote 3
Er	3.3E+04	Footnote 3
Tm	4.0E+02	Footnote 3
Yb	2.2E+02	Footnote 3
Lu	2.5E+01	Footnote 3
Hf	3.3E+00	Footnote 4
Ta	3.0E+04	Footnote 5
W	1.2E+03	6
Re	2.1E+02	Footnote 6
Os	5.5E+01	Footnote 7
Ir	3.0E+01	Footnote 8
Pt	1.0E+02	Footnote 9
Au	2.6E+01	Footnote 10
Hg	2.0E+03	Footnote 11
Tl	2.2E+03	Footnote 13
Pb	3.0E+02	98
Bi	2.0E+01	98
Ra	5.0E+01	98
Th	3.0E+01	98
U	1.0E+01	98
Np	1.0E+01	6
Am	3.0E+01	98

Footnotes:

NA = It is assumed that noble gases are not accumulated.

In Reference 6, see Table A-1 in the ODCM Training and Reference Material.

A number of bioaccumulation factors could not be found in literature. In this case, the periodic table was used in conjunction with published element values. This method was used for periodic table columns except where there were no values for column 3A so the average of columns 2B and 4A was assigned.

1. Value is the average of Reference 6 values in literature for H, Na, Rb and Cs.
2. Value is the average of Ref. 6 values in literature for Sr, Ba and Ref. 98 values for Ra.
3. Value is the same as the Reference 6 value used for Y.
4. Value is the same as the Reference 6 value used for Zr.
5. Value is the same as the Reference 6 value used for Nb.
6. Value is the average of Reference 6 values in literature for Mn and Tc.
7. Value is the average of Reference 6 values in literature for Fe and Ru.
8. Value is the average of Reference 6 values in literature for Co and Rh.
9. Value is the same as the Reference 6 value used for Ni.
10. Value is the average of Reference 6 values in literature for Cu and Reference 56 value for Ag.
11. Value used is the same as the Reference 6 value used for Zn.
12. Value is the average of Reference 6 value in literature for C and Reference 98 value for Pb.
13. Value is the average of columns 2B and 4A, where column 2B is the "Reference 6 value for Zn" and column 4A is the average of "Reference 6 value for C and Reference 98 value for Pb".
14. Value is the average of Ref. 6 value found in literature for P and the Ref. 98 values for Bi and Sb.
15. Value is the same as the Reference 6 value used for Te.
16. Value is the average of Reference 6 values found in literature for Br and I.

4. **GASEOUS EFFLUENTS**

4.1. Gaseous Effluents – General Information

This section reviews the offsite radiological limits applicable to the nuclear power stations and presents in detail the equations and procedures used to assess compliance with these limits. This calculational approach uses the methodology of NUREG-0133 (Reference 14), and incorporates certain simplifications such as the use of average meteorology.

4.1.1. Pre-calculated atmospheric transport parameters are based on historical average atmospheric conditions. These historical meteorological conditions have resulted in the dispersion parameters shown in Table 4-1, Table 4-2 and Table 4-8.

4.1.2. The equations and parameters of this section are for use in calculating offsite radiation doses during routine operating conditions. They are not for use in calculating doses due to non-routine releases (e.g., accident releases).

4.1.3. An overview of the required compliance is given in Table 1-1. The dose components are itemized and referenced, and an indication of their regulatory application is noted. Additionally, the locations of dose receivers for each dose component are given in Table 1-2.

4.1.4. Airborne Release Point Classifications

1. The pattern of dispersion of airborne releases is dependent on the height of the release point relative to adjacent structures. Each release point is classified as one of the following three height-dependent types:

- A. Stack (or Elevated) Release Point (denoted by the letter S or subscript s)
- B. Ground Level Release Point (denoted by the letter G or subscript g)
- C. Vent (or Mixed Mode) Release Point (denoted by the letter V or subscript v)

4.1.5. Operability and Use of Gaseous Effluent Treatment Systems

1. 10CFR50 Appendix I and ODCM Part 1 require that the ventilation exhaust treatment system and the waste gas holdup system be used when projected offsite doses in 31 days, due to gaseous effluent releases, from each reactor unit, exceed any of the following limits:
 - A. 0.2 mrad to air from gamma radiation.
 - B. 0.4 mrad to air from beta radiation.
 - C. 0.3 mrem to any organ of a member of the public.
2. The station must project doses due to gaseous releases from the site at least once per 31 days. The calculational methods shown in sections 4.2.2 and 4.2.3 are used for this dose projection.

4.1.6. For a release attributable to a processing or effluent system shared by more than one reactor unit, the dose due to an individual unit is obtained by proportioning the effluents among the units sharing the system.

4.2. Gaseous Effluents – Dose and Dose Rate Calculation Requirements

4.2.1. Instantaneous Dose Rates

4.2.1.1 Noble Gas: Total Body Dose Rate

1. ODCM Part 1 limits the total body dose rate due to noble gases in gaseous effluents released from a site to areas at and beyond the site boundary to less than or equal to 500 mrem/yr at all times.

2. The total body dose rate due to noble gases released in gaseous effluents is calculated by the following expression:

$$\dot{D}_{TB} = \sum_i K_i \left\{ (\chi/Q)_s Q_{is} + (\chi/Q)_v Q_{iv} + (\chi/Q)_g Q_{ig} \right\} \quad (4-1)$$

The summation is over noble gas radionuclides i .

Since Byron does not have an elevated release point, the Q_{is} term is not used.

\dot{D}_{TB} Total Body Dose Rate [mrem/yr]

Dose rate to the total body due to gamma radiation from noble gas radionuclides released in gaseous effluents.

Q_{is}, Q_{iv}, Q_{ig} Release Rate [$\mu\text{Ci/sec}$]

Measured release rate of radionuclide i from a stack, vent or ground level release point, respectively.

K_i Gamma Total Body Dose Conversion Factor [(mrem/yr)/($\mu\text{Ci/m}^3$)]

Gamma total body dose factor due to gamma emissions for noble gas radionuclide i . K values are taken from Table 4-28.

$(\chi/Q)_s$ Relative Concentration Factor [sec/m^3]

$(\chi/Q)_v$ Radioactivity concentration based on semi-infinite cloud methodology at a specified location per unit of radioactivity

$(\chi/Q)_g$ release rate for a stack, vent, or ground level release, respectively. See Table 4-1.