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HDI-IPEC-22-034

10 CFR 50.36a (a)(2)
10 CFR 72.44 (d)(3)

April 28, 2022

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

Indian Point Energy Center
Facility License No. DPR-05, DPR-26 and DPR-64
NRC Docket Nos. 50-03, 50-247, and 50-286

Subject: 2021 Annual Radioactive Effluent Release Report

Enclosed with this cover letter is the Indian Point Units 1, 2, and 3 Annual Radioactive Effluent Release Report for the period January 1 to December 31, 2021 and the updated Offsite Dose Calculation Manual (ODCM). The report is submitted in accordance with Technical Specification 5.6.2 and Regulatory Guide 1.21 and includes dose from the Independent Spent Fuel Storage Facility.

This letter contains no new regulatory commitments.

If you have any questions or need further information, please contact Mr. Walter Wittich, IPEC Licensing at 914-254-7212, or me at (856) 797-0900, ext. 3578.

Sincerely,

Jean A. Fleming

Digitally signed by Jean A. Fleming
Date: 2022.04.28 12:42:15 -04'00'

Jean A. Fleming
Vice President, Licensing, Regulatory Affairs, & PSA
Corporate Engineering Division
Holtec International, LLC

Enclosures: 1) 2021 Annual Radioactive Effluent Release Report
2) Offsite Dose Calculation Manual (ODCM)

cc: NRC Senior Project Manager, NRC NMSS
NRC Region I Regional Administrator
NRC Senior Regional Inspector, Indian Point Energy Center
New York State Liaison Officer Designee, NYSERDA
New York State (NYS) Public Service Commission

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# *ENCLOSURE 1 TO HDI-IPEC-22-034*

# 2021 Annual Radioactive Effluent Release Report

(121 pages not including this cover sheet)

HOLTEC DECOMMISSIONING INTERNATIONAL

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# SECTION 1.0

## EXECUTIVE SUMMARY

# 1.0 EXECUTIVE SUMMARY

## 1.1 INTRODUCTION

This report summarizes the results of the Radiological Environmental Monitoring Program (REMP) conducted in the vicinity of Indian Point Energy Center (IPEC) during the period from January 1 to December 31, 2021. The Indian Point site consists of Units 1, 2 and 3, which are operated by Holtec Decommissioning International Unit 1 was retired as a generating facility in 1974, and its reactor is no longer operated. Unit 2 was permanently shutdown on April 30th 2020. Unit 3 ceased operation April 30th 2021.

The REMP has been established to monitor/measure the radiation and radioactivity detectable in the environment that may be attributable to the operation of IPEC. This program, initiated in 1958, includes the collection, analysis, and evaluation of radiological data in order to assess the impact of IPEC on the environment.

## 1.2 SAMPLING AND ANALYSIS

The environmental sampling media collected in the vicinity of IPEC and at distant locations included air particulate filters and charcoal cartridges, soil, drinking water, broad leaf vegetation, river water, shoreline sediment, bottom sediment, aquatic vegetation, fish, and invertebrates.

During 2021 there were 1172 samples collected from the atmospheric, aquatic, and terrestrial environments. This includes 164 exposure measurements which were obtained using environmental thermoluminescent dosimeters (TLDs).

A small number of inadvertent issues were encountered in 2021 in the collection of environmental samples in accordance with the IPEC Offsite Dose Calculation Manual (ODCM). Equipment failures and electrical outages resulted in a small number of instances in which lower than normal sampling volumes were collected at the airborne monitoring stations. A full description of all discrepancies encountered with the environmental monitoring program is presented in the Table B-1 of this report.

There were 1319 analyses performed on the environmental media samples. The analyzes of the 2021 Indian Point environmental samples were performed by several laboratories. Thermoluminescent dosimeters were analyzed by Environmental Dosimetry Company (formerly Stanford Associates) of Sterling, MA. Teledyne Brown Engineering, Inc. of Knoxville, TN performed all the remaining analyses for 2021. Samples were analyzed as required by the IPEC ODCM.

## 1.3 LAND USE CENSUS

The annual land use census in the vicinity of IPEC was conducted as required by the IPEC ODCM in May through October. No dairy animals whose milk is used for human consumption were identified within 5 miles of the Station during the census. Due to the difficulty of locating individual gardens and determining those having an area greater than 500 square feet, broad leaf sampling was performed. As allowed for in the ODCM, monthly broad leaf sampling may be used in lieu of a garden census.

## 1.4 SUMMARY OF RESULTS

Samples collected as part of the IPEC REMP continued to contain detectable amounts of naturally-occurring and some man-made radioactive materials. Offsite ambient radiation measurements using environmental TLDs beyond the site boundary ranged between 43 and 61 milli-Roentgens (mR) per year. The range of ambient radiation levels observed with the TLDs is consistent with natural background radiation levels for New York.

Monitoring of the aquatic environment in the area of the station indicated the presence of the following potential station related radioactivity, tritium and cesium-137. Tritium was found in river water at the downstream mixing zone of the discharge canal at levels that were expected from routine plant operation, or other sources such as fallout from past weapons testing. Low-levels of cesium-137 were detected in Hudson River bottom sediment samples downstream of the discharge canal, as well as in the Off Verplanck, Lent's Cove, and Cold Spring locations. The levels detected were consistent with historical findings. No other plant related activity was detected in any offsite samples. The predominant radioactivity for all samples was from non-plant related sources, such as fallout from nuclear weapons tests and naturally occurring radionuclides.

## 1.5 CONCLUSIONS

The 2021 Radiological Environmental Monitoring Program for IPEC resulted in the collection and analysis of over a thousand environmental samples and measurements. The data obtained were used to determine the impact of IPEC's operation on the environment and on the general public.

In 2021 the only positive detectable plant related activity was three instances of low levels of H-3 detected in river water samples. An evaluation of direct radiation measurements, environmental sample analyses, and dose calculations demonstrates that all applicable federal criteria were met. Furthermore, radiation levels and resulting doses from station operation were a small fraction of those attributed to natural and man-made background radiation.

In summary, the levels of radionuclides in the environment surrounding Indian Point were within the historical ranges, i.e., previous levels resulting from natural and anthropogenic sources for the detected radionuclides. Further, IPEC operations in 2021 did not result in exposure to the public greater than the variability of environmental background levels.

# SECTION 2.0

## INTRODUCTION

# 2.0 INTRODUCTION

## 2.1 Overview

The Radiological Environmental Monitoring Program (REMP) for 2021 performed by Holtec for the Indian Point Energy Center (IPEC) is discussed in this report. Since the operation of a nuclear power plant results in the release of small amounts of radioactivity and low levels of radiation, the Nuclear Regulatory Commission (NRC) requires a program to be established to monitor radiation and radioactivity in the environment (Reference 1). This report, which is submitted to the NRC annually per Indian Point Technical Specifications, summarizes the results of measurements of radiation and radioactivity in the environment in the vicinity of the IPEC and at distant locations during the period January 1 to December 31, 2021.

The REMP is used to measure the direct radiation and the airborne and waterborne pathway activity in the vicinity of the Indian Point site. Direct radiation pathways include radiation from buildings and plant structures, airborne and liquid material that might be released from the plant, cosmic radiation, and the naturally occurring radioactive materials in the ground. Analysis of thermoluminescent dosimeters (TLDs), used to measure direct radiation, indicated that there were no increased radiation levels attributable to plant operations.

The airborne pathway includes measurements of air, drinking water, and broad leaf vegetation samples. The airborne pathway measurements indicated that there was no adverse radiological impact to the surrounding environment attributed to Indian Point Station operations.

The waterborne pathway consists of Hudson River water, fish and invertebrates, aquatic vegetation, bottom sediment, and shoreline sediment. Measurements of the media comprising the waterborne pathway indicated that there was no adverse radiological impact to the surrounding environment attributed to Indian Point Station operations.

These results are reviewed by IPEC's staff and have been reported semiannually or annually to the Nuclear Regulatory Commission and others for over 30 years.

This report contains a description of the REMP for IPEC and the conduct of that program in 2021 as required by the IPEC ODCM. Also included are summaries and discussions of the results of the 2021 program, trend analyses (where appropriate), comparison to historical results and evaluation of any potential impact on the environment. Results of the annual land use census, as well as the inter-laboratory comparison program are included, per the ODCM requirements.

## 2.2 Site Description

The Indian Point site occupies 239 acres on the east bank of the Hudson River on a point of land at Mile Point 42.6. The site is located in the Village of Buchanan, Westchester County, New York. Three nuclear reactors, Indian Point Unit Nos. 1, 2 and 3, and associated buildings occupy approximately 35 acres. Unit 1 began operation in 1962 and was retired as a generating facility in 1974. Units 2 and 3 began operation 1974 and 1978. Indian Point

Units 1 and 2 are owned by Holtec Decommissioning International Indian Point 2, LLC and Unit 3 is owned by Holtec Decommissioning International Indian Point 3 LLC. All three units are no longer in operation.

## 2.3 Program Background

Environmental monitoring and surveillance have been conducted at Indian Point since 1958, four years prior to the start-up of Unit 1. The pre-operational program was designed and implemented to determine the background radioactivity and to measure the variations in activity levels from natural and other sources in the vicinity, as well as fallout from atmospheric nuclear weapons tests. Thus, as used in this report, background levels consist of those resulting from both natural and anthropogenic sources of environmental radioactivity. Accumulation of this background data permits the detection and assessment of environmental activity attributable to plant operations.

## 2.4 Program Objectives

The current environmental monitoring program is designed to meet two primary objectives:

1. To enable the identification and quantification of changes in the radioactivity of the area.
2. To measure radionuclide concentrations in the environment attributable to operations of the Indian Point site.

To identify changes in activity, the environmental sampling schedule requires that analyses be conducted for specific environmental media on a regular basis. The radioactivity profile of the environment is established and monitored through routine evaluation of the analytical results obtained.

The REMP designates sampling locations for the collection of environmental media for analysis. These sample locations are divided into indicator and control locations. Indicator locations are established near the site, where the presence of environmental radioactivity of plant origin is most likely to be detected. Control locations are established farther away (and upwind/upstream, where applicable) from the site, where the level would not generally be affected by plant discharges. The use of indicator and control locations enables the identification of potential sources of detected radioactivity, thus meeting one of the program objectives.

Verification of expected radionuclide concentrations resulting from effluent releases attributable to the site is another objective of the REMP, which is met by meeting the two primary program objectives described above. Verifying projected concentrations through evaluating REMP data can be difficult since the environmental concentrations resulting from plant releases are typically too small to be detected. Plant related radionuclides were detected in 2021 in very low levels; however, residual radioactivity from atmospheric weapons tests and naturally occurring radioactivity were the predominant sources of radioactivity in the samples collected. Analysis of the 2021 REMP sample results confirms that environmental concentrations which could be attributed to radiological effluents were well below regulatory limits.

# SECTION 3.0

## RADIOLOGICAL ENVIRONMENTAL SAMPLING PROGRAM REQUIREMENTS

# 3.0 RADIOLOGICAL ENVIRONMENTAL SAMPLING PROGRAM REQUIREMENTS

To achieve the objectives of the REMP and ensure compliance with the ODCM, sampling and analysis of environmental media are performed as outlined in Table A-1 and described in section 3.3.

## 3.1 Sample Collection

Holtec personnel perform collection of environmental samples for the Indian Point site, with the exception of fish/invertebrate samples. Collection of fish and invertebrate samples is performed by a contracted environmental vendor, Normandeau Associates, Inc.

Environmental media are sampled at the locations specified in Table A-1 and shown in Figures A-1, A-2, and A-3. The samples are analyzed according to criteria established in the ODCM. These requirements include: methods of sample collection; types of sample analysis; minimum sample size required; lower limit of detection, which must be attained for each medium, sample, or analysis type, and environmental concentrations requiring special reports.

Table A-1 provides the sampling station number, location, sector, and distance from Indian Point, sample designation code, and sample type. This table gives the complete listing of sample locations used in the 2021 REMP.

Three maps are provided to show the locations of REMP sampling. Figure A-1 shows the sampling locations within two miles of Indian Point. Figures A-2 and A-3 show the sampling locations within ten miles of Indian Point.

## 3.2 Sample Analysis

The analysis of the 2021 Indian Point environmental samples was performed by several laboratories. Thermoluminescent dosimeters were analyzed by Environmental Dosimetry Company (formerly Stanford Associates) of Sterling, MA. Teledyne Brown Engineering, Inc. of Knoxville, TN performed all the remaining analyses.

## 3.3 Sample Collection and Analysis Methodology

### 3.3.1 Direct Radiation

Direct gamma radiation is measured using integrating calcium sulfate thermoluminescent dosimeters (TLDs), which provide cumulative measurements of radiation exposure (i.e., total integrated exposures in milli-roentgen, mR) for a given period. The area surrounding the Indian Point site is divided into 16 compass sectors. Each sector has two TLD sample locations. The inner ring is located near the site boundary at approximately 1 mile (1.6 km). The outer ring is located at approximately 5 miles (8 km) from the site (6.7- 8.0 km), see Figures A-1 and A-2. Additional TLD locations include a control location at Roseton (20.7 miles north) and eight locations of special interest. In total, there are 41 TLD sample sites, designated DR-1 through DR-41, with two TLDs placed at each site. TLDs are collected and processed on a quarterly basis. The results are reported as mR per standard quarter (91 days). The data reported is the average of the two TLDs from each sample site.

### 3.3.2 Airborne Particulates and Radioiodine

Air samples were taken at eight locations varying in distance from 0.28 to 20.7 miles (0.5 to 33 km) from the plant. These locations represent one control at sampling station 23 (A5) and seven indicator locations. These indicator locations are at sampling stations 4 (A1), 5 (A4), 27, 29, 94 (A2), 95 (A3), and 108. The locations are shown on Figures A-1, A-2, and A-3. The air samples are collected continuously by means of fixed air particulate filters followed by in-line charcoal cartridges. Both filters and cartridges are changed on a weekly basis. The filters are analyzed for gross beta and the cartridge samples for radioiodine. In addition, gamma spectroscopy analysis (GSA) is performed on quarterly composites of the air particulate filters.

### 3.3.3 Drinking Water

Samples of drinking water are collected monthly from the Camp Field Reservoir (3.4 miles NE, sample station 7, sample designation Wb1) and New Croton Reservoir (6.3 miles SE, sample station 8); see Figure A-2 and Figure A-3. Each monthly sample is approximately 4 liters and is analyzed for gross beta and gamma-emitting radionuclides. Monthly samples are composited quarterly and analyzed for tritium.

### 3.3.4 Soil

Soil samples are collected from two indicator locations (sampling stations 94 and 95), and one control location (23) on an annual basis; see Figure A-3. They are approximately 2 kg in size and consist of about twenty 2-inch deep cores. The soil samples are analyzed by gamma spectroscopy.

### 3.3.5 Broad Leaf Vegetation

Broad Leaf vegetation samples are collected from three locations during the growing season. The indicator locations are sampling stations 94 (Ic2) and 95 (Ic1), and the control location is at sampling station 23 (Ic3). See Figures A-1 and A-2. The samples are collected monthly, when available, and analyzed by gamma spectroscopy. These samples consist of at least 1 kg of leafy vegetation and are used in the assessment of the food product and milk ingestion pathways.

### 3.3.6 Hudson River Water

Hudson River water sampling is performed continuously at a point exterior to the discharge canal where Hudson River water and water from the discharge canal mix (sampling station 10, Wa2); see Figure A-1. Samples were also collected continuously at a control station 23 Roseton (Figure A-2 and A-3). An automatic composite sampler is used to take representative samples. On a weekly basis, accumulated samples are taken from both sample points. These weekly river water samples are composited for monthly gamma spectroscopy analysis and quarterly for tritium analysis.

### 3.3.7 Hudson River Bottom Sediment

Bottom sediment and benthos are sampled at four locations: three indicator locations (sampling stations 10, 17, and 28) and one control location (84), along the Hudson River, once each spring and summer; see Figure A-3. These samples are obtained using a

Peterson grab sampler or similar instrument. The bottom sediment samples are analyzed by gamma spectroscopy.

3.3.8 Hudson River Shoreline Soil

Shoreline soil samples are collected at three indicator and two control locations along the Hudson River. The indicator locations are at sampling stations 53 (Wc1), 28, and 17. The control locations are at sampling stations 50 (Wc2) and 84. Figures A-1, A-2, and A-3 show these locations. The samples are gathered at a level above low tide and below high tide and are approximately 2-kg grab samples. These samples are collected at greater than 90 days apart and are analyzed by gamma spectroscopy and for strontium-90.

3.3.9 Hudson River Aquatic Vegetation

During the spring and summer, aquatic vegetation samples are collected from the Hudson River at two indicator locations (sampling stations 17 and 28) and one control location (84); see Figure A-3. Samples of aquatic vegetation are obtained depending on sample availability. These samples are analyzed by gamma spectroscopy.

3.3.10 Fish and Invertebrates

Fish and invertebrate samples are obtained from the Hudson River at locations upstream and downstream of the plant discharge. The indicator location (downstream sample point) is designated as sampling station 25 (Ib1), and a second sampling station 107 is located further downstream. The control location (upstream) is at sampling station 23 (Ib2). See Figures A-1 and A-2. These samples are collected in season or semiannually if they are not seasonal. The fish and invertebrates sampled are analyzed by gamma spectroscopy as well as for strontium-90 and for nickel-63.

3.3.11 Land Use Census

In addition to the sampling outlined in Table A-1, there is an environmental surveillance requirement that an annual land use census be performed. Each year a land use census consisting of milch animal and residence surveys is conducted during the growing season to determine the current utilization of land within 5 miles (8 km) of the site. These surveys are used to determine whether there are changes in existing conditions that warrant changing the sampling program. The results of the census are discussed in Section 4.11.

For example, the milch animal census is used to identify animals producing milk for human consumption within 5 miles (8 km) of Indian Point. This census consists of visual field surveys of the areas where a high probability of milch animals exists and confirmation through New York State records or with personnel such as feed suppliers who deal with farm animals and dairy associations.

Visual inspections are made of the 5-mile area around the Indian Point Site during routine sample collections and emergency plan equipment inspections in the area throughout the year. An extensive land survey is conducted of the 5-mile area in an attempt to identify new residential areas, commercial developments and to identify milch animals in pasture.

A garden census is not required, since the ODCM allows sampling of vegetation in two sectors near the site boundary in lieu of a garden census. The sectors are chosen to be in the pre-dominant wind directions with the highest predicted deposition rates.

## 3.4 Statistical Methodology

There are several statistical calculation methodologies used in evaluating the data from the Indian Point REMP. These methods include determination of Lower Limits of Detection (LLD) and the Minimum Detectable Concentration (MDC), and estimation of the mean and associated propagated error.

### 3.4.1 Lower Limit of Detection (LLD)

The LLD is the smallest concentration of radioactive material in a sample that will yield a net count above system background, and be detected with 95% probability, with a 5% probability of falsely concluding that a blank observation represents a "real" signal.

For a particular measurement system (which may include radiochemical separation):

$$LLD = \frac{\frac{2.71}{T_s} + 3.29\, s_b * \sqrt{1 + (\frac{T_b}{T_s})}}{E * V * k * Y * e^{-\lambda t}}$$

Where:

| | |
|---|---|
| LLD = | The lower limit of detection as defined above (as picocurie per unit mass or volume) |
| $T_s$ = | The sample counting time in minutes |
| $s_b$ = | The standard deviation of the background counting rate or of the counting rate of a blank sample as appropriate (as counts per minute) |
| $T_b$ = | The background count time in minutes |
| $E$ = | The counting efficiency (as counts per transformation) |
| $V$ = | The sample size (in units of mass or volume) |
| $k$ = | A constant for the number of transformations per minute per unit of activity (normally, 2.22E+6 dpm per uCi) |
| $Y$ = | The fractional radiochemical yield (when applicable) |
| $\lambda$ = | The radioactive decay constant for the particular radionuclide |
| $t$ = | The elapsed time between midpoint of sample collection and time of counting |

Note: The above LLD formula accounts for differing background and sample count times. The Radiological Environmental Monitoring Program, REMP, may use an LLD formula that assumes equal background and sample count times, when appropriate. The constants 2.71 and 3.29 and the general LLD equation were derived from References 2 and 3.

The value of $S_b$ used in the calculation of the LLD for a detection system shall be based on the actual observed variance of the background counting rate or of the counting rate of the

blank samples (as appropriate) rather than on an unverified theoretically predicted variance. In calculating the LLD for a radionuclide determined by gamma ray spectrometry, the background shall include the typical contributions of other radionuclides normally present in the samples. Typical values of E, V, Y, and t shall be used in the calculation. The background count rate is calculated from the background counts that are determined by a separate background count or in the case of gamma ray spectroscopy, from adjacent channels of the energy band of the gamma ray peak used for the quantitative analysis for that radionuclide.

It should be recognized that the LLD is defined as an a priori (before the fact) limit representing the capability of a measurement process and not as an a posteriori (after the fact) limit for a particular measurement. To document the post priori (after the fact) measurement statistics, the MDC is calculated after the measurement using the same equation as above.

To handle the a posteriori problem, a decision level must be defined. To minimize the number of false positives, a value is not considered positive unless it is greater than the MDC or 3 times the total standard deviation of the post priori measurement, where MDC is

the post priori (after the fact) measurement statistic calculated similar to the LLD equation listed above (for $T_b = T_s$, the term $3.29\ s_b * [(1 + ( T_b / T_s ))^{1/2}] = 4.66\ s_b$).

The ODCM required lower limits of detection (LLD) for Indian Point sample analyses are presented in Table A-2. These required lower limits of detection are not the same as the lower limits of detection or critical levels actually achieved by the laboratory. The laboratory's lower limits of detection and critical levels must be equal to or lower than the required levels presented in Table A-2.

Table A-3 provides the reporting level for radioactivity in various media. Sample results that exceed these levels and are due to plant operations require that a special report be submitted to the NRC.

### 3.4.2 Table Statistics

The averages shown in the summary table (Table B-2) are the averages of the positive values in accordance with the NRC's Branch Technical Position (BTP) to Regulatory Guide 4.8 (Reference 4). Samples with "<" values are not included in the averages.

It should be noted that this statistic for the mean using only positive values tends to strongly bias the average high, particularly when only a few of the data are measurably positive. The REMP data show few positive values; thus the corresponding means are biased high. Exceptions to this include direct radiation measured by TLDs and gross beta radioactivity in air, which show positive monitoring results throughout the year.

The historical data tables contain the annual averages of the positive values for each year for 2011 through 2021. The historical averages are calculated using only the positive values presented for 2011 through 2020. The 2021 average values are included in these historic tables for purposes of comparison.

## TABLE A-1
## INDIAN POINT REMP SAMPLING STATION LOCATIONS

| SAMPLING STATION | SAMPLE DESIGNATION | LOCATION | DISTANCE | SAMPLE TYPES |
|---|---|---|---|---|
| 3 | DR8 | Service Center Building | Onsite - 0.35 Mi (SSE) at 158° | Direct Gamma |
| 4 | A1 | Algonquin Gas Line | Onsite - 0.28 Mi (SW) at 234° | Air Particulate |
| | A1 | | | Radioiodine |
| 5 | A4 | NYU Tower | Onsite - 0.88 Mi (SSW) at 208° | Air Particulate |
| | A4 | | | Radioiodine |
| | DR10 | | | Direct Gamma |
| 7 | Wb1 | Camp Field Reservoir | 3.4 Mi (NE) at 51° | Drinking Water |
| 8 | ** | Croton Reservoir | 6.3 Mi (SE) at 124° | Drinking Water |
| 10 | Wa2 | Discharge Canal (Mixing Zone) | Onsite - 0.3 Mi (WSW) at 249° | HR Water |
| | ** | | | HR Bottom Sediment |
| 14 | DR7 | Water Meter House | Onsite - 0.3 Mi (SE) at 133° | Direct Gamma |
| 17 | ** | Off Verplanck | 1.5 Mi (SSW) at 202.5° | HR Aquatic Vegetation |
| | ** | | | HR Shoreline Soil |
| | ** | | | HR Bottom Sediment |
| 20 | DR38 | Cortlandt Yacht Club (AKA Montrose Marina) | 1.5 Mi (S) at 180° | Direct Gamma |
| 23 | 23 | Roseton* | 20.7 Mi (N) at 357° | HR Water |
| | A5 | | | Air Particulate |
| | A5 | | | Radioiodine |
| | DR40 | | | Direct Gamma |
| | Ic3 | | | Broad Leaf Vegetation |
| | ** | | | Soil |
| | Ib2 | | | Fish & Invertebrates |
| 25 | Ib1 | Downstream | Downstream | Fish & Invertebrates |
| 27 | ** | Croton Point | 6.36 Mi (SSE) at 156° | Air Particulate |
| | ** | | | Radioiodine |
| | DR41 | | | Direct Gamma |
| 28 | ** | Lent's Cove | 0.45 Mi (ENE) at 069° | HR Shoreline Soil |
| | DR4 | | | Direct Gamma |
| | ** | | | HR Bottom Sediment |
| | ** | | | HR Aquatic Vegetation |
| 29 | ** | Grassy Point | 3.37 Mi (SSW) at 196° | Air Particulate |
| | ** | | | Radioiodine |
| | DR39 | | | Direct Gamma |
| 33 | DR33 | Hamilton Street (Substation) | 2.88 Mi (NE) at 053° | Direct Gamma |
| 34 | DR9 | South East Corner of Site | Onsite - 0.52 Mi (S) at 179° | Direct Gamma |
| 35 | DR5 | Broadway & Bleakley Avenue | Onsite - 0.37 Mi (E) at 092° | Direct Gamma |
| 38 | DR34 | Furnace Dock (Substation) | 3.43 Mi (SE) at 141° | Direct Gamma |

* = Control location
** = Locations listed do not have sample designation locations specified in the ODCM
HR = Hudson River
***= In 2021 Air sampler station 44 Peekskill was relocated to 108 Telcom. Bldg.
****= In 2021 River water station 9 Plant Inlet (Hudson River Intake) was moved to Roseton.

## TABLE A-1

## INDIAN POINT REMP SAMPLING STATION LOCATIONS

| SAMPLING STATION | SAMPLE DESIGNATION | LOCATION | DISTANCE | SAMPLE TYPES |
|---|---|---|---|---|
| 44** | ** | Peekskill Gas Holder Bldg | 1.84 Mi (NE) at 052° | Air Particulate |
| | ** | | | Radioiodine |
| 50 | Wc2 | Manitou Inlet* | 4.48 Mi (NNW) at 347° | HR Shoreline Soil |
| 53 | Wc1 | White Beach | 0.92 Mi (SW) at 226° | HR Shoreline Soil |
| | DR11 | | | Direct Gamma |
| 56 | DR37 | Verplanck - Broadway & 6th Street | 1.25 Mi (SSW) at 202° | Direct Gamma |
| 57 | DR1 | Roa Hook | 2 Mi (N) at 005° | Direct Gamma |
| 58 | DR17 | Route 9D - Garrison | 5.41 Mi (N) at 358° | Direct Gamma |
| 59 | DR2 | Old Pemart Avenue | 1.8 Mi (NNE) at 032° | Direct Gamma |
| 60 | DR18 | Gallows Hill Road & Sprout Brook Road | 5.02 Mi (NNE) at 029° | Direct Gamma |
| 61 | DR36 | Lower South Street & Franklin Street | 1.3 Mi (NE) at 052° | Direct Gamma |
| 62 | DR19 | Westbrook Drive (near the Community Center) | 5.03 Mi (NE) at 062° | Direct Gamma |
| 64 | DR20 | Lincoln Road - Cortlandt (School Parking Lot) | 4.6 Mi (ENE) at 067° | Direct Gamma |
| 66 | DR21 | Croton Avenue - Cortlandt | 4.87 Mi (E) at 083° | Direct Gamma |
| 67 | DR22 | Colabaugh Pond Road - Cortlandt | 4.5 Mi (ESE) at 114° | Direct Gamma |
| 69 | DR23 | Mt. Airy & Windsor Road | 4.97 Mi (SE) at 127° | Direct Gamma |
| 71 | DR25 | Warren Ave - Haverstraw | 4.83 Mi (S) at 188° | Direct Gamma |
| 72 | DR26 | Railroad Avenue & 9W - Haverstraw | 4.53 Mi (SSW) at 203° | Direct Gamma |
| 73 | DR27 | Willow Grove Road & Captain Faldermeyer Drive | 4.97 Mi (SW) at 226° | Direct Gamma |
| 74 | DR12 | West Shore Drive - South | 1.59 Mi (WSW) at 252° | Direct Gamma |
| 75 | DR31 | Palisades Parkway | 4.65 Mi (NW) at 225° | Direct Gamma |
| 76 | DR13 | West Shore Drive - North | 1.21 Mi (W) at 276° | Direct Gamma |
| 77 | DR29 | Palisades Parkway | 4.15 Mi (W) at 272° | Direct Gamma |
| 78 | DR14 | Rt. 9W across from R/S #14 | 1.2 Mi (WNW) at 295° | Direct Gamma |
| 79 | DR30 | Anthony Wayne Park | 4.57 Mi (WNW) at 296° | Direct Gamma |
| 80 | DR15 | Route 9W South of Ayers Road | 1.02 Mi (NW) at 317° | Direct Gamma |
| 81 | DR-28 | Palisades Pkwy - Lake Welch Exit | 4.96 Mi (WSW) at 310° | Direct Gamma |
| 82 | DR16 | Ayers Road | 1.01 Mi (NNW) at 334° | Direct Gamma |
| 83 | DR32 | Route 9W - Fort Montgomery | 4.82 Mi (NNW) at 339° | Direct Gamma |
| 84 | ** | Cold Spring * | 10.88 Mi (N) at 356° | HR Aquatic Vegetation |
| | ** | | | HR Shoreline Soil |
| | ** | | | HR Bottom Sediment |
| 88 | DR6 | Reuter Stokes Pole #6 | 0.32 Mi (ESE) at 118° | Direct Gamma |
| 89 | DR35 | Highland Ave & Sprout Brook Road (near rock cut) | 2.89 Mi (NNE) at 025° | Direct Gamma |

* = Control location

** = Locations listed do not have sample designation locations specified in the ODCM

HR = Hudson River

***= In 2021 Air sampler station 44 Peekskill was relocated to 108 Telcom. Bldg.

****= In 2021 River water station 9 Plant Inlet (Hudson River Intake) was moved to Roseton.

## TABLE A-1
## INDIAN POINT REMP SAMPLING STATION LOCATIONS

| SAMPLING STATION | SAMPLE DESIGNATION | LOCATION | DISTANCE | SAMPLE TYPES |
|---|---|---|---|---|
| 90 | DR3 | Charles Point | 0.88 Mi (NE) at 047° | Direct Gamma |
| 92 | DR24 | Warren Road - Cortlandt | 3.84 Mi (SSE) at 149° | Direct Gamma |
| 94 | A2 | IPEC Training Center | Onsite- 0.39 Mi (S) at 193° | Air Particulate |
| | A2 | | | Radioiodine |
| | Ic2 | | | Broad Leaf Vegetation |
| | ** | | | Soil |
| 95 | A3 | Meteorological Tower | Onsite - 0.46 Mi (SSW) at 208° | Air Particulate |
| | A3 | | | Radioiodine |
| | Ic1 | | | Broad Leaf Vegetation |
| | ** | | | Soil |
| 107 | ** | Vicinity of Haverstraw Bay | 2.5 mi SSW (downstream) | Fish & Invertebrates |
| 108*** | ** | Telecomm Bldg. | 0.36 mi ESE | Air Particulate |
| | ** | | | Radioiodine |

* = Control location

** = Locations listed do not have sample designation locations specified in the ODCM

HR = Hudson River

***= In 2021 Air sampler station 44 Peekskill was relocated to 108 Telcom. Bldg.

****= In 2021 River water station 9 Plant Inlet (Hudson River Intake) was moved to Roseton.

**FIGURE A-1**

**SAMPLING LOCATIONS**
**Within Two Miles of Indian Point**

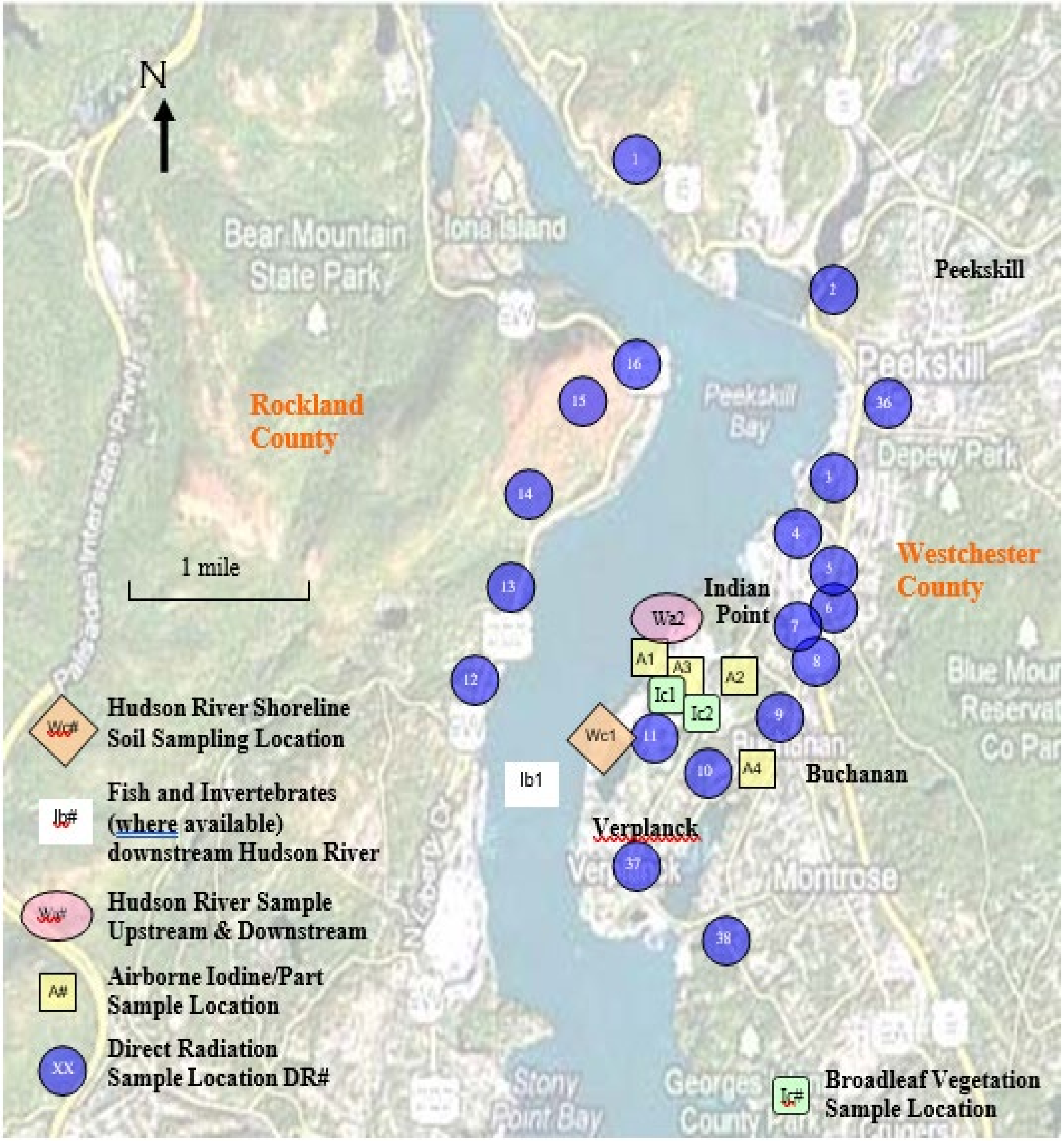


**FIGURE A-2**

**SAMPLING LOCATIONS**
**Greater than Two Miles from Indian Point**

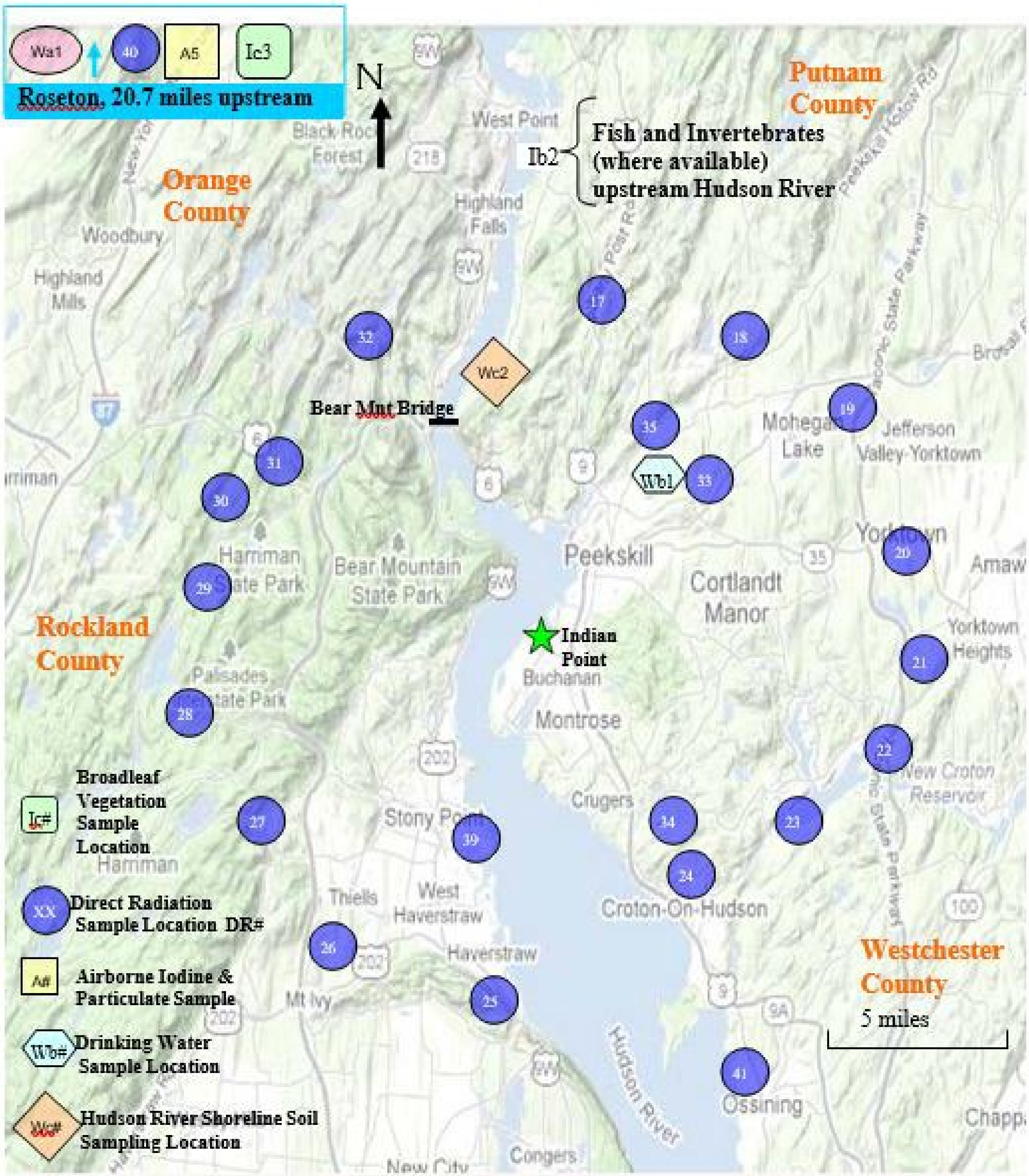
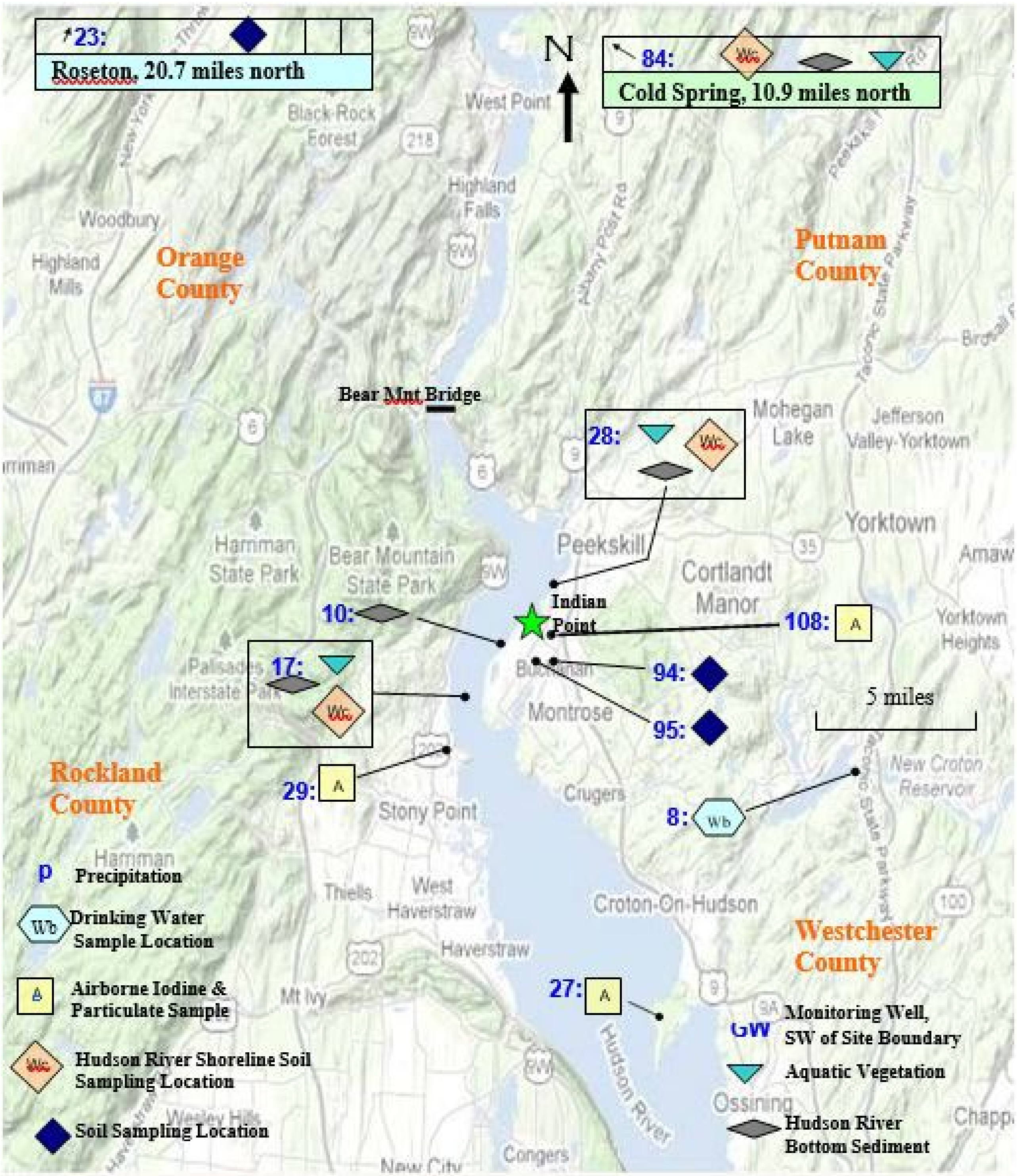


**FIGURE A-3**

**SAMPLING LOCATIONS**
**Additional Sampling Locations**



## TABLE A-2

## LOWER LIMIT OF DETECTION (LLD) REQUIREMENTS FOR ENVIRONMENTAL SAMPLES

| RADIONUCLIDE ANALYSIS | WATER (pCi/L) | AIRBORNE PARTIUCLATE OR GASES (pCi/m$^3$) | FISH (pCi/kg, wet) | MILK (pCi/L) | FOOD PRODUCTS (pCi/kg, wet) | SOIL or SEDIMENT (pCi/kg, dry) |
|---|---|---|---|---|---|---|
| Gross Beta | 4 | 0.01 | | | | |
| H-3 | 2,000 (d) | | | | | |
| Mn-54 | 15 | | 130 | | | |
| Fe-59 | 30 | | 260 | | | |
| Co-58 | 15 | | 130 | | | |
| Co-60 | 15 | | 130 | | | |
| Ni-63 (f) | 30 | | 100 | | | |
| Zn-65 | 30 | | 260 | | | |
| Sr-90 (f) | 1 | | 5 | | | 50 |
| Zr-95 | 30 | | | | | |
| Nb-95 | 15 | | | | | |
| I-131 | 1 (d) | 0.07 | | 1 | 60 | |
| Cs-134 | 15 | 0.05 | 130 | 15 | 60 | 150 |
| Cs-137 | 18 | 0.06 | 150 | 18 | 80 | 180 |
| Ba-140 | 60 | | | 60 | | |
| La-140 | 15 | | | 15 | | |

**TABLE A-2**

**LOWER LIMIT OF DETECTION (LLD) REQUIREMENTS FOR ENVIRONMENTAL SAMPLES**

## Table Notation

(a) This list does not mean that only these nuclides are to be considered. Other peaks that are identifiable, together with those of the above nuclides, shall also be analyzed and reported in the Annual Radiological Environmental Operating Report pursuant to the ODCM.

(b) Required detection capabilities for thermoluminescent dosimeters used for environmental measurements are given in Regulatory Guide 4.13.

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

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.

Analyses shall be performed in such a manner that the stated LLDs will be achieved under routine conditions. Occasionally background fluctuations, unavoidable small sample sizes, the presence of interfering nuclides, or other uncontrollable circumstances may render these LLDs unachievable.

In such cases, the contributing factors shall be identified and described in the Annual Radiological Environmental Operating Report pursuant to the ODCM.

(d) These LLDs are for drinking water samples. If no drinking water pathway exists, the LLDs may be increased to 3,000 pCi/liter for H-3 and 15 pCi/liter for I-131.

(e) These required lower limits of detection are associated only with the REMP requirements. The Radiological Ground Water Monitoring Program may involve unique reporting level criteria, independent of the REMP, and defined in station procedures.

(f) Sr-90 and Ni-63 are included in this table due to their historical presence in ground water and possible migration to the environment.

## TABLE A-3

## REPORTING LEVELS FOR RADIOACTIVITY CONCENTRATIONS IN ENVIRONMENTAL SAMPLES

| RADIONUCLIDE ANALYSIS | WATER (pCi/L) | AIRBORNE PARTIUCLATE OR GASES (pCi/m$^3$) | FISH (pCi/kg, wet) | MILK (pCi/L) | FOOD PRODUCTS (pCi/kg, wet) |
|---|---|---|---|---|---|
| H-3 | 20,000 * | | | | |
| Mn-54 | 1,000 | | 30,000 | | |
| Fe-59 | 400 | | 10,000 | | |
| Co-58 | 1,000 | | 30,000 | | |
| Co-60 | 300 | | 10,000 | | |
| Ni-63 *** | 300 | | 1,000 | | |
| Zn-65 | 300 | | 20,000 | | |
| Sr-90 *** | 8* | | 40 | | |
| Zr-95 | 400 | | | | |
| Nb-95 | 400 | | | | |
| I-131 | 2 * | 0.9 | | 3 | 100 |
| Cs-134 | 30 | 10 | 1,000 | 60 | 1,000 |
| Cs-137 | 50 | 20 | 2,000 | 70 | 2,000 |
| Ba-140 | 200 | | | 300 | |
| La-140 | 200 | | | 300 | |

* Values provided are for drinking water pathways. If no drinking water pathway exists, higher values are allowed, as follows:

| | |
|---|---|
| H-3 | 30,000 pCi/L (This is a 40 CFR 141 value) |
| Sr-90 | 12 pCi/L |
| I-131 | 20 pCi/L |

** These reporting levels are associated only with the REMP requirements. The Radiological Ground Water Monitoring Program may involve unique reporting level criteria, independent of the REMP, and defined in station procedures.

*** Sr-90 and Ni-63 are included in this table due to their historical presence in ground water and possible migration to the environment

# SECTION 4.0

## INTERPRETATION AND TRENDS OF RESULTS

## 4.0 INTERPRETATION AND TRENDS OF RESULTS

The 2021 Radiological Environmental Monitoring Program (REMP) was conducted in accordance with Indian Point's Offsite Dose Calculation Manual ODCM. The ODCM contains requirements for the number and distribution of sampling locations, the types of samples to be collected, and the types of analyses to be performed for measurement of radioactivity.

The REMP at Indian Point includes measurements of radioactivity levels in the following environmental pathways.

| | |
| --- | --- |
| Direct Gamma Radiation | Drinking Water |
| Broad Leaf Vegetation | Hudson River Water |
| Bottom Sediment | Shoreline Soil |
| Aquatic Vegetation | Fish and Invertebrates |
| Airborne Particulates and Radioiodine | Soil |

An annual land use and milch animal census is also part of the REMP.

To evaluate the contribution of plant operations to environmental radioactivity levels, other man-made and natural sources of environmental radioactivity, as well as the aggregate of past monitoring data, must be considered. It is not merely the detection of a radionuclide, but the evaluation of the location, magnitude, source, and history of its detection that determines its significance. Therefore, we have reported the data collected in 2021 and assessed the significance of the findings.

A summary of the results of the 2021 REMP is presented in Table B-2. This Table lists the mean and range of all positive results obtained for each of the media sampled at ODCM indicator and control locations. Discussions of these results and their evaluations are provided below.

The radionuclides detected in the environment can be grouped into three categories: (1) naturally occurring radionuclides; (2) radionuclides resulting from weapons testing and other non-plant related, anthropogenic sources; and (3) radionuclides that could be related to plant operations.

The environment contains a broad inventory of naturally occurring radionuclides which can be classified as, cosmic ray induced (e.g., Be-7) or geologically derived (e.g., Ra-226 and progeny, Th-228 and progeny, and K-40.) These radionuclides constitute the majority of the background radiation source and thus account for a majority of the annual background dose detected. Since the detected concentrations of these radionuclides were consistent at indicator and control locations, and unrelated to plant operations, their presence is noted only in the data tables and will not be discussed further.

The second group of radionuclides detected in 2021 consists of those resulting from past weapons testing in the earth's atmosphere. The more recent contamination events resulting from the Chernobyl and Fukushima accidents only indicated detectable activity shortly after their occurrences (Reference 5). However, weapons testing in the 1950's and 1960's resulted in a significant atmospheric radionuclide inventory, which, in turn, still contributes to the concentrations in the ecological systems. Although reduced in frequency, atmospheric weapons testing continued into the 1980's. The resultant radionuclide inventory of some radionuclides, although diminishing with time (e.g., through radioactive decay and natural dispersion processes), remains detectable.

In 2021, the detected radionuclides that may be attributable to past atmospheric weapons testing consisted of Cs-137 in several media. The levels detected were consistent with the historical levels of radionuclides resulting from weapons tests as measured in previous years.

The final group of radionuclides detected by the 2021 REMP comprises those that may be attributable to current plant operations. During 2021, Cs-137 and Tritium were the only potentially plant-related radionuclides detected in any environmental samples.

H-3 may be present in the local environment due to either natural occurrence, other man-made sources, or as a result of plant operations. Natural occurrence is very low (on the order of approximately 5 pCi/liter - well below typical detectable levels). The major source of H-3 is typically from above ground nuclear weapons testing, in the range of 50 to 150 pCi/liter). Other sources include weapons production and industrial uses where levels are highly dependent on the release rates and distance from the source term. One such industrial source is nuclear power plant operation. In 2021, very low levels of H-3 were detected in three river water samples.

Cs-137 is ubiquitous in the environment from atmospheric testing debris and a lesser amount from the Chernobyl accident. In 2021, there were six detections of Cs-137 in bottom sediment at indicator and control locations. In all cases, the Cs-137 concentrations, when detected, were consistent with historical values.

Strontium-90 (Sr-90) may also be present in the environment from atmospheric testing debris. Sr-90 was not detected in any of the fish, invertebrate, or shoreline soil.

I-131 is also produced in fission reactors, but can result from non-plant related anthropogenic sources, e.g., medical administrations, such as has been noted in previous years. I-131 was not detected in 2021 in aquatic or terrestrial vegetation indicator and control locations.

Co-58 and Co-60 are activation/corrosion products also related to plant operations. They are produced by neutron activation in the reactor core. Co-58 has a much shorter half-life than Co-60. If Co-58 and Co-60 are concurrently detected in environmental samples, then the source of these radionuclides is more likely the result of recent releases. When significant concentrations of Co-60 are detected but no Co-58, there is an increased likelihood that the Co-60 is due to residual Co-60 from past operations. There was no Co-58 or Co-60 detected in the 2021 REMP, although they were observed in historical data.

In the following sections, a summary of the results of the 2021 REMP is presented by sample medium and the significance of any positive findings discussed. As previously mentioned, Table B-2 provides an annual summary of the following media.

## 4.1 Direct Radiation

The environmental TLDs used to measure the direct radiation were TLDs supplied and processed by Environmental Dosimetry Company. In 2021, the TLD program produced a consistent picture of ambient background radiation levels in the vicinity of the Indian Point Station. A summary of the annual TLD data is provided in Table B-2 and all the TLD data are presented in Tables B-3, B-4 and B-5. TLD sample site DR-40 is the control site for the direct radiation (DR) series of measurements.

Table B-3 provides the quarterly and annual average reported doses in mR per standard quarter for each of the direct radiation sample points, DR-1 through DR-41. Table B-4 provides the mean, standard deviation, minimum and maximum values in mR per year for the years 2012 through 2020. The 2021 means are also presented in Table B-4. Table B-5 presents the 2021 TLD data for the inner ring and outer ring of TLDs. The table also provides the sector for each of the DR sample points.

The 2021 mean value for the indicator direct radiation sample points was 13.2 mR per standard quarter – which is consistent with historical values. At those locations where the 2021 mean value was higher than historical means, they are within historical bounds for the respective locations.

The DR sample locations are arranged so that there are two concentric rings of TLDs around the Indian Point site. The inner ring (DR-1 to DR-16) is close to the site boundary. The outer ring (DR-17 to DR-32) has a radius of approximately 5 miles from the three Indian Point units. The results of the annual totals for these two rings of TLDs are provided in Table B-5. The annual average for the inner ring was 13.2 mR per standard quarter and also average for the outer ring was 13.3 mR per standard quarter. The control location average for 2021 was 14.1 mR per standard quarter.

Table C-1 and Figure C-1 present the 10-year historical averages for the inner and outer rings of TLDs. The 2021 averages are consistent with the historical data. The 2021 and previous years' data show that there is no measurable direct radiation in the environment due to the operation of the Indian Point site.

## 4.2 Airborne Particulates and Radioiodine

The results of the analyses of weekly air particulate filter samples for gross beta activity are presented in Table B-6 and the weekly charcoal cartridge analytical results are presented in Table B-7.

Gross beta activity was found in air particulate samples throughout the year at all indicator and control locations. The average gross beta activity for the seven indicator air sample locations was 0.014 pCi/$m^3$ and the average for the control location was 0.014 pCi/$m^3$. The activities detected were consistent for all locations, with no significant differences in gross beta activity in any sample due to location.

The results of the gamma spectral analyses (GSA) of the quarterly composites of these samples are shown in Table B-8. These quarterly composite air samples indicate that no reactor-related radionuclides were detected and that only Be-7, a naturally-occurring radionuclide was present at detectable levels.

The mean annual gross beta concentrations and Cs-137 concentrations in air for the past 10 years are presented in Table C-2. From this table and Figure C-2, it can be seen that the average 2021 gross beta concentration was consistent with historical levels. Cs-137 has not been detected since 1987. This is consistent with the trend of decreasing ambient Cs-137 concentrations in recent years.

From the data, it can be seen that no airborne radioactivity attributable to the operation of Indian Point was detected in 2021.

## 4.3 Drinking Water

Results of the gross beta, tritium and gamma spectroscopy analyses of the monthly drinking water samples are in Table B-9. Other than Gross Beta activity consistent with historical values, no radioactivity was detected in drinking water samples. This has historically been the case for the radionuclide results for this media. Operation of the Indian Point units had no detectable radiological impact on drinking water.

## 4.4 Soil

Table B-10 contains the results of the soil samples for 2021. There were no plant related nuclides detected in the 2021 samples.

## 4.5 Broad Leaf Vegetation

Data from analysis of the 2021 samples are presented in Table B-11. Table C-6 contains an historical summary and Figure C-6 is an illustration of the broad leaf vegetation analysis results. There were no plant related nuclides detected in the 2021 samples. The detection of low levels of Cs-137 has occurred sporadically at indicator locations at relatively low concentrations for the past ten years, most likely the result of previous atmospheric weapons testing.

## 4.6 Hudson River Water

Data resulting from analysis of monthly Hudson River water samples for gamma emitters and quarterly composites of H-3 are presented in Tables B-12.

The only plant related activity detected was H-3; detected at low levels in three indicator samples. The levels are consistent with occasional historical detection of H-3 related to plant operation. Table C-3 shows historical H-3 concentrations at the plant inlet and discharge points. Table C-8 contains a comparison of H-3 detected at the plant discharge (Hudson River Water mixing point) versus calculated quarterly average effluents concentrations. The data in table C-8 provides assurance that the REMP is indeed providing verification of the calculated radionuclide concentrations resulting from effluent releases attributable to the site.

## 4.7 Hudson River Bottom Sediment

Table B-13 contains the results of the analysis of bottom sediment samples for 2021. Cesium-137 was detected in five of six indicator station samples, and one of two control location samples. Detection of positive levels of Cs-137 in river bottom sediment is not unusual. Cs-137 is often detected in the control location sediments and therefore not likely due to plant releases.

Historical levels of Cs-137 in bottom sediment samples are shown in table C-9 and figure C-9. This data shows the continued detection of Cs-137 in bottom sediment samples at varying levels, and demonstrates that the levels observed during 2021 sampling are within the range of levels identified in historical samples.

## 4.8 Hudson River Shoreline Soil

Table B-14 contains the results of the gamma spectroscopic and strontium-90 analyses of the shoreline soil samples. Naturally occurring radionuclides were detected in the shoreline soil samples. There were no plant related nuclides detected in the 2021 samples.

An historical look at Cs-137 detected in shoreline soil at indicator and control locations can be viewed in Table C-5 and Figure C-5. Cesium-137 has been present in this media, both at indicator and occasionally at the control location, at a consistent level over the past ten years. Cesium-134 and Cs-137 are both discharged from the plant in similar quantities. The lack of Cs-134 activity is an indication that the primary source of the Cs-137 in the shoreline soil is legacy contamination from weapons fallout.

Strontium-90 (Sr-90) was not detected in any of the six indicator location samples or any of the control location samples.

## 4.9 Hudson River Aquatic Vegetation

Table B-15 results show no plant related radionuclides were detected in any indicator or control aquatic vegetation samples in 2021. This is consistent with historical findings.

## 4.10 Fish and Invertebrates

Table B-16 contains the results of the analysis of fish and invertebrate samples for 2021. No plant related radionuclides were detected. This is consistent with historical results which are shown in Table and Figure C-7.

## 4.11 Land Use Census

A census was performed in the vicinity of Indian Point in 2021. This census consisted of a milch animal and a residence census. Results of this census are presented in Tables B-17 and B-18.

The results of the 2021 census were generally same as the 2020 census results. In 2020 the presence of goats was noted on a property located less than 5.0 miles of IPEC, discussions with the owner of the property indicated that the goats did not produce milk for human consumption. Similar to 2020, it was noted in 2021 that no animals were producing milk for human consumption at this location or any other location within 5 miles to IPEC.

However, discussions with the owner for the 2021 land use surveys confirmed that the goats did not produce milk for human consumption and are therefore not milch animals.

The 2021 land use census indicated there were no new residences that were closer in proximity to IPEC.

The ODCM allows the sampling of broad leaf vegetation in two sectors at the site boundary in lieu of performing a garden census. Analysis results for these two sectors are discussed in Section 4.5 and presented in Table B-11, Table C-6 and Figure C-6.

### 4.12 Conclusion

The Radiological Environmental Monitoring Program is conducted each year to determine the radiological impact of Indian Point operations on the environment. The preceding discussions of the results of the 2021 REMP reveal that operations at the station did not result in an impact on the environment.

The 2021 REMP results demonstrate the relative contributions of different radionuclide sources, both natural and anthropogenic, to the environmental concentrations. The results indicate that the fallout from previous atmospheric weapons testing continues to contribute to detection of Cs-137 in some environmental samples. There are infrequent detections of plant related activity in the environs; however, the radiological levels are very low and are significantly less than those from natural background and other anthropogenic sources.

# SECTION 5.0

## RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM SUMMARY

# 5.0 RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM SUMMARY

## 5.1 2021 Annual Radiological Environmental Monitoring Program Summary

The results of the 2021 radiological environmental sampling program are presented in Tables B-2 through B-16. Table B-2 is a summary table of the sample results for 2021. The format of this summary table conforms to the reporting requirements of the ODCM, NRC Regulatory Guide 4.8, and NRC Branch Technical Position to Regulatory Guide 4.8 (Reference 4). In addition, the data obtained from the analysis of samples are provided in Tables B-3 through B-16.

REMP samples were analyzed by various counting methods as appropriate. The methods are; gross beta, gamma spectroscopy analysis, liquid scintillation, radiochemical analysis, and TLD processing. Gamma spectroscopy analysis was performed for gamma emitting nuclides, including the following: Be-7, K-40, Mn-54, Co-58, Co-60, Fe-59, Zn-65, Zr-95, Nb-95, Ru-103, Ru-106, I-131, Cs-134, Cs-137, Ba/La-140, Ce-141, Ce-144, Ra-226 and Ac/Th-228. Radiochemical analyses were performed for H-3, Ni-63, Sr-90 and I-131 for specific media and locations as required in the ODCM.

## 5.2 Land Use Census

In accordance with Sections IP2-D3.5.2 and IP3-2.8 of the ODCM, a land use census was conducted to identify the nearest milch animal and the nearest residence. The results of the milch animal and land use census are presented in Tables B-17 and B-18, respectively. In lieu of identifying and sampling the nearest garden of greater than 50 $m^2$, at least three kinds of broad leaf vegetation were sampled near the site boundary in two sectors and at a designated control location (results are presented in Table B-11).

## 5.3 Sampling Deviations

During 2021, environmental sampling was performed for 10 unique media types addressed in the ODCM and for direct radiation. A total of 1172 samples of 1177 scheduled were obtained. Of the scheduled samples, 99.6% were collected and analyzed for the program. Sampling deviations are summarized in Table B-1. Discussions of the reasons for the deviations are provided in Table B-1a for the air samples, Table B-1b for other media, and Table B-1c for changes to the REMP program. Analytical deviations noted in Table B-6 and B-7 due to insufficient sample volumes as noted in Table B-1a.

## 5.4 Analytical Deviations

No analytical deviations were found in 2021.

## 5.5 Special Reports

No special reports were required under the REMP.

## TABLE B-1

## Summary of Sampling Deviations - 2021

| MEDIA | TOTAL SCHEDULED SAMPLES | NUMBER OF DEVIATIONS* | SAMPLING EFFICIENCY % | NUMBER OF ANALYSES** | REASON FOR DEVIATION |
|---|---|---|---|---|---|
| **MEDIA** | | | | | |
| TLD | 164 | 0 | 100% | 164 | N/A |
| PARTICULATES IN AIR | 424 | 0 | 100% | 456 | N/A |
| CHARCOAL FILTER | 424 | 0 | 100% | 424 | N/A |
| DRINKING WATER | 24 | 0 | 100% | 56 | N/A |
| SOIL | 3 | 0 | 100% | 3 | N/A |
| BROAD LEAF VEGETATION | 54 | 0 | 100% | 54 | N/A |
| HUDSON RIVER WATER | 24 | 0 | 100% | 32 | N/A |
| SHORELINE SOIL | 10 | 0 | 100% | 20 | N/A |
| HUDSON RIVER BOTTOM SEDIMENT | 8 | 0 | 100% | 8 | N/A |
| AQUATIC VEGETATION | 6 | 2 | 67% | 4 | See Table B-1b |
| FISH & INVERTEBRATES | 36 | 3 | 94% | 98 | See Table B-1b |
| **TOTALS** | 1177 | 5 | 99.6% | 1319 | |

TOTAL NUMBER OF SAMPLES COLLECTED = 1172

* Samples not collected or unable to be analyzed.

** Several sample types require more than one analysis

## TABLE B-1a

## 2021 Air Sampling Deviations

| LOCATION | DATE | PROBLEM / ACTIONS TO PREVENT RECURRENCE |
|---|---|---|
| 04 Algonquin | 2/4/2021 | Air sampler collection frequency exceeded 7 days + 25%. CPR-IP3-2021-00333. Cb. |
| 05 NYC Tower | 2/4/2021 | Air sampler collection frequency exceeded 7 days + 25%. CPR-IP3-2021-00333. Cb. |
| 29 Grassy Point | 2/4/2021 | Air sampler collection frequency exceeded 7 days + 25%. CPR-IP3-2021-00333. Cb. |
| 108 Telecomm | 2/4/2021 | Air sampler collection frequency exceeded 7 days + 25%. CPR-IP3-2021-00333. Cb. |
| 27 Croton Point | 10/4/2021 | Air sampler lost 22 hours of run time due to hour meter repair. IR-IP3-2021-00229. |

## TABLE B-1b

## 2021 Other Media Deviations

| LOCATION | DATE | PROBLEM / ACTIONS TO PREVENT RECURRENCE |
|---|---|---|
| 38 Furnace Dock | 1/7/2021 | During collection of 1st Quarter REMP TLDs it was discovered that the TLD was missing from the Cortlandt Yacht Club location. CR-IP2-2021-00017. |
| 10 Hudson River Discharge | 2/4/2021 | Sample was not able to be obtained due to pump failure. Grab sample was collected. CR-IP2-2021-00058. |
| 23 Roseton Hudson River | 5/3/2021 | Sample was not able to be obtained due to the pump being in pause mode. Grab sample was collected. CR-IP2-2021-00237. |
| 17 Verplanck | Spring | Aquatic Vegetation samples were not available in the riverbed areas designated for these samples during the Spring sampling event. |
| 25 Indian Point | Spring | Crab samples were not available during the Spring sampling event. |
| 23 Poughkeepsie | Spring | Crab samples were not available during the Spring sampling event. |
| 17 Verplanck | Summer | Aquatic Vegetation samples were not available in the riverbed areas designated for these samples during the Summer sampling event. |
| 107 Croton - Haverstraw | Summer | Striped Bass samples were not available during the Spring sampling event |
| 25 Downstream | 9/15/21 | Stripped Bass samples had limited amount of sample. Strontium-90 was unable to be performed. |

**TABLE B-1c**

**2021 Changes to the REMP Program**

| LOCATION | DATE | Discussion of REMP Change |
|---|---|---|
| No changes to the REMP program in 2021. | | |

TABLE B-2 RADIOLOGICIAL ENVIRONMENTAL MONITORING PROGRAM SUMMARY
INDIAN POINT ENERGY CENTER - 2021
Dockets 50-003, 50-247 & 50-286

| Medium or Pathway Sampled (Units) | Analysis Type | Total Number | LLD* | Indicator Locations Mean ** (Range) | Location with Highest Mean Location Number | Distance Direction | Mean** (Range) | Control Locations Mean** (Range) | Non-Routine Reported Measurements |
|---|---|---|---|---|---|---|---|---|---|
| Direct Radiation (mR/Standard Quarter) | TLD-Quarterly | 164 | | 13.2 (160/160) (9.4/16.6) | DR-13 | 1.21 Mi. W | 15.5 (4/4) (14.8/16.6) | 14.1 (4/4) (13.1/15.6) | 0 |
| Air Particulate (pCi/m$^3$) | Gr-B | 424 | 0.01 | .014 (371/371) (.005/.026) | 4 | 0.28 Mi. SW | .015 (53/53) (.006/.026) | .014 (53/53) (.005/.023) | 0 |
| Air Iodine (pCi/m$^3$) | GAMMA I-131 | 424 | 0.07 | <LLD | | | - | <LLD | 0 |
| Air Particulate ($10^{-3}$ pCi/m$^3$) | GAMMA Be-7 | 32 | NA | 112.9 (28/28) (84.5/151.6) | 94 | 0.39 Mi. S | 117.1 (4/4) (99.7/131.1) | 95.0 (4/4) (77.8/124.2) | 0 |
| | K-40 | | NA | <LLD | | | - | <LLD | 0 |
| | Cs-134 | | 0.05 | <LLD | | | - | <LLD | 0 |
| | Cs-137 | | 0.06 | <LLD | | | - | <LLD | 0 |
| | Th-228 | | NA | <LLD | | | - | <LLD | 0 |
| Drinking Water (pCi/L) | Gr-B | 24 | 4 | 3.16 (9/24) (2.49/5.38) | 8 | 6.3 Mi. SE | 3.47 (5/12) (2.54/5.38) | NA | 0 |
| | H-3 | 8 | 200 | <LLD | | | - | NA | 0 |
| | GAMMA Mn-54 | 24 | 15 | <LLD | | | - | NA | 0 |
| | Co-58 | | 15 | <LLD | | | - | NA | 0 |
| | Fe-59 | | 30 | <LLD | | | - | NA | 0 |
| | Co-60 | | 15 | <LLD | | | - | NA | 0 |
| | Zn-65 | | 30 | <LLD | | | - | NA | 0 |
| | Nb-95 | | 15 | <LLD | | | - | NA | 0 |
| | Zr-95 | | 30 | <LLD | | | - | NA | 0 |
| | I-131 | | 15 | <LLD | | | - | NA | 0 |
| | Cs-134 | | 15 | <LLD | | | - | NA | 0 |

TABLE B-2 RADIOLOGICIAL ENVIRONMENTAL MONITORING PROGRAM SUMMARY
INDIAN POINT ENERGY CENTER - 2021
Dockets 50-003, 50-247 & 50-286

| Medium or Pathway Sampled (Units) | Analysis Type | Total Number | LLD* | Indicator Locations Mean ** (Range) | Location with Highest Mean Location Number | Distance Direction | Mean** (Range) | Control Locations Mean** (Range) | Non-Routine Reported Measurements |
|---|---|---|---|---|---|---|---|---|---|
| Drinking Water (cont'd) (pCi/L) | Cs-137 | | 18 | <LLD | | | - | NA | 0 |
| | Ba-140 | | 60 | <LLD | | | - | NA | 0 |
| | La-140 | | 15 | <LLD | | | - | NA | 0 |
| Soil (pCi/kg dry) | GAMMA | 3 | | | | | | | |
| | Be-7 | | NA | <LLD | | | - | <LLD | 0 |
| | K-40 | | NA | 10320 (2/2) (8669/11970) | 23 | 20.7 Mi. N | 14750 (1/1) | 14750 (1/1) | 0 |
| | Co-60 | | NA | <LLD | | | - | <LLD | 0 |
| | Cs-134 | | 150 | <LLD | | | - | <LLD | 0 |
| | Cs-137 | | 180 | <LLD | | | - | <LLD | 0 |
| | Ra-226 | | NA | <LLD | | | - | <LLD | 0 |
| | Th-228 | | NA | 589 (1/2) | 23 | 20.7 Mi. N | 715 (1/1) | 715 (1/1) | 0 |
| Broad leaf Vegetation (pCi/kg wet) | GAMMA | 54 | | | | | | | |
| | Be-7 | | NA | 2133 (36/36) (758.2/5935) | 23 | 20.7 Mi. N | 2486 (17/18) (1009/5319) | 2486 (17/18) (1009/5319) | 0 |
| | K-40 | | NA | 4814 (36/36) (2224/10050) | 95 | 0.46 Mi. SSW | 5638 (18/18) (3285/10050) | 4637 (18/18) (2381/7444) | 0 |
| | Co-60 | | NA | <LLD | | | - | <LLD | 0 |
| | I-131 | | 60 | <LLD | | | - | <LLD | 0 |
| | Cs-134 | | 60 | <LLD | | | - | <LLD | 0 |
| | Cs-137 | | 80 | <LLD | | | - | <LLD | 0 |
| | Th-228 | | NA | 127 (3/36) (98.5/169.4) | 95 | 0.46 Mi. SSW | 141.8 (2/18) (114.2/169.4) | <LLD | 0 |

TABLE B-2 RADIOLOGICIAL ENVIRONMENTAL MONITORING PROGRAM SUMMARY
INDIAN POINT ENERGY CENTER - 2021
Dockets 50-003, 50-247 & 50-286

| Medium or Pathway Sampled (Units) | Analysis Type | Total Number | LLD* | Indicator Locations Mean ** (Range) | Location with Highest Mean Location Number | Distance Direction | Mean** (Range) | Control Locations Mean** (Range) | Non-Routine Reported Measurements |
|---|---|---|---|---|---|---|---|---|---|
| River Water (pCi/L) | H-3 | 8 | 200 | 380.0 (3/4) (214/483) | 10 | 0.3 Mi. WSW | 380.0 (3/4) (214/483) | <LLD | 0 |
| | GAMMA | 24 | | | | | | | |
| | Mn-54 | | 15 | <LLD | | | - | <LLD | 0 |
| | Co-58 | | 15 | <LLD | | | - | <LLD | 0 |
| | Fe-59 | | 30 | <LLD | | | - | <LLD | 0 |
| | Co-60 | | 15 | <LLD | | | - | <LLD | 0 |
| | Zn-65 | | 30 | <LLD | | | - | <LLD | 0 |
| | Nb-95 | | 15 | <LLD | | | - | <LLD | 0 |
| | Zr-95 | | 30 | <LLD | | | - | <LLD | 0 |
| | Cs-134 | | 15 | <LLD | | | - | <LLD | 0 |
| | I-131 | | 15 | <LLD | | | - | <LLD | 0 |
| | Cs-137 | | 18 | <LLD | | | - | <LLD | 0 |
| | Ba-140 | | 60 | <LLD | | | - | <LLD | 0 |
| | La-140 | | 15 | <LLD | | | - | <LLD | 0 |
| | Th-228 | | NA | 9.974 (1/12) | 10 | 0.3 Mi. WSW | 9.974 (1/12) | <LLD | 0 |
| Bottom Sediment (pCi/kg dry) | GAMMA | 8 | | | | | | | |
| | K-40 | | NA | 16472 (6/6) (13790/21400) | 84 | 10.88 Mi. N | 19885 (2/2) (19560/20210) | 19885 (2/2) (19560/20210) | 0 |
| | Co-60 | | NA | <LLD | | | - | <LLD | 0 |
| | Cs-134 | | 150 | <LLD | | | - | <LLD | 0 |
| | Cs-137 | | 180 | 182.5 (5/6) (94.4/321.4) | 84 | 10.88 Mi. N | 256.9 (1/2) | 256.9 (1/2) | 0 |

TABLE B-2 RADIOLOGICIAL ENVIRONMENTAL MONITORING PROGRAM SUMMARY
INDIAN POINT ENERGY CENTER - 2021
Dockets 50-003, 50-247 & 50-286

| Medium or Pathway Sampled (Units) | Analysis Type | Total Number | LLD* | Indicator Locations Mean ** (Range) | Location with Highest Mean Location Number | Distance Direction | Mean** (Range) | Control Locations Mean** (Range) | Non-Routine Reported Measurements |
|---|---|---|---|---|---|---|---|---|---|
| Bottom Sediment (cont'd) (pCi/kg dry) | Ra-226 | | NA | 2270 (2/6) (1962/2578) | 17 | 1.5 Mi. SSW | 2270 (2/2) (1962/2578) | <LLD | 0 |
| | Th-228 | | NA | 718.6 (6/6) (244/900) | 84 | 10.88 Mi. N | 1027.4 (2/2) (970/1085) | 1027.4 (2/2) (970/1085) | 0 |
| Shoreline Soil (pCi/kg dry) | Sr-90 | 10 | 50 | <LLD | | | - | <LLD | 0 |
| | GAMMA | 10 | | | | | | | |
| | K-40 | | NA | 11083 (6/6) (8047/13410) | 84 | 10.88 Mi. N | 31200 (2/2) (30250/32150) | 21160 (4/4) (9070/32150) | 0 |
| | Cs-134 | | 150 | <LLD | | | - | <LLD | 0 |
| | Cs-137 | | 180 | <LLD | | | - | <LLD | 0 |
| | Ra-226 | | NA | <LLD | 50 | 4.48 Mi. NNW | 2435 (1/4) | 2435 (1/4) | 0 |
| | Ac-228 | | NA | <LLD | | | - | <LLD | 0 |
| | Th-228 | | NA | 368.0 (4/6) (203/493) | 50 | 4.48 Mi. NNW | 613.7 (2/2) (577/650) | 512.0 (4/4) (335/650) | 0 |
| Aquatic Vegetation (pCi/kg wet) | GAMMA | 4 | | | | | | | |
| | Be-7 | | NA | 385.5 (1/2) | 28 | 0.45 Mi. ENE | 385.5 (1/2) | <LLD | 0 |
| | K-40 | | NA | 2173 (2/2) (2134/2212) | 84 | 10.88 Mi. N | 2688 (2/2) (2405/2971) | 2688 (2/2) (2405/2971) | 0 |
| | Co-60 | | NA | <LLD | | | - | <LLD | 0 |
| | I-131 | | 60 | <LLD | | | - | <LLD | 0 |
| | Cs-134 | | 60 | <LLD | | | - | <LLD | 0 |
| | Cs-137 | | 80 | <LLD | | | - | <LLD | 0 |
| | Ra-226 | | NA | <LLD | | | - | <LLD | 0 |
| | Ac-228 | | NA | <LLD | | | - | <LLD | 0 |
| | Th-228 | | NA | <LLD | | | - | <LLD | 0 |

TABLE B-2 RADIOLOGICIAL ENVIRONMENTAL MONITORING PROGRAM SUMMARY
INDIAN POINT ENERGY CENTER - 2021
Dockets 50-003, 50-247 & 50-286

| Medium or Pathway Sampled (Units) | Analysis Type | Total Number | LLD* | Indicator Locations Mean ** (Range) | Location with Highest Mean Location Number | Distance Direction | Mean** (Range) | Control Locations Mean** (Range) | Non-Routine Reported Measurements |
|---|---|---|---|---|---|---|---|---|---|
| Fish (pCi/kg wet) | Ni-63 | 33 | 100 | <LLD | | | - | <LLD | 0 |
| | Sr-90 | 32 | 5 | <LLD | | | - | <LLD | 0 |
| | GAMMA | 33 | | | | | | | |
| | K-40 | | NA | 2422 (22/22) (1185/3573) | 23 | 20.7 Mi. N | 2780 (11/11) (1827/4154) | 2780 (11/11) (1827/4154) | 0 |
| | Mn-54 | | 130 | <LLD | | | - | <LLD | 0 |
| | Co-58 | | 130 | <LLD | | | - | <LLD | 0 |
| | Fe-59 | | 260 | <LLD | | | - | <LLD | 0 |
| | Co-60 | | 130 | <LLD | | | - | <LLD | 0 |
| | Zn-65 | | 260 | <LLD | | | - | <LLD | 0 |
| | Cs-134 | | 130 | <LLD | | | - | <LLD | 0 |
| | Cs-137 | | 150 | <LLD | | | - | <LLD | 0 |
| | Th-228 | | NA | 212.1 (1/22) | 25 | Downstream | 212.1 (1/22) | <LLD | 0 |
| | Environment | Samples | 1172 | | | | | | |
| | | Analysis | 1319 | | | | | | |

* LLD IS THE LOWER LIMIT OF DETECTION
** THE MEAN VALUES ARE CALCULATED USING THE POSITIVE VALUES

**INDIAN POINT ENERGY CENTER**

TABLE B-3

DIRECT RADIATION, QUARTERLY DATA - 2021

mR/Quarter ± 1 sigma

| Sample Nuclide | Station Number | First Quarter 01/01-03/31 | Second Quarter 04/01-06/30 | Third Quarter 07/01-09/30 | Fourth Quarter 10/01-01/01 | Annual Average | Annual Total |
|---|---|---|---|---|---|---|---|
| TLD | DR-01 | 14.1 ± 0.5 | 15.8 ± 0.6 | 15.7 ± 1.0 | 15.0 ± 1.1 | 15.1 ± 0.8 | 60.6 |
| | DR-02 | 13.5 ± 0.6 | 14.6 ± 0.6 | 14.9 ± 1.0 | 14.3 ± 0.6 | 14.3 ± 0.6 | 57.3 |
| | DR-03 | 11.8 ± 0.8 | 12.8 ± 0.5 | 12.6 ± 0.9 | 12.2 ± 0.7 | 12.4 ± 0.4 | 49.4 |
| | DR-04 | 12.1 ± 0.6 | 14.0 ± 0.5 | 13.6 ± 0.9 | 12.9 ± 0.6 | 13.2 ± 0.8 | 52.6 |
| | DR-05 | 12.2 ± 0.5 | 13.9 ± 0.7 | 13.7 ± 0.8 | 12.6 ± 0.6 | 13.1 ± 0.8 | 52.3 |
| | DR-06 | 12.9 ± 0.8 | 14.0 ± 0.7 | 13.8 ± 0.9 | 13.7 ± 0.6 | 13.6 ± 0.5 | 54.4 |
| | DR-07 | 13.7 ± 0.5 | 15.7 ± 0.5 | 15.6 ± 1.1 | 14.4 ± 0.7 | 14.8 ± 0.9 | 59.3 |
| | DR-08 | 10.9 ± 0.6 | 11.9 ± 0.4 | 12.3 ± 0.8 | 11.6 ± 0.5 | 11.7 ± 0.6 | 46.6 |
| | DR-09 | 12.2 ± 0.6 | 13.3 ± 0.6 | 12.8 ± 0.8 | 12.7 ± 0.7 | 12.7 ± 0.5 | 50.9 |
| | DR-10 | 11.4 ± 0.6 | 12.5 ± 0.5 | 13.5 ± 1.0 | 12.7 ± 0.6 | 12.5 ± 0.8 | 50.1 |
| | DR-11 | 9.9 ± 0.5 | 11.2 ± 0.4 | 9.4 ± 0.7 | 9.9 ± 0.5 | 10.1 ± 0.8 | 40.4 |
| | DR-12 | 14.0 ± 0.8 | 16.2 ± 0.7 | 14.7 ± 0.9 | 14.5 ± 0.6 | 14.8 ± 0.9 | 59.3 |
| | DR-13 | 14.8 ± 0.9 | 16.6 ± 0.6 | 15.4 ± 1.0 | 15.2 ± 0.7 | 15.5 ± 0.8 | 62.0 |
| | DR-14 | 11.7 ± 0.8 | 13.3 ± 0.5 | 12.3 ± 0.8 | 12.3 ± 0.7 | 12.4 ± 0.7 | 49.5 |
| | DR-15 | 11.4 ± 0.7 | 13.2 ± 0.5 | 12.0 ± 0.8 | 12.3 ± 0.5 | 12.2 ± 0.7 | 49.0 |
| | DR-16 | 12.5 ± 0.6 | 14.9 ± 0.6 | 13.2 ± 0.9 | 13.7 ± 0.6 | 13.6 ± 1.0 | 54.3 |
| | DR-17 | 12.4 ± 0.5 | 14.0 ± 0.7 | 13.7 ± 0.9 | 13.5 ± 0.7 | 13.4 ± 0.7 | 53.5 |
| | DR-18 | 12.4 ± 0.7 | 14.4 ± 0.6 | 13.3 ± 0.8 | 13.7 ± 0.6 | 13.4 ± 0.8 | 53.8 |
| | DR-19 | 12.7 ± 0.6 | 14.7 ± 0.5 | 13.7 ± 0.9 | 13.2 ± 0.6 | 13.6 ± 0.8 | 54.3 |
| | DR-20 | 12.2 ± 0.5 | 14.0 ± 0.7 | 13.3 ± 0.8 | 13.3 ± 0.6 | 13.2 ± 0.8 | 52.8 |
| | DR-21 | 12.6 ± 0.7 | 14.2 ± 0.5 | 13.2 ± 0.9 | 13.4 ± 0.6 | 13.3 ± 0.6 | 53.4 |
| | DR-22 | 10.0 ± 0.4 | 11.7 ± 0.4 | 10.4 ± 0.7 | 10.5 ± 0.5 | 10.6 ± 0.7 | 42.5 |
| | DR-23 | 12.6 ± 0.6 | 13.8 ± 0.5 | 12.4 ± 0.8 | 13.4 ± 0.7 | 13.1 ± 0.6 | 52.3 |
| | DR-24 | 12.8 ± 0.6 | 14.3 ± 0.9 | 14.1 ± 0.7 | 13.7 ± 0.7 | 13.7 ± 0.6 | 54.9 |
| | DR-25 | 10.8 ± 0.5 | 12.0 ± 0.8 | 12.1 ± 0.7 | 11.2 ± 0.6 | 11.5 ± 0.6 | 46.1 |
| | DR-26 | 12.4 ± 0.4 | 13.6 ± 0.5 | 12.7 ± 0.7 | 12.6 ± 0.5 | 12.8 ± 0.5 | 51.2 |
| | DR-27 | 12.0 ± 0.7 | 13.6 ± 0.8 | 13.0 ± 0.6 | 12.6 ± 0.6 | 12.8 ± 0.7 | 51.3 |
| | DR-28 | 13.7 ± 0.6 | 15.3 ± 0.5 | 14.6 ± 0.5 | 14.2 ± 0.7 | 14.4 ± 0.7 | 57.8 |
| | DR-29 | 12.1 ± 0.5 | 13.8 ± 0.6 | 13.6 ± 0.7 | 13.1 ± 0.7 | 13.2 ± 0.8 | 52.6 |
| | DR-30 | 12.3 ± 0.5 | 13.9 ± 0.9 | 13.7 ± 0.7 | 13.1 ± 0.8 | 13.3 ± 0.7 | 53.1 |
| | DR-31 | 14.4 ± 0.7 | 15.9 ± 0.7 | 15.4 ± 0.9 | 15.0 ± 0.6 | 15.2 ± 0.7 | 60.7 |
| | DR-32 | 13.6 ± 0.5 | 15.3 ± 0.8 | 15.5 ± 0.9 | 14.7 ± 0.7 | 14.8 ± 0.9 | 59.1 |
| | DR-33 | 12.1 ± 0.7 | 13.1 ± 0.6 | 13.0 ± 0.7 | 12.6 ± 0.7 | 12.7 ± 0.4 | 50.7 |
| | DR-34 | 11.6 ± 0.4 | 13.0 ± 0.5 | 12.6 ± 0.6 | 12.4 ± 0.6 | 12.4 ± 0.6 | 49.5 |
| | DR-35 | 11.9 ± 0.5 | 14.1 ± 0.7 | 14.2 ± 0.5 | 15.0 ± 0.7 | 13.8 ± 1.3 | 55.2 |
| | DR-36 | 13.5 ± 0.6 | 14.5 ± 0.6 | 14.1 ± 0.6 | 13.8 ± 0.7 | 14.0 ± 0.4 | 55.8 |
| | DR-37 | 12.1 ± 0.5 | 13.4 ± 0.6 | 13.1 ± 0.5 | 12.2 ± 0.6 | 12.7 ± 0.6 | 50.8 |
| | DR-38 | 11.2 ± 0.5 | 12.1 ± 0.6 | 11.8 ± 0.6 | 11.3 ± 0.7 | 11.6 ± 0.4 | 46.4 |
| | DR-39 | 13.1 ± 0.4 | 14.5 ± 0.7 | 14.3 ± 0.6 | 13.9 ± 0.6 | 13.9 ± 0.6 | 55.8 |
| | DR-40* | 13.1 ± 0.5 | 13.7 ± 0.4 | 15.6 ± 0.7 | 13.9 ± 0.7 | 14.1 ± 1.0 | 56.3 |
| | DR-41 | 11.5 ± 0.6 | 13.4 ± 0.8 | 12.6 ± 0.5 | 11.6 ± 0.6 | 12.3 ± 0.9 | 49.1 |
| AVERAGE (Indicator Locations) | | 12.4 ± 1.1 | 13.9 ± 1.2 | 13.4 ± 1.3 | 13.1 ± 1.2 | 13.2 ± 1.2 | 52.8 |

* Control location

**INDIAN POINT ENERGY CENTER**
TABLE B-4
DIRECT RADIATION, 2012 THROUGH 2021 DATA

mR per Year

| Station Number | Mean (2012-2020) | Standard Deviation (2012-2020) | Minimum Value (2012-2020) | Maximum Value (2012-2020) | 2021 Annual Total |
|---|---|---|---|---|---|
| DR-01 | 62.0 | 3.0 | 55.6 | 65.6 | 60.6 |
| DR-02 | 58.3 | 1.7 | 55.9 | 60.4 | 57.3 |
| DR-03 | 46.9 | 5.0 | 35.0 | 50.9 | 49.4 |
| DR-04 | 53.3 | 1.0 | 52.1 | 54.8 | 52.6 |
| DR-05 | 54.9 | 1.6 | 53.3 | 58.2 | 52.3 |
| DR-06 | 56.2 | 1.4 | 54.7 | 58.0 | 54.4 |
| DR-07 | 62.6 | 1.4 | 60.7 | 64.6 | 59.3 |
| DR-08 | 47.4 | 1.6 | 45.1 | 49.5 | 46.6 |
| DR-09 | 53.4 | 2.1 | 50.0 | 55.8 | 50.9 |
| DR-10 | 56.9 | 4.7 | 53.0 | 67.7 | 50.1 |
| DR-11 | 43.2 | 1.1 | 41.4 | 44.6 | 40.4 |
| DR-12 | 60.6 | 4.5 | 49.2 | 64.8 | 59.3 |
| DR-13 | 64.7 | 1.9 | 62.3 | 67.6 | 62.0 |
| DR-14 | 52.3 | 1.2 | 50.5 | 54.0 | 49.5 |
| DR-15 | 52.2 | 1.3 | 50.3 | 53.8 | 49.0 |
| DR-16 | 57.6 | 1.6 | 55.1 | 59.3 | 54.3 |
| DR-17 | 57.8 | 1.7 | 55.6 | 60.1 | 53.5 |
| DR-18 | 56.4 | 1.3 | 54.4 | 58.2 | 53.8 |
| DR-19 | 58.3 | 1.5 | 55.9 | 60.4 | 54.3 |
| DR-20 | 55.5 | 1.3 | 53.4 | 57.5 | 52.8 |
| DR-21 | 55.2 | 2.5 | 51.9 | 58.4 | 53.4 |
| DR-22 | 45.1 | 1.7 | 42.6 | 47.7 | 42.5 |
| DR-23 | 55.6 | 1.4 | 53.6 | 57.4 | 52.3 |
| DR-24 | 58.2 | 1.6 | 55.8 | 60.2 | 54.9 |
| DR-25 | 48.3 | 1.3 | 45.7 | 50.0 | 46.1 |
| DR-26 | 55.0 | 1.2 | 53.0 | 56.5 | 51.2 |
| DR-27 | 54.0 | 1.6 | 51.5 | 56.5 | 51.3 |
| DR-28 | 69.5 | 11.3 | 51.3 | 80.6 | 57.8 |
| DR-29 | 56.3 | 1.2 | 54.8 | 58.3 | 52.6 |
| DR-30 | 57.0 | 1.4 | 54.7 | 59.3 | 53.1 |
| DR-31 | 64.7 | 1.9 | 61.5 | 67.4 | 60.7 |
| DR-32 | 54.9 | 5.2 | 48.7 | 63.3 | 59.1 |
| DR-33 | 53.7 | 1.1 | 52.3 | 55.6 | 50.7 |
| DR-34 | 52.6 | 1.8 | 50.2 | 55.0 | 49.5 |
| DR-35 | 52.9 | 2.6 | 49.9 | 56.3 | 55.2 |
| DR-36 | 57.6 | 1.3 | 55.9 | 59.6 | 55.8 |
| DR-37 | 54.8 | 1.2 | 53.3 | 56.8 | 50.8 |
| DR-38 | 47.5 | 3.7 | 38.5 | 50.9 | 46.4 |
| DR-39 | 57.8 | 1.8 | 54.8 | 59.4 | 55.8 |
| DR-40* | 58.7 | 4.2 | 49.3 | 62.4 | 56.3 |
| DR-41 | 52.0 | 1.7 | 49.7 | 53.9 | 49.1 |
| AVERAGE (Indicator Locations) | 55.3 | | | | 52.8 |

* Control location

**INDIAN POINT ENERGY CENTER**

TABLE B-5

DIRECT RADIATION, INNER AND OUTER RINGS - 2021

(mR per Year)

| Inner Ring | Outer Ring | Sector | Inner Ring | Outer Ring |
|---|---|---|---|---|
| ID | ID | | Annual Total | Annual Total |
| DR-01 | DR-17 | N | 60.57 | 53.54 |
| DR-02 | DR-18 | NNE | 57.26 | 53.78 |
| DR-03 | DR-19 | NE | 49.43 | 54.29 |
| DR-04 | DR-20 | ENE | 52.62 | 52.78 |
| DR-05 | DR-21 | E | 52.29 | 53.38 |
| DR-06 | DR-22 | ESE | 54.37 | 42.50 |
| DR-07 | DR-23 | SE | 59.32 | 52.25 |
| DR-08 | DR-24 | SSE | 46.63 | 54.93 |
| DR-09 | DR-25 | S | 50.91 | 46.10 |
| DR-10 | DR-26 | SSW | 50.08 | 51.21 |
| DR-11 | DR-27 | SW | 40.36 | 51.27 |
| DR-12 | DR-28 | WSW | 59.33 | 57.79 |
| DR-13 | DR-29 | W | 61.95 | 52.63 |
| DR-14 | DR-30 | WNW | 49.54 | 53.06 |
| DR-15 | DR-31 | NW | 48.95 | 60.71 |
| DR-16 | DR-32 | NNW | 54.33 | 59.07 |
| | | Average | 53.00 | 53.08 |

**INDIAN POINT ENERGY CENTER**

TABLE B-6

GROSS BETA ACTIVITY IN AIRBORNE PARTICULATE SAMPLES - 2021

pCi/$m^3$ ± 2 Sigma

| PERIOD ENDING | Algonquin 4 | NYU Tower 5 | Roseton 23* | Croton Point 27 | Grassy Point 29 | Training Building 94 | Met Tower 95 | Telcom Bldg. 108 |
|---|---|---|---|---|---|---|---|---|
| 01/05/21 | 0.009 ± 0.002 | 0.008 ± 0.002 | 0.008 ± 0.002 | 0.012 ± 0.002 | 0.009 ± 0.002 | 0.010 ± 0.002 | 0.009 ± 0.002 | 0.011 ± 0.002 |
| 01/11/21 | 0.009 ± 0.002 | 0.006 ± 0.002 | 0.008 ± 0.002 | 0.009 ± 0.002 | 0.008 ± 0.002 | 0.007 ± 0.002 | 0.008 ± 0.002 | 0.010 ± 0.002 |
| 01/19/21 | 0.026 ± 0.003 | 0.025 ± 0.003 | 0.019 ± 0.002 | 0.018 ± 0.003 | 0.022 ± 0.003 | 0.021 ± 0.003 | 0.023 ± 0.003 | 0.022 ± 0.003 |
| 01/25/21 | 0.011 ± 0.002 | 0.010 ± 0.002 | 0.009 ± 0.002 | 0.011 ± 0.003 | 0.009 ± 0.002 | 0.010 ± 0.002 | 0.010 ± 0.002 | 0.011 ± 0.002 |
| 02/04/21 | 0.006 ± 0.001 | 0.008 ± 0.002 | 0.007 ± 0.002 | 0.009 ± 0.002 | 0.008 ± 0.002 | 0.007 ± 0.002 | 0.007 ± 0.002 | 0.007 ± 0.001 |
| 02/08/21 | 0.021 ± 0.004 | 0.018 ± 0.004 | 0.016 ± 0.003 | 0.013 ± 0.003 | 0.020 ± 0.004 | 0.014 ± 0.003 | 0.015 ± 0.003 | 0.020 ± 0.004 |
| 02/16/21 | 0.019 ± 0.003 | 0.021 ± 0.003 | 0.017 ± 0.002 | 0.021 ± 0.003 | 0.018 ± 0.002 | 0.020 ± 0.003 | 0.016 ± 0.002 | 0.020 ± 0.002 |
| 02/22/21 | 0.016 ± 0.003 | 0.016 ± 0.003 | 0.015 ± 0.003 | 0.014 ± 0.003 | 0.014 ± 0.003 | 0.017 ± 0.003 | 0.013 ± 0.003 | 0.014 ± 0.003 |
| 03/01/21 | 0.013 ± 0.003 | 0.014 ± 0.003 | 0.012 ± 0.002 | 0.012 ± 0.002 | 0.014 ± 0.002 | 0.011 ± 0.002 | 0.012 ± 0.002 | 0.014 ± 0.002 |
| 03/08/21 | 0.013 ± 0.002 | 0.015 ± 0.002 | 0.012 ± 0.002 | 0.013 ± 0.002 | 0.014 ± 0.002 | 0.014 ± 0.002 | 0.011 ± 0.002 | 0.012 ± 0.002 |
| 03/15/21 | 0.022 ± 0.003 | 0.021 ± 0.003 | 0.023 ± 0.003 | 0.021 ± 0.003 | 0.023 ± 0.003 | 0.019 ± 0.003 | 0.020 ± 0.003 | 0.022 ± 0.003 |
| 03/22/21 | 0.018 ± 0.003 | 0.019 ± 0.003 | 0.016 ± 0.002 | 0.016 ± 0.002 | 0.018 ± 0.003 | 0.020 ± 0.003 | 0.018 ± 0.003 | 0.019 ± 0.003 |
| 03/29/21 | 0.013 ± 0.002 | 0.012 ± 0.002 | 0.012 ± 0.002 | 0.011 ± 0.002 | 0.011 ± 0.002 | 0.013 ± 0.002 | 0.009 ± 0.002 | 0.011 ± 0.002 |
| 04/05/21 | 0.017 ± 0.003 | 0.015 ± 0.003 | 0.015 ± 0.003 | 0.016 ± 0.003 | 0.014 ± 0.003 | 0.016 ± 0.003 | 0.014 ± 0.002 | 0.016 ± 0.003 |
| 04/12/21 | 0.010 ± 0.002 | 0.011 ± 0.002 | 0.009 ± 0.002 | 0.009 ± 0.002 | 0.009 ± 0.002 | 0.011 ± 0.002 | 0.010 ± 0.002 | 0.010 ± 0.002 |
| 04/19/21 | 0.006 ± 0.002 | 0.006 ± 0.002 | 0.007 ± 0.002 | 0.006 ± 0.002 | 0.006 ± 0.002 | 0.006 ± 0.002 | 0.005 ± 0.002 | 0.006 ± 0.002 |
| 04/27/21 | 0.020 ± 0.003 | 0.015 ± 0.002 | 0.016 ± 0.003 | 0.018 ± 0.003 | 0.018 ± 0.003 | 0.018 ± 0.002 | 0.017 ± 0.003 | 0.018 ± 0.003 |
| 05/03/21 | 0.016 ± 0.003 | 0.015 ± 0.003 | 0.015 ± 0.003 | 0.019 ± 0.003 | 0.017 ± 0.003 | 0.017 ± 0.003 | 0.018 ± 0.003 | 0.020 ± 0.003 |
| 05/10/21 | 0.009 ± 0.002 | 0.009 ± 0.002 | 0.008 ± 0.002 | 0.007 ± 0.002 | 0.007 ± 0.002 | 0.007 ± 0.002 | 0.008 ± 0.002 | 0.010 ± 0.002 |
| 05/17/21 | 0.011 ± 0.002 | 0.012 ± 0.002 | 0.012 ± 0.002 | 0.013 ± 0.002 | 0.013 ± 0.002 | 0.012 ± 0.002 | 0.013 ± 0.002 | 0.012 ± 0.002 |
| 05/24/21 | 0.020 ± 0.003 | 0.017 ± 0.003 | 0.017 ± 0.003 | 0.017 ± 0.003 | 0.017 ± 0.003 | 0.018 ± 0.003 | 0.018 ± 0.003 | 0.018 ± 0.003 |
| 06/01/21 | 0.010 ± 0.002 | 0.010 ± 0.002 | 0.009 ± 0.002 | 0.009 ± 0.002 | 0.009 ± 0.002 | 0.008 ± 0.002 | 0.011 ± 0.002 | 0.010 ± 0.002 |
| 06/07/21 | 0.015 ± 0.003 | 0.015 ± 0.003 | 0.017 ± 0.003 | 0.015 ± 0.003 | 0.022 ± 0.003 | 0.019 ± 0.003 | 0.019 ± 0.003 | 0.019 ± 0.003 |
| 06/14/21 | 0.010 ± 0.002 | 0.010 ± 0.002 | 0.010 ± 0.002 | 0.009 ± 0.002 | 0.011 ± 0.002 | 0.010 ± 0.002 | 0.009 ± 0.002 | 0.010 ± 0.002 |
| 06/21/21 | 0.012 ± 0.002 | 0.016 ± 0.002 | 0.014 ± 0.002 | 0.017 ± 0.003 | 0.015 ± 0.002 | 0.014 ± 0.003 | 0.013 ± 0.002 | 0.015 ± 0.003 |
| 06/28/21 | 0.009 ± 0.002 | 0.009 ± 0.002 | 0.011 ± 0.002 | 0.010 ± 0.002 | 0.012 ± 0.002 | 0.011 ± 0.002 | 0.010 ± 0.002 | 0.009 ± 0.002 |

*Control Location

**INDIAN POINT ENERGY CENTER**

TABLE B-6

GROSS BETA ACTIVITY IN AIRBORNE PARTICULATE SAMPLES - 2021

pCi/m$^3$ ± 2 Sigma

| PERIOD ENDING | Algonquin 4 | NYU Tower 5 | Roseton 23* | Croton Point 27 | Grassy Point 29 | Training Building 94 | Met Tower 95 | Telcom Bldg. 108 |
|---|---|---|---|---|---|---|---|---|
| 07/06/21 | 0.010 ± 0.002 | 0.009 ± 0.002 | 0.010 ± 0.002 | 0.010 ± 0.002 | 0.009 ± 0.002 | 0.012 ± 0.002 | 0.010 ± 0.002 | 0.010 ± 0.002 |
| 07/12/21 | 0.014 ± 0.003 | 0.013 ± 0.003 | 0.014 ± 0.003 | 0.016 ± 0.003 | 0.016 ± 0.003 | 0.015 ± 0.003 | 0.016 ± 0.003 | 0.014 ± 0.003 |
| 07/19/21 | 0.014 ± 0.002 | 0.012 ± 0.002 | 0.012 ± 0.002 | 0.014 ± 0.002 | 0.012 ± 0.002 | 0.013 ± 0.002 | 0.014 ± 0.003 | 0.012 ± 0.002 |
| 07/26/21 | 0.016 ± 0.002 | 0.015 ± 0.002 | 0.013 ± 0.002 | 0.017 ± 0.003 | 0.016 ± 0.002 | 0.014 ± 0.002 | 0.012 ± 0.002 | 0.015 ± 0.002 |
| 08/02/21 | 0.014 ± 0.003 | 0.015 ± 0.003 | 0.015 ± 0.003 | 0.013 ± 0.002 | 0.013 ± 0.002 | 0.014 ± 0.002 | 0.013 ± 0.002 | 0.014 ± 0.002 |
| 08/09/21 | 0.018 ± 0.003 | 0.019 ± 0.003 | 0.021 ± 0.003 | 0.019 ± 0.003 | 0.016 ± 0.002 | 0.017 ± 0.003 | 0.017 ± 0.003 | 0.019 ± 0.003 |
| 08/16/21 | 0.016 ± 0.002 | 0.011 ± 0.002 | 0.013 ± 0.002 | 0.013 ± 0.002 | 0.014 ± 0.002 | 0.014 ± 0.002 | 0.013 ± 0.002 | 0.013 ± 0.002 |
| 08/23/21 | 0.011 ± 0.002 | 0.012 ± 0.002 | 0.011 ± 0.002 | 0.013 ± 0.002 | 0.011 ± 0.002 | 0.010 ± 0.002 | 0.012 ± 0.002 | 0.011 ± 0.002 |
| 08/30/21 | 0.020 ± 0.003 | 0.019 ± 0.003 | 0.021 ± 0.003 | 0.020 ± 0.003 | 0.020 ± 0.003 | 0.020 ± 0.003 | 0.019 ± 0.003 | 0.020 ± 0.003 |
| 09/07/21 | 0.010 ± 0.002 | 0.011 ± 0.002 | 0.011 ± 0.002 | 0.011 ± 0.002 | 0.012 ± 0.002 | 0.011 ± 0.002 | 0.011 ± 0.002 | 0.011 ± 0.002 |
| 09/13/21 | 0.017 ± 0.003 | 0.017 ± 0.003 | 0.018 ± 0.003 | 0.017 ± 0.003 | 0.019 ± 0.003 | 0.019 ± 0.003 | 0.017 ± 0.003 | 0.017 ± 0.003 |
| 09/20/21 | 0.021 ± 0.003 | 0.021 ± 0.003 | 0.021 ± 0.003 | 0.020 ± 0.003 | 0.023 ± 0.003 | 0.019 ± 0.003 | 0.019 ± 0.003 | 0.021 ± 0.003 |
| 09/27/21 | 0.010 ± 0.002 | 0.010 ± 0.002 | 0.013 ± 0.002 | 0.013 ± 0.002 | 0.011 ± 0.002 | 0.012 ± 0.002 | 0.013 ± 0.002 | 0.012 ± 0.002 |
| 10/04/21 | 0.015 ± 0.002 | 0.017 ± 0.003 | 0.015 ± 0.002 | 0.017 ± 0.003 | 0.016 ± 0.003 | 0.017 ± 0.003 | 0.014 ± 0.002 | 0.016 ± 0.002 |
| 10/12/21 | 0.007 ± 0.002 | 0.007 ± 0.002 | 0.005 ± 0.002 | 0.008 ± 0.002 | 0.008 ± 0.003 | 0.005 ± 0.002 | 0.006 ± 0.002 | 0.008 ± 0.002 |
| 10/18/21 | 0.016 ± 0.002 | 0.016 ± 0.003 | 0.015 ± 0.002 | 0.017 ± 0.003 | 0.016 ± 0.003 | 0.014 ± 0.002 | 0.013 ± 0.002 | 0.016 ± 0.002 |
| 10/25/21 | 0.021 ± 0.003 | 0.020 ± 0.003 | 0.018 ± 0.003 | 0.019 ± 0.003 | 0.021 ± 0.003 | 0.021 ± 0.003 | 0.022 ± 0.003 | 0.021 ± 0.003 |
| 11/01/21 | 0.014 ± 0.002 | 0.012 ± 0.002 | 0.013 ± 0.002 | 0.012 ± 0.002 | 0.014 ± 0.003 | 0.016 ± 0.003 | 0.014 ± 0.002 | 0.015 ± 0.002 |
| 11/08/21 | 0.014 ± 0.002 | 0.012 ± 0.002 | 0.012 ± 0.002 | 0.014 ± 0.002 | 0.013 ± 0.002 | 0.013 ± 0.002 | 0.013 ± 0.002 | 0.014 ± 0.002 |
| 11/15/21 | 0.025 ± 0.003 | 0.021 ± 0.003 | 0.022 ± 0.003 | 0.024 ± 0.003 | 0.023 ± 0.003 | 0.018 ± 0.003 | 0.023 ± 0.003 | 0.023 ± 0.003 |
| 11/22/21 | 0.011 ± 0.002 | 0.010 ± 0.002 | 0.011 ± 0.002 | 0.013 ± 0.002 | 0.009 ± 0.002 | 0.011 ± 0.002 | 0.009 ± 0.002 | 0.011 ± 0.002 |
| 11/29/21 | 0.011 ± 0.002 | 0.011 ± 0.002 | 0.010 ± 0.002 | 0.010 ± 0.002 | 0.012 ± 0.002 | 0.012 ± 0.002 | 0.010 ± 0.002 | 0.011 ± 0.002 |
| 12/06/21 | 0.020 ± 0.003 | 0.015 ± 0.002 | 0.017 ± 0.003 | 0.015 ± 0.002 | 0.016 ± 0.002 | 0.017 ± 0.003 | 0.018 ± 0.003 | 0.018 ± 0.003 |
| 12/13/21 | 0.018 ± 0.003 | 0.019 ± 0.003 | 0.016 ± 0.003 | 0.017 ± 0.003 | 0.020 ± 0.003 | 0.020 ± 0.003 | 0.017 ± 0.003 | 0.019 ± 0.003 |
| 12/20/21 | 0.017 ± 0.003 | 0.015 ± 0.003 | 0.016 ± 0.003 | 0.017 ± 0.003 | 0.016 ± 0.003 | 0.016 ± 0.003 | 0.015 ± 0.002 | 0.016 ± 0.002 |
| 12/28/21 | 0.016 ± 0.002 | 0.016 ± 0.002 | 0.016 ± 0.002 | 0.017 ± 0.002 | 0.018 ± 0.002 | 0.016 ± 0.002 | 0.016 ± 0.002 | 0.017 ± 0.002 |
| 01/03/22 | 0.024 ± 0.003 | 0.016 ± 0.003 | 0.020 ± 0.003 | 0.018 ± 0.003 | 0.020 ± 0.003 | 0.019 ± 0.003 | 0.021 ± 0.003 | 0.020 ± 0.003 |

*Control Location

**INDIAN POINT ENERGY CENTER**

TABLE B-7

IODINE-131 ACTIVITY IN AIRBORNE CHARCOAL SAMPLES - 2021

pCi/m$^3$ ± 2 Sigma

| PERIOD ENDING | Algonquin 4 | NYU Tower 5 | Roseton 23* | Croton Point 27 | Grassy Point 29 | Training Building 94 | Met Tower 95 | Telcom Bldg. 108 |
|---|---|---|---|---|---|---|---|---|
| 01/05/21 | < 0.038 | < 0.040 | < 0.035 | < 0.039 | < 0.036 | < 0.037 | < 0.042 | < 0.040 |
| 01/11/21 | < 0.034 | < 0.035 | < 0.018 | < 0.035 | < 0.022 | < 0.033 | < 0.024 | < 0.025 |
| 01/19/21 | < 0.015 | < 0.016 | < 0.016 | < 0.015 | < 0.017 | < 0.015 | < 0.018 | < 0.018 |
| 01/25/21 | < 0.023 | < 0.024 | < 0.021 | < 0.023 | < 0.022 | < 0.021 | < 0.024 | < 0.021 |
| 02/04/21 | < 0.028 | < 0.028 | < 0.019 | < 0.038 | < 0.015 | < 0.036 | < 0.024 | < 0.014 |
| 02/08/21 | < 0.030 | < 0.030 | < 0.030 | < 0.021 | < 0.042 | < 0.020 | < 0.033 | < 0.043 |
| 02/16/21 | < 0.031 | < 0.031 | < 0.029 | < 0.031 | < 0.031 | < 0.029 | < 0.032 | < 0.030 |
| 02/22/21 | < 0.020 | < 0.018 | < 0.008 | < 0.020 | < 0.019 | < 0.018 | < 0.020 | < 0.019 |
| 03/01/21 | < 0.025 | < 0.024 | < 0.015 | < 0.023 | < 0.019 | < 0.024 | < 0.020 | < 0.019 |
| 03/08/21 | < 0.021 | < 0.022 | < 0.027 | < 0.021 | < 0.027 | < 0.021 | < 0.029 | < 0.027 |
| 03/15/21 | < 0.026 | < 0.026 | < 0.024 | < 0.027 | < 0.025 | < 0.025 | < 0.026 | < 0.025 |
| 03/22/21 | < 0.019 | < 0.020 | < 0.021 | < 0.020 | < 0.022 | < 0.008 | < 0.022 | < 0.021 |
| 03/29/21 | < 0.016 | < 0.017 | < 0.016 | < 0.017 | < 0.016 | < 0.015 | < 0.015 | < 0.016 |
| 04/05/21 | < 0.037 | < 0.038 | < 0.049 | < 0.037 | < 0.051 | < 0.039 | < 0.049 | < 0.052 |
| 04/12/21 | < 0.022 | < 0.023 | < 0.019 | < 0.022 | < 0.019 | < 0.021 | < 0.018 | < 0.019 |
| 04/19/21 | < 0.018 | < 0.018 | < 0.018 | < 0.018 | < 0.019 | < 0.008 | < 0.017 | < 0.018 |
| 04/27/21 | < 0.016 | < 0.016 | < 0.017 | < 0.016 | < 0.016 | < 0.015 | < 0.014 | < 0.017 |
| 05/03/21 | < 0.029 | < 0.029 | < 0.019 | < 0.029 | < 0.018 | < 0.028 | < 0.022 | < 0.020 |
| 05/10/21 | < 0.021 | < 0.022 | < 0.021 | < 0.021 | < 0.010 | < 0.021 | < 0.022 | < 0.020 |
| 05/17/21 | < 0.036 | < 0.036 | < 0.022 | < 0.036 | < 0.021 | < 0.034 | < 0.023 | < 0.021 |
| 05/24/21 | < 0.015 | < 0.016 | < 0.014 | < 0.016 | < 0.016 | < 0.016 | < 0.016 | < 0.016 |
| 06/01/21 | < 0.022 | < 0.024 | < 0.032 | < 0.025 | < 0.035 | < 0.024 | < 0.036 | < 0.034 |
| 06/07/21 | < 0.023 | < 0.011 | < 0.031 | < 0.026 | < 0.030 | < 0.026 | < 0.026 | < 0.030 |
| 06/14/21 | < 0.027 | < 0.025 | < 0.017 | < 0.027 | < 0.017 | < 0.027 | < 0.017 | < 0.018 |
| 06/21/21 | < 0.029 | < 0.028 | < 0.024 | < 0.029 | < 0.024 | < 0.029 | < 0.024 | < 0.026 |
| 06/28/21 | < 0.020 | < 0.020 | < 0.030 | < 0.020 | < 0.030 | < 0.021 | < 0.031 | < 0.030 |

*Control Location

**INDIAN POINT ENERGY CENTER**
TABLE B-7
IODINE-131 ACTIVITY IN AIRBORNE CHARCOAL SAMPLES - 2021

pCi/m$^3$ ± 2 Sigma

| PERIOD ENDING | Algonquin 4 | NYU Tower 5 | Roseton 23* | Croton Point 27 | Grassy Point 29 | Training Building 94 | Met Tower 95 | Telcom Bldg. 108 |
|---|---|---|---|---|---|---|---|---|
| 07/06/21 | < 0.017 | < 0.017 | < 0.018 | < 0.017 | < 0.009 | < 0.019 | < 0.019 | < 0.018 |
| 07/12/21 | < 0.031 | < 0.032 | < 0.019 | < 0.031 | < 0.018 | < 0.033 | < 0.020 | < 0.019 |
| 07/19/21 | < 0.026 | < 0.027 | < 0.024 | < 0.026 | < 0.023 | < 0.028 | < 0.026 | < 0.011 |
| 07/26/21 | < 0.017 | < 0.018 | < 0.019 | < 0.017 | < 0.018 | < 0.017 | < 0.019 | < 0.019 |
| 08/02/21 | < 0.022 | < 0.022 | < 0.022 | < 0.022 | < 0.021 | < 0.022 | < 0.021 | < 0.021 |
| 08/09/21 | < 0.025 | < 0.025 | < 0.017 | < 0.025 | < 0.016 | < 0.026 | < 0.017 | < 0.014 |
| 08/16/21 | < 0.014 | < 0.015 | < 0.015 | < 0.014 | < 0.015 | < 0.015 | < 0.015 | < 0.015 |
| 08/23/21 | < 0.016 | < 0.016 | < 0.012 | < 0.016 | < 0.012 | < 0.016 | < 0.013 | < 0.012 |
| 08/30/21 | < 0.027 | < 0.028 | < 0.043 | < 0.027 | < 0.042 | < 0.028 | < 0.043 | < 0.042 |
| 09/07/21 | < 0.017 | < 0.017 | < 0.017 | < 0.017 | < 0.017 | < 0.017 | < 0.017 | < 0.017 |
| 09/13/21 | < 0.014 | < 0.014 | < 0.028 | < 0.014 | < 0.027 | < 0.014 | < 0.027 | < 0.026 |
| 09/20/21 | < 0.021 | < 0.022 | < 0.021 | < 0.021 | < 0.020 | < 0.021 | < 0.021 | < 0.020 |
| 09/27/21 | < 0.033 | < 0.034 | < 0.019 | < 0.033 | < 0.019 | < 0.034 | < 0.019 | < 0.015 |
| 10/04/21 | < 0.030 | < 0.032 | < 0.026 | < 0.029 | < 0.027 | < 0.030 | < 0.026 | < 0.011 |
| 10/12/21 | < 0.022 | < 0.019 | < 0.039 | < 0.022 | < 0.039 | < 0.022 | < 0.009 | < 0.037 |
| 10/18/21 | < 0.028 | < 0.031 | < 0.027 | < 0.031 | < 0.028 | < 0.029 | < 0.027 | < 0.027 |
| 10/25/21 | < 0.026 | < 0.026 | < 0.019 | < 0.025 | < 0.019 | < 0.026 | < 0.018 | < 0.018 |
| 11/01/21 | < 0.019 | < 0.019 | < 0.015 | < 0.019 | < 0.016 | < 0.020 | < 0.015 | < 0.010 |
| 11/08/21 | < 0.064 | < 0.064 | < 0.018 | < 0.063 | < 0.019 | < 0.065 | < 0.018 | < 0.008 |
| 11/15/21 | < 0.024 | < 0.024 | < 0.021 | < 0.023 | < 0.022 | < 0.025 | < 0.020 | < 0.009 |
| 11/22/21 | < 0.017 | < 0.017 | < 0.020 | < 0.016 | < 0.020 | < 0.018 | < 0.020 | < 0.020 |
| 11/29/21 | < 0.025 | < 0.025 | < 0.018 | < 0.025 | < 0.018 | < 0.025 | < 0.018 | < 0.018 |
| 12/06/21 | < 0.021 | < 0.021 | < 0.021 | < 0.021 | < 0.021 | < 0.023 | < 0.021 | < 0.021 |
| 12/13/21 | < 0.014 | < 0.014 | < 0.013 | < 0.013 | < 0.013 | < 0.015 | < 0.013 | < 0.013 |
| 12/20/21 | < 0.018 | < 0.018 | < 0.017 | < 0.018 | < 0.018 | < 0.019 | < 0.017 | < 0.017 |
| 12/28/21 | < 0.019 | < 0.019 | < 0.017 | < 0.019 | < 0.017 | < 0.021 | < 0.017 | < 0.016 |
| 01/03/22 | < 0.047 | < 0.048 | < 0.029 | < 0.046 | < 0.029 | < 0.046 | < 0.031 | < 0.024 |

*Control Location

**INDIAN POINT ENERGY CENTER**

TABLE B-8

GAMMA EMITTERS IN AIRBORNE PARTICULATE SAMPLES - 2021

$10^{-3}$ pCi/$m^3$ ± 2 Sigma

| | Algonquin 4 | | | | NYU Tower 5 | | | |
|---|---|---|---|---|---|---|---|---|
| DATE | 1st Quarter | 2nd Quarter | 3rd Quarter | 4th Quarter | 1st Quarter | 2nd Quarter | 3rd Quarter | 4th Quarter |
| Be-7 | 110 ± 21 | 133 ± 27 | 85 ± 28 | 85 ± 19 | 122 ± 23 | 121 ± 21 | 94 ± 19 | 91 ± 19 |
| K-40 | < 19 | < 27 | < 22 | < 13 | < 24 | < 16 | < 15 | < 15 |
| Mn-54 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 |
| Co-58 | < 2 | < 2 | < 2 | < 2 | < 2 | < 2 | < 2 | < 2 |
| Fe-59 | < 5 | < 7 | < 6 | < 6 | < 4 | < 4 | < 5 | < 4 |
| Co-60 | < 1 | < 2 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 |
| Zn-65 | < 2 | < 3 | < 4 | < 3 | < 4 | < 2 | < 3 | < 3 |
| Nb-95 | < 2 | < 3 | < 3 | < 2 | < 2 | < 1 | < 2 | < 1 |
| Zr-95 | < 3 | < 4 | < 5 | < 3 | < 4 | < 4 | < 4 | < 3 |
| Ru-103 | < 2 | < 3 | < 4 | < 2 | < 3 | < 2 | < 3 | < 2 |
| Ru-106 | < 9 | < 16 | < 11 | < 9 | < 13 | < 9 | < 9 | < 9 |
| I-131 | < 118 | < 222 | < 410 | < 386 | < 184 | < 149 | < 302 | < 405 |
| Cs-134 | < 1 | < 2 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 |
| Cs-137 | < 1 | < 2 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 |
| Ba-140 | < 71 | < 138 | < 147 | < 152 | < 113 | < 61 | < 131 | < 109 |
| La-140 | < 2 | < 65 | < 54 | < 70 | < 33 | < 18 | < 50 | < 39 |
| Ce-141 | < 4 | < 5 | < 6 | < 4 | < 5 | < 3 | < 4 | < 4 |
| Ce-144 | < 5 | < 7 | < 6 | < 5 | < 7 | < 4 | < 5 | < 4 |
| Ra-226 | < 17 | < 22 | < 20 | < 15 | < 22 | < 15 | < 17 | < 14 |
| Ac-228 | < 4 | < 6 | < 5 | < 4 | < 4 | < 4 | < 4 | < 4 |
| Th-228 | < 2 | < 2 | < 2 | < 1 | < 2 | < 1 | < 1 | < 1 |

**INDIAN POINT ENERGY CENTER**

TABLE B-8

GAMMA EMITTERS IN AIRBORNE PARTICULATE SAMPLES - 2021

$10^{-3}$ pCi/m$^3$ ± 2 Sigma

| | Roseton 23* | | | | Croton Point 27 | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| DATE | 1st Quarter | 2nd Quarter | 3rd Quarter | 4th Quarter | 1st Quarter | 2nd Quarter | 3rd Quarter | 4th Quarter |
| Be-7 | 79 ± 24 | 124 ± 21 | 100 ± 23 | 78 ± 24 | 121 ± 20 | 137 ± 25 | 105 ± 22 | 101 ± 22 |
| K-40 | < 26 | < 16 | < 17 | < 25 | < 19 | < 21 | < 18 | < 19 |
| Mn-54 | < 2 | < 0 | < 1 | < 2 | < 1 | < 2 | < 1 | < 1 |
| Co-58 | < 2 | < 1 | < 2 | < 3 | < 2 | < 2 | < 2 | < 2 |
| Fe-59 | < 7 | < 3 | < 6 | < 8 | < 5 | < 6 | < 5 | < 5 |
| Co-60 | < 1 | < 1 | < 1 | < 2 | < 1 | < 2 | < 1 | < 1 |
| Zn-65 | < 5 | < 2 | < 2 | < 3 | < 3 | < 3 | < 3 | < 3 |
| Nb-95 | < 2 | < 1 | < 2 | < 3 | < 2 | < 2 | < 2 | < 2 |
| Zr-95 | < 4 | < 2 | < 4 | < 6 | < 4 | < 4 | < 4 | < 4 |
| Ru-103 | < 3 | < 1 | < 2 | < 4 | < 2 | < 3 | < 3 | < 3 |
| Ru-106 | < 13 | < 8 | < 8 | < 14 | < 8 | < 9 | < 10 | < 10 |
| I-131 | < 195 | < 83 | < 266 | < 534 | < 117 | < 218 | < 326 | < 465 |
| Cs-134 | < 2 | < 1 | < 1 | < 2 | < 1 | < 1 | < 1 | < 2 |
| Cs-137 | < 2 | < 1 | < 1 | < 2 | < 1 | < 1 | < 1 | < 1 |
| Ba-140 | < 120 | < 47 | < 102 | < 233 | < 56 | < 102 | < 117 | < 181 |
| La-140 | < 61 | < 27 | < 27 | < 101 | < 41 | < 46 | < 39 | < 57 |
| Ce-141 | < 5 | < 3 | < 4 | < 6 | < 3 | < 4 | < 4 | < 5 |
| Ce-144 | < 7 | < 3 | < 4 | < 7 | < 5 | < 6 | < 5 | < 6 |
| Ra-226 | < 23 | < 14 | < 14 | < 26 | < 17 | < 20 | < 17 | < 19 |
| Ac-228 | < 6 | < 4 | < 4 | < 7 | < 4 | < 5 | < 4 | < 5 |
| Th-228 | < 2 | < 1 | < 1 | < 2 | < 1 | < 2 | < 1 | < 2 |

* Control Location

**INDIAN POINT ENERGY CENTER**

TABLE B-8

GAMMA EMITTERS IN AIRBORNE PARTICULATE SAMPLES - 2021

$10^{-3}$ pCi/$m^3$ ± 2 Sigma

| | Grassy Point 29 | | | | Training Building 94 | | | |
|---|---|---|---|---|---|---|---|---|
| DATE | 1st Quarter | 2nd Quarter | 3rd Quarter | 4th Quarter | 1st Quarter | 2nd Quarter | 3rd Quarter | 4th Quarter |
| Be-7 | 117 ± 21 | 135 ± 23 | 120 ± 23 | 94 ± 22 | 131 ± 25 | 130 ± 22 | 100 ± 28 | 107 ± 23 |
| K-40 | < 22 | < 21 | < 24 | < 26 | < 30 | < 13 | < 27 | < 26 |
| Mn-54 | < 1 | < 1 | < 1 | < 2 | < 2 | < 1 | < 2 | < 2 |
| Co-58 | < 2 | < 2 | < 2 | < 2 | < 2 | < 1 | < 3 | < 2 |
| Fe-59 | < 5 | < 4 | < 8 | < 7 | < 5 | < 5 | < 8 | < 8 |
| Co-60 | < 2 | < 1 | < 1 | < 1 | < 1 | < 1 | < 2 | < 1 |
| Zn-65 | < 3 | < 2 | < 3 | < 3 | < 4 | < 2 | < 4 | < 4 |
| Nb-95 | < 2 | < 2 | < 2 | < 3 | < 3 | < 1 | < 3 | < 3 |
| Zr-95 | < 4 | < 3 | < 4 | < 4 | < 5 | < 3 | < 4 | < 5 |
| Ru-103 | < 2 | < 3 | < 4 | < 3 | < 4 | < 2 | < 5 | < 5 |
| Ru-106 | < 12 | < 11 | < 14 | < 12 | < 11 | < 8 | < 17 | < 13 |
| I-131 | < 120 | < 147 | < 378 | < 686 | < 200 | < 138 | < 491 | < 626 |
| Cs-134 | < 1 | < 1 | < 1 | < 1 | < 2 | < 1 | < 2 | < 2 |
| Cs-137 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 |
| Ba-140 | < 86 | < 77 | < 170 | < 224 | < 114 | < 56 | < 207 | < 198 |
| La-140 | < 27 | < 25 | < 58 | < 84 | < 48 | < 25 | < 66 | < 92 |
| Ce-141 | < 3 | < 3 | < 5 | < 5 | < 5 | < 3 | < 6 | < 6 |
| Ce-144 | < 5 | < 4 | < 6 | < 6 | < 7 | < 4 | < 8 | < 8 |
| Ra-226 | < 16 | < 16 | < 18 | < 19 | < 24 | < 15 | < 26 | < 22 |
| Ac-228 | < 5 | < 4 | < 4 | < 5 | < 6 | < 3 | < 7 | < 6 |
| Th-228 | < 2 | < 2 | < 2 | < 2 | < 2 | < 2 | < 2 | < 2 |

**INDIAN POINT ENERGY CENTER**

TABLE B-8

GAMMA EMITTERS IN AIRBORNE PARTICULATE SAMPLES - 2021

$10^{-3}$ pCi/m$^3$ ± 2 Sigma

| | Met Tower 95 | | | | Telecomm Bldg 108 | | | |
|---|---|---|---|---|---|---|---|---|
| DATE | 1st Quarter | 2nd Quarter | 3rd Quarter | 4th Quarter | 1st Quarter | 2nd Quarter | 3rd Quarter | 4th Quarter |
| Be-7 | 98 ± 20 | 152 ± 23 | 121 ± 19 | 92 ± 19 | 102 ± 20 | 124 ± 29 | 135 ± 23 | 101 ± 17 |
| K-40 | < 22 | < 16 | < 10 | < 17 | < 25 | < 32 | < 29 | < 17 |
| Mn-54 | < 1 | < 1 | < 1 | < 1 | < 1 | < 2 | < 2 | < 1 |
| Co-58 | < 2 | < 2 | < 1 | < 2 | < 2 | < 3 | < 3 | < 1 |
| Fe-59 | < 5 | < 6 | < 5 | < 5 | < 6 | < 4 | < 10 | < 6 |
| Co-60 | < 1 | < 1 | < 1 | < 1 | < 2 | < 2 | < 2 | < 1 |
| Zn-65 | < 3 | < 3 | < 2 | < 3 | < 3 | < 3 | < 5 | < 2 |
| Nb-95 | < 1 | < 2 | < 2 | < 2 | < 2 | < 3 | < 3 | < 2 |
| Zr-95 | < 4 | < 4 | < 3 | < 3 | < 4 | < 5 | < 4 | < 3 |
| Ru-103 | < 2 | < 3 | < 2 | < 2 | < 3 | < 4 | < 5 | < 2 |
| Ru-106 | < 8 | < 11 | < 8 | < 6 | < 13 | < 13 | < 17 | < 8 |
| I-131 | < 132 | < 220 | < 296 | < 404 | < 179 | < 198 | < 522 | < 406 |
| Cs-134 | < 1 | < 1 | < 1 | < 1 | < 1 | < 1 | < 2 | < 1 |
| Cs-137 | < 1 | < 1 | < 1 | < 1 | < 2 | < 1 | < 2 | < 1 |
| Ba-140 | < 67 | < 100 | < 101 | < 146 | < 98 | < 96 | < 203 | < 128 |
| La-140 | < 33 | < 52 | < 44 | < 40 | < 29 | < 49 | < 85 | < 45 |
| Ce-141 | < 3 | < 5 | < 4 | < 4 | < 4 | < 6 | < 7 | < 4 |
| Ce-144 | < 4 | < 5 | < 4 | < 4 | < 6 | < 7 | < 7 | < 4 |
| Ra-226 | < 14 | < 21 | < 13 | < 13 | < 21 | < 24 | < 26 | < 16 |
| Ac-228 | < 4 | < 4 | < 2 | < 4 | < 5 | < 5 | < 7 | < 3 |
| Th-228 | < 1 | < 2 | < 1 | < 1 | < 2 | < 2 | < 2 | < 1 |

**INDIAN POINT ENERGY CENTER**

TABLE B-9

RADIONUCLIDES IN DRINKING WATER SAMPLES - 2021

pCi/L ± 2 Sigma

| | Camp Field 7 | | | | | |
|---|---|---|---|---|---|---|
| DATE | 01/12/21 | 02/17/21 | 03/17/21 | 04/05/21 | 5/11/2021 | 06/07/21 |
| RADIOCHEMICAL | | | | | | |
| Gr-B | 3 ± 1 | < 3 | < 2 | < 2 | < 3 | < 2 |
| H-3 (a) | | | < 177 | | | < 184 |
| GAMMA | | | | | | |
| Be-7 | < 54 | < 42 | < 60 | < 56 | < 52 | < 49 |
| K-40 | < 145 | < 75 | < 68 | < 119 | < 110 | < 110 |
| Mn-54 | < 9 | < 4 | < 8 | < 6 | < 6 | < 5 |
| Co-58 | < 7 | < 4 | < 7 | < 7 | < 6 | < 6 |
| Fe-59 | < 12 | < 9 | < 15 | < 13 | < 13 | < 12 |
| Co-60 | < 7 | < 4 | < 6 | < 9 | < 7 | < 6 |
| Zn-65 | < 14 | < 8 | < 11 | < 14 | < 11 | < 14 |
| Nb-95 | < 8 | < 4 | < 7 | < 6 | < 5 | < 4 |
| Zr-95 | < 13 | < 6 | < 13 | < 15 | < 10 | < 9 |
| Ru-103 | < 7 | < 5 | < 7 | < 7 | < 5 | < 6 |
| Ru-106 | < 59 | < 42 | < 56 | < 48 | < 64 | < 52 |
| I-131 | < 9 | < 7 | < 9 | < 7 | < 6 | < 8 |
| Cs-134 | < 7 | < 6 | < 9 | < 9 | < 8 | < 7 |
| Cs-137 | < 8 | < 5 | < 7 | < 7 | < 6 | < 6 |
| Ba-140 | < 27 | < 26 | < 32 | < 29 | < 22 | < 20 |
| La-140 | < 8 | < 9 | < 9 | < 9 | < 11 | < 9 |
| Ce-141 | < 13 | < 7 | < 11 | < 11 | < 11 | < 9 |
| Ce-144 | < 53 | < 30 | < 43 | < 46 | < 43 | < 43 |
| Ra-226 | < 166 | < 110 | < 162 | < 153 | < 182 | < 153 |
| Ac-228 | < 27 | < 17 | < 25 | < 27 | < 30 | < 19 |
| Th-228 | < 14 | < 8 | < 11 | < 11 | < 12 | < 10 |

(a) Quarterly Composite

**INDIAN POINT ENERGY CENTER**

TABLE B-9

RADIONUCLIDES IN DRINKING WATER SAMPLES - 2021

pCi/L ± 2 Sigma

| | Camp Field 7 | | | | | |
|---|---|---|---|---|---|---|
| DATE | 07/12/21 | 08/10/21 | 09/14/21 | 10/11/21 | 11/08/21 | 12/14/21 |
| RADIOCHEMICAL | | | | | | |
| Gr-B | 2 ± 2 | < 3 | < 2 | < 2 | 3 ± 2 | 3 ± 2 |
| H-3 (a) | | | < 187 | | | < 187 |
| GAMMA | | | | | | |
| Be-7 | < 46 | < 39 | < 44 | < 33 | < 46 | < 30 |
| K-40 | < 101 | < 79 | < 142 | < 74 | < 93 | < 73 |
| Mn-54 | < 7 | < 4 | < 5 | < 3 | < 5 | < 4 |
| Co-58 | < 7 | < 3 | < 5 | < 4 | < 4 | < 4 |
| Fe-59 | < 12 | < 8 | < 13 | < 8 | < 10 | < 7 |
| Co-60 | < 7 | < 5 | < 7 | < 5 | < 5 | < 4 |
| Zn-65 | < 13 | < 9 | < 15 | < 11 | < 13 | < 9 |
| Nb-95 | < 5 | < 4 | < 5 | < 4 | < 5 | < 4 |
| Zr-95 | < 12 | < 9 | < 12 | < 7 | < 10 | < 7 |
| Ru-103 | < 6 | < 5 | < 6 | < 4 | < 5 | < 4 |
| Ru-106 | < 68 | < 40 | < 56 | < 32 | < 52 | < 35 |
| I-131 | < 7 | < 5 | < 7 | < 5 | < 6 | < 4 |
| Cs-134 | < 8 | < 5 | < 7 | < 5 | < 6 | < 4 |
| Cs-137 | < 7 | < 5 | < 7 | < 5 | < 4 | < 4 |
| Ba-140 | < 23 | < 16 | < 22 | < 15 | < 26 | < 16 |
| La-140 | < 9 | < 7 | < 8 | < 7 | < 7 | < 5 |
| Ce-141 | < 9 | < 7 | < 9 | < 7 | < 10 | < 6 |
| Ce-144 | < 40 | < 29 | < 41 | < 28 | < 42 | < 23 |
| Ra-226 | < 167 | < 114 | < 142 | < 108 | < 139 | < 100 |
| Ac-228 | < 30 | < 19 | < 29 | < 17 | < 21 | < 16 |
| Th-228 | < 12 | < 12 | < 12 | < 8 | < 10 | < 7 |

(a) Quarterly Composite

**INDIAN POINT ENERGY CENTER**

TABLE B-9

RADIONUCLIDES IN DRINKING WATER SAMPLES - 2021

pCi/L ± 2 Sigma

| | Croton 8 | | | | | |
|---|---|---|---|---|---|---|
| DATE | 01/12/21 | 02/17/21 | 03/17/21 | 04/05/21 | 05/11/21 | 06/07/21 |
| RADIOCHEMICAL | | | | | | |
| Gr-B | 3 ± 1 | < 2 | < 2 | 5 ± 2 | < 3 | < 2 |
| H-3 (a) | | | | | | < 182 |
| GAMMA | | | | | | |
| Be-7 | < 46 | < 39 | < 54 | < 57 | < 48 | < 38 |
| K-40 | < 133 | < 93 | < 101 | < 104 | < 120 | < 83 |
| Mn-54 | < 6 | < 5 | < 8 | < 7 | < 5 | < 5 |
| Co-58 | < 8 | < 5 | < 7 | < 7 | < 5 | < 5 |
| Fe-59 | < 14 | < 9 | < 15 | < 9 | < 12 | < 10 |
| Co-60 | < 6 | < 5 | < 8 | < 6 | < 5 | < 7 |
| Zn-65 | < 12 | < 12 | < 11 | < 10 | < 12 | < 10 |
| Nb-95 | < 8 | < 5 | < 7 | < 7 | < 6 | < 5 |
| Zr-95 | < 9 | < 9 | < 13 | < 12 | < 12 | < 7 |
| Ru-103 | < 7 | < 6 | < 5 | < 6 | < 5 | < 5 |
| Ru-106 | < 67 | < 46 | < 49 | < 61 | < 53 | < 38 |
| I-131 | < 8 | < 9 | < 9 | < 8 | < 6 | < 5 |
| Cs-134 | < 8 | < 5 | < 7 | < 7 | < 7 | < 5 |
| Cs-137 | < 8 | < 5 | < 7 | < 6 | < 6 | < 6 |
| Ba-140 | < 19 | < 21 | < 27 | < 26 | < 20 | < 14 |
| La-140 | < 6 | < 8 | < 7 | < 5 | < 9 | < 8 |
| Ce-141 | < 9 | < 7 | < 12 | < 9 | < 11 | < 8 |
| Ce-144 | < 47 | < 30 | < 40 | < 41 | < 49 | < 27 |
| Ra-226 | < 160 | < 105 | < 159 | < 148 | < 160 | < 117 |
| Ac-228 | < 31 | < 18 | < 23 | < 25 | < 28 | < 18 |
| Th-228 | < 12 | < 8 | < 13 | < 10 | < 13 | < 8 |

(a) Quarterly Composite

**INDIAN POINT ENERGY CENTER**

TABLE B-9

RADIONUCLIDES IN DRINKING WATER SAMPLES - 2021

pCi/L ± 2 Sigma

| | Croton 8 | | | | | |
|---|---|---|---|---|---|---|
| DATE | 07/12/21 | 08/10/21 | 09/14/21 | 10/11/21 | 11/08/21 | 12/14/21 |
| RADIOCHEMICAL | | | | | | |
| Gr-B | 3 ± 2 | < 2 | < 2 | < 2 | 3 ± 1 | 4 ± 2 |
| H-3 (a) | | | < 183 | | | < 193 |
| GAMMA | | | | | | |
| Be-7 | < 51 | < 48 | < 59 | < 31 | < 33 | < 43 |
| K-40 | < 136 | < 87 | < 132 | < 64 | < 67 | < 101 |
| Mn-54 | < 6 | < 4 | < 7 | < 4 | < 4 | < 4 |
| Co-58 | < 6 | < 5 | < 6 | < 3 | < 4 | < 5 |
| Fe-59 | < 14 | < 10 | < 14 | < 7 | < 8 | < 10 |
| Co-60 | < 6 | < 6 | < 8 | < 4 | < 4 | < 4 |
| Zn-65 | < 13 | < 12 | < 8 | < 7 | < 9 | < 11 |
| Nb-95 | < 6 | < 6 | < 7 | < 4 | < 4 | < 5 |
| Zr-95 | < 7 | < 9 | < 11 | < 6 | < 7 | < 7 |
| Ru-103 | < 5 | < 6 | < 6 | < 3 | < 4 | < 5 |
| Ru-106 | < 55 | < 56 | < 63 | < 33 | < 47 | < 43 |
| I-131 | < 7 | < 7 | < 7 | < 4 | < 5 | < 6 |
| Cs-134 | < 6 | < 5 | < 5 | < 4 | < 5 | < 5 |
| Cs-137 | < 6 | < 7 | < 5 | < 4 | < 5 | < 5 |
| Ba-140 | < 22 | < 15 | < 22 | < 14 | < 18 | < 20 |
| La-140 | < 9 | < 5 | < 8 | < 5 | < 5 | < 6 |
| Ce-141 | < 9 | < 10 | < 10 | < 7 | < 7 | < 8 |
| Ce-144 | < 43 | < 45 | < 45 | < 27 | < 28 | < 36 |
| Ra-226 | < 160 | < 155 | < 164 | < 103 | < 99 | < 129 |
| Ac-228 | < 35 | < 23 | < 22 | < 14 | < 15 | < 17 |
| Th-228 | < 13 | < 10 | < 11 | < 7 | < 7 | < 9 |

(a) Quarterly Composite

**INDIAN POINT ENERGY CENTER**

TABLE B-10

GAMMA EMITTERS IN SOIL SAMPLES - 2021

pCi/kg dry ± 2 Sigma

| | Roseton 23* | Training Building 94 | Met Tower 95 |
|---|---|---|---|
| DATE | 09/13/21 | 09/13/21 | 09/13/21 |
| Be-7 | < 793 | < 739 | < 613 |
| K-40 | 14750 ± 1948 | 11970 ± 1713 | 8669 ± 1253 |
| Mn-54 | < 87 | < 79 | < 66 |
| Co-58 | < 84 | < 80 | < 55 |
| Fe-59 | < 151 | < 149 | < 129 |
| Co-60 | < 92 | < 84 | < 60 |
| Zn-65 | < 198 | < 178 | < 153 |
| Nb-95 | < 97 | < 78 | < 56 |
| Zr-95 | < 151 | < 136 | < 97 |
| Ru-103 | < 81 | < 62 | < 49 |
| Ru-106 | < 866 | < 603 | < 572 |
| I-131 | < 96 | < 79 | < 69 |
| Cs-134 | < 96 | < 102 | < 67 |
| Cs-137 | < 103 | < 94 | < 70 |
| Ba-140 | < 317 | < 292 | < 257 |
| La-140 | < 127 | < 122 | < 67 |
| Ce-141 | < 110 | < 85 | < 90 |
| Ce-144 | < 434 | < 316 | < 361 |
| Ra-226 | < 1944 | < 1684 | < 1263 |
| Th-228 | 715 ± 189 | 589 ± 116 | < 103 |

* Control Location

**INDIAN POINT ENERGY CENTER**

TABLE B-11

GAMMA EMITTERS IN BROAD LEAF VEGETATION SAMPLES - 2021

pCi/kg wet ± 2 Sigma

| | Roseton 23* | | | | | |
|---|---|---|---|---|---|---|
| DATE | 05/17/21 | 05/17/21 | 05/17/21 | 06/21/21 | 06/21/21 | 06/21/21 |
| GAMMA | | | | | | |
| Be-7 | 1152 ± 258 | < 322 | 1052 ± 274 | 2324 ± 419 | 1009 ± 305 | 1640 ± 272 |
| K-40 | 7444 ± 760 | 3426 ± 606 | 4446 ± 618 | 5838 ± 823 | 5048 ± 660 | 4256 ± 506 |
| Mn-54 | < 29 | < 27 | < 23 | < 35 | < 26 | < 18 |
| Co-58 | < 26 | < 19 | < 19 | < 31 | < 22 | < 14 |
| Fe-59 | < 59 | < 50 | < 54 | < 59 | < 51 | < 36 |
| Co-60 | < 28 | < 30 | < 26 | < 36 | < 30 | < 22 |
| Zn-65 | < 72 | < 63 | < 65 | < 79 | < 60 | < 54 |
| Nb-95 | < 25 | < 33 | < 24 | < 30 | < 25 | < 16 |
| Zr-95 | < 51 | < 42 | < 43 | < 49 | < 44 | < 35 |
| Ru-103 | < 23 | < 25 | < 26 | < 29 | < 22 | < 19 |
| Ru-106 | < 230 | < 236 | < 193 | < 318 | < 197 | < 179 |
| I-131 | < 31 | < 30 | < 31 | < 30 | < 29 | < 19 |
| Cs-134 | < 33 | < 26 | < 27 | < 37 | < 32 | < 24 |
| Cs-137 | < 26 | < 26 | < 29 | < 30 | < 25 | < 22 |
| Ba-140 | < 79 | < 95 | < 90 | < 122 | < 108 | < 80 |
| La-140 | < 31 | < 7 | < 28 | < 31 | < 34 | < 13 |
| Ce-141 | < 42 | < 34 | < 39 | < 33 | < 38 | < 27 |
| Ce-144 | < 191 | < 131 | < 177 | < 153 | < 158 | < 109 |
| Ra-226 | < 694 | < 440 | < 654 | < 685 | < 655 | < 473 |
| Th-228 | < 53 | < 42 | < 53 | < 50 | < 48 | < 37 |

* Control Location

**INDIAN POINT ENERGY CENTER**

TABLE B-11

GAMMA EMITTERS IN BROAD LEAF VEGETATION SAMPLES - 2021

pCi/kg wet ± 2 Sigma

| | Roseton 23* | | | | | |
|---|---|---|---|---|---|---|
| DATE | 07/19/21 | 07/19/21 | 07/19/21 | 08/16/21 | 08/16/21 | 08/16/21 |
| GAMMA | | | | | | |
| Be-7 | 2857 ± 346 | 4521 ± 444 | 1119 ± 339 | 1989 ± 321 | 1154 ± 309 | 4092 ± 362 |
| K-40 | 5559 ± 617 | 4640 ± 674 | 4731 ± 748 | 4817 ± 577 | 5655 ± 700 | 4470 ± 565 |
| Mn-54 | < 20 | < 27 | < 29 | < 22 | < 26 | < 24 |
| Co-58 | < 25 | < 19 | < 29 | < 22 | < 26 | < 21 |
| Fe-59 | < 54 | < 48 | < 65 | < 49 | < 51 | < 60 |
| Co-60 | < 26 | < 25 | < 33 | < 30 | < 28 | < 29 |
| Zn-65 | < 67 | < 57 | < 61 | < 61 | < 63 | < 60 |
| Nb-95 | < 21 | < 24 | < 27 | < 24 | < 31 | < 25 |
| Zr-95 | < 44 | < 48 | < 47 | < 40 | < 48 | < 32 |
| Ru-103 | < 26 | < 27 | < 21 | < 19 | < 22 | < 23 |
| Ru-106 | < 217 | < 261 | < 257 | < 196 | < 254 | < 250 |
| I-131 | < 33 | < 33 | < 36 | < 28 | < 33 | < 25 |
| Cs-134 | < 27 | < 26 | < 30 | < 26 | < 34 | < 26 |
| Cs-137 | < 25 | < 32 | < 29 | < 25 | < 34 | < 22 |
| Ba-140 | < 92 | < 112 | < 98 | < 84 | < 110 | < 97 |
| La-140 | < 14 | < 30 | < 35 | < 23 | < 25 | < 33 |
| Ce-141 | < 40 | < 48 | < 33 | < 32 | < 39 | < 36 |
| Ce-144 | < 158 | < 191 | < 143 | < 127 | < 183 | < 138 |
| Ra-226 | < 640 | < 689 | < 574 | < 538 | < 761 | < 565 |
| Th-228 | < 50 | < 53 | < 39 | < 59 | < 55 | < 53 |

* Control Location

**INDIAN POINT ENERGY CENTER**

TABLE B-11

GAMMA EMITTERS IN BROAD LEAF VEGETATION SAMPLES - 2021

pCi/kg wet ± 2 Sigma

| | Roseton 23* | | | | | |
|---|---|---|---|---|---|---|
| DATE | 09/20/21 | 09/20/21 | 09/20/21 | 10/18/21 | 10/18/21 | 10/18/21 |
| GAMMA | | | | | | |
| Be-7 | 2068 ± 454 | 3834 ± 545 | 5319 ± 497 | 3146 ± 399 | 1632 ± 282 | 3355 ± 358 |
| K-40 | 4042 ± 654 | 2925 ± 640 | 4307 ± 686 | 2381 ± 570 | 4113 ± 562 | 5372 ± 644 |
| Mn-54 | < 26 | < 37 | < 28 | < 23 | < 24 | < 20 |
| Co-58 | < 27 | < 34 | < 28 | < 29 | < 27 | < 17 |
| Fe-59 | < 55 | < 65 | < 58 | < 52 | < 55 | < 52 |
| Co-60 | < 33 | < 33 | < 21 | < 33 | < 27 | < 29 |
| Zn-65 | < 51 | < 49 | < 51 | < 62 | < 49 | < 48 |
| Nb-95 | < 30 | < 31 | < 25 | < 31 | < 19 | < 19 |
| Zr-95 | < 45 | < 71 | < 46 | < 39 | < 37 | < 30 |
| Ru-103 | < 31 | < 31 | < 29 | < 28 | < 19 | < 21 |
| Ru-106 | < 235 | < 252 | < 214 | < 303 | < 208 | < 197 |
| I-131 | < 36 | < 36 | < 37 | < 38 | < 26 | < 30 |
| Cs-134 | < 32 | < 37 | < 24 | < 30 | < 27 | < 22 |
| Cs-137 | < 26 | < 38 | < 31 | < 31 | < 25 | < 20 |
| Ba-140 | < 114 | < 126 | < 87 | < 123 | < 92 | < 82 |
| La-140 | < 30 | < 37 | < 33 | < 38 | < 30 | < 17 |
| Ce-141 | < 44 | < 45 | < 47 | < 42 | < 36 | < 38 |
| Ce-144 | < 195 | < 180 | < 198 | < 185 | < 176 | < 157 |
| Ra-226 | < 698 | < 877 | < 687 | < 688 | < 583 | < 536 |
| Th-228 | < 54 | < 64 | < 60 | < 52 | < 45 | < 43 |

* Control Location

**INDIAN POINT ENERGY CENTER**

TABLE B-11

GAMMA EMITTERS IN BROAD LEAF VEGETATION SAMPLES - 2021

pCi/kg wet ± 2 Sigma

| | Training Center 94 | | | | | |
|---|---|---|---|---|---|---|
| DATE | 05/18/21 | 05/18/21 | 05/18/21 | 06/22/21 | 06/22/21 | 06/22/21 |
| GAMMA | | | | | | |
| Be-7 | 886 ± 245 | 1076 ± 279 | 758 ± 328 | 1574 ± 208 | 779 ± 232 | 763 ± 244 |
| K-40 | 5587 ± 586 | 2858 ± 519 | 4094 ± 564 | 6101 ± 506 | 3136 ± 440 | 2224 ± 467 |
| Mn-54 | < 27 | < 20 | < 26 | < 19 | < 23 | < 25 |
| Co-58 | < 23 | < 18 | < 27 | < 21 | < 19 | < 26 |
| Fe-59 | < 46 | < 56 | < 59 | < 44 | < 38 | < 44 |
| Co-60 | < 33 | < 27 | < 17 | < 23 | < 19 | < 24 |
| Zn-65 | < 54 | < 59 | < 54 | < 52 | < 35 | < 45 |
| Nb-95 | < 25 | < 21 | < 25 | < 20 | < 20 | < 25 |
| Zr-95 | < 38 | < 34 | < 44 | < 38 | < 30 | < 33 |
| Ru-103 | < 24 | < 20 | < 25 | < 18 | < 23 | < 23 |
| Ru-106 | < 183 | < 201 | < 217 | < 151 | < 193 | < 191 |
| I-131 | < 26 | < 29 | < 26 | < 21 | < 26 | < 26 |
| Cs-134 | < 30 | < 30 | < 25 | < 22 | < 24 | < 26 |
| Cs-137 | < 22 | < 24 | < 23 | < 21 | < 19 | < 22 |
| Ba-140 | < 67 | < 78 | < 94 | < 67 | < 85 | < 95 |
| La-140 | < 20 | < 28 | < 24 | < 18 | < 26 | < 24 |
| Ce-141 | < 36 | < 35 | < 33 | < 26 | < 29 | < 35 |
| Ce-144 | < 138 | < 153 | < 150 | < 103 | < 115 | < 142 |
| Ra-226 | < 571 | < 587 | < 512 | < 432 | < 500 | < 548 |
| Th-228 | < 39 | < 50 | < 46 | < 40 | < 37 | < 54 |

**INDIAN POINT ENERGY CENTER**

TABLE B-11

GAMMA EMITTERS IN BROAD LEAF VEGETATION SAMPLES - 2021

pCi/kg wet ± 2 Sigma

| | Training Center 94 | | | | | |
|---|---|---|---|---|---|---|
| DATE | 07/20/21 | 07/20/21 | 07/20/21 | 08/17/21 | 08/17/21 | 08/17/21 |
| GAMMA | | | | | | |
| Be-7 | 1358 ± 280 | 3719 ± 431 | 1498 ± 284 | 2056 ± 339 | 1549 ± 384 | 2668 ± 391 |
| K-40 | 3114 ± 547 | 2758 ± 447 | 2872 ± 423 | 3121 ± 637 | 3473 ± 568 | 5876 ± 732 |
| Mn-54 | < 26 | < 26 | < 23 | < 22 | < 25 | < 29 |
| Co-58 | < 18 | < 22 | < 22 | < 26 | < 28 | < 24 |
| Fe-59 | < 51 | < 34 | < 48 | < 56 | < 60 | < 45 |
| Co-60 | < 21 | < 21 | < 30 | < 33 | < 25 | < 21 |
| Zn-65 | < 48 | < 51 | < 55 | < 51 | < 58 | < 54 |
| Nb-95 | < 27 | < 25 | < 26 | < 24 | < 25 | < 25 |
| Zr-95 | < 43 | < 42 | < 39 | < 48 | < 36 | < 42 |
| Ru-103 | < 23 | < 24 | < 20 | < 27 | < 22 | < 24 |
| Ru-106 | < 185 | < 204 | < 214 | < 257 | < 265 | < 231 |
| I-131 | < 26 | < 28 | < 26 | < 29 | < 28 | < 29 |
| Cs-134 | < 28 | < 17 | < 27 | < 30 | < 33 | < 29 |
| Cs-137 | < 23 | < 26 | < 26 | < 29 | < 30 | < 32 |
| Ba-140 | < 94 | < 88 | < 81 | < 121 | < 102 | < 104 |
| La-140 | < 17 | < 23 | < 31 | < 24 | < 36 | < 28 |
| Ce-141 | < 33 | < 37 | < 35 | < 38 | < 39 | < 44 |
| Ce-144 | < 142 | < 168 | < 136 | < 155 | < 179 | < 198 |
| Ra-226 | < 537 | < 627 | < 558 | < 745 | < 678 | < 692 |
| Th-228 | < 46 | < 49 | < 42 | < 68 | < 66 | 99 ± 46 |

**INDIAN POINT ENERGY CENTER**

TABLE B-11

GAMMA EMITTERS IN BROAD LEAF VEGETATION SAMPLES - 2021

pCi/kg wet ± 2 Sigma

| | Training Center 94 | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| DATE | 09/21/21 | 09/21/21 | 09/21/21 | 10/19/21 | 10/19/21 | 10/19/21 |
| GAMMA | | | | | | |
| Be-7 | 1472 ± 356 | 2908 ± 543 | 4129 ± 541 | 2315 ± 302 | 1597 ± 370 | 5935 ± 537 |
| K-40 | 3048 ± 710 | 4275 ± 716 | 5496 ± 816 | 5134 ± 604 | 2959 ± 551 | 5677 ± 764 |
| Mn-54 | < 37 | < 48 | < 34 | < 31 | < 31 | < 28 |
| Co-58 | < 26 | < 42 | < 26 | < 23 | < 31 | < 28 |
| Fe-59 | < 53 | < 86 | < 75 | < 60 | < 52 | < 61 |
| Co-60 | < 42 | < 43 | < 44 | < 27 | < 32 | < 40 |
| Zn-65 | < 75 | < 75 | < 81 | < 56 | < 64 | < 62 |
| Nb-95 | < 27 | < 35 | < 30 | < 21 | < 33 | < 20 |
| Zr-95 | < 48 | < 67 | < 62 | < 44 | < 55 | < 51 |
| Ru-103 | < 28 | < 35 | < 33 | < 24 | < 30 | < 25 |
| Ru-106 | < 295 | < 324 | < 260 | < 252 | < 227 | < 255 |
| I-131 | < 35 | < 41 | < 41 | < 30 | < 39 | < 27 |
| Cs-134 | < 45 | < 52 | < 41 | < 25 | < 33 | < 24 |
| Cs-137 | < 40 | < 38 | < 36 | < 27 | < 29 | < 25 |
| Ba-140 | < 112 | < 167 | < 137 | < 87 | < 95 | < 107 |
| La-140 | < 50 | < 49 | < 30 | < 23 | < 33 | < 32 |
| Ce-141 | < 43 | < 53 | < 53 | < 40 | < 40 | < 43 |
| Ce-144 | < 184 | < 235 | < 236 | < 168 | < 210 | < 175 |
| Ra-226 | < 726 | < 957 | < 802 | < 649 | < 686 | < 650 |
| Th-228 | < 68 | < 77 | < 73 | < 52 | < 63 | < 52 |

**INDIAN POINT ENERGY CENTER**

TABLE B-11

GAMMA EMITTERS IN BROAD LEAF VEGETATION SAMPLES - 2021

pCi/kg wet ± 2 Sigma

| | Met Tower 95 | | | | | |
|---|---|---|---|---|---|---|
| DATE | 05/18/21 | 05/18/21 | 05/18/21 | 06/22/21 | 06/22/21 | 06/22/21 |
| GAMMA | | | | | | |
| Be-7 | 1153 ± 204 | 764 ± 252 | 892 ± 225 | 1107 ± 230 | 868 ± 198 | 1331 ± 264 |
| K-40 | 3620 ± 451 | 6815 ± 859 | 6840 ± 640 | 6201 ± 597 | 3633 ± 439 | 3843 ± 586 |
| Mn-54 | < 18 | < 29 | < 22 | < 23 | < 19 | < 21 |
| Co-58 | < 19 | < 24 | < 21 | < 25 | < 18 | < 20 |
| Fe-59 | < 32 | < 56 | < 49 | < 50 | < 37 | < 38 |
| Co-60 | < 21 | < 25 | < 25 | < 23 | < 22 | < 25 |
| Zn-65 | < 41 | < 58 | < 51 | < 54 | < 47 | < 40 |
| Nb-95 | < 19 | < 28 | < 17 | < 28 | < 18 | < 22 |
| Zr-95 | < 33 | < 45 | < 30 | < 42 | < 32 | < 41 |
| Ru-103 | < 14 | < 25 | < 23 | < 26 | < 20 | < 20 |
| Ru-106 | < 197 | < 190 | < 180 | < 198 | < 164 | < 204 |
| I-131 | < 20 | < 25 | < 24 | < 25 | < 21 | < 16 |
| Cs-134 | < 15 | < 30 | < 26 | < 26 | < 22 | < 22 |
| Cs-137 | < 17 | < 26 | < 25 | < 26 | < 21 | < 19 |
| Ba-140 | < 68 | < 94 | < 82 | < 96 | < 67 | < 73 |
| La-140 | < 16 | < 23 | < 19 | < 21 | < 21 | < 19 |
| Ce-141 | < 26 | < 34 | < 31 | < 33 | < 29 | < 27 |
| Ce-144 | < 101 | < 134 | < 143 | < 152 | < 132 | < 112 |
| Ra-226 | < 420 | < 507 | < 479 | < 550 | < 496 | < 470 |
| Th-228 | < 30 | < 43 | < 45 | < 46 | < 40 | < 38 |

**INDIAN POINT ENERGY CENTER**

TABLE B-11

GAMMA EMITTERS IN BROAD LEAF VEGETATION SAMPLES - 2021

pCi/kg wet ± 2 Sigma

| | Met Tower 95 | | | | | |
|---|---|---|---|---|---|---|
| DATE | 07/19/21 | 07/19/21 | 07/19/21 | 08/17/21 | 08/17/21 | 08/17/21 |
| GAMMA | | | | | | |
| Be-7 | 4524 ± 382 | 1306 ± 321 | 2884 ± 396 | 2376 ± 319 | 1987 ± 424 | 1460 ± 341 |
| K-40 | 6970 ± 649 | 6118 ± 781 | 3285 ± 549 | 6274 ± 769 | 6249 ± 804 | 4640 ± 846 |
| Mn-54 | < 21 | < 23 | < 27 | < 34 | < 33 | < 33 |
| Co-58 | < 19 | < 26 | < 25 | < 21 | < 32 | < 33 |
| Fe-59 | < 47 | < 53 | < 49 | < 41 | < 63 | < 74 |
| Co-60 | < 27 | < 24 | < 24 | < 33 | < 39 | < 46 |
| Zn-65 | < 48 | < 72 | < 64 | < 64 | < 54 | < 64 |
| Nb-95 | < 20 | < 26 | < 28 | < 28 | < 34 | < 30 |
| Zr-95 | < 34 | < 50 | < 43 | < 39 | < 53 | < 51 |
| Ru-103 | < 22 | < 26 | < 25 | < 23 | < 28 | < 34 |
| Ru-106 | < 222 | < 254 | < 257 | < 233 | < 311 | < 253 |
| I-131 | < 27 | < 32 | < 35 | < 33 | < 31 | < 31 |
| Cs-134 | < 28 | < 26 | < 29 | < 28 | < 36 | < 38 |
| Cs-137 | < 25 | < 30 | < 30 | < 30 | < 35 | < 37 |
| Ba-140 | < 89 | < 96 | < 115 | < 74 | < 110 | < 87 |
| La-140 | < 19 | < 37 | < 31 | < 27 | < 36 | < 27 |
| Ce-141 | < 28 | < 40 | < 42 | < 31 | < 47 | < 40 |
| Ce-144 | < 131 | < 172 | < 166 | < 142 | < 189 | < 165 |
| Ra-226 | < 524 | < 614 | < 649 | < 605 | < 614 | < 665 |
| Th-228 | < 37 | < 49 | < 51 | < 39 | < 70 | 114 ± 66 |

**INDIAN POINT ENERGY CENTER**

TABLE B-11

GAMMA EMITTERS IN BROAD LEAF VEGETATION SAMPLES - 2021

pCi/kg wet ± 2 Sigma

| | Met Tower 95 | | | | | |
|---|---|---|---|---|---|---|
| DATE | 09/20/21 | 09/20/21 | 09/20/21 | 10/19/21 | 10/19/21 | 10/19/21 |
| GAMMA | | | | | | |
| Be-7 | 4266 ± 568 | 3871 ± 565 | 4224 ± 600 | 964 ± 239 | 3496 ± 269 | 2277 ± 354 |
| K-40 | 10050 ± 993 | 6231 ± 854 | 3565 ± 720 | 4309 ± 544 | 6634 ± 488 | 6209 ± 773 |
| Mn-54 | < 32 | < 37 | < 34 | < 22 | < 16 | < 32 |
| Co-58 | < 39 | < 41 | < 40 | < 18 | < 19 | < 30 |
| Fe-59 | < 87 | < 62 | < 95 | < 42 | < 40 | < 66 |
| Co-60 | < 44 | < 48 | < 44 | < 19 | < 20 | < 36 |
| Zn-65 | < 92 | < 84 | < 88 | < 47 | < 43 | < 74 |
| Nb-95 | < 39 | < 34 | < 44 | < 22 | < 18 | < 25 |
| Zr-95 | < 75 | < 73 | < 71 | < 36 | < 32 | < 54 |
| Ru-103 | < 41 | < 33 | < 35 | < 18 | < 17 | < 32 |
| Ru-106 | < 347 | < 358 | < 391 | < 185 | < 172 | < 236 |
| I-131 | < 47 | < 36 | < 51 | < 25 | < 22 | < 33 |
| Cs-134 | < 41 | < 47 | < 37 | < 24 | < 21 | < 35 |
| Cs-137 | < 43 | < 41 | < 33 | < 22 | < 18 | < 29 |
| Ba-140 | < 150 | < 127 | < 145 | < 83 | < 74 | < 100 |
| La-140 | < 29 | < 37 | < 39 | < 20 | < 19 | < 34 |
| Ce-141 | < 64 | < 52 | < 66 | < 29 | < 29 | < 39 |
| Ce-144 | < 251 | < 192 | < 279 | < 136 | < 127 | < 184 |
| Ra-226 | < 1040 | < 826 | < 1093 | < 495 | < 475 | < 689 |
| Th-228 | 169 ± 69 | < 62 | < 76 | < 43 | < 38 | < 61 |

**INDIAN POINT ENERGY CENTER**

TABLE B-12

RADIONUCLIDES IN RIVER WATER SAMPLES - 2021

pCi/L ± 2 Sigma

| | Discharge Canal 10 | | | | | |
|---|---|---|---|---|---|---|
| DATE | 01/26/21 | 02/23/21 | 03/30/21 | 04/27/21 | 06/02/21 | 07/07/21 |
| RADIOCHEMICAL | | | | | | |
| H-3 (a) | | | 483 ± 128 | | | 214 ± 122 |
| GAMMA | | | | | | |
| K-40 | < 23 | < 24 | < 38 | < 60 | < 27 | 27 ± 16 |
| Mn-54 | < 1 | < 2 | < 2 | < 5 | < 1 | < 1 |
| Co-58 | < 2 | < 3 | < 2 | < 4 | < 2 | < 1 |
| Fe-59 | < 3 | < 6 | < 5 | < 10 | < 4 | < 3 |
| Co-60 | < 2 | < 3 | < 2 | < 4 | < 2 | < 1 |
| Zn-65 | < 3 | < 6 | < 4 | < 8 | < 4 | < 2 |
| Nb-95 | < 2 | < 2 | < 2 | < 4 | < 2 | < 1 |
| Zr-95 | < 3 | < 5 | < 4 | < 7 | < 4 | < 2 |
| Ru-103 | < 2 | < 3 | < 3 | < 5 | < 2 | < 2 |
| Ru-106 | < 13 | < 22 | < 18 | < 39 | < 15 | < 12 |
| I-131 | < 5 | < 9 | < 11 | < 15 | < 11 | < 6 |
| Cs-134 | < 2 | < 3 | < 2 | < 5 | < 2 | < 1 |
| Cs-137 | < 2 | < 3 | < 2 | < 4 | < 2 | < 1 |
| Ba-140 | < 11 | < 21 | < 19 | < 32 | < 19 | < 12 |
| La-140 | < 4 | < 7 | < 7 | < 12 | < 7 | < 4 |
| Ce-141 | < 3 | < 5 | < 5 | < 10 | < 4 | < 3 |
| Ce-144 | < 11 | < 16 | < 16 | < 31 | < 11 | < 9 |
| Ra-226 | < 32 | < 56 | < 52 | < 109 | < 39 | < 26 |
| Ac-228 | < 6 | < 9 | < 8 | < 16 | < 6 | < 4 |
| Th-228 | < 3 | < 4 | < 4 | < 8 | < 3 | < 3 |

(a) Quarterly Composite

**INDIAN POINT ENERGY CENTER**

TABLE B-12

RADIONUCLIDES IN RIVER WATER SAMPLES - 2021

pCi/L ± 2 Sigma

| | Discharge Canal 10 | | | | | |
|---|---|---|---|---|---|---|
| DATE | 08/03/21 | 08/31/21 | 09/28/21 | 10/26/21 | 11/30/21 | 12/29/21 |
| RADIOCHEMICAL | | | | | | |
| H-3 (a) | | | 442 ± 129 | | | < 170 |
| GAMMA | | | | | | |
| K-40 | < 21 | < 30 | < 27 | < 90 | < 15 | < 15 |
| Mn-54 | < 1 | < 2 | < 2 | < 4 | < 1 | < 1 |
| Co-58 | < 1 | < 2 | < 2 | < 5 | < 2 | < 2 |
| Fe-59 | < 3 | < 4 | < 4 | < 12 | < 4 | < 4 |
| Co-60 | < 1 | < 2 | < 2 | < 5 | < 2 | < 1 |
| Zn-65 | < 3 | < 3 | < 4 | < 10 | < 3 | < 3 |
| Nb-95 | < 2 | < 2 | < 2 | < 5 | < 2 | < 2 |
| Zr-95 | < 3 | < 3 | < 3 | < 9 | < 3 | < 3 |
| Ru-103 | < 2 | < 2 | < 2 | < 5 | < 2 | < 2 |
| Ru-106 | < 13 | < 15 | < 16 | < 38 | < 15 | < 14 |
| I-131 | < 5 | < 7 | < 6 | < 15 | < 8 | < 8 |
| Cs-134 | < 2 | < 2 | < 2 | < 4 | < 2 | < 2 |
| Cs-137 | < 1 | < 2 | < 2 | < 4 | < 2 | < 2 |
| Ba-140 | < 10 | < 14 | < 14 | < 36 | < 15 | < 15 |
| La-140 | < 4 | < 4 | < 4 | < 13 | < 5 | < 5 |
| Ce-141 | < 3 | < 4 | < 4 | < 9 | < 4 | < 4 |
| Ce-144 | < 9 | < 12 | < 12 | < 31 | < 11 | < 11 |
| Ra-226 | < 28 | < 41 | < 39 | < 111 | < 33 | < 40 |
| Ac-228 | < 5 | < 7 | < 7 | < 18 | < 6 | < 5 |
| Th-228 | < 2 | < 3 | 10 ± 3 | < 8 | < 3 | < 3 |

(a) Quarterly Composite

**INDIAN POINT ENERGY CENTER**

TABLE B-12

RADIONUCLIDES IN RIVER WATER SAMPLES - 2021

pCi/L ± 2 Sigma

| | Roseton 23* | | | | | |
|---|---|---|---|---|---|---|
| DATE | 01/25/21 | 02/22/21 | 03/29/21 | 04/26/21 | 06/01/21 | 07/06/21 |
| RADIOCHEMICAL | | | | | | |
| H-3 (a) | | | < 175 | | | < 180 |
| GAMMA | | | | | | |
| K-40 | < 16 | < 35 | < 14 | < 46 | < 15 | < 15 |
| Mn-54 | < 1 | < 2 | < 2 | < 3 | < 2 | < 2 |
| Co-58 | < 1 | < 2 | < 2 | < 3 | < 2 | < 2 |
| Fe-59 | < 3 | < 5 | < 4 | < 8 | < 5 | < 4 |
| Co-60 | < 1 | < 2 | < 2 | < 3 | < 2 | < 2 |
| Zn-65 | < 2 | < 5 | < 3 | < 6 | < 3 | < 3 |
| Nb-95 | < 1 | < 3 | < 2 | < 3 | < 2 | < 2 |
| Zr-95 | < 2 | < 4 | < 3 | < 7 | < 3 | < 3 |
| Ru-103 | < 1 | < 3 | < 2 | < 4 | < 2 | < 2 |
| Ru-106 | < 9 | < 18 | < 14 | < 23 | < 15 | < 15 |
| I-131 | < 4 | < 9 | < 10 | < 13 | < 12 | < 9 |
| Cs-134 | < 1 | < 2 | < 2 | < 4 | < 2 | < 2 |
| Cs-137 | < 1 | < 2 | < 2 | < 4 | < 2 | < 2 |
| Ba-140 | < 9 | < 17 | < 16 | < 26 | < 19 | < 16 |
| La-140 | < 3 | < 7 | < 5 | < 9 | < 6 | < 6 |
| Ce-141 | < 2 | < 4 | < 4 | < 7 | < 4 | < 4 |
| Ce-144 | < 5 | < 14 | < 12 | < 22 | < 10 | < 13 |
| Ra-226 | < 16 | < 54 | < 43 | < 79 | < 33 | < 39 |
| Ac-228 | < 4 | < 7 | < 6 | < 11 | < 7 | < 6 |
| Th-228 | < 3 | < 6 | < 3 | < 6 | < 3 | < 3 |

* Control Location
(a) Quarterly Composite

**INDIAN POINT ENERGY CENTER**

TABLE B-12

RADIONUCLIDES IN RIVER WATER SAMPLES - 2021

pCi/L ± 2 Sigma

| | Roseton 23* | | | | | |
|---|---|---|---|---|---|---|
| DATE | 08/02/21 | 08/30/21 | 09/27/21 | 10/25/21 | 11/29/21 | 12/28/21 |
| RADIOCHEMICAL | | | | | | |
| H-3 (a) | | | < 173 | | | < 173 |
| GAMMA | | | | | | |
| K-40 | < 14 | < 14 | < 38 | < 41 | < 16 | < 29 |
| Mn-54 | < 1 | < 1 | < 2 | < 3 | < 1 | < 2 |
| Co-58 | < 2 | < 2 | < 2 | < 3 | < 1 | < 2 |
| Fe-59 | < 3 | < 4 | < 6 | < 6 | < 3 | < 4 |
| Co-60 | < 2 | < 2 | < 2 | < 2 | < 1 | < 2 |
| Zn-65 | < 3 | < 3 | < 4 | < 6 | < 2 | < 4 |
| Nb-95 | < 2 | < 2 | < 2 | < 3 | < 1 | < 2 |
| Zr-95 | < 3 | < 3 | < 5 | < 5 | < 2 | < 3 |
| Ru-103 | < 2 | < 2 | < 3 | < 3 | < 1 | < 2 |
| Ru-106 | < 14 | < 14 | < 21 | < 25 | < 10 | < 16 |
| I-131 | < 6 | < 7 | < 8 | < 11 | < 6 | < 9 |
| Cs-134 | < 2 | < 2 | < 3 | < 3 | < 1 | < 2 |
| Cs-137 | < 2 | < 2 | < 2 | < 3 | < 1 | < 2 |
| Ba-140 | < 12 | < 14 | < 19 | < 21 | < 11 | < 17 |
| La-140 | < 4 | < 5 | < 6 | < 8 | < 4 | < 5 |
| Ce-141 | < 4 | < 4 | < 5 | < 6 | < 2 | < 4 |
| Ce-144 | < 12 | < 12 | < 15 | < 19 | < 7 | < 11 |
| Ra-226 | < 35 | < 41 | < 57 | < 67 | < 27 | < 41 |
| Ac-228 | < 5 | < 6 | < 8 | < 10 | < 4 | < 6 |
| Th-228 | < 3 | < 3 | < 4 | < 5 | < 3 | < 3 |

* Control Location

(a) Quarterly Composite

**INDIAN POINT ENERGY CENTER**

TABLE B-13

GAMMA EMITTERS IN BOTTOM SEDIMENT SAMPLES - 2021

pCi/kg dry ± 2 Sigma

| | Discharge Canal 10 | | Off Verplanck 17 | |
|---|---|---|---|---|
| DATE | 06/15/21 | 08/30/21 | 06/15/21 | 08/30/21 |
| GAMMA | | | | |
| Be-7 | < 355 | < 612 | < 561 | < 476 |
| K-40 | 14330 ± 1303 | 21400 ± 2042 | 16460 ± 1784 | 18130 ± 1411 |
| Mn-54 | < 45 | < 65 | < 69 | < 52 |
| Co-58 | < 45 | < 60 | < 59 | < 48 |
| Fe-59 | < 86 | < 124 | < 138 | < 112 |
| Co-60 | < 55 | < 92 | < 76 | < 56 |
| Zn-65 | < 106 | < 175 | < 151 | < 137 |
| Nb-95 | < 41 | < 65 | < 73 | < 51 |
| Zr-95 | < 78 | < 114 | < 117 | < 90 |
| Ru-103 | < 40 | < 63 | < 60 | < 50 |
| Ru-106 | < 423 | < 566 | < 600 | < 509 |
| I-131 | < 43 | < 102 | < 72 | < 100 |
| Cs-134 | < 61 | < 84 | < 79 | < 70 |
| Cs-137 | 94 ± 55 | 321 ± 118 | < 108 | 141 ± 54 |
| Ba-140 | < 159 | < 305 | < 250 | < 252 |
| Ce-141 | < 52 | < 80 | < 79 | < 67 |
| Ce-144 | < 239 | < 305 | < 336 | < 246 |
| Ra-226 | < 982 | < 1578 | 2578 ± 1241 | 1962 ± 984 |
| Th-228 | 244 ± 71 | 864 ± 107 | 776 ± 100 | 803 ± 88 |

**INDIAN POINT ENERGY CENTER**

TABLE B-13

GAMMA EMITTERS IN BOTTOM SEDIMENT SAMPLES - 2021

pCi/kg dry ± 2 Sigma

| | Lent's Cove 28 | | Cold Spring 84* | |
|---|---|---|---|---|
| DATE | 06/15/21 | 08/30/21 | 06/15/21 | 08/30/21 |
| GAMMA | | | | |
| Be-7 | < 684 | < 1074 | < 690 | < 980 |
| K-40 | 13790 ± 1874 | 14720 ± 1999 | 20210 ± 2075 | 19560 ± 2036 |
| Mn-54 | < 107 | < 119 | < 97 | < 104 |
| Co-58 | < 81 | < 108 | < 82 | < 114 |
| Fe-59 | < 190 | < 240 | < 195 | < 211 |
| Co-60 | < 107 | < 115 | < 91 | < 110 |
| Zn-65 | < 202 | < 228 | < 207 | < 215 |
| Nb-95 | < 81 | < 131 | < 98 | < 138 |
| Zr-95 | < 153 | < 211 | < 168 | < 200 |
| Ru-103 | < 87 | < 116 | < 89 | < 108 |
| Ru-106 | < 624 | < 906 | < 836 | < 936 |
| I-131 | < 84 | < 187 | < 97 | < 187 |
| Cs-134 | < 109 | < 143 | < 111 | < 124 |
| Cs-137 | 142 ± 78 | 214 ± 109 | < 131 | 257 ± 107 |
| Ba-140 | < 308 | < 564 | < 330 | < 528 |
| Ce-141 | < 88 | < 177 | < 138 | < 155 |
| Ce-144 | < 398 | < 642 | < 518 | < 624 |
| Ra-226 | < 1850 | < 2667 | < 2229 | < 1913 |
| Th-228 | 724 ± 144 | 900 ± 197 | 970 ± 232 | 1085 ± 153 |

* Control Location

**INDIAN POINT ENERGY CENTER**

TABLE B-14

RADIONUCLIDES IN SHORELINE SOIL SAMPLES - 2021

pCi/kg dry ± 2 Sigma

| | Off Verplanck 17 | | Lent's Cove 28 | |
|---|---|---|---|---|
| DATE | 06/02/21 | 09/08/21 | 06/02/21 | 09/08/21 |
| RADIOCHEMICAL | | | | |
| Sr-90 | < 45 | < 42 | < 45 | < 49 |
| GAMMA | | | | |
| Be-7 | < 431 | < 524 | < 396 | < 439 |
| K-40 | 13410 ± 1311 | 12060 ± 1219 | 11950 ± 1238 | 12390 ± 1287 |
| Mn-54 | < 52 | < 52 | < 57 | < 52 |
| Co-58 | < 53 | < 51 | < 56 | < 49 |
| Fe-59 | < 117 | < 97 | < 106 | < 94 |
| Co-60 | < 54 | < 51 | < 48 | < 43 |
| Zn-65 | < 82 | < 114 | < 113 | < 120 |
| Nb-95 | < 66 | < 58 | < 53 | < 53 |
| Zr-95 | < 89 | < 88 | < 92 | < 94 |
| Ru-103 | < 46 | < 52 | < 50 | < 42 |
| Ru-106 | < 348 | < 488 | < 388 | < 422 |
| I-131 | < 74 | < 53 | < 75 | < 60 |
| Cs-134 | < 61 | < 68 | < 57 | < 57 |
| Cs-137 | < 64 | < 75 | < 53 | < 53 |
| Ba-140 | < 220 | < 191 | < 208 | < 177 |
| La-140 | < 69 | < 66 | < 73 | < 34 |
| Ce-141 | < 72 | < 70 | < 69 | < 66 |
| Ce-144 | < 279 | < 260 | < 262 | < 281 |
| Ra-226 | < 1226 | < 1263 | < 1127 | < 1185 |
| Ac-228 | < 336 | < 349 | < 277 | < 280 |
| Th-228 | 384 ± 115 | 493 ± 97 | 392 ± 97 | 203 ± 73 |

**INDIAN POINT ENERGY CENTER**

TABLE B-14

RADIONUCLIDES IN SHORELINE SOIL SAMPLES - 2021

pCi/kg dry ± 2 Sigma

| | Manitou Inlet 50* | | White Beach 53 | |
|---|---|---|---|---|
| DATE | 06/02/21 | 09/07/21 | 06/02/21 | 09/07/21 |
| RADIOCHEMICAL | | | | |
| Sr-90 | < 43 | < 44 | < 43 | < 47 |
| GAMMA | | | | |
| Be-7 | < 867 | < 516 | < 273 | < 572 |
| K-40 | 9070 ± 1502 | 13170 ± 1507 | 8047 ± 974 | 8639 ± 1145 |
| Mn-54 | < 81 | < 54 | < 36 | < 66 |
| Co-58 | < 75 | < 54 | < 43 | < 65 |
| Fe-59 | < 164 | < 122 | < 81 | < 136 |
| Co-60 | < 80 | < 61 | < 45 | < 66 |
| Zn-65 | < 185 | < 141 | < 91 | < 139 |
| Nb-95 | < 103 | < 69 | < 38 | < 69 |
| Zr-95 | < 137 | < 111 | < 60 | < 108 |
| Ru-103 | < 78 | < 60 | < 29 | < 48 |
| Ru-106 | < 656 | < 470 | < 296 | < 517 |
| I-131 | < 112 | < 65 | < 45 | < 64 |
| Cs-134 | < 112 | < 68 | < 41 | < 69 |
| Cs-137 | < 125 | < 65 | < 40 | < 65 |
| Ba-140 | < 362 | < 213 | < 161 | < 198 |
| La-140 | < 108 | < 68 | < 42 | < 75 |
| Ce-141 | < 109 | < 76 | < 44 | < 69 |
| Ce-144 | < 412 | < 301 | < 171 | < 288 |
| Ra-226 | 2435 ± 1596 | < 1114 | < 786 | < 1275 |
| Ac-228 | < 601 | < 387 | < 195 | < 266 |
| Th-228 | 650 ± 152 | 577 ± 97 | < 57 | < 116 |

* Control Location

**INDIAN POINT ENERGY CENTER**

TABLE B-14

RADIONUCLIDES IN SHORELINE SOIL SAMPLES - 2021

pCi/kg dry ± 2 Sigma

| | Cold Spring 84* | |
|---|---|---|
| DATE | 06/02/21 | 09/07/21 |
| RADIOCHEMICAL | | |
| Sr-90 | < 45 | < 46 |
| GAMMA | | |
| Be-7 | < 450 | < 413 |
| K-40 | 32150 ± 2225 | 30250 ± 2163 |
| Mn-54 | < 67 | < 62 |
| Co-58 | < 60 | < 57 |
| Fe-59 | < 158 | < 130 |
| Co-60 | < 62 | < 75 |
| Zn-65 | < 166 | < 148 |
| Nb-95 | < 64 | < 70 |
| Zr-95 | < 112 | < 113 |
| Ru-103 | < 48 | < 55 |
| Ru-106 | < 438 | < 561 |
| I-131 | < 73 | < 57 |
| Cs-134 | < 84 | < 70 |
| Cs-137 | < 60 | < 63 |
| Ba-140 | < 249 | < 231 |
| La-140 | < 68 | < 45 |
| Ce-141 | < 67 | < 71 |
| Ce-144 | < 274 | < 279 |
| Ra-226 | < 1060 | < 1203 |
| Ac-228 | < 333 | < 432 |
| Th-228 | 335 ± 81 | 486 ± 94 |

* Control Location

**INDIAN POINT ENERGY CENTER**

TABLE B-15

GAMMA EMITTERS IN AQUATIC VEGETATION SAMPLES - 2021

pCi/kg wet ± 2 Sigma

| | Lent's Cove 28 | |
|---|---|---|
| DATE | 06/15/21 Peltandra Virginica | 08/30/21 Peltandra Virginica |
| Be-7 | < 169 | 386 ± 233 |
| K-40 | 2212 ± 328 | 2134 ± 457 |
| Mn-54 | < 17 | < 30 |
| Co-58 | < 14 | < 31 |
| Fe-59 | < 41 | < 52 |
| Co-60 | < 21 | < 36 |
| Zn-65 | < 35 | < 69 |
| Nb-95 | < 16 | < 30 |
| Zr-95 | < 28 | < 49 |
| Ru-103 | < 16 | < 30 |
| Ru-106 | < 159 | < 277 |
| I-131 | < 17 | < 38 |
| Cs-134 | < 19 | < 36 |
| Cs-137 | < 18 | < 29 |
| Ba-140 | < 53 | < 127 |
| La-140 | < 19 | < 22 |
| Ce-141 | < 20 | < 48 |
| Ce-144 | < 87 | < 205 |
| Ra-226 | < 345 | < 708 |
| Ac-228 | < 64 | < 106 |
| Th-228 | < 29 | < 60 |

**INDIAN POINT ENERGY CENTER**

TABLE B-15

GAMMA EMITTERS IN AQUATIC VEGETATION SAMPLES - 2021

pCi/kg wet ± 2 Sigma

| | Off Verplanck 17 | |
|---|---|---|
| DATE | 06/17/21 | 08/30/21 |
| Be-7 | (a) | (a) |
| K-40 | | |
| Mn-54 | | |
| Co-58 | | |
| Fe-59 | | |
| Co-60 | | |
| Zn-65 | | |
| Nb-95 | | |
| Zr-95 | | |
| Ru-103 | | |
| Ru-106 | | |
| I-131 | | |
| Cs-134 | | |
| Cs-137 | | |
| Ba-140 | | |
| La-140 | | |
| Ce-141 | | |
| Ce-144 | | |
| Ra-226 | | |
| Ac-228 | | |
| Th-228 | | |

(a) Refer to deviation table B-1b

**INDIAN POINT ENERGY CENTER**

TABLE B-15

GAMMA EMITTERS IN AQUATIC VEGETATION SAMPLES - 2021

pCi/kg wet ± 2 Sigma

| | Cold Spring 84* | |
|---|---|---|
| DATE | 06/15/21<br>Peltandra Virginica | 08/30/21<br>Peltandra Virginica |
| Be-7 | < 200 | < 374 |
| K-40 | 2971 ± 446 | 2405 ± 528 |
| Mn-54 | < 17 | < 36 |
| Co-58 | < 20 | < 37 |
| Fe-59 | < 32 | < 67 |
| Co-60 | < 20 | < 28 |
| Zn-65 | < 40 | < 55 |
| Nb-95 | < 18 | < 34 |
| Zr-95 | < 30 | < 47 |
| Ru-103 | < 18 | < 29 |
| Ru-106 | < 137 | < 246 |
| I-131 | < 24 | < 43 |
| Cs-134 | < 19 | < 36 |
| Cs-137 | < 18 | < 29 |
| Ba-140 | < 73 | < 142 |
| La-140 | < 13 | < 34 |
| Ce-141 | < 23 | < 51 |
| Ce-144 | < 105 | < 231 |
| Ra-226 | < 329 | < 844 |
| Ac-228 | < 80 | < 158 |
| Th-228 | < 35 | < 69 |

* Control Location

**INDIAN POINT ENERGY CENTER**

TABLE B-16

RADIONUCLIDES IN FISH / INVERTEBRATES - 2021

pCi/kg wet ± 2 Sigma

| | Downstream 107 | | | | | |
|---|---|---|---|---|---|---|
| DATE | 06/01/21 Striped Bass | 06/01/21 Sunfish | 06/01/21 Perch | 06/01/21 Catfish | 06/01/21 Eel | 06/16/21 Blue Crab |
| RADIOCHEMICAL | | | | | | |
| Ni-63 | < 63 | < 56 | < 80 | < 87 | < 83 | < 80 |
| Sr-90 | < 5 | < 5 | < 4 | < 4 | < 4 | < 5 |
| GAMMA | | | | | | |
| Be-7 | < 420 | < 353 | < 503 | < 487 | < 419 | < 400 |
| K-40 | 2505 ± 959 | 2209 ± 707 | 2424 ± 775 | 2426 ± 911 | 2605 ± 895 | 2713 ± 717 |
| Mn-54 | < 59 | < 49 | < 44 | < 47 | < 52 | < 61 |
| Co-58 | < 53 | < 46 | < 54 | < 53 | < 38 | < 58 |
| Fe-59 | < 114 | < 86 | < 139 | < 120 | < 112 | < 87 |
| Co-60 | < 76 | < 51 | < 57 | < 57 | < 58 | < 54 |
| Zn-65 | < 59 | < 83 | < 94 | < 145 | < 63 | < 106 |
| Nb-95 | < 52 | < 35 | < 64 | < 58 | < 47 | < 52 |
| Zr-95 | < 75 | < 103 | < 129 | < 117 | < 84 | < 89 |
| Ru-103 | < 37 | < 38 | < 67 | < 52 | < 48 | < 52 |
| Ru-106 | < 465 | < 376 | < 356 | < 537 | < 366 | < 459 |
| I-131 | < 86 | < 69 | < 93 | < 96 | < 80 | < 156 |
| Cs-134 | < 45 | < 42 | < 41 | < 60 | < 55 | < 46 |
| Cs-137 | < 46 | < 41 | < 52 | < 54 | < 51 | < 44 |
| Ba-140 | < 243 | < 226 | < 252 | < 247 | < 217 | < 348 |
| La-140 | < 72 | < 68 | < 104 | < 59 | < 89 | < 136 |
| Ce-141 | < 55 | < 73 | < 64 | < 77 | < 67 | < 77 |
| Ce-144 | < 248 | < 263 | < 245 | < 256 | < 221 | < 239 |
| Ra-226 | < 875 | < 1125 | < 1035 | < 1186 | < 949 | < 896 |
| Th-228 | < 89 | < 89 | < 91 | < 92 | < 89 | < 73 |

**INDIAN POINT ENERGY CENTER**

TABLE B-16

RADIONUCLIDES IN FISH / INVERTEBRATES - 2021

pCi/kg wet ± 2 Sigma

| | Downstream 107 | | | | | |
|---|---|---|---|---|---|---|
| DATE | 08/23/21 Sunfish | 08/26/21 Eel | 09/01/21 Catfish | 09/01/21 Perch | 09/08/21 Blue Crab | 09/08/21 Stripped Bass |
| RADIOCHEMICAL | | | | | | |
| Ni-63 | < 82 | < 38 | < 70 | < 89 | < 96 | (a) |
| Sr-90 | < 4 | < 4 | < 4 | < 5 | < 4 | |
| GAMMA | | | | | | |
| Be-7 | < 472 | < 511 | < 443 | < 743 | < 343 | |
| K-40 | 3251 ± 988 | 1970 ± 797 | 1466 ± 617 | 3169 ± 1087 | 2193 ± 936 | |
| Mn-54 | < 75 | < 60 | < 70 | < 86 | < 50 | |
| Co-58 | < 52 | < 61 | < 66 | < 90 | < 44 | |
| Fe-59 | < 118 | < 109 | < 134 | < 138 | < 110 | |
| Co-60 | < 73 | < 68 | < 51 | < 77 | < 59 | |
| Zn-65 | < 186 | < 114 | < 143 | < 180 | < 106 | |
| Nb-95 | < 71 | < 61 | < 67 | < 106 | < 51 | |
| Zr-95 | < 84 | < 122 | < 85 | < 157 | < 65 | |
| Ru-103 | < 65 | < 53 | < 59 | < 74 | < 43 | |
| Ru-106 | < 480 | < 456 | < 515 | < 691 | < 480 | |
| I-131 | < 167 | < 103 | < 208 | < 260 | < 103 | |
| Cs-134 | < 54 | < 76 | < 65 | < 85 | < 54 | |
| Cs-137 | < 76 | < 56 | < 66 | < 81 | < 50 | |
| Ba-140 | < 294 | < 290 | < 352 | < 654 | < 232 | |
| La-140 | < 114 | < 99 | < 104 | < 173 | < 86 | |
| Ce-141 | < 80 | < 71 | < 92 | < 134 | < 61 | |
| Ce-144 | < 338 | < 271 | < 307 | < 464 | < 225 | |
| Ra-226 | < 1393 | < 1097 | < 1016 | < 1592 | < 976 | |
| Th-228 | < 89 | < 78 | < 77 | < 144 | < 80 | |

(a) Refer to deviation table B-1b

**INDIAN POINT ENERGY CENTER**

TABLE B-16

RADIONUCLIDES IN FISH / INVERTEBRATES - 2021

pCi/kg wet ± 2 Sigma

| | Roseton 23* | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| DATE | 06/01/21 Striped Bass | 06/01/21 Sunfish | 06/01/21 Catfish | 06/01/21 Perch | 06/01/21 Eel | 06/01/21 Blue Crabs |
| RADIOCHEMICAL | | | | | | |
| Ni-63 | < 98 | < 63 | < 74 | < 89 | < 93 | (a) |
| Sr-90 | < 4 | < 4 | < 4 | < 4 | < 4 | |
| GAMMA | | | | | | |
| Be-7 | < 532 | < 410 | < 577 | < 512 | < 550 | |
| K-40 | 2203 ± 1252 | 2570 ± 871 | 4154 ± 973 | 2635 ± 1035 | 3037 ± 902 | |
| Mn-54 | < 76 | < 60 | < 72 | < 56 | < 61 | |
| Co-58 | < 84 | < 55 | < 67 | < 59 | < 63 | |
| Fe-59 | < 136 | < 73 | < 131 | < 139 | < 156 | |
| Co-60 | < 76 | < 61 | < 70 | < 64 | < 52 | |
| Zn-65 | < 135 | < 105 | < 146 | < 112 | < 137 | |
| Nb-95 | < 76 | < 55 | < 72 | < 65 | < 70 | |
| Zr-95 | < 119 | < 96 | < 125 | < 146 | < 122 | |
| Ru-103 | < 82 | < 50 | < 78 | < 53 | < 61 | |
| Ru-106 | < 650 | < 497 | < 644 | < 419 | < 671 | |
| I-131 | < 138 | < 64 | < 116 | < 107 | < 117 | |
| Cs-134 | < 84 | < 46 | < 84 | < 66 | < 79 | |
| Cs-137 | < 72 | < 51 | < 73 | < 52 | < 64 | |
| Ba-140 | < 361 | < 310 | < 378 | < 264 | < 323 | |
| La-140 | < 131 | < 109 | < 104 | < 109 | < 102 | |
| Ce-141 | < 97 | < 63 | < 96 | < 66 | < 97 | |
| Ce-144 | < 418 | < 212 | < 373 | < 234 | < 361 | |
| Ra-226 | < 1523 | < 1017 | < 1502 | < 1032 | < 1503 | |
| Th-228 | < 120 | < 86 | < 127 | < 86 | < 122 | |

* Control Location

(a) Refer to deviation table B-1b

**INDIAN POINT ENERGY CENTER**

TABLE B-16

RADIONUCLIDES IN FISH / INVERTEBRATES - 2021

pCi/kg wet ± 2 Sigma

| | Roseton 23* | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| DATE | 08/23/21 Sunfish | 08/26/21 Eel | 09/01/21 Catfish | 09/01/21 Perch | 09/08/21 Blue Crab | 09/15/21 Striped Bass |
| RADIOCHEMICAL | | | | | | |
| Ni-63 | < 84 | < 49 | < 65 | < 99 | < 94 | < 91 |
| Sr-90 | < 4 | < 4 | < 4 | < 5 | < 4 | < 5 |
| GAMMA | | | | | | |
| Be-7 | < 589 | < 641 | < 478 | < 436 | < 592 | < 502 |
| K-40 | 2235 ± 937 | 1827 ± 1013 | 3072 ± 875 | 2287 ± 676 | 2780 ± 752 | 3784 ± 1106 |
| Mn-54 | < 73 | < 82 | < 50 | < 48 | < 62 | < 57 |
| Co-58 | < 60 | < 73 | < 51 | < 44 | < 56 | < 60 |
| Fe-59 | < 105 | < 120 | < 133 | < 94 | < 141 | < 132 |
| Co-60 | < 69 | < 74 | < 29 | < 47 | < 68 | < 67 |
| Zn-65 | < 147 | < 191 | < 102 | < 108 | < 108 | < 110 |
| Nb-95 | < 57 | < 77 | < 58 | < 45 | < 47 | < 74 |
| Zr-95 | < 108 | < 161 | < 93 | < 83 | < 102 | < 104 |
| Ru-103 | < 54 | < 70 | < 71 | < 50 | < 61 | < 52 |
| Ru-106 | < 433 | < 606 | < 453 | < 326 | < 551 | < 500 |
| I-131 | < 176 | < 149 | < 169 | < 139 | < 97 | < 128 |
| Cs-134 | < 69 | < 74 | < 63 | < 39 | < 73 | < 71 |
| Cs-137 | < 55 | < 67 | < 47 | < 44 | < 57 | < 65 |
| Ba-140 | < 405 | < 344 | < 381 | < 322 | < 322 | < 404 |
| La-140 | < 139 | < 131 | < 119 | < 127 | < 117 | < 133 |
| Ce-141 | < 82 | < 108 | < 83 | < 64 | < 90 | < 96 |
| Ce-144 | < 271 | < 412 | < 244 | < 203 | < 298 | < 312 |
| Ra-226 | < 950 | < 1674 | < 1065 | < 954 | < 1438 | < 1297 |
| Th-228 | < 94 | < 138 | < 116 | < 102 | < 110 | < 89 |

* Control Location

**INDIAN POINT ENERGY CENTER**

TABLE B-16

RADIONUCLIDES IN FISH / INVERTEBRATES - 2021

pCi/kg wet ± 2 Sigma

| | Downstream 25 | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| DATE | 06/01/21 Striped Bass | 06/01/21 Perch | 06/01/21 Sunfish | 06/01/21 Catfish | 06/01/21 Eel | 06/01/21 Blue Crabs |
| RADIOCHEMICAL | | | | | | |
| Ni-63 | < 97 | < 93 | < 86 | < 71 | < 79 | (a) |
| Sr-90 | < 4 | < 4 | < 4 | < 5 | < 4 | |
| GAMMA | | | | | | |
| Be-7 | < 722 | < 483 | < 442 | < 422 | < 441 | |
| K-40 | 2253 ± 967 | 1959 ± 854 | 3044 ± 937 | 2341 ± 666 | 2903 ± 1014 | |
| Mn-54 | < 81 | < 64 | < 48 | < 52 | < 52 | |
| Co-58 | < 77 | < 50 | < 64 | < 41 | < 42 | |
| Fe-59 | < 133 | < 116 | < 141 | < 110 | < 124 | |
| Co-60 | < 71 | < 46 | < 68 | < 45 | < 62 | |
| Zn-65 | < 188 | < 108 | < 84 | < 104 | < 156 | |
| Nb-95 | < 80 | < 68 | < 70 | < 52 | < 49 | |
| Zr-95 | < 118 | < 109 | < 105 | < 68 | < 110 | |
| Ru-103 | < 64 | < 59 | < 54 | < 53 | < 47 | |
| Ru-106 | < 852 | < 458 | < 467 | < 476 | < 504 | |
| I-131 | < 140 | < 85 | < 88 | < 79 | < 95 | |
| Cs-134 | < 80 | < 43 | < 73 | < 47 | < 65 | |
| Cs-137 | < 88 | < 55 | < 64 | < 44 | < 56 | |
| Ba-140 | < 443 | < 329 | < 275 | < 229 | < 270 | |
| La-140 | < 87 | < 88 | < 68 | < 64 | < 76 | |
| Ce-141 | < 118 | < 68 | < 74 | < 51 | < 68 | |
| Ce-144 | < 450 | < 252 | < 256 | < 211 | < 248 | |
| Ra-226 | < 1555 | < 897 | < 1212 | < 927 | < 1084 | |
| Th-228 | < 133 | < 85 | < 86 | < 67 | < 86 | |

(a) Refer to deviation table B-1b

**INDIAN POINT ENERGY CENTER**

TABLE B-16

RADIONUCLIDES IN FISH / INVERTEBRATES - 2021

pCi/kg wet ± 2 Sigma

| | Downstream 25 | | | | | |
|---|---|---|---|---|---|---|
| DATE | 08/23/21 Sunfish | 08/26/21 Eel | 09/01/21 Catfish | 09/01/21 Perch | 09/08/21 Blue Crab | 09/15/21 Striped Bass |
| RADIOCHEMICAL | | | | | | |
| Ni-63 | < 97 | < 66 | < 57 | < 98 | < 86 | < 68 |
| Sr-90 | < 4 | < 4 | < 4 | < 5 | < 4 | (a) |
| GAMMA | | | | | | |
| Be-7 | < 643 | < 490 | < 585 | < 460 | < 424 | < 810 |
| K-40 | 2691 ± 1054 | 2593 ± 1005 | 2116 ± 988 | 1688 ± 591 | 1185 ± 741 | 3573 ± 1298 |
| Mn-54 | < 62 | < 75 | < 91 | < 55 | < 48 | < 91 |
| Co-58 | < 82 | < 28 | < 51 | < 46 | < 45 | < 90 |
| Fe-59 | < 156 | < 116 | < 151 | < 99 | < 101 | < 248 |
| Co-60 | < 84 | < 49 | < 51 | < 47 | < 61 | < 122 |
| Zn-65 | < 139 | < 148 | < 149 | < 97 | < 120 | < 205 |
| Nb-95 | < 80 | < 72 | < 55 | < 58 | < 47 | < 115 |
| Zr-95 | < 142 | < 97 | < 151 | < 98 | < 68 | < 158 |
| Ru-103 | < 85 | < 63 | < 75 | < 51 | < 36 | < 108 |
| Ru-106 | < 682 | < 513 | < 531 | < 467 | < 380 | < 809 |
| I-131 | < 249 | < 150 | < 266 | < 190 | < 78 | < 235 |
| Cs-134 | < 74 | < 51 | < 65 | < 48 | < 64 | < 101 |
| Cs-137 | < 82 | < 48 | < 58 | < 45 | < 43 | < 89 |
| Ba-140 | < 492 | < 398 | < 556 | < 371 | < 209 | < 541 |
| La-140 | < 125 | < 99 | < 207 | < 63 | < 85 | < 260 |
| Ce-141 | < 115 | < 87 | < 105 | < 86 | < 55 | < 145 |
| Ce-144 | < 416 | < 276 | < 339 | < 263 | < 223 | < 454 |
| Ra-226 | < 1602 | < 1075 | < 1352 | < 1081 | < 851 | < 2023 |
| Th-228 | < 135 | < 98 | < 104 | < 79 | < 85 | 212 ± 119 |

(a) Refer to deviation table B1-b

## TABLE B-17

### LAND USE CENSUS - RESIDENCE AND MILCH ANIMAL RESULTS 2021

The 2021 land use census indicated there were no new residences that were closer in proximity to IPEC.

IPEC maintains a complete nearest residence survey with updated distances.

No milch animals were observed during this reporting period within the 5-mile zone. There are no animals producing milk for human consumption within five miles of Indian Point.

# TABLE B-18
# LAND USE CENSUS
# 2021

## UNRESTRICTED AREA BOUNDARY AND NEAREST RESIDENCES

| Sector | Compass Point | Distance to site Boundary from Unit 2 Plant Vent (meters) | Distance to site Boundary from Unit 3 Plant Vent (meters) | Distance to nearest resident, from Unit 1 superheater (meters) | Address of nearest resident, Last Census |
|---|---|---|---|---|---|
| 1 | N | RIVER | RIVER | 1788 | 41 River Road Tomkins Cove |
| 2 | NNE | RIVER | RIVER | 3111 | Chateau Rive Apts. John St. Peekskill |
| 3 | NE | 550 | 636 | 1907 | 211 Viewpoint Terrace, Peekskill |
| 4 | ENE | 600 | 775 | 1478 | 1018 Lower South St. Peekskill |
| 5 | E | 662 | 785 | 1371 | 1103 Lower South St. Peekskill |
| 6 | ESE | 569 | 622 | 715 | 461 Broadway Buchanan |
| 7 | SE | 553 | 564 | 1168 | 223 First St. Buchanan |
| 8 | SSE | 569 | 551 | 1240 | 5 Pheasant's Run Buchanan |
| 9 | S | 700 | 566 | 1133 | 320 Broadway Verplanck |
| 10 | SSW | 755 | 480 | 1574 | 240 Eleventh St. Verplanck |
| 11 | SW | 544 | 350 | 3016 | 8 Spring St. Tomkins Cove |
| 12 | WSW | RIVER | RIVER | 2170 | 9 West Shore Dr. Tomkins Cove |
| 13 | W | RIVER | RIVER | 1919 | 712 Rt. 9W Tomkins Cove |
| 14 | WNW | RIVER | RIVER | 1752 | 770 Rt. 9W Tomkins Cove |
| 15 | NW | RIVER | RIVER | 1693 | 807 Rt. 9W Tomkins Cove |
| 16 | NNW | RIVER | RIVER | 1609 | 4 River Rd. Tomkins Cove |

# SECTION 6.0

## HISTORICAL TRENDS

## HISTORICAL TRENDS

The past ten years of historical data for various radionuclides and media are presented both in tabular form and graphical form to facilitate the comparison of 2021 data with historical values. Although other samples were taken and analyzed, values were only tabulated and plotted where positive indications were present.

Averaging the positive values in these tables can result in a biased high value, especially, when the radionuclide is detected in only one or two quarters for the year.

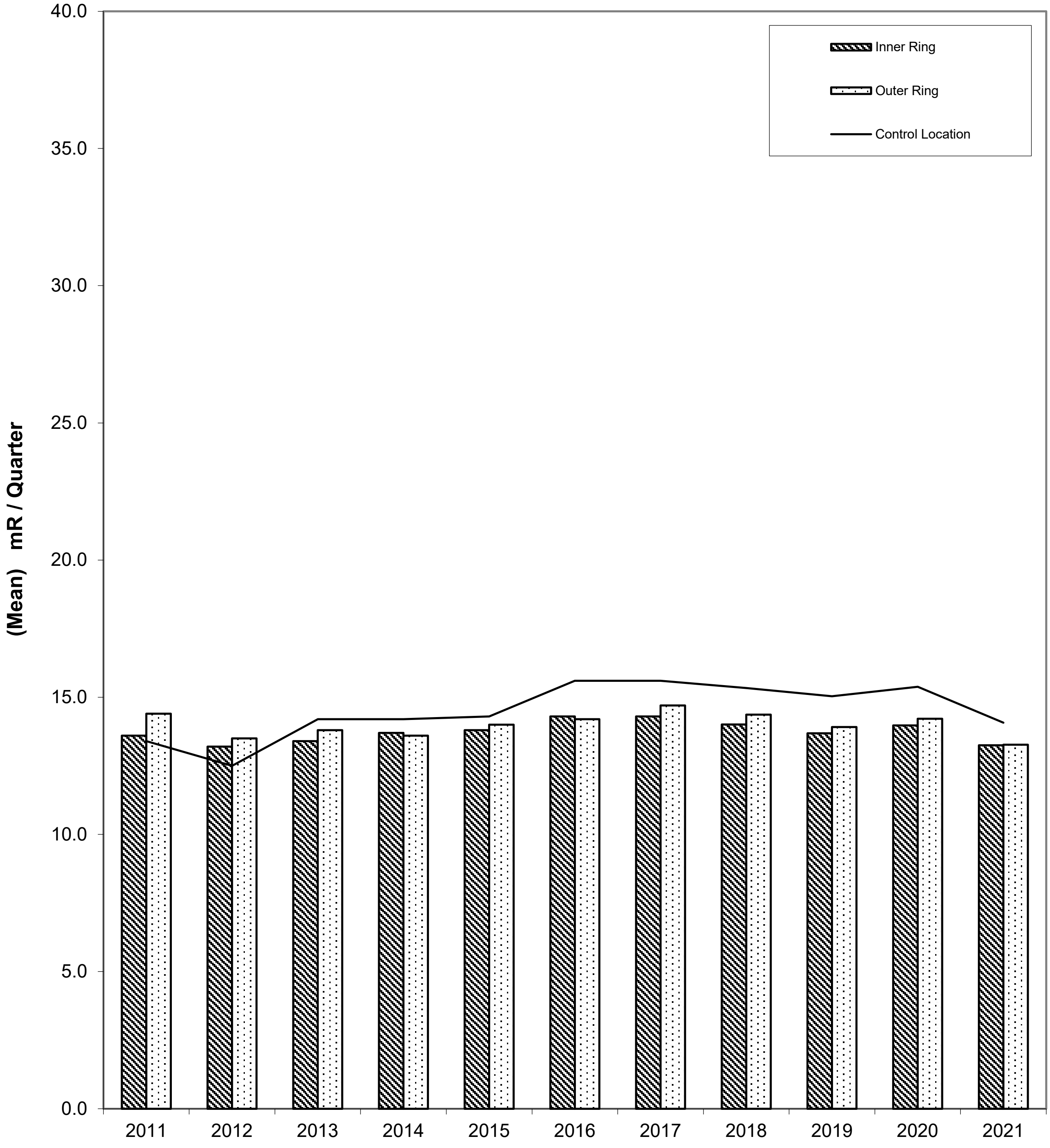
# TABLE C-1
# DIRECT RADIATION, ANNUAL SUMMARY
# 2011-2021

| Average Quarterly Dose (mR/Quarter) | | | |
|---|---|---|---|
| Year | Inner Ring | Outer Ring | Control Location |
| 2011 | 13.6 | 14.4 | 13.4 |
| 2012 | 13.2 | 13.5 | 12.5 |
| 2013 | 13.4 | 13.8 | 14.2 |
| 2014 | 13.7 | 13.6 | 14.2 |
| 2015 | 13.8 | 14.0 | 14.3 |
| 2016 | 14.3 | 14.2 | 15.6 |
| 2017 | 14.3 | 14.7 | 15.6 |
| 2018 | 14.0 | 14.4 | 15.3 |
| 2019 | 13.7 | 13.9 | 15.0 |
| 2020 | 14.0 | 14.2 | 15.4 |
| 2021 | 13.2 | 13.3 | 14.1 |

| | | | |
|---|---|---|---|
| Historical Average 2011-2020 | 13.8 | 14.1 | 14.6 |

# Figure C-1

## DIRECT RADIATION, ANNUAL SUMMARY 2011-2021



# TABLE C-2
# RADIONUCLIDES IN AIR
# 2011-2021
# (pCi/m$^3$)

| | Gross Beta | | Cs-137 | |
|---|---|---|---|---|
| **Year** | **All Indicator Locations** | **Control Location** | **All Indicator Locations** | **Control Location** |
| 2011 | 0.014 | 0.014 | < $L_c$ | < $L_c$ |
| 2012 | 0.014 | 0.014 | < $L_c$ | < $L_c$ |
| 2013 | 0.014 | 0.014 | < $L_c$ | < $L_c$ |
| 2014 | 0.013 | 0.013 | < $L_c$ | < $L_c$ |
| 2015 | 0.016 | 0.015 | < $L_c$ | < $L_c$ |
| 2016 | 0.015 | 0.015 | < $L_c$ | < $L_c$ |
| 2017 | 0.013 | 0.012 | < $L_c$ | < $L_c$ |
| 2018 | 0.013 | 0.012 | < $L_c$ | < $L_c$ |
| 2019 | 0.012 | 0.012 | < $L_c$ | < $L_c$ |
| 2020 | 0.013 | 0.013 | < $L_c$ | < $L_c$ |
| 2021 | 0.014 | 0.014 | < $L_c$ | < $L_c$ |

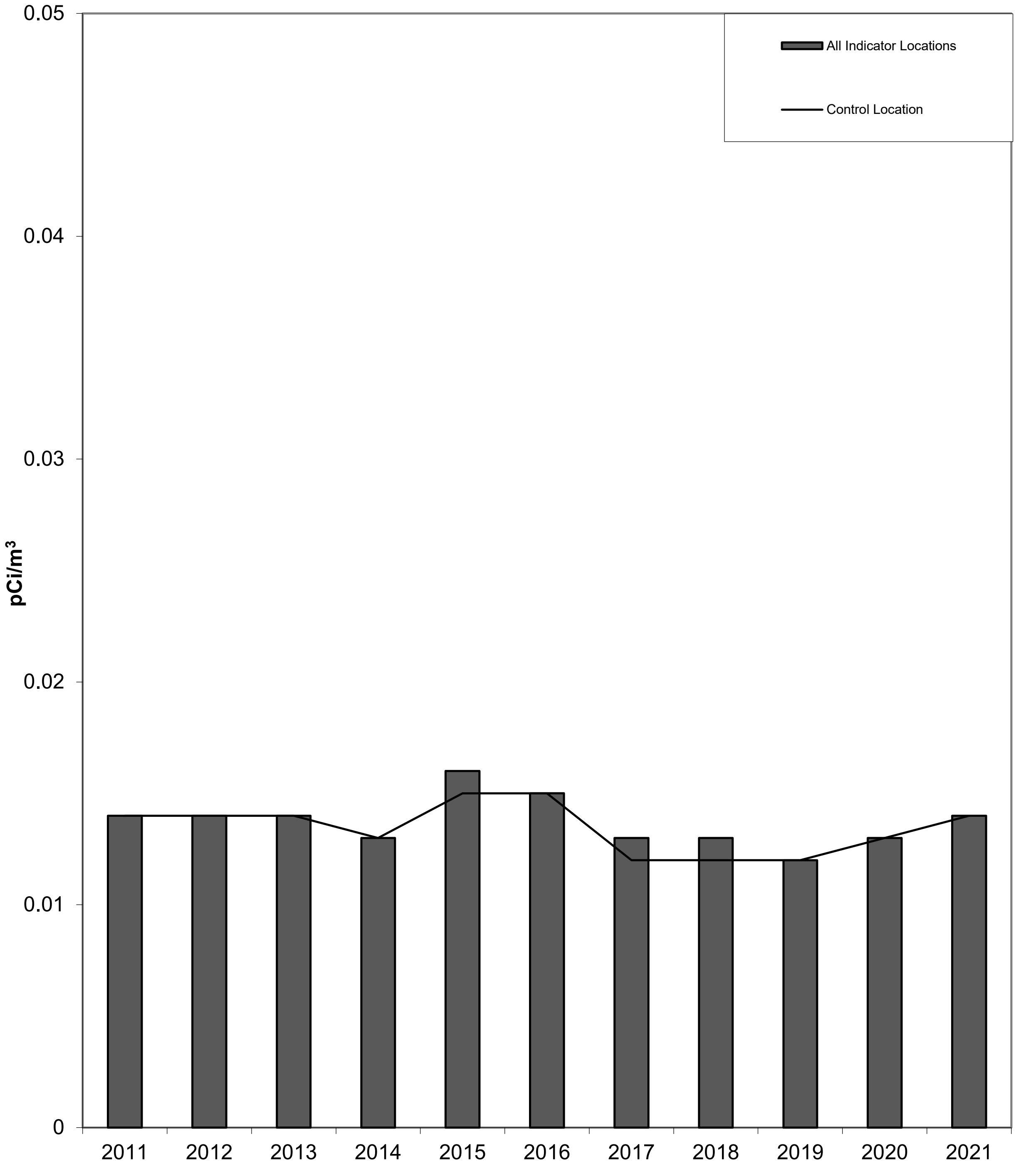
| **Historical Average 2011-2020** | 0.01 | 0.01 | < $L_c$ | < $L_c$ |
|---|---|---|---|---|

Critical Level ($L_c$) is less than the ODCM required LLD.

<$L_c$ indicates no positive values above sample critical level.

## Figure C-2

## RADIONUCLIDES IN AIR - GROSS BETA 2011-2021



# TABLE C-3
# RADIONUCLIDES IN HUDSON RIVER WATER-TRITIUM
# 2011-2021
# (pCi/L)

| | Tritium (H-3) | | Cs-137 | |
| --- | --- | --- | --- | --- |
| **Year** | **Inlet** | **Discharge** | **Inlet** | **Discharge** |
| 2011 | < $L_c$ | 661 | < $L_c$ | < $L_c$ |
| 2012 | < $L_c$ | 539 | < $L_c$ | < $L_c$ |
| 2013 | 241 | 462 | < $L_c$ | < $L_c$ |
| 2014 | 224 | 253 | < $L_c$ | < $L_c$ |
| 2015 | 188 | 341 | < $L_c$ | < $L_c$ |
| 2016 | < $L_c$ | 415 | < $L_c$ | < $L_c$ |
| 2017 | < $L_c$ | 299 | < $L_c$ | < $L_c$ |
| 2018 | 236 | 266 | < $L_c$ | < $L_c$ |
| 2019 | 273 | 295 | < $L_c$ | < $L_c$ |
| 2020 (b) | < $L_c$ | 288 | < $L_c$ | < $L_c$ |
| 2021 | < $L_c$ | 380 | < $L_c$ | < $L_c$ |
| **Historical Average 2011-2020** | 232 | 382 | < $L_c$ | < $L_c$ |

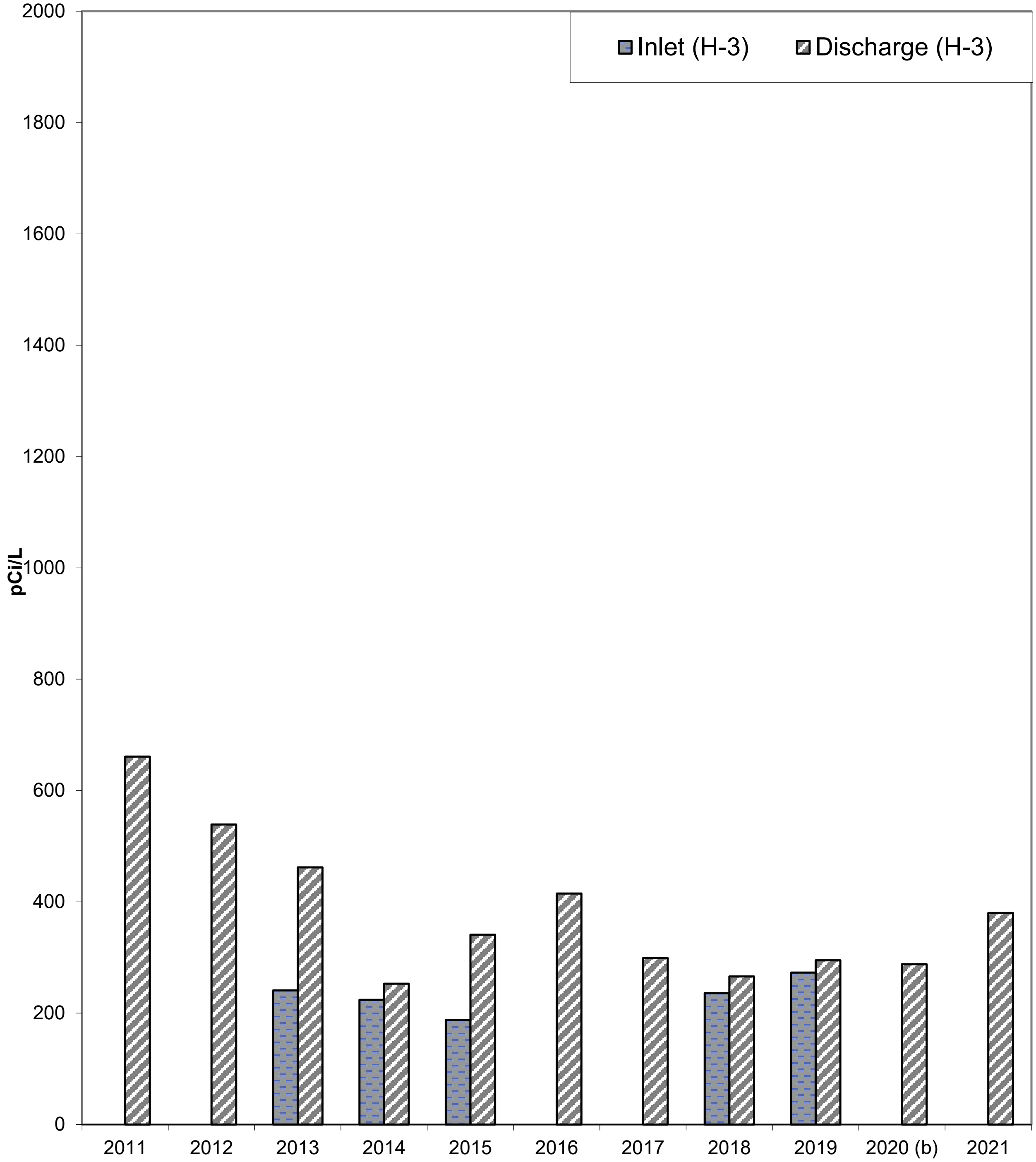
Critical Level ($L_c$) is less than the ODCM required LLD.

<$L_c$ indicates no positive values above sample critical level.

(b) Refer REMP changes table B-1c

# Figure C-3

## RADIONUCLIDES IN HUDSON RIVER WATER - TRITIUM 2011-2021



# TABLE C-4
# RADIONUCLIDES IN DRINKING WATER
# 2011-2021
# (pCi/L)

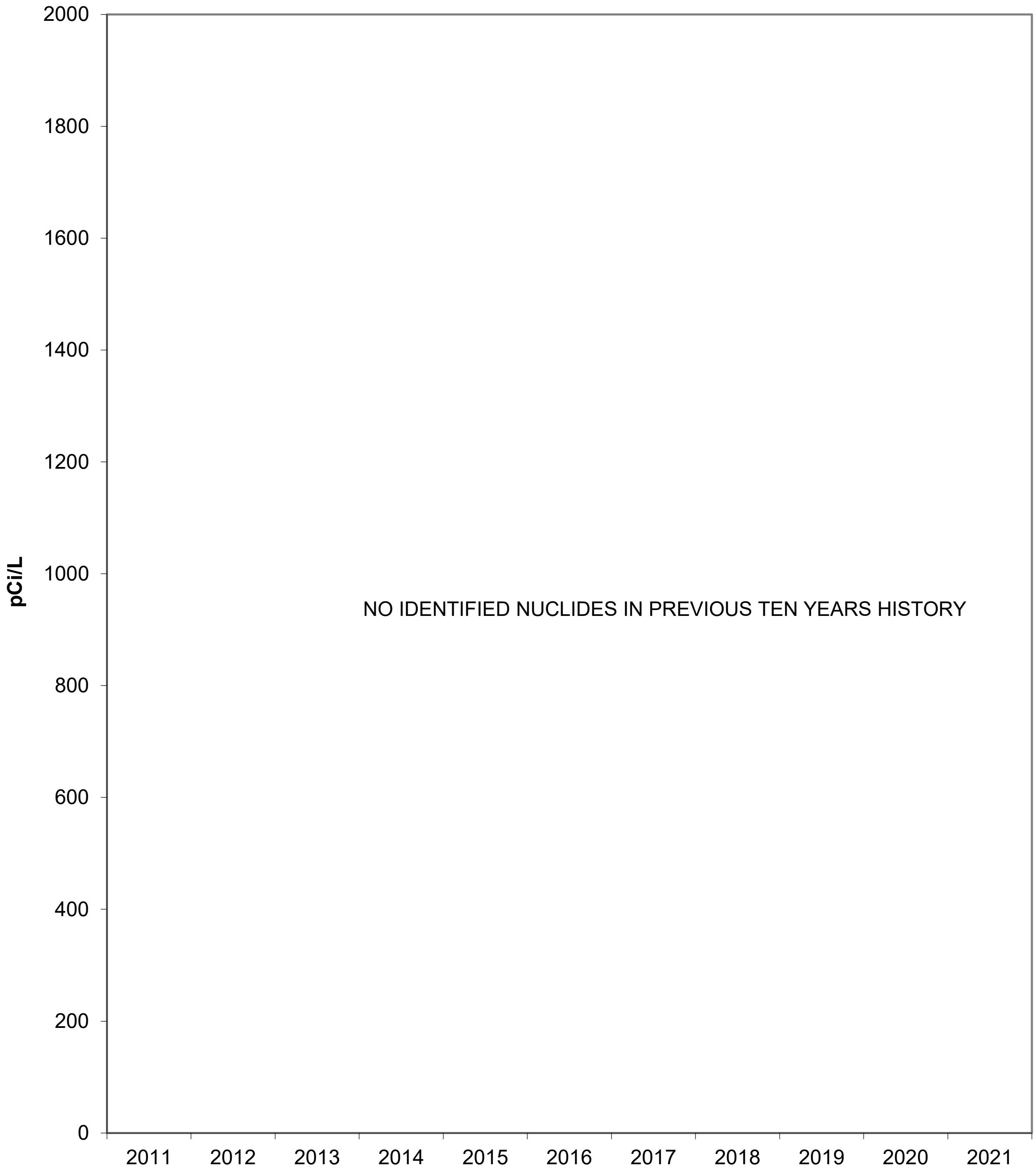
| Year | Tritium (H-3) | Cs-137 |
| --- | --- | --- |
| 2011 | < $L_c$ | < $L_c$ |
| 2012 | < $L_c$ | < $L_c$ |
| 2013 | < $L_c$ | < $L_c$ |
| 2014 | < $L_c$ | < $L_c$ |
| 2015 | < $L_c$ | < $L_c$ |
| 2016 | < $L_c$ | < $L_c$ |
| 2017 | < $L_c$ | < $L_c$ |
| 2018 | < $L_c$ | < $L_c$ |
| 2019 | < $L_c$ | < $L_c$ |
| 2020 | < $L_c$ | < $L_c$ |
| 2021 | < $L_c$ | < $L_c$ |
| **Historical Average 2011-2020** | < $L_C$ | < $L_C$ |

Critical Level ($L_c$) is less than the ODCM required LLD.

<$L_c$ indicates no positive values above sample critical level.

# Figure C-4

## RADIONUCLIDES IN DRINKING WATER 2011-2021



# TABLE C-5
# RADIONUCLIDES IN SHORELINE SOIL
# 2011-2021
# (pCi/Kg, dry)

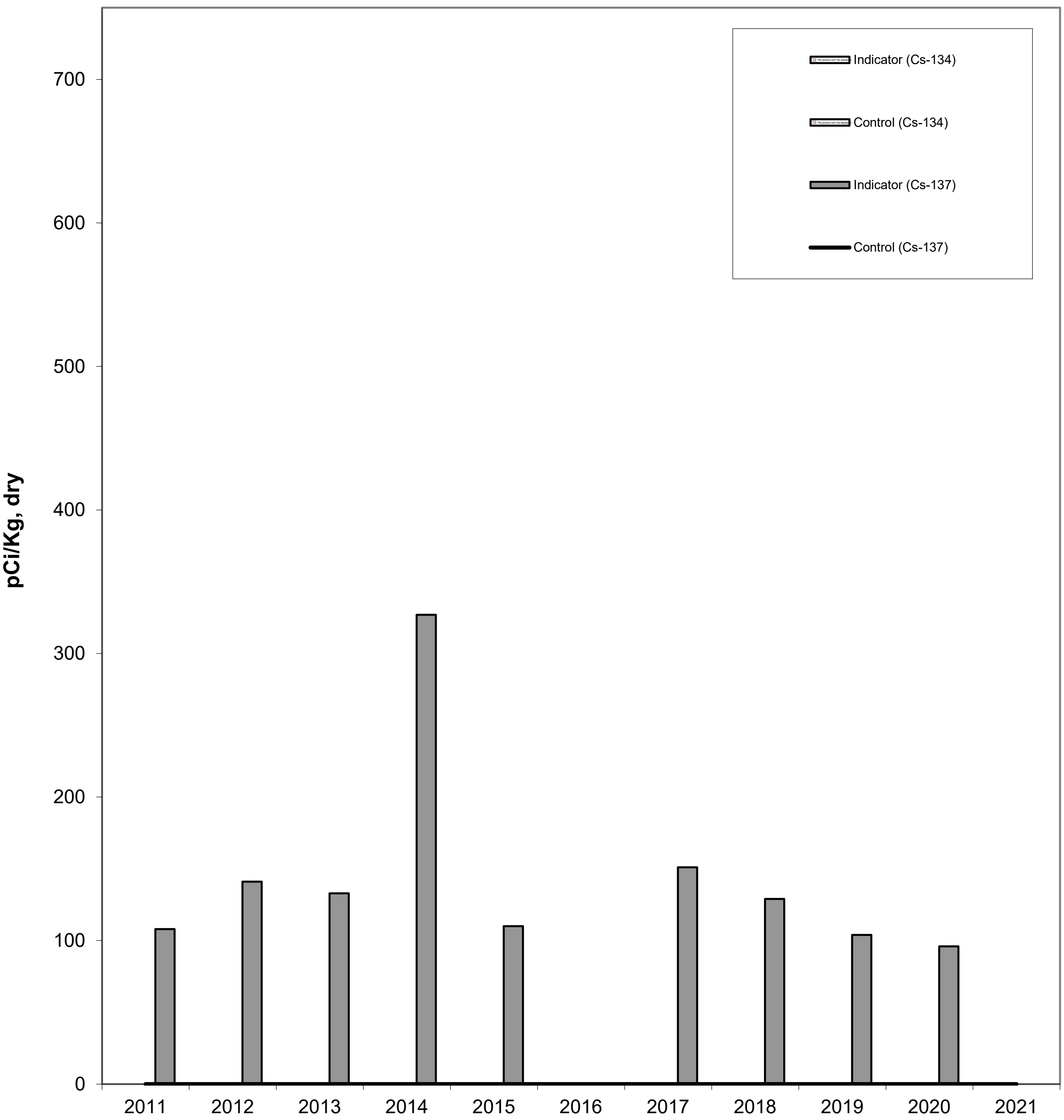
| | Cs-134 | | Cs-137 | |
|---|---|---|---|---|
| **Year** | **Indicator** | **Control** | **Indicator** | **Control** |
| 2011 | $< L_c$ | $< L_c$ | 108 | $< L_c$ |
| 2012 | $< L_c$ | $< L_c$ | 141 | $< L_c$ |
| 2013 | $< L_c$ | $< L_c$ | 133 | $< L_c$ |
| 2014 | $< L_c$ | $< L_c$ | 327 | $< L_c$ |
| 2015 | $< L_c$ | $< L_c$ | 110 | $< L_c$ |
| 2016 | $< L_c$ | $< L_c$ | $< L_c$ | $< L_c$ |
| 2017 | $< L_c$ | $< L_c$ | 151 | $< L_c$ |
| 2018 | $< L_c$ | $< L_c$ | 129 | $< L_c$ |
| 2019 | $< L_c$ | $< L_c$ | 104 | $< L_c$ |
| 2020 | $< L_c$ | $< L_c$ | 96 | $< L_c$ |
| 2021 | $< L_c$ | $< L_c$ | $< L_c$ | $< L_c$ |
| **Historical Average 2011-2020** | $< L_c$ | $< L_c$ | 144 | $< L_c$ |

Critical Level ($L_c$) is less than the ODCM required LLD.

$<L_c$ indicates no positive values above sample critical level.

# Figure C-5

## RADIONUCLIDES IN SHORELINE SOIL 2011-2021



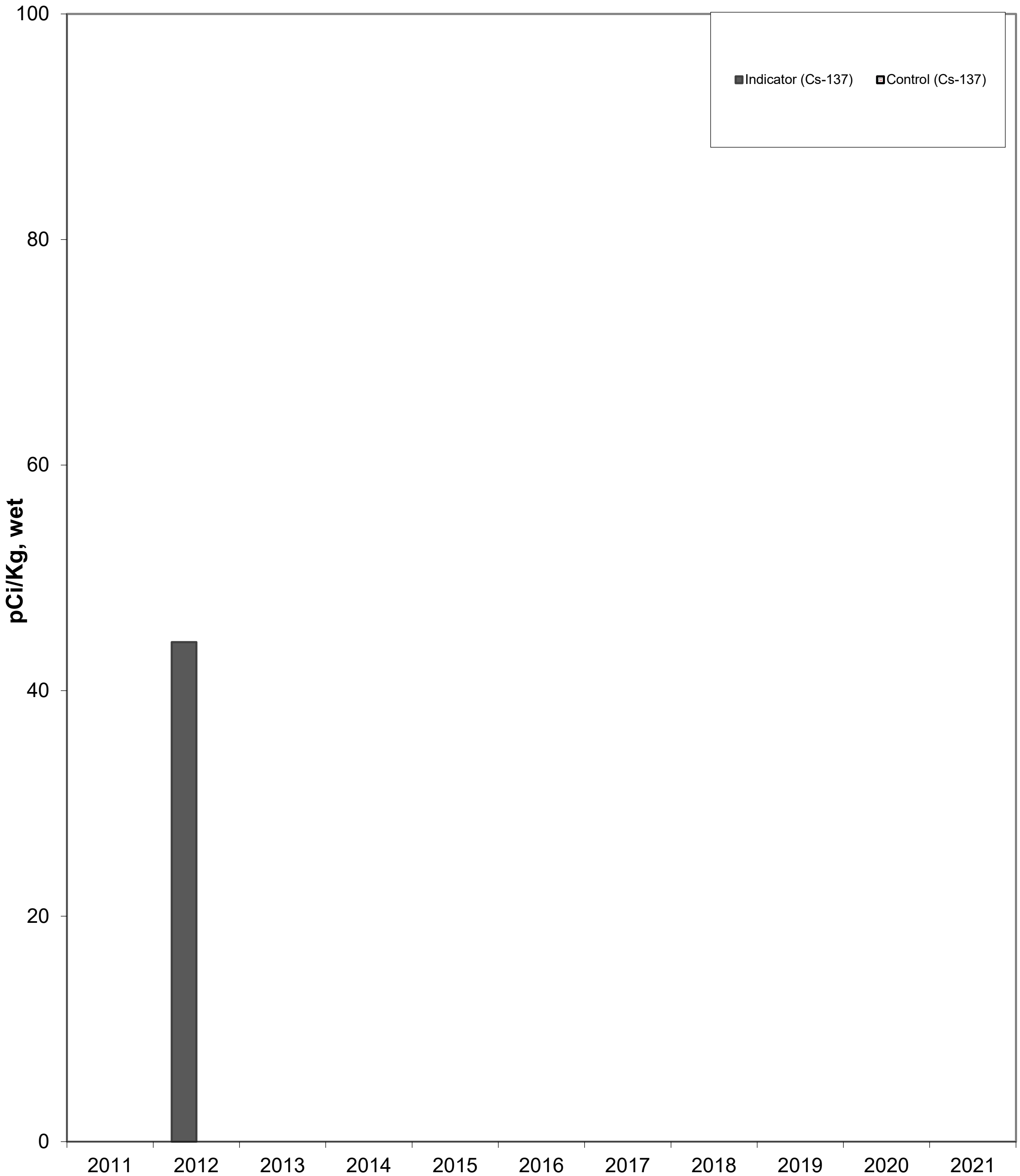
# TABLE C-6
# RADIONUCLIDES IN BROAD LEAF VEGETATION
# 2011-2021
# (pCi/Kg, wet)

| | Cs-137 | |
|---|---|---|
| **Year** | **Indicator** | **Control** |
| 2011 | < $L_c$ | < $L_c$ |
| 2012 | 44 | < $L_c$ |
| 2013 | < $L_c$ | < $L_c$ |
| 2014 | < $L_c$ | < $L_c$ |
| 2015 | < $L_c$ | < $L_c$ |
| 2016 | < $L_c$ | < $L_c$ |
| 2017 | < $L_c$ | < $L_c$ |
| 2018 | < $L_c$ | < $L_c$ |
| 2019 | < $L_c$ | < $L_c$ |
| 2020 | < $L_c$ | < $L_c$ |
| 2021 | < $L_c$ | < $L_c$ |
| **Historical Average 2011-2020** | 44 | < $L_c$ |

Critical Level ($L_c$) is less than the ODCM required LLD.
<$L_c$ indicates no positive values above sample critical level.

## Figure C-6

## RADIONUCLIDES IN BROAD LEAF VEGETATION 2011-2021



# TABLE C-7
# RADIONUCLIDE IN FISH AND INVERTEBRATES
# 2011-2021
# (pCi/Kg, Wet)

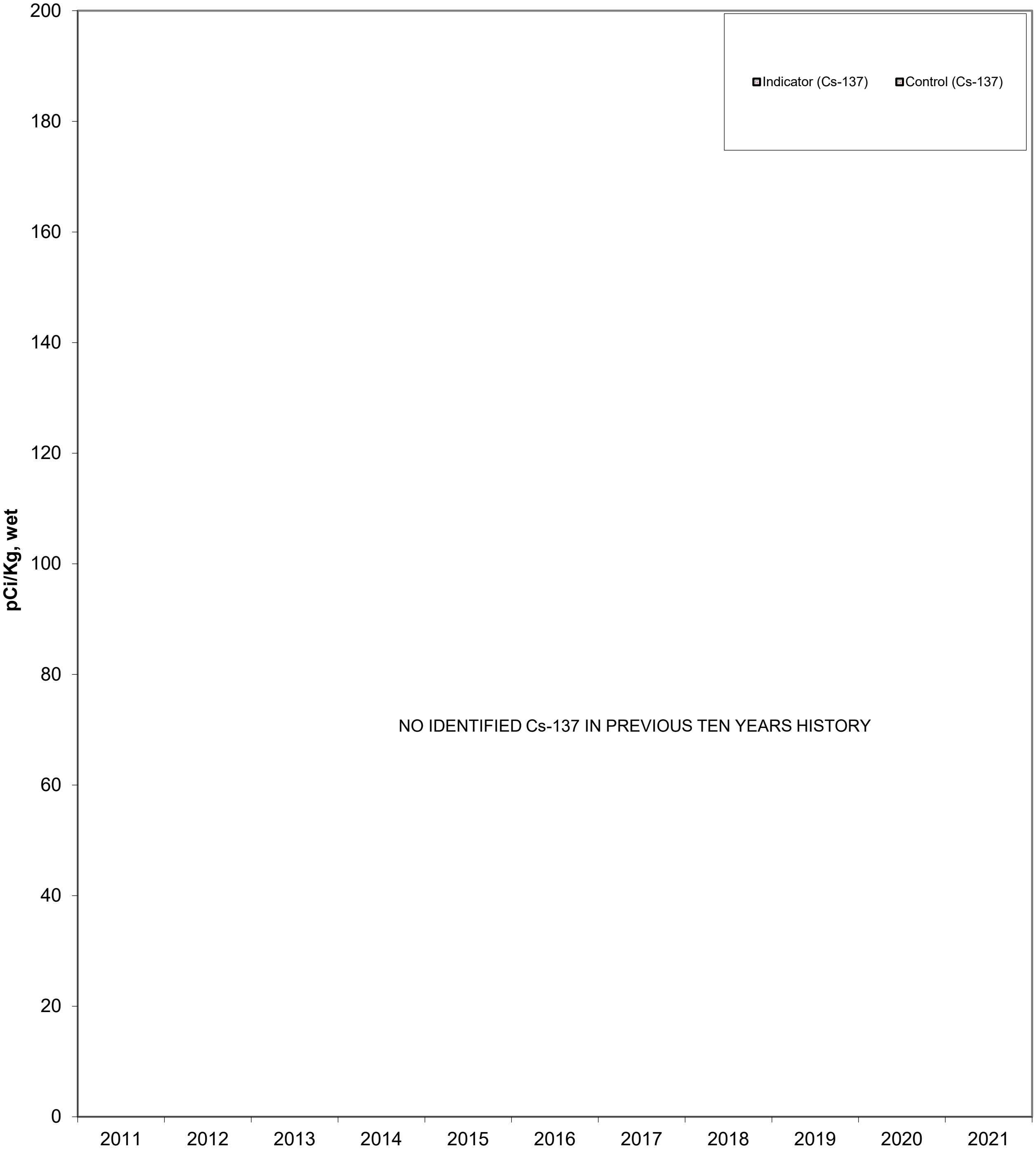
| Cs-137 | | |
|---|---|---|
| **Year** | **Indicator** | **Control** |
| 2011 | < $L_c$ | < $L_c$ |
| 2012 | < $L_c$ | < $L_c$ |
| 2013 | < $L_c$ | < $L_c$ |
| 2014 | < $L_c$ | < $L_c$ |
| 2015 | < $L_c$ | < $L_c$ |
| 2016 | < $L_c$ | < $L_c$ |
| 2017 | < $L_c$ | < $L_c$ |
| 2018 | < $L_c$ | < $L_c$ |
| 2019 | < $L_c$ | < $L_c$ |
| 2020 | < $L_c$ | < $L_c$ |
| 2021 | < $L_c$ | < $L_c$ |
| **Historical Average 2011-2020** | < $L_c$ | < $L_c$ |

Critical Level ($L_c$) is less than the ODCM required LLD.

<$L_c$ indicates no positive values above sample critical level.

# Figure C-7

## RADIONUCLIDES IN FISH AND INVERTEBRATES 2011-2021



# TABLE C-8
# RIVER WATER - Discharge Area - Tritium
# REMP vs. EFFLUENT
# (pCi/L)

| Year | REMP* | EFFLUENT ** |
|---|---|---|
| 1Q 2018 | 273 | 659 |
| 2Q 2018 | 326 | 439 |
| 3Q 2018 | <197 | 332 |
| 4Q 2018 | 199 | 418 |
| 1Q 2019 | 296 | 484 |
| 2Q 2019 | 294 | 602 |
| 3Q 2019 | <187 | 74 |
| 4Q 2019 | <181 | 7.68 |
| 1Q 2020 | 347 | 1021 |
| 2Q 2020 | <176 | 470 |
| 3Q 2020 | <177 | 188 |
| 4Q 2020 | 229 | 866 |
| 1Q 2021 | 483 | 4.95 |
| 2Q 2021 | 214 | 115 |
| 3Q 2021 | 442 | 737 |
| 4Q 2021 | <170 | 174 |
| **Four Year Average, by Quarter, 2018 - 2021** | 310 | 412 |

* Sample from mixing zone, expected to be less than average activity in the discharge canal.

** Based upon Effluent Report data, average activity in the discharge canal calculated from the total H-3 discharged divided by the total dilution volume for the quarter.

# TABLE C-9
# RADIONUCLIDES IN BOTTOM SEDIMENT
# 2011-2021
# (pCi/Kg, dry)

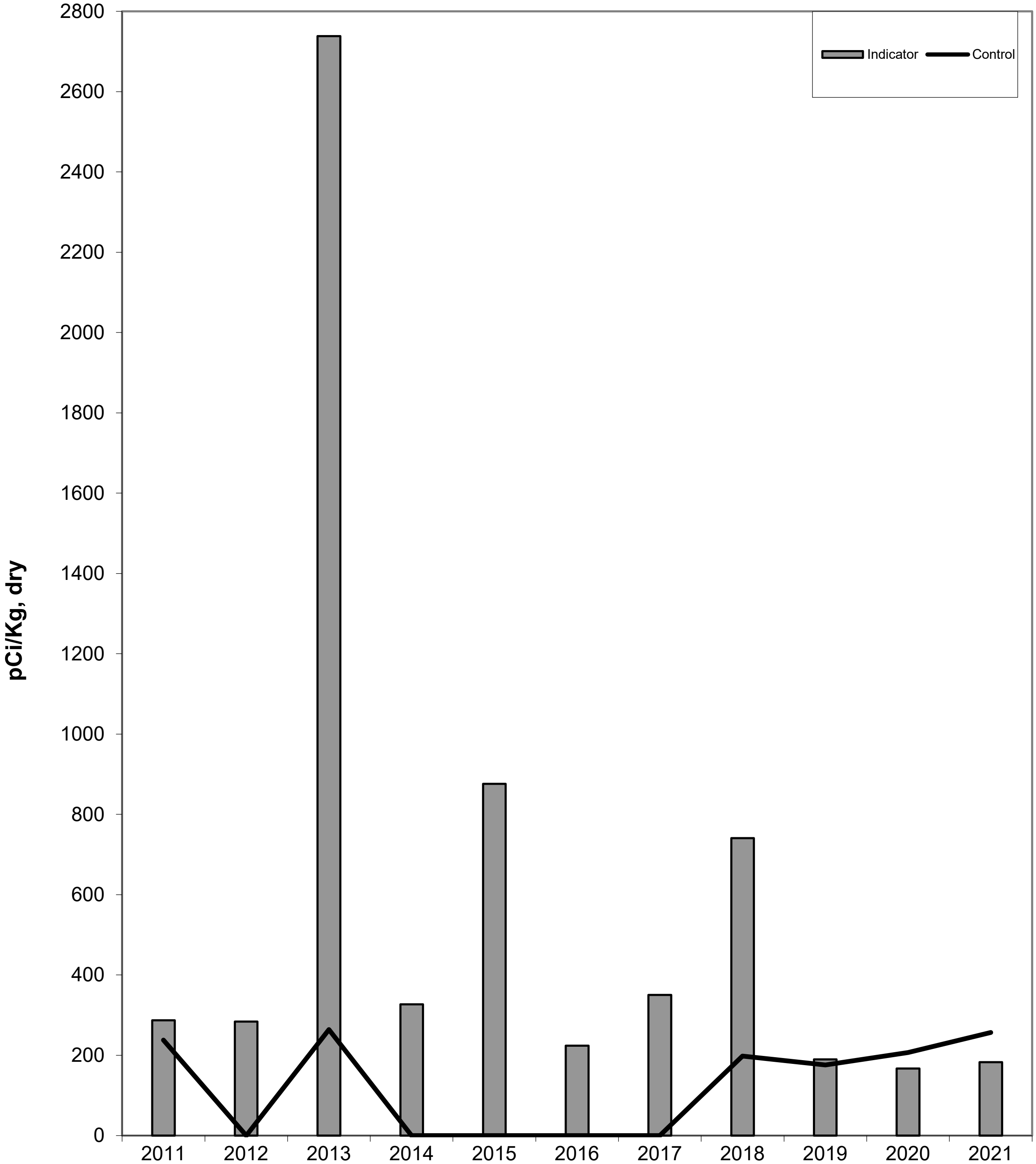
| Cs-137 | | |
|---|---|---|
| **Year** | **Indicator** | **Control** |
| 2011 | 287 | 238 |
| 2012 | 284 | < $L_c$ |
| 2013 | 2738 | 264 |
| 2014 | 327 | < $L_c$ |
| 2015 | 876 | < $L_c$ |
| 2016 | 224 | < $L_c$ |
| 2017 | 350 | < $L_c$ |
| 2018 | 741 | 198 |
| 2019 | 190 | 176 |
| 2020 | 167 | 207 |
| 2021 | 183 | 257 |
| **Historical Average 2011-2020** | 618 | 217 |

Critical Level ($L_c$) is less than the RETS required LLD.

<$L_c$ indicates no positive values above sample critical level.

## Figure C-9

## RADIONUCLIDES IN BOTTOM SEDIMENT 2011-2021



SECTION 7.0

# INTERLABORATORY COMPARISON PROGRAM

## INTERLABORATORY COMPARISON PROGRAM

This section presents the results of the interlaboratory comparison program for the Teledyne Brown Engineering Environmental Services and Environmental Dosimetry Company.

### 7.1 Program Description – Teledyne Brown Engineering Environmental Services Comparison Programs

The Teledyne Brown Engineering Environmental Services participates in several interlaboratory comparison programs. These programs include sample media for which samples are routinely collected and for which comparison samples are commercially available. Participation in these interlaboratory comparison programs ensure that independent checks on the precision and accuracy of the measurement of radioactive material in the environmental samples are performed as part of the Quality Assurance Program for environmental monitoring. To fulfill the requirement for an Interlaboratory Comparison Program, Teledyne Brown Engineering Environmental Services has engaged the following programs:

- Eckert & Ziegler Analytics Environmental Radioactivity Cross Check Program
- Department of Energy (DOE) Mixed Analyte Performance Evaluation Program (MAPEP)
- Environmental Resource Associates (ERA) Cross Check Program

These programs supply sample media as blind samples (typically spikes), which contain certified levels of radioactivity unknown to the analysis laboratory. These samples are prepared and analyzed by the Teledyne Brown Engineering Environmental Services using standard laboratory procedures. Each program issues a statistical summary report of the results. Teledyne Brown Engineering Environmental Services uses predetermined acceptance criteria methodology for evaluating its laboratory performance.

Teledyne Brown Engineering Environmental Services also analyzes laboratory blanks. The analysis of laboratory blanks provides a means to detect and measure radioactive contamination of analytical samples. The analysis of analytical blanks also provides information on the adequacy of background subtraction. Laboratory blank results are analyzed using control charts.

### 7.2 Acceptance Criteria

Each sample result is evaluated to determine the accuracy and precision of the laboratory's analysis result. The sample evaluation method is discussed below.

#### 7.2.1 Analytics Sample Results Evaluation

Samples provided by Analytics are evaluated using what is specified as the NRC method. This method is based on the calculation of the ratio of results reported by the participating laboratory (QC result) to the Vendor Laboratory Known value (reference result).

An Environmental Laboratory analytical result is evaluated using the following calculation:

The value for the error resolution is calculated.

$$\text{Error Resolution} = \frac{\text{Reference Result}}{\text{Reference Results Error (1 sigma)}}$$

Using the appropriate row under the Error Resolution column in Table D-2.1, a corresponding Ratio of Agreement interval is given for use in Tables D-3.1, D-3.2, and D-3.3

The value for the ratio is then calculated.

$$\text{Ratio of agreement} = \frac{\text{QC Result}}{\text{Reference Result}}$$

If the value falls within the agreement interval, the result is acceptable.

TABLE D-2.1 Ratio of Agreement

| ERROR RESOLUTION | RATIO OF AGREEMENT |
| --- | --- |
| < 4 | No Comparison |
| 4 to 7 | 0.5-2.0 |
| 8 to 15 | 0.6-1.66 |
| 16 to 50 | 0.75-1.33 |
| 51 to 200 | 0.8-1.25 |
| >200 | 0.85-1.18 |

This acceptance test is generally referred to as the "NRC" method. The acceptance criteria are contained in Procedure EN-CY-102. The NRC method generally results in an acceptance range of approximately ± 25% of the Known value when applied to sample results from the Eckert & Ziegler Analytics Interlaboratory Comparison Program. This method is used as the procedurally required assessment method and requires the generation of a deviation from QA/QC program report when results are unacceptable.

### 7.2.2 ERA and MAPEP Sample Result Evaluation

Both these programs supply an acceptance range for evaluating the results.

## 7.3 Program Results Summary

The Interlaboratory Comparison Program numerical results are summarized in the following tables.

**TABLE D-3.1** **Analytics Environmental Radioactivity Cross Check Program**
**Teledyne Brown Engineering Environmental Services**

| Month/Year | Identification Number | Matrix | Nuclide | Units | TBE Reported Value | Known Value [(a)] | Ratio of TBE to Analytics Result | Evaluation [(b)] |
|---|---|---|---|---|---|---|---|---|
| March 2021 | E13466 | Milk | Sr-89 | pCi/L | 84.6 | 87.1 | 0.97 | A |
| | | | Sr-90 | pCi/L | 11.5 | 12.6 | 0.91 | A |
| | E13467 | Milk | Ce-141 | pCi/L | 111 | 125 | 0.89 | A |
| | | | Co-58 | pCi/L | 123 | 128 | 0.96 | A |
| | | | Co-60 | pCi/L | 140 | 154 | 0.91 | A |
| | | | Cr-51 | pCi/L | 252 | 242 | 1.04 | A |
| | | | Cs-134 | pCi/L | 130 | 151 | 0.86 | A |
| | | | Cs-137 | pCi/L | 110 | 110 | 1.00 | A |
| | | | Fe-59 | pCi/L | 105 | 109 | 0.96 | A |
| | | | I-131 | pCi/L | 77.6 | 86.9 | 0.89 | A |
| | | | Mn-54 | pCi/L | 111 | 112 | 0.99 | A |
| | | | Zn-65 | pCi/L | 200 | 211 | 0.95 | A |
| | E13468 | Charcoal | I-131 | pCi | 83.5 | 88.5 | 0.94 | A |
| | E13469 | AP | Ce-141 | pCi | 103.0 | 103 | 1.00 | A |
| | | | Co-58 | pCi | 93.3 | 105 | 0.89 | A |
| | | | Co-60 | pCi | 136 | 126 | 1.08 | A |
| | | | Cr-51 | pCi | 213 | 198 | 1.07 | A |
| | | | Cs-134 | pCi | 123.0 | 124 | 0.99 | A |
| | | | Cs-137 | pCi | 86.3 | 90.1 | 0.96 | A |
| | | | Fe-59 | pCi | 81.3 | 89.6 | 0.91 | A |
| | | | Mn-54 | pCi | 93.5 | 92.0 | 1.02 | A |
| | | | Zn-65 | pCi | 166 | 173 | 0.96 | A |
| | E13470 | Soil | Ce-141 | pCi/g | 0.232 | 0.262 | 0.89 | A |
| | | | Co-58 | pCi/g | 0.251 | 0.268 | 0.94 | A |
| | | | Co-60 | pCi/g | 0.306 | 0.322 | 0.95 | A |
| | | | Cr-51 | pCi/g | 0.517 | 0.506 | 1.02 | A |
| | | | Cs-134 | pCi/g | 0.263 | 0.317 | 0.83 | A |
| | | | Cs-137 | pCi/g | 0.278 | 0.301 | 0.92 | A |
| | | | Fe-59 | pCi/g | 0.228 | 0.229 | 1.00 | A |
| | | | Mn-54 | pCi/g | 0.221 | 0.235 | 0.94 | A |
| | | | Zn-65 | pCi/g | 0.448 | 0.441 | 1.02 | A |
| | E13471 | AP | Sr-89 | pCi | 92.2 | 95.5 | 0.97 | A |
| | | | Sr-90 | pCi | 11.7 | 13.9 | 0.84 | A |

*(a) The Analytics known value is equal to 100% of the parameter present in the standard as determined by gravimetric and/or volumetric measurements made during standard preparation*

*(b) Analytics evaluation based on TBE internal QC limits:*
*A = Acceptable - reported result falls within ratio limits of 0.80-1.20*
*W = Acceptable with warning - reported result falls within 0.70-0.80 or 1.20-1.30*
*N = Not Acceptable - reported result falls outside the ratio limits of < 0.70 and > 1.30*

**TABLE D-3.1** **Analytics Environmental Radioactivity Cross Check Program**
**Teledyne Brown Engineering Environmental Services**

| Month/Year | Identification Number | Matrix | Nuclide | Units | TBE Reported Value | Known Value [(a)] | Ratio of TBE to Known Result | Evaluation [(b)] |
|---|---|---|---|---|---|---|---|---|
| September 2021 | E13472 | Milk | Sr-89 | pCi/L | 66.4 | 85.4 | 0.78 | W |
| | | | Sr-90 | pCi/L | 11.9 | 14.0 | 0.85 | A |
| | E13473 | Milk | Ce-141 | pCi/L | 118 | 114 | 1.03 | A |
| | | | Co-58 | pCi/L | 116 | 118 | 0.98 | A |
| | | | Co-60 | pCi/L | 142 | 145 | 0.98 | A |
| | | | Cr-51 | pCi/L | 244 | 236 | 1.03 | A |
| | | | Cs-134 | pCi/L | 81 | 93.1 | 0.87 | A |
| | | | Cs-137 | pCi/L | 105 | 112 | 0.94 | A |
| | | | Fe-59 | pCi/L | 105 | 102 | 1.03 | A |
| | | | I-131 | pCi/L | 65.1 | 85.6 | 0.76 | W |
| | | | Mn-54 | pCi/L | 128 | 128 | 1.00 | A |
| | | | Zn-65 | pCi/L | 158 | 153 | 1.03 | A |
| | E13474 | Charcoal | I-131 | pCi | 85.2 | 90.9 | 0.94 | A |
| | E13475 | AP | Ce-141 | pCi | 126 | 135 | 0.94 | A |
| | | | Co-58 | pCi | 148 | 139 | 1.07 | A |
| | | | Co-60 | pCi | 183 | 171 | 1.07 | A |
| | | | Cr-51 | pCi | 322 | 278 | 1.16 | A |
| | | | Cs-134 | pCi | 118 | 110 | 1.08 | A |
| | | | Cs-137 | pCi | 147 | 132 | 1.12 | A |
| | | | Fe-59 | pCi | 131 | 120 | 1.09 | A |
| | | | Mn-54 | pCi | 161 | 151 | 1.06 | A |
| | | | Zn-65 | pCi | 202 | 180 | 1.12 | A |
| | E13476 | Soil | Ce-141 | pCi/g | 0.215 | 0.219 | 0.98 | A |
| | | | Co-58 | pCi/g | 0.208 | 0.226 | 0.92 | A |
| | | | Co-60 | pCi/g | 0.277 | 0.277 | 1.00 | A |
| | | | Cr-51 | pCi/g | 0.388 | 0.452 | 0.86 | A |
| | | | Cs-134 | pCi/g | 0.157 | 0.178 | 0.88 | A |
| | | | Cs-137 | pCi/g | 0.270 | 0.284 | 0.95 | A |
| | | | Fe-59 | pCi/g | 0.218 | 0.195 | 1.12 | A |
| | | | Mn-54 | pCi/g | 0.239 | 0.246 | 0.97 | A |
| | | | Zn-65 | pCi/g | 0.312 | 0.293 | 1.06 | A |
| | E13477 | AP | Sr-89 | pCi | 85.6 | 68.3 | 1.25 | W |
| | | | Sr-90 | pCi | 12.6 | 11.2 | 1.13 | A |

*(a) The Analytics known value is equal to 100% of the parameter present in the standard as determined by gravimetric and/or volumetric measurements made during standard preparation*
*(b) Analytics evaluation based on TBE internal QC limits:*
*A = Acceptable - reported result falls within ratio limits of 0.80-1.20*
*W = Acceptable with warning - reported result falls within 0.70-0.80 or 1.20-1.30*
*N = Not Acceptable - reported result falls outside the ratio limits of < 0.70 and > 1.30*

**TABLE D-3.2 DOE's Mixed Analyte Performance Evaluation Program (MAPEP)**
**Teledyne Brown Engineering Environmental Services**

| Month/Year | Identification Number | Matrix | Nuclide | Units | TBE Reported Value | Known Value (a) | Acceptance Range | Evaluation (b) |
|---|---|---|---|---|---|---|---|---|
| February 2021 | 21-GrF44 | AP | Gross Alpha | Bq/sample | 0.371 | 1.77 | 0.53 - 3.01 | N(3) |
| | | | Gross Beta | Bq/sample | 0.731 | 0.65 | 0.325 - 0.974 | A |
| | 21-MaS44 | Soil | Ni-63 | Bq/kg | 310 | 689.0 | 482 - 896 | N(4) |
| | | | Tc-99 | Bq/kg | 457 | 638 | 447 - 829 | W |
| | 21-MaSU44 | Urine | Cs-134 | Bq/L | 2.34 | 2.73 | 1.91 - 3.55 | A |
| | | | Cs-137 | Bq/L | 2.54 | 2.71 | 1.90 - 3.52 | A |
| | | | Co-57 | Bq/L | 0.4100 | | *(1)* | A |
| | | | Co-60 | Bq/L | 2.24 | 2.44 | 1.71 - 3.17 | A |
| | | | Mn-54 | Bq/L | 2.03 | 2.03 | 1.42 - 2.64 | A |
| | | | K-40 | Bq/L | 52.8 | 54.0 | 38 - 70 | A |
| | | | U-234 | Bq/L | 0.108 | 0.0877 | 0.0614 - 0.114 | W |
| | | | U-238 | Bq/L | 0.101 | 0.091 | 0.064 - 0.118 | A |
| | | | Zn-65 | Bq/L | 1.06 | 1.34 | *(2)* | A |
| | 21-MaW44 | Water | Ni-63 | Bq/L | 6.7 | 8.2 | 5.7 - 10.7 | A |
| | | | Tc-99 | Bq/L | 3.850 | 4.01 | 2.81 - 5.21 | A |
| | 21-RdV44 | Vegetation | Cs-134 | Bq/sample | 3.13 | 3.60 | 2.5 - 4.7 | A |
| | | | Cs-137 | Bq/sample | 4.64 | 4.69 | 3.28 - 6.10 | A |
| | | | Co-57 | Bq/sample | 5.25 | 5.05 | 3.54 - 6.57 | A |
| | | | Co-60 | Bq/sample | 2.86 | 2.99 | 2.09 - 3.89 | A |
| | | | Mn-54 | Bq/sample | 5.02 | 5.25 | 3.68 - 6.83 | A |
| | | | Sr-90 | Bq/sample | 0.631 | 0.673 | 0.471 - 0.875 | A |
| | | | Zn-65 | Bq/sample | -0.233 | | *(1)* | A |
| August 2021 | 21-GrF45 | AP | Gross Alpha | Bq/sample | 0.368 | 0.960 | 0.288 - 1.632 | A |
| | | | Gross Beta | Bq/sample | 0.595 | 0.553 | 0.277 - 0.830 | A |
| | 21-MaS45 | Soil | Ni-63 | Bq/kg | 546 | 1280 | 896 - 1664 | N(5) |
| | | | Tc-99 | Bq/kg | 453 | 777 | 544 - 1010 | N(6) |
| | 21-MaSU45 | Urine | Cs-134 | Bq/L | 3.10 | 3.62 | 2.53 - 4.71 | A |
| | | | Cs-137 | Bq/L | 0.083 | | *(1)* | A |
| | | | Co-57 | Bq/L | 0.844 | 0.87 | 0.606 - 1.125 | A |
| | | | Co-60 | Bq/L | 0.0535 | | *(1)* | A |
| | | | Mn-54 | Bq/L | 0.459 | 0.417 | *(2)* | A |
| | | | K-40 | Bq/L | 48.8 | 54.0 | 38 - 70 | A |
| | | | U-234 | Bq/L | 0.133 | 0.116 | 0.081 - 0.151 | A |
| | | | U-238 | Bq/L | 0.137 | 0.121 | 0.085 - 0.157 | A |
| | | | Zn-65 | Bq/L | 0.339 | 0.420 | *(2)* | A |
| | 21-MaW45 | Water | Ni-63 | Bq/L | 33.5 | 39.5 | 27.7 - 51.4 | A |
| | | | Tc-99 | Bq/L | 3.5 | 3.7 | 2.60 - 4.82 | A |
| | 21-RdV45 | Vegetation | Cs-134 | Bq/sample | 3.42 | 4.34 | 3.04 - 5.64 | W |
| | | | Cs-137 | Bq/sample | 2.14 | 2.21 | 1.55 - 2.87 | A |
| | | | Co-57 | Bq/sample | 4.08 | 4.66 | 3.26 - 6.06 | A |
| | | | Co-60 | Bq/sample | 2.81 | 3.51 | 2.46 - 4.56 | A |
| | | | Mn-54 | Bq/sample | 0.035 | | *(1)* | A |
| | | | Sr-90 | Bq/sample | 1.15 | 1.320 | 0.92 - 1.72 | A |
| | | | Zn-65 | Bq/sample | 2.05 | 2.43 | 1.70 - 3.16 | A |

*(a) The MAPEP known value is equal to 100% of the parameter present in the standard as determined by gravimetric and/or volumetric measurements made during standard preparation*

*(b) DOE/MAPEP evaluation:*
*A = Acceptable - reported result falls within ratio limits of 0.80-1.20*
*W = Acceptable with warning - reported result falls within 0.70-0.80 or 1.20-1.30*
*N = Not Acceptable - reported result falls outside the ratio limits of < 0.70 and > 1.30*

*(1) False positive test*
*(2) Sensitivity evaluation*
*(3) See **NCR 21-02***
*(4) See **NCR 21-03***
*(5) See **NCR 21-13***
*(6) Tc-99 cross-checks done for TBE information only - not required*

**TABLE D-3.3** **ERA Environmental Radioactivity Cross Check Program**
**Teledyne Brown Engineering Environmental Services**

| Month/Year | Identification Number | Matrix | Nuclide | Units | TBE Reported Value | Known Value (a) | Acceptance Limits | Evaluation (b) |
|---|---|---|---|---|---|---|---|---|
| March 2021 | MRAD-34 | Water | Am-241 | pCi/L | 175 | 157 | 108 - 201 | A |
| | | | Fe-55 | pCi/L | 579 | 275 | 162 - 400 | N(1) |
| | | | Pu-238 | pCi/L | 181 | 171 | 103 - 222 | A |
| | | | Pu-239 | pCi/L | 153 | 142 | 87.9 - 175 | A |
| | | Soil | Sr-90 | pCi/kg | 6570 | 9190 | 2860 - 14,300 | A |
| | | AP | Fe-55 | pCi/filter | 107 | 121 | 44.2 - 193 | A |
| | | | U-234 | pCi/filter | 25.99 | 25.5 | 18.9 - 29.9 | A |
| | | | U-238 | pCi/filter | 24.7 | 25.3 | 19.1 - 30.2 | A |
| April 2021 | RAD-125 | Water | Ba-133 | pCi/L | 92.3 | 90.5 | 76.2 - 99.6 | A |
| | | | Cs-134 | pCi/L | 62.9 | 70.5 | 57.5 - 77.6 | A |
| | | | Cs-137 | pCi/L | 161 | 168 | 151 - 187 | A |
| | | | Co-60 | pCi/L | 22.5 | 20.9 | 17.7 - 25.8 | A |
| | | | Zn-65 | pCi/L | 183 | 177.0 | 159 - 208 | A |
| | | | GR-A | pCi/L | 30.8 | 30.2 | 15.4 - 39.4 | A |
| | | | GR-B | pCi/L | 60.1 | 67.5 | 46.8 - 74.2 | A |
| | | | U-Nat | pCi/L | 36.45 | 36.9 | 30.0 - 40.8 | A |
| | | | H-3 | pCi/L | 13,400 | 14,600 | 12,800 - 16,100 | A |
| | | | Sr-89 | pCi/L | 64.5 | 63.5 | 51.4 - 71.5 | A |
| | | | Sr-90 | pCi/L | 22.8 | 23.0 | 16.5 - 27.0 | A |
| | | | I-131 | pCi/L | 28.2 | 26.7 | 22.2 - 31.4 | A |
| September 2021 | MRAD-35 | Water | Am-241 | pCi/L | 68 | 63.7 | 43.7 - 81.5 | A |
| | | | Fe-55 | pCi/L | 179 | 246 | 145 - 358 | A |
| | | | Pu-238 | pCi/L | 102 | 114 | 68.5 - 148 | A |
| | | | Pu-239 | pCi/L | 32 | 34.3 | 21.2 - 42.3 | A |
| | | Soil | Sr-90 | pCi/kg | 6160 | 6090 | 1,900 - 9,490 | A |
| | | AP | Fe-55 | pCi/filter | 493 | 548 | 200 - 874 | A |
| | | | Pu-238 | pCi/filter | 28 | 28.5 | 21.5 - 35.0 | A |
| | | | Pu-239 | pCi/filter | 21 | 21.6 | 16.1 - 26.1 | A |
| | | | U-234 | pCi/filter | 7.95 | 7.76 | 5.75 - 9.09 | A |
| | | | U-238 | pCi/filter | 8.0 | 7.69 | 5.81 - 9.17 | A |
| October 2021 | RAD-127 | Water | Ba-133 | pCi/L | 82.8 | 87.5 | 73.6 - 96.2 | A |
| | | | Cs-134 | pCi/L | 64.0 | 70.1 | 57.1 - 77.1 | A |
| | | | Cs-137 | pCi/L | 145 | 156 | 140 - 174 | A |
| | | | Co-60 | pCi/L | 83.2 | 85.9 | 77.3 - 96.8 | A |
| | | | Zn-65 | pCi/L | 133 | 145 | 130 - 171 | A |
| | | | GR-A | pCi/L | 76.0 | 66.7 | 35.0 - 82.5 | A |
| | | | GR-B | pCi/L | 63.0 | 55.7 | 38.1 - 62.6 | N(2) |
| | | | U-Nat | pCi/L | 52.88 | 55.5 | 45.3 - 61.1 | A |
| | | | H-3 | pCi/L | 13,800 | 17,200 | 15,000 - 18,900 | N(3) |
| | | | Sr-89 | pCi/L | 54.9 | 61.0 | 49.1 - 68.9 | A |
| | | | Sr-90 | pCi/L | 24.8 | 29.3 | 21.3 - 34.0 | A |
| | | | I-131 | pCi/L | 27.4 | 26.4 | 21.9 - 31.1 | A |
| December 2021 | QR 120121Y | Water | GR-B | pCi/L | 47.6 | 39.8 | 26.4 - 47.3 | N(4) |
| | | | H-3 | pCi/L | 17,500 | 17,800 | 15,600 - 19,600 | A |

*(a) The ERA known value is equal to 100% of the parameter present in the standard as determined by gravimetric and/or volumetric measurements made during standard preparation.*

*(b) ERA evaluation: A = Acceptable - Reported value falls within the Acceptance Limits*
*N = Not Acceptable - Reported value falls outside of the Acceptance Limits*

*(1) See **NCR 21-01***
*(2) See **NCR 21-10***
*(3) See **NCR 21-11***
*(4) See **NCR 21-14***

## 7.4 Environmental TLD Quality Assurance

Environmental dosimetry services for the reporting period of January – December, 2021 were provided by the Environmental Dosimetry Company (EDC), Sterling, Massachusetts. The TLD systems at the Environmental Dosimetry Company (EDC) are calibrated and operated to ensure consistent and accurate evaluation of TLDs. The quality of the dosimetric results reported to EDC clients is ensured by in house performance testing and independent performance testing by EDC clients.

The purpose of the dosimetry quality assurance program is to provide performance documentation of the routine processing of EDC dosimeters. Performance testing provides a statistical measure of the bias and precision of dosimetry processing against a reliable standard, which in turn points out any trends or performance changes. Dosimetry quality control tests are performed on EDC Panasonic 814 Environmental dosimeters. These tests include: (1) the in house testing program conducted by the EDC QA Officer and (2) independent test perform by EDC clients.

Excluded from this report are instrumentation checks. Although instrumentation checks represent an important aspect of the quality assurance program, they are not included as process checks in this report. Instrumentation checks represent between 5-10% of the TLDs processed.

Table D-4.1 provides a summary of individual dosimeter results evaluated against the EDC internal acceptance criteria for high-energy photons (Cs-137) only. The internal acceptance (tolerance) criteria for the Panasonic Environmental dosimeters are: ± 15% for bias and ± 12.8% for precision. During this period, 100% (72/72) of the individual dosimeters, evaluated against these criteria met the tolerance limits for accuracy and 100% (72/72) met the criterion for precision.

Table D-4.2 provides the Bias + Standard deviation results for each group (N=6) of dosimeters evaluated against the internal tolerance criteria. Overall, 100% (12/12) of the dosimeter sets evaluated against the internal tolerance performance criteria met these criteria.

Table D-4.3 presents the independent blind spike results for irradiated dosimeters provided by client utilities during this annual period. All results passed the performance acceptance criterion.

**TABLE D-4.1**

**PERCENTAGE OF INDIVIDUAL DOSIMETERS THAT PASSED EDC INTERNAL CRITERIA JANUARY – DECEMBER 2021 (1), (2)**

| Dosimeter Type | Number Tested | % Passed Bias Criteria | % Passed Precision Criteria |
|---|---|---|---|
| Panasonic Environmental | 72 | 100 | 100 |

(1)This table summarizes results of tests conducted by EDC.
(2)Environmental dosimeter results are free in air.

**TABLE D-4.2**

**MEAN DOSIMETER ANALYSES (N=6)**
**JANUARY – DECEMBER 2021 (1), (2)**

| Process Date | Mean Bias % | Standard Deviation % | Tolerance Limit +/-15% |
|---|---|---|---|
| 5/04/2021 | 0.6 | 0.9 | Pass |
| 5/06/2021 | -0.2 | 1.4 | Pass |
| 5/26/2021 | -3.8 | 1.6 | Pass |
| 7/27/2021 | 2.8 | 1.4 | Pass |
| 8/04/2021 | -1.8 | 2.3 | Pass |
| 9/14/2021 | -0.2 | 2.3 | Pass |
| 11/01/2021 | 3.7 | 0.6 | Pass |
| 11/03/2021 | 1.9 | 1.9 | Pass |
| 11/09/2021 | 1.1 | 1.1 | Pass |
| 01/26/2022 | 2.6 | 1.9 | Pass |
| 01/30/2022 | -4.2 | 1.1 | Pass |
| 02/06/2022 | 2.9 | 1.2 | Pass |

(1) This table summarizes results of tests conducted by EDC for TLDs issued in 2021.
(2) Environmental dosimeter results are free in air.

**TABLE D-4.3**
**SUMMARY OF INDEPENDENT DOSIMETER TESTING**
**JANUARY – DECEMBER 2021 (1), (2)**

| Issuance Period | Client | Mean Bias % | Standard Deviation % | Pass / Fail |
|---|---|---|---|---|
| 1st Qtr. 2021 | SONGS | -3.8 | 1.4 | Pass |
| 1st Qtr. 2021 | SONGS | -4.7 | 1.1 | Pass |
| 2nd Qtr.2021 | Seabrook | 3.1 | 1.0 | Pass |
| 3rd Qtr. 2021 | Millstone | -4.7 | 1.4 | Pass |
| 4th Qtr.2021 | PSEG(PNNL) 50mR | 1.3 | 0.8 | Pass |
| 4th Qtr.2021 | PSEG(PNNL) 100mR | 1.8 | 0.8 | Pass |
| 4th Qtr.2021 | PSEG(PNNL) 150mR | -0.6 | 0.5 | Pass |
| 4th Qtr.2021 | PSEG(PNNL) 200mR | -2.6 | 2.0 | Pass |
| 4th Qtr.2021 | Seabrook | 2.6 | 1.4 | Pass |

(1) Performance criteria are +/- 30%.
(2) Blind spike irradiations using Cs-137

# SECTION 8.0

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## 8.0 REFERENCES

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# *ENCLOSURE 2 TO HDI-IPEC-22-034*

# Offsite Dose Calculation Manual (ODCM)

(242 pages not including this cover sheet)

Entergy Nuclear Northeast

# Indian Point Energy Center

Units 1, 2, and 3

# OFFSITE DOSE CALCULATION MANUAL

# (ODCM)

Rev. 6

| | | |
|---|---|---|
| WRITTEN BY: | John Doroski | 04/12/2021 (date) |
| REVIEWED BY: | | 4/20/2021 (date) |
| OSRC REVIEW: | OSRC 21-06 | 4/14/21 (date) |
| APPROVED BY: | | 4/21/2021 (date) |
| EFFECTIVE DATE: | 04/29/2021 | |

**BASES**

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**Figures:**

LIST OF TABLES AND FIGURES PAGE

**PART II - CALCULATIONAL METHODOLOGIES**

The OFFSITE DOSE CALCULATION MANUAL (ODCM) is established and maintained pursuant to Technical Specifications Section 5.5. for both IPEC units 2 and 3. Previous revisions of each unit's ODCM have been combined to form a station ODCM. The IPEC ODCM consists of two parts:

1) Part I, Radiological Effluent Controls, (RECS) – previously, often referred to as the Radiological Effluent Technical Specifications, or RETS (Section 3.9 of original Unit 2 Technical Specifications, and Appendix B or original Unit 3 Technical Specifications).

2) Part II, Calculational Methodologies (previously often referred to as simply the "ODCM")

Part I, Radiological Effluent Controls, includes the Radiological Effluent Control Specifications (RECS) and Radiological Environmental Monitoring Programs (REMP) required by Technical Specification 5.5. It also includes descriptions of the information that should be included in the Annual Radiological Environmental Operating and Radioactive Effluent Release Reports required by each unit's Technical Specifications.

Part II, Calculational Methodologies, provides the methodology to manually calculate radiation dose rates and doses to individual persons in UNRESTRICTED AREAS in the vicinity of Indian Point due to the routine release of gaseous and liquid effluents. Long term cumulative effects are usually calculated through computer programs employing approved methodology. At IPEC, this method includes the use of ten-year averaged meteorology in the case of gaseous effluents. Other computer programs are utilized to routinely estimate the doses due to radioactivity in liquid effluents. Manual dose calculations are performed when computerized calculations are not available. The ODCM also provides setpoint methodology that is applied to effluent monitors and optionally to other process monitors.

The sources for criteria found in the ODCM and the Radiological Effluent Control Specifications include the following:

- **Liquid Effluent Release Rate:** Diluted concentrations in the discharge canal are limited to ten times the EFFLUENT CONCENTRATIONS identified in 10CFR20 Appendix B.
- **Airborne Effluent Release Rate**: Release rates are limited to corresponding dose rate limits from NUREG 0133 and 0472.
- **Integrated Radiological Effluent Dose**: The design objectives of 10CFR50 Appendix I.

The ODCM and associated tracking software implements the methodology of

1) Reg. Guide 1.109 "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10CFR50 Appendix I", and
2) NUREG-0133 "Guidance Manual for Preparation of Radiological Effluent Technical Specifications for Nuclear Power Plants."

Other references may be cited to permit reasonable handling of a situation not covered by either of the two cited references. In some cases, site-specific data or reasonable simplifying assumptions are used and justified to permit formulation of more workable methodologies for implementing RECS dose calculation requirements.

# Indian Point Energy Center

# Offsite Dose Calculation Manual

## PART I – RADIOACTIVE EFFLUENT CONTROLS

# D 1.0 USE AND APPLICATION

## D 1.1 Definitions

------------------------------------------------------------NOTE------------------------------------------------------------
Terms defined in Technical Specifications and the following additional defined terms appear in capitalized type and are applicable throughout these specifications and bases.
--------------------------------------------------------------------------------------------------------------------------------

| Term | Definition |
|---|---|
| GASEOUS RADWASTE TREATMENT SYSTEM | A GASEOUS RADWASTE TREATMENT SYSTEM is any system designed and installed to reduce radioactive gaseous effluents by collecting primary coolant system offgases from the primary system and providing for delay or holdup for the purpose of reducing the total radioactivity prior to release to the environment. |
| MEMBER(S) OF THE PUBLIC | MEMBER(S) OF THE PUBLIC includes all persons who are not occupationally associated with the site. This category does not include employees of the utility, their contractors or vendors. Also excluded from this category are persons who enter the site to service equipment or to make deliveries. |
| MAXIMUM PERMISSIBLE CONCENTRATION WATER (MPCW) | MPCW is that concentration of a radionuclide equal to ten times the EFFLUENT CONCENTRATIONS specified in 10CFR20, Appendix B, Table 2, Column 2. |
| OFFSITE DOSE CALCULATION MANUAL | The OFFSITE DOSE CALCULATION MANUAL shall contain the current methodology and parameters used in the calculation of offsite doses due to radioactive gaseous and liquid effluents, in the calculation of gaseous and liquid effluent monitoring alarm/trip setpoints, and in the conduct of the environmental radiological monitoring program. |
| PRIMARY TO SECONDARY LEAK | A PRIMARY TO SECONDARY LEAK is defined by a quantifiable leak rate equal to or greater than 0.5 gpd, AND<br>a) The presence of fission or activation products in the secondary fluid, verified as Steam Generator U-tube leaks (and not from other known contamination, such as IVSWS leaks), OR<br>b) Tritium activity in the secondary fluid indicating an increase above historical baseline (normal diffusion) of 5.00E-6 uCi/ml or greater. |
| PROCESS CONTROL PROGRAM | The PROCESS CONTROL PROGRAM is a manual containing and/or referencing selected operational information concerning the solidification of radioactive wastes from liquid systems. |

D 1.1 Definitions

| | |
|---|---|
| PURGE - PURGING | PURGE or PURGING is the controlled process of discharging air or gas from a confinement to maintain temperature, pressure, humidity, concentration or other operating condition, in such a manner that replacement air or gas is required to purify the confinement. |
| SITE BOUNDARY | The SITE BOUNDARY is that line beyond which the land is neither owned, leased, nor otherwise controlled by the licensee(s). |
| SOLIDIFICATION | SOLIDIFICATION is the conversion of wet wastes into a form that meets shipping and burial ground requirements. |
| SOURCE CHECK | A SOURCE CHECK shall be the qualitative assessment of channel response when the channel sensor is exposed to a source of increased radioactivity. |
| UNRESTRICTED AREA | An UNRESTRICTED AREA is any area at or beyond the SITE BOUNDARY, access to which is not controlled by the licensee(s) for purposes of protection of individuals from exposure to radiation and radioactive materials. (See Figure D 4.1-1) |
| VENTILATION EXHAUST TREATMENT SYSTEM | A VENTILATION EXHAUST TREATMENT SYSTEM is 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 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 Feature (ESF) atmospheric cleanup systems are not considered to be VENTILATION EXHAUST TREATMENT SYSTEM components. |
| VENTING | VENTING is the controlled process of discharging air or gas from a confinement to maintain temperature, pressure, humidity, concentration or other operating condition, in such a manner that replacement air or |

# 1.0 USE AND APPLICATION

## 1.2 Logical Connectors

Logical Connectors are discussed in Section 1.2 of the Technical Specifications and are applicable throughout the Offsite Dose Calculation Manual and Bases.

## 1.3 Completion Times

Completion Times are discussed in Section 1.3 of the Technical Specifications and are applicable throughout the Offsite Dose Calculation Manual and Bases.

## 1.4 Frequency

Frequency is discussed in Section 1.4 of the Technical Specifications and is applicable throughout the Offsite Dose Calculation Manual and Bases

## D 3.0 ODCM Limiting Condition for Operation (DLCO) Applicability

---

DLCO 3.0.1 DLCOs shall be met during the MODES or other specified condition in the Applicability, except as provided in DLCO 3.0.2.

---

DLCO 3.0.2 Upon discovery of a failure to meet a DLCO, the Required Actions of the associated Conditions shall be met, except as provided in DLCO 3.0.5.

If the DLCO is met or is no longer applicable prior to expiration of the specified Completion Time(s), completion of the Required Action(s) is not required unless otherwise stated.

---

DLCO 3.0.3 When a DLCO is not met and the associated ACTIONS are not met, an associated ACTION is not provided, or if directed by the associated ACTIONS, action shall be initiated within 1 hour to:

a. Restore compliance with the DLCO or associated ACTIONS, and

b. Enter the circumstances into the Corrective Action Program.

-------------------------------------NOTE----------------------------------
DLCO 3.0.3.b shall be completed if DLCO 3.0.3 is entered.
------------------------------------------------------------------------------

Exceptions to this Specification are stated in the individual Specifications.

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DLCO 3.0.4 Not Applicable to ODCM Specifications.

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DLCO 3.0.5 Equipment removed from service or declared inoperable to comply with ACTIONS may be returned to service under administrative control solely to perform testing required to demonstrate its OPERABILITY or the OPERABILITY of other equipment. This is an exception to TRO 3.0.B for the system returned to service under administrative control to perform the testing required to demonstrate OPERABILITY.

D 3.0 ODCM Surveillance Requirement (DSR) Applicability

DSR 3.0.1 DSRs shall be met during the MODES or other specified conditions in the Applicability for individual DLCOs, unless otherwise stated in the DSR. Failure to meet a Surveillance, whether such failure is experienced during the performance of the Surveillance or between performances of the Surveillance, shall be failure to meet the DLCO. Failure to perform a Surveillance within the specified Frequency shall be failure to meet the DLCO except as provided in DSR 3.0.3. Surveillances do not have to be performed on inoperable equipment or variables outside specified limits.

DSR 3.0.2 The specified Frequency for each DSR is met if the Surveillance is performed within 1.25 times the interval specified in the Frequency, as measured from the previous performance or as measured from the time a specified condition of the Frequency is met.

For Frequencies specified as "once," the above interval extension does not apply.

If a Completion Time requires periodic performance on a "once per . . ." basis, the above Frequency extension applies to each performance after the initial performance.

Exceptions to this Specification are stated in the individual Specifications.

DSR 3.0.3 If it is discovered that a Surveillance was not performed within its specified Frequency, then compliance with the requirement to declare the DLCO not met may be delayed, from the time of discovery, up to 24 hours or up to the limit of the specified Frequency, whichever is greater. This delay period is permitted to allow performance of the Surveillance. A risk evaluation shall be performed for any Surveillance delayed greater than 24 hours and the risk impact shall be managed.

If the Surveillance is not performed within the delay period, the DLCO must immediately be declared not met, and the applicable Condition(s) must be entered.

When the Surveillance is performed within the delay period and the Surveillance is not met, the DLCO must immediately be declared not met, and the applicable Condition(s) must be entered.

## D 3.1 RADIOACTIVE LIQUID EFFLUENTS

### D 3.1.1 Liquid Effluents Concentration

DLCO 3.1.1 The concentration of radioactive material released in liquid effluents to UNRESTRICTED AREAS (Figure D 4.1-1) shall be limited to:

a. The MPCW concentrations as defined in D1.1 for radionuclides other than dissolved or entrained noble gases; and

b. 2E-4 uCi/ml total activity concentration for dissolved or entrained noble gases.

APPLICABILITY: At all times.

ACTIONS

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---|---|---|
| A. Concentration of radioactive material released in liquid effluents to UNRESTRICTED AREAS exceeds limits. | A.1 Initiate action to restore concentration to within limits. | Immediately |

SURVEILLANCE REQUIREMENTS

| SURVEILLANCE | | FREQUENCY |
|---|---|---|
| DSR 3.1.1.1 | Perform radioactive liquid waste sampling and activity analysis. | In accordance with Table D 3.1.1-1 |
| DSR 3.1.1.2 | Verify the results of the DSR 3.1.1.1 analyses to assure that the concentrations at the point of release are maintained within the limits of DLCO 3.1.1. | In accordance with Table D 3.1.1-1 |

Table D 3.1.1-1 (Page 1 of 2)
Radioactive Liquid Waste Sampling and Analysis

| LIQUID RELEASE TYPE | SAMPLE TYPE | SAMPLE FREQUENCY | MINIMUM ANALYSIS FREQUENCY | SAMPLE ANALYSIS | LOWER LIMIT OF DETECTION (LLD) in uCi/ml, (a),(g),(c) |
|---|---|---|---|---|---|
| 1. Batch Waste Release Tanks (b)<br>*eg, Waste Tanks,*<br>*SG Draindowns,*<br>*etc* | Grab Sample | Each Batch (h) | Each Batch (h) | Principal Gamma Emitters<br>Mo-99, Ce-144<br>I-131 | 5E-7<br>5E-6<br>1E-6 |
| | Grab Sample | One batch per 31 days (h) | 31 days | Dissolved and Entrained Gases (gamma emitters) | 1E-5 |
| | Composite (d) | Each batch (h) | 31 days | H-3<br>Gross Alpha | 1E-5<br>1E-7 |
| | Composite (d) | Each batch (h) | 92 days | Sr-89, Sr-90 | 5E-8 |
| | | | | Fe-55 | 1E-6 |
| Releases (e)<br>*eg, SG Blowdown,*<br>*U1 NCD,*<br>*U1 SFDS,*<br>*Foundation Drain Line (k)*<br>*etc* | Composite (d) | Composite | 7 days | Principal Gamma Emitters (c)<br>Mo-99, Ce-144<br>I-131 | 5E-7<br>5E-6<br>1E-6 |
| | Grab Sample | 31 days | 31 days | Dissolved and Entrained Gases (gamma emitters) | 1E-5 |
| | Composite (d) | Composite | 31 days | H-3 | 1E-5 |
| | | | | Gross Alpha | 1E-7 |
| | | | 92 days | Sr-89, Sr-90 | 5E-8 |
| | | | | Fe-55 | 1E-6 |
| 3. Service Water<br>(in Radiologically Controlled Areas) | Grab Sample | 31 days | 31 days | Gamma and Beta emitters (j) | Per liquid batch releases, above. |
| 4. Turbine Hall Drains, SG Feedwater (i) | Composite (d) | Composite | 7 days | Gamma and Beta emitters (j) | Per liquid batch releases, above. |

Table D 3.1.1-1 (Page 2 of 2)
Radioactive Liquid Waste Sampling and Analysis

(a) The LLD is defined as the smallest concentration of radioactive material in a sample that will yield a net count, above system background, that will be detected with 95% probability with only 5% probability of falsely concluding that a blank observation represents a “real” signal. The LLD shall be determined in accordance with the methodology and parameters in the ODCM. 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 posterior (after-the-fact) limit for a particular measurement.

(b) A batch release is the discharge of liquid wastes of a discrete volume. Prior to sampling for analyses, each batch shall be isolated, and then thoroughly mixed by the method described in Part II, Section 2.1.4 to assure representative sampling.

(c) The principal gamma emitters for which the LLD (of 5E-7 uCi/ml) applies include the following radionuclides: Mn-54, Fe-59, Co-58, Co-60, Zn-65, Cs-134, Cs-137, and Ce-141. Mo-99 and Ce-144 shall also be measured, but with an LLD of 5E-6 uCi/ml, per Reference 49. This list does not mean that only these nuclides are to be considered. Other gamma peaks that are identified, together with those of the above nuclides, shall also be analyzed and reported in the Radioactive Effluent Release Report pursuant to Specification D 5.2.

(d) A composite sample is one in which the quantity of liquid sampled is proportional to the quantity of liquid waste discharged and in which the method of sampling employed results in a specimen that is representative of the liquids released.

(e) A continuous release is the discharge of liquid wastes of a nondiscrete volume, e.g., from a volume of a system that has an input flow during the continuous release.

(f) When operational or other limitations preclude specific gamma radionuclide analysis in batch releases, the provisions of Regulatory Guide 1.21 (Revision 1), Appendix A Section C.4 and Appendix A, Section B shall be followed.

(g) For certain radionuclides with low gamma yield or low energies, or for certain radionuclide mixtures, it may not be possible to measure radionuclides in concentration near the LLD. Under these circumstances, the LLD may be increased in inverse proportion to the magnitude of the gamma yield (i.e., $5 \times 10^{-7}/I$ where I is the photon abundance expressed as a decimal fraction).

(h) Complete prior to each release.

(i) Steam Generator Feedwater and Turbine Hall Drains are adequately monitored from Steam Generator Blowdown Composites. Increased monitoring need only be performed when a Primary to Secondary leak exists, as defined in RECS Section D.1.1.

(j) Beta emitters need only be analyzed if gamma emitters have been positively identified.

(k) Foundation Drain Line samples are grab samples (at least once per month).

## D 3.1 RADIOACTIVE LIQUID EFFLUENTS

### D 3.1.2 Liquid Effluents Dose

DLCO 3.1.2 The dose or dose commitment to a MEMBER OF THE PUBLIC from radioactive materials released in liquid effluents from each unit to UNRESTRICTED AREAS (Figure D 4.1-1) shall be limited to:

a. ≤ 1.5 mrem to the whole body and ≤ 5 mrem to any organ during any calendar quarter; and

b. ≤ 3 mrem to the whole body and ≤ 10 mrem to any organ during any calendar year.

APPLICABILITY: At all times.

ACTIONS

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---|---|---|
| A. Calculated dose to a MEMBER OF THE PUBLIC from the release of radioactive materials in liquid effluents to UNRESTRICTED AREAS exceeds limits. | A.1 Prepare and submit to the NRC, pursuant to D 5.3, a Special Report that (1) Identifies the cause(s) for exceeding the limit(s) and (2) Defines the corrective actions that have been taken to reduce the releases and the proposed corrective actions to be taken to assure that subsequent releases will be in compliance with DLCO 3.1.2. | 30 days |

ACTIONS (continued)

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---|---|---|
| B. Calculated dose to a MEMBER OF THE PUBLIC from the release of radioactive materials in liquid effluents exceeds 2 times the limits. | B.1 Calculate the annual dose to a MEMBER OF THE PUBLIC which includes contributions from direct radiation from the units (including outside storage tanks, etc.). | Immediately |
| | <u>AND</u> | |
| | B.2 Verify that the limits of DLCO 3.4 have not been exceeded. | Immediately |
| C. Required Action B.2 and Associated Completion time not met. | C.1 Prepare and submit to the NRC, pursuant to D 5.3, a Special Report, as defined in 10 CFR 20.2203 (a)(4), of Required Action A.1 shall also include the following:<br>(1) The corrective action(s) to be taken to prevent recurrence of exceeding the limits of DLCO 3.4 and the schedule for achieving conformance,<br>(2) An analysis that estimates the dose to a MEMBER OF THE PUBLIC from uranium fuel cycle sources, including all effluent pathways and direct radiation, for the calendar year that includes the release(s), and<br>(3) Describes the levels of radiation and concentrations of radioactive material involved and the cause of the exposure levels or | 30 days |

SURVEILLANCE REQUIREMENTS

| SURVEILLANCE | | FREQUENCY |
|---|---|---|
| DSR 3.1.2.1 | Determine cumulative dose contributions from liquid effluents for the current calendar quarter and the current calendar year. | 31 days |

## D 3.1 RADIOACTIVE LIQUID EFFLUENTS

### D 3.1.3 Liquid Radwaste Treatment System

DLCO 3.1.3 The Liquid Radwaste Treatment System shall be in operation when projected liquid effluent doses, from each unit, to UNRESTRICTED AREAS (Figure D 4.1-1) would be:

a. > 0.06 mrem to the total body in a 31 day period; or

b. >0.2 mrem to any organ in a 31 day period.

APPLICABILITY: Prior to each release.

ACTIONS

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---|---|---|
| A. Radioactive liquid waste being discharged without treatment.<br><br><u>AND</u><br><br>Projected doses due to the liquid effluent, from the unit, to UNRESTRICTED AREAS would exceed limits. | A.1 Prepare and submit to the NRC, pursuant to D 5.3, a Special Report that includes:<br>(1) An explanation of why liquid radwaste was being discharged without treatment, identification of any inoperable equipment or subsystems, and the reason for the inoperability,<br>(2) Action(s) taken to restore the inoperable equipment to OPERABLE status, and<br>(3) Summary description of action(s) taken to prevent a recurrence. | 30 days |

SURVEILLANCE REQUIREMENTS

| SURVEILLANCE | | FREQUENCY |
|---|---|---|
| DSR 3.1.3.1 | Project the doses due to liquid effluents from each unit to UNRESTRICTED AREAS. | 31 days |

D 3.1 LIQUID EFFLUENTS

D 3.1.4 Liquid Holdup Tanks

DLCO 3.1.4 Radioactive liquid contained in unprotected outdoor liquid storage tanks shall be limited to ≤ 10 Curies, excluding tritium and dissolved or entrained gases.

APPLICABILITY: At all times.

ACTIONS

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---|---|---|
| A. Level of radioactivity exceeds the limits in any listed tank:<br><br>*U2 & U3 PWSTs*<br>*U2 & U3 RWSTs*<br>*U1 Waste Dist Storage Tanks*<br>*U3 Monitor Tanks*<br>*U3 CPF High/Low TDS Tanks*<br>*Outdoor Temporary Tanks* | A.1 Suspend addition of radioactive material. | Immediately |
| | AND | |
| | A.2 Initiate measures to reduce content to within the limits. | 48 hours |
| | AND | |
| | A.3 Describe the events leading to the condition in the Radioactive Effluent Release Report. | Prior to submittal of next Radioactive Effluent Release Report |

SURVEILLANCE REQUIREMENTS

| SURVEILLANCE | | FREQUENCY |
|---|---|---|
| DSR 3.1.4.1 | Determine that the quantity of radioactivity in outdoor liquid unprotected ta<br>does not exceed the limit. | 31 days, during periods where radioactive liquid is being added to the tanks, in accordance with the methodology and parameters of the ODCM |

## D 3.2 RADIOACTIVE GASEOUS EFFLUENTS

### D 3.2.1 Gaseous Effluents Dose Rate

DLCO 3.2.1 The dose rate from radioactive materials released in gaseous effluents from the site to areas at or beyond the SITE BOUNDARY (Figure D 4.1-1) shall be limited to:

a. For noble gases, 500 mrem/yr to the whole body and 3000 mrem/yr to the skin and

b. For I-131, tritium (H-3) and all radionuclides in particulate form with half-lives $>$ 8 days, 1500 mrem/yr to any organ.

APPLICABILITY: At all times.

ACTIONS

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---|---|---|
| A. The dose rate(s) at or beyond the SITE BOUNDARY due to radioactive gaseous effluents exceeds limits. | A.1 Restore the release rate to within the limit. | Immediately |

SURVEILLANCE REQUIREMENTS

| SURVEILLANCE | | FREQUENCY |
|---|---|---|
| DSR 3.2.1.1 | The dose rate from noble gases in gaseous effluents shall be determined to be within the limits of DLCO 3.2.1.a. | In accordance with Table D 3.2.1-1 |
| DSR 3.2.1.2 | The dose rate from I-131, H-3 and all radionuclides in particulate form with half-lives $>$ 8 days in gaseous effluents shall be determined to be within the limits of DLCO 3.2.1.b. | In accordance with Table D 3.2.1-1 |

Table D 3.2.1-1 (Page 1 of 2)
Radioactive Gaseous Waste Sampling and Analysis

| GASEOUS RELEASE TYPE | SAMPLE TYPE | SAMPLE FREQUENCY | ANALYSIS FREQUENCY | SAMPLE ANALYSIS | SAMPLE LOWER LIMIT OF DETECTION |
|---|---|---|---|---|---|
| 1. Waste Gas Storage Tank | Grab Sample | Each Tank (h) | Each Tank (h) | Principal Noble Gas (NG) Gamma Emitters (b) | 1E-4 μCi/cc |
| 2. Vapor Containment — Purge | Grab Sample | Each Purge (h) | Each Purge (h) | Principal NG Gamma Emitters (b) | 1E-4 μCi/cc |
| 2. Vapor Containment — Press Relief | Grab Sample | 31 days (i) | 31 days (i) | Principal NG Gamma Emitters (b) | 1E-4 μCi/cc |
| 3. Condenser Air Ejector | Grab Sample | 31 days | 31 days | Principal NG Gamma Emitters (b) | 1E-4 μCi/cc |
| 4. Continuous Ventilation: a. Main Plant Vent (unit 2) b. Stack Vent (unit 1) c. Main Plant Vent (unit 3) d. Radioactive Machine Shop Vent (unit 3) e. Admin Bldg Vent (unit 3) | Grab Sample | 31 days (c) | 31 days (c) | Principal NG Gamma Emitters (b) | 1E-4 μCi/cc |
| | H-3 Specific | Continuous | 31 days (e) | H-3 | 1E-6 μCi/cc (e) |
| | Charcoal Sample (j) | Continuous (f) | 7 days (c), (g) | I-131 | 1E-12 μCi/cc |
| | Particulate Sample | Continuous (f) | 7 days (c), (g) | Gamma Emitters (b) (I-131, | 1E-11 μCi/cc |
| | Composite Particulate Sample | Continuous (f) | 31 days | Gross Alpha | 1E-11 μCi/cc |
| | Composite Particulate Sample | Continuous (f) | 92 days | Sr-89 / Sr-90 | 1E-11 μCi/cc |
| | Noble Gas Monitor | Continuous (f) | Continuous (f) | Noble Gases Gross Beta or Gamma | 1E-6 μCi/cc (d) |

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## Table D 3.2.1-1 (Page 2 of 2)
## Radioactive Gaseous Waste Sampling and Analysis

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

(b) The principal gamma emitters for which the LLD Control applies exclusively are the following radionuclides: Kr-87, Kr-88, Xe-133, Xe-133m, Xe-135, and Xe-138 for gaseous emissions and Mn-54, Fe-59, Co-58, Co-60, Zn-65, Mo-99, Cs-134, Cs-137, Ce-141 and Ce-144 for particulate emissions. Other identifiable gamma peaks (I-131 in particulate form, for example), together with those of the above nuclides, shall also be analyzed and reported in the Annual Radioactive Effluent Release Report pursuant to Section D 5.2.

(c) IF following a shutdown, startup, or a thermal power change (within one hour) exceeding 15 percent of RATED THERMAL POWER, analysis shows that the DOSE EQUIVALENT I-131 concentration in the primary coolant has increased by a factor of 3 or more, AND the noble gas monitor shows that effluent activity has increased by a factor of 3 or more THEN:

1) Sample the main Plant Vent for Noble Gases within 24 hours, AND

2) Sample the main Plant Vent for Iodine and Particulate once per 24 hours for at least 7 days with analyses completed within 48 hours of sample changeout. The LLDs of these samples may be increased by a factor of 10.

(d) This value is the established Radiation Monitor sensitivity (minimum).

(e) Grab samples can be used as alternative to continuous sampling, provided the periodicity of these grab samples is increased from monthly to once per 24 hours when the refueling canal is flooded, or at least once per 7 days when spent fuel is in the Spent Fuel Pool. The LLD value of 1E-6 uCi/cc applies to the liquid distillate from the selected sample (or approximately 1E-10 uCi/cc in the exhaust vent air stream).

(f) The ratio of the sample flow rate to the sampled stream flow rate shall be known for the time period covered by each dose or dose rate calculation made in accordance with Specifications D 3.2.1, D 3.2.2 and D 3.2.3.

(g) Continuous samples shall be changed at least once per 7 days and analyses shall be completed within 48 hours after changing, or after removal from sampler.
Additionally, IF routine Iodine sampling indicates I-131 in any of the listed continuous streams, THEN collect a 24 hour sample from the applicable vent (within 48 hours) for short-lived Iodine isotope quantification, on a periodicity not to exceed once per 31 days. The LLDs of these samples may be increased by a factor of 10.

(h) Complete prior to each release.

(i) Vapor Containment noble gas shall be sampled at least monthly to ensure Pressure Reliefs are quantified with an accurate isotopic mixture. Containment noble gas radiation monitor readings can be used for quantification of Pressure Reliefs, provided the monitor readings are consistent with those observed during recent (at least monthly) grab samples. Sample data is adjusted by the noble gas radiation monitor reading for purposes of quantification of each release. Should the monitor be inoperable, a containment noble gas grab sample is required within 24 hours prior to the Pressure Relief. Should BOTH the containment noble gas and particulate monitors be inoperable, two independent samples of the VC are required prior to a Pressure Relief.
(j) Charcoal sample not required for Unit 1 and Unit 2. 4/21

## D 3.2 RADIOACTIVE GASEOUS EFFLUENTS

### D 3.2.2 Gaseous Effluent Dose - Noble Gas

DLCO 3.2.2 The air dose from noble gases released in gaseous effluents from each unit to areas at or beyond the SITE BOUNDARY (Figure D 4.1-1) shall be limited to:

a. 5 mrad to the whole body from gamma radiation and
10 mrad to the skin from beta radiation during any calendar quarter,

and

b. 10 mrad to the whole body from gamma radiation and
20 mrad to the skin from beta radiation during any calendar year.

APPLICABILITY: At all times.

ACTIONS

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---|---|---|
| A. The calculated air dose at or beyond the SITE BOUNDARY due to noble gases released in gaseous effluents exceeds limits. | A.1 Prepare and submit to the NRC, pursuant to D 5.3, a Special Report that (1) Identifies the cause(s) for exceeding the limit(s) and (2) Defines the corrective actions that have been taken to reduce the releases and the proposed corrective actions to be taken to assure that subsequent releases will be in compliance with DLCO 3.2.2. | 30 days |

ACTIONS (continued)

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---|---|---|
| B. Calculated dose to a MEMBER OF THE PUBLIC from the release of radioactive materials in airborne effluents exceeds 2 times the limits. | B.1 Calculate the annual dose to a MEMBER OF THE PUBLIC which includes contributions from direct radiation from the units (including outside storage tanks, etc.). | Immediately |
| | <u>AND</u> | |
| | B.2 Verify that the limits of DLCO 3.4 have not been exceeded. | Immediately |
| C. Required Action B.2 and Associated Completion time not met. | C.1 Prepare and submit to the NRC, pursuant to D 5.3, a Special Report, as defined in 10 CFR 20.2203 (a)(4), of Required Action A.1 shall also include the following:<br>(1) The corrective action(s) to be taken to prevent recurrence of exceeding the limits of DLCO 3.4 and the schedule for achieving conformance,<br>(2) An analysis that estimates the dose to a MEMBER OF THE PUBLIC from uranium fuel cycle sources, including all effluent pathways and direct radiation, for the calendar year that includes the release(s), and<br>(3) Describes the levels of radiation and concentrations of radioactive material involved and the cause of the exposure levels or | 30 days |

SURVEILLANCE REQUIREMENTS

| SURVEILLANCE | | FREQUENCY |
|---|---|---|
| DSR 3.2.2.1 | Determine cumulative dose contributions for the current calendar quarter and current calendar year. | 31 days |

## D 3.2 RADIOACTIVE GASEOUS EFFLUENTS

### D 3.2.3 Gaseous Effluent Dose – Iodine and Particulate

DLCO 3.2.3 The dose to a MEMBER OF THE PUBLIC from I-131, tritium, and all radionuclides in particulate form with half-lives > 8 days, in gaseous effluents, released from each unit to areas at or beyond the SITE BOUNDARY (Figure D 4.1-1) shall be limited to:

a. 7.5 mrem to any organ during any calendar quarter, and

b. 15 mrem to any organ during any calendar year.

APPLICABILITY: At all times.

ACTIONS

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---|---|---|
| A. The dose from I-131, tritium, and radioactive material in particulate form with half-lives > 8 days released in gaseous effluents at or beyond the SITE BOUNDARY exceeds limits. | A.1 Prepare and submit to the NRC, pursuant to D 5.3, a Special Report that<br>(1) Identifies the cause(s) for exceeding the limit(s)<br>and<br>(2) Defines the corrective actions that have been taken to reduce the releases and the proposed corrective actions to be taken to assure that subsequent releases will be in compliance with DLCO 3.2.3. | 30 days |

ACTIONS (continued)

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---|---|---|
| B. Calculated dose to a MEMBER OF THE PUBLIC from the release of radioactive materials in liquid effluents exceeds 2 times the limits. | B.1 Calculate the annual dose to a MEMBER OF THE PUBLIC which includes contributions from direct radiation from the units (including outside storage tanks, etc.). | Immediately |
| | AND | |
| | B.2 Verify that the limits of DLCO 3.4 have not been exceeded. | Immediately |
| C. Required Action B.2 and Associated Completion time not met. | C.1 Prepare and submit to the NRC, pursuant to D 5.3, a Special Report, as defined in 10 CFR 20.2203 (a)(4), of Required Action A.1 shall also include the following:<br>(1) The corrective action(s) to be taken to prevent recurrence of exceeding the limits of DLCO 3.4 and the schedule for achieving conformance,<br>(2) An analysis that estimates the dose to a MEMBER OF THE PUBLIC from uranium fuel cycle sources, including all effluent pathways and direct radiation, for the calendar year that includes the release(s), and<br>(3) Describes the levels of radiation and concentrations of radioactive material involved and the cause of the exposure levels or | 30 days |

SURVEILLANCE REQUIREMENTS

| SURVEILLANCE | | FREQUENCY |
|---|---|---|
| DSR 3.2.3.1 | Determine cumulative dose contributions for the current calendar quarter and current calendar year for I-131, tritium, and radioactive material in particulate form with half-lives > 8 days. | 31 days |

## D 3.2 RADIOACTIVE GASEOUS EFFLUENTS

### D 3.2.4 Gaseous Radwaste Treatment System

DLCO 3.2.4 The GASEOUS RADWASTE TREATMENT SYSTEM shall be in operation when projected gaseous effluent doses, from each unit, at and beyond the SITE BOUNDARY (Figure D 4.1-1) would be:

a. > 0.2 mrad for gamma radiation; and

b. > 0.4 mrad for beta radiation in a 31 day period.

APPLICABILITY: Prior to each release.

ACTIONS

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---|---|---|
| A. Radioactive gaseous waste is being discharged without treatment.<br><br><u>AND</u><br><br>Projected doses due to the gaseous effluent, from the unit, at and beyond the SITE BOUNDARY would exceed limits. | A.1 Prepare and submit to the NRC, pursuant to D 5.3, a Special Report that includes the following:<br>(1) Identification of any inoperable equipment or subsystems and the reason for the inoperability,<br>(2) Action(s) taken to restore the inoperable equipment to OPERABLE status, and<br>(3) Summary description of action(s) taken to prevent a recurrence. | 30 days |

SURVEILLANCE REQUIREMENTS

| SURVEILLANCE | | FREQUENCY |
|---|---|---|
| DSR 3.2.4.1 | Project the doses due to gaseous effluents from each unit at and beyond the SITE BOUNDARY. | 31 days |

## D 3.2 RADIOACTIVE GASEOUS EFFLUENTS

### D 3.2.5 Ventilation Exhaust Treatment System

DLCO 3.2.5 The VENTILATION EXHAUST TREATMENT SYSTEM shall be in operation when projected gaseous effluent doses, from each unit, at and beyond the SITE BOUNDARY (Figure D 4.1-1) would be:

a. > 0.2 mrad air dose from gamma radiation; and

b. > 0.4 mrad air dose from beta radiation in a 31 day period; or

c. > 0.3 mrem to any organ in a 31 day period.

APPLICABILITY: Prior to each release.

ACTIONS

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---|---|---|
| A. Radioactive gaseous waste is being discharged without treatment.<br><br>AND<br><br>Projected doses due to gaseous effluent, from each unit, to areas at or beyond the SITE BOUNDARY would exceed limits. | A.1 Prepare and submit to the NRC, pursuant to D 5.3, a Special Report that includes the following:<br>(1) Identification of any inoperable equipment or subsystems and the reason for the inoperability,<br>(2) Action(s) taken to restore the inoperable equipment to OPERABLE status, and<br>(3) Summary description of action(s) taken to prevent a recurrence. | 30 days |

SURVEILLANCE REQUIREMENTS

| SURVEILLANCE | | FREQUENCY |
|---|---|---|
| DSR 3.2.5.1 | Project the doses from gaseous releases from each unit to areas at and beyond the SITE BOUNDARY when the GASEOUS RADWASTE TREATMENT SYSTEMS are not being fully utilized. | 31 days |

## D 3.2 GASEOUS EFFLUENTS

### D 3.2.6 Gas Storage Tanks

DLCO 3.2.6 The radioactivity contained in each gas storage tank shall be limited to the following unit-specific curie levels of noble gas (considered as Xe-133):

Unit 2: $\leq$ 29,761 Curies    Unit 3: $\leq$ 50,000 Curies

APPLICABILITY: At all times.

ACTIONS

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---|---|---|
| A. Level of radioactivity exceeds the limits. | A.1 Suspend addition of radioactive material.<br><br><u>AND</u><br><br>A.2 Reduce content to within the limits. | Immediately<br><br><br><br>48 hours |

SURVEILLANCE REQUIREMENTS

| SURVEILLANCE | | FREQUENCY |
|---|---|---|
| DSR 3.2.6.1 | The quantity of radioactive material contained in each gas storage tank shall be determined to be within the limits above, at least once per 24 hours when radioactive materials are being added to the tank in accordance with the methodology and parameters in the ODCM. | 24 hours during addition of radioactive material to the tank |

## D 3.3 INSTRUMENTATION

### D 3.3.1 Radioactive Liquid Effluent Monitoring Instrumentation

DLCO 3.3.1 The unit-specific radioactive liquid effluent monitoring instrumentation channels shown in Table D 3.3.1-1 shall be OPERABLE with:

a. The minimum OPERABLE channel(s) in service.

b. The alarm/trip setpoints set to ensure that the limits of DLCO 3.1.1 are not exceeded.

APPLICABILITY: According to Table D 3.3.1-1 for the applicable unit.

ACTIONS

---------------------------------------------------------------NOTE---------------------------------------------------
Separate condition entry is allowed for each channel.
-------------------------------------------------------------------------------------------------------------------

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---|---|---|
| A. Liquid effluent monitoring instrumentation channel alarm/trip setpoint less conservative than required. | A.1 Suspend the release of radioactive liquid effluents monitored by the affected channel. | Immediately |
| | <u>OR</u> | |
| | A.2 Declare the channel inoperable. | Immediately |
| | <u>OR</u> | |
| | A.3 Change the setpoint so it is acceptably conservative. | Immediately |

ACTIONS (continued)

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---|---|---|
| B. One or more required channels inoperable. | B.1 Enter the Condition referenced in Table D 3.3.1-1 for the channel.<br><br>AND<br><br>B.2 Restore inoperable channel(s) to OPERABLE status. | Immediately<br><br><br><br>30 days<br><br>. |
| C. As required by Required Action B.1 and referenced in Table D 3.3.1-1. | C.1 Analyze at least 2 independent samples in accordance with Table D 3.1.1-1.<br><br>AND<br><br>C.2 -----------NOTE----------------<br>Verification Action will be performed by at least 2 separate technically qualified members of the facility staff.<br>----------------------------------<br><br>Independently verify the release rate calculations and discharge line valving. | Prior to initiating a release<br><br><br><br><br><br>Prior to initiating a release |
| D. As required by Required Action B.1 and referenced in Table D 3.3.1-1. | D.1 Collect and analyze grab samples for radioactivity at a limit of detection of at least $5 \times 10^{-7}$ μCi/ml. | 12 hours<br><br>AND<br><br>Once per 12 hours thereafter |

ACTIONS (continued)

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---|---|---|
| E. As required by Required Action B.1 and referenced in Table D 3.3.1-1. | E.1 Collect and analyze grab samples for radioactivity at a limit of detection of at least 5 x $10^{-7}$ μCi/ml, when specific activity is > 0.01 μCi/gm DOSE EQUIVALENT I-131. | 12 hours<br><br>AND<br><br>Once per 12 hours thereafter |
| | OR | |
| | E.2 Collect and analyze grab samples for radioactivity at a limit of detection of at least 5 x $10^{-7}$ μCi/ml, when specific activity is ≤ 0.01 μCi/gm DOSE EQUIVALENT I-131. | 24 hours<br><br>AND<br><br>Once per 24 hours thereafter |
| F. As required by Required Action B.1 and referenced in Table D 3.3.1-1. | F.1 ---------------NOTE------------<br>Pump performance curves generated in place may be used to estimate flow.<br>----------------------------------<br><br>Estimate the flow rate during actual releases. | 4 hours<br><br>AND<br><br>Once per 4 hours thereafter |
| G. As required by Required Action B.1 and referenced in Table D 3.3.1-1. | G.1 Estimate tank liquid level. | Immediately<br><br>AND<br><br>During liquid additions to the tank |
| H. Required Action B.2 and associated Completion Time not met. | H.1 Explain in the next Radioactive Effluent Release Report why the inoperability was not corrected in a timely manner. | In accordance with Radioactive Effluent Release Report |

ACTIONS (continued)

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---|---|---|
| I. Required Action and associated Completion Time for Condition C, D, E, or F not met. | I.1 Suspend liquid effluent releases monitored by the inoperable channel(s). | Immediately |
| J. Required Action and associated Completion Time for Condition G not met. | J.1 Suspend liquid additions to the tank monitored by the inoperable channel(s). | Immediately |

SURVEILLANCE REQUIREMENTS

---------------------------------------------------- NOTE ----------------------------------------------------
Refer to Table D 3.3.1-1 to determine which DSRs apply for each function.
-------------------------------------------------------------------------------------------------------------

| SURVEILLANCE | | FREQUENCY |
|---|---|---|
| DSR 3.3.1.1 | Perform CHANNEL CHECK. | 24 hours |
| DSR 3.3.1.2 | Perform CHANNEL CHECK by verifying indication of flow during periods of release. | 24 hours on any day on which continuous, periodic, or batch releases are made |
| DSR 3.3.1.3 | Perform SOURCE CHECK. | Prior to release |
| DSR 3.3.1.4 | Perform SOURCE CHECK. | 31 days |
| DSR 3.3.1.5 | Perform CHANNEL OPERATIONAL TEST | 92 days |

SURVEILLANCE REQUIREMENTS (continued)

| SURVEILLANCE | | FREQUENCY |
|---|---|---|
| DSR 3.3.1.6 | Perform CHANNEL OPERATIONAL TEST. The CHANNEL OPERATIONAL TEST shall also demonstrate that automatic isolation of this pathway and control room alarm annunciation (or control panel indications/display) occurs if the instrument indicates measured levels above the alarm/trip setpoint | 92 days |
| DSR 3.3.1.7 | Perform CHANNEL OPERATIONAL TEST. The CHANNEL OPERATIONAL TEST shall also demonstrate control room alarm annunciation (or control panel indications/display) occurs if any of the following conditions exist, instrument indicates measured levels above the alarm setpoint, instrument controls not set in operate mode. | 92 days |
| DSR 3.3.1.8 | Perform CHANNEL OPERATIONAL TEST | 24 months |
| DSR 3.3.1.9 | Perform CHANNEL CALIBRATION | 24 months |

Table D 3.3.1-1 (page 1 of 3)
Radioactive Liquid Effluent Monitoring Instrumentation – Units 1, 2, and 3

| INSTRUMENT | APPLICABILITY OR OTHER SPECIFIED CONDITIONS | REQUIRED CHANNELS PER INSTRUMENT | CONDITIONS REFERENCED FROM REQUIRED ACTION B.1 | SURVEILLANCE REQUIREMENTS |
|---|---|---|---|---|
| 1. **Gross Radioactivity Monitors Providing Alarm and Automatic Termination of Release** | | | | |
| a. Unit 2 Liquid Radioactive Waste Effluent Line *(R-54)* | (a) | 1 | C | DSR 3.3.1.1<br>DSR 3.3.1.3<br>DSR 3.3.1.6 (e)<br>DSR 3.3.1.9 (d) |
| b. Unit 2 Steam Generator Effluent Blowdown Line *(R-49)* | (a) (i) | 1 | E | DSR 3.3.1.1<br>DSR 3.3.1.4<br>DSR 3.3.1.6 (e)<br>DSR 3.3.1.9 (d) |
| c. Unit 3 Liquid Radioactive Waste Effluent Line *(R-18)* | (a) | 1 | C | DSR 3.3.1.1<br>DSR 3.3.1.3<br>DSR 3.3.1.6 (e)<br>DSR 3.3.1.9 (d) |
| d. Unit 3 Condensate Polisher Facility (CPF) Waste Line *(R-61)* | (a) | 1 | C | DSR 3.3.1.1 (h)<br>DSR 3.3.1.4 (h)<br>DSR 3.3.1.6 (e)<br>DSR 3.3.1.9 (d) |
| e. Unit 3 Steam Generator Effluent Blowdown Line *(R-19)* | (a) (i) | 1 | E | DSR 3.3.1.1<br>DSR 3.3.1.4<br>DSR 3.3.1.6 (e)<br>DSR 3.3.1.9 (d) |
| 2. **Gross Beta or Gamma Radioactivity Monitors Providing Alarm but NOT Providing Automatic Termination of Release** | | | | |
| a. Unit 1 or 2 Service Water or River Water Effluent Lines<br>- VC FCU *(R-46* or *R-53)*<br>- 21 CCW HX *(R-39)*<br>- 22 CCW HX *(R-40)* | (a) | 1 (g) | D | DSR 3.3.1.1<br>DSR 3.3.1.4<br>DSR 3.3.1.7 (e)<br>DSR 3.3.1.9 (d) |
| b. Unit 1 Sphere Foundation Drain Sump Effluent Line *(R-62)* | (a) | 1 | D | DSR 3.3.1.1<br>DSR 3.3.1.4<br>DSR 3.3.1.7 (e)<br>DSR 3.3.1.9 (d) |
| c. Unit 3 Service Water Effluent Lines | | | | |
| - SW for VC FCU return *(R-16A or R-16B)* | (a) | 1 (g) | D | DSR 3.3.1.1<br>DSR 3.3.1.4<br>DSR 3.3.1.7 (e)<br>DSR 3.3.1.9 (d) |
| - SW for CCW Heat Exchanger *(R-23)* | (a) | 1 | D | DSR 3.3.1.1<br>DSR 3.3.1.4<br>DSR 3.3.1.7 (e)<br>DSR 3.3.1.9 (d) |

Table D 3.3.1-1 (page 2 of 3)
Radioactive Liquid Effluent Monitoring Instrumentation – Units 1, 2, and 3

| INSTRUMENT | APPLICABILITY OR OTHER SPECIFIED CONDITIONS | REQUIRED CHANNELS PER INSTRUMENT | CONDITIONS REFERENCED FROM REQUIRED ACTION B.1 | SURVEILLANCE REQUIREMENTS |
|---|---|---|---|---|
| 3. **Flow Rate Measurement Devices** | | | | |
| a. Unit 2 Liquid Radwaste Effluent Line | (a) | 1 | F | DSR 3.3.1.2<br>DSR 3.3.1.5<br>DSR 3.3.1.9 |
| b. Unit 2 Steam Generator Blowdown Effluent Line | (a) (i) | 1 | F | DSR 3.3.1.2<br>DSR 3.3.1.5<br>DSR 3.3.1.9 |
| c. Unit 1 North Curtain Drain Effluent Line (f) | (a) | 1 | F | DSR 3.3.1.2<br>DSR 3.3.1.9 |
| d. Unit 1 Sphere Foundation Drain Sump (f) | (a) | 1 | F | DSR 3.3.1.2<br>DSR 3.3.1.9 |
| e. Unit 3 Liquid Radwaste Effluent Line | (a) | 1 | F | DSR 3.3.1.2<br>DSR 3.3.1.5<br>DSR 3.3.1.9 |
| f. Unit 3 Cond Polisher (CPF) Effluent Line | (a) | 1 | F | DSR 3.3.1.2<br>DSR 3.3.1.5<br>DSR 3.3.1.9 (h) |
| g. Unit 3 Steam Generator Blowdown Effluent Line | (a) (i) | 1 | F | DSR 3.3.1.2<br>DSR 3.3.1.5<br>DSR 3.3.1.9 |
| 4. **Tank Level Indicating Devices** (c) | | | | |
| a. Unit 1 Waste Distillate Storage Tank #13 | (a) | 1 | G | DSR 3.3.1.1 (b)<br>DSR 3.3.1.5<br>DSR 3.3.1.9 |
| b. Unit 1 Waste Distillate Storage Tank #14 | (a) | 1 | G | DSR 3.3.1.1 (b)<br>DSR 3.3.1.5<br>DSR 3.3.1.9 |
| c. Unit 2 Primary Water Storage Tank | (a) | 1 | G | DSR 3.3.1.1 (b)<br>DSR 3.3.1.5<br>DSR 3.3.1.9 |
| d. Unit 2 Refueling Water Storage Tank | (a) | 1 | G | DSR 3.3.1.1 (b)<br>(j) |
| e. Unit 3 Refueling Water Storage Tank | (a) | 1 | G | DSR 3.3.1.1 (b)<br>(j) |

Table D 3.3.1-1 (page 3 of 3)
Radioactive Liquid Effluent Monitoring Instrumentation – Units 1, 2, and 3

| INSTRUMENT | APPLICABILITY OR OTHER SPECIFIED CONDITIONS | REQUIRED CHANNELS PER INSTRUMENT | CONDITIONS REFERENCED FROM REQUIRED ACTION B.1 | SURVEILLANCE REQUIREMENTS |
|---|---|---|---|---|
| 4. **Tank Level Indicating Devices** (c) | (continued) | | | |
| f. Unit 3 Primary Water Storage Tank | (a) | 1 | G | DSR 3.3.1.1 (b)<br>DSR 3.3.1.8<br>DSR 3.3.1.9 |
| g. Unit 3 Monitor Tank #31 | (a) | 1 | G | DSR 3.3.1.1 (b)<br>DSR 3.3.1.8<br>DSR 3.3.1.9 |
| h. Unit 3 Monitor Tank #32 | (a) | 1 | G | DSR 3.3.1.1 (b)<br>DSR 3.3.1.8<br>DSR 3.3.1.9 |
| i. Unit 3 CPF High Total Dissolved Solids Tank | (a) | 1 | G | DSR 3.3.1.1 (b)<br>DSR 3.3.1.8<br>DSR 3.3.1.9 (h) |
| j. Unit 3 CPF Low Total Dissolved Solids Tank | (a) | 1 | G | DSR 3.3.1.1 (b)<br>DSR 3.3.1.8<br>DSR 3.3.1.9 (h) |

**NOTES**

(a) Applicability is defined as anytime releases are being performed via this pathway. During periods of release, channels shall be OPERABLE and in service on a continuous basis, except that outages are permitted, within the time frame of the specified action, for the purpose of maintenance and performance of required CHANNEL CHECK, SOURCE CHECK, CHANNEL CALIBRATION, or CHANNEL OPERATIONAL TEST.

(b) During liquid addition to the associated tank.

(c) Tanks included in this Specification are those outdoor tanks that are not surrounded by liners, dikes, or walls capable of holding the tank contents and do not have tank overflows and surrounding area drains connected to the liquid radwaste treatment system, as specified in RECS Section D 3.1.4.

(d) Radioactive calibration standards used for CHANNEL CALIBRATIONS shall be analyzed with instrumentation which is calibrated NIST traceable standards. Standards from suppliers who participate in approved measurement assurance activities with NIST are acceptable.

(e) Test will include: Low sample flow, no counts per minute failure, and alarm setpoint reached. The CHANNEL OPERATIONAL TEST does not include testing or trouble shooting, nor the performance of any equipment diagnostic capabilities provided with the monitor installation.

(f) Flow rate for these continuous intermittent release pathways is normally obtained from a flow totalizer on the system outlet.

(g) One instrument per operating Service Water system is required. For example, unit-specific VC FCU monitors are redundant and compensatory actions are only required when BOTH monitors are OOS for any one unit. However, for Unit 2's CCW HX's (R-39 and R-40), the appropriate SW monitor is required to be in service anytime the effected loop is in service.

(h) Channel and Source Checks for effluent instrumentation/indication in Unit 3's Condensate Polisher Facility (CPF) are required only during or after a primary to secondary leak, as defined in RECS Section 1. Surveillances on these items are performed to be prepared for this type of leak. The level instrument calibration is also required by the SPDES permit.

(i) Applicable for Continuous Steam Generator Blowdown to the environment only. These requirements are not applicable for Batch Steam Generator Draindowns.

(j) Surveillance requirements for the RWST level instruments (CHECKS and CALIBRATIONS) are prescribed in Technical Specifications (Sections 3.3.3 and 3.5.4 for Unit 2 and Section 3.5.4 for Unit 3). However, the requirement for a daily channel check (when making additions to the tank, per earlier footnote b) is maintained in the ODCM per the original licensing bases (NUREG 0472) and the 10 curie rule.

## D 3.3 INSTRUMENTATION

### D 3.3.2 Radioactive Gaseous Effluent Monitoring Instrumentation

DLCO 3.3.2 The radioactive gaseous effluent monitoring instrumentation channels shown in Table D 3.3.2-1 shall be OPERABLE with:

a. The minimum OPERABLE channel(s) in service.

b. The alarm/trip setpoints set to ensure that the limits of DLCO 3.2.1 are not exceeded.

APPLICABILITY: According to Table D 3.3.2-1.

ACTIONS

------------------------------------------------------------NOTE------------------------------------------------------------
Separate condition entry is allowed for each channel.
--------------------------------------------------------------------------------------------------------------------------------

| | | |
|---|---|---|
| A. Gaseous effluent monitoring instrumentation channel alarm/trip setpoint less conservative than required. | A.1 Suspend the release of radioactive gaseous effluents monitored by the affected channel. | Immediately |
| | <u>OR</u> | |
| | A.2 Declare the channel inoperable. | Immediately |
| | <u>OR</u> | |
| | A.3 Change the setpoint so it is acceptably conservative. | Immediately |
| B. One or more channels inoperable. | B.1 Enter the Condition referenced in Table D 3.3.2-1 for the channel. | Immediately |
| | <u>AND</u> | |
| | B.2 Restore inoperable channel(s) to OPERABLE status. | 30 days |

ACTIONS (continued)

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---|---|---|
| C. As required by Required Action B.1 and referenced in Table D 3.3.2-1. | C.1 Take grab samples.<br><br>AND<br><br>C.2 Analyze samples for gross activity. | 12 hours<br><br>AND<br><br>Once per 12 hours thereafter<br><br>24 hours from time of sampling completion |
| D. As required by Required Action B.1 and referenced in Table D 3.3.2-1. | D.1 Estimate the flow rate for the inoperable channel(s). | 4 hours<br><br>AND<br><br>Once per 4 hours thereafter |
| E. As required by Required Action B.1 and referenced in Table D 3.3.2-1. | E.1 Continuously collect samples using auxiliary sampling equipment as required in | 8 hours |
| F. As required by Required Action B.1 and referenced in Table D 3.3.2-1. | F.1 Determine the radioactive content of the receiving gas decay tank is in compliance with DLCO 3.2.1. | 24 hours<br><br>AND<br><br>Once per 24 hours thereafter |

ACTIONS (continued)

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---|---|---|
| G. As required by Required Action B.1 and referenced in Table D 3.3.2-1, for gas decay tank releases. | G.1 Analyze at least 2 independent samples in accordance with Table D 3.2.1-1.<br><br><u>AND</u><br><br>G.2 -----------NOTE----------------<br>Verification Action will be performed by at least 2 separate technically qualified members of the facility staff.<br>----------------------------------<br><br>Independently verify the release rate calculations and | Prior to initiating a gas decay tank release<br><br>Prior to initiating a gas decay tank release |
| H. Required Action B.2 and associated Completion Time not met. | H.1 Explain in the next Radioactive Effluent Release Report why the inoperability was not corrected in a timely | In accordance with Radioactive Effluent Release Report frequency |
| I. Required Action and associated Completion Time for Condition C, D, E or F not met. | I.1 Suspend gaseous effluent releases monitored by the inoperable channel(s). | Immediately |
| J. Required Action and associated Completion Time for Condition G not met. | J.1 Suspend gaseous effluent releases from Waste Gas Holdup System. | Immediately |
| K. As required by Required Action B.1 and referenced in Table D 3.3.2-1 (in MODES 1-4 only). | K.1 Take Noble Gas grab samples and analyze for gross activity.<br><br>K.2 Immediately suspend PURGING the VC. | Prior to venting Vapor Containment (VC) |

SURVEILLANCE REQUIREMENTS

| SURVEILLANCE | | FREQUENCY |
|---|---|---|
| DSR 3.3.2.1 | Perform CHANNEL CHECK. | 24 hours |
| DSR 3.3.2.2 | Perform CHANNEL CHECK. | 7 days |
| DSR 3.3.2.3 | Perform SOURCE CHECK. | Prior to release |
| DSR 3.3.2.4 | Perform SOURCE CHECK. | 31 days |
| DSR 3.3.2.5 | Perform CHANNEL OPERATIONAL TEST.<br><br>The test shall include 1) low sample flow, 2) no counts per minute failure, 3) a demonstration of the automatic isolation capability of this pathway and that control room alarm annunciation (or control panel indications/display) occurs if the instrument indicates measured levels above the alarm/trip setpoint.<br><br>This test does NOT include testing of troubleshooting and equipment diagnostic capabilities provided with the monitor installation. | 92 days |
| DSR 3.3.2.6 | Perform CHANNEL OPERATIONAL TEST.<br><br>The test shall include 1) low sample flow (except for Condenser Air Ejector monitors), 2) no counts per minute failure, 3) a demonstration that control room alarm annunciation (or control panel indications or display) occurs if the instrument indicates measured levels above the alarm setpoint, or the instrument controls are not set in operate mode.<br><br>This test does NOT include testing of troubleshooting and equipment diagnostic capabilities provided with the monitor installation. | 92 days |
| DSR 3.3.2.7 | Perform CHANNEL CALIBRATION. | 24 months |

Table D 3.3.2-1 (page 1 of 4)
Radioactive Gaseous Effluent Monitoring Instrumentation – Units 1, 2, and 3

| INSTRUMENT and APPLICABLE UNIT (1, 2, or 3) | APPLICABILITY OR OTHER SPECIFIED CONDITIONS | REQUIRED CHANNELS PER INSTRUMENT | CONDITIONS REFERENCED FROM REQUIRED | SURVEILLANCE REQUIREMENTS |
|---|---|---|---|---|
| 1. Waste Gas Holdup System | | | | |
| a. Unit 2 Noble Gas Monitor, providing Alarm, *(R-50)* | (b) | 1 | F | DSR 3.3.2.1<br>DSR 3.3.2.4<br>DSR 3.3.2.6<br>DSR 3.3.2.7 (c) |
| b. Unit 3 Noble Gas Monitor, providing Alarm, *(R-20)* | (b) | 1 | F | DSR 3.3.2.1<br>DSR 3.3.2.4<br>DSR 3.3.2.6<br>DSR 3.3.2.7 (c) |
| 2. Condenser Air Evacuation System | | | | |
| a. Unit 3 Noble Gas Activity, (R-15) | (a) | 1 | C | *DSR 3.3.2.1*<br>*DSR 3.3.2.4*<br>*DSR 3.3.2.6 (d)*<br>*DSR 3.3.2.7 (c)* 4/21 |
| 3. Vapor Containment Atmosphere | | | | |
| a. Unit 3 Noble Gas Activity Monitor, providing ALARM and automatic termination of release *(R-12)* | (a) | 1 | K | DSR 3.3.2.4 (g) 4/21 |

Table D 3.3.2-1 (page 2 of 4)
Radioactive Gaseous Effluent Monitoring Instrumentation – Units 1, 2, and 3

| INSTRUMENT and APPLICABLE UNIT (1, 2, or 3) | APPLICABILITY OR OTHER SPECIFIED CONDITIONS | REQUIRED CHANNELS PER INSTRUMENT | CONDITIONS REFERENCED FROM REQUIRED | SURVEILLANCE REQUIREMENTS |
|---|---|---|---|---|
| 4. **Unit 2 Main Plant Vent** | | | | |
| *Radiation Monitor:* | | | | |
| a. Noble Gas Monitor *(R-44)* | (a) & (b) | 1 | C & G | DSR 3.3.2.1<br>DSR 3.3.2.4<br>DSR 3.3.2.5<br>DSR 3.3.2.7 (c) |
| *Other Monitoring Equipment:* | | | | |
| b. Particulate Sampler | (a) | 1 | E | DSR 3.3.2.2 |
| c. Process Flow-Rate Monitor *(SV2-DPT, SV2-1-DPT, SV2-DPI)* | (a) | 1 | D | DSR 3.3.2.1<br>DSR 3.3.2.7 |
| d. Sample Flow-Rate Monitor *(Chem Totalizer)* | (a) | 1 | D | DSR 3.3.2.1<br>DSR 3.3.2.7 |
| 5. **Unit 3 Main Plant Vent** | | | | |
| *Radiation Monitor:* | | | | |
| a. Noble Gas Monitor(s) *(R-14 or R-27)* | (a) & (b) | 1 | C & G | DSR 3.3.2.1<br>DSR 3.3.2.4<br>DSR 3.3.2.5<br>DSR 3.3.2.7 (c) |
| *Other Monitoring Equipment:* | | | | |
| b. Iodine Sampler | (a) | 1 | E | DSR 3.3.2.2 |
| c. Particulate Sampler | (a) | 1 | E | DSR 3.3.2.2 |
| d. Process Flow-Rate Monitor *(from R-27's Kurz probes and RM80 processing computer)* | (a) | 1 | D | DSR 3.3.2.1<br>DSR 3.3.2.7 |
| e. Sample Flow-Rate Monitor *(Chem Totalizer)* | (a) | 1 | D | DSR 3.3.2.1<br>DSR 3.3.2.7 |

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Table D 3.3.2-1 (page 3 of 4)
Radioactive Gaseous Effluent Monitoring Instrumentation – Units 1, 2, and 3

| INSTRUMENT and APPLICABLE UNIT (1, 2, or 3) | APPLICABILITY OR OTHER SPECIFIED CONDITIONS | REQUIRED CHANNELS PER INSTRUMENT | CONDITIONS REFERENCED FROM REQUIRED | SURVEILLANCE REQUIREMENTS |
|---|---|---|---|---|
| 6. **Unit 1 Stack Vent** | | | | |
| *Radiation Monitor:* | | | | |
| a. Noble Gas Monitor *(R-60)* | (a) | 1 | C | DSR 3.3.2.1<br>DSR 3.3.2.4<br>DSR 3.3.2.6<br>DSR 3.3.2.7 (c) |
| *Other Monitoring Equipment:* | | | | |
| b. Particulate Sampler | (a) | 1 | E | DSR 3.3.2.2 |
| c. Process Flow-Rate Monitor *(SV1-DPT, SV1-FR)* | (a) | 1 | D | DSR 3.3.2.1<br>DSR 3.3.2.7 |
| d. Sample Flow-Rate Monitor *(Chem Totalizer)* | (a) | 1 | D | DSR 3.3.2.1<br>DSR 3.3.2.7 |
| 7. **Unit 3 Radioactive Machine Shop (RAMS) Vent** | | | | |
| *Radiation Monitor:* | | | | |
| a. Noble Gas Monitor *(R-59)* | (a) | 1 | C | DSR 3.3.2.1<br>DSR 3.3.2.4<br>DSR 3.3.2.6<br>DSR 3.3.2.7 (c) |
| *Other Monitoring Equipment:* | | | | |
| b. Iodine Sampler | (a) | 1 | E | DSR 3.3.2.2 |
| c. Particulate Sampler | (a) | 1 | E | DSR 3.3.2.2 |
| d. Process Flow-Rate Monitor *(from R-59's RM80 processor)* | (a) | 1 | D | DSR 3.3.2.1<br>DSR 3.3.2.7 |
| e. Sample Flow-Rate Monitor *(Chem Totalizer)* | (a) | 1 | D | DSR 3.3.2.1<br>DSR 3.3.2.7 |

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Table D 3.3.2-1 (page 4 of 4)
Radioactive Gaseous Effluent Monitoring Instrumentation – Units 1, 2, and 3

| INSTRUMENT and APPLICABLE UNIT (1, 2, or 3) | APPLICABILITY OR OTHER SPECIFIED CONDITIONS | REQUIRED CHANNELS PER INSTRUMENT | CONDITIONS REFERENCED FROM REQUIRED | SURVEILLANCE REQUIREMENTS |
|---|---|---|---|---|
| 8. **Unit 3 Admin Bldg Vent** (f) | | | | |
| *Radiation Monitor:* | | | | |
| a. Noble Gas Monitor *(R-46)* | (a) | 1 | C | DSR 3.3.2.1<br>DSR 3.3.2.4<br>DSR 3.3.2.6<br>DSR 3.3.2.7 (c) |
| *Other Monitoring Equipment:* | | | | |
| b. Iodine Sampler | (a) | 1 | E | DSR 3.3.2.2 |
| c. Particulate Sampler | (a) | 1 | E | DSR 3.3.2.2 |
| d. Sample Flow-Rate Monitor *(Chem Totalizer)* | (a) | 1 | D | DSR 3.3.2.1<br>DSR 3.3.2.7 |

## NOTES

(a) During release via this pathway. Channels shall be OPERABLE and in service on a continuous basis, except that outages are permitted, within the time frame of the specified action for the purpose of maintenance and performance of required CHANNEL CHECK, SOURCE CHECK, CHANNEL CALIBRATION, or CHANNEL OPERATIONAL TEST.

(b) During waste gas holdup system operation (treatment for primary system off-gases).

(c) Radioactive Calibration Standards used for channel calibrations shall be traceable to the National Institute of Standards and Technology (NIST) or an aliquot of calibration gas shall be analyzed with instrumentation which is calibrated with NIST traceable standards. Standards from suppliers who participate in measurement assurance activities with NIST are acceptable.

(d) The CHANNEL OPERATIONAL TEST for the Condenser Air Ejector monitors does NOT require a loss of sample flow test.

(e) The main Plant Vents for Units 2 and 3 monitors the Fuel Storage Building vents, in addition to ventilation from the Primary Auxiliary Buildings.

(f) The Unit 3 Admin Bldg Controlled Area ventilation system does NOT have an installed process flow meter. Default fan flow is used in lieu of a measurement , per ODCM Part II, Section 3.1.11.

(g) Most surveillance requirements for Vapor Containment monitors are located in Technical Specifications, Section 3.3.6. Source checks, however, are NOT required per Technical Specifications. Since these checks are valuable to ensure accurate quantification of VC Pressure Reliefs (as described below), a monthly source check requirement is listed here, in addition to the requirements of Technical Specifications.

Grab samples of the Vapor Containment atmosphere are routinely collected at least monthly and compared to the gas monitor for use in quantification of VC Pressure Reliefs (by scaling the monitor reading for each release to the reading obtained at time of grab sample). If the noble gas monitor is inoperable, a grab samples shall be taken and analyzed within 24 hours prior to performing a Pressure Relief. During containment building ventilation in Modes 5 or 6, continuous monitoring and automatic termination of release is not required. In this condition, one continuous monitor at the Plant Vent is sufficient.

## D 3.4 RADIOACTIVE EFFLUENTS TOTAL DOSE

### D 3.4.1 Radioactive Effluents Total Dose

DLCO 3.4.1 The annual (calendar year) dose or dose commitment to any MEMBER OF THE PUBLIC due to releases of radioactivity and to radiation from uranium fuel cycle sources shall be limited to 25 mrem to the whole body or any organ, except the thyroid, which shall be limited to 75 mrem.

APPLICABILITY: At all times.

ACTIONS

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---|---|---|
| A. Estimated dose or dose commitment due to direct radiation and the release of radioactive materials in liquid or gaseous effluents exceeds the limits. | A.1 Verify the condition resulting in doses exceeding these limits has been corrected. | Immediately |
| B. Required Action and associated Completion Time not met. | B.1 --------------NOTE------------- This is the Special Report required by D 3.1.2, D 3.2.2, or D 3.2.3 supplemented with the following. ---------------------------------- | |
| | Submit a Special Report, pursuant to D 5.3, including a request for a variance in accordance with the provisions of 40 CFR 190. This submission is considered a timely request, and a variance is granted until staff action on the request is complete. | 30 days |

SURVEILLANCE REQUIREMENTS

| SURVEILLANCE | | FREQUENCY |
|---|---|---|
| DSR 3.4.1.1 | Perform a cumulative dose calculation due to radioactive material in gaseous and liquid effluents to determine compliance with DLCO 3.4.1. | 12 months |

## 3.5 RADIOLOGICAL ENVIRONMENTAL MONITORING

### D 3.5.1 Monitoring Program

DLCO 3.5.1 The Radiological Environmental Monitoring Program shall be conducted as specified in Table D 3.5.1-1.

APPLICABILITY: At all times.

ACTIONS

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---|---|---|
| A. Radiological Environmental Monitoring Program not conducted as specified in Table D 3.5.1-1. | A.1 Prepare and submit to the NRC in the Annual Radiological Environmental Operating Report, a description of the reasons for not conducting the program as required and the plans for preventing a recurrence. | In accordance with the Annual Radiological Environmental Operating Report frequency |
| B. Level of radioactivity in an environmental sampling medium at a specified location exceeds the reporting levels of Table D 3.5.1-2 when averaged over any calendar quarter.<br><br><u>OR</u> | B.1 ------------NOTES-------------<br>1. If the radioactivity (radionuclides) detected is not the result of plant effluents no report is necessary, however this condition needs to be described in the Annual Radiological Environmental Operating Report.<br><br>2. For radionuclides other than those in Table D 3.5.1-2, this report shall indicate the methodology and parameters used to estimate the potential annual dose to a MEMBER OF THE PUBLIC.<br>------------------------------------- | |

ACTIONS (continued)

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---|---|---|
| More than one of the radionuclides in Table D 3.5.1-2 are detected in the environmental sampling medium and<br><br>Concentration 1 + <br>reporting level 1<br><br>concentration 2 + … 1.0.<br>reporting level 2<br><br>OR<br><br>Radionuclides other than those in Table D 3.5.1-2 are detected in an environmental sampling medium at a specified location which are the result of plant effluents and the potential annual dose to a MEMBER OF THE PUBLIC from all radionuclides is the calendar year limits of Specifications D 3.1.2, D 3.2.2 or D 3.2.3. | Prepare and submit to the NRC, pursuant to D 5.3, a Special Report that<br>(1) Identifies the cause(s) for exceeding the limit(s) and<br>(2) Defines the corrective actions to be taken to reduce radioactive effluents so that the potential annual dose to a MEMBER OF THE PUBLIC is less than the calendar year limits of Specifications D 3.1.2, D 3.2.2, or D 3.2.3.<br>(3) For radionuclides other than those listed in Table D 3.5.1-2, this report shall indicate the methodology and parameters used to estimate the potential annual dose to a MEMBER OF THE PUBLIC. | 30 days |

ACTIONS (continued)

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---|---|---|
| C. Milk or fresh leafy vegetation samples unavailable from one or more of the sample locations required by Table D 3.5.1-1. | C.1 Identify specific locations for obtaining replacement samples and add them to the Radiological Environmental Monitoring Program. | 30 days |
| | <u>AND</u> | |
| | C.2 Delete the specific locations from which samples were unavailable from the Radiological Environmental Monitoring Program. | 30 days |
| | <u>AND</u> | |
| | C.3 Pursuant to D 5.2, submit in the next Radioactive Effluent Release Report documentation for a change in the ODCM reflecting the new location(s) with supporting information identifying the cause of the unavailability of samples and justifying the selection of the new location(s) for obtaining samples. | In accordance with the Radioactive Effluent Release Report |
| D. Environmental samples required in Table D 3.5.1-1 are unobtainable due to sampling equipment malfunctions. | D.1 Ensure all efforts are made to complete corrective action(s). | Prior to the end of the next sampling period |
| | <u>AND</u> | |
| | D.2 Report all deviations from the sampling schedule in the Annual Radiological Environmental Operating Report. | In accordance with the Annual Radiological Environmental Operating Report |

ACTIONS (continued)

| CONDITION | REQUIRED ACTION | | COMPLETION TIME |
|---|---|---|---|
| E. Samples required by Table D 3.5.1-1 not obtained in the media of choice, at the most desired location, or at the most desired time. | E.1 | Choose suitable alternative media and locations for the pathway in question. | 30 days |
| | AND | | |
| | E.2 | Make appropriate substitutions in the Radiological Environmental Monitoring Program. | 30 days |
| | AND | | |
| | E.3 | Submit in the next Radioactive Effluent Release Report documentation for a change in the ODCM reflecting the new location(s) with supporting information identifying the cause of the unavailability of samples for that pathway and justifying the selection of the new location(s) for obtaining samples. | In accordance with the Radioactive Effluent Release Report |

SURVEILLANCE REQUIREMENTS

| SURVEILLANCE | | FREQUENCY |
|---|---|---|
| DSR 3.5.1.1 | Collect and analyze radiological environmental monitoring samples pursuant to the requirements of Table D 3.5.1-1 and the detection capabilities required by Table D 3.5.1-3. | In accordance with Table D 3.5.1-1 |

Table D 3.5.1-1 (page 1 of 3)
Radiological Environmental Monitoring Program

| EXPOSURE PATHWAY AND/OR SAMPLE | NUMBER OF SAMPLE LOCATIONS | SAMPLE LOCATIONS (a) and DESIGNATIONS | SAMPLING AND COLLECTION FREQUENCY | TYPE AND FREQUENCY OF ANALYSIS |
|---|---|---|---|---|
| 1. Direct Radiation | 41 routine monitoring stations (b) (DR1-DR41) | (1) An inner ring of stations (DR1-DR16), one in each meteorological sector in the general area of the SITE BOUNDARY<br>(2) An outer ring of stations (DR17-DR32), one in each meteorological sector in the 6 to 8 km range from the site<br>(3) The balance of the stations (DR33-DR41), should be placed in special interest areas such as population centers, nearby residences, schools, and in one or two areas to serve as control stations | Quarterly | Gamma dose quarterly |
| 2. Airborne Radioiodine and Particulates | 4 locations (A1-A5) | (1) 3 locations (A1-A3) close to the site boundary in different sectors, of the highest calculated annual average ground level D/Q<br>(2) 1 location (A4) from the vicinity of an established year-round community having the highest calculated annual average ground level D/Q<br>(3) 1 control location (A5) located approximately 15-30 km distant, and in the least prevalent wind direction (c) | Continuous sampler operation with sample collection weekly or more frequently if required by dust loading | Radioiodine canister: Analyze weekly for I-131<br>Particulate sampler:<br>(1) Analyze for gross beta radioactivity 24 hours following filter change (d).<br>(2) Perform gamma isotopic analysis on each sample (e) in which gross beta activity is > 10 times the previous yearly mean of control samples.<br>(3) Gamma isotopic analysis of composite sample (e) (by location) once per 3 months. |
| 3. Waterborne | | | | |
| a. Surface (f) | 1 location<br>1 location | Upstream (Wa1) (used as a Control Station)<br>Downstream (Wa2) | Composite sample over a one month period (g) | (1) Gamma isotopic analysis of each sample (e) once per month.<br>(2) Composite and analyze for H-3 quarterly. |
| b. Drinking | 1 location | Nearest water supply (Wb1) | Grab sample: Monthly | (1) Gamma isotopic analyses(e) of each sample monthly.<br>(2) Composite and analyze for H-3 quarterly. |

Table D 3.5.1-1 (page 2 of 3)
Radiological Environmental Monitoring Program

<table>
<tr><th>EXPOSURE PATHWAY AND/OR SAMPLE</th><th>NUMBER OF LOCATONS</th><th>SAMPLE LOCATIONS (a) and DESIGNATIONS</th><th>SAMPLING AND COLLECTION FREQUENCY</th><th>TYPE AND FREQUENCY OF ANALYSIS</th></tr>
<tr><td>3. Waterborne (continued)<br><br>c. Soil from Shoreline</td><td>2 locations</td><td>Downstream area (Wc1) with existing or potential recreational value<br><br>Upstream area (Wc2) control sample</td><td>Twice per year at least 90 days apart</td><td>Gamma isotopic (e) and Sr-90 analyses of each sample, semi-annually.</td></tr>
<tr><td rowspan="2">4. Ingestion<br><br>a. Milk (i)</td><td>3 milk animal locations</td><td>In 3 locations (Ia1-Ia3) within 5 km having the highest dose potential (human consumption).<br><br>If there are none within 5 km, then a milk location in each of 3 areas (Ia1-Ia3) 5 to 8 km distance, if available, where doses are calculated to be > 1mrem per year (h)</td><td>Twice per month when animals are on pasture; monthly at other times</td><td rowspan="2">Gamma isotopic (e) and I-131 analyses of each sample.</td></tr>
<tr><td>1 control milk animal location</td><td>At a control location (Ia4), approximately 15 to 30 km distant, and in the least prevalent wind direction</td><td>Concurrently, with indicator locations</td></tr>
<tr><td>b. Fish and Invertebrates</td><td>2 indicator location<br><br>1 control location</td><td>One In the vicinity of the plant discharge area (Ib1) and one further downstream (Ib3)<br><br>If available, 1 location of same species as the above location, in an area not influenced by plant discharge (Ib2)</td><td>Samples from edible portions of each commercially or recreationally important species when in season,<br><br>or<br><br>Semiannually if species is not seasonal</td><td>Gamma isotopic, Ni-63, and Sr-90 analyses of each sample (e)</td></tr>
</table>

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Table D 3.5.1-1 (page 3 of 3)
Radiological Environmental Monitoring Program

| EXPOSURE PATHWAY AND/OR SAMPLE | NUMBER OF SAMPLE LOCATIONS | SAMPLE LOCATIONS (a) and DESIGNATIONS | SAMPLING AND COLLECTION FREQUENCY | TYPE AND FREQUENCY OF ANALYSIS |
|---|---|---|---|---|
| 4. Ingestion (continued)<br><br>c. Food Products | 2 locations<br><br><br><br><br><br><br><br><br><br>1control location | Vegetation grown nearest to each of 2 different offsite locations of highest predicted annual average ground level D/Q if milk sampling is not performed (Ic1-Ic2)<br><br>Vegetation grown 15 to 30 km distant in the least prevalent wind direction if milk sampling is not performed (Ic3) | Monthly when available<br><br>Samples of 3 different kinds of broad leaf vegetation (edible or inedible) (j) | Gamma isotopic (e) and I-131 analyses |

(a) The code letters in parenthesis, e.g., DR1, A1 refer to sample locations specified in ODCM, Part II. Specific parameters of distance and direction sector from the centerline of one reactor, and additional descriptions where pertinent, shall be provided for each and every sample location in Table D 3.5.1-1. Refer to NUREG-0133, "Preparation of Radiological Effluent Technical Specifications for Nuclear Power Plants," October 1978, and to Radiological Assessment Branch Technical Position on Environmental Monitoring, Revision 1, November 1979. Deviations are permitted from the required sampling schedule if specimens are unobtainable due to hazardous conditions, seasonal unavailability, malfunction of automatic sampling equipment and other legitimate reasons. If specimens are unobtainable due to sampling equipment malfunction, every effort shall be made to complete corrective action prior to the end of the next sampling period. All deviations from the sampling schedule shall be documented in the Annual Radiological Environmental Operating Report pursuant to D5.1.

(b) One or more instruments, such as a pressurized ion chamber, for measuring and recording dose rate continuously may be used in place of, or in addition to integrating dosimeters. Each of the 40 routine monitoring stations shall be equipped with 2 or more dosimeters or with 1 instrument for measuring and recording dose rate continuously. For the purpose of this table, a thermoluminescent dosimeter (TLD) is considered to be one phosphor; 2 or more phosphors in a packet are considered as 2 or more dosimeters. Film badges shall not be used as dosimeters for measuring direct radiation.

(c) The purpose of these samples is to obtain background information. If it is not practical to establish control locations in accordance with the distance and wind direction criteria, other sites, which provide valid background data, may be substituted.

(d) Airborne particulate sample filters shall be analyzed for gross beta activity 24 hours or more after sampling to allow for radon and thoron daughter decay.

(e) Gamma isotopic analysis means the identification and quantification of gamma –emitting radionuclides that may be attributable to the effluents from the facility.

(f) The upstream sample(s) should be from a "Control Location". The "downstream" sample shall be taken from the mixing zone at the diffuser of the discharge canal. 4/21

(g) In this program, a composite sample is one in which the quantity (aliquot) shall be collected at time intervals that are very short (e.g., hourly) relative to the compositing period (e.g., monthly) in order to assure obtaining a representative sample.

(h) The dose shall be calculated for the maximum organ and age group, using the methodology and parameters in the ODCM.

(i) The requirement to obtain and analyze samples from milch animals within 8 km of the site is intended to ensure monitoring of the "cow-milk" and vegetation pathways. Thus, only milch animals whose milk is used for human consumption are considered in the pathway and sample evaluation.

(j) Broad leaf vegetation sampling of at least three different kinds of vegetation may be performed at the SITE BOUNDARY in each of two different sectors with the highest predicted D/Q in lieu of the garden census. Similar species should be obtained at both locations.

Table D 3.5.1-2 (page 1 of 1)
Reporting Levels for Radioactivity in Environmental Samples **

| RADIONUCLIDE ANALYSIS | WATER (pCi/L) | AIRBORNE PARTICULATE OR GASES (pCi/m$^3$) | FISH (pCi/kg, wet) | MILK (pCi/L) | FOOD PRODUCTS (pCi/kg, wet) |
|---|---|---|---|---|---|
| H-3 | 20,000 * | | | | |
| Mn-54 | 1,000 | | 30,000 | | |
| Fe-59 | 400 | | 10,000 | | |
| Co-58 | 1,000 | | 30,000 | | |
| Co-60 | 300 | | 10,000 | | |
| Ni-63 *** | 300 | | 1,000 | | |
| Zn-65 | 300 | | 20,000 | | |
| Sr-90 *** | 8* | | 40 | | |
| Zr-95 | 400 | | | | |
| Nb-95 | 400 | | | | |
| I-131 | 2 * | 0.9 | | 3 | 100 |
| Cs-134 | 30 | 10 | 1,000 | 60 | 1,000 |
| Cs-137 | 50 | 20 | 2,000 | 70 | 2,000 |
| Ba-140 | 200 | | | 300 | |
| La-140 | 200 | | | 300 | |

* Values provided are for drinking water pathways. If no drinking water pathway exists, higher values are allowed, as follows:

H-3 30,000 pCi/L (This is a 40 CFR 141 value)

Sr-90 12 pCi/L

I-131 20 pCi/L

** These reporting levels are associated only with the REMP requirements. The Radiological Ground Water Monitoring Program may involve unique reporting level criteria, independent of the REMP, and defined in station procedures.

*** Sr-90 and Ni-63 are included in this table due to their historical presence in ground water and possible migration to the environment, per References 45 and 46.

Table D 3.5.1-3 (page 1 of 2)
Detection Capabilities for Environmental Sample Analysis (a) (e)

LOWER LIMIT OF DETECTION (LLD) (b) (c)

| RADIONUCLIDE ANALYSIS | WATER (pCi/L) | AIRBORNE PARTICULATE OR GASES (pCi/m$^3$) | FISH (pCi/kg, wet) | MILK (pCi/L) | FOOD PRODUCTS (pCi/kg, wet) | SOIL or SEDIMENT (pCi/kg, dry) |
|---|---|---|---|---|---|---|
| Gross Beta | 4 | 0.01 | | | | |
| H-3 | 2,000 (d) | | | | | |
| Mn-54 | 15 | | 130 | | | |
| Fe-59 | 30 | | 260 | | | |
| Co-58 | 15 | | 130 | | | |
| Co-60 | 15 | | 130 | | | |
| Ni-63 (f) | 30 | | 100 | | | |
| Zn-65 | 30 | | 260 | | | |
| Sr-90 (f) | 1 | | 5 | | | 50 |
| Zr-95 | 30 | | | | | |
| Nb-95 | 15 | | | | | |
| I-131 | 1 (d) | 0.07 | | 1 | 60 | |
| Cs-134 | 15 | 0.05 | 130 | 15 | 60 | 150 |
| Cs-137 | 18 | 0.06 | 150 | 18 | 80 | 180 |
| Ba-140 | 60 | | | 60 | | |
| La-140 | 15 | | | 15 | | |

Table D 3.5.1-3 (page 2 of 2)
Detection Capabilities for Environmental Sample Analysis

**Table Notation**

(a) This list does not mean that only these nuclides are to be considered. Other peaks that are identifiable, together with those of the above nuclides, shall also be analyzed and reported in the Annual Radiological Environmental Operating Report pursuant to Specification D 5.1.

(b) Required detection capabilities for thermoluminescent dosimeters used for environmental measurements are given in Regulatory Guide 4.13.

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

For the purposes of defining the LLD as described above the $\Delta t$ is the elapsed time between environmental collection, or end of the sample collection period, and time of counting (sec).

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. Analyses shall be performed in such a manner that the stated LLDs will be achieved under routine conditions. Occasionally background fluctuations, unavoidable small sample sizes, the presence of interfering nuclides, or other uncontrollable circumstances may render these LLDs unachievable. In such cases, the contributing factors shall be identified and described in the Annual Radiological Environmental Operating Report pursuant to RECS D 5.1.

(d) These LLDs are for drinking water samples. If no drinking water pathway exists, the LLDs may be increased to 3,000 for H-3 and 15 for I-131.

(e) These required lower limits of detection are associated only with the REMP requirements. The Radiological Ground Water Monitoring Program may involve unique reporting level criteria, independent of the REMP, and defined in station procedures.

(f) Sr-90 and Ni-63 are included in this table due to their historical presence in ground water and possible migration to the environment, per References 45 and 46.

D 3.5 RADIOLOGICAL ENVIRONMENTAL MONITORING

D 3.5.2 Land Use Census

DLCO 3.5.2 A land use census shall:

a. Be conducted.

b. Identify within a distance of 8 km (5 miles) the location, in each of the 16 meteorological sectors, of the nearest milk animal, the nearest residence, and the nearest garden of > 50 $m^2$ (500 $ft^2$) producing broad leaf vegetation. Broad leaf vegetation sampling of at least three different kinds of vegetation may be performed at the SITE BOUNDARY in each of two different direction sectors with the highest predicted D/Qs in lieu of a garden census, per Table D 3.5.1-1, part 4.c.

APPLICABILITY: At all times.

ACTIONS

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---|---|---|
| A. Land use census identifies location(s) that yields a calculated dose, dose commitment, or D/Q value greater than the values currently being calculated in DSR 3.2.3.1. | A.1 Identify the new location(s) in the next Radioactive Effluent Release Report. | In accordance with the Radioactive Effluent Release Report |

ACTIONS (continued)

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---|---|---|
| B. Land use census identifies location(s) that yields a calculated dose, or dose commitment (via the same exposure pathway) a factor greater than 2 than at a location from which samples are currently being obtained in accordance with Table D 3.5.1-1. | B.1 Add the new location(s) to the Radiological Environmental Monitoring Program. | 30 days |
| | <u>AND</u> | |
| | B.2 Delete the sampling location(s), excluding the control station location, having the lowest calculated dose, dose commitment(s) or D/Q value, via the same exposure pathway, from the Radiological Environmental Monitoring Program. | After October 31 of the year in which the land use census was conducted |
| | <u>AND</u> | |
| | B.3 Submit in the next Radioactive Effluent Release Report documentation for a change in the ODCM including revised figure(s) and table(s) for the ODCM reflecting the new location(s) with information supporting the change in sampling locations. | In accordance with the Radioactive Effluent Release Report |

SURVEILLANCE REQUIREMENTS

| SURVEILLANCE | | FREQUENCY |
|---|---|---|
| DSR 3.5.2.1 | Conduct the land use census during the growing season using that information that will provide the best results, such as by a door-to-door survey, aerial survey, or by consulting local agriculture authorities. | 366 days |
| DSR 3.5.2.2 | Report the results of the land use census in the Annual Radiological Environmental Operating Report. | In accordance with the Annual Radiological Environmental Operating Report |

D 3.5 RADIOLOGICAL ENVIRONMENTAL MONITORING

D 3.5.3 Interlaboratory Comparison Program

DLCO 3.5.3 The Interlaboratory Comparison Program shall be described in the ODCM.

AND

Analyses shall be performed on all radioactive materials, supplied as part of an Interlaboratory Comparison Program that has been approved by the Commission.

APPLICABILITY: At all times.

ACTIONS

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---|---|---|
| A. Analyses not performed as required. | A.1 Report the corrective actions taken to prevent a recurrence to the NRC in the Annual Radiological Environmental Operating Report. | In accordance with the Annual Radiological Environmental Operating Report |

SURVEILLANCE REQUIREMENTS

| SURVEILLANCE | | FREQUENCY |
|---|---|---|
| DSR 3.5.3.1 | Report a summary of the results obtained as part of the Interlaboratory Comparison Program in the Annual Radiological Environmental Operating Report. | In accordance with the Annual Radiological Environmental Operating Report |

## D 3.6 SOLID RADIOACTIVE WASTE

### D 3.6.1 Solid Radwaste Treatment System

DLCO 3.6.1 The appropriate equipment of the Solid Radwaste Treatment System shall be in operation process wet radioactive wastes in accordance with the Process Control Program.

APPLICABILITY: During solid radwaste processing

ACTIONS

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---|---|---|
| A. Radioactive solid waste does not comply with Process Control Program requirements. | A.1 Suspend shipments of solid radioactive waste. | Immediately |

SURVEILLANCE REQUIREMENTS

| SURVEILLANCE | | FREQUENCY |
|---|---|---|
| DSR 3.6.1.1 | Verify solidification of specimens in accordance with the Processing Control Program. | Prior to each shipment |
| DSR 3.6.1.2 | Record the following information for each class of solid waste (as defined by 10 CFR Part 61) shipped offsite during the Radioactive Effluent Release Report period:<br><br>a. Container volume,<br><br>b. total curie quantity (specify determined by measurement or estimate),<br><br>c. principal radionuclides (specify determined by measurement or estimate),<br><br>d. source of waste and processing employed (e.g., dewatered spent resin, compacted dry waste, evaporator bottoms),<br><br>e. type of container (e.g., LSA Type A, Type B, Large Quantity), and<br><br>f. solidification agent or absorbent (e.g., cement, urea formaldehyde). | Prior to each shipment |

# D 4.0 DESIGN FEATURES

## D 4.1 UNRESTRICTED AREA

D 4.1.1 The definition of UNRESTRICED AREA used in implementing the Radiological Effluent Controls (RECS or ODCM Part I) has been expanded over that in 10 CFR 20.1003. For calculations performed pursuant to 10 CFR 50.36a, the concept of UNRESTRICTED AREAS refers to areas “at or beyond the SITE BOUNDARY” and does not include areas over water bodies.

A map representing the UNRESTRICTED AREA is shown in Figure D 4.1-1

Information which will allow identification of structures and release points for radioactive gaseous and liquid effluents is shown in Figure D 4.1-2.

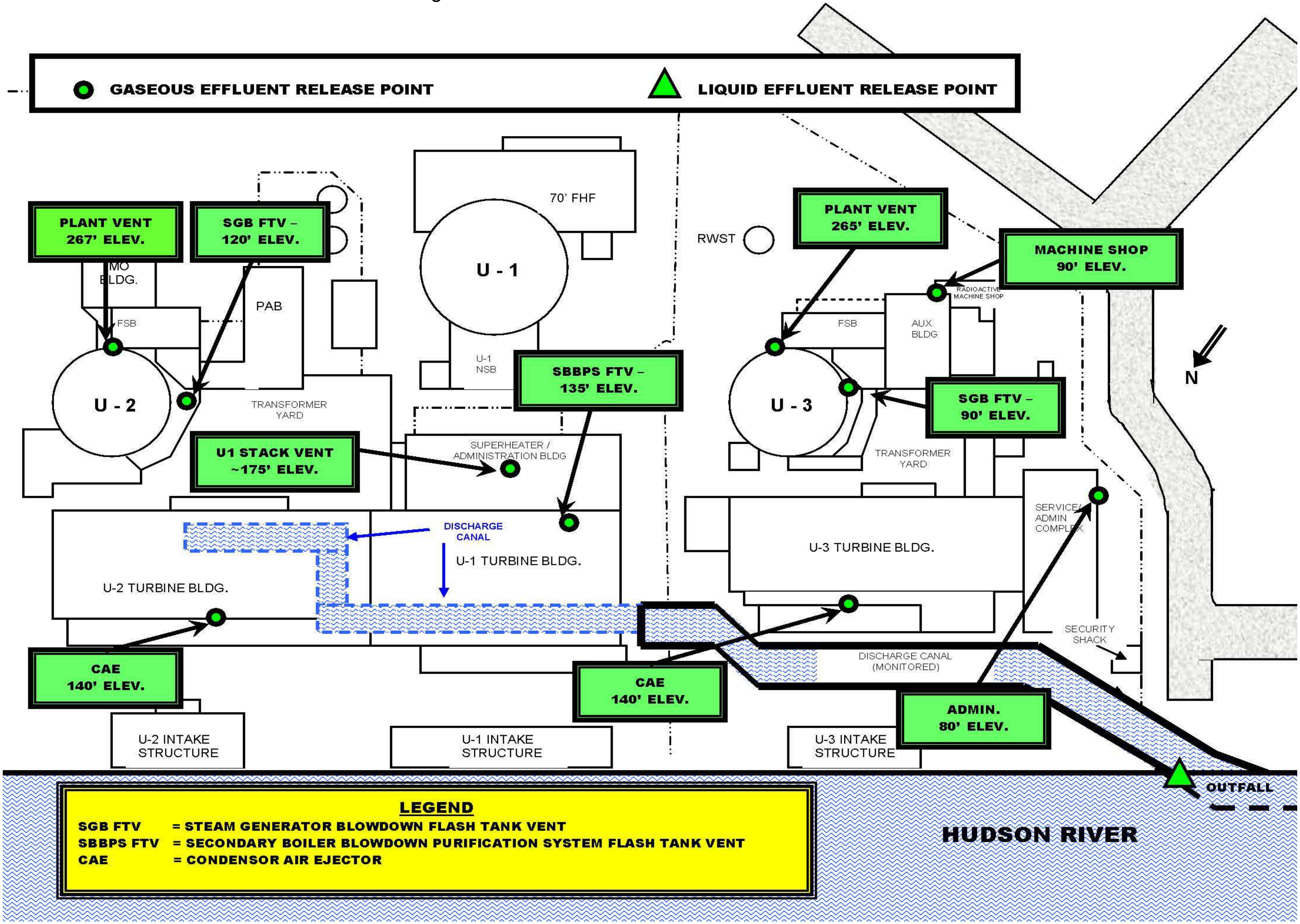
D 4.1.2 For the purpose of satisfying 10 CFR Part 20, the "Restricted Area" is the same as the "Exclusion Area" defined in the FSARs.

Figure D 4.1-1

## MAP DEFINING UNRESTRICTED AREAS

FOR RADIOACTIVE GASEOUS AND LIQUID EFFLUENTS

Figure D 4.1-2 MAP DEFINING RELEASE POINTS



# D 5.0 ADMINISTRATIVE CONTROLS

## D 5.1 Annual Radiological Environmental Operating Report

An annual Radiological Environmental Operating Report covering the operation of the unit during the previous calendar year shall be submitted prior to May 15th of each year. Per the Technical Specification Reporting Requirements, a single submittal may be made for a multiple unit station.

The Annual Radiological Environmental Operating Report shall include:

- Summaries, interpretations, and an analysis of trends of the results of the Radiological Environmental Monitoring Program for the report period, including a comparison, as appropriate, with preoperational studies, with operational controls, and with previous environmental surveillance reports, and an assessment of the observed impacts of the plant operation on the environment.

- At least two legible maps covering all sampling locations keyed to a table giving distances and directions from the centerline of one reactor. One map shall cover stations near the site boundary and the second shall include the more distant stations.

- The results of analysis 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 the ODCM, as well as summarized and tabulated results of these analyses and measurements in the general format of the Radiological Assessment Branch Technical Position, Revision 1, November 1979. 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.

- A summary description of the Radiological Environmental Monitoring Program.

- A discussion of the reasons for not conducting the Radiological Environmental Monitoring Program as specified by D 3.5.1 and the plans for preventing recurrence.

- A discussion of environmental sample measurements that exceed the reporting levels of Table D 3.5.1-2 but are not the result of plant effluents.

- A discussion of all deviations from the sampling schedule of Table D 3.5.1-1.

- A discussion of the contributing factors for cases in which the LLD required by Table D 3.5.1-3 was not achievable.

- A discussion of identifiable nuclide peaks, including those of nuclides specified in Table D 3.5.1-3.

- The results of the land use census.

- The corrective actions taken to prevent a recurrence if the Interlaboratory Comparison Program is not being performed as required.

- The results of licensee participation in the Interlaboratory Comparison Program.

## D 5.0 ADMINISTRATIVE CONTROLS

## D 5.2 Radioactive Effluent Release Report

The Radioactive Effluent Release Report to be submitted by May 1 of each year shall include:

a. 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 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.

b. An annual summary of hourly meteorological data collected over the previous 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 distribution of wind speed, wind direction, and atmospheric stability. In lieu of submission with the Radioactive Effluent Release Report, the licensee has the option of retaining this summary of required meteorological data onsite in a file that shall be provided to the NRC upon request.

c. An assessment of the offsite radiation doses due to the radioactive liquid and gaseous effluent releases from the unit or station during the previous calendar year. This assessment shall include potential offsite dose determined with data collected from the Radiological Ground Water Monitoring Program (RGWMP).

d. An assessment of the radiation doses from radioactive liquid and gaseous effluents to members of the public due to their activities inside the SITE BOUNDARY (Figure D 4.1-1) during the report period. All assumptions used in making these assessments, i.e., specific activity, exposure time and location, shall be included in these reports.

   Gaseous pathway doses are determined from sampling and measurements at the exhaust points, coupled with the use of annual-averaged meteorological data collected from a period of live data to verify its validity. The assessment of radiation doses shall be performed in accordance with the methodology and parameters in the Offsite Dose Calculation Manual (ODCM).

   Acceptable methods for calculating the dose contribution from liquid and gaseous effluents are given in Regulatory Guide 1.109, Rev. 1, October 1977.

D 5.2 Radioactive Effluent Release Report (continued)

e. The following information for each class of solid waste (in compliance with 10 CFR Part 61) shipped offsite during the report period:

1. Container volume,

2. total curie quantity (specify whether determined by measurement or estimate),

3. principal radionuclides (specify whether determined by measurement or estimate),

4. source of waste and processing employed (e.g., dewatered spent resin, compacted dry-waste, evaporator bottoms),

5. type of container (e.g., LSA, Type A, Type B, Large Quantity), and

6. solidification agent or absorbent (e.g., cement, urea formaldehyde).

f. 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.

g. A summary of data collected for the RGWMP, per D5.6 and NEI 07-07 - Industry Ground Water Protection Initiative.

h. Any changes made during the reporting period to the Process Control Program (PCP) and to the Offsite Dose Calculation Manual (ODCM), as well as a listing of new locations for dose calculations and/or environmental monitoring identified by the land use census pursuant to Specification D 3.5.2.

# D 5.0 ADMINISTRATIVE CONTROLS

## D 5.3 Special Reports

Special reports shall be submitted to the NRC Regional Administrator of the Region I Office within the time period specified for each report. These reports shall be submitted covering the activities identified below pursuant to the applicable Specification:

a. Radioactive Effluents (Specifications D 3.1, D 3.2 and D 3.4)

b. Radiological Environmental Monitoring (Specification D 3.5)

# D 5.0 ADMINISTRATIVE CONTROLS

## D 5.4 Major Changes to Radioactive Waste Systems

Licensee initiated major changes to the radioactive waste systems (liquid, gaseous and solid) shall be reported to the Commission in the Radioactive Effluent Release Report for the period in which the change was made. 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 Part 50.59,

b. sufficient detailed information to totally support the reason for the change without benefit of additional or 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 and/or quantity of solid waste 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 individuals 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 and in solid waste to the actual releases for the period in which 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 OSRC.

## D 5.0 ADMINISTRATIVE CONTROLS

## D 5.5 Process Control Program

Licensee initiated changes to the Process Control Program (PCP):

a. Shall be submitted to the Commission in the Annual Radioactive Effluent Release Report for the period in which the change(s) was made. This submittal shall contain:

   1. sufficiently detailed information to totally support the rationale for the change without benefit of additional or supplemental information,

   2. a determination that the change did not reduce the overall conformance of the solidified waste product to existing criteria for solid wastes, and

   3. documentation of the fact that the change has been reviewed and found acceptable by the OSRC.

b. Shall become effective upon review and acceptance by the OSRC.

## D 5.6 Radiological Ground Water Monitoring Program (RGWMP)

The purpose of the RGWMP is to monitor, investigate, and characterize any contamination of groundwater from licensed radioactive material at Indian Point Energy Center (IPEC).

a. The program is also required in order to meet the following objectives:

   - The Nuclear Energy Institute Groundwater Protection Initiative (NEI-07-07),
   - American Nuclear Insurers Guideline for unmonitored releases (ANI 07-01),
   - EPRI Groundwater Protection Guidelines, (report #1015118, Nov 2007),
   - NRC Information Notice 2006-13, Groundwater Contamination Due to Undetected Leakage of Radioactive Water,
   - IPEC commitments to the NRC, Entergy Letter NL-06-033, “Current Status/Future Plans Regarding Onsite Groundwater Contamination at IPEC”,
   - IPEC commitments to the NRC, Entergy Letter NL-08-079, “Remediation and Long Term Monitoring of Site Groundwater”.

b. Specific monitoring objectives of the program include:

   - Monitoring the status of any known radiological groundwater plumes,
   - Detecting and quantifying previously unidentified sources of groundwater contamination, such as spills or leaks from a radioactively contaminated system, structure, or component,
   - Providing data to calculate potential offsite doses to a member of the public,
   - Monitoring and evaluating the long term effectiveness of remediation or intervention.

D 5.0 ADMINISTRATIVE CONTROLS

D 5.6 Radiological Ground Water Monitoring Program (RGWMP) (continued)

c. Investigation and characterization activities are performed to evaluate and understand any groundwater contamination once it has been identified, or an event (such as a spill or leak) with the potential to contaminate the groundwater to levels above the investigation levels has occurred. Specific investigation and characterization objectives of the program include:

- Determining the source(s) of groundwater contamination (eg, leaking radioactive components or systems, radioactive spills, or legacy soil/bedrock contamination),
- Determining the locations, extent, and concentrations of groundwater contamination (eg, plume definition),
- Evaluating necessary corrective or investigative actions, utilizing the Corrective Action Program.

d. Station procedures shall include detailed information regarding the following:

- The purpose and scope of the program, as defined above,
- Location and periodicities of samples,
- Required radionuclides for analysis, including limits of detection,
- Guidance for communication of abnormal results,
- Guidance regarding the generation of periodic summary reports.

e. Elements of the RGWMP program that intersect the REMP shall be included in the Annual Radiological Environmental Operating Report, per D 5.1.

f. An evaluation of the EFFLUENT impact, and a summary of the sample data from the RGWMP shall be included in the annual Radiological Effluent Release Report, as identified in ODCM D 5.2.

# Indian Point Energy Center

# Offsite Dose Calculation Manual

## Part I (RECS)

## <u>BASES</u>

# 3.0 APPLICABILITY

## BASES

DLCOs 3.0.1, 3.0.2, and 3.0.5, and DSRs 3.0.1, 3.0.2, and 3.0.3 reflect parallel requirements in the Technical Specifications. Refer to Technical Specification Bases for appropriate discussions.

ODCM Specification DLCO 3.0.3, in lieu of imposing a plant shutdown as paralleled in Technical Specifications, requires: (a) an Action to initiate efforts to restore compliance with the ODCM or associated Actions; and (b) an Action that requires entering the circumstances into the Corrective Action Program (CAP). These requirements ensure that the appropriate actions continue to be focused on and that the circumstances concerning failure to comply with the ODCM Actions would be reviewed. This review will be conducted in accordance with the procedural guidance for CAP Notifications.

There are no ODCM 3.0 Specifications that parallel Technical Specification LCO 3.0.4 or SR 3.0.4. Restrictions in entering MODES or other specified conditions in the Applicability have historically not been applied to ODCM Specifications. There are also no ODCM 3.0 Specifications that parallel Technical Specification LCO 3.0.6 and LCO 3.0.7, which allow for exceptions and revisions of other Technical Specifications. They are not applicable to the ODCM since it is not permitted to allow the ODCM to revise a Technical Specification.

(Note, currently no identified ODCM DLCOs support Technical Specification systems; however, this discussion is presented to address the philosophy that would be applied.) An allowance similar to Technical Specification LCO 3.0.6 does not apply to the ODCM. When a Technical Specification supported system LCO is discovered to be not met solely due to a ODCM support system DLCO not met, appropriate Technical Specification ACTIONS are required to be entered immediately. This applies even in instances where the ODCM contains a delay prior to declaring a Technical Specification supported system inoperable. In this case, certain ODCM inoperabilities may not directly impact the OPERABILITY of the Technical Specification supported system and delayed declaration of inoperability of the supported system is acceptable. In other cases, discovered support system inoperabilities that directly result in supported system inability to perform the safety function, should result in immediate declaration of inoperability of the supported system.

Technical Specification LCO 3.0.7 has no parallel in the ODCM since it provides for explicit changes to specified Technical Specifications by the Section 3.1.8 Specifications. However, in the event that LCO 3.0.7 provides for changes to the Technical Specification MODE definitions by the Section 3.1.8 Specifications, the revised MODE definitions apply to all plant references, including ODCM references.

## D 3.1 RADIOACTIVE LIQUID EFFLUENTS

### D 3.1.1 Liquid Effluent Concentrations

BASES

It is expected that the release of radioactive materials in liquid and gaseous effluents to UNRESTRICTED AREAS will not exceed a small fraction of the concentration limits specified in 10 CFR Part 20 and should be as low as reasonably achievable (ALARA) in accordance with the requirement of 10 CFR 50.36a. While providing reasonable assurance that the design objectives will be met, these Specifications permit the flexibility of operation, compatible with considerations of health and safety, to ensure that the public is provided a dependable source of power under unusual operating conditions which may temporarily result in releases higher than the design objective levels, but still less than ten times the effluent concentration limits (EC's) specified in 10 CFR Part 20. It is expected that using this operational flexibility under unusual operation conditions, and exerting every effort to keep levels of radioactive materials in liquid and gaseous wastes as low as reasonably achievable, releases will not exceed a small fraction of the concentration limits specified in 10 CFR Part 20.

The design objectives have been developed based on operating experience, taking into account a combination of variables including defective fuel, primary system leakage, primary to secondary system leakage, steam generator blowdown and the performance of the various waste treatment systems, and are consistent with 10 CFR Part 50.36a.

The Indian Point site is a multiple-unit site. There exist shared radwaste treatment systems and shared effluent release points. Where site limits must be met, the effluents of all the units will be combined to determine site compliance. For instances where unit-specific information may be required for radwaste processed or released via a shared system, the effluents shall be proportioned among the units sharing the system(s) in accordance with the methods and agreements set forth in the ODCM.

This specification is provided to ensure that the concentration of radioactive materials released in liquid waste effluents to UNRESTRICTED AREAS will be less than ten times the EFFLUENT CONCENTRATIONS specified in 10 CFR Part 20. This limitation provides additional 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 limits of 10 CFR Part 20.1302 to the population. The concentration limit for dissolved or entrained noble gases is based upon the assumption that Xe-135 is the controlling radioisotope and its MPC in air (submersion) was converted to an equivalent concentration in water using the methods described in International Commission on Radiological Protection (ICRP) Publication 2.

This specification applies to the release of liquid effluents from all units on site.

D 3.1 RADIOACTIVE LIQUID EFFLUENTS

D 3.1.2 Liquid Effluents Dose

BASES

This Specification is provided to implement the requirements of Sections II.A, III.A and IV.A of Appendix I, 10 CFR Part 50. The DLCO 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 reasonably achievable".

Also, for fresh water sites to UNRESTRICTED AREA 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 concentration 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.

In addition to the limiting conditions for operation, the reporting requirements specify that the licensee shall identify the cause whenever the dose from the release of radioactive materials in liquid waste effluent exceeds the above limits and describe the proposed program of action to reduce such releases to design objective levels on a timely basis.

## D 3.1 RADIOACTIVE LIQUID EFFLUENTS

### D 3.1.3 Liquid Radwaste Treatment System

BASES

This Specification requires that the licensee maintain and operate appropriate equipment installed in the liquid waste systems, when necessary, to provide assurance that the releases of radioactive materials in liquid effluents will be kept "as low as reasonably achievable". This Specification implements the requirements of 10 CFR 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 to 10 CFR Part 50 for liquid effluents.

D 3.1 RADIOACTIVE LIQUID EFFLUENTS

D 3.1.4 Liquid Holdup Tanks

BASES

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The tanks listed in this Specification include outdoor 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. These tanks include the following:

a. Refueling Water Storage Tanks

b. Primary Water Storage Tanks

c. 13 Waste Distillate Storage Tank

d. 14 Waste Distillate Storage Tank

e. 31 Monitor Tank

f. 32 Monitor Tank

g. Unit 3 CPF High Total Dissolved Solids Tank

h. Unit 3 CPF Low Total Dissolved Solids Tank

i. Any Outside Temporary Tank

Restricting the quantity of radioactive material contained in the specified tanks provides assurance that, in the event of an uncontrolled release of any such tank's contents, the resulting concentration would be less than the limits of 10 CFR 20 at the nearest potable water supply and the nearest surface water supply in an UNRESTRICTED AREA.

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## D 3.2 RADIOACTIVE GASEOUS EFFLUENTS

### D 3.2.1 Gaseous Effluents Dose Rate

BASES

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.

This Control applies to the release of gaseous effluents from all units at the site.

# D 3.2 RADIOACTIVE GASEOUS EFFLUENTS

## D 3.2.2 Gaseous Effluents Dose – Noble Gas

### BASES

This Specification is provided to implement the requirements of Sections II.B, III.A, and IV.A of Appendix I to 10 CFR Part 50. The DLCO implements the guides set forth in Section II.B of Appendix I. The action statements provide the required operating flexibility and, at the same time, implement the guides set forth in Section IV.A of Appendix I to assure that the releases of radioactive material in gaseous effluents to UNRESTRICTED AREAS will be kept "as low as 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. 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 form Light-Water Cooled Reactors," Revision 1, July 1977. The ODCM equations provided for determining the doses at and beyond the SITE BOUNDARY are based upon the historical average atmospheric conditions.

This Control applies to the release of gaseous effluents from each unit on site.

D 3.2 RADIOACTIVE GASEOUS EFFLUENTS

D 3.2.3 Gaseous Effluents Dose – Iodine and Particulate

BASES

This Specification is provided to implement the requirements of Section II.C, III.A and IV.A of Appendix I to 10 CFR Part 50. The DLCOs 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 to UNRESTRICTED AREAS will be kept "as low as 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.

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 specifications 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 (applied where applicable), and (4) deposition on the ground with subsequent exposure of man.

This Control applies to the release of gaseous effluents from each reactor on site.

D 3.2 RADIOACTIVE GASEOUS EFFLUENTS

D 3.2.4 Gaseous Radwaste Treatment System

BASES

This Specification requires that the appropriate portions of the Gaseous Radwaste Treatment System be used, when specified, to provide reasonable assurance that the releases of radioactive materials in gaseous effluents will be kept "as low as reasonably achievable." This Specification 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. 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.

This Specification applies to the release of gaseous effluents from each reactor on site.

## D 3.2 RADIOACTIVE GASEOUS EFFLUENTS

### D 3.2.5 Ventilation Exhaust Treatment System

BASES

This Specification requires that the appropriate portions of the Ventilation Exhaust Treatment System be used, when specified, to provide reasonable assurance that the releases of radioactive materials in gaseous effluents will be kept "as low as reasonably achievable." This Specification 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. 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.

This Specification applies to the release of gaseous effluents from each reactor on site.

D 3.2 RADIOACTIVE GASEOUS EFFLUENTS

D 3.2.6 Gas Storage Tanks

BASES

The tanks included in this Specification are those tanks for which the quantity of radioactivity contained is not limited directly or indirectly by other specifications to a quantity that is less than the quantity that provides assurance that, in the event of an uncontrolled release of the tank's contents, the resulting total body exposure to a MEMBER OF THE PUBLIC at the nearest SITE BOUNDARY will not exceed 0.5 Rem in an event of 2 hours duration.

Restricting the quantity of radioactivity contained in each gas storage tank provides assurances that, in the event of an uncontrolled release of the tank's contents, the resulting total body exposure to a MEMBER OF THE PUBLIC at the nearest SITE BOUNDARY will not exceed 0.5 Rem. This is consistent with Branch Technical Position ETSB 11-5 in NUREG-0800, July 1981, and NUREG 0133.

## D 3.3 INSTRUMENTATION

### D 3.3.1 Radioactive Liquid Effluent Monitoring Instrumentation

BASES

The radioactive liquid effluent instrumentation, required OPERABLE by this Specification, is provided to monitor and control, as applicable, the releases of radioactive materials in liquid effluents during actual or potential releases. The alarm/trip setpoints for these instruments shall be calculated in accordance with methods set forth in the ODCM to ensure that the alarm/trip will occur prior to exceeding ten times the EFFLUENT CONCENTRATION values specified in 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. 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.

## D 3.3 INSTRUMENTATION

### D 3.3.2 Radioactive Gaseous Effluent Monitoring Instrumentation

### BASES

The radioactive gaseous effluent instrumentation, required OPERABLE by this Specification, is provided to monitor and control, as applicable, the releases of radioactive materials in 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 release rates corresponding to effluent dose rates of 0.5 Rem/yr whole body, and 3.0 Rem/yr to the skin.

This instrumentation also includes provisions for monitoring the concentrations of potentially explosive gas mixtures in the waste gas holdup system. The OPERABILITY and use of this instrumentation is consistent with the requirements of General Design criteria 60, 63 and 64 in Appendix A to 10 CFR Part 50.

# D 3.4 RADIOACTIVE EFFLUENTS TOTAL DOSE

## D 3.4.1 Radioactive Effluents Total Dose

BASES

This Specification is provided to meet the dose limitation of 40 CFR Part 190 that has been incorporated into 10 CFR Part 20 by 46 FR 18525. The Specification requires the preparation and submittal of a special report whenever the calculated doses from plant-generated radioactive effluents and direct radiation exceed 25 mrem to the total body or any organ, except the thyroid, which shall be limited to less than or equal to 75 mrem.

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 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 contribution from other nuclear fuel cycle facilities at the same site or within a radius of 8 km must be considered.

If the dose to any MEMBER OF THE PUBLIC is estimated to exceed the requirements of 40 CFR Part 190, the special report with a request for a variance (provided the release conditions resulting in violation of 40 CFR Part 190 have not already been corrected), in accordance with the provisions of 40 CFR Part 190.11 and 10 CFR Part 20.2203(a)(4), is considered to be a timely request and fulfills the requirements of 40 CFR Part 190 until NRC staff action is completed.

The variance only relates to the limits of 40 CFR Part 190, and does not apply in any way to the other requirements for dose limitation of 10 CFR Part 20, as addressed in Specifications D 3.1.1 and D 3.2.1. An individual is not considered a MEMBER OF THE PUBLIC during any period in which he/she is engaged in carrying out any operation that is part of the nuclear fuel cycle.

## D 3.5 RADIOLOGICAL ENVIRONMENTAL MONITORING

### D 3.5.1 Radiological Environmental Monitoring Program

BASES

The radiological environmental monitoring program required by this specification 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.

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.

Guidance for this monitoring program is provided by the Radiological Assessment Branch Technical Position on Environmental Monitoring. Program changes may be initiated based on operational experience.

The required detection capabilities for environmental sample analyses are tabulated in terms of the lower limits of detection (LLDs). The LLDs required by Table D 3.5.1-3 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.

## D 3.5 RADIOLOGICAL ENVIRONMENTAL MONITORING

### D 3.5.2 Land Use Census

### BASES

This specification 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 $m^2$ 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 $kg/m^2$.

D 3.5 RADIOLOGICAL ENVIRONMENTAL MONITORING

D 3.5.3 Interlaboratory Comparison Program

BASES

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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 (developed using the guidance in Regulatory Guide 1.21, Revision 1, April 1974 and Regulatory Guide 4.1, Revision 1, April 1975) in order to demonstrate that the results are valid for the purposes of Section IV.B.2 of Appendix I to 10 CFR Part 50.

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## D 3.6 SOLID RADWASTE TREATMENT SYSTEM

### D 3.6.1 Solid Radwaste Treatment System

BASES

This Specification implements the requirements of 10 CFR Part 50.36a and General Design Criterion 60 of Appendix A to 10 CFR Part 50. The process parameters included in establishing the process control program may include, but are not limited to, waste type, waste pH, waste/liquid/solidification agent/catalyst ratios, waste oil content, waste principal chemical constituents, and mixing and curing times.

# 1.0 RADIATION MONITORS AND SETPOINTS

## 1.1 Effluent Monitoring System Description

Information regarding effluent radiation monitor function and setpoint bases is provided in Tables 1-1 and 1-2. Additionally, Appendices B and C show a schematic of release pathways, including the relative position and application of these monitors.

## 1.2 Setpoints for Airborne Effluent Monitors

Setpoints for airborne (gaseous) monitors are based on the permissible discharge rate as calculated in Section 3 of the ODCM, Part II, and shown in Appendix I. These setpoints are inherently conservative due to the assumed mixture (Table 3-8). They are tiered in such a way as to ensure proper (higher) authentication is obtained as the selected limit (and expected release rate) increases.

The Annual Limit is used to conservatively establish initial setpoints for routine operation. For releases associated with unit shutdown, etc, additional permission may be obtained to apply the quarterly or instantaneous values, per Section 3.1.8. This method ensures operational control of releases, while precluding approaching the limits of D3.2.1.

The methodology identified in Section 3 and Appendix I is used to generate the following release rate limits. Default radiation monitor setpoints are calculated from these values:

| Conservative Permissible Discharge Rates (μCi/sec) | | | | | |
|---|---|---|---|---|---|
| Type of Limit | Basis | Iodine/Particulate* Unit 2 | Iodine/Particulate* Unit 3 | Noble Gases Unit 2 | Noble Gases Unit 3 |
| **Annual Average** | ODCM, Part II, App I | **4.01E-2** | **4.05E-2** | **7.20E+3** | **3.57E+3** |
| **Quarterly Average** | ODCM, Part II, App I | **8.02E-2** | **8.10E-2** | **1.44E+4** | **7.14E+3** |
| **Instantaneous** | RECS D3.2.1 and App I | **1.38E+1** | **1.38E+1** | **7.00E+4** | **7.00E+4** |

* Half-lives greater than 8 days

1.2.1 The Plant Vent Wide Range Gas Monitor (R-27) reads in μCi/sec. Therefore, at unit 3, the alarm setpoints are set directly in μCi/sec. (Unit 2 does not apply alarm setpoints to R-27).

1.2.2 If the monitor reads and alarms in μCi/cc, the maximum alarm set point is calculated as follows:

$$S = D / [(F) * (4.72E+2)]$$ where;

S = Maximum alarm setpoint in μCi/cc

D = Permissible discharge rate in μCi/sec

F = Vent duct flow in $ft^3$/min

4.72E+2 = unit conversion factor (28317 cc•min/$ft^3$•60sec)

For example,

*A plant vent flow of 60,000 cfm for noble gas: 70,000/(60,000 * 472) = 2.47E-3 uCi/cc*

*A containment purge of 28,000 cfm for particulates: 13.8/(28,000 * 472) = 1.04E-6 uCi/cc*

1.2.3 If the monitor reads and alarms in cpm, then the maximum alarm setpoint is calculated as follows:

$$S = D / [(F) * (4.72E+2) * (CF)]$$

where:

S, D, F, and 4.72E+2 are defined in the previous step

CF = Rad Monitor Conversion Factor ($\mu$Ci/cc per net cpm)

1.2.4 Normally, maximum allowable limits are calculated using a standard nuclide mix. However, setpoints may be determined based on the actual mix, on a case by case basis. This method is usually performed when the instantaneous release rate is applied. Should this method be applied, extra care should be applied to setpoint partitioning (for all release points) to ensure site dose rate limits are not approached.

1.2.5 During normal operation, the main plant vent is the only significant release point at either unit. Hence, monitors on the plant vent are routinely set at the *annual* limit, which is approximately 10% of the conservative *instantaneous* limit.

Monitor setpoints on other pathways are routinely set to 1% of the *instantaneous* limit. If multiple pathways become significant, each pathway's permissible release rate is apportioned with the Plant Vent's to ensure the total discharge rate for all release points remains less than the maximum permissible discharge rate.

If necessary, release rates may be apportioned (per 10CFR20 applicability to a site, rather than any one unit) for maximum operational flexibility such that one unit "borrows" routine apportionment from the other unit. This evolution is controlled by station procedures, which require direct communication with the Shift Managers and the Chemistry Department.

1.3 <u>Setpoints for Liquid Effluent Monitors</u>

1.3.1 Liquid Effluent Monitors have setpoints based on limiting the concentrations in the discharge canal to ten times the concentration values in Appendix B, Table 2, Column 2 to 10CFR20 in accordance with 10CFR20.1302(2)(i).

1.3.2 Monitor setpoints are inherently conservative due to the routine use of determining dilution from Circulating Water Pumps at the applicable unit only. In actuality, both Circulating and Service Water systems for the entire site contribute to site dilution.

1.3.3 For monitors that read and alarm in μCi/ml, setpoints are calculated as follows:

S = [(ADC) (F)] / [f] = Maximum alarm setpoint in μCi/ml

where:

F = Available discharge canal dilution flow for this release, in gpm

f = calculated allowable release rate in gpm (Section 2.2.6)

ADC = The Allowed Diluted Concentration is the equivalent MPCW for gamma emitting isotopes weighted for total specific activity (both gamma and beta emitters). This term is necessary to correct the MPCW due to the relatively insignificant effect of beta emitters on the radiation monitor, as described in Section 2.2.6 and ODCM Appendix E.

1.3.4 Alert or Warn setpoints should be used on batch liquid release monitors to ensure the contents of the batch tank have not changed since sampling. The alert setpoint is calculated as follows:

AS = (C) * (M)

where:

| | | |
|---|---|---|
| AS | = | Alert or Warn setpoint in μCi/ml |
| C | = | Average monitor reading at time of sample |
| M | = | A conservative factor based upon the mixing ratio of two tank volumes and an expected monitor response error term (typically 1.25, coinciding with 25%). |

NOTE: Liquid Monitor alert setpoints do not control any auto functions but simply provide indication to the operators. Alert or Warn setpoints for other monitors are typically initially established at approximately 75% of the Alarm value.

TABLE 1 – 1 Unit 2 Effluent Radiation Monitor System Data

| CHANNEL | MONITOR DESCRIPTION | SAMPLING LOCATIONS | TYPICAL RANGE [1] | EFFLUENT CONTROL FUNCTIONS |
|---|---|---|---|---|
| R-44 | Plant Vent Radiogas Monitor | 88' Fan Bldg | 4.6E-7 to 4.6E-1 µCi/cc | Shuts RCV-014 (isolating gas tanks), stops VC release fans and shuts VC vent/purge valves. (The charcoal bank remains in service at all times). |
| R-50 | Waste Gas Disposal System Monitor | 98' PAB | 0.1 to 1E5 Curies | None. RECS D3.2.6 is assured by setpoint basis per ODCM Part II, Sec 3.1.12. |
| R-27 | Plant Vent Wide-Range (Accident) Monitor | Drawn from inside Plant Vent, to 85' BAB | Ch1-3) E-7 to E+6 µCi/cc<br>Ch4) 10 to E+13 µCi/sec | None. PV Concentration and release rate information only, for accident applications. |
| R-60 | Unit 1 Stack Vent Radiogas Monitor | Unit 1 Nuclear Services Bldg 100' Elevation | 4.6E-7 to 4.6E-2 µCi/cc | None |
| R-46 / 53 | Fan Cooler Unit Service Water Return | Adjacent to service water return line from V.C. fan cooler units and motor coolers | 1E-7 to 1E-1 µCi/ml | None |
| R-47 | Component Cooling System pump outlet | Adjacent to line monitors on each pump outlet | 1E-7 to 1E-1 µCi/ml | None. Setpoints are not based on effluent. They are for ALARA and information only. |
| R-39 / 40 | Component Cooling Heat Exchanger Service Water Monitors | 80' PAB | 1E-7 to 1E-1 µCi/ml | None |
| R-54 | Waste Disposal Liquid Effluent Monitor | In-line monitor on 70' CSB | 4.3E-8 to 4.3E-2 µCi/ml | Terminates Distillate Tank releases on alarm |

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[1] Actual Ranges of Rad Monitors (in Engineering Units) are a function of the selection of isotopes (average energy) and other factors.

TABLE 1 – 2 Unit 3 Effluent Radiation Monitor System Data

| CHANNEL | MONITOR DESCRIPTION | SAMPLING LOCATIONS | TYPICAL RANGE [1] | EFFLUENT CONTROL FUNCTIONS |
|---|---|---|---|---|
| R-12 | Containment Gas Monitor | Samples drawn from 32 and 35 Containment Fan Coolers | 9.2E-8 to 9.2E-2 µCi/cc | Containment Ventilation Isolation |
| R-14 | Plant Vent (PV) Radiogas Monitor | Installed within the plenum of the Plant Vent, 105' elevation | 1.6E-7 to 1.6E-1 µCi/cc | Secures waste gas tank release, isolates containment, aligns PV charcoal |
| R-15 | Condenser Air Ejector Monitor | Adjecent-to-line detector, on the exhaust header, 53' Turbine Hall | 2.8E-7 to 2.8E-1 µCi/cc | On alarm, diverts air ejector exhaust to VC and secures steam to priming air ejectors re-heaters |
| R-20 | Waste Gas Disposal System Monitor | Adjacent to line, on suction to waste gas compressors | 1E-2 to 1E+3 µCi/cc | None. This setpoint is based on limiting 50,000 Ci per tank, per RECS D3.2.6. |
| R-27 | Plant Vent Wide-Range (Accident) Monitor | Drawn from inside Plant Vent to fan house near 80' airlock | Ch1-3) E-7 to E+5 µCi/cc<br>Ch4) 10 to E+13 µCi/sec | (Same functions as R-14) |
| R-46 | Administration Building Vent Radiogas Monitor | 4th Floor Administration Building Monitor Exhaust Plenum for Controlled Areas | 1E+1 to 1E+6 cpm (approx 5.0E-8 to 5.0E-2 µCi/cc) | None |
| R-59 | RAMS Building Vent Radiogas Monitor | 55' RAMS Building Monitor Exhaust Plenum | 1E-6 to 1E+2 µCi/cc | None |
| R-16 A/B | Fan Cooler and Motor Cooler Service Water Return | Adjacent to service water return line from V.C. fan cooler units and motor coolers | 7.1E-7 to 7.1E-1 µCi/ml | None |
| R-17 A/B | Component Cooling System pump outlet | Adjacent to line monitors on each pump outlet | 2.3E-6 to 2.3E-1 µCi/ml | None. These setpoints are based on early indication of RCS leak into CCW. |
| R-23 | Component Cooling Heat Exchanger Service Water Monitor | Adjacent to line, mounted on SW return from Component Cooling Heat Exchanger | 1.3E-6 to 1.3E-2 µCi/ml | None |
| R-18 | Waste Disposal Liquid Effluent Monitor | In-line monitor on monitor tank recirc pump discharge | 4.0E-8 to 4.0E-2 µCi/ml | Terminates monitor tank release on alarm |
| R-19 | SG Blowdown Monitor | PAB blowdown room monitors steam generator blown | 7.0E-8 to 8.2E+2 µCi/ml (using 2 ranges, per RG 1.97) | Closes blowdown isolation valves and SG sample valves |
| R-61 | Condensate Polisher Facility (CPF) Regen Waste Release Monitor | Recirc line of HTDS/LTDS tanks in CPF (used during a primary to secondary leak). | 1E-7 to 1E-1 µCi/ml | Terminates HTDS or LTDS tank release. Applicable only in a primary to secondary leak, as defined in RECS D1.1. |

[1] Actual Ranges of Rad Monitors (in Engineering Units) are a function of the selction of isotopes (average energy) and other factors.

# 2.0 **LIQUID EFFLUENTS**

## 2.1 Liquid Effluent Releases - General Information

2.1.1 A completed and properly authorized Liquid Radioactive Waste Permit is required prior to performing any BATCH release (a release of known volume and activity from an isolated source).

2.1.2 All activity determinations for liquid radioactive effluents are performed in such a manner as to be representative of the activity released to the river.

2.1.3 The radioactivity in liquid waste tanks shall be continuously monitored during release except as allowed by RECS D3.3.1. If the flowmeter is inoperable, the flow shall be estimated every four hours by difference in tank level or by discharge pump curves.

2.1.4 Prior to discharge, the radioactive waste tank contents shall be recirculated for at least three tank volumes. After this recirculation, and prior to discharge, a sample shall be taken and analyzed for activity with a portion of the sample set aside for composite analysis. The measured activity shall be used for calculating allowable discharge rate and the alarm setpoint for the liquid waste discharge monitor. 4/21

2.1.5 Steam Generators or other CONTINUOUS releases shall be quantified and included in effluent reports, but do not require a pre-release permit. Continuous releases are typically quantified from periodic sampling and the use of radiation monitoring. In Modes 4-6, however, SG Draindowns are typically quantified in BATCH mode.

2.1.6 Assurance that the combined liquid releases from Units 2 and 3 maintain compliance with 10CFR20 is provided by administrative controls which include an administrative minimum dilution of 80,000 gpm for any batch release, and limiting to only one unit discharging at a time. 4/21

2.1.7 Steam Generator Blowdown activity is determined by composite samples collected in a manner to be proportional to the rate of flow of individual steam generator to total steam generator blowdown. These samples are then analyzed for the various radionuclides at frequencies specified in the RECS. Due to appropriate compositing, total blowdown flow is then routinely multiplied by average concentrations to determine the actual effluent contribution from Steam Generator Blowdown.

2.1.8 Time average dose calculations (10CFR50) may use total site dilution flow for both units, with the determined dose contributions additive for a site report over any specified period.

2.1.9 The discharge canal flow rate is determined by the use of pump flow characteristics curves. Unit 2 circulator pumps are operated at either low or high speed (approximately 88,000 to 140,000 gpm). Unit 3 circulator pumps have a variable speed capacity, and can produce a range from 65,000 to 140,000 gpm. 4/21

2.1.10 Radioactivity content in outdoor tanks is to be limited to less than 10 curies, excluding tritium and noble gas, as per RECS D3.1.4. Compliance with this requirement is demonstrated by limiting the radioactive concentration in these tanks to the value which results in 10 curies when the tank is at full liquid capacity, except as modified below. The radioactive concentration limits for these tanks are:

<u>RWST</u>:

$$\frac{10\,curies \times 10^{6}\,\mu Ci/curie}{358{,}500\,gal \times 3785\,ml/gal} = 7.3 \times 10^{-3}\,\mu Ci/ml$$

<u>PWST</u>:

$$\frac{10\,curies \times 10^{6}\,\mu Ci/curie}{165{,}000\,gals \times 3785\,ml/gal} = 1.6 \times 10^{-2}\,\mu Ci/ml$$

<u>31 & 32 Monitor Tanks (Unit 3)</u>:

$$\frac{10\;curies \times 10^{6}\,\mu Ci/curie}{11{,}750\,gals \times 3785\,ml/gal} = 2.2 \times 10^{-1}\,\mu Ci/ml$$

<u>13 & 14 Waste Distillate Storage Tanks (Units 1/2)</u>:

$$\frac{10\;\mathrm{curies} \times 10^{6}\,\mathrm{\mu Ci/curie}}{23{,}577\,\mathrm{gals} \times 3785\,\mathrm{ml/gal}} = 1.1 \times 10^{-1}\,\mathrm{\mu Ci/ml}$$

<u>Unit 3's Condensate Polisher High and Low Total Dissolved Solids Tanks:</u>

$$\frac{10\;curies \times 10^{6}\,\mu Ci/curie}{60{,}000\,gals \times 3785\,ml/gal} = 4.4 \times 10^{-2}\,\mu Ci/ml$$

<u>Outside Temporary Tanks</u>:

$$\frac{10\;curies \times 10^{-6}\,\mu Ci/curie}{Volume\;(gal) \times 3785\,ml/\;gal} = \mu Ci/ml$$

Integrated curies in a tank can similarly be determined by calculating the curies added from known inlet concentrations and volumes, which would then be combined with previously determined tank curie levels.

The refueling water storage tank has the potential to be filled from the reactor cavity with liquid which exceeds the limits stated. Therefore, prior to filling the RWST from the reactor cavity after refueling operations, the reactor cavity (or residual heat removal system) must be sampled for radioactivity and action taken to ensure that the total activity in the tank does not exceed 10 curies.

Outside temporary tanks should not be filled with liquid which could exceed the concentration limit calculated. Therefore, prior to transfer to outside temporary tanks, the source of liquid shall be sampled for radioactivity. If it exceeds the concentration limit calculated, action shall be taken to ensure that the total activity in the tank does not exceed 10 curies.

2.1.11 Turbine hall drains (from sumps in the five foot elevation for units 2 and 3) receive drains from areas containing secondary plant components at sub-atmospheric pressures. These sumps do not meet the intent of a turbine hall drain system as defined in NUREG 0472, however their effluent contribution should be evaluated.

Quantification of effluents is performed on this pathway during a Primary to Secondary Leak , as defined by RECS D1.1. In these cases, releases from this pathway would be quantified by periodic sampling multiplying the source term by a determination of the release rate to the river, generally bounded by secondary system loss or make-up rate.

At elevated Steam Generator activity levels (approximately 1.0E-4 or above), turbine hall drains may require temporary processing, should effluents via this pathway approach the 31-day dose projection limits per RECS D3.1.3. In this case, water at Unit 3 can be directed to the Condensate Polishing Facility prior to release. At Unit 2, a temporary processing skid will need to be applied, or other installed cleanup system.

Activity released via this pathway is determined as follows:

$$\begin{pmatrix}\text{Turbine Hall}\\ \text{Drain}\\ \text{Effluent Activity}\end{pmatrix} = \begin{pmatrix}\text{Feedwater}\\ \text{Specific}\\ \text{Activity}\end{pmatrix} * \begin{pmatrix}\text{Steam Plant} & & \text{SG Blowdown}\\ \text{Makeup} & - & \text{Rate to the}\\ \text{Rate} & & \text{River}\end{pmatrix}$$

2.1.12 Studies performed by the NY State Department of Health (1981-82) determined that waterborne Carbon 14 is released at IPEC, at a conservative estimate of .07 curies per year. The curies released and offsite dose from liquid C-14 effluent is reported separately from other, more common isotopes, to prevent confusion, loss of relevance of the more common isotopes, and to preserve historical trends.

Carbon-14 effluent is discussed in detail in Appendix K. Annual curies released and offsite dose are summarized in the Radiological Impact on Man section of the Annual Radioactive Effluent Release Report.

2.1.13 Several normally non-radioactive systems are periodically analyzed for radioactivity. Examples include Unit 3's Condensate Polisher regenerant waste tank, the Spent Fuel Pool Auxiliary Heat Exchanger Secondary Cooling Systems (when in use), and Site Storm Drains, etc. The monitoring program for these type of release points is consistent with the direction set forth in NRC IE Bulletin 80-10 "Contamination of Non-radioactive Systems and Resulting Potential for Unmonitored, Uncontrolled Release of Radioactivity to Environment". Should a system become contaminated, releases will be evaluated and quantified (as either batch or continuous) in accordance with the requirements listed in the RECS and the IPEC 80-10 program.

2.1.14 The Unit 3 liquid waste monitor tanks have an airborne release pathway. The original plant design limited the gases through this pathway by reducing the entrained gases to less than 2E-3 μCi/ml. When the entrained gas concentration in the monitor tank inlet exceeds 2E-3 μCi/ml, the noble gas release will be quantified by calculating the difference (in μCi's) between the gaseous activity added to the tank and the gaseous activity present in the effluent release sample. This difference will be the activity released through the tank vents and is quantified as an airborne release.

2.1.15 Due to the addition of Hafnium control rods at Unit 3, an offsite dose may need to be calculated for Hafnium isotopes in waste pathways. In the absence of site-specific bioaccumulation and dose factors for Hafnium, factors for Zirconium are used, as suggested in ICRP 30. Should these calculations become necessary, they will be performed per the following sections, and manually added to other totals.

2.1.16 Investigations from the Radiological Ground Water Monitoring Program (RGWMP) have resulted in a determination of liquid effluent. A quantification and dose assessment of radioactive groundwater and storm water leaving the site shall be performed at least annually. This quantification shall include, as a minimum, the source term from samples obtained near the effluent points of each applicable pathway (eg, ground water wells nearest the site boundary), and a determination of release rate and dilution flow.

Release rates to the river from both the bedrock pathways and collective storm drain pathways are provided from modeling by hydrologists. Initially, a general precipitation mass balance model was applied to assess groundwater flow rates (Reference 32). During calendar year 2007, and again in 2010, this model was calibrated using an independent Darcy's Law model. The precipitation mass balance model, as modified through the final calibration in 2010, will continue to be used going forward, as discussed in Appendix J, Groundwater and Stormwater Flow and Offsite Dose Calculation Details.

Dilution flow is directly measured in the Discharge Canal, for any water directed there. For storm or groundwater reaching the Hudson via a direct path under the canal, a dilution factor equivalent to a 6-hour half-tidal surge in the effected area of the Hudson is applied. As discussed in Reference 33, this dilution is equivalent to 5.83E10 gallons per year, or 1.11E5 gallons per minute.

Dose calculations are otherwise then completed per the following sections.

2.2 <u>Liquid Effluent Concentrations</u>

This section provides a description of the means that will be used to demonstrate compliance with the RECS D3.1.1.

2.2.1 Compliance with the instantaneous limits of 10CFR20 is achieved by allocating dilution flow on a per unit basis, as described in Section 2.1.6. Compliance with 10CFR50 (quarterly and annual limitations) is assured by completing a monthly report which summarizes the releases from the site.

2.2.2 Each isolated liquid waste tank must be recirculated for at least three tank volumes prior to sampling in order to ensure a representative sample is obtained. At Unit 2, this duration is determined from station procedures with every batch release. At Unit 4/21
3, a default minimum recirculation time of 6 hours may be used for 31 and 32 monitor tanks in lieu of the actual calculation:

$$\frac{11750\ gals * 3\ Tank\ Volunes}{100\ gal/min} = 5.9\ Hours\ \approx 6\ Hours$$

Note: Nominal monitor tank pump flow rate is approximately 135 gpm. For conservativism however, 100 gpm is used for the recirculation flow rate, while 150 gpm is used for the discharge flow rate in all release calculations.

2.2.3 For batch releases, the concentration in liquid effluents prior to dilution in the discharge canal is determined by sampling prior to release. For continuous releases, the concentrations can be determined by either grab sampling, or by direct reading radiation monitor. If the process radiation monitor is utilized, the conversion factor should be verified as appropriate for the mixture being released.

For non-direct reading monitors, the following calculation is used:

$$C = CF * CR$$

C = Concentration of liquid effluent (uCi/ml) prior to dilution

CF = Conversion factor of monitor (uCi/ml per net cpm)

CR = Count rate of monitor (in net cpm)

2.2.4 The final diluted concentration in the canal is determined as follows:

$$CD = (C) * (f) / (F)$$

Where: CD = Diluted concentration in the discharge canal in uCi/ml

C = Pre-dilution liquid concentration in uCi/ml

F = Dilution flow in the discharge canal in gal/min

f = Release rate of liquid effluent in gal/min

2.2.5 <u>Calculation of Maximum Permissible Concentration in Liquid Effluents</u>

a. This section describes the methodology used to ensure compliance with RECS D3.1.1. The discharge canal concentration of radionuclides must be maintained less than those identified as limits (10 times the EC's of 10CFR20). The noble gas limit has been specified as 2E-4 uCi/ml.

These criteria are normally assured by using an ***Allowed Diluted Concentration*** (ADC) on each discrete release. This differs from the ECs given in 10CFR20 Appendix B in that, for radioisotopes that do not have gammas greater than 60 kev emitted during decay, default values are included to estimate their contribution.

The Allowed Diluted Concentration is derived and calculated as follows:

$$\text{ADC} = \frac{\text{MPCW t} * \text{CG}}{\text{Total activity}} \quad \text{or} \quad \text{ADC} = \frac{\text{MPCW t} * \text{CG}}{\text{CG+CB}} \quad \text{or} \quad \text{ADC} = \frac{\text{MPCW t}}{1 + \text{CB}/\text{CG}}$$

where:

ADC = Allowed diluted concentration in uCi/ml as defined in ODCM Appendix E.

MPCWt = Maximum permissible concentration in water for all isotopes (beta & gamma), in uCi/ml, as defined in RECS, D1.1, as follows:

$$MPCWt = \frac{\sum_i Ci}{\sum_i \left\langle Ci \big/ MPCWi \right\rangle}$$

Ci and MPCWi = Concentration and MPCW for each isotope

CB = The concentration of the non gamma emitters, in uCi/ml

CG = The concentration of the gamma emitters, in uCi/ml

b. A representative sample must be obtained. For batch releases, at least two tank volumes are recirculated after the tank has been isolated to meet these requirements. The minimum recirculation time is determined as follows:

T = 2 (V) / (G) where;

T = Minimum recirculation time in min

V = Volumes in the tank to be discharged, in gal

G = Recirculation rate in gal/min

c. After the tank has been sampled, the Allowed Diluted Concentration is determined, per the equations above.

d. A determination of other liquid radioactive discharges is evaluated. If other releases are in progress at an affected unit, the radioactive concentrations and discharge rates are included to determine a potentially new required dilution factor.

e. Available dilution flow may be adjusted by physically using more pumps or altering an allocation fraction. Additionally, if required, release rate can be adjusted to comply with diluted concentration limits with existing dilution flow. Typically, however, these measures are not required.

f. The required dilution flow is calculated as follows:

$$E = \frac{Dr * CG}{ADC}$$ where;

Dr = Current release discharge rate, gpm

E = Required dilution for current existing release(s), gpm

CG and ADC are defined in Section 2.2.6.a

g. The permissible discharge rate is calculated as follows:

$$D = \frac{ADC * B}{CG}$$

Where:

D = Permissible discharge rate in gal/min

ADC = Calculated and described in Step 2.2.6.a

CG = Gamma emitter concentration in μCi/ml

B = Adjusted dilution flow from the unit, in gpm, from Step 2.2.6.d, above, as follows:

$$B = \begin{bmatrix} \text{Available Dilution} \\ \text{Flow, gpm} \end{bmatrix} - \begin{bmatrix} \text{Required Dilution Flow} \\ \text{from Other Releases, gpm} \end{bmatrix}$$

Note: With no other releases, *B* simply becomes the *Available Dilution Flow*.

## 2.3 Liquid Effluent Dose Calculation Requirements

RECS D3.1.2 requires that the dose or dose commitment above background to an individual in an unrestricted area from radioactive materials in liquid effluents released from each reactor unit shall be limited:

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

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

c) If either of the above limits is exceeded by a factor of two or more, then cumulative dose contributions from direct radiation would be determined by evaluation of existing perimeter and environmental TLDs per RECS D3.4.1.

2.3.1 RECS D3.1.3 requires that appropriate portions of the radwaste treatment system be used to reduce the radioactive material in liquid waste prior to their discharge when the projected dose due to liquid effluent from each reactor unit when averaged over 31 days, would exceed 0.06 mrem to the total body or 0.2 mrem to any organ. Doses due to liquid release shall be projected at least once per 31 days. These doses are projected based on the dose methodology in Section 2.4. or 2.5. The average of previous months' doses is used to project future dose, as follows:

$$\begin{bmatrix} \text{Dose} \\ \text{Projection} \end{bmatrix} = \frac{\text{Current Month Dose} + \text{Previous months' Dose}}{\text{number of months used}} \pm \begin{bmatrix} \textit{major} \\ \textit{planned} \\ \textit{evolutions} \end{bmatrix}$$

The term for planned evolutions is routinely determined from previous similar evolutions, such as releases associated with plant shutdown.

## 2.4 Dose Methodology (Computer Calculation)

2.4.1 NUREG 0133 (Ref. 1, Section 4.3, Pg. 14) states that cumulative dose contributions should consider the dose contribution from the maximum exposed individual's consumption of fish, invertebrates, and potable water as appropriate. The river near IPEC is considered to be fresh water when in reality it is a tidal estuary and never completely fresh. Observed average chlorosity at IPEC has ranged as high as 2.5 gm/liter or about 13% sea water and 87% fresh water.

Hence, use of the Hudson River for fresh water supply purposes is precluded south of Chelsea (mile point 65) which is the nearest point of potable water supply (approximately 15 miles upstream of IPEC). Radionuclide concentrations in the nearest water supply have been calculated (Ref. 2) to be a factor of at least 500 lower than the river water in the Indian Point area.

Due to the absence of a potable water pathway, RECS D3.1.2 reporting regulations for a 3 mile downstream limit do not apply. There is no exposures from ingestion of drinking water.

Thus, at IPEC, the cumulative dose considers only the dose contributions from the maximum exposed individuals consumption of fish and invertebrates. Tables of dose factors for three age groups were developed as per Section 2.4.3 and are included as Tables 2-1, 2-2, and 2-3. (Infant dose factors are 0 and are not included).

2.4.2 The relationships and methods that form the calculational base for dose accounting for the liquid effluent pathway are described in this section. These relationships can be used to meet the calculational requirements of Section 2.3.1. The cumulative dose factors (Ait) are calculated in Section 2.4.3. The following equation is generally applicable and can be used for any number of isotopes released over a time period:

$$D(T) = \sum_{i=1}^{m} [A_{iT} * \sum_{k=1}^{n} (dt_k)(C_{ik})(F_k)]$$

Where:

m = The total number of isotopes released.

D(T) = The liquid effluent cumulative dose commitment from nuclides to the total body or any organ, T, for the time period k, in mrem.

$dt_k$ = The length of the time period, k over which $C_{ik}$ and $F_k$ are averaged for all liquid releases, in hours. (This can be individual release durations summed, or an entire period duration, defined with each application of this equation.)

$C_{ik}$ = The undiluted liquid effluent average concentration of nuclide, i, in uCi/ml, during time period $dt_k$ from any liquid release.

n = The total number of releases considered.

$A_{iT}$ = The site related ingestion dose commitment factor to the total body or any organ for each identified principal gamma and beta emitter listed in Table 2-1, 2-2, and 2-3, in mrem-ml per hr-uCi.

$F_k$ = The total dilution factor for $C_{ik}$ during any liquid effluent releases; defined as the ratio of the maximum undiluted liquid waste flow during release to the average flow from the site discharge structure to unrestricted receiving waters, times an applicable factor.

The term $C_{ik}$ represents the total undiluted concentration of radioactive material in liquid waste at the release point as determined by the radioactive liquid waste sampling and analysis program as contained in the RECS. All dilution factors beyond the sample point are included in the $F_k$ and $A_{iT}$ terms.

The term $F_k$ is a total dilution factor and is determined as follows:

$$F_k = \frac{\text{Liquid Radioactive Waste Flow}}{[\text{Discharge Structure Exit Flow} * \text{Applicable Factor}]}$$

The liquid radioactive waste flow is the flow from all continuous and batch radioactive effluent releases specified in the RECS from all liquid radioactive waste management systems. The discharge structure exit flow is the average flow during disposal from the discharge structure release point into the receiving body of water. Based on studies by New York University Medical Center (ref. 14 page 7), the appropriate "Applicable Factor" (a mixing factor in the near field), is **5.0**.

For permitting of liquid effluent releases, $F_k$ is typically determined with a conservative dilution flow concurrent with the applicable release. (see Section 2.2). Initial doses are later calculated for each permit based upon the best estimate of the total dilution flow. If necessary doses are later recalculated with a more accurate estimate of the total dilution flow. This method allows both 1) an immediate assessment of proximity to 10CFR20 (release rate) limits, and 2) a more accurate long-term assessment of doses per 10CFR50. 4/21

### 2.4.3 Dose Factor for Liquid Effluent Calculations

The equation for dose from liquid effluents requires the use of a dose factor $A_{iT}$ for each nuclide, i, which embodies the dose factors, pathway transfer factor, pathway usage factors, and dilution factors for the points of pathway origin.

IPEC follows the guidance of NUREG 0133 and has calculated $A_{iT}$ for the total body and critical organ of the maximum exposed individual for Adult, Teen and Child doses. Most factors needed in the equation were obtained from Regulatory Guide 1.109 with the following exceptions (see Section 2.6 and Ref 2, 12, 13, 14, and 25):

The fish and invertebrate bioaccumulation factors ($BF_i$ and $BI_i$) for Cesium, Niobium, Silver, and Antimony, were determined locally.

For Cesium, a site specific factor of 224 was used instead of the 2,000 presented in Table A-1 of the Regulatory Guide for fish. Similarly, a factor of 224 was used for invertebrates instead of the Regulatory Guide value of 1000.

For Silver, the fish and invertebrate factors are 2.3 and 3300, respectively.

For Niobium, the fish and invertebrate factors are 300 and 100 respectively.

For Antimony, the fish and invertebrate factors are 1 and 300 respectively.

The summary dose factor is as follows:

$$A_{iT} = K[(UF)BF_i + (UI)BI_i]Df$$

<u>Where</u>:

$A_{iT}$ = Composite dose parameter for the total body or critical organ for nuclide, i, for all appropriate pathways, mrem/hr per μCi/ml.

K = Units conversion factor, 114155 = $\frac{(1E6 pCi/\mu Ci) * (1E3 ml/kg)}{8760 hr/yr}$

UF = kg/yr fish consumption from Table E-5 of Reg Guide 1.109:

| | |
|---|---|
| 21 Adult | 6.9 Child |
| 16 Teen | 0 Infant |

BFi = Fresh Water Fish Bioaccumulation factor for nuclide, i, in pCi/kg per pCi/l from Table A-1 of Regulatory Guide 1.109.

UI = kg/yr invertebrate consumption from Table E-5 of Regulatory Guide 1.109:

| | |
|---|---|
| 5.0 Adult | 1.7 Child |
| 3.8 Teen | 0 Infant |

BIi = Salt Water Invertebrates Bioaccumulation factor for nuclide, i, in pCi/kg per pCi/l from Table A-1 of Regulatory Guide 1.109.

$DF_i$ = Dose conversion factor for nuclide i, for age groups in pre-selected organs, T, in mrem/pCi, from Tables E-11, 12 & 13 of Regulatory Guide 1.109.

IPEC has compiled $A_{iT}$ factors for 3 age groups and various organs for the maximum exposed individual. These are included as Table 2-1, 2-2, and 2-3. For completeness, this table includes all isotopes found in Reg Guide 1.109, however, several isotopes listed are not routinely identified at IPEC. In addition, the values for Antimony, Silver, Cesium, and Niobium are site specific as previously discussed.

## 2.5 Backup Simplified Dose Methodology

2.5.1 An alternate computer method which completely complies with Section 2.4 is available should the primary computer system be inoperable.

2.5.2 Hand Calculations which completely comply with Section 2.4 can be employed if the primary and secondary computer codes are inoperable. Because they are time consuming and subject to calculational errors, procedural guidance in the actual flow of calculations should be used to maintain a standard format. These procedures are also used for benchmark tests of the computer codes.

## 2.6 Site Specific Bio-Accumulation & Dose Factors

2.6.1 As stated in Section 2.4.3 the bioaccumulation factor ($BF_i$) for Cesium in fish is assumed to be 224 instead of the 2000 listed in Regulatory Guide 1.109 (Ref. 3). Similarly, the bioaccumulation factor for invertebrates is 224. This is based on three facts; 1) the Hudson River at IPEC is not completely fresh, 2) the Bioaccumulation Factor for salt water is 40 (Ref. 2), and 3) the behavior of Cesium in the Hudson is a complex phenomenon, as discussed below.

The NYU Study (Ref. 2) shows that Cesium concentrations in fish are regulated at a relatively constant value independent of the concentration of Cesium in water, and the bioaccumulation factors are thus inversely proportional to the water concentration of Cesium. This explains the lower bioaccumulation factor for Cesium reported by numerous investigators for salt water fish as opposed to fresh water fish because of the higher stable Cesium content of sea water. The NYU Report states that water at Indian Point has a dissolved Cesium concentration which is much higher than would be expected from simple mixing between sea water and fresh water and postulates that these higher concentrations result from leaching of Cesium from bottom sediment by saline water.

Use of the bioaccumulation factors of Regulatory Guide 1.109 for a fresh water site will thus substantially overestimate fish ingestion doses because no account is taken of the phenomena just discussed. However, radio-cesium concentrations in fish may still be estimated through the use of a bioaccumulation factor, provided that this factor is determined from the body of water of interest. This factor has been estimated (Ref. 12, page 33) to be about 224 for the flesh of indigenous fish caught in the Indian Point area. In contrast, the Cesium fresh water bioaccumulation factor presented by Regulatory Guide 1.109 for fish is 2000.

Fish ingestion doses would therefore be overestimated by a factor of 13 if the Regulatory Guide values were used.

Similarly for invertebrates, the site specific bioaccumulation factor of 224 is used. This is larger than the value of 25 given in Reg Guide 1.109 for salt water invertebrates.

A second conservatism in the NRC model concerns the location at which the concentrations in the river of the discharged Cesium are evaluated. Use of this model implies that these fish have grown directly in such a location prior to being caught, which is unrealistic and adds about a factor of five in conservation. This conservatism remains in the calculation, thus the use of the NYU (Ref. 12) bioaccumulation factor is justifiable.

2.6.2 No bioaccumulation factor for Silver is listed in Rev. 1 of Regulatory Guide 1.109, Table A-1. The values of 2.3 and 5000 for fish and invertebrates were obtained from ORNL-4992 (sponsored by ERDA 660, Ref. 25) and are included in the ODCM in the interests of increased accuracy since Ag-110m is a potential component of IPEC liquid releases.

2.6.3 International Atomic Energy Agency Report No. 57 provides data more recent than that presented in Regulatory Guide 1.109 for niobium bioaccumulation factors. The factor in the Regulatory Guide appears to be substantially over-conservative and, therefore, the more recent IAEA information is incorporated into the dose calculation methodology for liquid releases of radio-niobium. The values from Table XVII of IAEA No. 57 are 300 and 100 for freshwater fish and marine invertebrates respectively and are incorporated into this ODCM.

2.6.4 Antimony isotopes are not listed in Reg. Guide 1.109. As for Niobium above, IAEA Report No. 57 was used to provide bioaccumulation factors for the Antimony isotopes in Table 2-1. Dose factors were calculated for Antimony as per Reference 13.

2.6.5 Te-123m dose factors are not listed in Reg. Guide 1.109. Since this isotope is identified from potentially failed secondary startup sources and previously identified at IPEC, ingestion dose factors were derived from ICRP 30 and calculated per Ref 34.

2.6.6 In summary, with the exception of the bioaccumulation and dose factors discussed above, all remaining factors applied at IPEC are defined in Reg Guide 1.109 for a combination of fresh water fish and salt water invertebrates.

Table 2 - 1

Site Related Adult Ingestion Dose Commitment Factors
(Freshwater Fish and Saltwater Invertebrate Consumption)

(AiT)
mrem/hr per uCi/ml

| ISOTOPE | BONE | LIVER | TOT BODY | THYROID | KIDNEY | LUNG | GI-LLI |
|---|---|---|---|---|---|---|---|
| H-3 | 0.00E+00 | 2.82E-01 | 2.82E-01 | 2.82E-01 | 2.82E-01 | 2.82E-01 | 2.82E-01 |
| BE-7 | 3.29E-01 | 7.45E-01 | 3.69E-01 | 0.00E+00 | 7.83E-01 | 0.00E+00 | 1.28E+02 |
| NA-24 | 4.08E+02 | 4.08E+02 | 4.08E+02 | 4.08E+02 | 4.08E+02 | 4.08E+02 | 4.08E+02 |
| P-32 | 4.96E+07 | 3.08E+06 | 1.92E+06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.57E+06 |
| CR-51 | 0.00E+00 | 0.00E+00 | 4.31E+00 | 2.58E+00 | 9.50E-01 | 5.72E+00 | 1.08E+03 |
| MN-54 | 0.00E+00 | 5.43E+03 | 1.04E+03 | 0.00E+00 | 1.61E+03 | 0.00E+00 | 1.66E+04 |
| MN-56 | 0.00E+00 | 1.37E+02 | 2.42E+01 | 0.00E+00 | 1.73E+02 | 0.00E+00 | 4.36E+03 |
| FE-55 | 3.21E+04 | 2.21E+04 | 5.16E+03 | 0.00E+00 | 0.00E+00 | 1.24E+04 | 1.27E+04 |
| FE-59 | 5.06E+04 | 1.19E+05 | 4.56E+04 | 0.00E+00 | 0.00E+00 | 3.32E+04 | 3.96E+05 |
| CO-58 | 0.00E+00 | 5.15E+02 | 1.15E+03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.04E+04 |
| CO-60 | 0.00E+00 | 1.48E+03 | 3.26E+03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.78E+04 |
| NI-63 | 4.97E+04 | 3.45E+03 | 1.67E+03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.19E+02 |
| NI-65 | 2.02E+02 | 2.62E+01 | 1.20E+01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.65E+02 |
| CU-64 | 0.00E+00 | 9.08E+01 | 4.26E+01 | 0.00E+00 | 2.29E+02 | 0.00E+00 | 7.74E+03 |
| ZN-65 | 1.61E+05 | 5.13E+05 | 2.32E+05 | 0.00E+00 | 3.43E+05 | 0.00E+00 | 3.23E+05 |
| ZN-69 | 3.43E+02 | 6.57E+02 | 4.57E+01 | 0.00E+00 | 4.27E+02 | 0.00E+00 | 9.87E+01 |
| BR-83 | 0.00E+00 | 0.00E+00 | 4.05E+01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.84E+01 |
| BR-84 | 0.00E+00 | 0.00E+00 | 5.25E+01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.13E-04 |
| BR-85 | 0.00E+00 | 0.00E+00 | 2.16E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| RB-86 | 0.00E+00 | 1.01E+05 | 4.72E+04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.00E+04 |
| RB-88 | 0.00E+00 | 2.91E+02 | 1.54E+02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.02E-09 |
| RB-89 | 0.00E+00 | 1.93E+02 | 1.35E+02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.12E-11 |
| SR-89 | 2.57E+04 | 0.00E+00 | 7.37E+02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.12E+03 |
| SR-90 | 6.32E+05 | 0.00E+00 | 1.55E+05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.82E+04 |
| SR-91 | 4.72E+02 | 0.00E+00 | 1.91E+01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.25E+03 |
| SR-92 | 1.79E+02 | 0.00E+00 | 7.75E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.55E+03 |
| Y-90 | 6.07E+00 | 0.00E+00 | 1.63E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.43E+04 |
| Y-91M | 5.73E-02 | 0.00E+00 | 2.22E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.68E-01 |
| Y-91 | 8.89E+01 | 0.00E+00 | 2.38E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.89E+04 |
| Y-92 | 5.33E-01 | 0.00E+00 | 1.56E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 9.33E+03 |
| Y-93 | 1.69E+00 | 0.00E+00 | 4.67E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.36E+04 |
| ZR-95 | 1.63E+00 | 5.22E-01 | 3.54E-01 | 0.00E+00 | 8.20E-01 | 0.00E+00 | 1.66E+03 |
| ZR-97 | 9.00E-02 | 1.82E-02 | 8.30E-03 | 0.00E+00 | 2.74E-02 | 0.00E+00 | 5.63E+03 |
| NB-95 | 4.83E+00 | 2.69E+00 | 1.44E+00 | 0.00E+00 | 2.65E+00 | 0.00E+00 | 1.63E+04 |
| MO-99 | 0.00E+00 | 1.28E+02 | 2.43E+01 | 0.00E+00 | 2.90E+02 | 0.00E+00 | 2.97E+02 |
| TC-99M | 1.59E-02 | 4.50E-02 | 5.73E-01 | 0.00E+00 | 6.84E-01 | 2.21E-02 | 2.66E+01 |
| TC-101 | 1.64E-02 | 2.36E-02 | 2.32E-01 | 0.00E+00 | 4.25E-01 | 1.21E-02 | 7.09E-14 |
| RU-103 | 1.10E+02 | 0.00E+00 | 4.74E+01 | 0.00E+00 | 4.20E+02 | 0.00E+00 | 1.28E+04 |
| RU-105 | 9.16E+00 | 0.00E+00 | 3.62E+00 | 0.00E+00 | 1.18E+02 | 0.00E+00 | 5.60E+03 |
| RU-106 | 1.64E+03 | 0.00E+00 | 2.07E+02 | 0.00E+00 | 3.16E+03 | 0.00E+00 | 1.06E+05 |
| AG-110M | 4.58E+02 | 4.23E+02 | 2.51E+02 | 0.00E+00 | 8.32E+02 | 0.00E+00 | 1.73E+05 |
| SB-122 | 3.47E+01 | 7.99E-01 | 1.20E+01 | 5.38E-01 | 0.00E+00 | 2.08E+01 | 1.32E+04 |
| SB-124 | 4.86E+02 | 9.20E+00 | 1.91E+02 | 1.18E+00 | 0.00E+00 | 3.79E+02 | 1.38E+04 |
| SB-125 | 3.11E+02 | 3.47E+00 | 7.40E+01 | 3.16E-01 | 0.00E+00 | 2.40E+02 | 3.42E+03 |

Table 2 - 1

Site Related Adult Ingestion Dose Commitment Factors
(Freshwater Fish and Saltwater Invertebrate Consumption)

(AiT)
mrem/hr per uCi/ml

| ISOTOPE | BONE | LIVER | TOT BODY | THYROID | KIDNEY | LUNG | GI-LLI |
|---|---|---|---|---|---|---|---|
| TE-125M | 2.72E+03 | 9.87E+02 | 3.65E+02 | 8.19E+02 | 1.11E+04 | 0.00E+00 | 1.09E+04 |
| TE-127M | 6.88E+03 | 2.46E+03 | 8.38E+02 | 1.76E+03 | 2.79E+04 | 0.00E+00 | 2.31E+04 |
| TE-127 | 1.12E+02 | 4.01E+01 | 2.42E+01 | 8.28E+01 | 4.55E+02 | 0.00E+00 | 8.82E+03 |
| TE-129M | 1.17E+04 | 4.36E+03 | 1.85E+03 | 4.01E+03 | 4.88E+04 | 0.00E+00 | 5.88E+04 |
| TE-129 | 3.19E+01 | 1.20E+01 | 7.77E+00 | 2.45E+01 | 1.34E+02 | 0.00E+00 | 2.41E+01 |
| TE-131M | 1.76E+03 | 8.60E+02 | 7.16E+02 | 1.36E+03 | 8.71E+03 | 0.00E+00 | 8.53E+04 |
| TE-131 | 2.00E+01 | 8.36E+00 | 6.32E+00 | 1.65E+01 | 8.77E+01 | 0.00E+00 | 2.83E+00 |
| TE-132 | 2.56E+03 | 1.66E+03 | 1.55E+03 | 1.83E+03 | 1.60E+04 | 0.00E+00 | 7.83E+04 |
| I-130 | 4.88E+01 | 1.44E+02 | 5.68E+01 | 1.22E+04 | 2.24E+02 | 0.00E+00 | 1.24E+02 |
| I-131 | 2.68E+02 | 3.84E+02 | 2.20E+02 | 1.26E+05 | 6.58E+02 | 0.00E+00 | 1.01E+02 |
| I-132 | 1.31E+01 | 3.50E+01 | 1.23E+01 | 1.23E+03 | 5.58E+01 | 0.00E+00 | 6.58E+00 |
| I-133 | 9.16E+01 | 1.59E+02 | 4.86E+01 | 2.34E+04 | 2.78E+02 | 0.00E+00 | 1.43E+02 |
| I-134 | 6.84E+00 | 1.86E+01 | 6.64E+00 | 3.22E+02 | 2.95E+01 | 0.00E+00 | 1.62E-02 |
| I-135 | 2.86E+01 | 7.48E+01 | 2.76E+01 | 4.93E+03 | 1.20E+02 | 0.00E+00 | 8.45E+01 |
| CS-134 | 4.14E+04 | 9.84E+04 | 8.04E+04 | 0.00E+00 | 3.18E+04 | 1.06E+04 | 1.72E+03 |
| CS-136 | 4.33E+03 | 1.71E+04 | 1.23E+04 | 0.00E+00 | 9.51E+03 | 1.30E+03 | 1.94E+03 |
| CS-137 | 5.30E+04 | 7.25E+04 | 4.75E+04 | 0.00E+00 | 2.46E+04 | 8.18E+03 | 1.40E+03 |
| CS-138 | 3.67E+01 | 7.25E+01 | 3.59E+01 | 0.00E+00 | 5.33E+01 | 5.26E+00 | 3.09E-04 |
| BA-139 | 6.47E+00 | 4.61E-03 | 1.89E-01 | 0.00E+00 | 4.31E-03 | 2.61E-03 | 1.15E+01 |
| BA-140 | 1.35E+03 | 1.70E+00 | 8.87E+01 | 0.00E+00 | 5.78E-01 | 9.73E-01 | 2.79E+03 |
| BA-141 | 3.14E+00 | 2.37E-03 | 1.06E-01 | 0.00E+00 | 2.21E-03 | 1.35E-03 | 1.48E-09 |
| BA-142 | 1.42E+00 | 1.46E-03 | 8.93E-02 | 0.00E+00 | 1.23E-03 | 8.27E-04 | 2.00E-18 |
| LA-140 | 1.58E+00 | 7.95E-01 | 2.10E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.83E+04 |
| LA-142 | 8.07E-02 | 3.67E-02 | 9.15E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.68E+02 |
| CE-141 | 3.23E+00 | 2.18E+00 | 2.48E-01 | 0.00E+00 | 1.01E+00 | 0.00E+00 | 8.35E+03 |
| CE-143 | 5.69E-01 | 4.21E+02 | 4.66E-02 | 0.00E+00 | 1.85E-01 | 0.00E+00 | 1.57E+04 |
| CE-144 | 1.68E+02 | 7.04E+01 | 9.04E+00 | 0.00E+00 | 4.17E+01 | 0.00E+00 | 5.69E+04 |
| PR-143 | 5.80E+00 | 2.33E+00 | 2.88E-01 | 0.00E+00 | 1.34E+00 | 0.00E+00 | 2.54E+04 |
| PR-144 | 1.90E-02 | 7.88E-03 | 9.65E-04 | 0.00E+00 | 4.45E-03 | 0.00E+00 | 2.73E-09 |
| ND-147 | 3.97E+00 | 4.59E+00 | 2.74E-01 | 0.00E+00 | 2.68E+00 | 0.00E+00 | 2.20E+04 |
| W-187 | 2.98E+02 | 2.49E+02 | 8.71E+01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 8.16E+04 |
| NP-239 | 3.53E-02 | 3.47E-03 | 1.91E-03 | 0.00E+00 | 1.08E-02 | 0.00E+00 | 7.12E+02 |
| K-40 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| CO-57 | 0.00E+00 | 1.21E+02 | 2.01E+02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.07E+03 |
| SR-85 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Y-88 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| NB-94 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| NB-97 | 4.05E-02 | 1.02E-02 | 3.74E-03 | 0.00E+00 | 1.20E-02 | 0.00E+00 | 3.78E+01 |
| CD-109 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| SN-113 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| BA-133 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| TE-134 | 3.29E+01 | 2.15E+01 | 1.32E+01 | 2.88E+01 | 2.08E+02 | 0.00E+00 | 3.65E-02 |
| CE-139 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| HG-203 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

Table 2 - 2

Site Related Teen Ingestion Dose Commitment Factors
(Freshwater Fish and Saltwater Invertebrate Consumption)

(AiT)
mrem/hr per uCi/ml

| ISOTOPE | BONE | LIVER | TOT BODY | THYROID | KIDNEY | LUNG | GI-LLI |
|---|---|---|---|---|---|---|---|
| H-3 | 0.00E+00 | 2.17E-01 | 2.17E-01 | 2.17E-01 | 2.17E-01 | 2.17E-01 | 2.17E-01 |
| BE-7 | 3.58E-01 | 8.02E-01 | 4.01E-01 | 0.00E+00 | 8.50E-01 | 0.00E+00 | 9.76E+01 |
| NA-24 | 4.20E+02 | 4.20E+02 | 4.20E+02 | 4.20E+02 | 4.20E+02 | 4.20E+02 | 4.20E+02 |
| P-32 | 5.40E+07 | 3.35E+06 | 2.09E+06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.54E+06 |
| CR-51 | 0.00E+00 | 0.00E+00 | 4.44E+00 | 2.47E+00 | 9.73E-01 | 6.34E+00 | 7.46E+02 |
| MN-54 | 0.00E+00 | 5.33E+03 | 1.06E+03 | 0.00E+00 | 1.59E+03 | 0.00E+00 | 1.09E+04 |
| MN-56 | 0.00E+00 | 1.43E+02 | 2.54E+01 | 0.00E+00 | 1.81E+02 | 0.00E+00 | 9.40E+03 |
| FE-55 | 3.35E+04 | 2.37E+04 | 5.54E+03 | 0.00E+00 | 0.00E+00 | 1.51E+04 | 1.03E+04 |
| FE-59 | 5.20E+04 | 1.21E+05 | 4.69E+04 | 0.00E+00 | 0.00E+00 | 3.83E+04 | 2.87E+05 |
| CO-58 | 0.00E+00 | 5.10E+02 | 1.18E+03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.04E+03 |
| CO-60 | 0.00E+00 | 1.48E+03 | 3.32E+03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.92E+04 |
| NI-63 | 5.15E+04 | 3.64E+03 | 1.75E+03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.79E+02 |
| NI-65 | 2.18E+02 | 2.79E+01 | 1.27E+01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.51E+03 |
| CU-64 | 0.00E+00 | 9.53E+01 | 4.48E+01 | 0.00E+00 | 2.41E+02 | 0.00E+00 | 7.39E+03 |
| ZN-65 | 1.46E+05 | 5.07E+05 | 2.36E+05 | 0.00E+00 | 3.24E+05 | 0.00E+00 | 2.15E+05 |
| ZN-69 | 3.73E+02 | 7.10E+02 | 4.97E+01 | 0.00E+00 | 4.64E+02 | 0.00E+00 | 1.31E+03 |
| BR-83 | 0.00E+00 | 0.00E+00 | 4.41E+01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| BR-84 | 0.00E+00 | 0.00E+00 | 5.55E+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 | 5.12E+04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.61E+04 |
| RB-88 | 0.00E+00 | 3.12E+02 | 1.66E+02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.67E-05 |
| RB-89 | 0.00E+00 | 2.01E+02 | 1.42E+02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.09E-07 |
| SR-89 | 2.79E+04 | 0.00E+00 | 8.00E+02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.33E+03 |
| SR-90 | 5.27E+05 | 0.00E+00 | 1.30E+05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.48E+04 |
| SR-91 | 5.12E+02 | 0.00E+00 | 2.04E+01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.32E+03 |
| SR-92 | 1.94E+02 | 0.00E+00 | 8.25E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.93E+03 |
| Y-90 | 6.57E+00 | 0.00E+00 | 1.77E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.42E+04 |
| Y-91M | 6.18E-02 | 0.00E+00 | 2.36E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.92E+00 |
| Y-91 | 9.64E+01 | 0.00E+00 | 2.58E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.95E+04 |
| Y-92 | 5.80E-01 | 0.00E+00 | 1.68E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.59E+04 |
| Y-93 | 1.84E+00 | 0.00E+00 | 5.03E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.61E+04 |
| ZR-95 | 1.68E+00 | 5.29E-01 | 3.64E-01 | 0.00E+00 | 7.78E-01 | 0.00E+00 | 1.22E+03 |
| ZR-97 | 9.65E-02 | 1.91E-02 | 8.80E-03 | 0.00E+00 | 2.90E-02 | 0.00E+00 | 5.17E+03 |
| NB-95 | 4.86E+00 | 2.70E+00 | 1.48E+00 | 0.00E+00 | 2.61E+00 | 0.00E+00 | 1.15E+04 |
| MO-99 | 0.00E+00 | 1.36E+02 | 2.60E+01 | 0.00E+00 | 3.12E+02 | 0.00E+00 | 2.44E+02 |
| TC-99M | 1.63E-02 | 4.55E-02 | 5.89E-01 | 0.00E+00 | 6.77E-01 | 2.52E-02 | 2.98E+01 |
| TC-101 | 1.77E-02 | 2.51E-02 | 2.47E-01 | 0.00E+00 | 4.55E-01 | 1.53E-02 | 4.30E-09 |
| RU-103 | 1.15E+02 | 0.00E+00 | 4.93E+01 | 0.00E+00 | 4.06E+02 | 0.00E+00 | 9.63E+03 |
| RU-105 | 9.85E+00 | 0.00E+00 | 3.82E+00 | 0.00E+00 | 1.24E+02 | 0.00E+00 | 7.96E+03 |
| RU-106 | 1.77E+03 | 0.00E+00 | 2.23E+02 | 0.00E+00 | 3.42E+03 | 0.00E+00 | 8.50E+04 |
| AG-110M | 4.45E+02 | 4.22E+02 | 2.56E+02 | 0.00E+00 | 8.04E+02 | 0.00E+00 | 1.18E+05 |
| SB-122 | 4.35E+01 | 8.47E-01 | 1.27E+01 | 5.53E-01 | 0.00E+00 | 2.72E+01 | 9.13E+03 |
| SB-124 | 5.09E+02 | 9.40E+00 | 1.99E+02 | 1.16E+00 | 0.00E+00 | 4.45E+02 | 1.03E+04 |
| SB-125 | 3.27E+02 | 3.58E+00 | 7.64E+01 | 3.11E-01 | 0.00E+00 | 2.85E+02 | 2.53E+03 |

Table 2 - 2

Site Related Teen Ingestion Dose Commitment Factors
(Freshwater Fish and Saltwater Invertebrate Consumption)

(AiT)
mrem/hr per uCi/ml

| ISOTOPE | BONE | LIVER | TOT BODY | THYROID | KIDNEY | LUNG | GI-LLI |
|---|---|---|---|---|---|---|---|
| TE-125M | 2.96E+03 | 1.07E+03 | 3.96E+02 | 8.28E+02 | 0.00E+00 | 0.00E+00 | 8.75E+03 |
| TE-127M | 7.48E+03 | 2.65E+03 | 8.90E+02 | 1.78E+03 | 3.03E+04 | 0.00E+00 | 1.87E+04 |
| TE-127 | 1.22E+02 | 4.33E+01 | 2.63E+01 | 8.44E+01 | 4.95E+02 | 0.00E+00 | 9.44E+03 |
| TE-129M | 1.26E+04 | 4.68E+03 | 2.00E+03 | 4.07E+03 | 5.28E+04 | 0.00E+00 | 4.74E+04 |
| TE-129 | 3.47E+01 | 1.29E+01 | 8.44E+00 | 2.48E+01 | 1.46E+02 | 0.00E+00 | 1.90E+02 |
| TE-131M | 1.89E+03 | 9.06E+02 | 7.55E+02 | 1.36E+03 | 9.44E+03 | 0.00E+00 | 7.27E+04 |
| TE-131 | 2.16E+01 | 8.90E+00 | 6.75E+00 | 1.66E+01 | 9.44E+01 | 0.00E+00 | 1.77E+00 |
| TE-132 | 2.70E+03 | 1.71E+03 | 1.61E+03 | 1.80E+03 | 1.64E+04 | 0.00E+00 | 5.42E+04 |
| I-130 | 5.06E+01 | 1.46E+02 | 5.84E+01 | 1.19E+04 | 2.25E+02 | 0.00E+00 | 1.12E+02 |
| I-131 | 2.87E+02 | 4.02E+02 | 2.16E+02 | 1.17E+05 | 6.92E+02 | 0.00E+00 | 7.95E+01 |
| I-132 | 1.37E+01 | 3.58E+01 | 1.29E+01 | 1.21E+03 | 5.64E+01 | 0.00E+00 | 1.56E+01 |
| I-133 | 9.87E+01 | 1.67E+02 | 5.11E+01 | 2.34E+04 | 2.94E+02 | 0.00E+00 | 1.27E+02 |
| I-134 | 7.17E+00 | 1.90E+01 | 6.82E+00 | 3.17E+02 | 2.99E+01 | 0.00E+00 | 2.50E-01 |
| I-135 | 2.99E+01 | 7.71E+01 | 2.86E+01 | 4.96E+03 | 1.22E+02 | 0.00E+00 | 8.54E+01 |
| CS-134 | 4.24E+04 | 9.97E+04 | 4.63E+04 | 0.00E+00 | 3.17E+04 | 1.21E+04 | 1.24E+03 |
| CS-136 | 4.35E+03 | 1.71E+04 | 1.15E+04 | 0.00E+00 | 9.32E+03 | 1.47E+03 | 1.38E+03 |
| CS-137 | 5.67E+04 | 7.54E+04 | 2.63E+04 | 0.00E+00 | 2.57E+04 | 9.97E+03 | 1.07E+03 |
| CS-138 | 3.93E+01 | 7.54E+01 | 3.77E+01 | 0.00E+00 | 5.57E+01 | 6.48E+00 | 3.42E-02 |
| BA-139 | 7.05E+00 | 4.96E-03 | 2.05E-01 | 0.00E+00 | 4.67E-03 | 3.42E-03 | 6.28E+01 |
| BA-140 | 1.44E+03 | 1.76E+00 | 9.28E+01 | 0.00E+00 | 5.98E-01 | 1.19E+00 | 2.22E+03 |
| BA-141 | 3.40E+00 | 2.54E-03 | 1.14E-01 | 0.00E+00 | 2.36E-03 | 1.74E-03 | 7.25E-06 |
| BA-142 | 1.52E+00 | 1.52E-03 | 9.33E-02 | 0.00E+00 | 1.28E-03 | 1.01E-03 | 4.65E-12 |
| LA-140 | 1.67E+00 | 8.20E-01 | 2.18E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.71E+04 |
| LA-142 | 8.58E-02 | 3.81E-02 | 9.49E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.16E+03 |
| CE-141 | 3.49E+00 | 2.33E+00 | 2.67E-01 | 0.00E+00 | 1.10E+00 | 0.00E+00 | 6.66E+03 |
| CE-143 | 6.16E-01 | 4.48E+02 | 5.01E-02 | 0.00E+00 | 2.01E-01 | 0.00E+00 | 1.35E+04 |
| CE-144 | 1.82E+02 | 7.55E+01 | 9.80E+00 | 0.00E+00 | 4.51E+01 | 0.00E+00 | 4.59E+04 |
| PR-143 | 6.28E+00 | 2.51E+00 | 3.13E-01 | 0.00E+00 | 1.46E+00 | 0.00E+00 | 2.07E+04 |
| PR-144 | 2.06E-02 | 8.44E-03 | 1.05E-03 | 0.00E+00 | 4.84E-03 | 0.00E+00 | 2.27E-05 |
| ND-147 | 4.50E+00 | 4.89E+00 | 2.93E-01 | 0.00E+00 | 2.87E+00 | 0.00E+00 | 1.76E+04 |
| W-187 | 3.22E+02 | 2.62E+02 | 9.19E+01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.10E+04 |
| NP-239 | 3.98E-02 | 3.75E-03 | 2.08E-03 | 0.00E+00 | 1.18E-02 | 0.00E+00 | 6.03E+02 |
| K-40 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| CO-57 | 0.00E+00 | 1.25E+02 | 2.10E+02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.33E+03 |
| SR-85 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Y-88 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| NB-94 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| NB-97 | 4.36E-02 | 1.08E-02 | 3.95E-03 | 0.00E+00 | 1.27E-02 | 0.00E+00 | 2.58E+02 |
| CD-109 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| SN-113 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| BA-133 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| TE-134 | 3.46E+01 | 2.22E+01 | 2.32E+01 | 2.84E+01 | 2.12E+02 | 0.00E+00 | 1.28E+00 |
| CE-139 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| HG-203 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

Table 2 - 3

Site Related Child Ingestion Dose Commitment Factors
(Freshwater Fish and Saltwater Invertebrate Consumption)

(AiT)
mrem/hr per uCi/ml

| ISOTOPE | BONE | LIVER | TOT BODY | THYROID | KIDNEY | LUNG | GI-LLI |
|---|---|---|---|---|---|---|---|
| H-3 | 0.00E+00 | 1.81E-01 | 1.81E-01 | 1.81E-01 | 1.81E-01 | 1.81E-01 | 1.81E-01 |
| BE-7 | 4.77E-01 | 8.08E-01 | 5.33E-01 | 0.00E+00 | 7.96E-01 | 0.00E+00 | 4.52E+01 |
| NA-24 | 4.57E+02 | 4.57E+02 | 4.57E+02 | 4.57E+02 | 4.57E+02 | 4.57E+02 | 4.57E+02 |
| P-32 | 6.98E+07 | 3.27E+06 | 2.69E+06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.93E+06 |
| CR-51 | 0.00E+00 | 0.00E+00 | 4.86E+00 | 2.70E+00 | 7.37E-01 | 4.92E+00 | 2.58E+02 |
| MN-54 | 0.00E+00 | 4.20E+03 | 1.12E+03 | 0.00E+00 | 1.18E+03 | 0.00E+00 | 3.53E+03 |
| MN-56 | 0.00E+00 | 1.31E+02 | 2.96E+01 | 0.00E+00 | 1.59E+02 | 0.00E+00 | 1.90E+04 |
| FE-55 | 4.55E+04 | 2.42E+04 | 7.48E+03 | 0.00E+00 | 0.00E+00 | 1.37E+04 | 4.47E+03 |
| FE-59 | 6.53E+04 | 1.06E+05 | 5.27E+04 | 0.00E+00 | 0.00E+00 | 3.07E+04 | 1.10E+05 |
| CO-58 | 0.00E+00 | 4.20E+02 | 1.29E+03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.45E+03 |
| CO-60 | 0.00E+00 | 1.23E+03 | 3.64E+03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.84E+03 |
| NI-63 | 6.85E+04 | 3.67E+03 | 2.33E+03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.47E+02 |
| NI-65 | 2.83E+02 | 2.66E+01 | 1.55E+01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.26E+03 |
| CU-64 | 0.00E+00 | 9.05E+01 | 5.47E+01 | 0.00E+00 | 2.19E+02 | 0.00E+00 | 4.25E+03 |
| ZN-65 | 1.55E+05 | 4.12E+05 | 2.56E+05 | 0.00E+00 | 2.59E+05 | 0.00E+00 | 7.23E+04 |
| ZN-69 | 4.94E+02 | 7.14E+02 | 6.60E+01 | 0.00E+00 | 4.33E+02 | 0.00E+00 | 4.50E+04 |
| BR-83 | 0.00E+00 | 0.00E+00 | 5.67E+01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| BR-84 | 0.00E+00 | 0.00E+00 | 6.56E+01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| BR-85 | 0.00E+00 | 0.00E+00 | 3.02E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| RB-86 | 0.00E+00 | 1.06E+05 | 6.50E+04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.80E+03 |
| RB-88 | 0.00E+00 | 3.00E+02 | 2.08E+02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.47E+01 |
| RB-89 | 0.00E+00 | 1.85E+02 | 1.64E+02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.61E+00 |
| SR-89 | 3.63E+04 | 0.00E+00 | 1.04E+03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.41E+03 |
| SR-90 | 4.68E+05 | 0.00E+00 | 1.19E+05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.30E+03 |
| SR-91 | 6.60E+02 | 0.00E+00 | 2.49E+01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.46E+03 |
| SR-92 | 2.48E+02 | 0.00E+00 | 9.96E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.70E+03 |
| Y-90 | 8.79E+00 | 0.00E+00 | 2.35E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.50E+04 |
| Y-91M | 8.17E-02 | 0.00E+00 | 2.97E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.60E+02 |
| Y-91 | 1.29E+02 | 0.00E+00 | 3.44E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.71E+04 |
| Y-92 | 7.70E-01 | 0.00E+00 | 2.20E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.22E+04 |
| Y-93 | 2.44E+00 | 0.00E+00 | 6.69E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.63E+04 |
| ZR-95 | 2.10E+00 | 4.62E-01 | 4.11E-01 | 0.00E+00 | 6.62E-01 | 0.00E+00 | 4.82E+02 |
| ZR-97 | 1.27E-01 | 1.83E-02 | 1.08E-02 | 0.00E+00 | 2.63E-02 | 0.00E+00 | 2.77E+03 |
| NB-95 | 5.75E+00 | 2.24E+00 | 1.60E+00 | 0.00E+00 | 2.10E+00 | 0.00E+00 | 4.14E+03 |
| MO-99 | 0.00E+00 | 1.31E+02 | 3.23E+01 | 0.00E+00 | 2.79E+02 | 0.00E+00 | 1.08E+02 |
| TC-99M | 1.99E-02 | 3.89E-02 | 6.46E-01 | 0.00E+00 | 5.66E-01 | 1.98E-02 | 2.22E+01 |
| TC-101 | 2.30E-02 | 2.41E-02 | 3.06E-01 | 0.00E+00 | 4.11E-01 | 1.27E-02 | 7.66E-02 |
| RU-103 | 1.48E+02 | 0.00E+00 | 5.67E+01 | 0.00E+00 | 3.72E+02 | 0.00E+00 | 3.82E+03 |
| RU-105 | 1.30E+01 | 0.00E+00 | 4.73E+00 | 0.00E+00 | 1.15E+02 | 0.00E+00 | 8.50E+03 |
| RU-106 | 2.36E+03 | 0.00E+00 | 2.95E+02 | 0.00E+00 | 3.19E+03 | 0.00E+00 | 3.68E+04 |
| AG-110M | 5.24E+02 | 3.54E+02 | 2.83E+02 | 0.00E+00 | 6.59E+02 | 0.00E+00 | 4.21E+04 |
| SB-122 | 5.80E+01 | 8.56E-01 | 1.70E+01 | 7.43E-01 | 0.00E+00 | 2.36E+01 | 4.46E+03 |
| SB-124 | 6.55E+02 | 8.50E+00 | 2.29E+02 | 1.44E+00 | 0.00E+00 | 3.63E+02 | 4.09E+03 |
| SB-125 | 4.22E+02 | 3.25E+00 | 8.85E+01 | 3.91E-01 | 0.00E+00 | 2.35E+02 | 1.01E+03 |

Table 2 - 3

Site Related Child Ingestion Dose Commitment Factors
(Freshwater Fish and Saltwater Invertebrate Consumption)

(AiT)
mrem/hr per uCi/ml

| ISOTOPE | BONE | LIVER | TOT BODY | THYROID | KIDNEY | LUNG | GI-LLI |
|---|---|---|---|---|---|---|---|
| TE-125M | 3.81E+03 | 1.03E+03 | 5.08E+02 | 1.07E+03 | 0.00E+00 | 0.00E+00 | 3.68E+03 |
| TE-127M | 9.67E+03 | 2.60E+03 | 1.15E+03 | 2.31E+03 | 2.76E+04 | 0.00E+00 | 7.83E+03 |
| TE-127 | 1.58E+02 | 4.25E+01 | 3.38E+01 | 1.09E+02 | 4.48E+02 | 0.00E+00 | 6.15E+03 |
| TE-129M | 1.63E+04 | 4.55E+03 | 2.53E+03 | 5.25E+03 | 4.78E+04 | 0.00E+00 | 1.99E+04 |
| TE-129 | 4.48E+01 | 1.25E+01 | 1.06E+01 | 3.20E+01 | 1.31E+02 | 0.00E+00 | 2.79E+03 |
| TE-131M | 2.41E+03 | 8.33E+02 | 8.86E+02 | 1.71E+03 | 8.06E+03 | 0.00E+00 | 3.38E+04 |
| TE-131 | 2.78E+01 | 8.46E+00 | 8.26E+00 | 2.12E+01 | 8.40E+01 | 0.00E+00 | 1.46E+02 |
| TE-132 | 3.38E+03 | 1.50E+03 | 1.81E+03 | 2.18E+03 | 1.39E+04 | 0.00E+00 | 1.51E+04 |
| I-130 | 6.28E+01 | 1.27E+02 | 6.54E+01 | 1.40E+04 | 1.90E+02 | 0.00E+00 | 5.94E+01 |
| I-131 | 3.70E+02 | 3.72E+02 | 2.12E+02 | 1.23E+05 | 6.11E+02 | 0.00E+00 | 3.31E+01 |
| I-132 | 1.72E+01 | 3.16E+01 | 1.45E+01 | 1.47E+03 | 4.84E+01 | 0.00E+00 | 3.72E+01 |
| I-133 | 1.27E+02 | 1.58E+02 | 5.96E+01 | 2.93E+04 | 2.63E+02 | 0.00E+00 | 6.35E+01 |
| I-134 | 9.02E+00 | 1.67E+01 | 7.70E+00 | 3.85E+02 | 2.56E+01 | 0.00E+00 | 1.11E+01 |
| I-135 | 3.77E+01 | 6.78E+01 | 3.21E+01 | 6.00E+03 | 1.04E+02 | 0.00E+00 | 5.16E+01 |
| CS-134 | 5.15E+04 | 8.44E+04 | 1.78E+04 | 0.00E+00 | 2.62E+04 | 9.39E+03 | 4.55E+02 |
| CS-136 | 5.17E+03 | 1.42E+04 | 9.19E+03 | 0.00E+00 | 7.56E+03 | 1.13E+03 | 4.99E+02 |
| CS-137 | 7.19E+04 | 6.88E+04 | 1.02E+04 | 0.00E+00 | 2.24E+04 | 8.07E+03 | 4.31E+02 |
| CS-138 | 5.01E+01 | 6.97E+01 | 4.42E+01 | 0.00E+00 | 4.90E+01 | 5.28E+00 | 3.21E+01 |
| BA-139 | 9.34E+00 | 4.99E-03 | 2.71E-01 | 0.00E+00 | 4.35E-03 | 2.93E-03 | 5.39E+02 |
| BA-140 | 1.87E+03 | 1.64E+00 | 1.09E+02 | 0.00E+00 | 5.35E-01 | 9.79E-01 | 9.50E+02 |
| BA-141 | 4.51E+00 | 2.53E-03 | 1.47E-01 | 0.00E+00 | 2.19E-03 | 1.48E-02 | 2.57E+00 |
| BA-142 | 1.97E+00 | 1.42E-03 | 1.10E-01 | 0.00E+00 | 1.15E-03 | 8.35E-04 | 2.57E-02 |
| LA-140 | 2.16E+00 | 7.55E-01 | 2.54E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.10E+04 |
| LA-142 | 1.12E-01 | 3.57E-02 | 1.12E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.08E+03 |
| CE-141 | 4.65E+00 | 2.32E+00 | 3.45E-01 | 0.00E+00 | 1.02E+00 | 0.00E+00 | 2.90E+03 |
| CE-143 | 8.19E-01 | 4.44E+02 | 6.44E-02 | 0.00E+00 | 1.86E-01 | 0.00E+00 | 6.51E+03 |
| CE-144 | 2.44E+02 | 7.64E+01 | 1.30E+01 | 0.00E+00 | 4.23E+01 | 0.00E+00 | 1.99E+04 |
| PR-143 | 8.40E+00 | 2.52E+00 | 4.17E-01 | 0.00E+00 | 1.37E+00 | 0.00E+00 | 9.06E+03 |
| PR-144 | 2.76E-02 | 8.53E-03 | 1.39E-03 | 0.00E+00 | 4.51E-03 | 0.00E+00 | 1.84E+01 |
| ND-147 | 5.96E+00 | 4.83E+00 | 3.74E-01 | 0.00E+00 | 2.65E+00 | 0.00E+00 | 7.65E+03 |
| W-187 | 4.08E+02 | 2.42E+02 | 1.08E+02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.40E+04 |
| NP-239 | 5.15E-02 | 3.70E-03 | 2.60E-03 | 0.00E+00 | 1.07E-02 | 0.00E+00 | 2.74E+02 |
| K-40 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| CO-57 | 0.00E+00 | 1.15E+02 | 2.33E+02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 9.43E+02 |
| SR-85 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Y-88 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| NB-94 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| NB-97 | 5.55E-02 | 1.00E-02 | 4.68E-03 | 0.00E+00 | 1.11E-02 | 0.00E+00 | 3.09E+03 |
| CD-109 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| SN-113 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| BA-133 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| TE-134 | 4.31E+01 | 1.94E+01 | 2.59E+01 | 3.41E+01 | 1.80E+02 | 0.00E+00 | 1.97E+02 |
| CE-139 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| HG-203 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

Table 2-4

Bio-Accumulation Factors for Liquid Effluent Isotopes
(pCi/kg per pCi/liter)

| ISOTOPE | Freshwater Fish BFi | Saltwater Invertebrates BIi | ISOTOPE | Freshwater Fish BFi | Saltwater Invertebrates BIi |
|---|---|---|---|---|---|
| H-3 | 9.000E-01 | 9.300E-01 | TE-125M | 4.000E+02 | 1.000E+02 |
| BE-7 | 2.000E+00 | 2.000E+02 | TE-127M | 4.000E+02 | 1.000E+02 |
| NA-24 | 1.000E+02 | 1.900E-01 | TE-127 | 4.000E+02 | 1.000E+02 |
| P-32 | 1.000E+05 | 3.000E+04 | TE-129M | 4.000E+02 | 1.000E+02 |
| CR-51 | 2.000E+02 | 2.000E+03 | TE-129 | 4.000E+02 | 1.000E+02 |
| MN-54 | 4.000E+02 | 4.000E+02 | TE-131M | 4.000E+02 | 1.000E+02 |
| MN-56 | 4.000E+02 | 4.000E+02 | TE-131 | 4.000E+02 | 1.000E+02 |
| FE-55 | 1.000E+02 | 2.000E+04 | TE-132 | 4.000E+02 | 1.000E+02 |
| FE-59 | 1.000E+02 | 2.000E+04 | I-130 | 1.500E+01 | 5.000E+01 |
| CO-58 | 5.000E+01 | 1.000E+03 | I-131 | 1.500E+01 | 5.000E+01 |
| CO-60 | 5.000E+01 | 1.000E+03 | I-132 | 1.500E+01 | 5.000E+01 |
| NI-63 | 1.000E+02 | 2.500E+02 | I-133 | 1.500E+01 | 5.000E+01 |
| NI-65 | 1.000E+02 | 2.500E+02 | I-134 | 1.500E+01 | 5.000E+01 |
| CU-64 | 5.000E+01 | 1.700E+03 | I-135 | 1.500E+01 | 5.000E+01 |
| ZN-65 | 2.000E+03 | 5.000E+04 | CS-134 | 2.240E+02 | 2.240E+02 |
| ZN-69 | 2.000E+03 | 5.000E+04 | CS-136 | 2.240E+02 | 2.240E+02 |
| BR-83 | 4.200E+02 | 3.100E+00 | CS-137 | 2.240E+02 | 2.240E+02 |
| BR-84 | 4.200E+02 | 3.100E+00 | CS-138 | 2.240E+02 | 2.240E+02 |
| BR-85 | 4.200E+02 | 3.100E+00 | BA-139 | 4.000E+00 | 1.000E+02 |
| RB-86 | 2.000E+03 | 1.700E+01 | BA-140 | 4.000E+00 | 1.000E+02 |
| RB-88 | 2.000E+03 | 1.700E+01 | BA-141 | 4.000E+00 | 1.000E+02 |
| RB-89 | 2.000E+03 | 1.700E+01 | BA-142 | 4.000E+00 | 1.000E+02 |
| SR-89 | 3.000E+01 | 2.000E+01 | LA-140 | 2.500E+01 | 1.000E+03 |
| SR-90 | 3.000E+01 | 2.000E+01 | LA-142 | 2.500E+01 | 1.000E+03 |
| SR-91 | 3.000E+01 | 2.000E+01 | CE-141 | 1.000E+00 | 6.000E+02 |
| SR-92 | 3.000E+01 | 2.000E+01 | CE-143 | 1.000E+00 | 6.000E+02 |
| Y-90 | 2.500E+01 | 1.000E+03 | CE-144 | 1.000E+00 | 6.000E+02 |
| Y-91M | 2.500E+01 | 1.000E+03 | PR-143 | 2.500E+01 | 1.000E+03 |
| Y-91 | 2.500E+01 | 1.000E+03 | PR-144 | 2.500E+01 | 1.000E+03 |
| Y-92 | 2.500E+01 | 1.000E+03 | ND-147 | 2.500E+01 | 1.000E+03 |
| Y-93 | 2.500E+01 | 1.000E+03 | W-187 | 1.200E+03 | 3.000E+01 |
| ZR-95 | 3.300E+00 | 8.000E+01 | NP-239 | 1.000E+01 | 1.000E+01 |
| ZR-97 | 3.300E+00 | 8.000E+01 | K-40 | 0.000E+00 | 0.000E+00 |
| NB-95 | 3.000E+02 | 1.000E+02 | CO-57 | 5.000E+01 | 1.000E+03 |
| MO-99 | 1.000E+01 | 1.000E+01 | SR-85 | 0.000E+00 | 0.000E+00 |
| TC-99M | 1.500E+01 | 5.000E+01 | Y-88 | 0.000E+00 | 0.000E+00 |
| TC-101 | 1.500E+01 | 5.000E+01 | NB-94 | 3.000E+02 | 1.000E+02 |
| RU-103 | 1.000E+01 | 1.000E+03 | NB-97 | 3.000E+02 | 1.000E+02 |
| RU-105 | 1.000E+01 | 1.000E+03 | CD-109 | 0.000E+00 | 0.000E+00 |
| RU-106 | 1.000E+01 | 1.000E+03 | SN-113 | 0.000E+00 | 0.000E+00 |
| AG-110M | 2.300E+00 | 5.000E+03 | BA-133 | 0.000E+00 | 0.000E+00 |
| SB-122 | 1.000E+00 | 3.000E+02 | TE-134 | 4.000E+02 | 1.000E+02 |
| SB-124 | 1.000E+00 | 3.000E+02 | CE-139 | 0.000E+00 | 0.000E+00 |
| SB-125 | 1.000E+00 | 3.000E+02 | HG-203 | 0.000E+00 | 0.000E+00 |

Bio-Accumulation Factors and DFi's for Noble Gases = 0

# 3.0 **GASEOUS EFFLUENTS**

## 3.1 Gaseous Effluent Releases - General Information

3.1.1 A completed and properly authorized Airborne Radioactive Waste Release Permit shall be issued prior to the release of airborne activity from the waste gas holding system, containment purge, or any other batch release.

3.1.2 Since Indian Point is a two unit site, the derived instantaneous μCi/sec limits for each unit, (Section 3.2) were derived from an actual site limit (Appendix I). The time-average limits are "per reactor", and applicable to each unit.

3.1.3 During Modes 4 through 6, there is no flowpath for a release from the Condenser Air Ejector. During these intervals, when there is no actual release pathway, the monthly grab sample described in RECS D3.2.1 is not required.

3.1.4 During normal plant operation (without a primary to secondary leak), almost all gaseous releases are through the main Plant Vent. A negligible amount may be identified in other pathways (see Appendix C).

In the event of extended operation with a primary to secondary leak, low level releases are expected from both the blowdown flash tank vent and condenser air ejector. However, the limits on steam generator leakage are much more restrictive than those for effluent releases. Therefore, allocation of portions of the allowable release rate to these various release points during routine operation is not warranted.

If, on the other hand, the instantaneous release rate is being considered for the Plant Vent, then ALL release points should be considered when establishing alarm setpoints, per ODCM Part II, Section 1.

3.1.5 For releases that are expected to continue for periods over two days, a new release permit will normally be issued each day.

A containment purge permit may be closed, with the release reclassified as continuous building ventilation, when activity in containment is sufficiently reduced to that level which, if released for 31-days, would remain BELOW the dose projection limits.

However, when plant conditions change, such that releases to containment are likely, a new permit should be evaluated.

3.1.6 Assurance that the combined gaseous releases from Units 2 and 3 do not exceed limits of Section 3.2.1 is provided by administrative controls for both units. These controls include apportionment of the 10CFR20 limitations and back-calculating radiation monitor setpoints accordingly. These calculations are discussed in Appendix I.

3.1.7 By mutual agreement with units 2 and 3 Shift Supervisors, one unit can reduce or eliminate discharges for a period of time to allow the other unit to use the full site permissible discharge rate, or a specific portion thereof, for unique releases that may require the site limit for release rate. To better control these evolutions, written agreement to the apportionment is generally kept with each unit's CRS and included on applicable permits for the duration.

3.1.8 Conservative release rate limitations have been established to ensure compliance with 10CFR20, and to aid in controlling time average dose limits. The annual average release rate limit (Appendix I) shall normally be used for calculating limitations on discharge. If this limitation is unduly restrictive, other release rates may be allowed, per Appendix I, and summarized below:

| Release Rate (μCi/sec) | Permission Required |
|---|---|
| Quarterly Average | Site Operations Manager / designee |
| Default Instantaneous | General Manager Plant Operations (GMPO) / designee |
| ODCM Instantaneous | GMPO and Chemistry Manager / designee |

As described in Appendix I, the ODCM instantaneous limit provides a maximum release rate with an actual or suspected isotopic mixture, back-calculated from the actual 10CFR20 limit (500 mrem/yr for the site). The calculations for the use of this limit should be verified within the Chemistry department. The default interval in which to determine the proximity to this limit (uCi/sec or mrem/yr) is one hour or less.

3.1.9 Containment Pressure Reliefs

Containment pressure reliefs occur frequently enough to be considered continuous releases. Grab samples of containment atmosphere are obtained periodically to ensure the use of accurate mixtures in effluent calculations. The containment noble gas monitors (R-42 for Unit 2 and R-12 for Unit 3) are used in conjuction with expected flow rates to determine a release rate. The effluent noble gas monitor in the plant vent is also used to verify total unit release rate remains below the current authorized limit.

3.1.10 Composite Particulate Samples

Continuous building ventilation exhaust points are sampled continuously for Iodine and Particulate. Media is replaced weekly, with composite filters prepared for vendor lab analyses monthly.

3.1.11 Flow rate measurement for the Continuous Building Ventilation systems is typically obtained from the installed process monitor or nearby instrument. When the process flow rate instrument is OOS, estimates are performed every 4 hours per the RECS, to allow appropriate quantification of continuous airborne effluent. The estimates are typically performed by summing the exhaust flow rates (or design flow rate) from any operable fans. Unit 3's PV flow may be estimated from a backup instrument.

Unit 3's Admin Bldg does NOT have a flow rate instrument (design flow of 12500 cfm is used). The process flow rate monitor surveillance requirements specified in the RECS are not applicable for the Unit 3 Admin Building.

3.1.12 <u>Gas Storage Tank Activity Limits</u>

The quantity of radioactivity in each gas storage tank is limited to 50,000 Ci of noble gas, Xenon-133 equivalent, per RECS D3.2.6. The source of this requirement is NUREG 0133 (Section 5.6.1) for both units. However, the parameters used in the given equation are applied differently at each unit, as defined in the FSARs and summarized in the following discussion:

**<u>Unit 2:</u>**

$$Q_{133} = \frac{(500 mrem) * \ 3.15E+7 \ \ \sec/yr}{(1E6 \mu Ci/Ci)(294 mrem - m^3/\mu Ci - yr)(1.81E-3 \ \ \sec/m^3)} = \underline{\mathbf{29{,}761\ Ci}}$$

Where;

294 mrem-m$^3$/μCi-yr = the Xe-133 WB dose factor, RG 1.109, table B-1 (K).
1.81E-3 sec/m$^3$ = Design Basis Accident X/Q from Indian Point 2 FSAR

An actual curie limit is calculated by substituting the actual mixture $K_{eff}$ into the equation above. For example, the $K_{eff}$ for the accident mix computed using Table 14.2-5 of the FSAR is 476 mrem-m$^3$/μCi-yr. Thus, the actual activity limit (for an expected mixture of radionuclides, not just Xe-133) is:

$$Q_{mixture} = \frac{(500 mrem) * \ 3.15E+7 \ \ \sec/yr}{(1E6 \mu Ci/Ci)(476 \, mrem - m^3/\mu Ci - yr)(1.81E-3 \ \ \sec/m^3)} = \underline{\mathbf{18{,}300\ Ci}}$$

Similar calculations could be performed with actual $K_{eff}$ and X/Q data.

As demonstrated above, the setpoints calculated from NUREG 0133 modeling assume Xe-133 equivalent and no tank interconnections (29,761 Ci of Xe-133 equivalent or 18,300 Ci for an expected accident mixture).

However, the tanks are, in fact, generally interconnected, requiring a more conservative approach. The unit 2 FSAR (14.2.3) has established a specific gas decay tank limit of **6,000 Ci** each. This value is based on the original RECS required 29,761 curies of Xe-133 equivalent, divided into 4 large and all 6 small gas decay tanks. Given the actual atmospheric volume of the tanks (525 ft$^3$ for each large and 40 ft$^3$ for each small), the total volume is approximately 4.5 tanks:

$$\frac{29{,}761}{4.5} = \underline{\mathbf{6{,}000\ Ci}} \ \ \text{Xe-133 Equivalent}$$

The RECS required gas storage tank radiation monitor (R-50), is therefore set to alarm at 6,000 curies. Warn setpoints are established by procedure, usually with consideration for measured tank contents and anticipated release rate.

In the event R-50 becomes inoperable, but a depressurized sample can be taken, the quantity limits can still be verified. Compliance with the appropriate curie limit in a tank is assured if the following inequality holds:

$$[A]_m < \frac{14.7\,(Q)}{(14.7 + P)V} \quad \text{or} \quad [A]_{eq} < \frac{14.7\,(Q133)}{(14.7 + P)V}$$

Where:

$[A]_m$ ≡ total measured depressurized sample concentration (μCi/cc)

$[A]_{eq}$ ≡ Xe-133 equivalent measured depressurized sample concentration (μCi/cc)

V ≡ tank volume (cc) P ≡ tank pressure (psig)

Q ≡ activity limit for selected mix (μCi) Q133 ≡ dose equivalent Xe133 limit(μCi)

**Unit 3:**

$$\text{Qit} = \frac{(500 mrem) * \ 3.15E+7 \ \sec/yr}{(1E6 \mu Ci/Ci)(294 mrem - m^3/\mu Ci - yr)(1.03E-3 \ \sec/m^3)} = \underline{\textbf{50,000 Ci}}$$

Where;

Ki = 294 mrem-m$^3$/μCi-yr, Xe-133 equivalent Table B-1 (RG 1.109)
X/Q = 1.03 x $10^{-3}$ sec/m$^3$, Indian Point 3 FSAR

This limit assumes 100% Xe-133 as per NUREG 0133. Utilizing the Ki from an expected mixture during RCS degasification (787 mrem-m$^3$ per uCi-yr), the gas tank conservative administrative limit should becomes:

$$\text{Qit} = \frac{(500 \text{mrem}) * \ 3.15\text{E}+7 \ \sec/\text{yr}}{(1\text{E}6 \mu\text{Ci}/\text{Ci})(787 \text{mrem} - \text{m}^3/\mu\text{Ci} - \text{yr})(1.03\text{E}-3 \ \sec/\text{m}^3)} = \underline{\textbf{19,400 Ci}}$$

There are two methods available to ensure that the activity in the gas storage tank is within the conservative administrative limit:

$$\frac{1.94\text{E}+4 * 1\text{E}6 \mu\text{Ci}/\text{Ci}}{525\,\text{ft}^3 * \left(\frac{164.7\text{psia}}{14.7\text{psia}}\right) * 2.83\text{E}4\,\text{cc}/\text{ft}^3} = 1.17\text{E}+2 \ \mu\text{Ci}/\text{cc}$$

1. The total gaseous activity will normally be limited to less than 117 μCi/cc. If this concentration limit is exceeded, then the contents of the tank will be monitored and actions taken to ensure the 19,400 curie per tank limit is not exceeded.
2. The waste gas line monitor (R-20) reads in μCi/cc. It allows for control of waste gas tank curie content by limiting the input concentration to 117 μCi/cc, thereby limiting the curies to 19,400.

Large gas decay tanks on fill and CVCS tanks (which are indicative of the gas mixture in or from the reuse system) are continuously monitored for $H_2$ and $O_2$ through in-line instrumentation. With either in-line instrument out of service, a grab sample of the tank on receipt shall be taken daily, unless in degassing operation, when the periodicity is every four hours.Other primary system tank cover gases can be manually directed through these instruments for individual samples.

Gas releases may also occur from the gas space atop liquid holdup tanks. The basis for assuring these tanks comply with the curie limits for noble gas is Technical Specification 3.4.16, which limits Reactor Coolant to ≤ 1 μCi/gm Dose Equivalent Iodine-131. Using the assumptions discussed in each unit's FSAR, the potential total curies of noble gas in the liquid holdup tanks is limited to less than the conservative limit for the Gas Storage Tanks.

3.1.13 The activity released via the blowdown flash tank vent is determined by obtaining the steam generator blowdown activity (tritium, noble gas, and iodine), partitioned per Regulatory Guide 1.42 "Interim Licensing Policy On As Low As Practicable for Gaseous Radioiodine Releases from Light Water Cooled Nuclear Power Reactors" (from NUREG 0472, Rev3, DRAFT 6, TABLE 3.3-13), or Reference 4, "An Evaluation to Demonstrate the Compliance of the Indian Point Reactors with the Design Objectives of 10CFR50, Appendix I".

3.1.14 Studies and measurements performed by the NY State Department of Health (1981 to 1982) determined that approximately 9.6 curies of Carbon-14 were released from IPEC annually. Recent EPRI studies have resulted in a model to apply plant-specific data to better calculate a curie value for airborne C-14 effluent. Using this updated model, IPEC's airborne C-14 releases are projected to be 10.5 Curies per year, with 26% as $CO_2$. Offsite dose resulting from these releases are calculated in accordance with the methodology in Reg. Guide 1.109, and discussed in detail in Appendix K.

Curies released and offsite dose from airborne C-14 effluent is reported separately from other, more common isotopes, to prevent confusion, loss of relevance of the more common isotopes, and to preserve historical trends.

3.1.15 The Unit 3 Liquid Waste Monitor Tanks have an airborne release pathway. The original plant design limited the gases through this pathway by reducing the entrained gases to less than 2E-3 μCi/ml. The removal of the CVCS gas stripper under modification 86-3-122 CVCS requires the quantification of these gases when the entrained gaseous activity in the Monitor Tank inlet exceeds 2E-3 μCi/ml. No action is required if the inlet noble gas concentration is less than 2E-3 μCi/ml. This gas release will be quantified by calculating the difference (in μCi's) between the gaseous activity added to the tank and the gaseous activity present in the effluent release sample. This difference will be quantified as an airborne ground level batch release, using a specifically determined ground level dispersion constant (Section 3.5.3).

A separate release permit evaluating this release is not required prior to release. Calculation of this rate of release is not required, however the time average dose contribution shall be calculated and controlled per Sections 3.3 and 3.4 of the ODCM. Section 3.6 provides additional detail relative to the finite cloud correction assumptions for this pathway.

Unit 2's Waste Distillate Storage Tanks are vented inside the Unit 1 facility, so there is no similar airborne release pathway from these tanks.

3.1.16 Evaluations of previous gas decay tank and containment purge releases have been performed. These evaluations indicate that these "Short Term Releases" (less than 500 hours per year and less than 150 hours per quarter) are sufficiently random to utilize the long term meteorological dispersion factor (NUREG 0133, Section 3.3, Page 8). The short-term correction factor, will only be used when non-random releases are to be made an a routine basis.

3.1.17 Airborne releases from the Steam Generator Safety or Atmospheric Dump Valves can occur during a Primary to Secondary leak. Tritium, Noble Gas, and Iodine effluent doses are determined using a source term activity (Main Steam or Steam Generator Blowdown), an Iodine partition factor (per Section 3.1.13), and a release rate, determined from Engineering Design Calculation 187 (Steam Generator Atmospherics), or design flowrate (from Steam Generator Safeties) at specific pressures in the Steam Generator.

3.1.18 Other release pathways resulting from Primary to Secondary leakage include the steam driven auxiliary feed pump vent, the gland seal exhaust vent, the air ejector vent, and the Feed Water heater flash tank vent. Offsite doses from these or other abnormal airborne release points are calculated by obtaining the release rate (from system descriptions and/or steam tables corrected for system pressure, as applicable) and source term activity (eg. Main Steam , Reactor Coolant, or best estimate) for Tritium, Noble Gas, and Iodine, partitioned as per Section 3.1.13.

3.1.19 The Unit 3 Monitor Tank vents, both unit Condenser Air Ejector, and the Gland Seal Exhaust points are ground level releases. Unless otherwise designated, other release points are considered mixed mode, per Section 3.6.

## 3.2 Gaseous Effluent Dose Calculation Requirements

3.2.1 RECS D3.2.1 requires that the dose rate due to radioactive materials released in gaseous effluents from the site at or beyond the site boundary shall be limited to:

a) For noble gases: Less than or equal to 500 mrem/yr to the total body and less than or equal to 3000 mrem/yr to the skin; and

b) For Iodine 131, H-3, and radioactive materials in particulate form with half lives greater than 8 days: Less than or equal to 1500 mrem/yr to any organ.

These are SITE limits and normally apportioned appropriately between the units to simplify assurance of compliance with the RECS. The methodologies for performing these calculations are discussed in Sections 3.3.1 and 3.3.2, respectively.

3.2.2 RECS Section D3.2.2 requires that the air dose due to noble gas released in gaseous effluents from each reactor unit at or beyond the site boundary shall be limited to:

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

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

The methodology for calculating these doses is discussed in Section 3.3.3.

3.2.3 RECS Section D3.2.3 requires that the dose to a member of the general public from Iodine 131, Tritium, and radionuclides in particulate form (half-lives > 8 days) in gaseous effluents released from each reactor unit shall be limited to:

a) Less than or equal to 7.5 mrem to any organ during a calendar quarter

b) Less than or equal to 15 mrem to any organ during a calendar year.

Cumulative dose contributions for the current calendar quarter and current calendar year shall be determined at least once every 31 days.

The methodology for calculating these doses is discussed in Section 3.3.4.

If either of the air dose or iodine/particulate dose cumulative limits is exceeded by a factor of two or more, then a cumulative dose evaluation is required from all contributions of direct radiation at the site boundary per RECS D3.4.1.

3.2.4 RECS D3.2.4 requires that for each reactor unit, the appropriate portions of the gaseous radwaste treatment system shall be used to reduce radioactive effluents in gaseous waste prior to their discharge when projected gaseous effluent air dose at the site boundary when averaged over 31 days, would exceed 0.2 mrad for gamma radiation or 0.4 mrad for beta radiation.

RECS D3.2.4 requires that for each reactor unit, the appropriate portions of the The appropriate portions of the ventilation exhaust treatment system shall be used to reduce radioactive materials in gaseous releases when the projected doses averaged over 31 days, would exceed 0.3 mrem to any organ (at nearest residence). Dose due to gaseous releases from the site shall be calculated at least once every 31 days.

These doses are projected based on the dose methodology discussed in Section 3.3.3 (noble gas) and 3.3.4 (iodine). The average of previous months' doses is used to project future dose as follows:

$$\begin{bmatrix} \text{Dose} \\ \text{Projection} \end{bmatrix} = \frac{\text{Current Month Dose} + \text{Previous months' Dose}}{\text{number of months used}} \pm \begin{bmatrix} \textit{major} \\ \textit{planned} \\ \textit{evolutions} \end{bmatrix}$$

The term for planned evolutions is routinely determined from previous similar evolutions, such as releases associated with plant shutdown.

## 3.3 Dose Methodology (Computer Calculation)

### 3.3.1 Instantaneous Dose Rates - Noble Gas Releases

When the instantaneous limit applies, the process radiation monitor response or release rate can be averaged over a one-hour time interval.

3.3.1.1 The equations developed in this section are used to meet the calculational requirements of paragraph 3.2.1. The magnitude of this pathway is the same for all age groups so there is no critical group. The site release rate is split to 50% per each unit, in terms of uCi/sec. Converted to actual mrem/yr dose rate, Unit 2’s portion is 44.6%, with Unit 3 being allocated 55.4% (Unit 3 is slightly closer to the site boundary where dose rates are calculated).

Each unit has different dispersion factors due to their relative positions to the critical sector of the unrestricted area boundary. The conversion from dose rate to Ci/sec was determined with the use of a model which incorporates a finite cloud exposure correction. The methodology is discussed in Section 3.6.

A calculation showing the relationship between Ci/sec and dose rates from Units 2 and 3 is shown in Appendix I. The equations for calculating the dose rate limitations are obtained from NUREG 0133 (Ref. 1, Section 5.2.1). Utilizing the above assumptions, these equations reduce to the following which are to be summed for each nuclide, i. (Note that these are default unit portions of a site release rate limit. The entire site limit can be applied to any one site, when required, per Section 3.1 and Appendix I).

$$\sum_i \left[(Ki) * \left(\overline{X/Q}\right) * (\dot{Q}i)\right] \leq \text{unit specific mrem/yr whole body limit}$$

$$\sum_i \left[(Li + 1.1Mi) * \left(\overline{X/Q}\right) * (\dot{Q}i)\right] \leq \text{unit specific skin limit, mrem/yr}$$

Where:

Ki = The total body dose factor due to gamma emissions for each identified noble gas radionuclide, in mrem/yr per μCi/m$^3$ (unit-specific finite cloud correction included, per Table 3-4).

Li = The skin dose factor due to beta emissions for each identified noble gas radionuclide, in mrem/yr per μCi/m$^3$, per Table 3-5.

Mi = The air dose factor due to gamma emissions for each identified noble gas radionuclide, in mrad/yr per μCi/m$^3$ (unit-specific finite cloud correction included, per Table 3-6).

Ni = The air dose factor due to beta emissions for each identified noble gas radionuclide, in mrad/yr per μCi/m$^3$, per Table 3-7.

$\dot{Q}$i = The release rate of radionuclides, i, in gaseous effluent for all release points in μCi/sec.

(X/Q) = For all vent releases, the highest calculated annual averaged relative concentration at the critical receptor (at a unit-specific distance and direction, in sec/m$^3$, as shown on Page 1 of Appendix I).

The Ki, Li, Mi, and Ni factors were obtained from Table B-1 of Regulatory Guide 1.109 and are included in this document as Tables 3-4, 3-5, 3-6, and 3-7 respectively. The gamma dose factors (Ki and Mi) have a unit-specific finite cloud correction factor included, as discussed in Sections 3.5 and 3.6.

Unit specific dose rate limits, as stated in Appendix I are as follows:

Unit 2: mrem/yr whole body = 234, skin limit = 1194 mrem/yr
Unit 3: mrem/yr whole body = 266, skin limit = 1806 mrem/yr

3.3.1.2 These equations can also be expressed in the following manner:

$(\overline{K})(\dot{Q}t)(\overline{X/Q})$ = mrem/yr dose to whole body

$(\overline{L} + 1.1\overline{M})(\overline{X/Q})(\dot{Q}t)$ = mrem/yr dose to skin

<u>Where:</u>

$\dot{Q}$t = The release rate of all noble gases summed together in μCi/sec, i.e., the sum of all $\dot{Q}$ i.

$\overline{K} = (1/\dot{Q}t)\ \sum_{i=1}^{n}(\dot{Q}i)\,(Ki)$

$\overline{L} = (1/\dot{Q}t)\ \sum_{i=1}^{n}(\dot{Q}i)\,(Li)$

$\overline{M} = (1/\dot{Q}t)\ \sum_{i=1}^{n}(\dot{Q}i)\,(Mi)$

$\overline{N} = (1/\dot{Q}t)\ \sum_{i=1}^{n}(\dot{Q}i)\,(Ni)$

The values of $\overline{K}$, $\overline{L}$, $\overline{M}$, and $\overline{N}$ are listed in Table 3-8 for the unrestricted area boundary, for both units.

3.3.2 <u>Instantaneous Dose Rates - I-131, Part w/>8 day t½ , and H-3</u>

The equation developed in this section is used to meet the calculational requirements of RECS D3.2.1. The critical organ is considered to be the child thyroid as stated in the RECS bases (BD3.2.1). Different dispersion factors are applied to the critical sector of the unrestricted area boundary for units 2 and 3. Therefore, while 50% of the site release limit (in Ci/sec) is applied to each unit, 32.8% of the limit is applied to Unit 2 and 67.2% to Unit 3 (per Appendix I). The equation for calculating the dose rate limitation is abbreviated from that shown in NUREG 0133 (Ref. 1, Section 5.2.1, Pg. 25) in that ground plane and milk pathways are not considered for this dose rate determination, due to insignificant contribution compared to the inhalation pathway.

Utilizing the above assumptions, the dose rate equation reduces to the following:

$\sum_i(Pi * (X/Q) * \dot{Q}i)$ must be less than the unit-specific mrem/yr limit

Where:

Unit-specific limits are 497 mrem/yr for Unit 2 and 1003 mrem/yr for Unit 3.

Pi = The dose parameter for radionuclides other than noble gases for the inhalation pathway in mrem/yr per μCi/m$^3$. These parameters (per Section 3.3.2.1) are calculated separately for each isotope, age group, and organ.

$\dot{Q}i$ = The release rate of radionuclide 131 and particulates, i, in gaseous effluents for all release points in μCi/sec.

X/Q = The unit-specific annual average dispersion parameter for the inhalation pathway at the controlling location due to all vent releases, per Section 3.5 and Appendix I.

3.3.2.1 Calculation of Pi(in): Inhalation Dose Factor

Pi (inhalation) = K' (BR) DFAi (mrem/yr per $\mu Ci/m^3$)

Where:

K' = A constant of conversion, $10^6$ pCi/μCi

BR = The breathing rate of each age group as per 3.3.4.5.a (Table E-5 of Reg. Guide 1.109).

DFAi = The inhalation dose factor for each age group, organ, and nuclide, in mrem/pCi. These values are taken from Reg Guide 1.109, Table E-7 through E-9 and are reproduced in Tables 3-1a through 3-1d.

3.3.3 Time Average Dose - Noble Gas Release

3.3.3.1 The equations in this section are used to meet the calculational requirements of RECS D3.2.2. All noble gas releases at IPEC are assumed to be mixed mode unless indicated otherwise. Because the limits are in measured air dose (mrad), the magnitude of a measured effect is the same for all age groups. Dispersion parameters are discussed in Section 3.5.

3.3.3.2 Equations for calculating the air dose limitations are obtained from NUREG 0133 (Ref. 1, Section 5.3). The doses are evaluated at the unrestricted area boundary in the worst meteorological sector (a unit-specific location identified in Appendix I). These equations reduce to the following:

$$gamma\ \ air\ mrad = 3.17E-8*\sum_i \mathrm{Mi}\,[(\mathrm{X/Q})\,(\widetilde{\mathrm{Q}}\mathrm{i}) + (\mathrm{x/q})\,(\widetilde{\mathrm{q}}\mathrm{i}) + (\mathrm{x/q_{mt}})\,(\widetilde{\mathrm{q}}\mathrm{i}_{\mathrm{mt}})]$$

$$beta\ \ air\ mrad = 3.17E-8*\sum_i \mathrm{Ni}\,[(\mathrm{X/Q})\,(\widetilde{\mathrm{Q}}\mathrm{i}) + (\mathrm{x/q})\,(\widetilde{\mathrm{q}}\mathrm{i}) + (\mathrm{x/q_{mt}})\,(\widetilde{\mathrm{q}}\mathrm{i}_{\mathrm{mt}})]$$

Where:

Air dose limits are as follows:

| | Any Calendar Quarter | Any Calendar Year |
|---|---|---|
| Gamma Air | *5 mrad* | *10 mrad* |
| Beta Air | *10 mrad* | *20 mrad* |

(X/Q) = The highest calculated annual average relative concentration for the unrestricted area boundary at the controlling sector for long term releases (greater than 500 hrs/yr or 150 hrs/qtr or as noted in 3.1.16), per Appendix I.

(x/q) = The relative concentration for the unrestricted area boundary for short term releases (equal to or less than 500 hrs/yr or 150 hrs/qtr and not random as defined in NUREG 0133, Section 3.3). This value is calculated as per Section 3.5.

$(x/q_{mt})$ = The relative concentration for the unrestricted area boundary for ground level releases from Unit 3 Monitor Tanks at the critical receptor, in sec/m$^3$, per Section 3.5.3.

Mi = The weighted air dose factor due to gamma emission for each identified noble gas radionuclide in mrad/yr per $\mu$Ci/m$^3$. This factor is unit-specific, per Table 3-6.

Ni = The weighted air dose factor due to beta emissions for each identified noble gas radionuclide in mrad/yr per $\mu$Ci/m$^3$.

$\widetilde{q}i_{mt}$ = The total releases of noble gas radionuclides in Monitor Tank vents in $\mu$Ci. Releases shall be cumulative over the calendar quarter or year, as appropriate.

$\widetilde{q}i$ = The total release of noble gas radionuclides in gaseous effluents, i, for short term releases (equal to or less than 500 hrs/yr or 150 hrs/qtr and not random as defined in NUREG 0133, Section 3.3) from all vents, in $\mu$Ci. Releases shall be cumulative over the calendar quarter or year as appropriate.

$\widetilde{Q}i$ = The total release of noble gas radionuclides in gaseous effluents, i, for long term releases (greater than 500 hrs/yr or 150 hrs/qtr or as noted in 3.1.16) from all vents in $\mu$Ci. Releases shall be cumulative over the calendar quarter or year as appropriate.

3.17 E-8 = The inverse of the number of seconds in a year.

The air dose factors Mi and Ni were obtained from Table B-1 of Regulatory Guide 1.109 and are listed in Table 3-6 and 3-7 respectively. The M air dose factors are finite cloud corrected and therefore unit-specific.

3.3.4 Time Averaged Dose - Radioiodine 131, Part w/t½ >8 days, and Tritium

3.3.4.1 The equations in this section are used to meet the calculational requirements of RECS D3.2.3.

3.3.4.2 The pathways considered in this analysis are as follows:

| *Pathway* | *Receptor* |
|---|---|
| Inhalation, Ground Plane, Vegetative Ingestion | Primary, Nearest Resident, per App I |
| Inhalation, Ground Plane, Vegatative, Cow-Milk Ingestion | Secondary Receptor at 5 mile, applied per the annual Land Use Census |

The land use census identifies a high degree of commercial, industrial, and residential land usage in the area, and as such, the meat ingestion pathway is not considered. Doses from the cow-milk pathway are included only if the applicable annual census has defined the pathway applicable. The methodology in nonetheless included here.

3.3.4.3 The equations for calculating the dose limitations are obtained from NUREG 0133 (Ref. 1, Section 5.3). These equations reduce to the following :

$$(3.17\,E\text{-}08)*\sum_i (Ri\,(W\,\tilde{Q}i \; + \; w\,\tilde{q}i) \;<\; 7.5 \text{ mrem} \quad \text{in a calendar quarter}$$

$$(3.17\,E\text{-}08)*\sum_i (Ri\,(W\,\tilde{Q}i \; + \; w\,\tilde{q}i) \;<\; 15 \text{ mrem} \quad \text{in a calendar year}$$

<u>Where:</u>

$\tilde{Q}i$ = The plant releases of radioiodine 131 and radioactive materials in particulate form with half-lives greater than 8 days for long term releases as defined in Section 3.1.16, in μCi. Releases shall be cumulative over the calendar quarter or year, as appropriate.

$\tilde{q}i$ = The plant releases of radioiodine 131 and radioactive materials in particulate form with half-lives greater than 8 days for short term releases as defined in Section 3.1.16, in μCi. Releases shall be cumulative over the calendar quarter or year, as appropriate.

W = The dispersion or deposition parameter (based on meteorological data defined in Section 3.5) for estimating the dose to an individual at the applicable receptor for long term releases as defined in Section 3.1.16 and Appendix I.

w = The vent dispersion or deposition parameter for estimating the dose to an individual at the applicable receptor for short term releases as calculated as in Section 3.5 and defined in Section 3.1.16 and Appendix I.

3.17 E-08 = The inverse number of seconds in a year.

Ri = The dose factor for each identified pathway, organ, and radionuclide, i, in $m^2$ ·mrem/yr per μCi/sec or mrem/yr per μCi/$m^3$. These dose factors are determined as described in Sections 3.3.4.5a-d.

3.3.4.4 Utilizing the assumptions contained in Section 3.3.4.3, these equations for the nearest resident and the 5-mile cow secondary receptor reduce to the following:

$$DN = (3.17E\text{-}8)\sum_i [Ri(I) * [Wn(in)\tilde{Q}i + wn(in)\tilde{q}i] + (Ri(G) + Ri(V)) * [Wn(dep)\tilde{Q}i + wn(dep)\tilde{q}i]]$$

$$DS = (3.17E\text{-}8)\sum_i [Ri(I) * [Ws(in)\tilde{Q}i + ws(in)\tilde{q}i] + (Ri(G) + Ri(c) + Ri(V)) * [Ws(dep)\tilde{Q}i + ws(dep)\tilde{q}i]]$$

Where:

DN = total dose at the nearest residence, in mrem

DS = total dose at the 5-mile cow secondary receptor, in mrem.

Wn(in) = The highest calculated annual average dispersion parameter for the inhalation pathway for the nearest residence in the unrestricted area, as defined in Appendix I.

wn(in) = The dispersion parameter Wn(in), corrected for short term releases, as defined in Appendix I.

Wn(dep)= The highest calculated annual average deposition parameter for the nearest residence in the unrestricted area, as defined in Appendix I, for all isotopes except Tritium, which uses the X/Q value instead (Wn(in)).

wn(dep)= The deposition parameter Wn(dep), corrected for short term releases, as defined in Appendix I.

Ws(in) = The highest calculated annual average dispersion parameter for the inhalation pathway at the 5-mile cow secondary receptor per Appendix I.

ws(in) = The dispersion parameter Ws(in), at the 5-mile cow secondary receptor, corrected for short term releases, as defined in Appendix I.

Ws(dep)= The highest calculated annual average deposition parameter for the 5-mile cow secondary receptor, as defined in Appendix I, for all isotopes except Tritium, which uses the X/Q value instead (Ws(in)).

ws(dep)= The deposition parameter Ws(dep), at the 5-mile cow secondary receptor, corrected for short term releases, as defined in Appendix I.

$\tilde{Q}i$ = The plant releases of radioiodine 131 and radioactive materials in particulate form with half-lives greater than 8 days for long term releases as defined earlier, (uCi).

$\tilde{q}i$ = The plant releases of radioiodine 131 and radioactive materials in particulate form with half-lives greater than 8 days for short term releases as defined earlier (uCi).

Ri (I): Inhalation pathway factor for each radionuclide, i, defined in Section 3.3.4.5.

Ri (G): Ground plane pathway factor for each radionuclide, i, defined in Section 3.3.4.5.

Ri (V): Vegetation pathway factor for each radionuclide, i, defined in Section 3.3.4.5.

Ri (C): Cow-Milk pathway factor for each radionuclide, i, defined in Section 3.3.4.5.

3.3.4.5 Calculation of Dose Factors

3.3.4.5.a Calculation of Ri (I) (X/Q) Inhalation Pathway Factor

$Ri\ (I)_{(X/Q)} = K'[(BR)\ a]\ [(DFAi)\ a]$ (mrem/yr per $\mu$Ci/$m^3$)

Where:

K' = Constant of unit conversion, $10^6$ pCi/uCi

(BR) a = Breathing rate of the receptor of age group (a) in $m^3$/yr. (from Regulatory Guide 1.109, Table E-5)

Infant = 1400 ($m^3$/yr) Child = 3700 ($m^3$/yr) Adult/Teen = 8000 ($m^3$/yr)

(DFAi) a = The maximum organ inhalation dose factor for the receptor of age group (a) for the $i_{th}$ radionuclide, in mrem/pCi. The total body is considered as an organ in the selection of (DFAi)a.

Child and infant inhalation dose factors are generally more restrictive, however, doses from each age group are calculated separately. The (DFAi)a values are listed in Tables 3-1a through 3-1d. The Ri values for the inhalation pathway are listed in Table 3-10a through 3-10d.

3.3.4.5.b Calculation of Ri(G)(D/Q) Ground Plane Pathway Factor

$$Ri(G)_{(D/Q)} = \frac{K'K''(SF)(DFGi)(1-e^{(-kit)})}{Ki} = \frac{m^2 \cdot mrem/yr}{uCi/sec}$$

Where:

K' = A constant of conversion, $10^6$ pCi/$\mu$Ci.

K" = A constant of conversion, 8760 hr/yr.

ki = Decay constant for the $i_{th}$ radionuclide $sec^{-1}$.

t = The exposure time, 4.73 x $10^8$ sec (15 years).

DFGi = The ground plane dose conversion factor for $i_{th}$ radionuclide (mrem/hr per pCi/$m^2$).

SF = Shielding factor (dimensionless) = 0.7 (from Table E-15 of Regulatory Guide 1.109).

The values of DFGi were obtained from Table E-6 of Regulatory Guide 1.109 and are listed in Table 3-2. These values were used to calculate Ri(G), which is the same for all age groups and organs and is listed in Table 3-13.

### 3.3.4.5.c Calculation of Ri(V)(D/Q) - Vegetation Pathway Factor

For non-Tritium isotopes:

$$Ri(V)_{(D/Q)} = \frac{m^2 \cdot mrem/yr}{uCi/sec} = \frac{K'(r)}{Yv(ki + kw)} * (DFLi)a * [(UaL)fL * e^{(-kitL)} + (UaS)fg * e^{(-kith)}]$$

Where:

K' = Constant of conversion, $10^6$ pCi/μCi

r = Dimensionless correction factor for Iodine and Particulate from Table E-15 of Reg Guide 1.109: 0.2 for particulates, 1.0 for radioiodine

$DFLi_a$ = Reg Guide 1.109 dose factor for each nuclide, in mrem/pCi, for each age group.

UaL = Consumption rate of fresh leafy vegetation by the receptor in age group (a) in kg/yr.

ki = Decay constant for the radionuclide, in sec $^{-1}$

UaS = Consumption rate of non-leafy vegetables by the receptor in age group (a) in kg/yr.

fL = The fraction of the annual intake of leafy vegetation grown locally.

fg = The fraction of the annual intake of non-leafy vegetation grown locally.

kw = Decay constant for removal of activity on leaf and plant surfaces by weathering, 5.73E-7 sec $^{-1}$ (corresponding to a 14 day half-life).

tL = The average time between harvest of leafy vegetation and its consumption, in seconds.

th = The average time between harvest of stored vegetation and its consumption, in seconds.

Yv = The vegetation area density in kg/$m^2$.

The concentration of Tritium in vegetation is based on the airborne concentration rather than the deposition. Therefore, the Ri(V) is based on X/Q:

$(RiV)_{(X/Q)}$ = K'K"[(UaL)fL+(UaS)fg](DFLi)a (0.75)(0.5/H) (mrem/yr per μCi/$m^3$)

Where:

K'' = A constant of unit conversion, 1000 gm/kg

H = Absolute humidity of the atmosphere in gm/m$^3$ . This value may be considered as 8 gm/m$^3$ (NUREG 0133, pg 27) in lieu of site specific information.

0.75 = The fraction of total feed that is water

0.5 = The ratio of the specific activity of the feed grass water to the atmospheric water

DFLia for each age group is given in Tables 3-3a through 3-3d and Ri(V) values are listed in Table 3-11a through 3-11c.

Ri(V) Parameters Are From The Following Sources:

| PARAMETER | VALUE | Reg Guide 1.109 Table |
|---|---|---|
| R (dimensionless) | 1.0 for iodines & 0.2 for part. | E-15 |
| (DFLi) a (mrem/pCi) | Each radionuclide | E-11 to E-14 |
| UaL (kg/yr) - infant | 0 | E-5 |
| - child | 26 | E-5 |
| - teen | 42 | E-5 |
| - adult | 64 | E-5 |
| UaS (kg/yr) - infant | 0 | E-5 |
| - child | 520 | E-5 |
| - teen | 630 | E-5 |
| - adult | 520 | E-5 |
| fL (dimensionless) | 1.0 | E-15 |
| fg (dimensionless) | 0.76 | E-15 |
| tL (seconds) | 8.6E4 (1 day) | E-15 |
| th (seconds) | 5.18E6 (60 days) | E-15 |
| Yv (kg/m$^2$) | 2.0 | E-15 |

### 3.3.4.5.d Calculation of Ri(c)(D/Q) - Grass-Cow-Milk Pathway Factor

(applied only as required by the Land Use Census)

$$\mathrm{Ri(c)\,(D/Q)} = \frac{\mathrm{m^2 \cdot mrem/yr}}{\mathrm{uCi/sec}} = \frac{\mathrm{K(QF)(Uap)(Fm)(r)(DFLi)a}}{\mathrm{ki + kw}} * \left\langle \frac{\mathrm{fpfs}}{\mathrm{Yp}} + \frac{\mathrm{(1 - fpfs)\,(e^{(-kith)})}}{\mathrm{Ys}} \right\rangle * \mathrm{e^{(-kitf)}}$$

Where:

K' = Constant of conversion, $10^6$ pCi/μCi

QF = Cow's consumption rate in kg/day (wet weight)

Uap= Receptor's milk consumption rate for age (a) in liters/yr.

Yp = Agricultural productivity by unit area of pasture grass in kg/$m^2$.

Ys = Agricultural productivity by unit area of stored feed in kg/$m^2$.

Fm = Stable element transfer coefficients in days/liters, Table 2-2.

r = Fraction of deposited activity retained on cow's feed grass.

(DFLi)a= The maximum organ ingestion dose for the radionuclide, I, for the receptor in age group (a) in mrem/pCi. Values are from Tables E-11 through E-14 of Regulatory Guide 1.109 and are listed in Tables 3-3a through 3-3d.

ki = Decay constant for the radionuclide in $sec^{-1}$.

kw = Decay constant for removal of activity on leaf and plant surfaces by weathering, 5.73E-7 $sec^{-1}$ (corresponding to a 14 day half-life).

tf = The transport time from pasture, to cow, to milk, to receptor in sec.

th = The transport time from pasture, to harvest, to cow, to milk, to receptor, in sec.

fp = Fraction of the year that the cow is on pasture.

fs = Fraction of the cow feed that is pasture grass while the cow is on pasture.

Note: The values of Ri (c) are listed in Table 3-12a-d.

The concentration of Tritium in milk is based on the airborne concentration rather than the deposition. Therefore, the Ri (c) is based on X/Q:

Ri (c) (X/Q) = K'K" (Fm) (QF) (Uap) (DFLi) a 0.75 (0.5/H) (mrem/yr per μCi/$m^3$)

Where:

K" = A constant of unit conversion, $10^3$ m/kg;

H = Absolute humidity of the atmosphere in gm/m$^3$;

0.75 = The fraction of total feed that is water;

0.5 = The ratio of the specific activity of the feed grass water to the atmospheric water;

Other parameters and values are given above. The value of H may be considered as 8 grams/meter$^3$ (NUREG 0133, PAGE 27) in lieu of site specific information.

Ri(c) Parameters Are Taken From The Following Sources:

| PARAMETER | VALUE | TABLE R.G. 1.109 |
|---|---|---|
| R (dimensionless) | 1.0 for radioiodine | E-15 |
| | 0.2 for particulates | E-15 |
| Fm (days/liter) | Each stable element | E-1 |
| Uap (liters/year) - infant | 330 | E-5 |
| - child | 330 | E-5 |
| - teen | 400 | E-5 |
| - adult | 310 | E-5 |
| (Dfli) a (mrem/pCi) | Each radionuclide | E-11 to E-14 |
| Yp (kg/m$^2$) | 0.7 | E-15 |
| Ys (kg/m$^2$) | 2.0 | E-15 |
| tf (seconds) | 1.73E5 (2 days) | E-15 |
| th (seconds) | 7.78E6 (90 days) | E-15 |
| Qf (kg/day) | 50 | E-15 |
| fs | Assumed to be unity | |
| fp | Assumed to be unity | |

Stable Element Transfer data is listed in Table 3-2 (Reg Guide 1.109, Table E-1). The (DFLi)a values for 4 age groups are given in Tables 3-3a through 3-3d.

## 3.4 Backup Simplified Dose Methodology

The dose calculation procedures described in this section are provided for use as a backup whenever the primary computer methodology cannot be followed.

### 3.4.1 Instantaneous Dose Rates - Noble Gas Releases

Note: While true instantaneous rates and limits generally apply, a one hour average can be chosen as the defining interval for determining process radiation monitor response or release rate determinations.

3.4.1.1 This section describes the alternative calculational methods to meet the requirements of Section 3.2.1 and the calculational results per Section 3.3.1.

3.4.1.2 To determine an acceptable noble gas instantaneous release rate in μCi/sec, a standard isotopic mixture of noble gas is assumed. This isotopic mixture was measured for a mixture of isotopes typical of reactor coolant with exposed fuel. This requirement is evaluated at the worst sector of the unrestricted area boundary. Based on this isotopic mixture, standard weighted values of K, L, M, and N is determined using the technique presented in paragraph 3.3.1.2, and the Ki, Li, Mi, and Ni values from Tables 3-4 through 3-7. The data and results of this calculation are shown in Table 3-8.

3.4.1.3 Utilizing the equations from Paragraph 3.3.1.2 and the values from Table 3-8, conservative IPEC maximum (site) release limits for all noble gases in μCi/sec are calculated in Appendix I, page 2.

The resulting calculations establish a default instantaneous noble gas release rate limit of **140,000** μCi/sec for the site, split equally between the units for conservativism. While both Units 2 and 3 originally apply the instantaneous limit at 70,000 μCi/sec, any one unit can use up to nearly 100% of the site limit, should it become necessary.

Generally, as these limits begin to apply, actual sample data is used to determine the true instantaneous limit associated with 10CFR20 requirements, for both whole body and skin dose rate, as shown in Appendix I.

3.4.1.4 For individual release rate determinations, alternate computer codes and/or a procedurally driven hand calculation template serve as back up methodologies should the primary computer method be inoperable. These methods comply with calculations in Section 3.3.

### 3.4.2 Instantaneous Dose Rates-I-131, Particulates w/t½ >8 days, & H-3

3.4.2.1 This section describes the alternative calculational method to meet the requirements of Section 3.2.1. The purposes of this method is to provide backup calculational techniques, both computer aided and hand calculated, which approximate section 3.3.2.

3.4.2.2 To determine an acceptable iodine and particulate release rate, it is assumed that the limit on these releases shall be met if

a) the total noble gas concentration in the VC is at least a factor of 20,000 more than the concentration of radioiodine and long lived particulates, or

b) VC iodines and long lived particulates are less than 1E-7 μCi/cc.

Both these conditions have historically been the case, assuring that noble gas activity continues to be more limiting.

3.4.2.3 Backup instantaneous dose rate calculations can be performed with an alternate computer code or by formatted hand calculations which are identical to section 3.3.2.

3.4.3 <u>Time Averaged Dose - Noble Gas Releases</u>

3.4.3.1 This section describes alternative methods of meeting the requirements of Paragraphs 3.2.2 and 3.2.4, and the alternative methods of implementing the calculation techniques presented in Section 3.3.3.

3.4.3.2 The values of $\overline{Ki}$, $\overline{Li}$, $\overline{Mi}$, and $\overline{Ni}$ for either unit's Plant Vent (PV) mixed mode releases, and the potential Unit 3 Monitor Tank (MT) ground plane releases are determined for each release using the dispersion parameter for the site boundary in the worst sector. The calculations are as follows:

$$PV\overline{Ki} = Ki * (X/Q)PV \quad \text{and} \quad MTKi = (\overline{Ki}) * (X/Q)MT$$

$$PV\overline{Li} = (Li) * (X/Q)PV \quad \text{and} \quad MTLi = (\overline{Li}) * (X/Q)MT$$

$$PV\overline{Mi} = (Mi) * (X/Q)PV \quad \text{and} \quad MTMi = (\overline{Mi}) * (X/Q)MT$$

$$PV\overline{Ni} = (Ni) * (X/Q)MT \quad \text{and} \quad MTNi = (\overline{Ni}) * (X/Q)MT$$

<u>Where:</u>

Ki = The total body dose factor due to gamma emissions for each identified noble gas radionuclide in mrem/yr per μCi/m$^3$ (unit-specific finite cloud correction used).

Li = The skin dose factor due to beta emissions for each identified noble gas radionuclide in mrem/yr per μCi/m$^3$.

Mi = The air dose factor due to gamma emissions for each identified noble gas radionuclide in mrem/yr per μCi/m$^3$ (unit-specific finite cloud correction used).

Ni = The air dose factor due to beta emissions for each identified noble gas radionuclide in mrad/yr per μCi/m$^3$.

(X/Q)PV = The highest calculated annual average dispersion parameter for the noble gas pathway at the unrestricted area boundary, applicable to plant vent mixed mode releases, per Appendix I.

(X/Q)MT = The highest calculated annual average X/Q for ground level monitor tank noble gas release pathway, 5.00E-5 sec/m$^3$.

3.4.3.3 Determine weighted average dose factors as follows:

All values of Ki, Li, Mi, and Ni are shown in Table 3-4 through 3-7 for the unrestricted area boundary.

Each of the following expressions is summed over all the nuclides:

PV Kt = $\sum[Ki * (Ci / Ct)]$

PV Lt = $\sum[Li * (Ci / Ct)]$

PV Mt = $\sum[Mi * (Ci / Ct)]$

PV Nt = $\sum[Ni * (Ci / Ct)]$

For the monitor tank pathway, MTKt, MTLt, MTMt, and MTNt are calculated in the same way as for plant vent (PV) releases above, except that Ci and Ct apply to gaseous activity for the monitor tank vent pathway.

Where:

Ci = Concentration of isotope i (μCi/cc) in analysis, t (for either PV or MT pathway)

Ct = Concentration of all noble gas isotopes (μCi/cc) for a specific analysis, *t*, (for either the PV or MT pathway)

These calculations can be performed by hand (via formatted procedure) or by using approved alternate computer codes to compute all or part of the dose calculation.

3.4.3.4 Resultant doses are compared with limits as per 3.3.3. The sum of all releases in a calendar quarter or calendar year should be compared to the limits of Section 3.2.2 and 3.2.4 as appropriate for gamma air dose and beta air dose.

### 3.4.4 Time Averaged Dose-Iodine 131 and Particulates w/t½ days& H-3

3.4.4.1 This section describes the alternate methods of meeting the requirements of Paragraphs 3.2.3 and 3.2.4 and of implementing the calculational techniques presented in Section 3.3.4.

3.4.4.2 If the primary computer method is inoperable, dose calculations can be performed by 1) an alternate computer code which complies with Section 3.3.4, using all identified Iodine and Particulate isotopes; or 2) hand calculations (via a formalized departmental procedure) which comply with Section 3.3.4.

3.4.4.3 Quarterly and annual Iodine, Particulate, and Tritium dose contributions are summed and compared to limits described in Section 3.2.3.

3.5 Calculation of Meteorological Dispersion Factors

3.5.1 For the purpose of these calculations, the site boundary was taken to be the unrestricted area boundary. The distances to the site boundary and nearest residents are shown in Table 3-9 for each of the 16 major compass sectors. Site boundary distances at IPEC are measured from the applicable unit's Plant Vent, while distances to the nearest resident in each of these sectors is measured from a common point, the Unit 1 superheater stack.

In the sectors where the Hudson River forms the site or exclusion area boundary, the near shore is assumed as the boundary of the "unrestricted area", because, in general, IPEC does not attempt to control population on the river. Potential confusion regarding the near or far shore for this application is effectively removed per the definition of "unrestricted area" in NUREG 0133 (Ref. 1, Section 2.2, Page 6). This section states that these criteria do "not include areas over water bodies" and the river is therefore not applicable for evaluating the maximum unrestricted area boundary concentrations.

3.5.2 The atmospheric transport and diffusion model used in the evaluation of dispersion and deposition factors is the sector-average straight-line model in Regulatory Guide 1.111 (Ref. 15) for mixed-mode releases with plume-rise effects, downwash, and building-wake correction.

The analyses were carried out using the AEOLUS-3 computer code (Ref. 16) and are documented in detail in Ref. 17 and Ref. 50. Hourly meteorological data was collected from 1981 through 1990, initially updated with data from 1992 to 2002 and updated again with data from 2006 to 2015, in accordance with the accuracy requirements of Safety (Draft Regulatory) Guide 1.23 (Ref. 18). The data recovery index for these periods was in excess of 99%.

Comparison of the new meteorological data (2006-2015) with previous data (1992 to 2002 and 1981 to 1990) continues to show little difference in the overall dispersion conditions at the site. The meteorological parameters selected were the higher values of the last two 10 year periods. In the analyses, wind-speed coefficients in Regulatory Guide 1.111 were used to extrapolate the measured wind speeds to the height of the main vent (on top of the primary containment).

Also, the regulatory plume entrainment model was used to determine plume partitioning between ground-level and elevated releases, and no credit was taken for decay and depletion in transit.

Recirculation effects were accounted for by confining in-valley flows within the valley out to a distance of 10 miles (up or down the valley) and allowing a portion of them to return to the site without additional dilution.

3.5.3 To meet the calculational requirements of Paragraphs 3.2.1, 3.2.2, and 3.2.4 the annual average dispersion factors are calculated approximately once every ten years, for each compass sector at the site unrestricted area boundary. The most restrictive meteorological dispersion and deposition factors determined from this accumulation of data is currently presented in Appendix I.

The distances to the site boundary and nearest resident in each sector were determined from the land use census and global positioning technology, and are listed in Table 3-9.

For the monitor tank release pathway, ground level dispersion values (X/Q) were assessed using the methodology discussed in Section 3.5.2. The most restrictive X/Q was determined to be in the SW sector at 350m with a value of 5.00E-5 sec/$m^3$ (concentration X/Q per Ref. 21). This value is specific only to the Unit 3 Monitor Tank pathway for noble gas dose at the site boundary.

3.5.4 To meet the calculational requirements of Paragraph 3.2.3 (Iodines and Particulates), the annual average deposition and dispersion parameters were calculated for the nearest residents in each of the compass sectors. Because no real dairy exists within 5 miles of the power plant, a hypothetical grass-cow-milk pathway and its dispersion and deposition factors are included, but turned on or off according to the applicable annual Land Use Census. Dispersion and deposition parameters for these locations were calculated using the models and data described in Sec. 3.5.2, and are represented as:

Wn(in) = The highest calculated annual average dispersion parameters for the inhalation pathway for the nearest residence in the unrestricted area, per Appendix I.

Wn(dep)= The highest calculated annual average deposition parameters for the ground plane and vegetation pathways for the nearest residence in the unrestricted area, per Appendix I. For Tritium in the vegetation pathway, Wn(in) is used.

Ws(in) = The highest calculated annual average dispersion parameters for the inhalation pathway at the 5-mile cow secondary receptor, per Appendix I.

Ws(dep)= The highest calculated annual average deposition parameters for the cow-milk, vegetation, and ground plane pathways at the 5-mile secondary receptor, per Appendix I. For Tritium at this location, Ws(in) is used.

NOTE: For the monitor tank pathway, iodines and particulates are effectively removed by demineralization, therefore deposition parameters for this pathway are not applicable.

3.5.5 To meet the calculational requirements of Paragraphs 3.2.2, 3.2.3 and 3.2.4, and the calculation methodologies described in Sections 3.3.4 and 3.3.3, short term release dispersion and deposition factors may need to be calculated.

Short term release dispersion and deposition factors are determined from the long term annual average parameters and a method presented by Sagendorf in NUREG 0324 (Ref. 5) as recommended by NUREG 0133 (Ref. 1, Section 3.3, Page 8). This method makes use of a factor (F), developed for a particular compass sector and distance, which is simply multiplied by the annual average dispersion or deposition parameter for the same sector and distance to develop the corresponding short-term parameter.

This factor is defined as: $F = [NTOTAL/8760]^m$

Where:

F = The non-dimensional correction factor used to convert annual average dispersion or deposition factors to short term dispersion or deposition factors.

NTOTAL = The total duration of a short-term release (or releases) in hours, during a chosen reporting period.

$$m = \frac{\log(ANMX / F15MX)}{\log(8760)}$$

8760 = The total number of hours in a year.

ANMX = The calculated historical average dispersion (sec/m$^3$) or deposition (m$^{-2}$) factor for the compass sector and distance of interest.

F15MX = The short term dispersion (sec/m$^3$) or deposition (m$^{-2}$) factor for the compass sector and distance of interest. This is the 15th percentile value such that worse weather conditions can only exist 15% of the time and better conditions 85% of the time.

The atmospheric transport and diffusion model used in the evaluation of short-term dispersion and deposition parameters (F15MX) is the Gaussian plume-centerline model in Regulatory Guide 1.145 (Ref. 19), adapted for mixed-mode releases with plume-rise effects, downwash, building-wake correction and plume meander considerations.

As was the case with the annual average parameters, the analyses were carried out using the AEOLUS-3 computer code (Ref. 16) and the most recent 10-year hourly meteorological data. They are documented in detail in Reference 17 and Reference 50. 4/21

Note that in line with the guidance in NUREG-0133, Sec. 5.3.1, page 29, short-term releases (equal to or less than 500 hours per year) are considered to be cumulative over the calendar quarter or year, as appropriate. However, from Sec. 3.1.16 of the ODCM Part II, and in line with Sec. 3.3, page 8 of NUREG-0133, gas-decay tank releases and containment purges have been determined to be sufficiently random so as to permit use of the long-term dispersion and deposition parameters for assessment of their radiological impact.

3.5.6 The short term 15th percentile dispersion or deposition factor for use in the equation of the preceding paragraphs and the simplified F factor equation for mixed-mode releases to critical locations of each IPEC unit are as follows:

a) Site Boundary Noble Gas:

| | | Unit 2 | Unit 3 |
|---|---|---|---|
| F15MX | = | 7.724E-5 sec/m$^3$ | 1.590E-4 sec/m$^3$ |
| ANMX | = | 2.219E-6 sec/m$^3$ | 4.470E-6 sec/m$^3$ |

$$m = \frac{\log(ANMX / F15MX)}{\log(8760)} = -0.391 \qquad -0.393$$

**F =** **[NTOTAL/8760]$^{-0.391}$** **[NTOTAL/8760]$^{-0.393}$**

b) Nearest Residence Inhalation:

| | | Unit 2 | Unit 3 |
|---|---|---|---|
| F15MX | = | 4.992E-5 sec/m$^3$ | 4.888E-5 sec/m$^3$ |
| ANMX | = | 1.030E-6 sec/m$^3$ | 1.016E-6 sec/m$^3$ |

$$m = \frac{\log(ANMX / F15MX)}{\log(8760)} = -0.428 \qquad -0.427$$

**F =** **[NTOTAL/8760]$^{-0.428}$** **[NTOTAL/8760]$^{-0.427}$**

c) Nearest Residence Deposition:

| | | Unit 2 | Unit 3 |
|---|---|---|---|
| F15MX | = | 3.995E-7 $m^{-2}$ | 4.019E-7 $m^{-2}$ |
| ANMX | = | 7.517E-9 $m^{-2}$ | 7.451E-9 $m^{-2}$ |

m = $\frac{\log(ANMX / F15MX)}{\log(8760)} = -0.438$ $-0.439$

**F =** **[NTOTAL/8760]$^{-0.438}$** **[NTOTAL/8760]$^{-0.439}$**

d) 5-mile Inhalation:

| | | Same for both Units 2 and 3 |
|---|---|---|
| F15MX | = | 6.192E-6 sec/$m^3$ |
| ANMX | = | 7.223E-7 sec/$m^3$ |

m = $\frac{\log(\mathrm{ANMX}/\mathrm{F15MX})}{\log(8760)} = -0.237$

**F = [NTOTAL/8760]$^{-0.237}$**

e) 5-mile Deposition:

| | | Same for both Units 2 and 3 |
|---|---|---|
| F15MX | = | 9.501E-9 $m^{-2}$ |
| ANMX | = | 1.350E-9 $m^{-2}$ |

m = $\frac{\log(\mathrm{ANMX}/\mathrm{F15MX})}{\log(8760)} = -0.215$

**F = [NTOTAL/8760]$^{-0.215}$**

f) The slopes (“m”) for ground level short term correction factors can be calculated in a similar fashion, use the most restrictive value from ground level data found in Reference 17 and Reference 50. For example:

| | Unit 2 | Unit 3 |
|---|---|---|
| Site Boundary Noble Gas: | -0.399 | -0.407 |
| Nearest Resident Inhalation: | -0.427 | -0.427 |
| Nearest Resident Deposition: | -0.455 | -0.455 |
| 5-mile Inhalation: | -0.235 | -0.235 |
| 5-mile Deposition: | -0.212 | -0.212 |

## 3.6 Justification for and Use of Finite Cloud Assumption for Assessing Site Boundary Dose

Two models are available for the computation of doses from external gamma radiation:

a) The semi-infinite cloud model, which is conservatively applicable only for ground-level releases assumes ground level airborne concentrations are the same throughout a cloud that is large in extent relative to the photon path lengths in air.

b) The finite-cloud model, which takes into consideration the actual plume dimensions and the elevation above the receptor.

The semi-infinite cloud model (which is normally used in a variety of applications because of its simplicity) has two drawbacks:

1. It could be overly conservative for receptors close to the release point (particularly for ground-level releases under stable conditions with limited plume dispersion) due to the basis that the high concentration at the receptor is assumed to exist everywhere, and;

2. It is not suitable for elevated releases since gamma radiation emanating from the radioactive cloud could still reach a receptor on the ground even though the plume is still aloft (the concentration at ground level is equal to zero).

For practical applications, it is possible to define isotope-dependent finite-cloud correction factors to express the difference in external radiation exposures between a finite cloud (which may be either at ground level or elevated) and a semi-finite cloud. Physically, when such a correction factor is applied to the calculated ground-level concentration resulting from a given plume, it will define the equivalent concentration in a semi-infinite cloud which would yield the same external exposure as the finite cloud. Such a correction factor is a function of both the airborne radionuclide energy and of plume dispersion under the prevailing conditions. At distant receptors, where the plume dimensions reach limiting conditions, such correction factors reduce to unity.

The AEOLUS-3 code (which was used for the determination of the annual average dispersion and deposition parameters listed in Section 3.5), also has the capability of providing a basis for computation of isotope-specific finite-cloud correction factors based on the models in "Meteorology and Atomic Energy" (Ref. 20, Sec. 7.5.2). The code was used (along with the mixed-mode release option and the 10-year hourly meteorological data base) for the determination of the correction factors as would be applicable at the IPEC site boundary. Note that the correction factors can be viewed as adjustment factors to the dose conversion factors in Regulatory Guide 1.109 (Ref. 3) for immersion in semi-infinite clouds. The nuclide specific correction factors and adjusted dose factors are presented in Tables 3-4 and 3-6 for the IPEC site boundary.

For the Unit 3 Monitor Tank pathway (ground release concentration X/Q), use of the finite cloud corrected data presented in tables 3-4 and 3-6 will provide a conservative result. The conservativism is due to the indicated correction factors for the mixed mode case yielding larger correction factors per nuclide. However, in the event that a ground level specific finite cloud correction factor is desired (which will yield lower calculated doses) the Xe-133 gamma X/Q value may be used as described in Reference 21.

Table 3-1a

ADULT INHALATION DOSE FACTORS

(mrem per pCi inhaled)

| Isotope | BONE | LIVER | TOT BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| H-3 | 0.00E+00 | 1.58E-07 | 1.58E-07 | 1.58E-07 | 1.58E-07 | 1.58E-07 | 1.58E-07 |
| Be-7 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Na-24 | 1.28E-06 | 1.28E-06 | 1.28E-06 | 1.28E-06 | 1.28E-06 | 1.28E-06 | 1.28E-06 |
| P-32 | 1.65E-04 | 9.64E-06 | 6.26E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.08E-05 |
| Cr-51 | 0.00E+00 | 0.00E+00 | 1.25E-08 | 7.44E-09 | 2.85E-09 | 1.80E-06 | 4.15E-07 |
| Mn-54 | 0.00E+00 | 4.95E-06 | 7.87E-07 | 0.00E+00 | 1.23E-06 | 1.75E-04 | 9.67E-06 |
| Mn-56 | 0.00E+00 | 1.55E-10 | 2.29E-11 | 0.00E+00 | 1.63E-10 | 1.18E-06 | 2.53E-06 |
| Fe-55 | 3.07E-06 | 2.12E-06 | 4.93E-07 | 0.00E+00 | 0.00E+00 | 9.01E-06 | 7.54E-07 |
| Fe-59 | 1.47E-06 | 3.47E-06 | 1.32E-06 | 0.00E+00 | 0.00E+00 | 1.27E-04 | 2.35E-05 |
| Co-58 | 0.00E+00 | 1.98E-07 | 2.59E-07 | 0.00E+00 | 0.00E+00 | 1.16E-04 | 1.33E-05 |
| Co-60 | 0.00E+00 | 1.44E-06 | 1.85E-06 | 0.00E+00 | 0.00E+00 | 7.46E-04 | 3.56E-05 |
| Ni-63 | 5.40E-05 | 3.93E-06 | 1.81E-06 | 0.00E+00 | 0.00E+00 | 2.23E-05 | 1.67E-06 |
| Ni-65 | 1.92E-10 | 2.62E-11 | 1.14E-11 | 0.00E+00 | 0.00E+00 | 7.00E-07 | 1.54E-06 |
| Cu-64 | 0.00E+00 | 1.83E-10 | 7.69E-11 | 0.00E+00 | 5.78E-10 | 8.48E-07 | 6.12E-06 |
| Zn-65 | 4.05E-06 | 1.29E-05 | 5.82E-06 | 0.00E+00 | 8.62E-06 | 1.08E-04 | 6.68E-06 |
| Zn-69 | 4.23E-12 | 8.14E-12 | 5.65E-13 | 0.00E+00 | 5.27E-12 | 1.15E-07 | 2.04E-09 |
| Br-83 | 0.00E+00 | 0.00E+00 | 3.01E-08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.90E-08 |
| Br-84 | 0.00E+00 | 0.00E+00 | 3.91E-08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.05E-13 |
| Br-85 | 0.00E+00 | 0.00E+00 | 1.60E-09 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Rb-86 | 0.00E+00 | 1.69E-05 | 7.37E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.08E-06 |
| Rb-88 | 0.00E+00 | 4.84E-08 | 2.41E-08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.18E-19 |
| Rb-89 | 0.00E+00 | 3.20E-08 | 2.12E-08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.16E-21 |
| Sr-89 | 3.80E-05 | 0.00E+00 | 1.09E-06 | 0.00E+00 | 0.00E+00 | 1.75E-04 | 4.37E-05 |
| Sr-90 | 1.24E-02 | 0.00E+00 | 7.62E-04 | 0.00E+00 | 0.00E+00 | 1.20E-03 | 9.02E-05 |
| Sr-91 | 7.74E-09 | 0.00E+00 | 3.13E-10 | 0.00E+00 | 0.00E+00 | 4.56E-06 | 2.39E-05 |
| Sr-92 | 8.43E-10 | 0.00E+00 | 3.64E-11 | 0.00E+00 | 0.00E+00 | 2.06E-06 | 5.38E-06 |
| Y-90 | 2.61E-07 | 0.00E+00 | 7.01E-09 | 0.00E+00 | 0.00E+00 | 2.12E-05 | 6.32E-05 |
| Y-91m | 3.26E-11 | 0.00E+00 | 1.27E-12 | 0.00E+00 | 0.00E+00 | 2.40E-07 | 1.66E-10 |
| Y-91 | 5.78E-05 | 0.00E+00 | 1.55E-06 | 0.00E+00 | 0.00E+00 | 2.13E-04 | 4.81E-05 |
| Y-92 | 1.29E-09 | 0.00E+00 | 3.77E-11 | 0.00E+00 | 0.00E+00 | 1.96E-06 | 9.19E-06 |
| Y-93 | 1.18E-08 | 0.00E+00 | 3.26E-10 | 0.00E+00 | 0.00E+00 | 6.06E-06 | 5.27E-05 |
| Zr-95 | 1.34E-05 | 4.30E-06 | 2.91E-06 | 0.00E+00 | 6.77E-06 | 2.21E-04 | 1.88E-05 |
| Zr-97 | 1.21E-08 | 2.45E-09 | 1.13E-09 | 0.00E+00 | 3.71E-09 | 9.84E-06 | 6.54E-05 |
| Nb-95 | 1.76E-06 | 9.77E-07 | 5.26E-07 | 0.00E+00 | 9.67E-07 | 6.31E-05 | 1.30E-05 |
| Mo-99 | 0.00E+00 | 1.51E-08 | 2.87E-09 | 0.00E+00 | 3.64E-08 | 1.14E-05 | 3.10E-05 |
| Tc-99m | 1.29E-13 | 3.64E-13 | 4.63E-12 | 0.00E+00 | 5.52E-12 | 9.55E-08 | 5.20E-07 |
| Tc-101 | 5.22E-15 | 7.52E-15 | 7.38E-14 | 0.00E+00 | 1.35E-13 | 4.99E-08 | 1.36E-21 |
| Ru-103 | 1.91E-07 | 0.00E+00 | 8.23E-08 | 0.00E+00 | 7.29E-07 | 6.31E-05 | 1.38E-05 |
| Ru-105 | 9.88E-11 | 0.00E+00 | 3.89E-11 | 0.00E+00 | 1.27E-10 | 1.37E-06 | 6.02E-06 |
| Ru-106 | 8.64E-06 | 0.00E+00 | 1.09E-06 | 0.00E+00 | 1.67E-05 | 1.17E-03 | 1.14E-04 |
| Ag-110m | 1.35E-06 | 1.25E-06 | 7.43E-07 | 0.00E+00 | 2.46E-06 | 5.79E-04 | 3.78E-05 |
| Sb-122 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Sb-124 | 3.90E-06 | 7.36E-08 | 1.55E-06 | 9.44E-09 | 0.00E+00 | 3.10E-04 | 5.08E-05 |
| Sb-125 | 6.67E-06 | 7.44E-08 | 1.58E-06 | 6.75E-09 | 0.00E+00 | 2.18E-04 | 1.26E-05 |

Table 3-1a

ADULT INHALATION DOSE FACTORS

(mrem per pCi inhaled)

| Isotope | BONE | LIVER | TOT BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| Te-125m | 4.27E-07 | 1.98E-07 | 5.84E-08 | 1.31E-07 | 1.55E-06 | 3.92E-05 | 8.83E-06 |
| Te-127m | 1.58E-06 | 7.21E-07 | 1.96E-07 | 4.11E-07 | 5.72E-06 | 1.20E-04 | 1.87E-05 |
| Te-127 | 1.75E-10 | 8.03E-11 | 3.87E-11 | 1.32E-10 | 6.37E-10 | 8.14E-07 | 7.17E-06 |
| Te-129m | 1.22E-06 | 5.84E-07 | 1.98E-07 | 4.30E-07 | 4.57E-06 | 1.45E-04 | 4.79E-05 |
| Te-129 | 6.22E-12 | 2.99E-12 | 1.55E-12 | 4.87E-12 | 2.34E-11 | 2.42E-07 | 1.96E-08 |
| Te-131m | 8.74E-09 | 5.45E-09 | 3.63E-09 | 6.88E-09 | 3.86E-08 | 1.82E-05 | 6.95E-05 |
| Te-131 | 1.39E-12 | 7.44E-13 | 4.49E-13 | 1.17E-12 | 5.46E-12 | 1.74E-07 | 2.30E-09 |
| Te-132 | 3.25E-08 | 2.69E-08 | 2.02E-08 | 2.37E-08 | 1.82E-07 | 3.60E-05 | 6.37E-05 |
| I-130 | 5.72E-07 | 1.68E-06 | 6.60E-07 | 1.42E-04 | 2.61E-06 | 0.00E+00 | 9.61E-07 |
| I-131 | 3.15E-06 | 4.47E-06 | 2.56E-06 | 1.49E-03 | 7.66E-06 | 0.00E+00 | 7.85E-07 |
| I-132 | 1.45E-07 | 4.07E-07 | 1.45E-07 | 1.43E-05 | 6.48E-07 | 0.00E+00 | 5.08E-08 |
| I-133 | 1.08E-06 | 1.85E-06 | 5.65E-07 | 2.69E-04 | 3.23E-06 | 0.00E+00 | 1.11E-06 |
| I-134 | 8.05E-08 | 2.16E-07 | 7.69E-08 | 3.73E-06 | 3.44E-07 | 0.00E+00 | 1.26E-10 |
| I-135 | 3.35E-07 | 8.73E-07 | 3.21E-07 | 5.60E-05 | 1.39E-06 | 0.00E+00 | 6.56E-07 |
| Cs-134 | 4.66E-05 | 1.06E-04 | 9.10E-05 | 0.00E+00 | 3.59E-05 | 1.22E-05 | 1.30E-06 |
| Cs-136 | 4.88E-06 | 1.83E-05 | 1.38E-05 | 0.00E+00 | 1.07E-05 | 1.50E-06 | 1.46E-06 |
| Cs-137 | 5.98E-05 | 7.76E-05 | 5.35E-05 | 0.00E+00 | 2.78E-05 | 9.40E-06 | 1.05E-06 |
| Cs-138 | 4.14E-08 | 7.76E-08 | 4.05E-08 | 0.00E+00 | 6.00E-08 | 6.07E-09 | 2.33E-13 |
| Ba-139 | 1.17E-10 | 8.32E-14 | 3.42E-12 | 0.00E+00 | 7.78E-14 | 4.70E-07 | 1.12E-07 |
| Ba-140 | 4.88E-06 | 6.13E-09 | 3.21E-07 | 0.00E+00 | 2.09E-09 | 1.59E-04 | 2.73E-05 |
| Ba-141 | 1.25E-11 | 9.41E-15 | 4.20E-13 | 0.00E+00 | 8.75E-15 | 2.42E-07 | 1.45E-17 |
| Ba-142 | 3.29E-12 | 3.38E-15 | 2.07E-13 | 0.00E+00 | 2.86E-15 | 1.49E-07 | 1.96E-26 |
| La-140 | 4.30E-08 | 2.17E-08 | 5.73E-09 | 0.00E+00 | 0.00E+00 | 1.70E-05 | 5.73E-05 |
| La-142 | 8.54E-11 | 3.88E-11 | 9.65E-12 | 0.00E+00 | 0.00E+00 | 7.91E-07 | 2.64E-07 |
| Ce-141 | 2.49E-06 | 1.69E-06 | 1.91E-07 | 0.00E+00 | 7.83E-07 | 4.52E-05 | 1.50E-05 |
| Ce-143 | 2.33E-08 | 1.72E-08 | 1.91E-09 | 0.00E+00 | 7.60E-09 | 9.97E-06 | 2.83E-05 |
| Ce-144 | 4.29E-04 | 1.79E-04 | 2.30E-05 | 0.00E+00 | 1.06E-04 | 9.72E-04 | 1.02E-04 |
| Pr-143 | 1.17E-06 | 4.69E-07 | 5.80E-08 | 0.00E+00 | 2.70E-07 | 3.51E-05 | 2.50E-05 |
| Pr-144 | 3.76E-12 | 1.56E-12 | 1.91E-13 | 0.00E+00 | 8.81E-13 | 1.27E-07 | 2.69E-18 |
| Nd-147 | 6.59E-07 | 7.62E-07 | 4.56E-08 | 0.00E+00 | 4.45E-07 | 2.76E-05 | 2.16E-05 |
| W-187 | 1.06E-09 | 8.85E-10 | 3.10E-10 | 0.00E+00 | 0.00E+00 | 3.63E-06 | 1.94E-05 |
| Np-239 | 2.87E-08 | 2.82E-09 | 1.55E-09 | 0.00E+00 | 8.75E-09 | 4.70E-06 | 1.49E-05 |
| K-40 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Co-57 | 0.00E+00 | 8.65E-08 | 8.39E-08 | 0.00E+00 | 0.00E+00 | 4.62E-05 | 3.93E-06 |
| Sr-85 | 4.00E-06 | 0.00E+00 | 9.70E-05 | 0.00E+00 | 0.00E+00 | 6.00E-05 | 7.60E-06 |
| Y-88 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nb-94 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nb-97 | 2.78E-11 | 7.03E-12 | 2.56E-12 | 0.00E+00 | 8.18E-12 | 3.00E-07 | 3.02E-08 |
| Cd-109 | 0.00E+00 | 4.90E-05 | 1.60E-06 | 0.00E+00 | 4.70E-05 | 9.10E-05 | 8.20E-06 |
| Sn-113 | 8.20E-06 | 2.70E-07 | 5.60E-07 | 1.70E-07 | 0.00E+00 | 1.20E-04 | 1.50E-06 |
| Ba-133 | 9.50E-06 | 4.20E-07 | 2.50E-06 | 0.00E+00 | 2.10E-09 | 1.90E-04 | 1.00E-05 |
| Te-134 | 3.84E-12 | 3.22E-12 | 1.57E-12 | 3.44E-12 | 2.18E-11 | 4.34E-07 | 2.97E-11 |
| Ce-139 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Hg-203 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

Table 3-1b

TEEN INHALATION DOSE FACTORS

(mrem per pCi inhaled)

| Isotope | BONE | LIVER | TOT BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| H-3 | 0.00E+00 | 1.59E-07 | 1.59E-07 | 1.59E-07 | 1.59E-07 | 1.59E-07 | 1.59E-07 |
| Be-7 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Na-24 | 1.72E-06 | 1.72E-06 | 1.72E-06 | 1.72E-06 | 1.72E-06 | 1.72E-06 | 1.72E-06 |
| P-32 | 2.36E-04 | 1.37E-05 | 8.95E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.16E-05 |
| Cr-51 | 0.00E+00 | 0.00E+00 | 1.69E-08 | 9.37E-09 | 3.84E-09 | 2.62E-06 | 3.75E-07 |
| Mn-54 | 0.00E+00 | 6.39E-06 | 1.05E-06 | 0.00E+00 | 1.59E-06 | 2.48E-04 | 8.35E-06 |
| Mn-56 | 0.00E+00 | 2.12E-10 | 3.15E-11 | 0.00E+00 | 2.24E-10 | 1.90E-06 | 7.18E-06 |
| Fe-55 | 4.18E-06 | 2.98E-06 | 6.93E-07 | 0.00E+00 | 0.00E+00 | 1.55E-05 | 7.99E-07 |
| Fe-59 | 1.99E-06 | 4.62E-06 | 1.79E-06 | 0.00E+00 | 0.00E+00 | 1.91E-04 | 2.23E-05 |
| Co-58 | 0.00E+00 | 2.59E-07 | 3.47E-07 | 0.00E+00 | 0.00E+00 | 1.68E-04 | 1.19E-05 |
| Co-60 | 0.00E+00 | 1.89E-06 | 2.48E-06 | 0.00E+00 | 0.00E+00 | 1.09E-03 | 3.24E-05 |
| Ni-63 | 7.25E-05 | 5.43E-06 | 2.47E-06 | 0.00E+00 | 0.00E+00 | 3.84E-05 | 1.77E-06 |
| Ni-65 | 2.73E-10 | 3.66E-11 | 1.59E-11 | 0.00E+00 | 0.00E+00 | 1.17E-06 | 4.59E-06 |
| Cu-64 | 0.00E+00 | 2.54E-10 | 1.06E-10 | 0.00E+00 | 8.01E-10 | 1.39E-06 | 7.68E-06 |
| Zn-65 | 4.82E-06 | 1.67E-05 | 7.80E-06 | 0.00E+00 | 1.08E-05 | 1.55E-04 | 5.83E-06 |
| Zn-69 | 6.04E-12 | 1.15E-11 | 8.07E-13 | 0.00E+00 | 7.53E-12 | 1.98E-07 | 3.56E-08 |
| Br-83 | 0.00E+00 | 0.00E+00 | 4.30E-08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Br-84 | 0.00E+00 | 0.00E+00 | 5.41E-08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Br-85 | 0.00E+00 | 0.00E+00 | 2.29E-09 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Rb-86 | 0.00E+00 | 2.38E-05 | 1.05E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.21E-06 |
| Rb-88 | 0.00E+00 | 6.82E-08 | 3.40E-08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.65E-15 |
| Rb-89 | 0.00E+00 | 4.40E-08 | 2.91E-08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.22E-17 |
| Sr-89 | 5.43E-05 | 0.00E+00 | 1.56E-06 | 0.00E+00 | 0.00E+00 | 3.02E-04 | 4.64E-05 |
| Sr-90 | 1.35E-02 | 0.00E+00 | 8.35E-04 | 0.00E+00 | 0.00E+00 | 2.06E-03 | 9.56E-05 |
| Sr-91 | 1.10E-08 | 0.00E+00 | 4.39E-10 | 0.00E+00 | 0.00E+00 | 7.59E-06 | 3.24E-05 |
| Sr-92 | 1.19E-09 | 0.00E+00 | 5.08E-11 | 0.00E+00 | 0.00E+00 | 3.43E-06 | 1.49E-05 |
| Y-90 | 3.73E-07 | 0.00E+00 | 1.00E-08 | 0.00E+00 | 0.00E+00 | 3.66E-05 | 6.99E-05 |
| Y-91m | 4.63E-11 | 0.00E+00 | 1.77E-12 | 0.00E+00 | 0.00E+00 | 4.00E-07 | 3.77E-09 |
| Y-91 | 8.26E-05 | 0.00E+00 | 2.21E-06 | 0.00E+00 | 0.00E+00 | 3.67E-04 | 5.11E-05 |
| Y-92 | 1.84E-09 | 0.00E+00 | 5.36E-11 | 0.00E+00 | 0.00E+00 | 3.35E-06 | 2.06E-05 |
| Y-93 | 1.69E-08 | 0.00E+00 | 4.65E-10 | 0.00E+00 | 0.00E+00 | 1.04E-05 | 7.24E-05 |
| Zr-95 | 1.82E-05 | 5.73E-06 | 3.94E-06 | 0.00E+00 | 8.42E-06 | 3.36E-04 | 1.86E-05 |
| Zr-97 | 1.72E-08 | 3.40E-09 | 1.57E-09 | 0.00E+00 | 5.15E-09 | 1.62E-05 | 7.88E-05 |
| Nb-95 | 2.32E-06 | 1.29E-06 | 7.08E-07 | 0.00E+00 | 1.25E-06 | 9.39E-05 | 1.21E-05 |
| Mo-99 | 0.00E+00 | 2.11E-08 | 4.03E-09 | 0.00E+00 | 5.14E-08 | 1.92E-05 | 3.36E-05 |
| Tc-99m | 1.73E-13 | 4.83E-13 | 6.24E-12 | 0.00E+00 | 7.20E-12 | 1.44E-07 | 7.66E-07 |
| Tc-101 | 7.40E-15 | 1.05E-14 | 1.03E-13 | 0.00E+00 | 1.90E-13 | 8.34E-08 | 1.09E-16 |
| Ru-103 | 2.63E-07 | 0.00E+00 | 1.12E-07 | 0.00E+00 | 9.29E-07 | 9.79E-05 | 1.36E-05 |
| Ru-105 | 1.40E-10 | 0.00E+00 | 5.42E-11 | 0.00E+00 | 1.76E-10 | 2.27E-06 | 1.13E-05 |
| Ru-106 | 1.23E-05 | 0.00E+00 | 1.55E-06 | 0.00E+00 | 2.38E-05 | 2.01E-03 | 1.20E-04 |
| Ag-110m | 1.73E-06 | 1.64E-06 | 9.99E-07 | 0.00E+00 | 3.13E-06 | 8.44E-04 | 3.41E-05 |
| Sb-122 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Sb-124 | 5.38E-06 | 9.92E-08 | 2.10E-06 | 1.22E-08 | 0.00E+00 | 4.81E-04 | 4.98E-05 |
| Sb-125 | 9.23E-06 | 1.01E-07 | 2.15E-06 | 8.80E-09 | 0.00E+00 | 3.42E-04 | 1.24E-05 |

Table 3-1b

TEEN INHALATION DOSE FACTORS

(mrem per pCi inhaled)

| Isotope | BONE | LIVER | TOT BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| Te-125m | 6.10E-07 | 2.80E-07 | 8.34E-08 | 1.75E-07 | 0.00E+00 | 6.70E-05 | 9.38E-06 |
| Te-127m | 2.25E-06 | 1.02E-06 | 2.73E-07 | 5.48E-07 | 8.17E-06 | 2.07E-04 | 1.99E-05 |
| Te-127 | 2.51E-10 | 1.14E-10 | 5.52E-11 | 1.77E-10 | 9.10E-10 | 1.40E-06 | 1.01E-05 |
| Te-129m | 1.74E-06 | 8.23E-07 | 2.81E-07 | 5.72E-07 | 6.49E-06 | 2.47E-04 | 5.06E-05 |
| Te-129 | 8.87E-12 | 4.22E-12 | 2.20E-12 | 6.48E-12 | 3.32E-11 | 4.12E-07 | 2.02E-07 |
| Te-131m | 1.23E-08 | 7.51E-09 | 5.03E-09 | 9.06E-09 | 5.49E-08 | 2.97E-05 | 7.76E-05 |
| Te-131 | 1.97E-12 | 1.04E-12 | 6.30E-13 | 1.55E-12 | 7.72E-12 | 2.92E-07 | 1.89E-09 |
| Te-132 | 4.50E-08 | 3.63E-08 | 2.74E-08 | 3.07E-08 | 2.44E-07 | 5.61E-05 | 5.79E-05 |
| I-130 | 7.80E-07 | 2.24E-06 | 8.96E-07 | 1.86E-04 | 3.44E-06 | 0.00E+00 | 1.14E-06 |
| I-131 | 4.43E-06 | 6.14E-06 | 3.30E-06 | 1.83E-03 | 1.05E-05 | 0.00E+00 | 8.11E-07 |
| I-132 | 1.99E-07 | 5.47E-07 | 1.97E-07 | 1.89E-05 | 8.65E-07 | 0.00E+00 | 1.59E-07 |
| I-133 | 1.52E-06 | 2.56E-06 | 7.78E-07 | 3.65E-04 | 4.49E-06 | 0.00E+00 | 1.29E-06 |
| I-134 | 1.11E-07 | 2.90E-07 | 1.05E-07 | 4.94E-06 | 4.58E-07 | 0.00E+00 | 2.55E-09 |
| I-135 | 4.62E-07 | 1.18E-06 | 4.36E-07 | 7.76E-05 | 1.86E-06 | 0.00E+00 | 8.69E-07 |
| Cs-134 | 6.28E-05 | 1.41E-04 | 6.86E-05 | 0.00E+00 | 4.69E-05 | 1.83E-05 | 1.22E-06 |
| Cs-136 | 6.44E-06 | 2.42E-05 | 1.71E-05 | 0.00E+00 | 1.38E-05 | 2.22E-06 | 1.36E-06 |
| Cs-137 | 8.38E-05 | 1.06E-04 | 3.89E-05 | 0.00E+00 | 3.80E-05 | 1.51E-05 | 1.06E-06 |
| Cs-138 | 5.82E-08 | 1.07E-07 | 5.58E-08 | 0.00E+00 | 8.28E-08 | 9.84E-09 | 3.38E-11 |
| Ba-139 | 1.67E-10 | 1.18E-13 | 4.87E-12 | 0.00E+00 | 1.11E-13 | 8.08E-07 | 8.06E-07 |
| Ba-140 | 6.84E-06 | 8.38E-09 | 4.40E-07 | 0.00E+00 | 2.85E-09 | 2.54E-04 | 2.86E-05 |
| Ba-141 | 1.78E-11 | 1.32E-14 | 5.93E-13 | 0.00E+00 | 1.23E-14 | 4.11E-07 | 9.33E-14 |
| Ba-142 | 4.62E-12 | 4.63E-15 | 2.84E-13 | 0.00E+00 | 3.92E-15 | 2.39E-07 | 5.99E-20 |
| La-140 | 5.99E-08 | 2.95E-08 | 7.82E-09 | 0.00E+00 | 0.00E+00 | 2.68E-05 | 6.09E-05 |
| La-142 | 1.20E-10 | 5.31E-11 | 1.32E-11 | 0.00E+00 | 0.00E+00 | 1.27E-06 | 1.50E-06 |
| Ce-141 | 3.55E-06 | 2.37E-06 | 2.71E-07 | 0.00E+00 | 1.11E-06 | 7.67E-05 | 1.58E-05 |
| Ce-143 | 3.32E-08 | 2.42E-08 | 2.70E-09 | 0.00E+00 | 1.08E-08 | 1.63E-05 | 3.19E-05 |
| Ce-144 | 6.11E-04 | 2.53E-04 | 3.28E-05 | 0.00E+00 | 1.51E-04 | 1.67E-03 | 1.08E-04 |
| Pr-143 | 1.67E-06 | 6.64E-07 | 8.28E-08 | 0.00E+00 | 3.86E-07 | 6.04E-05 | 2.67E-05 |
| Pr-144 | 5.37E-12 | 2.20E-12 | 2.72E-13 | 0.00E+00 | 1.26E-12 | 2.19E-07 | 2.94E-14 |
| Nd-147 | 9.83E-07 | 1.07E-06 | 6.41E-08 | 0.00E+00 | 6.28E-07 | 4.65E-05 | 2.28E-05 |
| W-187 | 1.50E-09 | 1.22E-09 | 4.29E-10 | 0.00E+00 | 0.00E+00 | 5.92E-06 | 2.21E-05 |
| Np-239 | 4.23E-08 | 3.99E-09 | 2.21E-09 | 0.00E+00 | 1.25E-08 | 8.11E-06 | 1.65E-05 |
| K-40 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Co-57 | 0.00E+00 | 1.18E-07 | 1.15E-07 | 0.00E+00 | 0.00E+00 | 7.33E-05 | 3.93E-06 |
| Sr-85 | 5.00E-06 | 0.00E+00 | 1.30E-06 | 0.00E+00 | 0.00E+00 | 8.80E-05 | 6.90E-06 |
| Y-88 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nb-94 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nb-97 | 3.93E-11 | 9.72E-12 | 3.55E-12 | 0.00E+00 | 1.14E-11 | 4.91E-07 | 2.71E-07 |
| Cd-109 | 0.00E+00 | 1.00E-04 | 3.40E-06 | 0.00E+00 | 6.70E-05 | 1.60E-04 | 8.60E-06 |
| Sn-113 | 1.50E-05 | 4.70E-07 | 9.70E-07 | 2.90E-07 | 0.00E+00 | 2.00E-04 | 1.50E-06 |
| Ba-133 | 4.70E-05 | 8.00E-07 | 3.30E-06 | 0.00E+00 | 2.80E-09 | 2.90E-04 | 9.70E-06 |
| Te-134 | 5.31E-12 | 4.35E-12 | 3.64E-12 | 4.46E-12 | 2.91E-11 | 6.75E-07 | 1.37E-09 |
| Ce-139 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Hg-203 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

Table 3-1c

CHILD INHALATION DOSE FACTORS

(mrem per pCi inhaled)

| Isotope | BONE | LIVER | TOT BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| H-3 | 0.00E+00 | 3.04E-07 | 3.04E-07 | 3.04E-07 | 3.04E-07 | 3.04E-07 | 3.04E-07 |
| Be-7 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Na-24 | 4.35E-06 | 4.35E-06 | 4.35E-06 | 4.35E-06 | 4.35E-06 | 4.35E-06 | 4.35E-06 |
| P-32 | 7.04E-04 | 3.09E-05 | 2.67E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.14E-05 |
| Cr-51 | 0.00E+00 | 0.00E+00 | 4.17E-08 | 2.31E-08 | 6.57E-09 | 4.59E-06 | 2.93E-07 |
| Mn-54 | 0.00E+00 | 1.16E-05 | 2.57E-06 | 0.00E+00 | 2.71E-06 | 4.26E-04 | 6.19E-06 |
| Mn-56 | 0.00E+00 | 4.48E-10 | 8.43E-11 | 0.00E+00 | 4.52E-10 | 3.55E-06 | 3.33E-05 |
| Fe-55 | 1.28E-05 | 6.80E-06 | 2.10E-06 | 0.00E+00 | 0.00E+00 | 3.00E-05 | 7.75E-07 |
| Fe-59 | 5.59E-06 | 9.04E-06 | 4.51E-06 | 0.00E+00 | 0.00E+00 | 3.43E-04 | 1.91E-05 |
| Co-58 | 0.00E+00 | 4.79E-07 | 8.55E-07 | 0.00E+00 | 0.00E+00 | 2.99E-04 | 9.29E-06 |
| Co-60 | 0.00E+00 | 3.55E-06 | 6.12E-06 | 0.00E+00 | 0.00E+00 | 1.91E-03 | 2.60E-05 |
| Ni-63 | 2.22E-04 | 1.25E-05 | 7.56E-06 | 0.00E+00 | 0.00E+00 | 7.43E-05 | 1.71E-06 |
| Ni-65 | 8.08E-10 | 7.99E-11 | 4.44E-11 | 0.00E+00 | 0.00E+00 | 2.21E-06 | 2.27E-05 |
| Cu-64 | 0.00E+00 | 5.39E-10 | 2.90E-10 | 0.00E+00 | 1.63E-09 | 2.59E-06 | 9.92E-06 |
| Zn-65 | 1.15E-05 | 3.06E-05 | 1.90E-05 | 0.00E+00 | 1.93E-05 | 2.69E-04 | 4.41E-06 |
| Zn-69 | 1.81E-11 | 2.61E-11 | 2.41E-12 | 0.00E+00 | 1.58E-11 | 3.84E-07 | 2.75E-06 |
| Br-83 | 0.00E+00 | 0.00E+00 | 1.28E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Br-84 | 0.00E+00 | 0.00E+00 | 1.48E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Br-85 | 0.00E+00 | 0.00E+00 | 6.84E-09 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Rb-86 | 0.00E+00 | 5.36E-05 | 3.09E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.16E-06 |
| Rb-88 | 0.00E+00 | 1.52E-07 | 9.90E-08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.66E-09 |
| Rb-89 | 0.00E+00 | 9.33E-08 | 7.83E-08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.11E-10 |
| Sr-89 | 1.62E-04 | 0.00E+00 | 4.66E-06 | 0.00E+00 | 0.00E+00 | 5.83E-04 | 4.52E-05 |
| Sr-90 | 2.73E-02 | 0.00E+00 | 1.74E-03 | 0.00E+00 | 0.00E+00 | 3.99E-03 | 9.28E-05 |
| Sr-91 | 3.28E-08 | 0.00E+00 | 1.24E-09 | 0.00E+00 | 0.00E+00 | 1.44E-05 | 4.70E-05 |
| Sr-92 | 3.54E-09 | 0.00E+00 | 1.42E-10 | 0.00E+00 | 0.00E+00 | 6.49E-06 | 6.55E-05 |
| Y-90 | 1.11E-06 | 0.00E+00 | 2.99E-08 | 0.00E+00 | 0.00E+00 | 7.07E-05 | 7.24E-05 |
| Y-91m | 1.37E-10 | 0.00E+00 | 4.98E-12 | 0.00E+00 | 0.00E+00 | 7.60E-07 | 4.64E-07 |
| Y-91 | 2.47E-04 | 0.00E+00 | 6.59E-06 | 0.00E+00 | 0.00E+00 | 7.10E-04 | 4.97E-05 |
| Y-92 | 5.50E-09 | 0.00E+00 | 1.57E-10 | 0.00E+00 | 0.00E+00 | 6.46E-06 | 6.46E-05 |
| Y-93 | 5.04E-08 | 0.00E+00 | 1.38E-09 | 0.00E+00 | 0.00E+00 | 2.01E-05 | 1.05E-04 |
| Zr-95 | 5.13E-05 | 1.13E-05 | 1.00E-05 | 0.00E+00 | 1.61E-05 | 6.03E-04 | 1.65E-05 |
| Zr-97 | 5.07E-08 | 7.34E-09 | 4.32E-09 | 0.00E+00 | 1.05E-08 | 3.06E-05 | 9.49E-05 |
| Nb-95 | 6.35E-06 | 2.48E-06 | 1.77E-06 | 0.00E+00 | 2.33E-06 | 1.66E-04 | 1.00E-05 |
| Mo-99 | 0.00E+00 | 4.66E-08 | 1.15E-08 | 0.00E+00 | 1.06E-07 | 3.66E-05 | 3.42E-05 |
| Tc-99m | 4.81E-13 | 9.41E-13 | 1.56E-11 | 0.00E+00 | 1.37E-11 | 2.57E-07 | 1.30E-06 |
| Tc-101 | 2.19E-14 | 2.30E-14 | 2.91E-13 | 0.00E+00 | 3.92E-13 | 1.58E-07 | 4.41E-09 |
| Ru-103 | 7.55E-07 | 0.00E+00 | 2.90E-07 | 0.00E+00 | 1.90E-06 | 1.79E-04 | 1.21E-05 |
| Ru-105 | 4.13E-10 | 0.00E+00 | 1.50E-10 | 0.00E+00 | 3.63E-10 | 4.30E-06 | 2.69E-05 |
| Ru-106 | 3.68E-05 | 0.00E+00 | 4.57E-06 | 0.00E+00 | 4.97E-05 | 3.87E-03 | 1.16E-04 |
| Ag-110m | 4.56E-06 | 3.08E-06 | 2.47E-06 | 0.00E+00 | 5.74E-06 | 1.48E-03 | 2.71E-05 |
| Sb-122 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Sb-124 | 1.55E-05 | 2.00E-07 | 5.41E-06 | 3.41E-08 | 0.00E+00 | 8.76E-04 | 4.43E-05 |
| Sb-125 | 2.66E-05 | 2.05E-07 | 5.59E-06 | 2.46E-08 | 0.00E+00 | 6.27E-04 | 1.09E-05 |

Table 3-1c

CHILD INHALATION DOSE FACTORS

(mrem per pCi inhaled)

| Isotope | BONE | LIVER | TOT BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| Te-125m | 1.82E-06 | 6.29E-07 | 2.47E-07 | 5.20E-07 | 0.00E+00 | 1.29E-04 | 9.13E-06 |
| Te-127m | 6.72E-06 | 2.31E-06 | 8.16E-07 | 1.64E-06 | 1.72E-05 | 4.00E-04 | 1.93E-05 |
| Te-127 | 7.49E-10 | 2.57E-10 | 1.65E-10 | 5.30E-10 | 1.91E-09 | 2.71E-06 | 1.52E-05 |
| Te-129m | 5.19E-06 | 1.85E-06 | 8.22E-07 | 1.71E-06 | 1.36E-05 | 4.76E-04 | 4.91E-05 |
| Te-129 | 2.64E-11 | 9.45E-12 | 6.44E-12 | 1.93E-11 | 6.94E-11 | 7.93E-07 | 6.89E-06 |
| Te-131m | 3.63E-08 | 1.60E-08 | 1.37E-08 | 2.64E-08 | 1.08E-07 | 5.56E-05 | 8.32E-05 |
| Te-131 | 5.87E-12 | 2.28E-12 | 1.78E-12 | 4.59E-12 | 1.59E-11 | 5.55E-07 | 3.60E-07 |
| Te-132 | 1.30E-07 | 7.36E-08 | 7.12E-08 | 8.58E-08 | 4.79E-07 | 1.02E-04 | 3.72E-05 |
| I-130 | 2.21E-06 | 4.43E-06 | 2.28E-06 | 4.99E-04 | 6.61E-06 | 0.00E+00 | 1.38E-06 |
| I-131 | 1.30E-05 | 1.30E-05 | 7.37E-06 | 4.39E-03 | 2.13E-05 | 0.00E+00 | 7.68E-07 |
| I-132 | 5.72E-07 | 1.10E-06 | 5.07E-07 | 5.23E-05 | 1.69E-06 | 0.00E+00 | 8.65E-07 |
| I-133 | 4.48E-06 | 5.49E-06 | 2.08E-06 | 1.04E-03 | 9.13E-06 | 0.00E+00 | 1.48E-06 |
| I-134 | 3.17E-07 | 5.84E-07 | 2.69E-07 | 1.37E-05 | 8.92E-07 | 0.00E+00 | 2.58E-07 |
| I-135 | 1.33E-06 | 2.36E-06 | 1.12E-06 | 2.14E-04 | 3.62E-06 | 0.00E+00 | 1.20E-06 |
| Cs-134 | 1.76E-04 | 2.74E-04 | 6.07E-05 | 0.00E+00 | 8.93E-05 | 3.27E-05 | 1.04E-06 |
| Cs-136 | 1.76E-05 | 4.62E-05 | 3.14E-05 | 0.00E+00 | 2.58E-05 | 3.93E-06 | 1.13E-06 |
| Cs-137 | 2.45E-04 | 2.23E-04 | 3.47E-05 | 0.00E+00 | 7.63E-05 | 2.81E-05 | 9.78E-07 |
| Cs-138 | 1.71E-07 | 2.27E-07 | 1.50E-07 | 0.00E+00 | 1.68E-07 | 1.84E-08 | 7.29E-08 |
| Ba-139 | 4.98E-10 | 2.66E-13 | 1.45E-11 | 0.00E+00 | 2.33E-13 | 1.56E-06 | 1.56E-05 |
| Ba-140 | 2.00E-05 | 1.75E-08 | 1.17E-06 | 0.00E+00 | 5.71E-09 | 4.71E-04 | 2.75E-05 |
| Ba-141 | 5.29E-11 | 2.95E-14 | 1.72E-12 | 0.00E+00 | 2.56E-14 | 7.89E-07 | 7.44E-08 |
| Ba-142 | 1.35E-11 | 9.73E-15 | 7.54E-13 | 0.00E+00 | 7.87E-15 | 4.44E-07 | 7.41E-10 |
| La-140 | 1.74E-07 | 6.08E-08 | 2.04E-08 | 0.00E+00 | 0.00E+00 | 4.94E-05 | 6.10E-05 |
| La-142 | 3.50E-10 | 1.11E-10 | 3.49E-11 | 0.00E+00 | 0.00E+00 | 2.35E-06 | 2.05E-05 |
| Ce-141 | 1.06E-05 | 5.28E-06 | 7.83E-07 | 0.00E+00 | 2.31E-06 | 1.47E-04 | 1.53E-05 |
| Ce-143 | 9.89E-08 | 5.37E-08 | 7.77E-09 | 0.00E+00 | 2.26E-08 | 3.12E-05 | 3.44E-05 |
| Ce-144 | 1.83E-03 | 5.72E-04 | 9.77E-05 | 0.00E+00 | 3.17E-04 | 3.23E-03 | 1.05E-04 |
| Pr-143 | 4.99E-06 | 1.50E-06 | 2.47E-07 | 0.00E+00 | 8.11E-07 | 1.17E-04 | 2.63E-05 |
| Pr-144 | 1.61E-11 | 4.99E-12 | 8.10E-13 | 0.00E+00 | 2.64E-12 | 4.23E-07 | 5.32E-08 |
| Nd-147 | 2.92E-06 | 2.36E-06 | 1.84E-07 | 0.00E+00 | 1.30E-06 | 8.87E-05 | 2.22E-05 |
| W-187 | 4.41E-09 | 2.61E-09 | 1.17E-09 | 0.00E+00 | 0.00E+00 | 1.11E-05 | 2.46E-05 |
| Np-239 | 1.26E-07 | 9.04E-09 | 6.35E-09 | 0.00E+00 | 2.63E-08 | 1.57E-05 | 1.73E-05 |
| K-40 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Co-57 | 0.00E+00 | 2.44E-07 | 2.88E-07 | 0.00E+00 | 0.00E+00 | 1.37E-04 | 3.58E-06 |
| Sr-85 | 1.20E-05 | 0.00E+00 | 3.20E-06 | 0.00E+00 | 0.00E+00 | 1.50E-04 | 5.50E-06 |
| Y-88 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nb-94 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nb-97 | 1.16E-10 | 2.08E-11 | 9.73E-12 | 0.00E+00 | 2.31E-11 | 9.24E-07 | 7.51E-06 |
| Cd-109 | 0.00E+00 | 1.90E-04 | 8.00E-06 | 0.00E+00 | 1.70E-04 | 3.00E-04 | 8.10E-06 |
| Sn-113 | 3.80E-05 | 8.90E-07 | 2.30E-06 | 7.10E-07 | 0.00E+00 | 3.60E-04 | 1.30E-06 |
| Ba-133 | 1.10E-04 | 1.10E-06 | 1.00E-05 | 0.00E+00 | 5.40E-09 | 5.20E-04 | 8.30E-06 |
| Te-134 | 1.53E-11 | 8.81E-12 | 9.40E-12 | 1.24E-11 | 5.71E-11 | 1.23E-06 | 4.87E-07 |
| Ce-139 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Hg-203 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

Table 3-1d

INFANT INHALATION DOSE FACTORS

(mrem per pCi inhaled)

| Isotope | BONE | LIVER | TOT BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| H-3 | 0.00E+00 | 4.62E-07 | 4.62E-07 | 4.62E-07 | 4.62E-07 | 4.62E-07 | 4.62E-07 |
| Be-7 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Na-24 | 7.54E-06 | 7.54E-06 | 7.54E-06 | 7.54E-06 | 7.54E-06 | 7.54E-06 | 7.54E-06 |
| P-32 | 1.45E-03 | 8.03E-05 | 5.53E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.15E-05 |
| Cr-51 | 0.00E+00 | 0.00E+00 | 6.39E-08 | 4.11E-08 | 9.45E-09 | 9.17E-06 | 2.55E-07 |
| Mn-54 | 0.00E+00 | 1.81E-05 | 3.56E-06 | 0.00E+00 | 3.56E-06 | 7.14E-04 | 5.04E-06 |
| Mn-56 | 0.00E+00 | 1.10E-09 | 1.58E-10 | 0.00E+00 | 7.86E-10 | 8.95E-06 | 5.12E-05 |
| Fe-55 | 1.41E-05 | 8.39E-06 | 2.38E-06 | 0.00E+00 | 0.00E+00 | 6.21E-05 | 7.82E-07 |
| Fe-59 | 9.69E-06 | 1.68E-05 | 6.77E-06 | 0.00E+00 | 0.00E+00 | 7.25E-04 | 1.77E-05 |
| Co-58 | 0.00E+00 | 8.71E-07 | 1.30E-06 | 0.00E+00 | 0.00E+00 | 5.55E-04 | 7.95E-06 |
| Co-60 | 0.00E+00 | 5.73E-06 | 8.41E-06 | 0.00E+00 | 0.00E+00 | 3.22E-03 | 2.28E-05 |
| Ni-63 | 2.42E-04 | 1.46E-05 | 8.29E-06 | 0.00E+00 | 0.00E+00 | 1.49E-04 | 1.73E-06 |
| Ni-65 | 1.71E-09 | 2.03E-10 | 8.79E-11 | 0.00E+00 | 0.00E+00 | 5.80E-06 | 3.58E-05 |
| Cu-64 | 0.00E+00 | 1.34E-09 | 5.53E-10 | 0.00E+00 | 2.84E-09 | 6.64E-06 | 1.07E-05 |
| Zn-65 | 1.38E-05 | 4.47E-05 | 2.22E-05 | 0.00E+00 | 2.32E-05 | 4.62E-04 | 3.67E-05 |
| Zn-69 | 3.85E-11 | 6.91E-11 | 5.13E-12 | 0.00E+00 | 2.87E-11 | 1.05E-06 | 9.44E-06 |
| Br-83 | 0.00E+00 | 0.00E+00 | 2.72E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Br-84 | 0.00E+00 | 0.00E+00 | 2.86E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Br-85 | 0.00E+00 | 0.00E+00 | 1.46E-08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Rb-86 | 0.00E+00 | 1.36E-04 | 6.30E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.17E-06 |
| Rb-88 | 0.00E+00 | 3.98E-07 | 2.05E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.42E-07 |
| Rb-89 | 0.00E+00 | 2.29E-07 | 1.47E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.87E-08 |
| Sr-89 | 2.84E-04 | 0.00E+00 | 8.15E-06 | 0.00E+00 | 0.00E+00 | 1.45E-03 | 4.57E-05 |
| Sr-90 | 2.92E-02 | 0.00E+00 | 1.85E-03 | 0.00E+00 | 0.00E+00 | 8.03E-03 | 9.36E-05 |
| Sr-91 | 6.83E-08 | 0.00E+00 | 2.47E-09 | 0.00E+00 | 0.00E+00 | 3.76E-05 | 5.24E-05 |
| Sr-92 | 7.50E-09 | 0.00E+00 | 2.79E-10 | 0.00E+00 | 0.00E+00 | 1.70E-05 | 1.00E-04 |
| Y-90 | 2.35E-06 | 0.00E+00 | 6.30E-08 | 0.00E+00 | 0.00E+00 | 1.92E-04 | 7.43E-05 |
| Y-91m | 2.91E-10 | 0.00E+00 | 9.90E-12 | 0.00E+00 | 0.00E+00 | 1.99E-06 | 1.68E-06 |
| Y-91 | 4.20E-04 | 0.00E+00 | 1.12E-05 | 0.00E+00 | 0.00E+00 | 1.75E-03 | 5.02E-05 |
| Y-92 | 1.17E-08 | 0.00E+00 | 3.29E-10 | 0.00E+00 | 0.00E+00 | 1.75E-05 | 9.04E-05 |
| Y-93 | 1.07E-07 | 0.00E+00 | 2.91E-09 | 0.00E+00 | 0.00E+00 | 5.46E-05 | 1.19E-04 |
| Zr-95 | 8.24E-05 | 1.99E-05 | 1.45E-05 | 0.00E+00 | 2.22E-05 | 1.25E-03 | 1.55E-05 |
| Zr-97 | 1.07E-07 | 1.83E-08 | 8.36E-09 | 0.00E+00 | 1.85E-08 | 7.88E-05 | 1.00E-04 |
| Nb-95 | 1.12E-05 | 4.59E-06 | 2.70E-06 | 0.00E+00 | 3.37E-06 | 3.42E-04 | 9.05E-06 |
| Mo-99 | 0.00E+00 | 1.18E-07 | 2.31E-08 | 0.00E+00 | 1.89E-07 | 9.63E-05 | 3.48E-05 |
| Tc-99m | 9.98E-13 | 2.06E-12 | 2.66E-11 | 0.00E+00 | 2.22E-11 | 5.79E-07 | 1.45E-06 |
| Tc-101 | 4.65E-14 | 5.88E-14 | 5.80E-13 | 0.00E+00 | 6.99E-13 | 4.17E-07 | 6.03E-07 |
| Ru-103 | 1.44E-06 | 0.00E+00 | 4.85E-07 | 0.00E+00 | 3.03E-06 | 3.94E-04 | 1.15E-05 |
| Ru-105 | 8.74E-10 | 0.00E+00 | 2.93E-10 | 0.00E+00 | 6.42E-10 | 1.12E-05 | 3.46E-05 |
| Ru-106 | 6.20E-05 | 0.00E+00 | 7.77E-06 | 0.00E+00 | 7.61E-05 | 8.26E-03 | 1.17E-04 |
| Ag-110m | 7.13E-06 | 5.16E-06 | 3.57E-06 | 0.00E+00 | 7.80E-06 | 2.62E-03 | 2.36E-05 |
| Sb-122 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Sb-124 | 2.71E-05 | 3.97E-07 | 8.56E-06 | 7.18E-08 | 0.00E+00 | 1.89E-03 | 4.22E-05 |
| Sb-125 | 3.69E-05 | 3.41E-07 | 7.78E-06 | 4.45E-08 | 0.00E+00 | 1.17E-03 | 1.05E-05 |

Table 3-1d

INFANT INHALATION DOSE FACTORS

(mrem per pCi inhaled)

| Isotope | BONE | LIVER | TOT BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| Te-125m | 3.40E-06 | 1.42E-06 | 4.70E-07 | 1.16E-06 | 0.00E+00 | 3.19E-04 | 9.22E-06 |
| Te-127m | 1.19E-05 | 4.93E-06 | 1.48E-06 | 3.48E-06 | 2.68E-05 | 9.37E-04 | 1.95E-05 |
| Te-127 | 1.59E-05 | 6.81E-10 | 3.49E-10 | 1.32E-09 | 3.47E-09 | 7.39E-06 | 1.74E-05 |
| Te-129m | 1.01E-05 | 4.35E-06 | 1.59E-06 | 3.91E-06 | 2.27E-05 | 1.20E-03 | 4.93E-05 |
| Te-129 | 5.63E-11 | 2.48E-11 | 1.34E-11 | 4.82E-11 | 1.25E-10 | 2.14E-06 | 1.88E-05 |
| Te-131m | 7.62E-08 | 3.93E-08 | 2.59E-08 | 6.38E-08 | 1.89E-07 | 1.42E-04 | 8.51E-05 |
| Te-131 | 1.24E-11 | 5.87E-12 | 3.57E-12 | 1.13E-11 | 2.85E-11 | 1.47E-06 | 5.87E-06 |
| Te-132 | 2.66E-07 | 1.69E-07 | 1.26E-07 | 1.99E-07 | 7.39E-07 | 2.43E-04 | 3.15E-05 |
| I-130 | 4.54E-06 | 9.91E-06 | 3.98E-06 | 1.14E-03 | 1.09E-05 | 0.00E+00 | 1.42E-06 |
| I-131 | 2.71E-05 | 3.17E-05 | 1.40E-05 | 1.06E-02 | 3.70E-05 | 0.00E+00 | 7.56E-07 |
| I-132 | 1.21E-06 | 2.53E-06 | 8.99E-07 | 1.21E-04 | 2.82E-06 | 0.00E+00 | 1.36E-06 |
| I-133 | 9.46E-06 | 1.37E-05 | 4.00E-06 | 2.54E-03 | 1.60E-05 | 0.00E+00 | 1.54E-06 |
| I-134 | 6.58E-07 | 1.34E-06 | 4.75E-07 | 3.18E-05 | 1.49E-06 | 0.00E+00 | 9.21E-07 |
| I-135 | 2.76E-06 | 5.43E-06 | 1.98E-06 | 4.97E-04 | 6.05E-06 | 0.00E+00 | 1.31E-06 |
| Cs-134 | 2.83E-04 | 5.02E-04 | 5.32E-05 | 0.00E+00 | 1.36E-04 | 5.69E-05 | 9.53E-07 |
| Cs-136 | 3.45E-05 | 9.61E-05 | 3.78E-05 | 0.00E+00 | 4.03E-05 | 8.40E-06 | 1.02E-06 |
| Cs-137 | 3.92E-04 | 4.37E-04 | 3.25E-05 | 0.00E+00 | 1.23E-04 | 5.09E-05 | 9.53E-07 |
| Cs-138 | 3.61E-07 | 5.58E-07 | 2.84E-07 | 0.00E+00 | 2.93E-07 | 4.67E-08 | 6.26E-07 |
| Ba-139 | 1.06E-09 | 7.03E-13 | 3.07E-11 | 0.00E+00 | 4.23E-13 | 4.25E-06 | 3.64E-05 |
| Ba-140 | 4.00E-05 | 4.00E-08 | 2.07E-06 | 0.00E+00 | 9.59E-09 | 1.14E-03 | 2.74E-05 |
| Ba-141 | 1.12E-10 | 7.70E-14 | 3.55E-12 | 0.00E+00 | 4.64E-14 | 2.12E-06 | 3.39E-06 |
| Ba-142 | 2.84E-11 | 2.36E-14 | 1.40E-12 | 0.00E+00 | 1.36E-14 | 1.11E-06 | 4.95E-07 |
| La-140 | 3.61E-07 | 1.43E-07 | 3.68E-08 | 0.00E+00 | 0.00E+00 | 1.20E-04 | 6.06E-05 |
| La-142 | 7.36E-10 | 2.69E-10 | 6.46E-11 | 0.00E+00 | 0.00E+00 | 5.87E-06 | 4.25E-05 |
| Ce-141 | 1.98E-05 | 1.19E-05 | 1.42E-06 | 0.00E+00 | 3.75E-06 | 3.69E-04 | 1.54E-05 |
| Ce-143 | 2.09E-07 | 1.38E-07 | 1.58E-08 | 0.00E+00 | 4.03E-08 | 8.30E-05 | 3.55E-05 |
| Ce-144 | 2.28E-03 | 8.65E-04 | 1.26E-04 | 0.00E+00 | 3.84E-04 | 7.03E-03 | 1.06E-04 |
| Pr-143 | 1.00E-05 | 3.74E-06 | 4.99E-07 | 0.00E+00 | 1.41E-06 | 3.09E-04 | 2.66E-05 |
| Pr-144 | 3.42E-11 | 1.32E-11 | 1.72E-12 | 0.00E+00 | 4.80E-12 | 1.15E-06 | 3.06E-06 |
| Nd-147 | 5.67E-06 | 5.81E-06 | 3.57E-07 | 0.00E+00 | 2.25E-06 | 2.30E-04 | 2.23E-05 |
| W-187 | 9.26E-09 | 6.44E-09 | 2.23E-09 | 0.00E+00 | 0.00E+00 | 2.83E-05 | 2.54E-05 |
| Np-239 | 2.65E-07 | 2.37E-08 | 1.34E-08 | 0.00E+00 | 4.73E-08 | 4.25E-05 | 1.78E-05 |
| K-40 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Co-57 | 0.00E+00 | 4.65E-07 | 4.58E-07 | 0.00E+00 | 0.00E+00 | 2.71E-04 | 3.47E-06 |
| Sr-85 | 2.70E-05 | 0.00E+00 | 5.40E-06 | 0.00E+00 | 0.00E+00 | 3.00E-04 | 4.80E-06 |
| Y-88 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nb-94 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nb-97 | 2.44E-10 | 5.21E-11 | 1.88E-11 | 0.00E+00 | 4.07E-11 | 2.37E-06 | 1.92E-05 |
| Cd-109 | 0.00E+00 | 2.60E-04 | 1.00E-05 | 0.00E+00 | 2.00E-04 | 6.20E-04 | 8.00E-06 |
| Sn-113 | 6.00E-05 | 1.60E-06 | 3.60E-06 | 1.30E-06 | 0.00E+00 | 7.80E-04 | 1.20E-06 |
| Ba-133 | 1.90E-04 | 1.70E-06 | 1.30E-05 | 0.00E+00 | 8.90E-09 | 9.10E-04 | 7.70E-06 |
| Te-134 | 3.18E-11 | 2.04E-11 | 1.68E-11 | 2.91E-11 | 9.59E-11 | 2.93E-06 | 2.53E-06 |
| Ce-139 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Hg-203 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

Table 3-2

Total Body & Skin Ground Plane Dose Factors (mrem/hr per $pCi/m^2$)
with Isotope half-life and Stable Element Tranfer Data (Fm, cow)

| Isotope | Halflife | unit | Fm | Ground Plane Dose Factors TotBody(DFg) | Skin(DFs) |
|---|---|---|---|---|---|
| H-3 | 12.350 | Y | 1.00E-02 | 0.00E+00 | 0.00E+00 |
| Be-7 | 53.300 | D | 1.00E-04 | 0.00E+00 | 0.00E+00 |
| Na-24 | 15.000 | H | 4.00E-02 | 2.50E-08 | 2.90E-08 |
| P-32 | 14.290 | D | 2.50E-02 | 0.00E+00 | 0.00E+00 |
| Cr-51 | 27.704 | D | 2.20E-03 | 2.20E-10 | 2.60E-10 |
| Mn-54 | 312.500 | D | 2.50E-04 | 5.80E-09 | 6.80E-09 |
| Mn-56 | 2.578 | H | 2.50E-04 | 1.10E-08 | 1.30E-08 |
| Fe-55 | 2.700 | Y | 1.20E-03 | 0.00E+00 | 0.00E+00 |
| Fe-59 | 44.529 | D | 1.20E-03 | 8.00E-09 | 9.40E-09 |
| Co-58 | 70.800 | D | 1.00E-03 | 7.00E-09 | 8.20E-09 |
| Co-60 | 5.271 | Y | 1.00E-03 | 1.70E-08 | 2.00E-08 |
| Ni-63 | 96.000 | Y | 6.70E-03 | 0.00E+00 | 0.00E+00 |
| Ni-65 | 2.520 | H | 6.70E-03 | 3.70E-09 | 4.30E-09 |
| Cu-64 | 12.701 | H | 1.40E-02 | 1.50E-09 | 1.70E-09 |
| Zn-65 | 243.900 | D | 3.90E-02 | 4.00E-09 | 4.60E-09 |
| Zn-69 | 0.950 | H | 3.90E-02 | 0.00E+00 | 0.00E+00 |
| Br-83 | 2.390 | H | 5.00E-02 | 6.40E-11 | 9.30E-11 |
| Br-84 | 0.530 | H | 5.00E-02 | 1.20E-08 | 1.40E-08 |
| Br-85 | 0.050 | H | 5.00E-02 | 0.00E+00 | 0.00E+00 |
| Rb-86 | 18.660 | D | 3.00E-02 | 6.30E-10 | 7.20E-10 |
| Rb-88 | 0.297 | H | 3.00E-02 | 3.50E-09 | 4.00E-09 |
| Rb-89 | 0.253 | H | 3.00E-02 | 1.50E-08 | 1.80E-08 |
| Sr-89 | 50.500 | D | 8.00E-04 | 5.60E-13 | 6.50E-13 |
| Sr-90 | 29.120 | Y | 8.00E-04 | 0.00E+00 | 0.00E+00 |
| Sr-91 | 9.500 | H | 8.00E-04 | 7.10E-09 | 8.30E-09 |
| Sr-92 | 2.710 | H | 8.00E-04 | 9.00E-09 | 1.00E-08 |
| Y-90 | 2.667 | D | 1.00E-05 | 2.20E-12 | 2.60E-12 |
| Y-91m | 0.829 | H | 1.00E-05 | 3.80E-09 | 4.40E-09 |
| Y-91 | 58.510 | D | 1.00E-05 | 2.40E-11 | 2.70E-11 |
| Y-92 | 3.540 | H | 1.00E-05 | 1.60E-09 | 1.90E-09 |
| Y-93 | 10.100 | H | 1.00E-05 | 5.70E-10 | 7.80E-10 |
| Zr-95 | 63.980 | D | 5.00E-06 | 5.00E-09 | 5.80E-09 |
| Zr-97 | 16.900 | H | 5.00E-06 | 5.50E-09 | 6.40E-09 |
| Nb-95 | 35.150 | D | 2.50E-03 | 5.10E-09 | 6.00E-09 |
| Mo-99 | 2.750 | D | 7.50E-03 | 1.90E-09 | 2.20E-09 |
| Tc-99m | 6.020 | H | 2.50E-02 | 9.60E-10 | 1.10E-09 |
| Tc-101 | 0.237 | H | 2.50E-02 | 2.70E-09 | 3.00E-09 |
| Ru-103 | 39.280 | D | 1.00E-06 | 3.60E-09 | 4.20E-09 |
| Ru-105 | 4.440 | H | 1.00E-06 | 4.50E-09 | 5.10E-09 |
| Ru-106 | 368.200 | D | 1.00E-06 | 1.50E-09 | 1.80E-09 |
| Ag-110m | 249.900 | D | 5.00E-02 | 1.80E-08 | 2.10E-08 |
| Sb-122 | 2.700 | D | 1.50E-03 | 0.00E+00 | 0.00E+00 |
| Sb-124 | 60.200 | D | 1.50E-03 | 1.30E-08 | 1.50E-08 |
| Sb-125 | 2.770 | Y | 1.50E-03 | 3.10E-09 | 3.50E-09 |

Table 3-2

Total Body & Skin Ground Plane Dose Factors (mrem/hr per $pCi/m^2$) with Isotope half-life and Stable Element Tranfer Data (Fm, cow)

| Isotope | Halflife | unit | Fm | Ground Plane Dose Factors TotBody(DFg) | Ground Plane Dose Factors Skin(DFs) |
|---|---|---|---|---|---|
| Te-125m | 58.000 | D | 1.00E-03 | 3.50E-11 | 4.80E-11 |
| Te-127m | 109.000 | D | 1.00E-03 | 1.10E-12 | 1.30E-12 |
| Te-127 | 9.350 | H | 1.00E-03 | 1.00E-11 | 1.10E-11 |
| Te-129m | 33.600 | D | 1.00E-03 | 7.70E-10 | 9.00E-10 |
| Te-129 | 1.160 | H | 1.00E-03 | 7.10E-10 | 8.40E-10 |
| Te-131m | 30.000 | H | 1.00E-03 | 8.40E-09 | 9.90E-09 |
| Te-131 | 0.417 | H | 1.00E-03 | 2.20E-09 | 2.60E-06 |
| Te-132 | 3.258 | D | 1.00E-03 | 1.70E-09 | 2.00E-09 |
| I-130 | 12.360 | H | 6.00E-03 | 1.40E-08 | 1.70E-08 |
| I-131 | 8.040 | D | 6.00E-03 | 2.80E-09 | 3.40E-09 |
| I-132 | 2.300 | H | 6.00E-03 | 1.70E-08 | 2.00E-08 |
| I-133 | 20.800 | H | 6.00E-03 | 3.70E-09 | 4.50E-09 |
| I-134 | 0.877 | H | 6.00E-03 | 1.60E-08 | 1.90E-08 |
| I-135 | 6.610 | H | 6.00E-03 | 1.20E-08 | 1.40E-08 |
| Cs-134 | 2.062 | Y | 1.20E-02 | 1.20E-08 | 1.40E-08 |
| Cs-136 | 13.100 | D | 1.20E-02 | 1.50E-08 | 1.70E-08 |
| Cs-137 | 30.000 | Y | 1.20E-02 | 4.20E-09 | 4.90E-09 |
| Cs-138 | 0.537 | H | 1.20E-02 | 2.10E-08 | 2.40E-08 |
| Ba-139 | 1.378 | H | 4.00E-04 | 2.40E-09 | 2.70E-09 |
| Ba-140 | 12.740 | D | 4.00E-04 | 2.10E-09 | 2.40E-09 |
| Ba-141 | 0.304 | H | 4.00E-04 | 4.30E-09 | 4.90E-09 |
| Ba-142 | 0.177 | H | 4.00E-04 | 7.90E-09 | 9.00E-09 |
| La-140 | 1.678 | D | 5.00E-06 | 1.50E-08 | 1.70E-08 |
| La-142 | 1.542 | H | 5.00E-06 | 1.50E-08 | 1.80E-08 |
| Ce-141 | 32.501 | D | 1.00E-04 | 5.50E-10 | 6.20E-10 |
| Ce-143 | 33.000 | H | 1.00E-04 | 2.20E-09 | 2.50E-09 |
| Ce-144 | 284.300 | D | 1.00E-04 | 3.20E-10 | 3.70E-10 |
| Pr-143 | 13.560 | D | 5.00E-06 | 0.00E+00 | 0.00E+00 |
| Pr-144 | 0.288 | H | 5.00E-06 | 2.00E-10 | 2.30E-10 |
| Nd-147 | 10.980 | D | 5.00E-06 | 1.00E-09 | 1.20E-09 |
| W-187 | 23.900 | H | 5.00E-04 | 3.10E-09 | 3.60E-09 |
| Np-239 | 2.360 | D | 5.00E-06 | 9.50E-10 | 1.10E-09 |
| K-40 | 1.28E+09 | Y | 1.00E-02 | 0.00E+00 | 0.00E+00 |
| Co-57 | 270.900 | D | 1.00E-03 | 9.10E-10 | 1.00E-09 |
| Sr-85 | 64.840 | D | 8.00E-04 | 0.00E+00 | 0.00E+00 |
| Y-88 | 106.640 | D | 1.00E-05 | 0.00E+00 | 0.00E+00 |
| Nb-94 | 2.03E+04 | Y | 2.50E-03 | 0.00E+00 | 0.00E+00 |
| Nb-97 | 1.202 | H | 2.50E-03 | 4.60E-09 | 5.40E-09 |
| Cd-109 | 1.271 | Y | 1.20E-04 | 0.00E+00 | 0.00E+00 |
| Sn-113 | 115.100 | D | 2.50E-03 | 0.00E+00 | 0.00E+00 |
| Ba-133 | 10.740 | Y | 4.00E-04 | 0.00E+00 | 0.00E+00 |
| Te-134 | 0.697 | H | 1.00E-03 | 1.00E-09 | 1.20E-09 |
| Ce-139 | 137.660 | D | 1.00E-04 | 0.00E+00 | 0.00E+00 |
| Hg-203 | 46.600 | D | 3.80E-02 | 0.00E+00 | 0.00E+00 |

Table 3-3a

ADULT INGESTION DOSE FACTORS

(mrem per pCi ingested)

| Isotope | BONE | LIVER | TOT BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| H-3 | 0.00E+00 | 1.05E-07 | 1.05E-07 | 1.05E-07 | 1.05E-07 | 1.05E-07 | 1.05E-07 |
| Be-7 | 2.77E-09 | 6.26E-09 | 3.10E-09 | 0.00E+00 | 6.58E-09 | 0.00E+00 | 1.08E-06 |
| Na-24 | 1.70E-06 | 1.70E-06 | 1.70E-06 | 1.70E-06 | 1.70E-06 | 1.70E-06 | 1.70E-06 |
| P-32 | 1.93E-04 | 1.20E-05 | 7.46E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.17E-05 |
| Cr-51 | 0.00E+00 | 0.00E+00 | 2.66E-09 | 1.59E-09 | 5.86E-10 | 3.53E-09 | 6.69E-07 |
| Mn-54 | 0.00E+00 | 4.57E-06 | 8.72E-07 | 0.00E+00 | 1.36E-06 | 0.00E+00 | 1.40E-05 |
| Mn-56 | 0.00E+00 | 1.15E-07 | 2.04E-08 | 0.00E+00 | 1.46E-07 | 0.00E+00 | 3.67E-06 |
| Fe-55 | 2.75E-06 | 1.90E-06 | 4.43E-07 | 0.00E+00 | 0.00E+00 | 1.06E-06 | 1.09E-06 |
| Fe-59 | 4.34E-06 | 1.02E-05 | 3.91E-06 | 0.00E+00 | 0.00E+00 | 2.85E-06 | 3.40E-05 |
| Co-58 | 0.00E+00 | 7.45E-07 | 1.67E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.51E-05 |
| Co-60 | 0.00E+00 | 2.14E-06 | 4.72E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.02E-05 |
| Ni-63 | 1.30E-04 | 9.01E-06 | 4.36E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.88E-06 |
| Ni-65 | 5.28E-07 | 6.86E-08 | 3.13E-08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.74E-06 |
| Cu-64 | 0.00E+00 | 8.33E-08 | 3.91E-08 | 0.00E+00 | 2.10E-07 | 0.00E+00 | 7.10E-06 |
| Zn-65 | 4.84E-06 | 1.54E-05 | 6.96E-06 | 0.00E+00 | 1.03E-05 | 0.00E+00 | 9.70E-06 |
| Zn-69 | 1.03E-08 | 1.97E-08 | 1.37E-09 | 0.00E+00 | 1.28E-08 | 0.00E+00 | 2.96E-09 |
| Br-83 | 0.00E+00 | 0.00E+00 | 4.02E-08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.79E-08 |
| Br-84 | 0.00E+00 | 0.00E+00 | 5.21E-08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.09E-13 |
| Br-85 | 0.00E+00 | 0.00E+00 | 2.14E-09 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Rb-86 | 0.00E+00 | 2.11E-05 | 9.83E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.16E-06 |
| Rb-88 | 0.00E+00 | 6.05E-08 | 3.21E-08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 8.36E-19 |
| Rb-89 | 0.00E+00 | 4.01E-08 | 2.82E-08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.33E-21 |
| Sr-89 | 3.08E-04 | 0.00E+00 | 8.84E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.94E-05 |
| Sr-90 | 7.58E-03 | 0.00E+00 | 1.86E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.19E-04 |
| Sr-91 | 5.67E-06 | 0.00E+00 | 2.29E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.70E-05 |
| Sr-92 | 2.15E-06 | 0.00E+00 | 9.30E-08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.26E-05 |
| Y-90 | 9.62E-09 | 0.00E+00 | 2.58E-10 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.02E-04 |
| Y-91m | 9.09E-11 | 0.00E+00 | 3.52E-12 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.67E-10 |
| Y-91 | 1.41E-07 | 0.00E+00 | 3.77E-09 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.76E-05 |
| Y-92 | 8.45E-10 | 0.00E+00 | 2.47E-11 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.48E-05 |
| Y-93 | 2.68E-09 | 0.00E+00 | 7.40E-11 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 8.50E-05 |
| Zr-95 | 3.04E-08 | 9.75E-09 | 6.60E-09 | 0.00E+00 | 1.53E-08 | 0.00E+00 | 3.09E-05 |
| Zr-97 | 1.68E-09 | 3.39E-10 | 1.55E-10 | 0.00E+00 | 5.12E-10 | 0.00E+00 | 1.05E-04 |
| Nb-95 | 6.22E-09 | 3.46E-09 | 1.86E-09 | 0.00E+00 | 3.42E-09 | 0.00E+00 | 2.10E-05 |
| Mo-99 | 0.00E+00 | 4.31E-06 | 8.20E-07 | 0.00E+00 | 9.76E-06 | 0.00E+00 | 9.99E-06 |
| Tc-99m | 2.47E-10 | 6.98E-10 | 8.89E-09 | 0.00E+00 | 1.06E-08 | 3.42E-10 | 4.13E-07 |
| Tc-101 | 2.54E-10 | 3.66E-10 | 3.59E-09 | 0.00E+00 | 6.59E-09 | 1.87E-10 | 1.10E-21 |
| Ru-103 | 1.85E-07 | 0.00E+00 | 7.97E-08 | 0.00E+00 | 7.06E-07 | 0.00E+00 | 2.16E-05 |
| Ru-105 | 1.54E-08 | 0.00E+00 | 6.08E-09 | 0.00E+00 | 1.99E-07 | 0.00E+00 | 9.42E-06 |
| Ru-106 | 2.75E-06 | 0.00E+00 | 3.48E-07 | 0.00E+00 | 5.31E-06 | 0.00E+00 | 1.78E-04 |
| Ag-110m | 1.60E-07 | 1.48E-07 | 8.79E-08 | 0.00E+00 | 2.91E-07 | 0.00E+00 | 6.04E-05 |
| Sb-122 | 2.00E-07 | 4.60E-09 | 6.90E-08 | 3.10E-09 | 0.00E+00 | 1.20E-07 | 7.60E-05 |
| Sb-124 | 2.80E-06 | 5.30E-08 | 1.10E-06 | 6.80E-09 | 0.00E+00 | 2.18E-06 | 7.95E-05 |
| Sb-125 | 1.79E-06 | 2.00E-08 | 4.26E-07 | 1.82E-09 | 0.00E+00 | 1.38E-06 | 1.97E-05 |

Table 3-3a

ADULT INGESTION DOSE FACTORS

(mrem per pCi ingested)

| Isotope | BONE | LIVER | TOT BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| Te-125m | 2.68E-06 | 9.71E-07 | 3.59E-07 | 8.06E-07 | 1.09E-05 | 0.00E+00 | 1.07E-05 |
| Te-127m | 6.77E-06 | 2.42E-06 | 8.25E-07 | 1.73E-06 | 2.75E-05 | 0.00E+00 | 2.27E-05 |
| Te-127 | 1.10E-07 | 3.95E-08 | 2.38E-08 | 8.15E-08 | 4.48E-07 | 0.00E+00 | 8.68E-06 |
| Te-129m | 1.15E-05 | 4.29E-06 | 1.82E-06 | 3.95E-06 | 4.80E-05 | 0.00E+00 | 5.79E-05 |
| Te-129 | 3.14E-08 | 1.18E-08 | 7.65E-09 | 2.41E-08 | 1.32E-07 | 0.00E+00 | 2.37E-08 |
| Te-131m | 1.73E-06 | 8.46E-07 | 7.05E-07 | 1.34E-06 | 8.57E-06 | 0.00E+00 | 8.40E-05 |
| Te-131 | 1.97E-08 | 8.23E-09 | 6.22E-09 | 1.62E-08 | 8.63E-08 | 0.00E+00 | 2.79E-09 |
| Te-132 | 2.52E-06 | 1.63E-06 | 1.53E-06 | 1.80E-06 | 1.57E-05 | 0.00E+00 | 7.71E-05 |
| I-130 | 7.56E-07 | 2.23E-06 | 8.80E-07 | 1.89E-04 | 3.48E-06 | 0.00E+00 | 1.92E-06 |
| I-131 | 4.16E-06 | 5.95E-06 | 3.41E-06 | 1.95E-03 | 1.02E-05 | 0.00E+00 | 1.57E-06 |
| I-132 | 2.03E-07 | 5.43E-07 | 1.90E-07 | 1.90E-05 | 8.65E-07 | 0.00E+00 | 1.02E-07 |
| I-133 | 1.42E-06 | 2.47E-06 | 7.53E-07 | 3.63E-04 | 4.31E-06 | 0.00E+00 | 2.22E-06 |
| I-134 | 1.06E-07 | 2.88E-07 | 1.03E-07 | 4.99E-06 | 4.58E-07 | 0.00E+00 | 2.51E-10 |
| I-135 | 4.43E-07 | 1.16E-06 | 4.28E-07 | 7.65E-05 | 1.86E-06 | 0.00E+00 | 1.31E-06 |
| Cs-134 | 6.22E-05 | 1.48E-04 | 1.21E-04 | 0.00E+00 | 4.79E-05 | 1.59E-05 | 2.59E-06 |
| Cs-136 | 6.51E-06 | 2.57E-05 | 1.85E-05 | 0.00E+00 | 1.43E-05 | 1.96E-06 | 2.92E-06 |
| Cs-137 | 7.97E-05 | 1.09E-04 | 7.14E-05 | 0.00E+00 | 3.70E-05 | 1.23E-05 | 2.11E-06 |
| Cs-138 | 5.52E-08 | 1.09E-07 | 5.40E-08 | 0.00E+00 | 8.01E-08 | 7.91E-09 | 4.65E-13 |
| Ba-139 | 9.70E-08 | 6.91E-11 | 2.84E-09 | 0.00E+00 | 6.46E-11 | 3.92E-11 | 1.72E-07 |
| Ba-140 | 2.03E-05 | 2.55E-08 | 1.33E-06 | 0.00E+00 | 8.67E-09 | 1.46E-08 | 4.18E-05 |
| Ba-141 | 4.71E-08 | 3.56E-11 | 1.59E-09 | 0.00E+00 | 3.31E-11 | 2.02E-11 | 2.22E-17 |
| Ba-142 | 2.13E-08 | 2.19E-11 | 1.34E-09 | 0.00E+00 | 1.85E-11 | 1.24E-11 | 3.00E-26 |
| La-140 | 2.50E-09 | 1.26E-09 | 3.33E-10 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 9.25E-05 |
| La-142 | 1.28E-10 | 5.82E-11 | 1.45E-11 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.25E-07 |
| Ce-141 | 9.36E-09 | 6.33E-09 | 7.18E-10 | 0.00E+00 | 2.94E-09 | 0.00E+00 | 2.42E-05 |
| Ce-143 | 1.65E-09 | 1.22E-06 | 1.35E-10 | 0.00E+00 | 5.37E-10 | 0.00E+00 | 4.56E-05 |
| Ce-144 | 4.88E-07 | 2.04E-07 | 2.62E-08 | 0.00E+00 | 1.21E-07 | 0.00E+00 | 1.65E-04 |
| Pr-143 | 9.20E-09 | 3.69E-09 | 4.56E-10 | 0.00E+00 | 2.13E-09 | 0.00E+00 | 4.03E-05 |
| Pr-144 | 3.01E-11 | 1.25E-11 | 1.53E-12 | 0.00E+00 | 7.05E-12 | 0.00E+00 | 4.33E-18 |
| Nd-147 | 6.29E-09 | 7.27E-09 | 4.35E-10 | 0.00E+00 | 4.25E-09 | 0.00E+00 | 3.49E-05 |
| W-187 | 1.03E-07 | 8.61E-08 | 3.01E-08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.82E-05 |
| Np-239 | 1.19E-09 | 1.17E-10 | 6.45E-11 | 0.00E+00 | 3.65E-10 | 0.00E+00 | 2.40E-05 |
| K-40 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Co-57 | 0.00E+00 | 1.75E-07 | 2.91E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.44E-06 |
| Sr-85 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Y-88 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nb-94 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nb-97 | 5.22E-11 | 1.32E-11 | 4.82E-12 | 0.00E+00 | 1.54E-11 | 0.00E+00 | 4.87E-08 |
| Cd-109 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Sn-113 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Ba-133 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Te-134 | 3.24E-08 | 2.12E-08 | 1.30E-08 | 2.83E-08 | 2.05E-07 | 0.00E+00 | 3.59E-11 |
| Ce-139 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Hg-203 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

Table 3-3b

TEEN INGESTION DOSE FACTORS

(mrem per pCi ingested)

| Isotope | BONE | LIVER | TOT BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| H-3 | 0.00E+00 | 1.06E-07 | 1.06E-07 | 1.06E-07 | 1.06E-07 | 1.06E-07 | 1.06E-07 |
| Be-7 | 3.96E-09 | 8.87E-09 | 4.43E-09 | 0.00E+00 | 9.40E-09 | 0.00E+00 | 1.08E-06 |
| Na-24 | 2.30E-06 | 2.30E-06 | 2.30E-06 | 2.30E-06 | 2.30E-06 | 2.30E-06 | 2.30E-06 |
| P-32 | 2.76E-04 | 1.71E-05 | 1.07E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.32E-05 |
| Cr-51 | 0.00E+00 | 0.00E+00 | 3.60E-09 | 2.00E-09 | 7.89E-10 | 5.14E-09 | 6.05E-07 |
| Mn-54 | 0.00E+00 | 5.90E-06 | 1.17E-06 | 0.00E+00 | 1.76E-06 | 0.00E+00 | 1.21E-05 |
| Mn-56 | 0.00E+00 | 1.58E-07 | 2.81E-08 | 0.00E+00 | 2.00E-07 | 0.00E+00 | 1.04E-05 |
| Fe-55 | 3.78E-06 | 2.68E-06 | 6.25E-07 | 0.00E+00 | 0.00E+00 | 1.70E-06 | 1.16E-06 |
| Fe-59 | 5.87E-06 | 1.37E-05 | 5.29E-06 | 0.00E+00 | 0.00E+00 | 4.32E-06 | 3.24E-05 |
| Co-58 | 0.00E+00 | 9.72E-07 | 2.24E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.34E-05 |
| Co-60 | 0.00E+00 | 2.81E-06 | 6.33E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.66E-05 |
| Ni-63 | 1.77E-04 | 1.25E-05 | 6.00E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.99E-06 |
| Ni-65 | 7.49E-07 | 9.57E-08 | 4.36E-08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.19E-06 |
| Cu-64 | 0.00E+00 | 1.15E-07 | 5.41E-08 | 0.00E+00 | 2.91E-07 | 0.00E+00 | 8.92E-06 |
| Zn-65 | 5.76E-06 | 2.00E-05 | 9.33E-06 | 0.00E+00 | 1.28E-05 | 0.00E+00 | 8.47E-06 |
| Zn-69 | 1.47E-08 | 2.80E-08 | 1.96E-09 | 0.00E+00 | 1.83E-08 | 0.00E+00 | 5.16E-08 |
| Br-83 | 0.00E+00 | 0.00E+00 | 5.74E-08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Br-84 | 0.00E+00 | 0.00E+00 | 7.22E-08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Br-85 | 0.00E+00 | 0.00E+00 | 3.05E-09 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Rb-86 | 0.00E+00 | 2.98E-05 | 1.40E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.41E-06 |
| Rb-88 | 0.00E+00 | 8.52E-08 | 4.54E-08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.30E-15 |
| Rb-89 | 0.00E+00 | 5.50E-08 | 3.89E-08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 8.43E-17 |
| Sr-89 | 4.40E-04 | 0.00E+00 | 1.26E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.24E-05 |
| Sr-90 | 8.30E-03 | 0.00E+00 | 2.05E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.33E-04 |
| Sr-91 | 8.07E-06 | 0.00E+00 | 3.21E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.66E-05 |
| Sr-92 | 3.05E-06 | 0.00E+00 | 1.30E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.77E-05 |
| Y-90 | 1.37E-08 | 0.00E+00 | 3.69E-10 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.13E-04 |
| Y-91m | 1.29E-10 | 0.00E+00 | 4.93E-12 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.09E-09 |
| Y-91 | 2.01E-07 | 0.00E+00 | 5.39E-09 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 8.24E-05 |
| Y-92 | 1.21E-09 | 0.00E+00 | 3.50E-11 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.32E-05 |
| Y-93 | 3.83E-09 | 0.00E+00 | 1.05E-10 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.17E-04 |
| Zr-95 | 4.12E-08 | 1.30E-08 | 8.94E-09 | 0.00E+00 | 1.91E-08 | 0.00E+00 | 3.00E-05 |
| Zr-97 | 2.37E-09 | 4.69E-10 | 2.16E-10 | 0.00E+00 | 7.11E-10 | 0.00E+00 | 1.27E-04 |
| Nb-95 | 8.22E-09 | 4.56E-09 | 2.51E-09 | 0.00E+00 | 4.42E-09 | 0.00E+00 | 1.95E-05 |
| Mo-99 | 0.00E+00 | 6.03E-06 | 1.15E-06 | 0.00E+00 | 1.38E-05 | 0.00E+00 | 1.08E-05 |
| Tc-99m | 3.32E-10 | 9.26E-10 | 1.20E-08 | 0.00E+00 | 1.38E-08 | 5.14E-10 | 6.08E-07 |
| Tc-101 | 3.60E-10 | 5.12E-10 | 5.03E-09 | 0.00E+00 | 9.26E-09 | 3.12E-10 | 8.75E-17 |
| Ru-103 | 2.55E-07 | 0.00E+00 | 1.09E-07 | 0.00E+00 | 8.99E-07 | 0.00E+00 | 2.13E-05 |
| Ru-105 | 2.18E-08 | 0.00E+00 | 8.46E-09 | 0.00E+00 | 2.75E-07 | 0.00E+00 | 1.76E-05 |
| Ru-106 | 3.92E-06 | 0.00E+00 | 4.94E-07 | 0.00E+00 | 7.56E-06 | 0.00E+00 | 1.88E-04 |
| Ag-110m | 2.05E-07 | 1.94E-07 | 1.18E-07 | 0.00E+00 | 3.70E-07 | 0.00E+00 | 5.45E-05 |
| Sb-122 | 3.30E-07 | 6.42E-09 | 9.64E-08 | 4.19E-09 | 0.00E+00 | 2.06E-07 | 6.92E-05 |
| Sb-124 | 3.86E-06 | 7.12E-08 | 1.51E-06 | 8.79E-09 | 0.00E+00 | 3.37E-06 | 7.81E-05 |
| Sb-125 | 2.48E-06 | 2.71E-08 | 5.79E-07 | 2.36E-09 | 0.00E+00 | 2.16E-06 | 1.92E-05 |

Table 3-3b

TEEN INGESTION DOSE FACTORS

(mrem per pCi ingested)

| Isotope | BONE | LIVER | TOT BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| Te-125m | 3.83E-06 | 1.38E-06 | 5.12E-07 | 1.07E-06 | 0.00E+00 | 0.00E+00 | 1.13E-05 |
| Te-127m | 9.67E-06 | 3.43E-06 | 1.15E-06 | 2.30E-06 | 3.92E-05 | 0.00E+00 | 2.41E-05 |
| Te-127 | 1.58E-07 | 5.60E-08 | 3.40E-08 | 1.09E-07 | 6.40E-07 | 0.00E+00 | 1.22E-05 |
| Te-129m | 1.63E-05 | 6.05E-06 | 2.58E-06 | 5.26E-06 | 6.82E-05 | 0.00E+00 | 6.12E-05 |
| Te-129 | 4.48E-08 | 1.67E-08 | 1.09E-08 | 3.20E-08 | 1.88E-07 | 0.00E+00 | 2.45E-07 |
| Te-131m | 2.44E-06 | 1.17E-06 | 9.76E-07 | 1.76E-06 | 1.22E-05 | 0.00E+00 | 9.39E-05 |
| Te-131 | 2.79E-08 | 1.15E-08 | 8.72E-09 | 2.15E-08 | 1.22E-07 | 0.00E+00 | 2.29E-09 |
| Te-132 | 3.49E-06 | 2.21E-06 | 2.08E-06 | 2.33E-06 | 2.12E-05 | 0.00E+00 | 7.00E-05 |
| I-130 | 1.03E-06 | 2.98E-06 | 1.19E-06 | 2.43E-04 | 4.59E-06 | 0.00E+00 | 2.29E-06 |
| I-131 | 5.85E-06 | 8.19E-06 | 4.40E-06 | 2.39E-03 | 1.41E-05 | 0.00E+00 | 1.62E-06 |
| I-132 | 2.79E-07 | 7.30E-07 | 2.62E-07 | 2.46E-05 | 1.15E-06 | 0.00E+00 | 3.18E-07 |
| I-133 | 2.01E-06 | 3.41E-06 | 1.04E-06 | 4.76E-04 | 5.98E-06 | 0.00E+00 | 2.58E-06 |
| I-134 | 1.46E-07 | 3.87E-07 | 1.39E-07 | 6.45E-06 | 6.10E-07 | 0.00E+00 | 5.10E-09 |
| I-135 | 6.10E-07 | 1.57E-06 | 5.82E-07 | 1.01E-04 | 2.48E-06 | 0.00E+00 | 1.74E-06 |
| Cs-134 | 8.37E-05 | 1.97E-04 | 9.14E-05 | 0.00E+00 | 6.26E-05 | 2.39E-05 | 2.45E-06 |
| Cs-136 | 8.59E-06 | 3.38E-05 | 2.27E-05 | 0.00E+00 | 1.84E-05 | 2.90E-06 | 2.72E-06 |
| Cs-137 | 1.12E-04 | 1.49E-04 | 5.19E-05 | 0.00E+00 | 5.07E-05 | 1.97E-05 | 2.12E-06 |
| Cs-138 | 7.76E-08 | 1.49E-07 | 7.45E-08 | 0.00E+00 | 1.10E-07 | 1.28E-08 | 6.76E-11 |
| Ba-139 | 1.39E-07 | 9.78E-11 | 4.05E-09 | 0.00E+00 | 9.22E-11 | 6.74E-11 | 1.24E-06 |
| Ba-140 | 2.84E-05 | 3.48E-08 | 1.83E-06 | 0.00E+00 | 1.18E-08 | 2.34E-08 | 4.38E-05 |
| Ba-141 | 6.71E-08 | 5.01E-11 | 2.24E-09 | 0.00E+00 | 4.65E-11 | 3.43E-11 | 1.43E-13 |
| Ba-142 | 2.99E-08 | 2.99E-11 | 1.84E-09 | 0.00E+00 | 2.53E-11 | 1.99E-11 | 9.18E-20 |
| La-140 | 3.48E-09 | 1.71E-09 | 4.55E-10 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 9.82E-05 |
| La-142 | 1.79E-10 | 7.95E-11 | 1.98E-11 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.42E-06 |
| Ce-141 | 1.33E-08 | 8.88E-09 | 1.02E-09 | 0.00E+00 | 4.18E-09 | 0.00E+00 | 2.54E-05 |
| Ce-143 | 2.35E-09 | 1.71E-06 | 1.91E-10 | 0.00E+00 | 7.67E-10 | 0.00E+00 | 5.14E-05 |
| Ce-144 | 6.96E-07 | 2.88E-07 | 3.74E-08 | 0.00E+00 | 1.72E-07 | 0.00E+00 | 1.75E-04 |
| Pr-143 | 1.31E-08 | 5.23E-09 | 6.52E-10 | 0.00E+00 | 3.04E-09 | 0.00E+00 | 4.31E-05 |
| Pr-144 | 4.30E-11 | 1.76E-11 | 2.18E-12 | 0.00E+00 | 1.01E-11 | 0.00E+00 | 4.74E-14 |
| Nd-147 | 9.38E-09 | 1.02E-08 | 6.11E-10 | 0.00E+00 | 5.99E-09 | 0.00E+00 | 3.68E-05 |
| W-187 | 1.46E-07 | 1.19E-07 | 4.17E-08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.22E-05 |
| Np-239 | 1.76E-09 | 1.66E-10 | 9.22E-11 | 0.00E+00 | 5.21E-10 | 0.00E+00 | 2.67E-05 |
| K-40 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Co-57 | 0.00E+00 | 2.38E-07 | 3.99E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.44E-06 |
| Sr-85 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Y-88 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nb-94 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nb-97 | 7.37E-11 | 1.83E-11 | 6.68E-12 | 0.00E+00 | 2.14E-11 | 0.00E+00 | 4.37E-07 |
| Cd-109 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Sn-113 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Ba-133 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Te-134 | 4.47E-08 | 2.87E-08 | 3.00E-08 | 3.67E-08 | 2.74E-07 | 0.00E+00 | 1.66E-09 |
| Ce-139 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Hg-203 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

Table 3-3c

CHILD INGESTION DOSE FACTORS

(mrem per pCi ingested)

| Isotope | BONE | LIVER | TOT BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| H-3 | 0.00E+00 | 2.03E-07 | 2.03E-07 | 2.03E-07 | 2.03E-07 | 2.03E-07 | 2.03E-07 |
| Be-7 | 1.18E-08 | 2.00E-08 | 1.32E-08 | 0.00E+00 | 1.97E-08 | 0.00E+00 | 1.12E-06 |
| Na-24 | 5.80E-06 | 5.80E-06 | 5.80E-06 | 5.80E-06 | 5.80E-06 | 5.80E-06 | 5.80E-06 |
| P-32 | 8.25E-04 | 3.86E-05 | 3.18E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.28E-05 |
| Cr-51 | 0.00E+00 | 0.00E+00 | 8.90E-09 | 4.94E-09 | 1.35E-09 | 9.02E-09 | 4.72E-07 |
| Mn-54 | 0.00E+00 | 1.07E-05 | 2.85E-06 | 0.00E+00 | 3.00E-06 | 0.00E+00 | 8.98E-06 |
| Mn-56 | 0.00E+00 | 3.34E-07 | 7.54E-08 | 0.00E+00 | 4.04E-07 | 0.00E+00 | 4.84E-05 |
| Fe-55 | 1.15E-05 | 6.10E-06 | 1.89E-06 | 0.00E+00 | 0.00E+00 | 3.45E-06 | 1.13E-06 |
| Fe-59 | 1.65E-05 | 2.67E-05 | 1.33E-05 | 0.00E+00 | 0.00E+00 | 7.74E-06 | 2.78E-05 |
| Co-58 | 0.00E+00 | 1.80E-06 | 5.51E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.05E-05 |
| Co-60 | 0.00E+00 | 5.29E-06 | 1.56E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.93E-05 |
| Ni-63 | 5.38E-04 | 2.88E-05 | 1.83E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.94E-06 |
| Ni-65 | 2.22E-06 | 2.09E-07 | 1.22E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.56E-05 |
| Cu-64 | 0.00E+00 | 2.45E-07 | 1.48E-07 | 0.00E+00 | 5.92E-07 | 0.00E+00 | 1.15E-05 |
| Zn-65 | 1.37E-05 | 3.65E-05 | 2.27E-05 | 0.00E+00 | 2.30E-05 | 0.00E+00 | 6.41E-06 |
| Zn-69 | 4.38E-08 | 6.33E-08 | 5.85E-09 | 0.00E+00 | 3.84E-08 | 0.00E+00 | 3.99E-06 |
| Br-83 | 0.00E+00 | 0.00E+00 | 1.71E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Br-84 | 0.00E+00 | 0.00E+00 | 1.98E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Br-85 | 0.00E+00 | 0.00E+00 | 9.12E-09 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Rb-86 | 0.00E+00 | 6.70E-05 | 4.12E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.31E-06 |
| Rb-88 | 0.00E+00 | 1.90E-07 | 1.32E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 9.32E-09 |
| Rb-89 | 0.00E+00 | 1.17E-07 | 1.04E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.02E-09 |
| Sr-89 | 1.32E-03 | 0.00E+00 | 3.77E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.11E-05 |
| Sr-90 | 1.70E-02 | 0.00E+00 | 4.31E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.29E-04 |
| Sr-91 | 2.40E-05 | 0.00E+00 | 9.06E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.30E-05 |
| Sr-92 | 9.03E-06 | 0.00E+00 | 3.62E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.71E-04 |
| Y-90 | 4.11E-08 | 0.00E+00 | 1.10E-09 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.17E-04 |
| Y-91m | 3.82E-10 | 0.00E+00 | 1.39E-11 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.48E-07 |
| Y-91 | 6.02E-07 | 0.00E+00 | 1.61E-08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 8.02E-05 |
| Y-92 | 3.60E-09 | 0.00E+00 | 1.03E-10 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.04E-04 |
| Y-93 | 1.14E-08 | 0.00E+00 | 3.13E-10 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.70E-04 |
| Zr-95 | 1.16E-07 | 2.55E-08 | 2.27E-08 | 0.00E+00 | 3.65E-08 | 0.00E+00 | 2.66E-05 |
| Zr-97 | 6.99E-09 | 1.01E-09 | 5.96E-10 | 0.00E+00 | 1.45E-09 | 0.00E+00 | 1.53E-04 |
| Nb-95 | 2.25E-08 | 8.76E-09 | 6.26E-09 | 0.00E+00 | 8.23E-09 | 0.00E+00 | 1.62E-05 |
| Mo-99 | 0.00E+00 | 1.33E-05 | 3.29E-06 | 0.00E+00 | 2.84E-05 | 0.00E+00 | 1.10E-05 |
| Tc-99m | 9.23E-10 | 1.81E-09 | 3.00E-08 | 0.00E+00 | 2.63E-08 | 9.19E-10 | 1.03E-06 |
| Tc-101 | 1.07E-09 | 1.12E-09 | 1.42E-08 | 0.00E+00 | 1.91E-08 | 5.92E-10 | 3.56E-09 |
| Ru-103 | 7.31E-07 | 0.00E+00 | 2.81E-07 | 0.00E+00 | 1.84E-06 | 0.00E+00 | 1.89E-05 |
| Ru-105 | 6.45E-08 | 0.00E+00 | 2.34E-08 | 0.00E+00 | 5.67E-07 | 0.00E+00 | 4.21E-05 |
| Ru-106 | 1.17E-05 | 0.00E+00 | 1.46E-06 | 0.00E+00 | 1.58E-05 | 0.00E+00 | 1.82E-04 |
| Ag-110m | 5.39E-07 | 3.64E-07 | 2.91E-07 | 0.00E+00 | 6.78E-07 | 0.00E+00 | 4.33E-05 |
| Sb-122 | 9.83E-07 | 1.45E-08 | 2.88E-07 | 1.26E-08 | 0.00E+00 | 4.00E-07 | 7.56E-05 |
| Sb-124 | 1.11E-05 | 1.44E-07 | 3.88E-06 | 2.44E-08 | 0.00E+00 | 6.15E-06 | 6.93E-05 |
| Sb-125 | 7.15E-06 | 5.51E-08 | 1.50E-06 | 6.63E-09 | 0.00E+00 | 3.98E-06 | 1.71E-05 |

Table 3-3c

CHILD INGESTION DOSE FACTORS

(mrem per pCi ingested)

| Isotope | BONE | LIVER | TOT BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| Te-125m | 1.14E-05 | 3.09E-06 | 1.52E-06 | 3.20E-06 | 0.00E+00 | 0.00E+00 | 1.10E-05 |
| Te-127m | 2.89E-05 | 7.78E-06 | 3.43E-06 | 6.91E-06 | 8.24E-05 | 0.00E+00 | 2.34E-05 |
| Te-127 | 4.71E-07 | 1.27E-07 | 1.01E-07 | 3.26E-07 | 1.34E-06 | 0.00E+00 | 1.84E-05 |
| Te-129m | 4.87E-05 | 1.36E-05 | 7.56E-06 | 1.57E-05 | 1.43E-04 | 0.00E+00 | 5.94E-05 |
| Te-129 | 1.34E-07 | 3.74E-08 | 3.18E-08 | 9.56E-08 | 3.92E-07 | 0.00E+00 | 8.34E-06 |
| Te-131m | 7.20E-06 | 2.49E-06 | 2.65E-06 | 5.12E-06 | 2.41E-05 | 0.00E+00 | 1.01E-04 |
| Te-131 | 8.30E-08 | 2.53E-08 | 2.47E-08 | 6.35E-08 | 2.51E-07 | 0.00E+00 | 4.36E-07 |
| Te-132 | 1.01E-05 | 4.47E-06 | 5.40E-06 | 6.51E-06 | 4.15E-05 | 0.00E+00 | 4.50E-05 |
| I-130 | 2.92E-06 | 5.90E-06 | 3.04E-06 | 6.50E-04 | 8.82E-06 | 0.00E+00 | 2.76E-06 |
| I-131 | 1.72E-05 | 1.73E-05 | 9.83E-06 | 5.72E-03 | 2.84E-05 | 0.00E+00 | 1.54E-06 |
| I-132 | 8.00E-07 | 1.47E-06 | 6.76E-07 | 6.82E-05 | 2.25E-06 | 0.00E+00 | 1.73E-06 |
| I-133 | 5.92E-06 | 7.32E-06 | 2.77E-06 | 1.36E-03 | 1.22E-05 | 0.00E+00 | 2.95E-06 |
| I-134 | 4.19E-07 | 7.78E-07 | 3.58E-07 | 1.79E-05 | 1.19E-06 | 0.00E+00 | 5.16E-07 |
| I-135 | 1.75E-06 | 3.15E-06 | 1.49E-06 | 2.79E-04 | 4.83E-06 | 0.00E+00 | 2.40E-06 |
| Cs-134 | 2.34E-04 | 3.84E-04 | 8.10E-05 | 0.00E+00 | 1.19E-04 | 4.27E-05 | 2.07E-06 |
| Cs-136 | 2.35E-05 | 6.46E-05 | 4.18E-05 | 0.00E+00 | 3.44E-05 | 5.13E-06 | 2.27E-06 |
| Cs-137 | 3.27E-04 | 3.13E-04 | 4.62E-05 | 0.00E+00 | 1.02E-04 | 3.67E-05 | 1.96E-06 |
| Cs-138 | 2.28E-07 | 3.17E-07 | 2.01E-07 | 0.00E+00 | 2.23E-07 | 2.40E-08 | 1.46E-07 |
| Ba-139 | 4.14E-07 | 2.21E-10 | 1.20E-08 | 0.00E+00 | 1.93E-10 | 1.30E-10 | 2.39E-05 |
| Ba-140 | 8.31E-05 | 7.28E-08 | 4.85E-06 | 0.00E+00 | 2.37E-08 | 4.34E-08 | 4.21E-05 |
| Ba-141 | 2.00E-07 | 1.12E-10 | 6.51E-09 | 0.00E+00 | 9.69E-11 | 6.58E-10 | 1.14E-07 |
| Ba-142 | 8.74E-08 | 6.29E-11 | 4.88E-09 | 0.00E+00 | 5.09E-11 | 3.70E-11 | 1.14E-09 |
| La-140 | 1.01E-08 | 3.53E-09 | 1.19E-09 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 9.84E-05 |
| La-142 | 5.24E-10 | 1.67E-10 | 5.23E-11 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.31E-05 |
| Ce-141 | 3.97E-08 | 1.98E-08 | 2.94E-09 | 0.00E+00 | 8.68E-09 | 0.00E+00 | 2.47E-05 |
| Ce-143 | 6.99E-09 | 3.79E-06 | 5.49E-10 | 0.00E+00 | 1.59E-09 | 0.00E+00 | 5.55E-05 |
| Ce-144 | 2.08E-06 | 6.52E-07 | 1.11E-07 | 0.00E+00 | 3.61E-07 | 0.00E+00 | 1.70E-04 |
| Pr-143 | 3.93E-08 | 1.18E-08 | 1.95E-09 | 0.00E+00 | 6.39E-09 | 0.00E+00 | 4.24E-05 |
| Pr-144 | 1.29E-10 | 3.99E-11 | 6.49E-12 | 0.00E+00 | 2.11E-11 | 0.00E+00 | 8.59E-08 |
| Nd-147 | 2.79E-08 | 2.26E-08 | 1.75E-09 | 0.00E+00 | 1.24E-08 | 0.00E+00 | 3.58E-05 |
| W-187 | 4.29E-07 | 2.54E-07 | 1.14E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.57E-05 |
| Np-239 | 5.25E-09 | 3.77E-10 | 2.65E-10 | 0.00E+00 | 1.09E-09 | 0.00E+00 | 2.79E-05 |
| K-40 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Co-57 | 0.00E+00 | 4.93E-07 | 9.98E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.04E-06 |
| Sr-85 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Y-88 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nb-94 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nb-97 | 2.17E-10 | 3.92E-11 | 1.83E-11 | 0.00E+00 | 4.35E-11 | 0.00E+00 | 1.21E-05 |
| Cd-109 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Sn-113 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Ba-133 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Te-134 | 1.29E-07 | 5.80E-08 | 7.74E-08 | 1.02E-07 | 5.37E-07 | 0.00E+00 | 5.89E-07 |
| Ce-139 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Hg-203 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

Table 3-3d

INFANT INGESTION DOSE FACTORS

(mrem per pCi ingested)

| Isotope | BONE | LIVER | TOT BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| H-3 | 0.00E+00 | 3.08E-07 | 3.08E-07 | 3.08E-07 | 3.08E-07 | 3.08E-07 | 3.08E-07 |
| Be-7 | 2.26E-08 | 4.72E-08 | 2.51E-08 | 0.00E+00 | 3.34E-08 | 0.00E+00 | 1.11E-06 |
| Na-24 | 1.01E-05 | 1.01E-05 | 1.01E-05 | 1.01E-05 | 1.01E-05 | 1.01E-05 | 1.01E-05 |
| P-32 | 1.70E-03 | 1.00E-04 | 6.59E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.30E-05 |
| Cr-51 | 0.00E+00 | 0.00E+00 | 1.41E-08 | 9.20E-09 | 2.01E-09 | 1.79E-08 | 4.11E-07 |
| Mn-54 | 0.00E+00 | 1.99E-05 | 4.51E-06 | 0.00E+00 | 4.41E-06 | 0.00E+00 | 7.31E-06 |
| Mn-56 | 0.00E+00 | 8.18E-07 | 1.41E-07 | 0.00E+00 | 7.03E-07 | 0.00E+00 | 7.43E-05 |
| Fe-55 | 1.39E-05 | 8.98E-06 | 2.40E-06 | 0.00E+00 | 0.00E+00 | 4.39E-06 | 1.14E-06 |
| Fe-59 | 3.08E-05 | 5.38E-05 | 2.12E-05 | 0.00E+00 | 0.00E+00 | 1.59E-05 | 2.57E-05 |
| Co-58 | 0.00E+00 | 3.60E-06 | 8.98E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 8.97E-06 |
| Co-60 | 0.00E+00 | 1.08E-05 | 2.55E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.57E-05 |
| Ni-63 | 6.34E-04 | 3.92E-05 | 2.20E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.95E-06 |
| Ni-65 | 4.70E-06 | 5.32E-07 | 2.42E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.05E-05 |
| Cu-64 | 0.00E+00 | 6.09E-07 | 2.82E-07 | 0.00E+00 | 1.03E-06 | 0.00E+00 | 1.25E-05 |
| Zn-65 | 1.84E-05 | 6.31E-05 | 2.91E-05 | 0.00E+00 | 3.06E-05 | 0.00E+00 | 5.33E-05 |
| Zn-69 | 9.33E-08 | 1.68E-07 | 1.25E-08 | 0.00E+00 | 6.98E-08 | 0.00E+00 | 1.37E-05 |
| Br-83 | 0.00E+00 | 0.00E+00 | 3.63E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Br-84 | 0.00E+00 | 0.00E+00 | 3.82E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Br-85 | 0.00E+00 | 0.00E+00 | 1.94E-08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Rb-86 | 0.00E+00 | 1.70E-04 | 8.40E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.35E-06 |
| Rb-88 | 0.00E+00 | 4.98E-07 | 2.73E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.85E-07 |
| Rb-89 | 0.00E+00 | 2.86E-07 | 1.97E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 9.74E-08 |
| Sr-89 | 2.51E-03 | 0.00E+00 | 7.20E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.16E-05 |
| Sr-90 | 1.85E-02 | 0.00E+00 | 4.71E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.31E-04 |
| Sr-91 | 5.00E-05 | 0.00E+00 | 1.81E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.92E-05 |
| Sr-92 | 1.92E-05 | 0.00E+00 | 7.13E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.07E-04 |
| Y-90 | 8.69E-08 | 0.00E+00 | 2.33E-09 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.20E-04 |
| Y-91m | 8.10E-10 | 0.00E+00 | 2.76E-11 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.70E-06 |
| Y-91 | 1.13E-06 | 0.00E+00 | 3.01E-08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 8.10E-05 |
| Y-92 | 7.65E-09 | 0.00E+00 | 2.15E-10 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.46E-04 |
| Y-93 | 2.43E-08 | 0.00E+00 | 6.62E-10 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.92E-04 |
| Zr-95 | 2.06E-07 | 5.02E-08 | 3.56E-08 | 0.00E+00 | 5.41E-08 | 0.00E+00 | 2.50E-05 |
| Zr-97 | 1.48E-08 | 2.54E-09 | 1.16E-09 | 0.00E+00 | 2.56E-09 | 0.00E+00 | 1.62E-04 |
| Nb-95 | 4.20E-08 | 1.73E-08 | 1.00E-08 | 0.00E+00 | 1.24E-08 | 0.00E+00 | 1.46E-05 |
| Mo-99 | 0.00E+00 | 3.40E-05 | 6.63E-06 | 0.00E+00 | 5.08E-05 | 0.00E+00 | 1.12E-05 |
| Tc-99m | 1.92E-09 | 3.96E-09 | 5.10E-08 | 0.00E+00 | 4.26E-08 | 2.07E-09 | 1.15E-06 |
| Tc-101 | 2.27E-09 | 2.86E-09 | 2.83E-08 | 0.00E+00 | 3.40E-08 | 1.56E-09 | 4.86E-07 |
| Ru-103 | 1.48E-06 | 0.00E+00 | 4.95E-07 | 0.00E+00 | 3.08E-06 | 0.00E+00 | 1.80E-05 |
| Ru-105 | 1.36E-07 | 0.00E+00 | 4.58E-08 | 0.00E+00 | 1.00E-06 | 0.00E+00 | 5.41E-05 |
| Ru-106 | 2.41E-05 | 0.00E+00 | 3.01E-06 | 0.00E+00 | 2.85E-05 | 0.00E+00 | 1.83E-04 |
| Ag-110m | 9.96E-07 | 7.27E-07 | 4.81E-07 | 0.00E+00 | 1.04E-06 | 0.00E+00 | 3.77E-05 |
| Sb-122 | 2.10E-06 | 3.85E-08 | 6.13E-07 | 3.14E-08 | 0.00E+00 | 1.09E-06 | 7.65E-05 |
| Sb-124 | 2.14E-05 | 3.15E-07 | 6.63E-06 | 5.68E-08 | 0.00E+00 | 1.34E-05 | 6.60E-05 |
| Sb-125 | 1.23E-05 | 1.19E-07 | 2.53E-06 | 1.54E-08 | 0.00E+00 | 7.72E-06 | 1.64E-05 |

Table 3-3d

INFANT INGESTION DOSE FACTORS

(mrem per pCi ingested)

| Isotope | BONE | LIVER | TOT BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| Te-125m | 2.33E-05 | 7.79E-06 | 3.15E-06 | 7.84E-06 | 0.00E+00 | 0.00E+00 | 1.11E-05 |
| Te-127m | 5.85E-05 | 1.94E-05 | 7.08E-06 | 1.69E-05 | 1.44E-04 | 0.00E+00 | 2.36E-05 |
| Te-127 | 1.00E-06 | 3.35E-07 | 2.15E-07 | 8.14E-07 | 2.44E-06 | 0.00E+00 | 2.10E-05 |
| Te-129m | 1.00E-04 | 3.43E-05 | 1.54E-05 | 3.84E-05 | 2.50E-04 | 0.00E+00 | 5.97E-05 |
| Te-129 | 2.84E-07 | 9.79E-08 | 6.63E-08 | 2.38E-07 | 7.07E-07 | 0.00E+00 | 2.27E-05 |
| Te-131m | 1.52E-05 | 6.12E-06 | 5.05E-06 | 1.24E-05 | 4.21E-05 | 0.00E+00 | 1.03E-04 |
| Te-131 | 1.76E-07 | 6.50E-08 | 4.94E-08 | 1.57E-07 | 4.50E-07 | 0.00E+00 | 7.11E-06 |
| Te-132 | 2.08E-05 | 1.03E-05 | 9.61E-06 | 1.52E-05 | 6.44E-05 | 0.00E+00 | 3.81E-05 |
| I-130 | 6.00E-06 | 1.32E-05 | 5.30E-06 | 1.48E-03 | 1.45E-05 | 0.00E+00 | 2.83E-06 |
| I-131 | 3.59E-05 | 4.23E-05 | 1.86E-05 | 1.39E-02 | 4.94E-05 | 0.00E+00 | 1.51E-06 |
| I-132 | 1.66E-06 | 3.37E-06 | 1.20E-06 | 1.58E-04 | 3.76E-06 | 0.00E+00 | 2.73E-06 |
| I-133 | 1.25E-05 | 1.82E-05 | 5.33E-06 | 3.31E-03 | 2.14E-05 | 0.00E+00 | 3.08E-06 |
| I-134 | 8.69E-07 | 1.78E-06 | 6.33E-07 | 4.15E-05 | 1.99E-06 | 0.00E+00 | 1.84E-06 |
| I-135 | 3.64E-06 | 7.24E-06 | 2.64E-06 | 6.49E-04 | 8.07E-06 | 0.00E+00 | 2.62E-06 |
| Cs-134 | 3.77E-04 | 7.03E-04 | 7.10E-05 | 0.00E+00 | 1.81E-04 | 7.42E-05 | 1.91E-06 |
| Cs-136 | 4.59E-05 | 1.35E-04 | 5.04E-05 | 0.00E+00 | 5.38E-05 | 1.10E-05 | 2.05E-06 |
| Cs-137 | 5.22E-04 | 6.11E-04 | 4.33E-05 | 0.00E+00 | 1.64E-04 | 6.64E-05 | 1.91E-06 |
| Cs-138 | 4.81E-07 | 7.82E-07 | 3.79E-07 | 0.00E+00 | 3.90E-07 | 6.09E-08 | 1.25E-06 |
| Ba-139 | 8.81E-07 | 5.84E-10 | 2.55E-08 | 0.00E+00 | 3.51E-10 | 3.54E-10 | 5.58E-05 |
| Ba-140 | 1.71E-04 | 1.71E-07 | 8.81E-06 | 0.00E+00 | 4.06E-08 | 1.05E-07 | 4.20E-05 |
| Ba-141 | 4.25E-07 | 2.91E-10 | 1.34E-08 | 0.00E+00 | 1.75E-10 | 1.77E-10 | 5.19E-06 |
| Ba-142 | 1.84E-07 | 1.53E-10 | 9.06E-09 | 0.00E+00 | 8.81E-11 | 9.26E-11 | 7.59E-07 |
| La-140 | 2.11E-08 | 8.32E-09 | 2.14E-09 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 9.77E-05 |
| La-142 | 1.10E-09 | 4.04E-10 | 9.67E-11 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.86E-05 |
| Ce-141 | 7.87E-08 | 4.80E-08 | 5.65E-09 | 0.00E+00 | 1.48E-08 | 0.00E+00 | 2.48E-05 |
| Ce-143 | 1.48E-08 | 9.82E-06 | 1.12E-09 | 0.00E+00 | 2.86E-09 | 0.00E+00 | 5.73E-05 |
| Ce-144 | 2.98E-06 | 1.22E-06 | 1.67E-07 | 0.00E+00 | 4.93E-07 | 0.00E+00 | 1.71E-04 |
| Pr-143 | 8.13E-08 | 3.04E-08 | 4.03E-09 | 0.00E+00 | 1.13E-08 | 0.00E+00 | 4.29E-05 |
| Pr-144 | 2.74E-10 | 1.06E-10 | 1.38E-11 | 0.00E+00 | 3.84E-11 | 0.00E+00 | 4.93E-06 |
| Nd-147 | 5.53E-08 | 5.68E-08 | 3.48E-09 | 0.00E+00 | 2.19E-08 | 0.00E+00 | 3.60E-05 |
| W-187 | 9.03E-07 | 6.28E-07 | 2.17E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.69E-05 |
| Np-239 | 1.11E-08 | 9.93E-10 | 5.61E-10 | 0.00E+00 | 1.98E-09 | 0.00E+00 | 2.87E-05 |
| K-40 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Co-57 | 0.00E+00 | 1.15E-06 | 1.87E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.92E-06 |
| Sr-85 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Y-88 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nb-94 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nb-97 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Cd-109 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Sn-113 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Ba-133 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Te-134 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Ce-139 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Hg-203 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

Table 3-4

Total Body Dose Factors

Ki

From Noble Gases (gamma)

| Nuclide | Gamma TB factor * | x | (pCi/uCi) | x | Finite Cloud Correction Factor** Unit 2 | Unit 3 | = | U2 Ki *** | U3 Ki *** |
|---|---|---|---|---|---|---|---|---|---|
| Kr-83m | 7.56E-08 | | 1E+6 | | 8.86E-01 | 5.78E-01 | | 6.70E-02 | 4.37E-02 |
| Kr-85m | 1.17E-03 | | 1E+6 | | 7.49E-01 | 4.46E-01 | | 8.76E+02 | 5.22E+02 |
| Kr-85 | 1.61E-05 | | 1E+6 | | 6.73E-01 | 3.85E-01 | | 1.08E+01 | 6.19E+00 |
| Kr-87 | 5.92E-03 | | 1E+6 | | 5.68E-01 | 3.09E-01 | | 3.36E+03 | 1.83E+03 |
| Kr-88 | 1.47E-02 | | 1E+6 | | 5.40E-01 | 2.88E-01 | | 7.93E+03 | 4.23E+03 |
| Kr-89 | 1.66E-02 | | 1E+6 | | 5.60E-01 | 3.03E-01 | | 9.30E+03 | 5.03E+03 |
| Kr-90 | 1.56E-02 | | 1E+6 | | 5.97E-01 | 3.29E-01 | | 9.31E+03 | 5.13E+03 |
| Xe-131m | 9.15E-05 | | 1E+6 | | 8.67E-01 | 5.62E-01 | | 7.94E+01 | 5.14E+01 |
| Xe-133m | 2.51E-04 | | 1E+6 | | 8.17E-01 | 5.12E-01 | | 2.05E+02 | 1.29E+02 |
| Xe-133 | 2.94E-04 | | 1E+6 | | 8.86E-01 | 5.78E-01 | | 2.60E+02 | 1.70E+02 |
| Xe-135m | 3.12E-03 | | 1E+6 | | 6.75E-01 | 3.87E-01 | | 2.11E+03 | 1.21E+03 |
| Xe-135 | 1.81E-03 | | 1E+6 | | 7.60E-01 | 4.55E-01 | | 1.38E+03 | 8.24E+02 |
| Xe-137 | 1.42E-03 | | 1E+6 | | 6.46E-01 | 3.65E-01 | | 9.18E+02 | 5.18E+02 |
| Xe-138 | 8.83E-03 | | 1E+6 | | 5.75E-01 | 3.14E-01 | | 5.07E+03 | 2.77E+03 |
| Ar-41 | 8.84E-03 | | 1E+6 | | 5.89E-01 | 3.21E-01 | | 5.21E+03 | 2.84E+03 |

* From Reg Guide 1.109, Table B-1 (mrem/yr per pCi/$m^3$)

** The finite cloud correction factor is described in Section 3.6

*** Ki (mrem/yr per uCi/$m^3$)

Table 3-5

Skin Dose Factors

Li

From Noble Gases (beta)

| Nuclide | Beta Skin* Dose Factor | x (pCi/uCi) = | Li** |
|---|---|---|---|
| Kr-83m | 0.00E+00 | 1E+6 | 0.00E+00 |
| Kr-85m | 1.46E-03 | 1E+6 | 1.46E+03 |
| Kr-85 | 1.34E-03 | 1E+6 | 1.34E+03 |
| Kr-87 | 9.73E-03 | 1E+6 | 9.73E+03 |
| Kr-88 | 2.37E-03 | 1E+6 | 2.37E+03 |
| Kr-89 | 1.01E-02 | 1E+6 | 1.01E+04 |
| Kr-90 | 7.29E-03 | 1E+6 | 7.29E+03 |
| Xe-131m | 4.76E-04 | 1E+6 | 4.76E+02 |
| Xe-133m | 9.94E-04 | 1E+6 | 9.94E+02 |
| Xe-133 | 3.06E-04 | 1E+6 | 3.06E+02 |
| Xe-135m | 7.11E-04 | 1E+6 | 7.11E+02 |
| Xe-135 | 1.86E-03 | 1E+6 | 1.86E+03 |
| Xe-137 | 1.22E-02 | 1E+6 | 1.22E+04 |
| Xe-138 | 4.13E-03 | 1E+6 | 4.13E+03 |
| Ar-41 | 2.69E-03 | 1E+6 | 2.69E+03 |

* From Reg Guide 1.109, Table B-1 (mrem/yr per pCi/$m^3$)

** Li (mrem/yr per uCi/$m^3$)

Table 3-6

Air Dose Factors

Mi

From Noble Gases (gamma)

| Nuclide | Gamma factor * | x | (pCi/uCi) | x | Finite Cloud Correction Factor** Unit 2 | Unit 3 | = | U2 Mi *** | U3 Mi *** |
|---|---|---|---|---|---|---|---|---|---|
| Kr-83m | 1.93E-05 | | 1E+6 | | 8.86E-01 | 5.78E-01 | | 1.71E+01 | 1.12E+01 |
| Kr-85m | 1.23E-03 | | 1E+6 | | 7.49E-01 | 4.46E-01 | | 9.21E+02 | 5.49E+02 |
| Kr-85 | 1.72E-05 | | 1E+6 | | 6.73E-01 | 3.85E-01 | | 1.16E+01 | 6.62E+00 |
| Kr-87 | 6.17E-03 | | 1E+6 | | 5.68E-01 | 3.09E-01 | | 3.50E+03 | 1.91E+03 |
| Kr-88 | 1.52E-02 | | 1E+6 | | 5.40E-01 | 2.88E-01 | | 8.20E+03 | 4.37E+03 |
| Kr-89 | 1.73E-02 | | 1E+6 | | 5.60E-01 | 3.03E-01 | | 9.69E+03 | 5.24E+03 |
| Kr-90 | 1.63E-02 | | 1E+6 | | 5.97E-01 | 3.29E-01 | | 9.73E+03 | 5.36E+03 |
| Xe-131m | 1.56E-04 | | 1E+6 | | 8.67E-01 | 5.62E-01 | | 1.35E+02 | 8.77E+01 |
| Xe-133m | 3.27E-04 | | 1E+6 | | 8.17E-01 | 5.12E-01 | | 2.67E+02 | 1.68E+02 |
| Xe-133 | 3.53E-04 | | 1E+6 | | 8.86E-01 | 5.78E-01 | | 3.13E+02 | 2.04E+02 |
| Xe-135m | 3.36E-03 | | 1E+6 | | 6.75E-01 | 3.87E-01 | | 2.27E+03 | 1.30E+03 |
| Xe-135 | 1.92E-03 | | 1E+6 | | 7.60E-01 | 4.55E-01 | | 1.46E+03 | 8.74E+02 |
| Xe-137 | 1.51E-03 | | 1E+6 | | 6.46E-01 | 3.65E-01 | | 9.76E+02 | 5.51E+02 |
| Xe-138 | 9.21E-03 | | 1E+6 | | 5.75E-01 | 3.14E-01 | | 5.29E+03 | 2.89E+03 |
| Ar-41 | 9.30E-03 | | 1E+6 | | 5.89E-01 | 3.21E-01 | | 5.48E+03 | 2.99E+03 |

* From Reg Guide 1.109, Table B-1 (mrad/yr per pCi/$m^3$)

** The finite cloud correction factor is described in Section 3.6

*** Mi (mrad/yr per uCi/$m^3$)

Table 3-7

Air Dose Factors

Ni

From Noble Gases (beta)

| Nuclide | Beta * Factor | x (pCi/uCi) | = Ni** |
|---|---|---|---|
| Kr-83m | 2.88E-04 | 1E+6 | 2.88E+02 |
| Kr-85m | 1.97E-03 | 1E+6 | 1.97E+03 |
| Kr-85 | 1.95E-03 | 1E+6 | 1.95E+03 |
| Kr-87 | 1.03E-02 | 1E+6 | 1.03E+04 |
| Kr-88 | 2.93E-03 | 1E+6 | 2.93E+03 |
| Kr-89 | 1.06E-02 | 1E+6 | 1.06E+04 |
| Kr-90 | 7.83E-03 | 1E+6 | 7.83E+03 |
| Xe-131m | 1.11E-03 | 1E+6 | 1.11E+03 |
| Xe-133m | 1.48E-03 | 1E+6 | 1.48E+03 |
| Xe-133 | 1.05E-03 | 1E+6 | 1.05E+03 |
| Xe-135m | 7.39E-04 | 1E+6 | 7.39E+02 |
| Xe-135 | 2.46E-03 | 1E+6 | 2.46E+03 |
| Xe-137 | 1.27E-02 | 1E+6 | 1.27E+04 |
| Xe-138 | 4.75E-03 | 1E+6 | 4.75E+03 |
| Ar-41 | 3.28E-03 | 1E+6 | 3.28E+03 |

* From Reg Guide 1.109, Table B-1 (mrad/yr per pCi/$m^3$)

** Ni (mrad/yr per uCi/$m^3$)

Table 3 – 8

NOBLE GAS DOSE FACTORS

For Instantaneous and Time Average Mixtures at the Site Boundary, Units 2 and 3

| Radionuclide | Instantaneous Mix (%) | Time Average Mix (%) |
|---|---|---|
| Kr-85m | 3.09 | |
| Kr-85 | 0 | 18.98 |
| Kr-87 | 2.80 | |
| Kr-88 | 5.22 | |
| Xe-131m | 0 | 0.162 |
| Xe-133m | 1.39 | 0.485 |
| Xe-133 | 56.8 | 78.1 |
| Xe-135m | 1.34 | |
| Xe-135 | 19.2 | 2.21 |
| Xe-138 | 2.81 | |
| Ar-41 | 7.43 | |
| Total | 100 | 100 |

| Unit 2 effective instantaneous dose factors | Unit 3 effective instantaneous dose factors | Units | Unit 2 effective average dose factors | Unit 3 effective average dose factors |
|---|---|---|---|---|
| $\overline{K}$ = 1507 | $\overline{K}$ = 849 | mrem/yr per uCi/m$^3$ | $\overline{K}$ = 237 | $\overline{K}$ = 153 |
| $\overline{L}$ = 1310 | $\overline{L}$ = 1310 | mrem/yr per uCi/m$^3$ | $\overline{L}$ = 540 | $\overline{L}$ = 540 |
| $\overline{M}$ = 1601 | $\overline{M}$ = 905 | mrad/yr per uCi/m$^3$ | $\overline{M}$ = 281 | $\overline{M}$ = 181 |
| $\overline{N}$ = 1977 | $\overline{N}$ = 1977 | mrad/yr per uCi/m$^3$ | $\overline{N}$ = 1254 | $\overline{N}$ = 1254 |

Instantaneous Mixture Basis:
This mix defines the shared-site noble gas limits between the two units, and is used for administrative guidelines for instantaneous releases based on an RCS noble gas mix at 1.6 yrs into a 24-month cycle, with two failed fuel rods, per Reference 30. These mixtures provide conservative application for calculating setpoints per 10CFR20, in terms of uCi/sec before an actual sample of the release is available, per Appendix I.

Time Averaged Release Mixture Basis:
This mix defines the routine (time-averaged) releases from either unit. It was derived from average noble-gas releases from year 2000-2003 at IPEC units 2 and 3 per Reference 30. They are used in conjunction with calculations to determine representative quarterly and annual time averaged release rates in curies per second for administrative purposes only, per Appendix I.

TABLE 3 – 9

LOCATIONS OF SITE BOUNDARY AND NEAREST RESIDENCE

| Sector by compass point | Distance to Site Boundary from Unit 2 Plant Vent, in meters | Distance to Site Boundary from Unit 3 Plant Vent, in meters | Distance to nearest residence, from Unit 1 superheater, in meters |
|---|---|---|---|
| **N** | **RIVER** | **RIVER** | **1788.1** |
| **NNE** | **RIVER** | **RIVER** | **3111.3** |
| **NE** | **550** | **636** | **1907.3** |
| **ENE** | **600** | **775** | **1478.2** |
| **E** | **662** | **785** | **1370.9** |
| **ESE** | **569** | **622** | **715.2** |
| **SE** | **553** | **564** | **1168.2** |
| **SSE** | **569** | **551** | **1239.7** |
| **S** | **700** | **566** | **1132.5** |
| **SSW** | **755** | **480** | **1573.5** |
| **SW** | **544** | **350** | **3015.9** |
| **WSW** | **RIVER** | **RIVER** | **2169.6** |
| **W** | **RIVER** | **RIVER** | **1918.7** |
| **WNW** | **RIVER** | **RIVER** | **1752.4** |
| **NW** | **RIVER** | **RIVER** | **1692.7** |
| **NNW** | **RIVER** | **RIVER** | **1609.3** |

Distances to the Site Boundary are unit-specific and measured from the applicable unit's Plant Vent release point. Distances to the Nearest Residence are measured from the Unit 1 Superheater Stack for both Units 2 and 3, per Reference 31.

Table 3-10a

ADULT INHALATION Ri(I) (mrem/yr per $uCi/m^3$)

| Isotope | BONE | LIVER | TOT BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| H-3 | 0.00E+00 | 1.26E+03 | 1.26E+03 | 1.26E+03 | 1.26E+03 | 1.26E+03 | 1.26E+03 |
| Be-7 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Na-24 | 1.02E+04 | 1.02E+04 | 1.02E+04 | 1.02E+04 | 1.02E+04 | 1.02E+04 | 1.02E+04 |
| P-32 | 1.32E+06 | 7.71E+04 | 5.01E+04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 8.64E+04 |
| Cr-51 | 0.00E+00 | 0.00E+00 | 1.00E+02 | 5.95E+01 | 2.28E+01 | 1.44E+04 | 3.32E+03 |
| Mn-54 | 0.00E+00 | 3.96E+04 | 6.30E+03 | 0.00E+00 | 9.84E+03 | 1.40E+06 | 7.74E+04 |
| Mn-56 | 0.00E+00 | 1.24E+00 | 1.83E-01 | 0.00E+00 | 1.30E+00 | 9.44E+03 | 2.02E+04 |
| Fe-55 | 2.46E+04 | 1.70E+04 | 3.94E+03 | 0.00E+00 | 0.00E+00 | 7.21E+04 | 6.03E+03 |
| Fe-59 | 1.18E+04 | 2.78E+04 | 1.06E+04 | 0.00E+00 | 0.00E+00 | 1.02E+06 | 1.88E+05 |
| Co-58 | 0.00E+00 | 1.58E+03 | 2.07E+03 | 0.00E+00 | 0.00E+00 | 9.28E+05 | 1.06E+05 |
| Co-60 | 0.00E+00 | 1.15E+04 | 1.48E+04 | 0.00E+00 | 0.00E+00 | 5.97E+06 | 2.85E+05 |
| Ni-63 | 4.32E+05 | 3.14E+04 | 1.45E+04 | 0.00E+00 | 0.00E+00 | 1.78E+05 | 1.34E+04 |
| Ni-65 | 1.54E+00 | 2.10E-01 | 9.12E-02 | 0.00E+00 | 0.00E+00 | 5.60E+03 | 1.23E+04 |
| Cu-64 | 0.00E+00 | 1.46E+00 | 6.15E-01 | 0.00E+00 | 4.62E+00 | 6.78E+03 | 4.90E+04 |
| Zn-65 | 3.24E+04 | 1.03E+05 | 4.66E+04 | 0.00E+00 | 6.90E+04 | 8.64E+05 | 5.34E+04 |
| Zn-69 | 3.38E-02 | 6.51E-02 | 4.52E-03 | 0.00E+00 | 4.22E-02 | 9.20E+02 | 1.63E+01 |
| Br-83 | 0.00E+00 | 0.00E+00 | 2.41E+02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.32E+02 |
| Br-84 | 0.00E+00 | 0.00E+00 | 3.13E+02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.64E-03 |
| Br-85 | 0.00E+00 | 0.00E+00 | 1.28E+01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Rb-86 | 0.00E+00 | 1.35E+05 | 5.90E+04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.66E+04 |
| Rb-88 | 0.00E+00 | 3.87E+02 | 1.93E+02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.34E-09 |
| Rb-89 | 0.00E+00 | 2.56E+02 | 1.70E+02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 9.28E-12 |
| Sr-89 | 3.04E+05 | 0.00E+00 | 8.72E+03 | 0.00E+00 | 0.00E+00 | 1.40E+06 | 3.50E+05 |
| Sr-90 | 9.92E+07 | 0.00E+00 | 6.10E+06 | 0.00E+00 | 0.00E+00 | 9.60E+06 | 7.22E+05 |
| Sr-91 | 6.19E+01 | 0.00E+00 | 2.50E+00 | 0.00E+00 | 0.00E+00 | 3.65E+04 | 1.91E+05 |
| Sr-92 | 6.74E+00 | 0.00E+00 | 2.91E-01 | 0.00E+00 | 0.00E+00 | 1.65E+04 | 4.30E+04 |
| Y-90 | 2.09E+03 | 0.00E+00 | 5.61E+01 | 0.00E+00 | 0.00E+00 | 1.70E+05 | 5.06E+05 |
| Y-91m | 2.61E-01 | 0.00E+00 | 1.02E-02 | 0.00E+00 | 0.00E+00 | 1.92E+03 | 1.33E+00 |
| Y-91 | 4.62E+05 | 0.00E+00 | 1.24E+04 | 0.00E+00 | 0.00E+00 | 1.70E+06 | 3.85E+05 |
| Y-92 | 1.03E+01 | 0.00E+00 | 3.02E-01 | 0.00E+00 | 0.00E+00 | 1.57E+04 | 7.35E+04 |
| Y-93 | 9.44E+01 | 0.00E+00 | 2.61E+00 | 0.00E+00 | 0.00E+00 | 4.85E+04 | 4.22E+05 |
| Zr-95 | 1.07E+05 | 3.44E+04 | 2.33E+04 | 0.00E+00 | 5.42E+04 | 1.77E+06 | 1.50E+05 |
| Zr-97 | 9.68E+01 | 1.96E+01 | 9.04E+00 | 0.00E+00 | 2.97E+01 | 7.87E+04 | 5.23E+05 |
| Nb-95 | 1.41E+04 | 7.82E+03 | 4.21E+03 | 0.00E+00 | 7.74E+03 | 5.05E+05 | 1.04E+05 |
| Mo-99 | 0.00E+00 | 1.21E+02 | 2.30E+01 | 0.00E+00 | 2.91E+02 | 9.12E+04 | 2.48E+05 |
| Tc-99m | 1.03E-03 | 2.91E-03 | 3.70E-02 | 0.00E+00 | 4.42E-02 | 7.64E+02 | 4.16E+03 |
| Tc-101 | 4.18E-05 | 6.02E-05 | 5.90E-04 | 0.00E+00 | 1.08E-03 | 3.99E+02 | 1.09E-11 |
| Ru-103 | 1.53E+03 | 0.00E+00 | 6.58E+02 | 0.00E+00 | 5.83E+03 | 5.05E+05 | 1.10E+05 |
| Ru-105 | 7.90E-01 | 0.00E+00 | 3.11E-01 | 0.00E+00 | 1.02E+00 | 1.10E+04 | 4.82E+04 |
| Ru-106 | 6.91E+04 | 0.00E+00 | 8.72E+03 | 0.00E+00 | 1.34E+05 | 9.36E+06 | 9.12E+05 |
| Ag-110m | 1.08E+04 | 1.00E+04 | 5.94E+03 | 0.00E+00 | 1.97E+04 | 4.63E+06 | 3.02E+05 |
| Sb-122 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Sb-124 | 3.12E+04 | 5.89E+02 | 1.24E+04 | 7.55E+01 | 0.00E+00 | 2.48E+06 | 4.06E+05 |
| Sb-125 | 5.34E+04 | 5.95E+02 | 1.26E+04 | 5.40E+01 | 0.00E+00 | 1.74E+06 | 1.01E+05 |

Table 3-10a

ADULT INHALATION Ri(I) (mrem/yr per $uCi/m^3$)

| Isotope | BONE | LIVER | TOT BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| Te-125m | 3.42E+03 | 1.58E+03 | 4.67E+02 | 1.05E+03 | 1.24E+04 | 3.14E+05 | 7.06E+04 |
| Te-127m | 1.26E+04 | 5.77E+03 | 1.57E+03 | 3.29E+03 | 4.58E+04 | 9.60E+05 | 1.50E+05 |
| Te-127 | 1.40E+00 | 6.42E-01 | 3.10E-01 | 1.06E+00 | 5.10E+00 | 6.51E+03 | 5.74E+04 |
| Te-129m | 9.76E+03 | 4.67E+03 | 1.58E+03 | 3.44E+03 | 3.66E+04 | 1.16E+06 | 3.83E+05 |
| Te-129 | 4.98E-02 | 2.39E-02 | 1.24E-02 | 3.90E-02 | 1.87E-01 | 1.94E+03 | 1.57E+02 |
| Te-131m | 6.99E+01 | 4.36E+01 | 2.90E+01 | 5.50E+01 | 3.09E+02 | 1.46E+05 | 5.56E+05 |
| Te-131 | 1.11E-02 | 5.95E-03 | 3.59E-03 | 9.36E-03 | 4.37E-02 | 1.39E+03 | 1.84E+01 |
| Te-132 | 2.60E+02 | 2.15E+02 | 1.62E+02 | 1.90E+02 | 1.46E+03 | 2.88E+05 | 5.10E+05 |
| I-130 | 4.58E+03 | 1.34E+04 | 5.28E+03 | 1.14E+06 | 2.09E+04 | 0.00E+00 | 7.69E+03 |
| I-131 | 2.52E+04 | 3.58E+04 | 2.05E+04 | 1.19E+07 | 6.13E+04 | 0.00E+00 | 6.28E+03 |
| I-132 | 1.16E+03 | 3.26E+03 | 1.16E+03 | 1.14E+05 | 5.18E+03 | 0.00E+00 | 4.06E+02 |
| I-133 | 8.64E+03 | 1.48E+04 | 4.52E+03 | 2.15E+06 | 2.58E+04 | 0.00E+00 | 8.88E+03 |
| I-134 | 6.44E+02 | 1.73E+03 | 6.15E+02 | 2.98E+04 | 2.75E+03 | 0.00E+00 | 1.01E+00 |
| I-135 | 2.68E+03 | 6.98E+03 | 2.57E+03 | 4.48E+05 | 1.11E+04 | 0.00E+00 | 5.25E+03 |
| Cs-134 | 3.73E+05 | 8.48E+05 | 7.28E+05 | 0.00E+00 | 2.87E+05 | 9.76E+04 | 1.04E+04 |
| Cs-136 | 3.90E+04 | 1.46E+05 | 1.10E+05 | 0.00E+00 | 8.56E+04 | 1.20E+04 | 1.17E+04 |
| Cs-137 | 4.78E+05 | 6.21E+05 | 4.28E+05 | 0.00E+00 | 2.22E+05 | 7.52E+04 | 8.40E+03 |
| Cs-138 | 3.31E+02 | 6.21E+02 | 3.24E+02 | 0.00E+00 | 4.80E+02 | 4.86E+01 | 1.86E-03 |
| Ba-139 | 9.36E-01 | 6.66E-04 | 2.74E-02 | 0.00E+00 | 6.22E-04 | 3.76E+03 | 8.96E+02 |
| Ba-140 | 3.90E+04 | 4.90E+01 | 2.57E+03 | 0.00E+00 | 1.67E+01 | 1.27E+06 | 2.18E+05 |
| Ba-141 | 1.00E-01 | 7.53E-05 | 3.36E-03 | 0.00E+00 | 7.00E-05 | 1.94E+03 | 1.16E-07 |
| Ba-142 | 2.63E-02 | 2.70E-05 | 1.66E-03 | 0.00E+00 | 2.29E-05 | 1.19E+03 | 1.57E-16 |
| La-140 | 3.44E+02 | 1.74E+02 | 4.58E+01 | 0.00E+00 | 0.00E+00 | 1.36E+05 | 4.58E+05 |
| La-142 | 6.83E-01 | 3.10E-01 | 7.72E-02 | 0.00E+00 | 0.00E+00 | 6.33E+03 | 2.11E+03 |
| Ce-141 | 1.99E+04 | 1.35E+04 | 1.53E+03 | 0.00E+00 | 6.26E+03 | 3.62E+05 | 1.20E+05 |
| Ce-143 | 1.86E+02 | 1.38E+02 | 1.53E+01 | 0.00E+00 | 6.08E+01 | 7.98E+04 | 2.26E+05 |
| Ce-144 | 3.43E+06 | 1.43E+06 | 1.84E+05 | 0.00E+00 | 8.48E+05 | 7.78E+06 | 8.16E+05 |
| Pr-143 | 9.36E+03 | 3.75E+03 | 4.64E+02 | 0.00E+00 | 2.16E+03 | 2.81E+05 | 2.00E+05 |
| Pr-144 | 3.01E-02 | 1.25E-02 | 1.53E-03 | 0.00E+00 | 7.05E-03 | 1.02E+03 | 2.15E-08 |
| Nd-147 | 5.27E+03 | 6.10E+03 | 3.65E+02 | 0.00E+00 | 3.56E+03 | 2.21E+05 | 1.73E+05 |
| W-187 | 8.48E+00 | 7.08E+00 | 2.48E+00 | 0.00E+00 | 0.00E+00 | 2.90E+04 | 1.55E+05 |
| Np-239 | 2.30E+02 | 2.26E+01 | 1.24E+01 | 0.00E+00 | 7.00E+01 | 3.76E+04 | 1.19E+05 |
| K-40 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Co-57 | 0.00E+00 | 6.92E+02 | 6.71E+02 | 0.00E+00 | 0.00E+00 | 3.70E+05 | 3.14E+04 |
| Sr-85 | 3.20E+04 | 0.00E+00 | 7.76E+05 | 0.00E+00 | 0.00E+00 | 4.80E+05 | 6.08E+04 |
| Y-88 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nb-94 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nb-97 | 2.22E-01 | 5.62E-02 | 2.05E-02 | 0.00E+00 | 6.54E-02 | 2.40E+03 | 2.42E+02 |
| Cd-109 | 0.00E+00 | 3.92E+05 | 1.28E+04 | 0.00E+00 | 3.76E+05 | 7.28E+05 | 6.56E+04 |
| Sn-113 | 6.56E+04 | 2.16E+03 | 4.48E+03 | 1.36E+03 | 0.00E+00 | 9.60E+05 | 1.20E+04 |
| Ba-133 | 7.60E+04 | 3.36E+03 | 2.00E+04 | 0.00E+00 | 1.68E+01 | 1.52E+06 | 8.00E+04 |
| Te-134 | 3.07E-02 | 2.58E-02 | 1.26E-02 | 2.75E-02 | 1.74E-01 | 3.47E+03 | 2.38E-01 |
| Ce-139 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Hg-203 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

Table 3-10b

TEEN INHALATION Ri(I) (mrem/yr per $uCi/m^3$)

| Isotope | BONE | LIVER | TOT BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| H-3 | 0.00E+00 | 1.27E+03 | 1.27E+03 | 1.27E+03 | 1.27E+03 | 1.27E+03 | 1.27E+03 |
| Be-7 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Na-24 | 1.38E+04 | 1.38E+04 | 1.38E+04 | 1.38E+04 | 1.38E+04 | 1.38E+04 | 1.38E+04 |
| P-32 | 1.89E+06 | 1.10E+05 | 7.16E+04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 9.28E+04 |
| Cr-51 | 0.00E+00 | 0.00E+00 | 1.35E+02 | 7.50E+01 | 3.07E+01 | 2.10E+04 | 3.00E+03 |
| Mn-54 | 0.00E+00 | 5.11E+04 | 8.40E+03 | 0.00E+00 | 1.27E+04 | 1.98E+06 | 6.68E+04 |
| Mn-56 | 0.00E+00 | 1.70E+00 | 2.52E-01 | 0.00E+00 | 1.79E+00 | 1.52E+04 | 5.74E+04 |
| Fe-55 | 3.34E+04 | 2.38E+04 | 5.54E+03 | 0.00E+00 | 0.00E+00 | 1.24E+05 | 6.39E+03 |
| Fe-59 | 1.59E+04 | 3.70E+04 | 1.43E+04 | 0.00E+00 | 0.00E+00 | 1.53E+06 | 1.78E+05 |
| Co-58 | 0.00E+00 | 2.07E+03 | 2.78E+03 | 0.00E+00 | 0.00E+00 | 1.34E+06 | 9.52E+04 |
| Co-60 | 0.00E+00 | 1.51E+04 | 1.98E+04 | 0.00E+00 | 0.00E+00 | 8.72E+06 | 2.59E+05 |
| Ni-63 | 5.80E+05 | 4.34E+04 | 1.98E+04 | 0.00E+00 | 0.00E+00 | 3.07E+05 | 1.42E+04 |
| Ni-65 | 2.18E+00 | 2.93E-01 | 1.27E-01 | 0.00E+00 | 0.00E+00 | 9.36E+03 | 3.67E+04 |
| Cu-64 | 0.00E+00 | 2.03E+00 | 8.48E-01 | 0.00E+00 | 6.41E+00 | 1.11E+04 | 6.14E+04 |
| Zn-65 | 3.86E+04 | 1.34E+05 | 6.24E+04 | 0.00E+00 | 8.64E+04 | 1.24E+06 | 4.66E+04 |
| Zn-69 | 4.83E-02 | 9.20E-02 | 6.46E-03 | 0.00E+00 | 6.02E-02 | 1.58E+03 | 2.85E+02 |
| Br-83 | 0.00E+00 | 0.00E+00 | 3.44E+02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Br-84 | 0.00E+00 | 0.00E+00 | 4.33E+02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Br-85 | 0.00E+00 | 0.00E+00 | 1.83E+01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Rb-86 | 0.00E+00 | 1.90E+05 | 8.40E+04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.77E+04 |
| Rb-88 | 0.00E+00 | 5.46E+02 | 2.72E+02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.92E-05 |
| Rb-89 | 0.00E+00 | 3.52E+02 | 2.33E+02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.38E-07 |
| Sr-89 | 4.34E+05 | 0.00E+00 | 1.25E+04 | 0.00E+00 | 0.00E+00 | 2.42E+06 | 3.71E+05 |
| Sr-90 | 1.08E+08 | 0.00E+00 | 6.68E+06 | 0.00E+00 | 0.00E+00 | 1.65E+07 | 7.65E+05 |
| Sr-91 | 8.80E+01 | 0.00E+00 | 3.51E+00 | 0.00E+00 | 0.00E+00 | 6.07E+04 | 2.59E+05 |
| Sr-92 | 9.52E+00 | 0.00E+00 | 4.06E-01 | 0.00E+00 | 0.00E+00 | 2.74E+04 | 1.19E+05 |
| Y-90 | 2.98E+03 | 0.00E+00 | 8.00E+01 | 0.00E+00 | 0.00E+00 | 2.93E+05 | 5.59E+05 |
| Y-91m | 3.70E-01 | 0.00E+00 | 1.42E-02 | 0.00E+00 | 0.00E+00 | 3.20E+03 | 3.02E+01 |
| Y-91 | 6.61E+05 | 0.00E+00 | 1.77E+04 | 0.00E+00 | 0.00E+00 | 2.94E+06 | 4.09E+05 |
| Y-92 | 1.47E+01 | 0.00E+00 | 4.29E-01 | 0.00E+00 | 0.00E+00 | 2.68E+04 | 1.65E+05 |
| Y-93 | 1.35E+02 | 0.00E+00 | 3.72E+00 | 0.00E+00 | 0.00E+00 | 8.32E+04 | 5.79E+05 |
| Zr-95 | 1.46E+05 | 4.58E+04 | 3.15E+04 | 0.00E+00 | 6.74E+04 | 2.69E+06 | 1.49E+05 |
| Zr-97 | 1.38E+02 | 2.72E+01 | 1.26E+01 | 0.00E+00 | 4.12E+01 | 1.30E+05 | 6.30E+05 |
| Nb-95 | 1.86E+04 | 1.03E+04 | 5.66E+03 | 0.00E+00 | 1.00E+04 | 7.51E+05 | 9.68E+04 |
| Mo-99 | 0.00E+00 | 1.69E+02 | 3.22E+01 | 0.00E+00 | 4.11E+02 | 1.54E+05 | 2.69E+05 |
| Tc-99m | 1.38E-03 | 3.86E-03 | 4.99E-02 | 0.00E+00 | 5.76E-02 | 1.15E+03 | 6.13E+03 |
| Tc-101 | 5.92E-05 | 8.40E-05 | 8.24E-04 | 0.00E+00 | 1.52E-03 | 6.67E+02 | 8.72E-07 |
| Ru-103 | 2.10E+03 | 0.00E+00 | 8.96E+02 | 0.00E+00 | 7.43E+03 | 7.83E+05 | 1.09E+05 |
| Ru-105 | 1.12E+00 | 0.00E+00 | 4.34E-01 | 0.00E+00 | 1.41E+00 | 1.82E+04 | 9.04E+04 |
| Ru-106 | 9.84E+04 | 0.00E+00 | 1.24E+04 | 0.00E+00 | 1.90E+05 | 1.61E+07 | 9.60E+05 |
| Ag-110m | 1.38E+04 | 1.31E+04 | 7.99E+03 | 0.00E+00 | 2.50E+04 | 6.75E+06 | 2.73E+05 |
| Sb-122 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Sb-124 | 4.30E+04 | 7.94E+02 | 1.68E+04 | 9.76E+01 | 0.00E+00 | 3.85E+06 | 3.98E+05 |
| Sb-125 | 7.38E+04 | 8.08E+02 | 1.72E+04 | 7.04E+01 | 0.00E+00 | 2.74E+06 | 9.92E+04 |

Table 3-10b

TEEN INHALATION Ri(I) (mrem/yr per $uCi/m^3$)

| Isotope | BONE | LIVER | TOT BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| Te-125m | 4.88E+03 | 2.24E+03 | 6.67E+02 | 1.40E+03 | 0.00E+00 | 5.36E+05 | 7.50E+04 |
| Te-127m | 1.80E+04 | 8.16E+03 | 2.18E+03 | 4.38E+03 | 6.54E+04 | 1.66E+06 | 1.59E+05 |
| Te-127 | 2.01E+00 | 9.12E-01 | 4.42E-01 | 1.42E+00 | 7.28E+00 | 1.12E+04 | 8.08E+04 |
| Te-129m | 1.39E+04 | 6.58E+03 | 2.25E+03 | 4.58E+03 | 5.19E+04 | 1.98E+06 | 4.05E+05 |
| Te-129 | 7.10E-02 | 3.38E-02 | 1.76E-02 | 5.18E-02 | 2.66E-01 | 3.30E+03 | 1.62E+03 |
| Te-131m | 9.84E+01 | 6.01E+01 | 4.02E+01 | 7.25E+01 | 4.39E+02 | 2.38E+05 | 6.21E+05 |
| Te-131 | 1.58E-02 | 8.32E-03 | 5.04E-03 | 1.24E-02 | 6.18E-02 | 2.34E+03 | 1.51E+01 |
| Te-132 | 3.60E+02 | 2.90E+02 | 2.19E+02 | 2.46E+02 | 1.95E+03 | 4.49E+05 | 4.63E+05 |
| I-130 | 6.24E+03 | 1.79E+04 | 7.17E+03 | 1.49E+06 | 2.75E+04 | 0.00E+00 | 9.12E+03 |
| I-131 | 3.54E+04 | 4.91E+04 | 2.64E+04 | 1.46E+07 | 8.40E+04 | 0.00E+00 | 6.49E+03 |
| I-132 | 1.59E+03 | 4.38E+03 | 1.58E+03 | 1.51E+05 | 6.92E+03 | 0.00E+00 | 1.27E+03 |
| I-133 | 1.22E+04 | 2.05E+04 | 6.22E+03 | 2.92E+06 | 3.59E+04 | 0.00E+00 | 1.03E+04 |
| I-134 | 8.88E+02 | 2.32E+03 | 8.40E+02 | 3.95E+04 | 3.66E+03 | 0.00E+00 | 2.04E+01 |
| I-135 | 3.70E+03 | 9.44E+03 | 3.49E+03 | 6.21E+05 | 1.49E+04 | 0.00E+00 | 6.95E+03 |
| Cs-134 | 5.02E+05 | 1.13E+06 | 5.49E+05 | 0.00E+00 | 3.75E+05 | 1.46E+05 | 9.76E+03 |
| Cs-136 | 5.15E+04 | 1.94E+05 | 1.37E+05 | 0.00E+00 | 1.10E+05 | 1.78E+04 | 1.09E+04 |
| Cs-137 | 6.70E+05 | 8.48E+05 | 3.11E+05 | 0.00E+00 | 3.04E+05 | 1.21E+05 | 8.48E+03 |
| Cs-138 | 4.66E+02 | 8.56E+02 | 4.46E+02 | 0.00E+00 | 6.62E+02 | 7.87E+01 | 2.70E-01 |
| Ba-139 | 1.34E+00 | 9.44E-04 | 3.90E-02 | 0.00E+00 | 8.88E-04 | 6.46E+03 | 6.45E+03 |
| Ba-140 | 5.47E+04 | 6.70E+01 | 3.52E+03 | 0.00E+00 | 2.28E+01 | 2.03E+06 | 2.29E+05 |
| Ba-141 | 1.42E-01 | 1.06E-04 | 4.74E-03 | 0.00E+00 | 9.84E-05 | 3.29E+03 | 7.46E-04 |
| Ba-142 | 3.70E-02 | 3.70E-05 | 2.27E-03 | 0.00E+00 | 3.14E-05 | 1.91E+03 | 4.79E-10 |
| La-140 | 4.79E+02 | 2.36E+02 | 6.26E+01 | 0.00E+00 | 0.00E+00 | 2.14E+05 | 4.87E+05 |
| La-142 | 9.60E-01 | 4.25E-01 | 1.06E-01 | 0.00E+00 | 0.00E+00 | 1.02E+04 | 1.20E+04 |
| Ce-141 | 2.84E+04 | 1.90E+04 | 2.17E+03 | 0.00E+00 | 8.88E+03 | 6.14E+05 | 1.26E+05 |
| Ce-143 | 2.66E+02 | 1.94E+02 | 2.16E+01 | 0.00E+00 | 8.64E+01 | 1.30E+05 | 2.55E+05 |
| Ce-144 | 4.89E+06 | 2.02E+06 | 2.62E+05 | 0.00E+00 | 1.21E+06 | 1.34E+07 | 8.64E+05 |
| Pr-143 | 1.34E+04 | 5.31E+03 | 6.62E+02 | 0.00E+00 | 3.09E+03 | 4.83E+05 | 2.14E+05 |
| Pr-144 | 4.30E-02 | 1.76E-02 | 2.18E-03 | 0.00E+00 | 1.01E-02 | 1.75E+03 | 2.35E-04 |
| Nd-147 | 7.86E+03 | 8.56E+03 | 5.13E+02 | 0.00E+00 | 5.02E+03 | 3.72E+05 | 1.82E+05 |
| W-187 | 1.20E+01 | 9.76E+00 | 3.43E+00 | 0.00E+00 | 0.00E+00 | 4.74E+04 | 1.77E+05 |
| Np-239 | 3.38E+02 | 3.19E+01 | 1.77E+01 | 0.00E+00 | 1.00E+02 | 6.49E+04 | 1.32E+05 |
| K-40 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Co-57 | 0.00E+00 | 9.44E+02 | 9.20E+02 | 0.00E+00 | 0.00E+00 | 5.86E+05 | 3.14E+04 |
| Sr-85 | 4.00E+04 | 0.00E+00 | 1.04E+04 | 0.00E+00 | 0.00E+00 | 7.04E+05 | 5.52E+04 |
| Y-88 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nb-94 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nb-97 | 3.14E-01 | 7.78E-02 | 2.84E-02 | 0.00E+00 | 9.12E-02 | 3.93E+03 | 2.17E+03 |
| Cd-109 | 0.00E+00 | 8.00E+05 | 2.72E+04 | 0.00E+00 | 5.36E+05 | 1.28E+06 | 6.88E+04 |
| Sn-113 | 1.20E+05 | 3.76E+03 | 7.76E+03 | 2.32E+03 | 0.00E+00 | 1.60E+06 | 1.20E+04 |
| Ba-133 | 3.76E+05 | 6.40E+03 | 2.64E+04 | 0.00E+00 | 2.24E+01 | 2.32E+06 | 7.76E+04 |
| Te-134 | 4.25E-02 | 3.48E-02 | 2.91E-02 | 3.57E-02 | 2.33E-01 | 5.40E+03 | 1.10E+01 |
| Ce-139 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Hg-203 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

Table 3-10c

CHILD INHALATION Ri(I) (mrem/yr per $uCi/m^3$)

| Isotope | BONE | LIVER | TOT BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| H-3 | 0.00E+00 | 1.12E+03 | 1.12E+03 | 1.12E+03 | 1.12E+03 | 1.12E+03 | 1.12E+03 |
| Be-7 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Na-24 | 1.61E+04 | 1.61E+04 | 1.61E+04 | 1.61E+04 | 1.61E+04 | 1.61E+04 | 1.61E+04 |
| P-32 | 2.60E+06 | 1.14E+05 | 9.88E+04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.22E+04 |
| Cr-51 | 0.00E+00 | 0.00E+00 | 1.54E+02 | 8.55E+01 | 2.43E+01 | 1.70E+04 | 1.08E+03 |
| Mn-54 | 0.00E+00 | 4.29E+04 | 9.51E+03 | 0.00E+00 | 1.00E+04 | 1.58E+06 | 2.29E+04 |
| Mn-56 | 0.00E+00 | 1.66E+00 | 3.12E-01 | 0.00E+00 | 1.67E+00 | 1.31E+04 | 1.23E+05 |
| Fe-55 | 4.74E+04 | 2.52E+04 | 7.77E+03 | 0.00E+00 | 0.00E+00 | 1.11E+05 | 2.87E+03 |
| Fe-59 | 2.07E+04 | 3.34E+04 | 1.67E+04 | 0.00E+00 | 0.00E+00 | 1.27E+06 | 7.07E+04 |
| Co-58 | 0.00E+00 | 1.77E+03 | 3.16E+03 | 0.00E+00 | 0.00E+00 | 1.11E+06 | 3.44E+04 |
| Co-60 | 0.00E+00 | 1.31E+04 | 2.26E+04 | 0.00E+00 | 0.00E+00 | 7.07E+06 | 9.62E+04 |
| Ni-63 | 8.21E+05 | 4.63E+04 | 2.80E+04 | 0.00E+00 | 0.00E+00 | 2.75E+05 | 6.33E+03 |
| Ni-65 | 2.99E+00 | 2.96E-01 | 1.64E-01 | 0.00E+00 | 0.00E+00 | 8.18E+03 | 8.40E+04 |
| Cu-64 | 0.00E+00 | 1.99E+00 | 1.07E+00 | 0.00E+00 | 6.03E+00 | 9.58E+03 | 3.67E+04 |
| Zn-65 | 4.26E+04 | 1.13E+05 | 7.03E+04 | 0.00E+00 | 7.14E+04 | 9.95E+05 | 1.63E+04 |
| Zn-69 | 6.70E-02 | 9.66E-02 | 8.92E-03 | 0.00E+00 | 5.85E-02 | 1.42E+03 | 1.02E+04 |
| Br-83 | 0.00E+00 | 0.00E+00 | 4.74E+02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Br-84 | 0.00E+00 | 0.00E+00 | 5.48E+02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Br-85 | 0.00E+00 | 0.00E+00 | 2.53E+01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Rb-86 | 0.00E+00 | 1.98E+05 | 1.14E+05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.99E+03 |
| Rb-88 | 0.00E+00 | 5.62E+02 | 3.66E+02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.72E+01 |
| Rb-89 | 0.00E+00 | 3.45E+02 | 2.90E+02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.89E+00 |
| Sr-89 | 5.99E+05 | 0.00E+00 | 1.72E+04 | 0.00E+00 | 0.00E+00 | 2.16E+06 | 1.67E+05 |
| Sr-90 | 1.01E+08 | 0.00E+00 | 6.44E+06 | 0.00E+00 | 0.00E+00 | 1.48E+07 | 3.43E+05 |
| Sr-91 | 1.21E+02 | 0.00E+00 | 4.59E+00 | 0.00E+00 | 0.00E+00 | 5.33E+04 | 1.74E+05 |
| Sr-92 | 1.31E+01 | 0.00E+00 | 5.25E-01 | 0.00E+00 | 0.00E+00 | 2.40E+04 | 2.42E+05 |
| Y-90 | 4.11E+03 | 0.00E+00 | 1.11E+02 | 0.00E+00 | 0.00E+00 | 2.62E+05 | 2.68E+05 |
| Y-91m | 5.07E-01 | 0.00E+00 | 1.84E-02 | 0.00E+00 | 0.00E+00 | 2.81E+03 | 1.72E+03 |
| Y-91 | 9.14E+05 | 0.00E+00 | 2.44E+04 | 0.00E+00 | 0.00E+00 | 2.63E+06 | 1.84E+05 |
| Y-92 | 2.04E+01 | 0.00E+00 | 5.81E-01 | 0.00E+00 | 0.00E+00 | 2.39E+04 | 2.39E+05 |
| Y-93 | 1.86E+02 | 0.00E+00 | 5.11E+00 | 0.00E+00 | 0.00E+00 | 7.44E+04 | 3.89E+05 |
| Zr-95 | 1.90E+05 | 4.18E+04 | 3.70E+04 | 0.00E+00 | 5.96E+04 | 2.23E+06 | 6.11E+04 |
| Zr-97 | 1.88E+02 | 2.72E+01 | 1.60E+01 | 0.00E+00 | 3.88E+01 | 1.13E+05 | 3.51E+05 |
| Nb-95 | 2.35E+04 | 9.18E+03 | 6.55E+03 | 0.00E+00 | 8.62E+03 | 6.14E+05 | 3.70E+04 |
| Mo-99 | 0.00E+00 | 1.72E+02 | 4.25E+01 | 0.00E+00 | 3.92E+02 | 1.35E+05 | 1.27E+05 |
| Tc-99m | 1.78E-03 | 3.48E-03 | 5.77E-02 | 0.00E+00 | 5.07E-02 | 9.51E+02 | 4.81E+03 |
| Tc-101 | 8.10E-05 | 8.51E-05 | 1.08E-03 | 0.00E+00 | 1.45E-03 | 5.85E+02 | 1.63E+01 |
| Ru-103 | 2.79E+03 | 0.00E+00 | 1.07E+03 | 0.00E+00 | 7.03E+03 | 6.62E+05 | 4.48E+04 |
| Ru-105 | 1.53E+00 | 0.00E+00 | 5.55E-01 | 0.00E+00 | 1.34E+00 | 1.59E+04 | 9.95E+04 |
| Ru-106 | 1.36E+05 | 0.00E+00 | 1.69E+04 | 0.00E+00 | 1.84E+05 | 1.43E+07 | 4.29E+05 |
| Ag-110m | 1.69E+04 | 1.14E+04 | 9.14E+03 | 0.00E+00 | 2.12E+04 | 5.48E+06 | 1.00E+05 |
| Sb-122 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Sb-124 | 5.74E+04 | 7.40E+02 | 2.00E+04 | 1.26E+02 | 0.00E+00 | 3.24E+06 | 1.64E+05 |
| Sb-125 | 9.84E+04 | 7.59E+02 | 2.07E+04 | 9.10E+01 | 0.00E+00 | 2.32E+06 | 4.03E+04 |

Table 3-10c

CHILD INHALATION Ri(I) (mrem/yr per uCi/$m^3$)

| Isotope | BONE | LIVER | TOT BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| Te-125m | 6.73E+03 | 2.33E+03 | 9.14E+02 | 1.92E+03 | 0.00E+00 | 4.77E+05 | 3.38E+04 |
| Te-127m | 2.49E+04 | 8.55E+03 | 3.02E+03 | 6.07E+03 | 6.36E+04 | 1.48E+06 | 7.14E+04 |
| Te-127 | 2.77E+00 | 9.51E-01 | 6.10E-01 | 1.96E+00 | 7.07E+00 | 1.00E+04 | 5.62E+04 |
| Te-129m | 1.92E+04 | 6.85E+03 | 3.04E+03 | 6.33E+03 | 5.03E+04 | 1.76E+06 | 1.82E+05 |
| Te-129 | 9.77E-02 | 3.50E-02 | 2.38E-02 | 7.14E-02 | 2.57E-01 | 2.93E+03 | 2.55E+04 |
| Te-131m | 1.34E+02 | 5.92E+01 | 5.07E+01 | 9.77E+01 | 4.00E+02 | 2.06E+05 | 3.08E+05 |
| Te-131 | 2.17E-02 | 8.44E-03 | 6.59E-03 | 1.70E-02 | 5.88E-02 | 2.05E+03 | 1.33E+03 |
| Te-132 | 4.81E+02 | 2.72E+02 | 2.63E+02 | 3.17E+02 | 1.77E+03 | 3.77E+05 | 1.38E+05 |
| I-130 | 8.18E+03 | 1.64E+04 | 8.44E+03 | 1.85E+06 | 2.45E+04 | 0.00E+00 | 5.11E+03 |
| I-131 | 4.81E+04 | 4.81E+04 | 2.73E+04 | 1.62E+07 | 7.88E+04 | 0.00E+00 | 2.84E+03 |
| I-132 | 2.12E+03 | 4.07E+03 | 1.88E+03 | 1.94E+05 | 6.25E+03 | 0.00E+00 | 3.20E+03 |
| I-133 | 1.66E+04 | 2.03E+04 | 7.70E+03 | 3.85E+06 | 3.38E+04 | 0.00E+00 | 5.48E+03 |
| I-134 | 1.17E+03 | 2.16E+03 | 9.95E+02 | 5.07E+04 | 3.30E+03 | 0.00E+00 | 9.55E+02 |
| I-135 | 4.92E+03 | 8.73E+03 | 4.14E+03 | 7.92E+05 | 1.34E+04 | 0.00E+00 | 4.44E+03 |
| Cs-134 | 6.51E+05 | 1.01E+06 | 2.25E+05 | 0.00E+00 | 3.30E+05 | 1.21E+05 | 3.85E+03 |
| Cs-136 | 6.51E+04 | 1.71E+05 | 1.16E+05 | 0.00E+00 | 9.55E+04 | 1.45E+04 | 4.18E+03 |
| Cs-137 | 9.07E+05 | 8.25E+05 | 1.28E+05 | 0.00E+00 | 2.82E+05 | 1.04E+05 | 3.62E+03 |
| Cs-138 | 6.33E+02 | 8.40E+02 | 5.55E+02 | 0.00E+00 | 6.22E+02 | 6.81E+01 | 2.70E+02 |
| Ba-139 | 1.84E+00 | 9.84E-04 | 5.36E-02 | 0.00E+00 | 8.62E-04 | 5.77E+03 | 5.77E+04 |
| Ba-140 | 7.40E+04 | 6.48E+01 | 4.33E+03 | 0.00E+00 | 2.11E+01 | 1.74E+06 | 1.02E+05 |
| Ba-141 | 1.96E-01 | 1.09E-04 | 6.36E-03 | 0.00E+00 | 9.47E-05 | 2.92E+03 | 2.75E+02 |
| Ba-142 | 4.99E-02 | 3.60E-05 | 2.79E-03 | 0.00E+00 | 2.91E-05 | 1.64E+03 | 2.74E+00 |
| La-140 | 6.44E+02 | 2.25E+02 | 7.55E+01 | 0.00E+00 | 0.00E+00 | 1.83E+05 | 2.26E+05 |
| La-142 | 1.29E+00 | 4.11E-01 | 1.29E-01 | 0.00E+00 | 0.00E+00 | 8.70E+03 | 7.59E+04 |
| Ce-141 | 3.92E+04 | 1.95E+04 | 2.90E+03 | 0.00E+00 | 8.55E+03 | 5.44E+05 | 5.66E+04 |
| Ce-143 | 3.66E+02 | 1.99E+02 | 2.87E+01 | 0.00E+00 | 8.36E+01 | 1.15E+05 | 1.27E+05 |
| Ce-144 | 6.77E+06 | 2.12E+06 | 3.61E+05 | 0.00E+00 | 1.17E+06 | 1.20E+07 | 3.89E+05 |
| Pr-143 | 1.85E+04 | 5.55E+03 | 9.14E+02 | 0.00E+00 | 3.00E+03 | 4.33E+05 | 9.73E+04 |
| Pr-144 | 5.96E-02 | 1.85E-02 | 3.00E-03 | 0.00E+00 | 9.77E-03 | 1.57E+03 | 1.97E+02 |
| Nd-147 | 1.08E+04 | 8.73E+03 | 6.81E+02 | 0.00E+00 | 4.81E+03 | 3.28E+05 | 8.21E+04 |
| W-187 | 1.63E+01 | 9.66E+00 | 4.33E+00 | 0.00E+00 | 0.00E+00 | 4.11E+04 | 9.10E+04 |
| Np-239 | 4.66E+02 | 3.34E+01 | 2.35E+01 | 0.00E+00 | 9.73E+01 | 5.81E+04 | 6.40E+04 |
| K-40 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Co-57 | 0.00E+00 | 9.03E+02 | 1.07E+03 | 0.00E+00 | 0.00E+00 | 5.07E+05 | 1.32E+04 |
| Sr-85 | 4.44E+04 | 0.00E+00 | 1.18E+04 | 0.00E+00 | 0.00E+00 | 5.55E+05 | 2.04E+04 |
| Y-88 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nb-94 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nb-97 | 4.29E-01 | 7.70E-02 | 3.60E-02 | 0.00E+00 | 8.55E-02 | 3.42E+03 | 2.78E+04 |
| Cd-109 | 0.00E+00 | 7.03E+05 | 2.96E+04 | 0.00E+00 | 6.29E+05 | 1.11E+06 | 3.00E+04 |
| Sn-113 | 1.41E+05 | 3.29E+03 | 8.51E+03 | 2.63E+03 | 0.00E+00 | 1.33E+06 | 4.81E+03 |
| Ba-133 | 4.07E+05 | 4.07E+03 | 3.70E+04 | 0.00E+00 | 2.00E+01 | 1.92E+06 | 3.07E+04 |
| Te-134 | 5.66E-02 | 3.26E-02 | 3.48E-02 | 4.59E-02 | 2.11E-01 | 4.55E+03 | 1.80E+03 |
| Ce-139 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Hg-203 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

Table 3-10d

INFANT INHALATION Ri(I) (mrem/yr per $uCi/m^3$)

| Isotope | BONE | LIVER | TOT BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| H-3 | 0.00E+00 | 6.47E+02 | 6.47E+02 | 6.47E+02 | 6.47E+02 | 6.47E+02 | 6.47E+02 |
| Be-7 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Na-24 | 1.06E+04 | 1.06E+04 | 1.06E+04 | 1.06E+04 | 1.06E+04 | 1.06E+04 | 1.06E+04 |
| P-32 | 2.03E+06 | 1.12E+05 | 7.74E+04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.61E+04 |
| Cr-51 | 0.00E+00 | 0.00E+00 | 8.95E+01 | 5.75E+01 | 1.32E+01 | 1.28E+04 | 3.57E+02 |
| Mn-54 | 0.00E+00 | 2.53E+04 | 4.98E+03 | 0.00E+00 | 4.98E+03 | 1.00E+06 | 7.06E+03 |
| Mn-56 | 0.00E+00 | 1.54E+00 | 2.21E-01 | 0.00E+00 | 1.10E+00 | 1.25E+04 | 7.17E+04 |
| Fe-55 | 1.97E+04 | 1.17E+04 | 3.33E+03 | 0.00E+00 | 0.00E+00 | 8.69E+04 | 1.09E+03 |
| Fe-59 | 1.36E+04 | 2.35E+04 | 9.48E+03 | 0.00E+00 | 0.00E+00 | 1.02E+06 | 2.48E+04 |
| Co-58 | 0.00E+00 | 1.22E+03 | 1.82E+03 | 0.00E+00 | 0.00E+00 | 7.77E+05 | 1.11E+04 |
| Co-60 | 0.00E+00 | 8.02E+03 | 1.18E+04 | 0.00E+00 | 0.00E+00 | 4.51E+06 | 3.19E+04 |
| Ni-63 | 3.39E+05 | 2.04E+04 | 1.16E+04 | 0.00E+00 | 0.00E+00 | 2.09E+05 | 2.42E+03 |
| Ni-65 | 2.39E+00 | 2.84E-01 | 1.23E-01 | 0.00E+00 | 0.00E+00 | 8.12E+03 | 5.01E+04 |
| Cu-64 | 0.00E+00 | 1.88E+00 | 7.74E-01 | 0.00E+00 | 3.98E+00 | 9.30E+03 | 1.50E+04 |
| Zn-65 | 1.93E+04 | 6.26E+04 | 3.11E+04 | 0.00E+00 | 3.25E+04 | 6.47E+05 | 5.14E+04 |
| Zn-69 | 5.39E-02 | 9.67E-02 | 7.18E-03 | 0.00E+00 | 4.02E-02 | 1.47E+03 | 1.32E+04 |
| Br-83 | 0.00E+00 | 0.00E+00 | 3.81E+02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Br-84 | 0.00E+00 | 0.00E+00 | 4.00E+02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Br-85 | 0.00E+00 | 0.00E+00 | 2.04E+01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Rb-86 | 0.00E+00 | 1.90E+05 | 8.82E+04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.04E+03 |
| Rb-88 | 0.00E+00 | 5.57E+02 | 2.87E+02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.39E+02 |
| Rb-89 | 0.00E+00 | 3.21E+02 | 2.06E+02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.82E+01 |
| Sr-89 | 3.98E+05 | 0.00E+00 | 1.14E+04 | 0.00E+00 | 0.00E+00 | 2.03E+06 | 6.40E+04 |
| Sr-90 | 4.09E+07 | 0.00E+00 | 2.59E+06 | 0.00E+00 | 0.00E+00 | 1.12E+07 | 1.31E+05 |
| Sr-91 | 9.56E+01 | 0.00E+00 | 3.46E+00 | 0.00E+00 | 0.00E+00 | 5.26E+04 | 7.34E+04 |
| Sr-92 | 1.05E+01 | 0.00E+00 | 3.91E-01 | 0.00E+00 | 0.00E+00 | 2.38E+04 | 1.40E+05 |
| Y-90 | 3.29E+03 | 0.00E+00 | 8.82E+01 | 0.00E+00 | 0.00E+00 | 2.69E+05 | 1.04E+05 |
| Y-91m | 4.07E-01 | 0.00E+00 | 1.39E-02 | 0.00E+00 | 0.00E+00 | 2.79E+03 | 2.35E+03 |
| Y-91 | 5.88E+05 | 0.00E+00 | 1.57E+04 | 0.00E+00 | 0.00E+00 | 2.45E+06 | 7.03E+04 |
| Y-92 | 1.64E+01 | 0.00E+00 | 4.61E-01 | 0.00E+00 | 0.00E+00 | 2.45E+04 | 1.27E+05 |
| Y-93 | 1.50E+02 | 0.00E+00 | 4.07E+00 | 0.00E+00 | 0.00E+00 | 7.64E+04 | 1.67E+05 |
| Zr-95 | 1.15E+05 | 2.79E+04 | 2.03E+04 | 0.00E+00 | 3.11E+04 | 1.75E+06 | 2.17E+04 |
| Zr-97 | 1.50E+02 | 2.56E+01 | 1.17E+01 | 0.00E+00 | 2.59E+01 | 1.10E+05 | 1.40E+05 |
| Nb-95 | 1.57E+04 | 6.43E+03 | 3.78E+03 | 0.00E+00 | 4.72E+03 | 4.79E+05 | 1.27E+04 |
| Mo-99 | 0.00E+00 | 1.65E+02 | 3.23E+01 | 0.00E+00 | 2.65E+02 | 1.35E+05 | 4.87E+04 |
| Tc-99m | 1.40E-03 | 2.88E-03 | 3.72E-02 | 0.00E+00 | 3.11E-02 | 8.11E+02 | 2.03E+03 |
| Tc-101 | 6.51E-05 | 8.23E-05 | 8.12E-04 | 0.00E+00 | 9.79E-04 | 5.84E+02 | 8.44E+02 |
| Ru-103 | 2.02E+03 | 0.00E+00 | 6.79E+02 | 0.00E+00 | 4.24E+03 | 5.52E+05 | 1.61E+04 |
| Ru-105 | 1.22E+00 | 0.00E+00 | 4.10E-01 | 0.00E+00 | 8.99E-01 | 1.57E+04 | 4.84E+04 |
| Ru-106 | 8.68E+04 | 0.00E+00 | 1.09E+04 | 0.00E+00 | 1.07E+05 | 1.16E+07 | 1.64E+05 |
| Ag-110m | 9.98E+03 | 7.22E+03 | 5.00E+03 | 0.00E+00 | 1.09E+04 | 3.67E+06 | 3.30E+04 |
| Sb-122 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Sb-124 | 3.79E+04 | 5.56E+02 | 1.20E+04 | 1.01E+02 | 0.00E+00 | 2.65E+06 | 5.91E+04 |
| Sb-125 | 5.17E+04 | 4.77E+02 | 1.09E+04 | 6.23E+01 | 0.00E+00 | 1.64E+06 | 1.47E+04 |

Table 3-10d

INFANT INHALATION Ri(I) (mrem/yr per uCi/$m^3$)

| Isotope | BONE | LIVER | TOT BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| Te-125m | 4.76E+03 | 1.99E+03 | 6.58E+02 | 1.62E+03 | 0.00E+00 | 4.47E+05 | 1.29E+04 |
| Te-127m | 1.67E+04 | 6.90E+03 | 2.07E+03 | 4.87E+03 | 3.75E+04 | 1.31E+06 | 2.73E+04 |
| Te-127 | 2.23E+04 | 9.53E-01 | 4.89E-01 | 1.85E+00 | 4.86E+00 | 1.03E+04 | 2.44E+04 |
| Te-129m | 1.41E+04 | 6.09E+03 | 2.23E+03 | 5.47E+03 | 3.18E+04 | 1.68E+06 | 6.90E+04 |
| Te-129 | 7.88E-02 | 3.47E-02 | 1.88E-02 | 6.75E-02 | 1.75E-01 | 3.00E+03 | 2.63E+04 |
| Te-131m | 1.07E+02 | 5.50E+01 | 3.63E+01 | 8.93E+01 | 2.65E+02 | 1.99E+05 | 1.19E+05 |
| Te-131 | 1.74E-02 | 8.22E-03 | 5.00E-03 | 1.58E-02 | 3.99E-02 | 2.06E+03 | 8.22E+03 |
| Te-132 | 3.72E+02 | 2.37E+02 | 1.76E+02 | 2.79E+02 | 1.03E+03 | 3.40E+05 | 4.41E+04 |
| I-130 | 6.36E+03 | 1.39E+04 | 5.57E+03 | 1.60E+06 | 1.53E+04 | 0.00E+00 | 1.99E+03 |
| I-131 | 3.79E+04 | 4.44E+04 | 1.96E+04 | 1.48E+07 | 5.18E+04 | 0.00E+00 | 1.06E+03 |
| I-132 | 1.69E+03 | 3.54E+03 | 1.26E+03 | 1.69E+05 | 3.95E+03 | 0.00E+00 | 1.90E+03 |
| I-133 | 1.32E+04 | 1.92E+04 | 5.60E+03 | 3.56E+06 | 2.24E+04 | 0.00E+00 | 2.16E+03 |
| I-134 | 9.21E+02 | 1.88E+03 | 6.65E+02 | 4.45E+04 | 2.09E+03 | 0.00E+00 | 1.29E+03 |
| I-135 | 3.86E+03 | 7.60E+03 | 2.77E+03 | 6.96E+05 | 8.47E+03 | 0.00E+00 | 1.83E+03 |
| Cs-134 | 3.96E+05 | 7.03E+05 | 7.45E+04 | 0.00E+00 | 1.90E+05 | 7.97E+04 | 1.33E+03 |
| Cs-136 | 4.83E+04 | 1.35E+05 | 5.29E+04 | 0.00E+00 | 5.64E+04 | 1.18E+04 | 1.43E+03 |
| Cs-137 | 5.49E+05 | 6.12E+05 | 4.55E+04 | 0.00E+00 | 1.72E+05 | 7.13E+04 | 1.33E+03 |
| Cs-138 | 5.05E+02 | 7.81E+02 | 3.98E+02 | 0.00E+00 | 4.10E+02 | 6.54E+01 | 8.76E+02 |
| Ba-139 | 1.48E+00 | 9.84E-04 | 4.30E-02 | 0.00E+00 | 5.92E-04 | 5.95E+03 | 5.10E+04 |
| Ba-140 | 5.60E+04 | 5.60E+01 | 2.90E+03 | 0.00E+00 | 1.34E+01 | 1.60E+06 | 3.84E+04 |
| Ba-141 | 1.57E-01 | 1.08E-04 | 4.97E-03 | 0.00E+00 | 6.50E-05 | 2.97E+03 | 4.75E+03 |
| Ba-142 | 3.98E-02 | 3.30E-05 | 1.96E-03 | 0.00E+00 | 1.90E-05 | 1.55E+03 | 6.93E+02 |
| La-140 | 5.05E+02 | 2.00E+02 | 5.15E+01 | 0.00E+00 | 0.00E+00 | 1.68E+05 | 8.48E+04 |
| La-142 | 1.03E+00 | 3.77E-01 | 9.04E-02 | 0.00E+00 | 0.00E+00 | 8.22E+03 | 5.95E+04 |
| Ce-141 | 2.77E+04 | 1.67E+04 | 1.99E+03 | 0.00E+00 | 5.25E+03 | 5.17E+05 | 2.16E+04 |
| Ce-143 | 2.93E+02 | 1.93E+02 | 2.21E+01 | 0.00E+00 | 5.64E+01 | 1.16E+05 | 4.97E+04 |
| Ce-144 | 3.19E+06 | 1.21E+06 | 1.76E+05 | 0.00E+00 | 5.38E+05 | 9.84E+06 | 1.48E+05 |
| Pr-143 | 1.40E+04 | 5.24E+03 | 6.99E+02 | 0.00E+00 | 1.97E+03 | 4.33E+05 | 3.72E+04 |
| Pr-144 | 4.79E-02 | 1.85E-02 | 2.41E-03 | 0.00E+00 | 6.72E-03 | 1.61E+03 | 4.28E+03 |
| Nd-147 | 7.94E+03 | 8.13E+03 | 5.00E+02 | 0.00E+00 | 3.15E+03 | 3.22E+05 | 3.12E+04 |
| W-187 | 1.30E+01 | 9.02E+00 | 3.12E+00 | 0.00E+00 | 0.00E+00 | 3.96E+04 | 3.56E+04 |
| Np-239 | 3.71E+02 | 3.32E+01 | 1.88E+01 | 0.00E+00 | 6.62E+01 | 5.95E+04 | 2.49E+04 |
| K-40 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Co-57 | 0.00E+00 | 6.51E+02 | 6.41E+02 | 0.00E+00 | 0.00E+00 | 3.79E+05 | 4.86E+03 |
| Sr-85 | 3.78E+04 | 0.00E+00 | 7.56E+03 | 0.00E+00 | 0.00E+00 | 4.20E+05 | 6.72E+03 |
| Y-88 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nb-94 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nb-97 | 3.42E-01 | 7.29E-02 | 2.63E-02 | 0.00E+00 | 5.70E-02 | 3.32E+03 | 2.69E+04 |
| Cd-109 | 0.00E+00 | 3.64E+05 | 1.40E+04 | 0.00E+00 | 2.80E+05 | 8.68E+05 | 1.12E+04 |
| Sn-113 | 8.40E+04 | 2.24E+03 | 5.04E+03 | 1.82E+03 | 0.00E+00 | 1.09E+06 | 1.68E+03 |
| Ba-133 | 2.66E+05 | 2.38E+03 | 1.82E+04 | 0.00E+00 | 1.25E+01 | 1.27E+06 | 1.08E+04 |
| Te-134 | 4.45E-02 | 2.86E-02 | 2.35E-02 | 4.07E-02 | 1.34E-01 | 4.10E+03 | 3.54E+03 |
| Ce-139 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Hg-203 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

Table 3-11a

ADULT INGESTION (Leafy Vegetable) Ri(V)

$m^2$ * mrem/yr per uCi/sec (H-3: mrem/yr per uCi/$m^3$)

| Isotope | BONE | LIVER | TOT BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| H-3 | 0.00E+00 | 2.26E+03 | 2.26E+03 | 2.26E+03 | 2.26E+03 | 2.26E+03 | 2.26E+03 |
| Be-7 | 9.36E+04 | 2.11E+05 | 1.05E+05 | 0.00E+00 | 2.22E+05 | 0.00E+00 | 3.65E+07 |
| Na-24 | 2.69E+05 | 2.69E+05 | 2.69E+05 | 2.69E+05 | 2.69E+05 | 2.69E+05 | 2.69E+05 |
| P-32 | 1.40E+09 | 8.73E+07 | 5.43E+07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.58E+08 |
| Cr-51 | 0.00E+00 | 0.00E+00 | 4.64E+04 | 2.78E+04 | 1.02E+04 | 6.16E+04 | 1.17E+07 |
| Mn-54 | 0.00E+00 | 3.13E+08 | 5.97E+07 | 0.00E+00 | 9.31E+07 | 0.00E+00 | 9.58E+08 |
| Mn-56 | 0.00E+00 | 1.59E+01 | 2.82E+00 | 0.00E+00 | 2.02E+01 | 0.00E+00 | 5.07E+02 |
| Fe-55 | 2.10E+08 | 1.45E+08 | 3.38E+07 | 0.00E+00 | 0.00E+00 | 8.08E+07 | 8.31E+07 |
| Fe-59 | 1.26E+08 | 2.96E+08 | 1.13E+08 | 0.00E+00 | 0.00E+00 | 8.27E+07 | 9.86E+08 |
| Co-58 | 0.00E+00 | 3.07E+07 | 6.89E+07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.23E+08 |
| Co-60 | 0.00E+00 | 1.67E+08 | 3.69E+08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.14E+09 |
| Ni-63 | 1.04E+10 | 7.21E+08 | 3.49E+08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.50E+08 |
| Ni-65 | 6.15E+01 | 7.99E+00 | 3.64E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.03E+02 |
| Cu-64 | 0.00E+00 | 9.20E+03 | 4.32E+03 | 0.00E+00 | 2.32E+04 | 0.00E+00 | 7.84E+05 |
| Zn-65 | 3.17E+08 | 1.01E+09 | 4.56E+08 | 0.00E+00 | 6.75E+08 | 0.00E+00 | 6.36E+08 |
| Zn-69 | 8.73E-06 | 1.67E-05 | 1.16E-06 | 0.00E+00 | 1.09E-05 | 0.00E+00 | 2.51E-06 |
| Br-83 | 0.00E+00 | 0.00E+00 | 3.11E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.47E+00 |
| Br-84 | 0.00E+00 | 0.00E+00 | 2.48E-11 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.94E-16 |
| Br-85 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Rb-86 | 0.00E+00 | 2.19E+08 | 1.02E+08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.33E+07 |
| Rb-88 | 0.00E+00 | 3.43E-22 | 1.82E-22 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.74E-33 |
| Rb-89 | 0.00E+00 | 1.39E-26 | 9.74E-27 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 8.05E-40 |
| Sr-89 | 9.96E+09 | 0.00E+00 | 2.86E+08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.60E+09 |
| Sr-90 | 6.05E+11 | 0.00E+00 | 1.48E+11 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.75E+10 |
| Sr-91 | 3.05E+05 | 0.00E+00 | 1.23E+04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.45E+06 |
| Sr-92 | 4.27E+02 | 0.00E+00 | 1.85E+01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 8.45E+03 |
| Y-90 | 1.33E+04 | 0.00E+00 | 3.56E+02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.41E+08 |
| Y-91m | 5.22E-09 | 0.00E+00 | 2.02E-10 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.53E-08 |
| Y-91 | 5.11E+06 | 0.00E+00 | 1.37E+05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.81E+09 |
| Y-92 | 9.15E-01 | 0.00E+00 | 2.68E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.60E+04 |
| Y-93 | 1.70E+02 | 0.00E+00 | 4.68E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.38E+06 |
| Zr-95 | 1.17E+06 | 3.77E+05 | 2.55E+05 | 0.00E+00 | 5.91E+05 | 0.00E+00 | 1.19E+09 |
| Zr-97 | 3.37E+02 | 6.81E+01 | 3.11E+01 | 0.00E+00 | 1.03E+02 | 0.00E+00 | 2.11E+07 |
| Nb-95 | 1.43E+05 | 7.94E+04 | 4.27E+04 | 0.00E+00 | 7.85E+04 | 0.00E+00 | 4.82E+08 |
| Mo-99 | 0.00E+00 | 6.15E+06 | 1.17E+06 | 0.00E+00 | 1.39E+07 | 0.00E+00 | 1.43E+07 |
| Tc-99m | 3.10E+00 | 8.77E+00 | 1.12E+02 | 0.00E+00 | 1.33E+02 | 4.30E+00 | 5.19E+03 |
| Tc-101 | 8.22E-31 | 1.18E-30 | 1.16E-29 | 0.00E+00 | 2.13E-29 | 6.05E-31 | 3.56E-42 |
| Ru-103 | 4.76E+06 | 0.00E+00 | 2.05E+06 | 0.00E+00 | 1.82E+07 | 0.00E+00 | 5.56E+08 |
| Ru-105 | 5.39E+01 | 0.00E+00 | 2.13E+01 | 0.00E+00 | 6.96E+02 | 0.00E+00 | 3.29E+04 |
| Ru-106 | 1.93E+08 | 0.00E+00 | 2.44E+07 | 0.00E+00 | 3.72E+08 | 0.00E+00 | 1.25E+10 |
| Ag-110m | 1.05E+07 | 9.75E+06 | 5.79E+06 | 0.00E+00 | 1.92E+07 | 0.00E+00 | 3.98E+09 |
| Sb-122 | 2.80E+05 | 6.43E+03 | 9.65E+04 | 4.34E+03 | 0.00E+00 | 1.68E+05 | 1.06E+08 |
| Sb-124 | 1.04E+08 | 1.96E+06 | 4.07E+07 | 2.52E+05 | 0.00E+00 | 8.07E+07 | 2.94E+09 |
| Sb-125 | 1.37E+08 | 1.53E+06 | 3.25E+07 | 1.39E+05 | 0.00E+00 | 1.05E+08 | 1.50E+09 |

Table 3-11a

ADULT INGESTION (Leafy Vegetable) Ri(V)

$m^2$ * mrem/yr per uCi/sec (H-3: mrem/yr per $uCi/m^3$ )

| Isotope | BONE | LIVER | TOT BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| Te-125m | 9.66E+07 | 3.50E+07 | 1.29E+07 | 2.90E+07 | 3.93E+08 | 0.00E+00 | 3.86E+08 |
| Te-127m | 3.49E+08 | 1.25E+08 | 4.26E+07 | 8.92E+07 | 1.42E+09 | 0.00E+00 | 1.17E+09 |
| Te-127 | 5.66E+03 | 2.03E+03 | 1.22E+03 | 4.19E+03 | 2.31E+04 | 0.00E+00 | 4.47E+05 |
| Te-129m | 2.51E+08 | 9.38E+07 | 3.98E+07 | 8.63E+07 | 1.05E+09 | 0.00E+00 | 1.27E+09 |
| Te-129 | 7.62E-04 | 2.87E-04 | 1.86E-04 | 5.85E-04 | 3.20E-03 | 0.00E+00 | 5.75E-04 |
| Te-131m | 9.12E+05 | 4.46E+05 | 3.72E+05 | 7.06E+05 | 4.52E+06 | 0.00E+00 | 4.43E+07 |
| Te-131 | 1.50E-15 | 6.27E-16 | 4.74E-16 | 1.23E-15 | 6.57E-15 | 0.00E+00 | 2.13E-16 |
| Te-132 | 4.30E+06 | 2.78E+06 | 2.61E+06 | 3.07E+06 | 2.68E+07 | 0.00E+00 | 1.32E+08 |
| I-130 | 3.92E+05 | 1.16E+06 | 4.57E+05 | 9.81E+07 | 1.81E+06 | 0.00E+00 | 9.96E+05 |
| I-131 | 8.08E+07 | 1.16E+08 | 6.62E+07 | 3.79E+10 | 1.98E+08 | 0.00E+00 | 3.05E+07 |
| I-132 | 5.76E+01 | 1.54E+02 | 5.39E+01 | 5.39E+03 | 2.45E+02 | 0.00E+00 | 2.89E+01 |
| I-133 | 2.09E+06 | 3.63E+06 | 1.11E+06 | 5.33E+08 | 6.33E+06 | 0.00E+00 | 3.26E+06 |
| I-134 | 9.65E-05 | 2.62E-04 | 9.38E-05 | 4.54E-03 | 4.17E-04 | 0.00E+00 | 2.29E-07 |
| I-135 | 3.90E+04 | 1.02E+05 | 3.77E+04 | 6.73E+06 | 1.64E+05 | 0.00E+00 | 1.15E+05 |
| Cs-134 | 4.67E+09 | 1.11E+10 | 9.08E+09 | 0.00E+00 | 3.59E+09 | 1.19E+09 | 1.94E+08 |
| Cs-136 | 4.24E+07 | 1.68E+08 | 1.21E+08 | 0.00E+00 | 9.32E+07 | 1.28E+07 | 1.90E+07 |
| Cs-137 | 6.36E+09 | 8.70E+09 | 5.70E+09 | 0.00E+00 | 2.95E+09 | 9.81E+08 | 1.68E+08 |
| Cs-138 | 3.91E-11 | 7.73E-11 | 3.83E-11 | 0.00E+00 | 5.68E-11 | 5.61E-12 | 3.30E-16 |
| Ba-139 | 2.68E-02 | 1.91E-05 | 7.86E-04 | 0.00E+00 | 1.79E-05 | 1.08E-05 | 4.76E-02 |
| Ba-140 | 1.28E+08 | 1.61E+05 | 8.38E+06 | 0.00E+00 | 5.46E+04 | 9.20E+04 | 2.63E+08 |
| Ba-141 | 1.15E-21 | 8.70E-25 | 3.89E-23 | 0.00E+00 | 8.09E-25 | 4.94E-25 | 5.43E-31 |
| Ba-142 | 2.46E-39 | 2.53E-42 | 1.55E-40 | 0.00E+00 | 2.14E-42 | 1.43E-42 | 0.00E+00 |
| La-140 | 1.98E+03 | 9.98E+02 | 2.64E+02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.33E+07 |
| La-142 | 1.41E-04 | 6.43E-05 | 1.60E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.69E-01 |
| Ce-141 | 1.97E+05 | 1.33E+05 | 1.51E+04 | 0.00E+00 | 6.19E+04 | 0.00E+00 | 5.10E+08 |
| Ce-143 | 9.98E+02 | 7.38E+05 | 8.16E+01 | 0.00E+00 | 3.25E+02 | 0.00E+00 | 2.76E+07 |
| Ce-144 | 3.29E+07 | 1.38E+07 | 1.77E+06 | 0.00E+00 | 8.16E+06 | 0.00E+00 | 1.11E+10 |
| Pr-143 | 6.26E+04 | 2.51E+04 | 3.10E+03 | 0.00E+00 | 1.45E+04 | 0.00E+00 | 2.74E+08 |
| Pr-144 | 3.09E-26 | 1.28E-26 | 1.57E-27 | 0.00E+00 | 7.23E-27 | 0.00E+00 | 4.44E-33 |
| Nd-147 | 3.33E+04 | 3.85E+04 | 2.31E+03 | 0.00E+00 | 2.25E+04 | 0.00E+00 | 1.85E+08 |
| W-187 | 3.82E+04 | 3.19E+04 | 1.12E+04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.05E+07 |
| Np-239 | 1.43E+03 | 1.41E+02 | 7.76E+01 | 0.00E+00 | 4.39E+02 | 0.00E+00 | 2.89E+07 |
| K-40 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Co-57 | 0.00E+00 | 1.17E+07 | 1.95E+07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.97E+08 |
| Sr-85 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Y-88 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nb-94 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nb-97 | 2.15E-06 | 5.45E-07 | 1.99E-07 | 0.00E+00 | 6.35E-07 | 0.00E+00 | 2.01E-03 |
| Cd-109 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Sn-113 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Ba-133 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Te-134 | 3.56E-08 | 2.33E-08 | 1.43E-08 | 3.11E-08 | 2.25E-07 | 0.00E+00 | 3.95E-11 |
| Ce-139 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Hg-203 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

Table 3-11b

TEEN INGESTION (Leafy Vegetable) Ri(V)

$m^2$ * mrem/yr per uCi/sec (H-3: mrem/yr per uCi/$m^3$)

| Isotope | BONE | LIVER | TOT BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| H-3 | 0.00E+00 | 2.59E+03 | 2.59E+03 | 2.59E+03 | 2.59E+03 | 2.59E+03 | 2.59E+03 |
| Be-7 | 1.43E+05 | 3.20E+05 | 1.60E+05 | 0.00E+00 | 3.39E+05 | 0.00E+00 | 3.90E+07 |
| Na-24 | 2.39E+05 | 2.39E+05 | 2.39E+05 | 2.39E+05 | 2.39E+05 | 2.39E+05 | 2.39E+05 |
| P-32 | 1.61E+09 | 9.97E+07 | 6.24E+07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.35E+08 |
| Cr-51 | 0.00E+00 | 0.00E+00 | 6.17E+04 | 3.43E+04 | 1.35E+04 | 8.81E+04 | 1.04E+07 |
| Mn-54 | 0.00E+00 | 4.54E+08 | 9.01E+07 | 0.00E+00 | 1.36E+08 | 0.00E+00 | 9.32E+08 |
| Mn-56 | 0.00E+00 | 1.43E+01 | 2.55E+00 | 0.00E+00 | 1.81E+01 | 0.00E+00 | 9.44E+02 |
| Fe-55 | 3.26E+08 | 2.31E+08 | 5.39E+07 | 0.00E+00 | 0.00E+00 | 1.47E+08 | 1.00E+08 |
| Fe-59 | 1.79E+08 | 4.18E+08 | 1.61E+08 | 0.00E+00 | 0.00E+00 | 1.32E+08 | 9.88E+08 |
| Co-58 | 0.00E+00 | 4.36E+07 | 1.00E+08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.01E+08 |
| Co-60 | 0.00E+00 | 2.49E+08 | 5.60E+08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.24E+09 |
| Ni-63 | 1.61E+10 | 1.13E+09 | 5.45E+08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.81E+08 |
| Ni-65 | 5.72E+01 | 7.31E+00 | 3.33E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.97E+02 |
| Cu-64 | 0.00E+00 | 8.34E+03 | 3.92E+03 | 0.00E+00 | 2.11E+04 | 0.00E+00 | 6.47E+05 |
| Zn-65 | 4.24E+08 | 1.47E+09 | 6.86E+08 | 0.00E+00 | 9.42E+08 | 0.00E+00 | 6.23E+08 |
| Zn-69 | 8.18E-06 | 1.56E-05 | 1.09E-06 | 0.00E+00 | 1.02E-05 | 0.00E+00 | 2.87E-05 |
| Br-83 | 0.00E+00 | 0.00E+00 | 2.91E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Br-84 | 0.00E+00 | 0.00E+00 | 2.25E-11 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Br-85 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Rb-86 | 0.00E+00 | 2.74E+08 | 1.29E+08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.05E+07 |
| Rb-88 | 0.00E+00 | 3.17E-22 | 1.69E-22 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.71E-29 |
| Rb-89 | 0.00E+00 | 1.25E-26 | 8.82E-27 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.91E-35 |
| Sr-89 | 1.51E+10 | 0.00E+00 | 4.33E+08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.80E+09 |
| Sr-90 | 7.51E+11 | 0.00E+00 | 1.85E+11 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.11E+10 |
| Sr-91 | 2.85E+05 | 0.00E+00 | 1.13E+04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.29E+06 |
| Sr-92 | 3.97E+02 | 0.00E+00 | 1.69E+01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.01E+04 |
| Y-90 | 1.24E+04 | 0.00E+00 | 3.34E+02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.02E+08 |
| Y-91m | 4.86E-09 | 0.00E+00 | 1.86E-10 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.29E-07 |
| Y-91 | 7.84E+06 | 0.00E+00 | 2.10E+05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.21E+09 |
| Y-92 | 8.60E-01 | 0.00E+00 | 2.49E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.36E+04 |
| Y-93 | 1.59E+02 | 0.00E+00 | 4.36E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.86E+06 |
| Zr-95 | 1.72E+06 | 5.43E+05 | 3.73E+05 | 0.00E+00 | 7.98E+05 | 0.00E+00 | 1.25E+09 |
| Zr-97 | 3.12E+02 | 6.18E+01 | 2.85E+01 | 0.00E+00 | 9.37E+01 | 0.00E+00 | 1.67E+07 |
| Nb-95 | 1.93E+05 | 1.07E+05 | 5.89E+04 | 0.00E+00 | 1.04E+05 | 0.00E+00 | 4.57E+08 |
| Mo-99 | 0.00E+00 | 5.65E+06 | 1.08E+06 | 0.00E+00 | 1.29E+07 | 0.00E+00 | 1.01E+07 |
| Tc-99m | 2.74E+00 | 7.63E+00 | 9.89E+01 | 0.00E+00 | 1.14E+02 | 4.24E+00 | 5.01E+03 |
| Tc-101 | 7.64E-31 | 1.09E-30 | 1.07E-29 | 0.00E+00 | 1.97E-29 | 6.62E-31 | 1.86E-37 |
| Ru-103 | 6.81E+06 | 0.00E+00 | 2.91E+06 | 0.00E+00 | 2.40E+07 | 0.00E+00 | 5.69E+08 |
| Ru-105 | 5.00E+01 | 0.00E+00 | 1.94E+01 | 0.00E+00 | 6.31E+02 | 0.00E+00 | 4.04E+04 |
| Ru-106 | 3.10E+08 | 0.00E+00 | 3.90E+07 | 0.00E+00 | 5.97E+08 | 0.00E+00 | 1.48E+10 |
| Ag-110m | 1.52E+07 | 1.43E+07 | 8.72E+06 | 0.00E+00 | 2.74E+07 | 0.00E+00 | 4.03E+09 |
| Sb-122 | 3.03E+05 | 5.89E+03 | 8.85E+04 | 3.85E+03 | 0.00E+00 | 1.89E+05 | 6.35E+07 |
| Sb-124 | 1.54E+08 | 2.84E+06 | 6.02E+07 | 3.50E+05 | 0.00E+00 | 1.34E+08 | 3.11E+09 |
| Sb-125 | 2.14E+08 | 2.34E+06 | 5.00E+07 | 2.04E+05 | 0.00E+00 | 1.86E+08 | 1.66E+09 |

Table 3-11b

TEEN INGESTION (Leafy Vegetable) Ri(V)

$m^2$ * mrem/yr per uCi/sec (H-3: mrem/yr per uCi/$m^3$)

| Isotope | BONE | LIVER | TOT BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| Te-125m | 1.48E+08 | 5.34E+07 | 1.98E+07 | 4.14E+07 | 0.00E+00 | 0.00E+00 | 4.37E+08 |
| Te-127m | 5.51E+08 | 1.96E+08 | 6.56E+07 | 1.31E+08 | 2.24E+09 | 0.00E+00 | 1.37E+09 |
| Te-127 | 5.34E+03 | 1.89E+03 | 1.15E+03 | 3.68E+03 | 2.16E+04 | 0.00E+00 | 4.12E+05 |
| Te-129m | 3.62E+08 | 1.34E+08 | 5.73E+07 | 1.17E+08 | 1.51E+09 | 0.00E+00 | 1.36E+09 |
| Te-129 | 7.14E-04 | 2.66E-04 | 1.74E-04 | 5.10E-04 | 3.00E-03 | 0.00E+00 | 3.90E-03 |
| Te-131m | 8.44E+05 | 4.05E+05 | 3.38E+05 | 6.09E+05 | 4.22E+06 | 0.00E+00 | 3.25E+07 |
| Te-131 | 1.39E-15 | 5.75E-16 | 4.36E-16 | 1.07E-15 | 6.10E-15 | 0.00E+00 | 1.14E-16 |
| Te-132 | 3.91E+06 | 2.47E+06 | 2.33E+06 | 2.61E+06 | 2.37E+07 | 0.00E+00 | 7.84E+07 |
| I-130 | 3.51E+05 | 1.01E+06 | 4.05E+05 | 8.28E+07 | 1.56E+06 | 0.00E+00 | 7.80E+05 |
| I-131 | 7.69E+07 | 1.08E+08 | 5.78E+07 | 3.14E+10 | 1.85E+08 | 0.00E+00 | 2.13E+07 |
| I-132 | 5.19E+01 | 1.36E+02 | 4.88E+01 | 4.58E+03 | 2.14E+02 | 0.00E+00 | 5.92E+01 |
| I-133 | 1.94E+06 | 3.29E+06 | 1.00E+06 | 4.59E+08 | 5.76E+06 | 0.00E+00 | 2.49E+06 |
| I-134 | 8.73E-05 | 2.31E-04 | 8.31E-05 | 3.85E-03 | 3.65E-04 | 0.00E+00 | 3.05E-06 |
| I-135 | 3.52E+04 | 9.07E+04 | 3.36E+04 | 5.83E+06 | 1.43E+05 | 0.00E+00 | 1.00E+05 |
| Cs-134 | 7.10E+09 | 1.67E+10 | 7.75E+09 | 0.00E+00 | 5.31E+09 | 2.03E+09 | 2.08E+08 |
| Cs-136 | 4.34E+07 | 1.71E+08 | 1.15E+08 | 0.00E+00 | 9.30E+07 | 1.47E+07 | 1.37E+07 |
| Cs-137 | 1.01E+10 | 1.35E+10 | 4.69E+09 | 0.00E+00 | 4.59E+09 | 1.78E+09 | 1.92E+08 |
| Cs-138 | 3.61E-11 | 6.93E-11 | 3.47E-11 | 0.00E+00 | 5.12E-11 | 5.96E-12 | 3.15E-14 |
| Ba-139 | 2.52E-02 | 1.78E-05 | 7.35E-04 | 0.00E+00 | 1.67E-05 | 1.22E-05 | 2.25E-01 |
| Ba-140 | 1.37E+08 | 1.68E+05 | 8.85E+06 | 0.00E+00 | 5.70E+04 | 1.13E+05 | 2.12E+08 |
| Ba-141 | 1.08E-21 | 8.04E-25 | 3.59E-23 | 0.00E+00 | 7.46E-25 | 5.50E-25 | 2.29E-27 |
| Ba-142 | 2.27E-39 | 2.27E-42 | 1.40E-40 | 0.00E+00 | 1.92E-42 | 1.51E-42 | 0.00E+00 |
| La-140 | 1.81E+03 | 8.89E+02 | 2.37E+02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.11E+07 |
| La-142 | 1.30E-04 | 5.76E-05 | 1.43E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.75E+00 |
| Ce-141 | 2.83E+05 | 1.89E+05 | 2.17E+04 | 0.00E+00 | 8.89E+04 | 0.00E+00 | 5.40E+08 |
| Ce-143 | 9.33E+02 | 6.79E+05 | 7.58E+01 | 0.00E+00 | 3.04E+02 | 0.00E+00 | 2.04E+07 |
| Ce-144 | 5.27E+07 | 2.18E+07 | 2.83E+06 | 0.00E+00 | 1.30E+07 | 0.00E+00 | 1.33E+10 |
| Pr-143 | 7.00E+04 | 2.80E+04 | 3.49E+03 | 0.00E+00 | 1.63E+04 | 0.00E+00 | 2.30E+08 |
| Pr-144 | 2.89E-26 | 1.18E-26 | 1.47E-27 | 0.00E+00 | 6.80E-27 | 0.00E+00 | 3.19E-29 |
| Nd-147 | 3.62E+04 | 3.94E+04 | 2.36E+03 | 0.00E+00 | 2.31E+04 | 0.00E+00 | 1.42E+08 |
| W-187 | 3.55E+04 | 2.90E+04 | 1.02E+04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.84E+06 |
| Np-239 | 1.39E+03 | 1.31E+02 | 7.28E+01 | 0.00E+00 | 4.11E+02 | 0.00E+00 | 2.11E+07 |
| K-40 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Co-57 | 0.00E+00 | 1.79E+07 | 3.00E+07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.33E+08 |
| Sr-85 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Y-88 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nb-94 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nb-97 | 2.00E-06 | 4.95E-07 | 1.81E-07 | 0.00E+00 | 5.79E-07 | 0.00E+00 | 1.18E-02 |
| Cd-109 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Sn-113 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Ba-133 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Te-134 | 3.23E-08 | 2.07E-08 | 2.17E-08 | 2.65E-08 | 1.98E-07 | 0.00E+00 | 1.20E-09 |
| Ce-139 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Hg-203 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

Table 3-11c

CHILD INGESTION (Leafy Vegetable) Ri(V)

$m^2$ * mrem/yr per uCi/sec (H-3: mrem/yr per uCi/$m^3$)

| Isotope | BONE | LIVER | TOT BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| H-3 | 0.00E+00 | 4.01E+03 | 4.01E+03 | 4.01E+03 | 4.01E+03 | 4.01E+03 | 4.01E+03 |
| Be-7 | 3.37E+05 | 5.72E+05 | 3.77E+05 | 0.00E+00 | 5.63E+05 | 0.00E+00 | 3.20E+07 |
| Na-24 | 3.73E+05 | 3.73E+05 | 3.73E+05 | 3.73E+05 | 3.73E+05 | 3.73E+05 | 3.73E+05 |
| P-32 | 3.37E+09 | 1.58E+08 | 1.30E+08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 9.31E+07 |
| Cr-51 | 0.00E+00 | 0.00E+00 | 1.17E+05 | 6.50E+04 | 1.78E+04 | 1.19E+05 | 6.21E+06 |
| Mn-54 | 0.00E+00 | 6.65E+08 | 1.77E+08 | 0.00E+00 | 1.86E+08 | 0.00E+00 | 5.58E+08 |
| Mn-56 | 0.00E+00 | 1.88E+01 | 4.24E+00 | 0.00E+00 | 2.27E+01 | 0.00E+00 | 2.72E+03 |
| Fe-55 | 8.01E+08 | 4.25E+08 | 1.32E+08 | 0.00E+00 | 0.00E+00 | 2.40E+08 | 7.87E+07 |
| Fe-59 | 3.97E+08 | 6.42E+08 | 3.20E+08 | 0.00E+00 | 0.00E+00 | 1.86E+08 | 6.68E+08 |
| Co-58 | 0.00E+00 | 6.44E+07 | 1.97E+08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.76E+08 |
| Co-60 | 0.00E+00 | 3.78E+08 | 1.12E+09 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.10E+09 |
| Ni-63 | 3.95E+10 | 2.11E+09 | 1.34E+09 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.42E+08 |
| Ni-65 | 1.05E+02 | 9.89E+00 | 5.77E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.21E+03 |
| Cu-64 | 0.00E+00 | 1.10E+04 | 6.64E+03 | 0.00E+00 | 2.66E+04 | 0.00E+00 | 5.16E+05 |
| Zn-65 | 8.12E+08 | 2.16E+09 | 1.35E+09 | 0.00E+00 | 1.36E+09 | 0.00E+00 | 3.80E+08 |
| Zn-69 | 1.51E-05 | 2.18E-05 | 2.02E-06 | 0.00E+00 | 1.32E-05 | 0.00E+00 | 1.37E-03 |
| Br-83 | 0.00E+00 | 0.00E+00 | 5.37E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Br-84 | 0.00E+00 | 0.00E+00 | 3.82E-11 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Br-85 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Rb-86 | 0.00E+00 | 4.52E+08 | 2.78E+08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.91E+07 |
| Rb-88 | 0.00E+00 | 4.37E-22 | 3.04E-22 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.15E-23 |
| Rb-89 | 0.00E+00 | 1.64E-26 | 1.46E-26 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.43E-28 |
| Sr-89 | 3.59E+10 | 0.00E+00 | 1.03E+09 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.39E+09 |
| Sr-90 | 1.24E+12 | 0.00E+00 | 3.15E+11 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.67E+10 |
| Sr-91 | 5.24E+05 | 0.00E+00 | 1.98E+04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.16E+06 |
| Sr-92 | 7.28E+02 | 0.00E+00 | 2.92E+01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.38E+04 |
| Y-90 | 2.30E+04 | 0.00E+00 | 6.17E+02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.56E+07 |
| Y-91m | 8.91E-09 | 0.00E+00 | 3.24E-10 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.74E-05 |
| Y-91 | 1.86E+07 | 0.00E+00 | 4.99E+05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.48E+09 |
| Y-92 | 1.58E+00 | 0.00E+00 | 4.53E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.58E+04 |
| Y-93 | 2.93E+02 | 0.00E+00 | 8.04E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.37E+06 |
| Zr-95 | 3.86E+06 | 8.48E+05 | 7.55E+05 | 0.00E+00 | 1.21E+06 | 0.00E+00 | 8.84E+08 |
| Zr-97 | 5.70E+02 | 8.24E+01 | 4.86E+01 | 0.00E+00 | 1.18E+02 | 0.00E+00 | 1.25E+07 |
| Nb-95 | 4.12E+05 | 1.60E+05 | 1.15E+05 | 0.00E+00 | 1.51E+05 | 0.00E+00 | 2.97E+08 |
| Mo-99 | 0.00E+00 | 7.71E+06 | 1.91E+06 | 0.00E+00 | 1.65E+07 | 0.00E+00 | 6.38E+06 |
| Tc-99m | 4.71E+00 | 9.24E+00 | 1.53E+02 | 0.00E+00 | 1.34E+02 | 4.69E+00 | 5.26E+03 |
| Tc-101 | 1.41E-30 | 1.47E-30 | 1.87E-29 | 0.00E+00 | 2.51E-29 | 7.78E-31 | 4.68E-30 |
| Ru-103 | 1.53E+07 | 0.00E+00 | 5.88E+06 | 0.00E+00 | 3.85E+07 | 0.00E+00 | 3.96E+08 |
| Ru-105 | 9.16E+01 | 0.00E+00 | 3.32E+01 | 0.00E+00 | 8.05E+02 | 0.00E+00 | 5.98E+04 |
| Ru-106 | 7.45E+08 | 0.00E+00 | 9.30E+07 | 0.00E+00 | 1.01E+09 | 0.00E+00 | 1.16E+10 |
| Ag-110m | 3.21E+07 | 2.17E+07 | 1.73E+07 | 0.00E+00 | 4.04E+07 | 0.00E+00 | 2.58E+09 |
| Sb-122 | 5.58E+05 | 8.24E+03 | 1.64E+05 | 7.16E+03 | 0.00E+00 | 2.27E+05 | 4.30E+07 |
| Sb-124 | 3.52E+08 | 4.56E+06 | 1.23E+08 | 7.73E+05 | 0.00E+00 | 1.95E+08 | 2.20E+09 |
| Sb-125 | 4.99E+08 | 3.84E+06 | 1.05E+08 | 4.63E+05 | 0.00E+00 | 2.78E+08 | 1.19E+09 |

Table 3-11c

CHILD INGESTION (Leafy Vegetable) Ri(V)

$m^2$ * mrem/yr per uCi/sec (H-3: mrem/yr per $uCi/m^3$)

| Isotope | BONE | LIVER | TOT BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| Te-125m | 3.51E+08 | 9.50E+07 | 4.67E+07 | 9.84E+07 | 0.00E+00 | 0.00E+00 | 3.38E+08 |
| Te-127m | 1.32E+09 | 3.56E+08 | 1.57E+08 | 3.16E+08 | 3.77E+09 | 0.00E+00 | 1.07E+09 |
| Te-127 | 9.85E+03 | 2.65E+03 | 2.11E+03 | 6.81E+03 | 2.80E+04 | 0.00E+00 | 3.85E+05 |
| Te-129m | 8.41E+08 | 2.35E+08 | 1.31E+08 | 2.71E+08 | 2.47E+09 | 0.00E+00 | 1.03E+09 |
| Te-129 | 1.32E-03 | 3.69E-04 | 3.14E-04 | 9.43E-04 | 3.87E-03 | 0.00E+00 | 8.23E-02 |
| Te-131m | 1.54E+06 | 5.33E+05 | 5.68E+05 | 1.10E+06 | 5.16E+06 | 0.00E+00 | 2.16E+07 |
| Te-131 | 2.57E-15 | 7.83E-16 | 7.64E-16 | 1.97E-15 | 7.77E-15 | 0.00E+00 | 1.35E-14 |
| Te-132 | 7.00E+06 | 3.10E+06 | 3.74E+06 | 4.51E+06 | 2.88E+07 | 0.00E+00 | 3.12E+07 |
| I-130 | 6.16E+05 | 1.24E+06 | 6.41E+05 | 1.37E+08 | 1.86E+06 | 0.00E+00 | 5.82E+05 |
| I-131 | 1.43E+08 | 1.44E+08 | 8.17E+07 | 4.75E+10 | 2.36E+08 | 0.00E+00 | 1.28E+07 |
| I-132 | 9.22E+01 | 1.69E+02 | 7.79E+01 | 7.86E+03 | 2.59E+02 | 0.00E+00 | 1.99E+02 |
| I-133 | 3.53E+06 | 4.37E+06 | 1.65E+06 | 8.11E+08 | 7.28E+06 | 0.00E+00 | 1.76E+06 |
| I-134 | 1.55E-04 | 2.88E-04 | 1.32E-04 | 6.62E-03 | 4.40E-04 | 0.00E+00 | 1.91E-04 |
| I-135 | 6.26E+04 | 1.13E+05 | 5.33E+04 | 9.97E+06 | 1.73E+05 | 0.00E+00 | 8.58E+04 |
| Cs-134 | 1.60E+10 | 2.63E+10 | 5.55E+09 | 0.00E+00 | 8.15E+09 | 2.93E+09 | 1.42E+08 |
| Cs-136 | 8.17E+07 | 2.25E+08 | 1.45E+08 | 0.00E+00 | 1.20E+08 | 1.78E+07 | 7.90E+06 |
| Cs-137 | 2.39E+10 | 2.29E+10 | 3.38E+09 | 0.00E+00 | 7.46E+09 | 2.68E+09 | 1.43E+08 |
| Cs-138 | 6.57E-11 | 9.13E-11 | 5.79E-11 | 0.00E+00 | 6.43E-11 | 6.91E-12 | 4.21E-11 |
| Ba-139 | 4.65E-02 | 2.48E-05 | 1.35E-03 | 0.00E+00 | 2.17E-05 | 1.46E-05 | 2.69E+00 |
| Ba-140 | 2.75E+08 | 2.41E+05 | 1.60E+07 | 0.00E+00 | 7.84E+04 | 1.44E+05 | 1.39E+08 |
| Ba-141 | 1.99E-21 | 1.11E-24 | 6.47E-23 | 0.00E+00 | 9.62E-25 | 6.53E-24 | 1.13E-21 |
| Ba-142 | 4.11E-39 | 2.96E-42 | 2.29E-40 | 0.00E+00 | 2.39E-42 | 1.74E-42 | 5.36E-41 |
| La-140 | 3.25E+03 | 1.14E+03 | 3.83E+02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.17E+07 |
| La-142 | 2.35E-04 | 7.49E-05 | 2.35E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.48E+01 |
| Ce-141 | 6.56E+05 | 3.27E+05 | 4.86E+04 | 0.00E+00 | 1.43E+05 | 0.00E+00 | 4.08E+08 |
| Ce-143 | 1.72E+03 | 9.31E+05 | 1.35E+02 | 0.00E+00 | 3.91E+02 | 0.00E+00 | 1.36E+07 |
| Ce-144 | 1.27E+08 | 3.98E+07 | 6.78E+06 | 0.00E+00 | 2.21E+07 | 0.00E+00 | 1.04E+10 |
| Pr-143 | 1.46E+05 | 4.37E+04 | 7.23E+03 | 0.00E+00 | 2.37E+04 | 0.00E+00 | 1.57E+08 |
| Pr-144 | 5.37E-26 | 1.66E-26 | 2.70E-27 | 0.00E+00 | 8.79E-27 | 0.00E+00 | 3.58E-23 |
| Nd-147 | 7.15E+04 | 5.79E+04 | 4.48E+03 | 0.00E+00 | 3.18E+04 | 0.00E+00 | 9.17E+07 |
| W-187 | 6.47E+04 | 3.83E+04 | 1.72E+04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.38E+06 |
| Np-239 | 2.57E+03 | 1.84E+02 | 1.29E+02 | 0.00E+00 | 5.33E+02 | 0.00E+00 | 1.36E+07 |
| K-40 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Co-57 | 0.00E+00 | 2.99E+07 | 6.04E+07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.45E+08 |
| Sr-85 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Y-88 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nb-94 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nb-97 | 3.64E-06 | 6.57E-07 | 3.07E-07 | 0.00E+00 | 7.29E-07 | 0.00E+00 | 2.03E-01 |
| Cd-109 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Sn-113 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Ba-133 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Te-134 | 5.76E-08 | 2.59E-08 | 3.46E-08 | 4.56E-08 | 2.40E-07 | 0.00E+00 | 2.63E-07 |
| Ce-139 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Hg-203 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

Table 3-12a

ADULT GRASS/COW/MILK PATHWAY Ri(C)

$m^2$ * mrem/yr per uCi/sec (H-3: mrem/yr per $uCi/m^3$)

| Isotope | BONE | LIVER | TOT BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| H-3 | 0.00E+00 | 7.63E+02 | 7.63E+02 | 7.63E+02 | 7.63E+02 | 7.63E+02 | 7.63E+02 |
| Be-7 | 1.65E+03 | 3.73E+03 | 1.85E+03 | 0.00E+00 | 3.92E+03 | 0.00E+00 | 6.44E+05 |
| Na-24 | 2.44E+06 | 2.44E+06 | 2.44E+06 | 2.44E+06 | 2.44E+06 | 2.44E+06 | 2.44E+06 |
| P-32 | 1.71E+10 | 1.06E+09 | 6.61E+08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.92E+09 |
| Cr-51 | 0.00E+00 | 0.00E+00 | 2.86E+04 | 1.71E+04 | 6.30E+03 | 3.79E+04 | 7.19E+06 |
| Mn-54 | 0.00E+00 | 8.41E+06 | 1.61E+06 | 0.00E+00 | 2.50E+06 | 0.00E+00 | 2.58E+07 |
| Mn-56 | 0.00E+00 | 4.15E-03 | 7.36E-04 | 0.00E+00 | 5.27E-03 | 0.00E+00 | 1.32E-01 |
| Fe-55 | 2.51E+07 | 1.74E+07 | 4.05E+06 | 0.00E+00 | 0.00E+00 | 9.68E+06 | 9.95E+06 |
| Fe-59 | 2.97E+07 | 6.98E+07 | 2.67E+07 | 0.00E+00 | 0.00E+00 | 1.95E+07 | 2.33E+08 |
| Co-58 | 0.00E+00 | 4.71E+06 | 1.06E+07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 9.55E+07 |
| Co-60 | 0.00E+00 | 1.64E+07 | 3.62E+07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.08E+08 |
| Ni-63 | 6.73E+09 | 4.66E+08 | 2.26E+08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 9.73E+07 |
| Ni-65 | 3.70E-01 | 4.81E-02 | 2.19E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.22E+00 |
| Cu-64 | 0.00E+00 | 2.38E+04 | 1.12E+04 | 0.00E+00 | 6.01E+04 | 0.00E+00 | 2.03E+06 |
| Zn-65 | 1.37E+09 | 4.36E+09 | 1.97E+09 | 0.00E+00 | 2.92E+09 | 0.00E+00 | 2.75E+09 |
| Zn-69 | 5.18E-12 | 9.91E-12 | 6.89E-13 | 0.00E+00 | 6.44E-12 | 0.00E+00 | 1.49E-12 |
| Br-83 | 0.00E+00 | 0.00E+00 | 9.72E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.40E-01 |
| Br-84 | 0.00E+00 | 0.00E+00 | 1.61E-23 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.26E-28 |
| Br-85 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Rb-86 | 0.00E+00 | 2.59E+09 | 1.21E+09 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.12E+08 |
| Rb-88 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Rb-89 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Sr-89 | 1.45E+09 | 0.00E+00 | 4.16E+07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.33E+08 |
| Sr-90 | 4.68E+10 | 0.00E+00 | 1.15E+10 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.35E+09 |
| Sr-91 | 2.89E+04 | 0.00E+00 | 1.17E+03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.38E+05 |
| Sr-92 | 4.88E-01 | 0.00E+00 | 2.11E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 9.68E+00 |
| Y-90 | 7.07E+01 | 0.00E+00 | 1.90E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.49E+05 |
| Y-91m | 5.98E-20 | 0.00E+00 | 2.32E-21 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.76E-19 |
| Y-91 | 8.59E+03 | 0.00E+00 | 2.30E+02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.73E+06 |
| Y-92 | 5.58E-05 | 0.00E+00 | 1.63E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 9.77E-01 |
| Y-93 | 2.23E-01 | 0.00E+00 | 6.17E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.08E+03 |
| Zr-95 | 9.43E+02 | 3.02E+02 | 2.05E+02 | 0.00E+00 | 4.75E+02 | 0.00E+00 | 9.59E+05 |
| Zr-97 | 4.33E-01 | 8.74E-02 | 4.00E-02 | 0.00E+00 | 1.32E-01 | 0.00E+00 | 2.71E+04 |
| Nb-95 | 8.26E+04 | 4.60E+04 | 2.47E+04 | 0.00E+00 | 4.54E+04 | 0.00E+00 | 2.79E+08 |
| Mo-99 | 0.00E+00 | 2.48E+07 | 4.71E+06 | 0.00E+00 | 5.61E+07 | 0.00E+00 | 5.74E+07 |
| Tc-99m | 3.32E+00 | 9.38E+00 | 1.20E+02 | 0.00E+00 | 1.43E+02 | 4.60E+00 | 5.55E+03 |
| Tc-101 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Ru-103 | 1.02E+03 | 0.00E+00 | 4.38E+02 | 0.00E+00 | 3.88E+03 | 0.00E+00 | 1.19E+05 |
| Ru-105 | 8.57E-04 | 0.00E+00 | 3.38E-04 | 0.00E+00 | 1.11E-02 | 0.00E+00 | 5.24E-01 |
| Ru-106 | 2.04E+04 | 0.00E+00 | 2.58E+03 | 0.00E+00 | 3.94E+04 | 0.00E+00 | 1.32E+06 |
| Ag-110m | 5.82E+07 | 5.39E+07 | 3.20E+07 | 0.00E+00 | 1.06E+08 | 0.00E+00 | 2.20E+10 |
| Sb-122 | 2.24E+05 | 5.16E+03 | 7.73E+04 | 3.47E+03 | 0.00E+00 | 1.35E+05 | 8.52E+07 |
| Sb-124 | 2.57E+07 | 4.87E+05 | 1.01E+07 | 6.25E+04 | 0.00E+00 | 2.00E+07 | 7.31E+08 |
| Sb-125 | 2.04E+07 | 2.28E+05 | 4.86E+06 | 2.08E+04 | 0.00E+00 | 1.58E+07 | 2.25E+08 |

Table 3-12a

ADULT GRASS/COW/MILK PATHWAY Ri(C)

$m^2$ * mrem/yr per uCi/sec (H-3: mrem/yr per uCi/$m^3$)

| Isotope | BONE | LIVER | TOT BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| Te-125m | 1.63E+07 | 5.90E+06 | 2.18E+06 | 4.90E+06 | 6.63E+07 | 0.00E+00 | 6.50E+07 |
| Te-127m | 4.58E+07 | 1.64E+07 | 5.58E+06 | 1.17E+07 | 1.86E+08 | 0.00E+00 | 1.54E+08 |
| Te-127 | 6.53E+02 | 2.34E+02 | 1.41E+02 | 4.84E+02 | 2.66E+03 | 0.00E+00 | 5.15E+04 |
| Te-129m | 6.02E+07 | 2.25E+07 | 9.53E+06 | 2.07E+07 | 2.51E+08 | 0.00E+00 | 3.03E+08 |
| Te-129 | 2.82E-10 | 1.06E-10 | 6.88E-11 | 2.17E-10 | 1.19E-09 | 0.00E+00 | 2.13E-10 |
| Te-131m | 3.61E+05 | 1.77E+05 | 1.47E+05 | 2.80E+05 | 1.79E+06 | 0.00E+00 | 1.75E+07 |
| Te-131 | 3.60E-33 | 1.51E-33 | 1.14E-33 | 2.96E-33 | 1.58E-32 | 0.00E+00 | 5.10E-34 |
| Te-132 | 2.40E+06 | 1.55E+06 | 1.46E+06 | 1.72E+06 | 1.50E+07 | 0.00E+00 | 7.35E+07 |
| I-130 | 4.20E+05 | 1.24E+06 | 4.89E+05 | 1.05E+08 | 1.93E+06 | 0.00E+00 | 1.07E+06 |
| I-131 | 2.96E+08 | 4.23E+08 | 2.43E+08 | 1.39E+11 | 7.26E+08 | 0.00E+00 | 1.12E+08 |
| I-132 | 1.64E-01 | 4.39E-01 | 1.54E-01 | 1.54E+01 | 7.00E-01 | 0.00E+00 | 8.25E-02 |
| I-133 | 3.87E+06 | 6.73E+06 | 2.05E+06 | 9.89E+08 | 1.17E+07 | 0.00E+00 | 6.05E+06 |
| I-134 | 2.02E-12 | 5.48E-12 | 1.96E-12 | 9.49E-11 | 8.71E-12 | 0.00E+00 | 4.77E-15 |
| I-135 | 1.28E+04 | 3.36E+04 | 1.24E+04 | 2.22E+06 | 5.39E+04 | 0.00E+00 | 3.80E+04 |
| Cs-134 | 5.65E+09 | 1.35E+10 | 1.10E+10 | 0.00E+00 | 4.35E+09 | 1.45E+09 | 2.35E+08 |
| Cs-136 | 2.63E+08 | 1.04E+09 | 7.46E+08 | 0.00E+00 | 5.77E+08 | 7.90E+07 | 1.18E+08 |
| Cs-137 | 7.38E+09 | 1.01E+10 | 6.61E+09 | 0.00E+00 | 3.43E+09 | 1.14E+09 | 1.95E+08 |
| Cs-138 | 9.04E-24 | 1.79E-23 | 8.85E-24 | 0.00E+00 | 1.31E-23 | 1.30E-24 | 7.62E-29 |
| Ba-139 | 3.92E-08 | 2.79E-11 | 1.15E-09 | 0.00E+00 | 2.61E-11 | 1.58E-11 | 6.94E-08 |
| Ba-140 | 2.68E+07 | 3.37E+04 | 1.76E+06 | 0.00E+00 | 1.15E+04 | 1.93E+04 | 5.52E+07 |
| Ba-141 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Ba-142 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| La-140 | 4.52E+00 | 2.28E+00 | 6.02E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.67E+05 |
| La-142 | 9.34E-12 | 4.25E-12 | 1.06E-12 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.10E-08 |
| Ce-141 | 4.84E+03 | 3.28E+03 | 3.72E+02 | 0.00E+00 | 1.52E+03 | 0.00E+00 | 1.25E+07 |
| Ce-143 | 4.16E+01 | 3.07E+04 | 3.40E+00 | 0.00E+00 | 1.35E+01 | 0.00E+00 | 1.15E+06 |
| Ce-144 | 3.58E+05 | 1.50E+05 | 1.92E+04 | 0.00E+00 | 8.87E+04 | 0.00E+00 | 1.21E+08 |
| Pr-143 | 1.58E+02 | 6.33E+01 | 7.83E+00 | 0.00E+00 | 3.66E+01 | 0.00E+00 | 6.92E+05 |
| Pr-144 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nd-147 | 9.42E+01 | 1.09E+02 | 6.51E+00 | 0.00E+00 | 6.36E+01 | 0.00E+00 | 5.22E+05 |
| W-187 | 6.56E+03 | 5.48E+03 | 1.92E+03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.80E+06 |
| Np-239 | 3.68E+00 | 3.62E-01 | 2.00E-01 | 0.00E+00 | 1.13E+00 | 0.00E+00 | 7.43E+04 |
| K-40 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Co-57 | 0.00E+00 | 1.28E+06 | 2.13E+06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.25E+07 |
| Sr-85 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Y-88 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nb-94 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nb-97 | 3.29E-12 | 8.32E-13 | 3.04E-13 | 0.00E+00 | 9.71E-13 | 0.00E+00 | 3.07E-09 |
| Cd-109 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Sn-113 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Ba-133 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Te-134 | 8.90E-19 | 5.83E-19 | 3.57E-19 | 7.78E-19 | 5.63E-18 | 0.00E+00 | 9.87E-22 |
| Ce-139 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Hg-203 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

Table 3-12b

TEEN GRASS/COW/MILK PATHWAY Ri(C)

$m^2$ * mrem/yr per uCi/sec (H-3: mrem/yr per uCi/$m^3$ )

| Isotope | BONE | LIVER | TOT BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| H-3 | 0.00E+00 | 9.94E+02 | 9.94E+02 | 9.94E+02 | 9.94E+02 | 9.94E+02 | 9.94E+02 |
| Be-7 | 3.05E+03 | 6.83E+03 | 3.41E+03 | 0.00E+00 | 7.23E+03 | 0.00E+00 | 8.31E+05 |
| Na-24 | 4.26E+06 | 4.26E+06 | 4.26E+06 | 4.26E+06 | 4.26E+06 | 4.26E+06 | 4.26E+06 |
| P-32 | 3.15E+10 | 1.95E+09 | 1.22E+09 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.65E+09 |
| Cr-51 | 0.00E+00 | 0.00E+00 | 4.99E+04 | 2.77E+04 | 1.09E+04 | 7.13E+04 | 8.39E+06 |
| Mn-54 | 0.00E+00 | 1.40E+07 | 2.78E+06 | 0.00E+00 | 4.18E+06 | 0.00E+00 | 2.87E+07 |
| Mn-56 | 0.00E+00 | 7.36E-03 | 1.31E-03 | 0.00E+00 | 9.31E-03 | 0.00E+00 | 4.84E-01 |
| Fe-55 | 4.45E+07 | 3.16E+07 | 7.36E+06 | 0.00E+00 | 0.00E+00 | 2.00E+07 | 1.37E+07 |
| Fe-59 | 5.18E+07 | 1.21E+08 | 4.67E+07 | 0.00E+00 | 0.00E+00 | 3.81E+07 | 2.86E+08 |
| Co-58 | 0.00E+00 | 7.94E+06 | 1.83E+07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.09E+08 |
| Co-60 | 0.00E+00 | 2.78E+07 | 6.26E+07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.62E+08 |
| Ni-63 | 1.18E+10 | 8.35E+08 | 4.01E+08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.33E+08 |
| Ni-65 | 6.77E-01 | 8.65E-02 | 3.94E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.69E+00 |
| Cu-64 | 0.00E+00 | 4.25E+04 | 2.00E+04 | 0.00E+00 | 1.07E+05 | 0.00E+00 | 3.29E+06 |
| Zn-65 | 2.11E+09 | 7.31E+09 | 3.41E+09 | 0.00E+00 | 4.68E+09 | 0.00E+00 | 3.10E+09 |
| Zn-69 | 9.55E-12 | 1.82E-11 | 1.27E-12 | 0.00E+00 | 1.19E-11 | 0.00E+00 | 3.35E-11 |
| Br-83 | 0.00E+00 | 0.00E+00 | 1.79E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Br-84 | 0.00E+00 | 0.00E+00 | 2.88E-23 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Br-85 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Rb-86 | 0.00E+00 | 4.73E+09 | 2.22E+09 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.00E+08 |
| Rb-88 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Rb-89 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Sr-89 | 2.67E+09 | 0.00E+00 | 7.66E+07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.18E+08 |
| Sr-90 | 6.61E+10 | 0.00E+00 | 1.63E+10 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.86E+09 |
| Sr-91 | 5.31E+04 | 0.00E+00 | 2.11E+03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.41E+05 |
| Sr-92 | 8.94E-01 | 0.00E+00 | 3.81E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.28E+01 |
| Y-90 | 1.30E+02 | 0.00E+00 | 3.50E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.07E+06 |
| Y-91m | 1.10E-19 | 0.00E+00 | 4.19E-21 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.17E-18 |
| Y-91 | 1.58E+04 | 0.00E+00 | 4.24E+02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.48E+06 |
| Y-92 | 1.03E-04 | 0.00E+00 | 2.98E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.83E+00 |
| Y-93 | 4.12E-01 | 0.00E+00 | 1.13E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.26E+04 |
| Zr-95 | 1.65E+03 | 5.20E+02 | 3.58E+02 | 0.00E+00 | 7.65E+02 | 0.00E+00 | 1.20E+06 |
| Zr-97 | 7.88E-01 | 1.56E-01 | 7.19E-02 | 0.00E+00 | 2.37E-01 | 0.00E+00 | 4.22E+04 |
| Nb-95 | 1.41E+05 | 7.82E+04 | 4.30E+04 | 0.00E+00 | 7.58E+04 | 0.00E+00 | 3.34E+08 |
| Mo-99 | 0.00E+00 | 4.47E+07 | 8.52E+06 | 0.00E+00 | 1.02E+08 | 0.00E+00 | 8.01E+07 |
| Tc-99m | 5.76E+00 | 1.61E+01 | 2.08E+02 | 0.00E+00 | 2.39E+02 | 8.92E+00 | 1.05E+04 |
| Tc-101 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Ru-103 | 1.81E+03 | 0.00E+00 | 7.74E+02 | 0.00E+00 | 6.38E+03 | 0.00E+00 | 1.51E+05 |
| Ru-105 | 1.56E-03 | 0.00E+00 | 6.07E-04 | 0.00E+00 | 1.97E-02 | 0.00E+00 | 1.26E+00 |
| Ru-106 | 3.75E+04 | 0.00E+00 | 4.73E+03 | 0.00E+00 | 7.24E+04 | 0.00E+00 | 1.80E+06 |
| Ag-110m | 9.63E+07 | 9.11E+07 | 5.54E+07 | 0.00E+00 | 1.74E+08 | 0.00E+00 | 2.56E+10 |
| Sb-122 | 4.77E+05 | 9.29E+03 | 1.39E+05 | 6.06E+03 | 0.00E+00 | 2.98E+05 | 1.00E+08 |
| Sb-124 | 4.58E+07 | 8.44E+05 | 1.79E+07 | 1.04E+05 | 0.00E+00 | 4.00E+07 | 9.26E+08 |
| Sb-125 | 3.65E+07 | 3.99E+05 | 8.53E+06 | 3.48E+04 | 0.00E+00 | 3.18E+07 | 2.83E+08 |

Table 3-12b

TEEN GRASS/COW/MILK PATHWAY Ri(C)

$m^2$ * mrem/yr per uCi/sec (H-3: mrem/yr per uCi/$m^3$)

| Isotope | BONE | LIVER | TOT BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| Te-125m | 3.00E+07 | 1.08E+07 | 4.02E+06 | 8.39E+06 | 0.00E+00 | 0.00E+00 | 8.86E+07 |
| Te-127m | 8.44E+07 | 2.99E+07 | 1.00E+07 | 2.01E+07 | 3.42E+08 | 0.00E+00 | 2.10E+08 |
| Te-127 | 1.21E+03 | 4.29E+02 | 2.60E+02 | 8.35E+02 | 4.90E+03 | 0.00E+00 | 9.34E+04 |
| Te-129m | 1.10E+08 | 4.09E+07 | 1.74E+07 | 3.55E+07 | 4.61E+08 | 0.00E+00 | 4.13E+08 |
| Te-129 | 5.20E-10 | 1.94E-10 | 1.26E-10 | 3.71E-10 | 2.18E-09 | 0.00E+00 | 2.84E-09 |
| Te-131m | 6.57E+05 | 3.15E+05 | 2.63E+05 | 4.74E+05 | 3.29E+06 | 0.00E+00 | 2.53E+07 |
| Te-131 | 6.58E-33 | 2.71E-33 | 2.06E-33 | 5.07E-33 | 2.88E-32 | 0.00E+00 | 5.40E-34 |
| Te-132 | 4.29E+06 | 2.72E+06 | 2.56E+06 | 2.87E+06 | 2.61E+07 | 0.00E+00 | 8.61E+07 |
| I-130 | 7.38E+05 | 2.14E+06 | 8.53E+05 | 1.74E+08 | 3.29E+06 | 0.00E+00 | 1.64E+06 |
| I-131 | 5.37E+08 | 7.52E+08 | 4.04E+08 | 2.19E+11 | 1.29E+09 | 0.00E+00 | 1.49E+08 |
| I-132 | 2.91E-01 | 7.62E-01 | 2.74E-01 | 2.57E+01 | 1.20E+00 | 0.00E+00 | 3.32E-01 |
| I-133 | 7.07E+06 | 1.20E+07 | 3.66E+06 | 1.67E+09 | 2.10E+07 | 0.00E+00 | 9.07E+06 |
| I-134 | 3.58E-12 | 9.50E-12 | 3.41E-12 | 1.58E-10 | 1.50E-11 | 0.00E+00 | 1.25E-13 |
| I-135 | 2.28E+04 | 5.87E+04 | 2.18E+04 | 3.78E+06 | 9.27E+04 | 0.00E+00 | 6.51E+04 |
| Cs-134 | 9.82E+09 | 2.31E+10 | 1.07E+10 | 0.00E+00 | 7.34E+09 | 2.80E+09 | 2.87E+08 |
| Cs-136 | 4.47E+08 | 1.76E+09 | 1.18E+09 | 0.00E+00 | 9.57E+08 | 1.51E+08 | 1.42E+08 |
| Cs-137 | 1.34E+10 | 1.78E+10 | 6.20E+09 | 0.00E+00 | 6.06E+09 | 2.35E+09 | 2.53E+08 |
| Cs-138 | 1.64E-23 | 3.15E-23 | 1.57E-23 | 0.00E+00 | 2.33E-23 | 2.71E-24 | 1.43E-26 |
| Ba-139 | 7.24E-08 | 5.09E-11 | 2.11E-09 | 0.00E+00 | 4.80E-11 | 3.51E-11 | 6.46E-07 |
| Ba-140 | 4.84E+07 | 5.93E+04 | 3.12E+06 | 0.00E+00 | 2.01E+04 | 3.99E+04 | 7.46E+07 |
| Ba-141 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Ba-142 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| La-140 | 8.12E+00 | 3.99E+00 | 1.06E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.29E+05 |
| La-142 | 1.69E-11 | 7.49E-12 | 1.86E-12 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.28E-07 |
| Ce-141 | 8.88E+03 | 5.93E+03 | 6.81E+02 | 0.00E+00 | 2.79E+03 | 0.00E+00 | 1.70E+07 |
| Ce-143 | 7.64E+01 | 5.56E+04 | 6.21E+00 | 0.00E+00 | 2.49E+01 | 0.00E+00 | 1.67E+06 |
| Ce-144 | 6.58E+05 | 2.72E+05 | 3.54E+04 | 0.00E+00 | 1.63E+05 | 0.00E+00 | 1.66E+08 |
| Pr-143 | 2.90E+02 | 1.16E+02 | 1.44E+01 | 0.00E+00 | 6.73E+01 | 0.00E+00 | 9.54E+05 |
| Pr-144 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nd-147 | 1.81E+02 | 1.97E+02 | 1.18E+01 | 0.00E+00 | 1.16E+02 | 0.00E+00 | 7.11E+05 |
| W-187 | 1.20E+04 | 9.78E+03 | 3.43E+03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.65E+06 |
| Np-239 | 7.03E+00 | 6.63E-01 | 3.68E-01 | 0.00E+00 | 2.08E+00 | 0.00E+00 | 1.07E+05 |
| K-40 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Co-57 | 0.00E+00 | 2.25E+06 | 3.76E+06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.19E+07 |
| Sr-85 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Y-88 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nb-94 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nb-97 | 5.99E-12 | 1.49E-12 | 5.43E-13 | 0.00E+00 | 1.74E-12 | 0.00E+00 | 3.55E-08 |
| Cd-109 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Sn-113 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Ba-133 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Te-134 | 1.59E-18 | 1.02E-18 | 1.06E-18 | 1.30E-18 | 9.72E-18 | 0.00E+00 | 5.89E-20 |
| Ce-139 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Hg-203 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

Table 3-12c

CHILD GRASS/COW/MILK PATHWAY Ri(C)

$m^2$ * mrem/yr per uCi/sec (H-3: mrem/yr per uCi/$m^3$ )

| Isotope | BONE | LIVER | TOT BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| H-3 | 0.00E+00 | 1.57E+03 | 1.57E+03 | 1.57E+03 | 1.57E+03 | 1.57E+03 | 1.57E+03 |
| Be-7 | 7.49E+03 | 1.27E+04 | 8.38E+03 | 0.00E+00 | 1.25E+04 | 0.00E+00 | 7.11E+05 |
| Na-24 | 8.85E+06 | 8.85E+06 | 8.85E+06 | 8.85E+06 | 8.85E+06 | 8.85E+06 | 8.85E+06 |
| P-32 | 7.78E+10 | 3.64E+09 | 3.00E+09 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.15E+09 |
| Cr-51 | 0.00E+00 | 0.00E+00 | 1.02E+05 | 5.65E+04 | 1.54E+04 | 1.03E+05 | 5.40E+06 |
| Mn-54 | 0.00E+00 | 2.10E+07 | 5.59E+06 | 0.00E+00 | 5.88E+06 | 0.00E+00 | 1.76E+07 |
| Mn-56 | 0.00E+00 | 1.28E-02 | 2.90E-03 | 0.00E+00 | 1.55E-02 | 0.00E+00 | 1.86E+00 |
| Fe-55 | 1.12E+08 | 5.93E+07 | 1.84E+07 | 0.00E+00 | 0.00E+00 | 3.35E+07 | 1.10E+07 |
| Fe-59 | 1.20E+08 | 1.94E+08 | 9.68E+07 | 0.00E+00 | 0.00E+00 | 5.64E+07 | 2.02E+08 |
| Co-58 | 0.00E+00 | 1.21E+07 | 3.71E+07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.07E+07 |
| Co-60 | 0.00E+00 | 4.32E+07 | 1.27E+08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.39E+08 |
| Ni-63 | 2.96E+10 | 1.59E+09 | 1.01E+09 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.07E+08 |
| Ni-65 | 1.66E+00 | 1.56E-01 | 9.10E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.91E+01 |
| Cu-64 | 0.00E+00 | 7.46E+04 | 4.51E+04 | 0.00E+00 | 1.80E+05 | 0.00E+00 | 3.50E+06 |
| Zn-65 | 4.13E+09 | 1.10E+10 | 6.85E+09 | 0.00E+00 | 6.94E+09 | 0.00E+00 | 1.93E+09 |
| Zn-69 | 2.35E-11 | 3.39E-11 | 3.13E-12 | 0.00E+00 | 2.06E-11 | 0.00E+00 | 2.14E-09 |
| 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 | 6.51E-23 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Br-85 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Rb-86 | 0.00E+00 | 8.77E+09 | 5.39E+09 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.64E+08 |
| Rb-88 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Rb-89 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Sr-89 | 6.62E+09 | 0.00E+00 | 1.89E+08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.56E+08 |
| Sr-90 | 1.12E+11 | 0.00E+00 | 2.83E+10 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.51E+09 |
| Sr-91 | 1.30E+05 | 0.00E+00 | 4.92E+03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.88E+05 |
| Sr-92 | 2.18E+00 | 0.00E+00 | 8.75E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.13E+01 |
| Y-90 | 3.21E+02 | 0.00E+00 | 8.60E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 9.15E+05 |
| Y-91m | 2.68E-19 | 0.00E+00 | 9.74E-21 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.24E-16 |
| Y-91 | 3.90E+04 | 0.00E+00 | 1.04E+03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.20E+06 |
| Y-92 | 2.53E-04 | 0.00E+00 | 7.24E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.31E+00 |
| Y-93 | 1.01E+00 | 0.00E+00 | 2.78E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.51E+04 |
| Zr-95 | 3.83E+03 | 8.42E+02 | 7.50E+02 | 0.00E+00 | 1.21E+03 | 0.00E+00 | 8.79E+05 |
| Zr-97 | 1.92E+00 | 2.77E-01 | 1.64E-01 | 0.00E+00 | 3.98E-01 | 0.00E+00 | 4.20E+04 |
| Nb-95 | 3.18E+05 | 1.24E+05 | 8.85E+04 | 0.00E+00 | 1.16E+05 | 0.00E+00 | 2.29E+08 |
| Mo-99 | 0.00E+00 | 8.13E+07 | 2.01E+07 | 0.00E+00 | 1.74E+08 | 0.00E+00 | 6.73E+07 |
| Tc-99m | 1.32E+01 | 2.59E+01 | 4.29E+02 | 0.00E+00 | 3.76E+02 | 1.32E+01 | 1.47E+04 |
| Tc-101 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Ru-103 | 4.28E+03 | 0.00E+00 | 1.65E+03 | 0.00E+00 | 1.08E+04 | 0.00E+00 | 1.11E+05 |
| Ru-105 | 3.82E-03 | 0.00E+00 | 1.39E-03 | 0.00E+00 | 3.36E-02 | 0.00E+00 | 2.49E+00 |
| Ru-106 | 9.24E+04 | 0.00E+00 | 1.15E+04 | 0.00E+00 | 1.25E+05 | 0.00E+00 | 1.44E+06 |
| Ag-110m | 2.09E+08 | 1.41E+08 | 1.13E+08 | 0.00E+00 | 2.63E+08 | 0.00E+00 | 1.68E+10 |
| Sb-122 | 1.17E+06 | 1.73E+04 | 3.44E+05 | 1.50E+04 | 0.00E+00 | 4.77E+05 | 9.02E+07 |
| Sb-124 | 1.09E+08 | 1.41E+06 | 3.80E+07 | 2.39E+05 | 0.00E+00 | 6.02E+07 | 6.78E+08 |
| Sb-125 | 8.69E+07 | 6.70E+05 | 1.82E+07 | 8.06E+04 | 0.00E+00 | 4.84E+07 | 2.08E+08 |

Table 3-12c

CHILD GRASS/COW/MILK PATHWAY Ri(C)

$m^2$ * mrem/yr per uCi/sec (H-3: mrem/yr per uCi/$m^3$)

| Isotope | BONE | LIVER | TOT BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| Te-125m | 7.38E+07 | 2.00E+07 | 9.84E+06 | 2.07E+07 | 0.00E+00 | 0.00E+00 | 7.12E+07 |
| Te-127m | 2.08E+08 | 5.60E+07 | 2.47E+07 | 4.97E+07 | 5.93E+08 | 0.00E+00 | 1.68E+08 |
| Te-127 | 2.98E+03 | 8.02E+02 | 6.38E+02 | 2.06E+03 | 8.47E+03 | 0.00E+00 | 1.16E+05 |
| Te-129m | 2.71E+08 | 7.58E+07 | 4.21E+07 | 8.75E+07 | 7.97E+08 | 0.00E+00 | 3.31E+08 |
| Te-129 | 1.28E-09 | 3.58E-10 | 3.04E-10 | 9.15E-10 | 3.75E-09 | 0.00E+00 | 7.98E-08 |
| Te-131m | 1.60E+06 | 5.53E+05 | 5.89E+05 | 1.14E+06 | 5.35E+06 | 0.00E+00 | 2.24E+07 |
| Te-131 | 1.62E-32 | 4.93E-33 | 4.81E-33 | 1.24E-32 | 4.89E-32 | 0.00E+00 | 8.49E-32 |
| Te-132 | 1.02E+07 | 4.53E+06 | 5.48E+06 | 6.60E+06 | 4.21E+07 | 0.00E+00 | 4.57E+07 |
| I-130 | 1.73E+06 | 3.49E+06 | 1.80E+06 | 3.84E+08 | 5.22E+06 | 0.00E+00 | 1.63E+06 |
| I-131 | 1.30E+09 | 1.31E+09 | 7.45E+08 | 4.33E+11 | 2.15E+09 | 0.00E+00 | 1.17E+08 |
| I-132 | 6.89E-01 | 1.27E+00 | 5.82E-01 | 5.87E+01 | 1.94E+00 | 0.00E+00 | 1.49E+00 |
| I-133 | 1.72E+07 | 2.12E+07 | 8.03E+06 | 3.94E+09 | 3.54E+07 | 0.00E+00 | 8.56E+06 |
| I-134 | 8.48E-12 | 1.58E-11 | 7.25E-12 | 3.62E-10 | 2.41E-11 | 0.00E+00 | 1.04E-11 |
| I-135 | 5.40E+04 | 9.72E+04 | 4.60E+04 | 8.61E+06 | 1.49E+05 | 0.00E+00 | 7.40E+04 |
| Cs-134 | 2.26E+10 | 3.72E+10 | 7.84E+09 | 0.00E+00 | 1.15E+10 | 4.13E+09 | 2.00E+08 |
| Cs-136 | 1.01E+09 | 2.77E+09 | 1.79E+09 | 0.00E+00 | 1.48E+09 | 2.20E+08 | 9.74E+07 |
| Cs-137 | 3.22E+10 | 3.09E+10 | 4.55E+09 | 0.00E+00 | 1.01E+10 | 3.62E+09 | 1.93E+08 |
| Cs-138 | 3.98E-23 | 5.53E-23 | 3.51E-23 | 0.00E+00 | 3.89E-23 | 4.19E-24 | 2.55E-23 |
| Ba-139 | 1.78E-07 | 9.50E-11 | 5.16E-09 | 0.00E+00 | 8.29E-11 | 5.59E-11 | 1.03E-05 |
| Ba-140 | 1.17E+08 | 1.02E+05 | 6.82E+06 | 0.00E+00 | 3.33E+04 | 6.10E+04 | 5.92E+07 |
| Ba-141 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Ba-142 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| La-140 | 1.94E+01 | 6.80E+00 | 2.29E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.89E+05 |
| La-142 | 4.07E-11 | 1.30E-11 | 4.06E-12 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.57E-06 |
| Ce-141 | 2.19E+04 | 1.09E+04 | 1.62E+03 | 0.00E+00 | 4.78E+03 | 0.00E+00 | 1.36E+07 |
| Ce-143 | 1.87E+02 | 1.02E+05 | 1.47E+01 | 0.00E+00 | 4.26E+01 | 0.00E+00 | 1.49E+06 |
| Ce-144 | 1.62E+06 | 5.09E+05 | 8.66E+04 | 0.00E+00 | 2.82E+05 | 0.00E+00 | 1.33E+08 |
| Pr-143 | 7.18E+02 | 2.16E+02 | 3.56E+01 | 0.00E+00 | 1.17E+02 | 0.00E+00 | 7.75E+05 |
| Pr-144 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nd-147 | 4.45E+02 | 3.60E+02 | 2.79E+01 | 0.00E+00 | 1.98E+02 | 0.00E+00 | 5.70E+05 |
| W-187 | 2.91E+04 | 1.72E+04 | 7.73E+03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.42E+06 |
| Np-239 | 1.73E+01 | 1.24E+00 | 8.73E-01 | 0.00E+00 | 3.59E+00 | 0.00E+00 | 9.19E+04 |
| K-40 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Co-57 | 0.00E+00 | 3.84E+06 | 7.77E+06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.14E+07 |
| Sr-85 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Y-88 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nb-94 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nb-97 | 1.46E-11 | 2.63E-12 | 1.23E-12 | 0.00E+00 | 2.92E-12 | 0.00E+00 | 8.12E-07 |
| Cd-109 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Sn-113 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Ba-133 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Te-134 | 3.77E-18 | 1.70E-18 | 2.26E-18 | 2.98E-18 | 1.57E-17 | 0.00E+00 | 1.72E-17 |
| Ce-139 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Hg-203 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

Table 3-12d

INFANT GRASS/COW/MILK PATHWAY Ri(C)

$m^2$ * mrem/yr per uCi/sec (H-3: mrem/yr per uCi/$m^3$)

| Isotope | BONE | LIVER | TOT BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| H-3 | 0.00E+00 | 2.38E+03 | 2.38E+03 | 2.38E+03 | 2.38E+03 | 2.38E+03 | 2.38E+03 |
| Be-7 | 1.43E+04 | 3.00E+04 | 1.59E+04 | 0.00E+00 | 2.12E+04 | 0.00E+00 | 7.05E+05 |
| Na-24 | 1.54E+07 | 1.54E+07 | 1.54E+07 | 1.54E+07 | 1.54E+07 | 1.54E+07 | 1.54E+07 |
| P-32 | 1.60E+11 | 9.43E+09 | 6.21E+09 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.17E+09 |
| Cr-51 | 0.00E+00 | 0.00E+00 | 1.61E+05 | 1.05E+05 | 2.30E+04 | 2.05E+05 | 4.70E+06 |
| Mn-54 | 0.00E+00 | 3.90E+07 | 8.84E+06 | 0.00E+00 | 8.64E+06 | 0.00E+00 | 1.43E+07 |
| Mn-56 | 0.00E+00 | 3.14E-02 | 5.42E-03 | 0.00E+00 | 2.70E-02 | 0.00E+00 | 2.85E+00 |
| Fe-55 | 1.35E+08 | 8.73E+07 | 2.33E+07 | 0.00E+00 | 0.00E+00 | 4.27E+07 | 1.11E+07 |
| Fe-59 | 2.24E+08 | 3.92E+08 | 1.54E+08 | 0.00E+00 | 0.00E+00 | 1.16E+08 | 1.87E+08 |
| Co-58 | 0.00E+00 | 2.42E+07 | 6.05E+07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.04E+07 |
| Co-60 | 0.00E+00 | 8.82E+07 | 2.08E+08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.10E+08 |
| Ni-63 | 3.49E+10 | 2.16E+09 | 1.21E+09 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.07E+08 |
| Ni-65 | 3.50E+00 | 3.97E-01 | 1.80E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.02E+01 |
| Cu-64 | 0.00E+00 | 1.86E+05 | 8.59E+04 | 0.00E+00 | 3.14E+05 | 0.00E+00 | 3.81E+06 |
| Zn-65 | 5.55E+09 | 1.90E+10 | 8.78E+09 | 0.00E+00 | 9.23E+09 | 0.00E+00 | 1.61E+10 |
| Zn-69 | 5.00E-11 | 9.00E-11 | 6.70E-12 | 0.00E+00 | 3.74E-11 | 0.00E+00 | 7.34E-09 |
| Br-83 | 0.00E+00 | 0.00E+00 | 9.34E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Br-84 | 0.00E+00 | 0.00E+00 | 1.26E-22 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Br-85 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Rb-86 | 0.00E+00 | 2.23E+10 | 1.10E+10 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.69E+08 |
| Rb-88 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Rb-89 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Sr-89 | 1.26E+10 | 0.00E+00 | 3.61E+08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.59E+08 |
| Sr-90 | 1.22E+11 | 0.00E+00 | 3.10E+10 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.52E+09 |
| Sr-91 | 2.72E+05 | 0.00E+00 | 9.83E+03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.21E+05 |
| Sr-92 | 4.64E+00 | 0.00E+00 | 1.72E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.00E+01 |
| Y-90 | 6.80E+02 | 0.00E+00 | 1.82E+01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 9.39E+05 |
| Y-91m | 5.67E-19 | 0.00E+00 | 1.93E-20 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.89E-15 |
| Y-91 | 7.33E+04 | 0.00E+00 | 1.95E+03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.25E+06 |
| Y-92 | 5.38E-04 | 0.00E+00 | 1.51E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.03E+01 |
| Y-93 | 2.16E+00 | 0.00E+00 | 5.87E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.70E+04 |
| Zr-95 | 6.80E+03 | 1.66E+03 | 1.18E+03 | 0.00E+00 | 1.79E+03 | 0.00E+00 | 8.26E+05 |
| Zr-97 | 4.06E+00 | 6.97E-01 | 3.18E-01 | 0.00E+00 | 7.03E-01 | 0.00E+00 | 4.45E+04 |
| Nb-95 | 5.94E+05 | 2.45E+05 | 1.41E+05 | 0.00E+00 | 1.75E+05 | 0.00E+00 | 2.06E+08 |
| Mo-99 | 0.00E+00 | 2.08E+08 | 4.05E+07 | 0.00E+00 | 3.11E+08 | 0.00E+00 | 6.85E+07 |
| Tc-99m | 2.75E+01 | 5.67E+01 | 7.30E+02 | 0.00E+00 | 6.10E+02 | 2.96E+01 | 1.65E+04 |
| Tc-101 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Ru-103 | 8.67E+03 | 0.00E+00 | 2.90E+03 | 0.00E+00 | 1.80E+04 | 0.00E+00 | 1.05E+05 |
| Ru-105 | 8.05E-03 | 0.00E+00 | 2.71E-03 | 0.00E+00 | 5.92E-02 | 0.00E+00 | 3.20E+00 |
| Ru-106 | 1.90E+05 | 0.00E+00 | 2.38E+04 | 0.00E+00 | 2.25E+05 | 0.00E+00 | 1.44E+06 |
| Ag-110m | 3.86E+08 | 2.82E+08 | 1.86E+08 | 0.00E+00 | 4.03E+08 | 0.00E+00 | 1.46E+10 |
| Sb-122 | 2.51E+06 | 4.59E+04 | 7.31E+05 | 3.75E+04 | 0.00E+00 | 1.30E+06 | 9.13E+07 |
| Sb-124 | 2.09E+08 | 3.08E+06 | 6.49E+07 | 5.56E+05 | 0.00E+00 | 1.31E+08 | 6.46E+08 |
| Sb-125 | 1.50E+08 | 1.45E+06 | 3.08E+07 | 1.87E+05 | 0.00E+00 | 9.38E+07 | 1.99E+08 |

Table 3-12d

INFANT GRASS/COW/MILK PATHWAY Ri(C)

$m^2$ * mrem/yr per uCi/sec (H-3: mrem/yr per uCi/$m^3$ )

| Isotope | BONE | LIVER | TOT BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| Te-125m | 1.51E+08 | 5.04E+07 | 2.04E+07 | 5.07E+07 | 0.00E+00 | 0.00E+00 | 7.18E+07 |
| Te-127m | 4.21E+08 | 1.40E+08 | 5.10E+07 | 1.22E+08 | 1.04E+09 | 0.00E+00 | 1.70E+08 |
| Te-127 | 6.32E+03 | 2.12E+03 | 1.36E+03 | 5.14E+03 | 1.54E+04 | 0.00E+00 | 1.33E+05 |
| Te-129m | 5.57E+08 | 1.91E+08 | 8.58E+07 | 2.14E+08 | 1.39E+09 | 0.00E+00 | 3.33E+08 |
| Te-129 | 2.72E-09 | 9.37E-10 | 6.35E-10 | 2.28E-09 | 6.77E-09 | 0.00E+00 | 2.17E-07 |
| Te-131m | 3.38E+06 | 1.36E+06 | 1.12E+06 | 2.75E+06 | 9.35E+06 | 0.00E+00 | 2.29E+07 |
| Te-131 | 3.43E-32 | 1.27E-32 | 9.62E-33 | 3.06E-32 | 8.76E-32 | 0.00E+00 | 1.38E-30 |
| Te-132 | 2.11E+07 | 1.04E+07 | 9.75E+06 | 1.54E+07 | 6.53E+07 | 0.00E+00 | 3.87E+07 |
| I-130 | 3.55E+06 | 7.81E+06 | 3.13E+06 | 8.75E+08 | 8.58E+06 | 0.00E+00 | 1.67E+06 |
| I-131 | 2.72E+09 | 3.20E+09 | 1.41E+09 | 1.05E+12 | 3.74E+09 | 0.00E+00 | 1.14E+08 |
| I-132 | 1.43E+00 | 2.90E+00 | 1.03E+00 | 1.36E+02 | 3.24E+00 | 0.00E+00 | 2.35E+00 |
| I-133 | 3.63E+07 | 5.28E+07 | 1.55E+07 | 9.60E+09 | 6.21E+07 | 0.00E+00 | 8.93E+06 |
| I-134 | 1.76E-11 | 3.60E-11 | 1.28E-11 | 8.40E-10 | 4.03E-11 | 0.00E+00 | 3.73E-11 |
| I-135 | 1.12E+05 | 2.23E+05 | 8.14E+04 | 2.00E+07 | 2.49E+05 | 0.00E+00 | 8.08E+04 |
| Cs-134 | 3.65E+10 | 6.80E+10 | 6.87E+09 | 0.00E+00 | 1.75E+10 | 7.18E+09 | 1.85E+08 |
| Cs-136 | 1.97E+09 | 5.79E+09 | 2.16E+09 | 0.00E+00 | 2.31E+09 | 4.72E+08 | 8.80E+07 |
| Cs-137 | 5.15E+10 | 6.02E+10 | 4.27E+09 | 0.00E+00 | 1.62E+10 | 6.55E+09 | 1.88E+08 |
| Cs-138 | 8.39E-23 | 1.36E-22 | 6.61E-23 | 0.00E+00 | 6.80E-23 | 1.06E-23 | 2.18E-22 |
| Ba-139 | 3.79E-07 | 2.51E-10 | 1.10E-08 | 0.00E+00 | 1.51E-10 | 1.52E-10 | 2.40E-05 |
| Ba-140 | 2.40E+08 | 2.40E+05 | 1.24E+07 | 0.00E+00 | 5.71E+04 | 1.48E+05 | 5.91E+07 |
| Ba-141 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Ba-142 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| La-140 | 4.06E+01 | 1.60E+01 | 4.12E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.88E+05 |
| La-142 | 8.55E-11 | 3.14E-11 | 7.51E-12 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.33E-06 |
| Ce-141 | 4.34E+04 | 2.64E+04 | 3.11E+03 | 0.00E+00 | 8.15E+03 | 0.00E+00 | 1.37E+07 |
| Ce-143 | 3.97E+02 | 2.63E+05 | 3.00E+01 | 0.00E+00 | 7.67E+01 | 0.00E+00 | 1.54E+06 |
| Ce-144 | 2.33E+06 | 9.52E+05 | 1.30E+05 | 0.00E+00 | 3.85E+05 | 0.00E+00 | 1.33E+08 |
| Pr-143 | 1.49E+03 | 5.55E+02 | 7.36E+01 | 0.00E+00 | 2.06E+02 | 0.00E+00 | 7.84E+05 |
| Pr-144 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nd-147 | 8.81E+02 | 9.05E+02 | 5.55E+01 | 0.00E+00 | 3.49E+02 | 0.00E+00 | 5.74E+05 |
| W-187 | 6.12E+04 | 4.26E+04 | 1.47E+04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.50E+06 |
| Np-239 | 3.66E+01 | 3.27E+00 | 1.85E+00 | 0.00E+00 | 6.53E+00 | 0.00E+00 | 9.46E+04 |
| K-40 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Co-57 | 0.00E+00 | 8.95E+06 | 1.46E+07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.05E+07 |
| Sr-85 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Y-88 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nb-94 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Nb-97 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Cd-109 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Sn-113 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Ba-133 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Te-134 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Ce-139 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Hg-203 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

Table 3-13

Total Body & Skin Ground Plane Dose Factors Ri(G) and Ri(S)

($m^2$ * mrem/yr per uCi/sec)

| Isotope | Decay Constant ($sec^{-1}$) | Ri(G) | Ri(S) |
|---|---|---|---|
| H-3 | 1.780E-09 | 0.00E+00 | 0.00E+00 |
| Be-7 | 1.505E-07 | 0.00E+00 | 0.00E+00 |
| Na-24 | 1.284E-05 | 1.19E+07 | 1.39E+07 |
| P-32 | 5.614E-07 | 0.00E+00 | 0.00E+00 |
| Cr-51 | 2.896E-07 | 4.66E+06 | 5.51E+06 |
| Mn-54 | 2.567E-08 | 1.39E+09 | 1.62E+09 |
| Mn-56 | 7.467E-05 | 9.03E+05 | 1.07E+06 |
| Fe-55 | 8.141E-09 | 0.00E+00 | 0.00E+00 |
| Fe-59 | 1.802E-07 | 2.72E+08 | 3.20E+08 |
| Co-58 | 1.133E-07 | 3.79E+08 | 4.44E+08 |
| Co-60 | 4.170E-09 | 2.15E+10 | 2.53E+10 |
| Ni-63 | 2.290E-10 | 0.00E+00 | 0.00E+00 |
| Ni-65 | 7.641E-05 | 2.97E+05 | 3.45E+05 |
| Cu-64 | 1.516E-05 | 6.07E+05 | 6.88E+05 |
| Zn-65 | 3.289E-08 | 7.46E+08 | 8.58E+08 |
| Zn-69 | 2.027E-04 | 0.00E+00 | 0.00E+00 |
| Br-83 | 8.056E-05 | 4.87E+03 | 7.08E+03 |
| Br-84 | 3.633E-04 | 2.03E+05 | 2.36E+05 |
| Br-85 | 3.851E-03 | 0.00E+00 | 0.00E+00 |
| Rb-86 | 4.299E-07 | 8.99E+06 | 1.03E+07 |
| Rb-88 | 6.490E-04 | 3.31E+04 | 3.78E+04 |
| Rb-89 | 7.600E-04 | 1.21E+05 | 1.45E+05 |
| Sr-89 | 1.589E-07 | 2.16E+04 | 2.51E+04 |
| Sr-90 | 7.548E-10 | 0.00E+00 | 0.00E+00 |
| Sr-91 | 2.027E-05 | 2.15E+06 | 2.51E+06 |
| Sr-92 | 7.105E-05 | 7.77E+05 | 8.63E+05 |
| Y-90 | 3.008E-06 | 4.48E+03 | 5.30E+03 |
| Y-91m | 2.324E-04 | 1.00E+05 | 1.16E+05 |
| Y-91 | 1.371E-07 | 1.07E+06 | 1.21E+06 |
| Y-92 | 5.439E-05 | 1.80E+05 | 2.14E+05 |
| Y-93 | 1.906E-05 | 1.83E+05 | 2.51E+05 |
| Zr-95 | 1.254E-07 | 2.45E+08 | 2.84E+08 |
| Zr-97 | 1.139E-05 | 2.96E+06 | 3.44E+06 |
| Nb-95 | 2.282E-07 | 1.37E+08 | 1.61E+08 |
| Mo-99 | 2.917E-06 | 3.99E+06 | 4.62E+06 |
| Tc-99m | 3.198E-05 | 1.84E+05 | 2.11E+05 |
| Tc-101 | 8.136E-04 | 2.04E+04 | 2.26E+04 |
| Ru-103 | 2.042E-07 | 1.08E+08 | 1.26E+08 |
| Ru-105 | 4.337E-05 | 6.36E+05 | 7.21E+05 |
| Ru-106 | 2.179E-08 | 4.22E+08 | 5.07E+08 |
| Ag-110m | 3.210E-08 | 3.44E+09 | 4.01E+09 |
| Sb-122 | 2.971E-06 | 0.00E+00 | 0.00E+00 |
| Sb-124 | 1.333E-07 | 5.98E+08 | 6.90E+08 |
| Sb-125 | 7.935E-09 | 2.34E+09 | 2.64E+09 |

Table 3-13

Total Body & Skin Ground Plane Dose Factors Ri(G) and Ri(S)

($m^2$ * mrem/yr per uCi/sec)

| Isotope | Decay Constant ($sec^{-1}$) | Ri(G) | Ri(S) |
|---|---|---|---|
| Te-125m | 1.383E-07 | 1.55E+06 | 2.13E+06 |
| Te-127m | 7.360E-08 | 9.16E+04 | 1.08E+05 |
| Te-127 | 2.059E-05 | 2.98E+03 | 3.28E+03 |
| Te-129m | 2.388E-07 | 1.98E+07 | 2.31E+07 |
| Te-129 | 1.660E-04 | 2.62E+04 | 3.10E+04 |
| Te-131m | 6.418E-06 | 8.03E+06 | 9.46E+06 |
| Te-131 | 4.621E-04 | 2.92E+04 | 3.45E+07 |
| Te-132 | 2.462E-06 | 4.23E+06 | 4.98E+06 |
| I-130 | 1.558E-05 | 5.51E+06 | 6.69E+06 |
| I-131 | 9.978E-07 | 1.72E+07 | 2.09E+07 |
| I-132 | 8.371E-05 | 1.25E+06 | 1.46E+06 |
| I-133 | 9.257E-06 | 2.45E+06 | 2.98E+06 |
| I-134 | 2.196E-04 | 4.47E+05 | 5.30E+05 |
| I-135 | 2.913E-05 | 2.53E+06 | 2.95E+06 |
| Cs-134 | 1.066E-08 | 6.86E+09 | 8.00E+09 |
| Cs-136 | 6.124E-07 | 1.50E+08 | 1.70E+08 |
| Cs-137 | 7.327E-10 | 1.03E+10 | 1.20E+10 |
| Cs-138 | 3.588E-04 | 3.59E+05 | 4.10E+05 |
| Ba-139 | 1.397E-04 | 1.05E+05 | 1.19E+05 |
| Ba-140 | 6.297E-07 | 2.04E+07 | 2.34E+07 |
| Ba-141 | 6.323E-04 | 4.17E+04 | 4.75E+04 |
| Ba-142 | 1.090E-03 | 4.44E+04 | 5.06E+04 |
| La-140 | 4.781E-06 | 1.92E+07 | 2.18E+07 |
| La-142 | 1.249E-04 | 7.36E+05 | 8.84E+05 |
| Ce-141 | 2.468E-07 | 1.37E+07 | 1.54E+07 |
| Ce-143 | 5.835E-06 | 2.31E+06 | 2.63E+06 |
| Ce-144 | 2.822E-08 | 6.95E+07 | 8.04E+07 |
| Pr-143 | 5.916E-07 | 0.00E+00 | 0.00E+00 |
| Pr-144 | 6.685E-04 | 1.83E+03 | 2.11E+03 |
| Nd-147 | 7.306E-07 | 8.39E+06 | 1.01E+07 |
| W-187 | 8.056E-06 | 2.36E+06 | 2.74E+06 |
| Np-239 | 3.399E-06 | 1.71E+06 | 1.98E+06 |
| K-40 | 1.717E-17 | 0.00E+00 | 0.00E+00 |
| Co-57 | 2.961E-08 | 1.88E+08 | 2.07E+08 |
| Sr-85 | 1.237E-07 | 0.00E+00 | 0.00E+00 |
| Y-88 | 7.523E-08 | 0.00E+00 | 0.00E+00 |
| Nb-94 | 1.083E-12 | 0.00E+00 | 0.00E+00 |
| Nb-97 | 1.602E-04 | 1.76E+05 | 2.07E+05 |
| Cd-109 | 1.729E-08 | 0.00E+00 | 0.00E+00 |
| Sn-113 | 6.970E-08 | 0.00E+00 | 0.00E+00 |
| Ba-133 | 2.047E-09 | 0.00E+00 | 0.00E+00 |
| Te-134 | 2.764E-04 | 2.22E+04 | 2.66E+04 |
| Ce-139 | 5.828E-08 | 0.00E+00 | 0.00E+00 |
| Hg-203 | 1.722E-07 | 0.00E+00 | 0.00E+00 |

# 4.0 **TOTAL DOSE DETERMINATIONS**

## 4.1 40CFR190 Dose Evaluation

Per RECS D3.4, the direct radiation component for potential offsite dose is routinely determined and reported, along with doses from effluent. Radiological Support has determined bounding calculations (using References 26 through 29) as follows:

Direct Radiation Dose = VC + IRWSF + SGM + ISFSI + RMHAs

where;

| | | |
|---|---|---|
| VC | = | The Vapor Containment structures |
| IRWSF | = | The Interim Radioactive Waste Storage Facility |
| SGM | = | The Steam Generator Mausoleums (both units) |
| ISFSI | = | The Dry Cask Storage Facility, once active |
| RMHA | = | Radioactive Material Handling Areas, as posted, summed |

Other structures or tanks are included as determined by Rad Support. The calculations in References 26 through 29 were performed in order to meet the requirements of the annual effluent report, and NRC Generic Letter 81-38, 11/10/1981, Storage of Low-Level Radioactive Wastes at Power Reactor Sites.

> "Offsite doses from onsite storage must be sufficiently low to account for other uranium fuel cycle sources (e.g., an additional dose of <1 mrem/year is not likely to cause the limits of 40 CFR 190 to be exceeded). On site dose limits will be controlled per 10CFR20…"

The IRWSF, SGM, and RMHAs fence line dose rates are limited by department procedures to keep dose rates at the SITE BOUNDARY fence < 1 mrem/yr based on calculations performed in References 26 through 29. These calculations contain realistic occupancy factors for the SITE BOUNDARY fence and the nearest neighbor.

ISFSI dose rate calculations and specification are bounded by a conservatively applied maximum annual dose of 17 mrem at the site boundary. This special bounding criteria ensure that combined offsite doses (effluent and direct shine) are in compliance with 40CFR190.

## 4.2 Doses From Liquid Releases

Doses to real individuals can be determined with the same (maximum individual) methodology described in the ODCM, but with more realistic assumptions with regard to dilution, diet, and occupenncy. Actual radionuclide concentrations in foodstuffs can be applied per the Radiological Environmental Monitoring Program (REMP), such that more accurate doses are determined from actual intakes, rather than models only.

## 4.3 Doses From Atmospheric Releases

Similarly, real individual methodology can be substituted for maximum individual modeling for airborne releases. Specific dose transfer factors can be used in lieu of weighted dose transfer factors. Information on the location and occupancy of real individuals, as well as more precise meteorological information and the consumption of foodstuffs, can be employed to re-calculate more accurate doses. The REMP can also provide actual concentrations to apply for a more accurate determination than modeling alone.

Data from the land use census can be used to either extend times from food production to consumption, or otherwise show that the exposure of the critical receptors is reduced.

Also, estimates of direct exposure through calculation may be supplanted by REMP results, since these are often more indicative of the true impact at specific locations. Default values used in NUREG-0133 and Reg Guide 1.109 methodology can be supplanted by more specific values if there has been sufficient science and pedigree involved in their determination.

## 4.4 Doses to MEMBERS OF THE PUBLIC Visiting the Site

Per the RECS Bases, and the discussion regarding gaseous effluent dose rate, visiting MEMBERS OF THE PUBLIC will receive negligible dose from plant effluents, as calculated per ODCM Part II, Sections 3.3.3 and 3.3.4, due the application of multiplicative occupancy factors. These factors are determined by comparing the expected hours on site to 8760 hours (the number of hours in a year, which is used in the calculations demonstrated in Sections 3.3.3 and 3.3.4). Examples of these calculations are as follows:

example 1: Several students visit the site for an 8-hour guided tour.
Their occupancy factor is: 8 / 8760 or **.0009**.

example 2: A man drives his wife to work and drops her off at the security gate each morning, with a total stay-time on site for 2 minutes per day. His occupancy factor is calculated as follows:

2 min/60 min per hour =.0333 hr ; 0.0333 / 8760 = **3.8E-6**

These factors, when multiplied by doses calculated per Sections 3.3.3 and 3.3.4, demonstrate that dose to these MEMBERS OF THE PUBLIC is negligible, despite any potential reduction in the atmospheric dispersion.

## 5.0 LOWER LIMIT OF DETECTION (LLD)

The LLD is the smallest concentration of radioactive material in a sample that will yield a net count above system background, and be detected with 95% probability, with a 5% probability of falsely concluding that a blank observation represents a "real" signal.

For a particular measurement system (which may include radiochemical separation):

$$LLD = \frac{\frac{2.71}{T_s} + 3.29\, s_b * \sqrt{1+(\frac{T_b}{T_s})}}{E * V * k * Y * e^{-\lambda t}}$$

where:

- LLD = The lower limit of detection as defined above (as picocurie per unit mass or volume)
- $T_s$ = The sample counting time in minutes
- $s_b$ = The standard deviation of the background counting rate or of the counting rate of a blank sample as appropriate (as counts per minute)
- $T_b$ = The background count time in minutes
- E = The counting efficiency (as counts per transformation)
- V = The sample size (in units of mass or volume)
- k = A constant for the number of transformations per minute per unit of activity (normally, 2.22E+6 dpm per μCi)
- Y = The fractional radiochemical yield (when applicable)
- $\lambda$ = The radioactive decay constant for the particular radionuclide
- t = The elapsed time between midpoint of sample collection and time of counting

Note: The above LLD formula accounts for differing background and sample count times. The Radiological Environmental Monitoring Program, REMP, uses an LLD formula that assumes equal background and sample count times, in accordance with the RECS. When the above LLD formula is more appropriate for the effluents program, it may be used.

The constants 2.71 and 3.29 and the general LLD equation were derived from the following two sources:

1) Currie, L.A. "Limits for Qualitative Detection of Quantitative Determination". (Anal. Chem. 40:586-593, 1968); and,

2) Mayer, Dauer "Application of Systematic Error Bounds to Detection Limits for Practical Counting". (HP Journal 65(1): 89-91, 1993)

The value of Sb used in the calculation of the LLD for a detection system shall be based on the actual observed variance of the background counting rate or of the counting rate of the blank samples (as appropriate) rather than on an unverified theoretically predicted variance. In calculating the LLD for a radionuclide determined by gamma ray spectrometry, the background shall include the typical contributions of other radionuclides normally present in the samples. Typical values of E, V, Y, and t shall be used in the calculation. The background count rate is calculated from the background counts that are determined to be within ± one FWHM (Full-Width-at-Half-Maximum) energy band about the energy of the gamma ray peak used for the quantitative analysis for that radionuclide.

It should be recognized that the LLD is defined as an a priori (before the fact) limit representing the capability of a measurement process and not as an a posteriori (after the fact) limit for a particular measurement.

To handle the a posteriori problem, a decision level must be defined, which has been identified as the Critical Level. Following an experimental observation, one must decide whether or not a real signal was, in fact, detected. This type of binary qualitative decision is subject to two kinds of error: deciding that the radioactive material is present when it is not (a: Type I error), and the converse, failing to decide that it is present when it is (b: Type II error). The maximum acceptable Type I error (a), together with the standard deviation, Snet, of the net signal when the net signal equals zero, establish the Critical Level, Lc, upon which decisions may be based.

Operationally, an observed signal, S, must exceed $L_c$ to yield the decision, detected.

$$L_c = k_a s_b (1+T_b/T_s)^{0.5}$$

where:

$k_a$ is related to the standardized normal distribution and corresponds to a probability level of 1-a. For instance, selection of a = 0.01 corresponds to a 99% confidence level that activity is present. When determining the Lc for different measurement processes, it is allowable to set a at less than or equal to 0.05 as long as the following condition is met:

To set a for $L_c$ determination at less than 0.05, the equation for the LLD (which places a less than or equal to 0.05) should be employed to verify that the calculated LLD is less than or equal to the LLDs specified in the RECS. This calculation, if necessary, will be performed on a case by case basis.

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# APPENDIX A

## SUMMARY of RADIOLOGICAL EFFLUENT CONTROLS (RECS)

| | ***LIQUID:*** | ***AIRBORNE:*** |
|---|---|---|
| **Dose Rate** | The diluted concentration of each isotope in UNRESTRICTED AREAS is limited to ten times the ECs of 10CFR20, defined as the Maximum Permissible Concentrations (MPCw) identified per Section D1.1. The diluted concentration of dissolved or entrained noble gases is limited to 2E-4 uCi/ml. | Dose rate is limited at or beyond the SITE BOUNDARY to:<br>• 500 mrem/yr whole body, per site, for noble gases;<br>• 3000 mrem/yr to the skin, per site, for noble gases;<br>• 1500 mrem/yr to any organ, per site for iodine-131, tritium, or 8 day particulates. |
| **Cumulative Dose** | Dose commitment to any member of public in UNRESTRICTED AREAS is limited to:<br>1) In any calendar quarter, 1.5 mrem to the total body and 5 mrem to any organ.<br>2) In a calendar year, 3 mrem to the total body and 10 mrem to any organ. | Air Dose at the SITE BOUNDARY is limited to:<br>5 mrad per quarter and 10 mrad per year for noble gases, gamma air dose;<br>10 mrad per quarter and 20 mrad per year for noble gases, beta air dose.<br>Maximum Individual Dose to a Member of the Public at the nearest resident is limited to 7.5 mrem per qtr and 15 mrem per yr for Iodine, H-3, & 8 day particulates to any organ. |
| **Dose Projection** | Projection of liquid effluent doses shall be computed at least every 31 days. If projected doses exceed:<br>0.06 mrem total body, or<br>0.2 mrem critical organ,<br>clean-up treatment systems are required to be operational and applied to future releases. | Projection of airborne effluent doses shall be computed at least every 31 days. If projected doses exceed<br>0.2 mrad gamma air dose,<br>0.4 mrad beta air dose, or<br>0.3 mrem to any organ at the nearest residence,<br>clean-up treatment systems are required to be operational. |

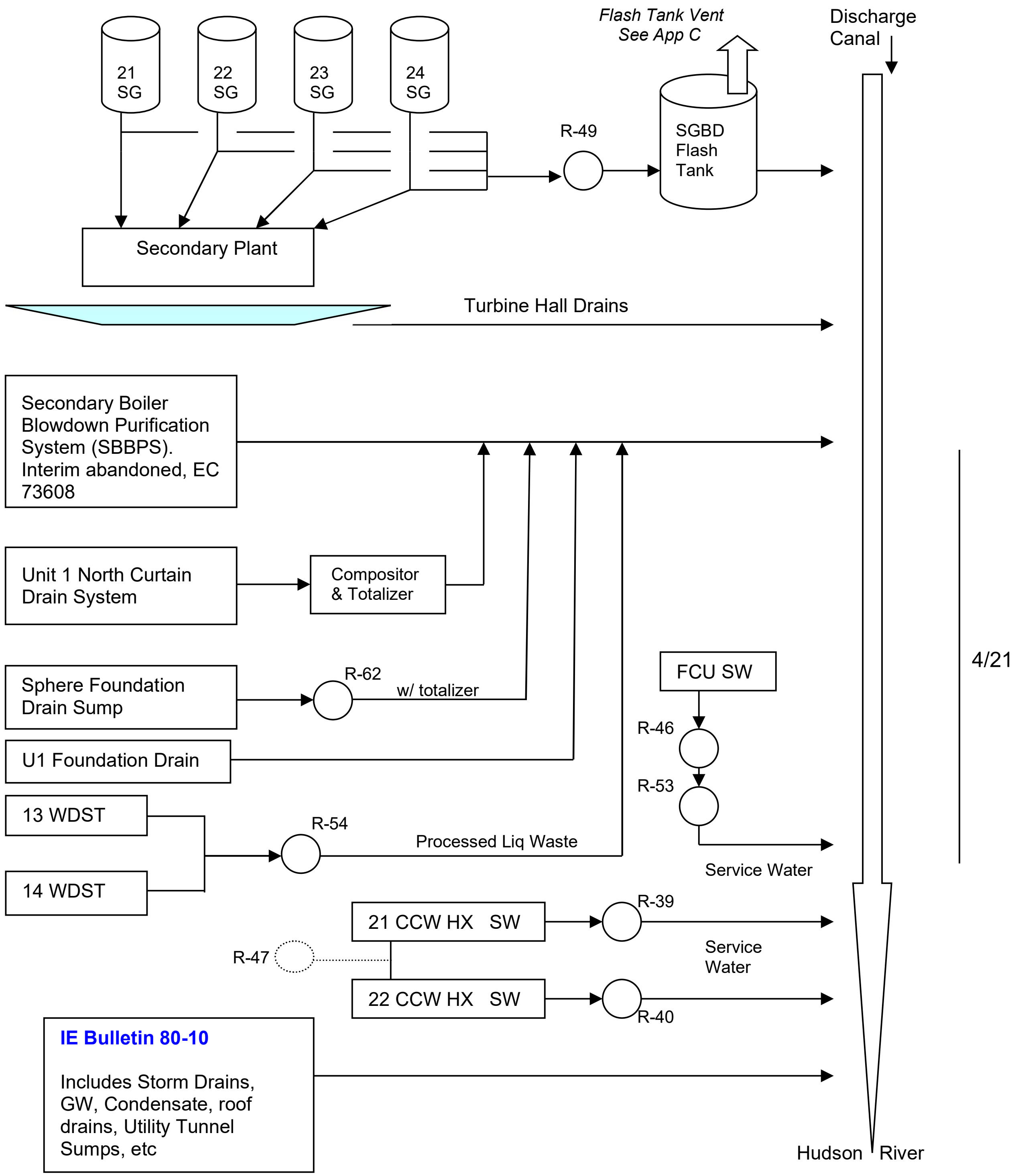
***TOTAL DOSE:***

(includes all effluents, plus direct shine from holding pens, or ISFSI, etc)

25 mrem/yr, all sources, whole body or any organ except thyroid,
75 mrem/yr, all sources, thyroid.

**APPENDIX B**
(Page 1 of 2)

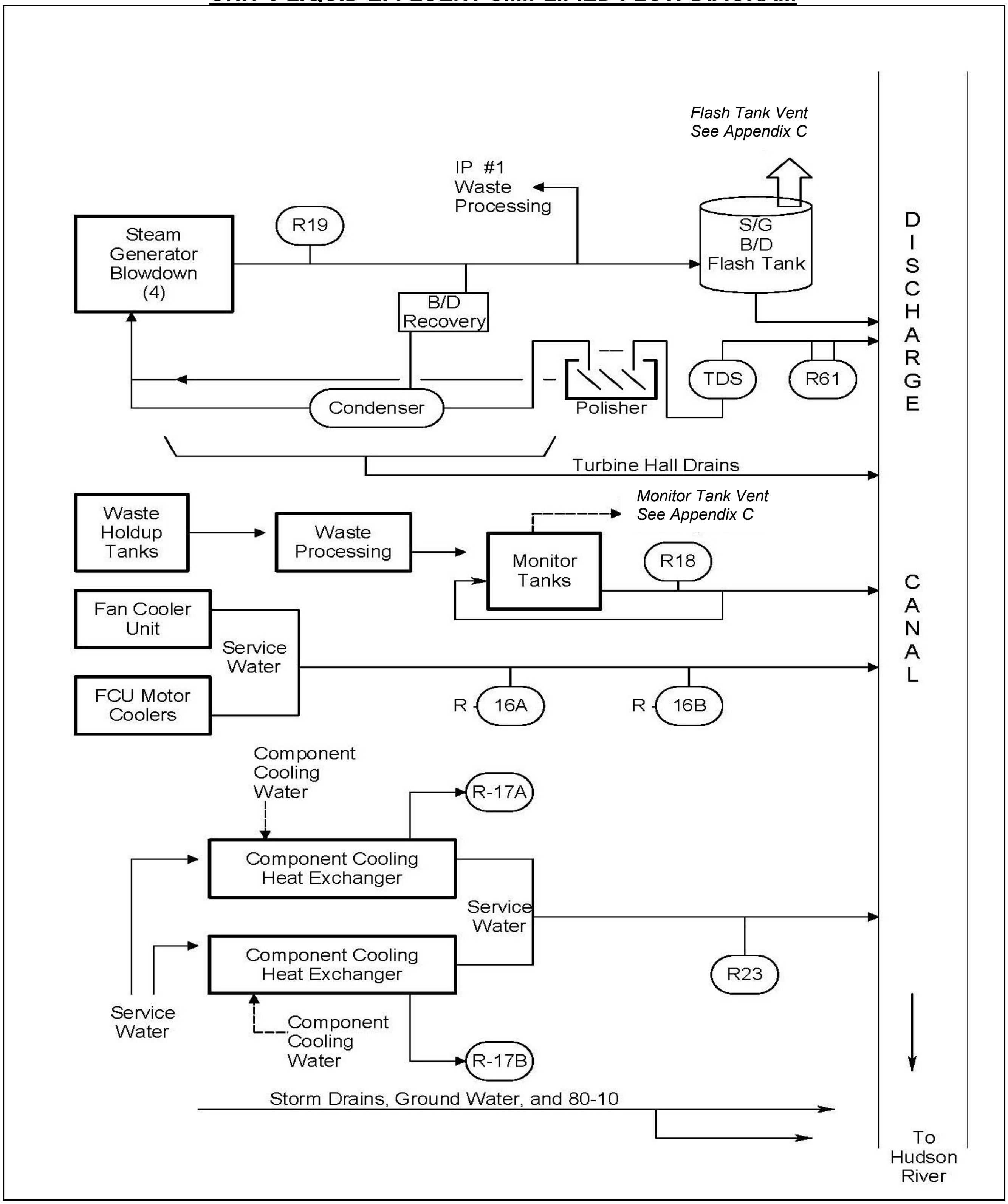
## UNITS 1 and 2 LIQUID EFFLUENT SIMPLIFIED FLOW DIAGRAM




Any other identified effluent is evaluated for inclusion in integrated totals.

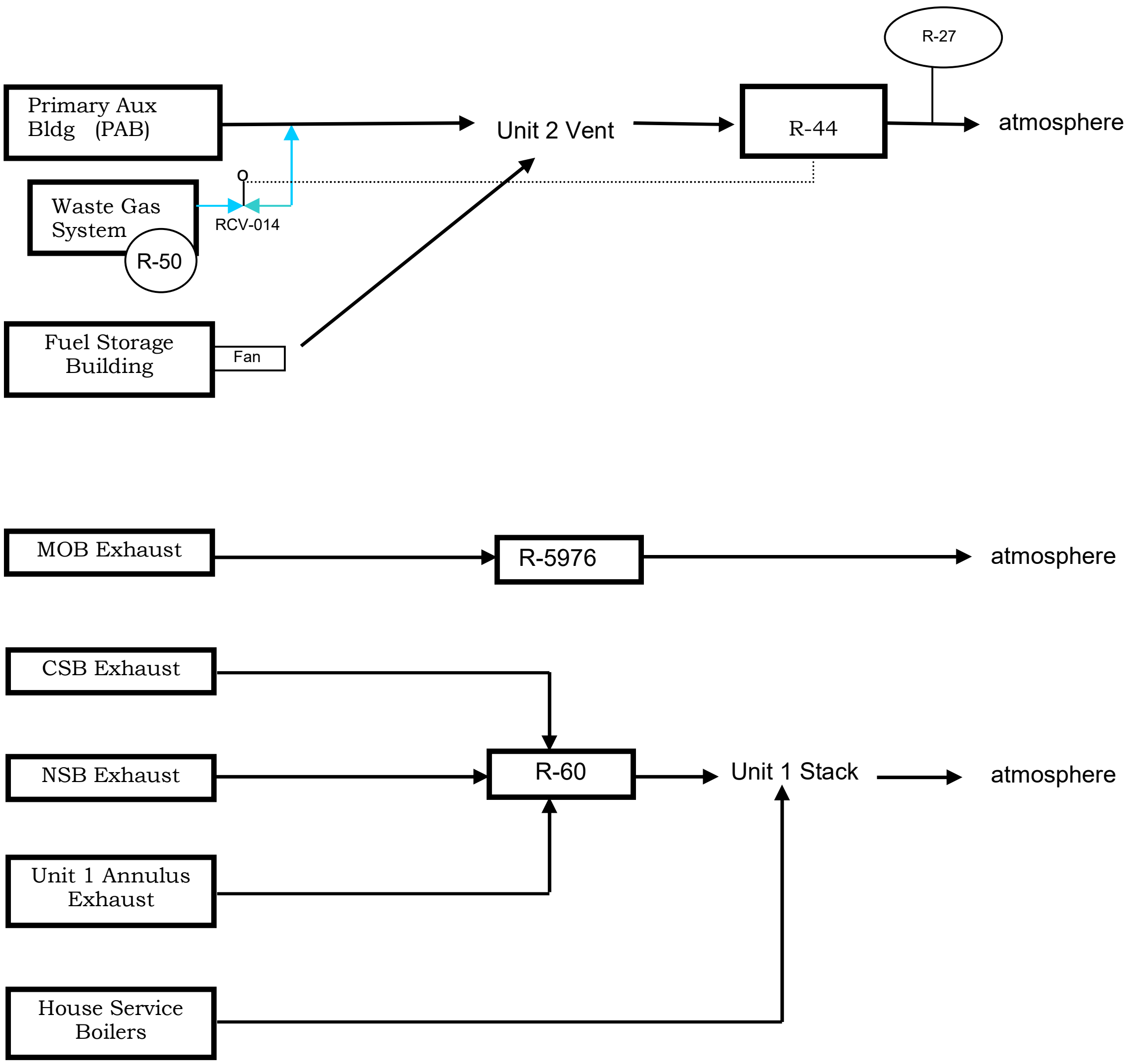
**APPENDIX B**
(Page 2 or 2)

**UNIT 3 LIQUID EFFLUENT SIMPLIFIED FLOW DIAGRAM**



**APPENDIX C**
(Page 1 of 2)

**UNITS 1 and 2 GASEOUS EFFLUENT SIMPLIFIED FLOW DIAGRAM**

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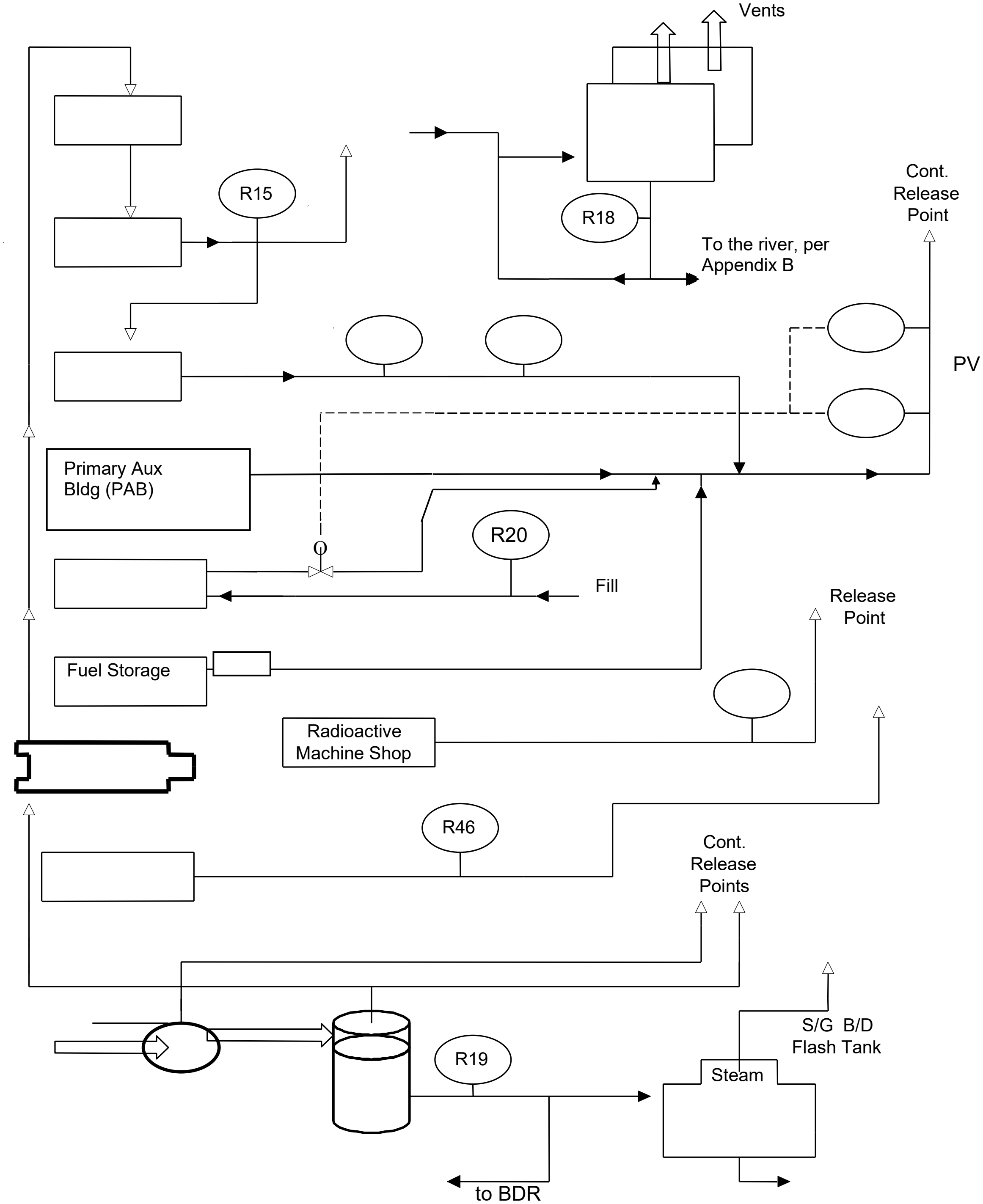
**APPENDIX C**
(Page 2 of 2)

## UNIT 3 GASEOUS EFFLUENT SIMPLIFIED FLOW DIAGRAM



**APPENDIX D**

Appendix D information deleted in Revision 6. 4/21

# APPENDIX E

## ALLOWED DILUTED CONCENTRATION (ADC)

The Allowed Diluted Concentration (ADC) is derived and calculated as follows:

$$ADC = \frac{MPCWt * CG}{Total\,activity} \quad or \quad ADC = \frac{MPCWt * CG}{CG + CB} \quad or \quad ADC = \frac{MPCWt}{1 + CB/CG}$$

Where;

ADC = Allowed diluted concentration in μCi/ml

MPCWt = Maximum permissible concentration in water for all isotopes (beta & gamma), in uCi/ml, as defined in RECS D3.1.1, as follows:

$$MPCWt = \frac{\sum_i Ci}{\sum_i \left\langle Ci/MPCWi \right\rangle}$$

Where;

Ci and MPCWi = Concentration and MPCW for each isotope

CB = The concentration of the non gamma emitters, in μCi/cc

CG = The concentration of the gamma emitters in uCi/ml

Applications of ADC:

If simultaneous liquid radioactive discharges are being performed from one unit, dilution flows may need to be re-apportioned. This may be performed by allocation or by calculation. The required dilution flow is calculated as follows:

$$E = \frac{Dr * CG}{ADC}$$

where;

Dr = Current release discharge rate, gpm

E = Required dilution for current existing release(s), gpm

The permissible discharge rate is then calculated as follows:

$$D = \frac{ADC * B}{CG}$$

Where:

D = Permissible discharge rate in gal/min

B = Adjusted dilution flow (Available – E, above), in gpm

Note that when there are no other releases (E=0), B simply becomes the available dilution flow.

## APPENDIX F

## CONVERSION FACTORS FOR LIQUID EFFLUENT MONITORS

Monitor conversion factors are derived from circulating a representative sample (or NIST traceable fluid) through the monitor until a stable reading is obtained. The conversion factor is then determined by quantifying the uCi/cc (by gamma spectroscopy or known activity) and dividing this value by the net cpm displayed on the monitor.

Fluid may be recirculated within the monitoring system, or introduced into a closed loop, to provide elevated, stable readings on the monitor. This fluid should be representative of the expected nuclide mixture in the system, as the conversion factor is energy-dependent.

When the process fluid itself is of sufficient activity to provide this function, it is this fluid that is measured and applied to develop a typical conversion factor.

When the process fluid is usually free of contamination, NIST traceable fluid must be injected into the sample chamber to accomplish this task.

Once the sample chamber is providing a stable reading, an alequate of the fluid is measured by gamma spectroscopy to determine the average energy and the monitor's conversion factor.

Conversion Factors for effluent monitors are maintained by Chemistry and updated when standard mixtures change which would warrant an improved average energy representation.

If desired, a more robust method can be applied per Reference 43.

**APPENDIX G** (Page 1 of 7)

**ENVIRONMENTAL SAMPLING POINTS**

| Sample Designation | IPEC Station Number | Location | Distance | Direction from U1 Stack |
|---|---|---|---|---|
| DR1 | 57 | Roa Hook | 2.0 mi | N |
| DR2 | 59 | Old Pemart Avenue | 1.8 mi | NNE |
| DR3 | 90 | Charles Point | 0.88 mi | NE |
| DR4 | 28 | Lents Cove | 0.45 mi | ENE |
| DR5 | 35 | Broadway and Bleakley Avenue | 0.37 mi | E |
| DR6 | 88 | Reuter-Stokes Pole #6 | 0.32 mi | ESE |
| DR7 | 14 | Water Meter House | 0.3 mi | SE |
| DR8 | 03 | Service Center Building | 0.35 mi | SSE |
| DR9 | 34 | South East Corner of Site | 0.52 mi | S |
| DR10 | 05 | NYU Tower | 0.88 mi | SSW |
| DR11 | 53 | White Beach | 0.92 mi | SW |
| DR12 | 74 | West Shore Drive - South | 1.59 mi | WSW |
| DR13 | 76 | West Shore Drive – North | 1.21 mi | W |
| DR14 | 78 | Rt. 9W, across from R/S #14 | 1.2 mi | WNW |
| DR15 | 80 | Rt. 9W - South of Ayers Road | 1.02 mi | NW |
| DR16 | 82 | Ayers Road | 1.01 mi | NNW |
| DR17 | 58 | Rt. 9D – Garrison | 5.41 mi | N |
| DR18 | 60 | Gallows Hill Road and Sprout Brook Road | 5.02 mi | NNE |
| DR19 | 62 | West Brook Drive (near the Community Center) | 5.03 mi | NE |
| DR20 | 64 | Lincoln Road – Cortlandt (School Parking Lot) | 4.6 mi | ENE |
| DR21 | 66 | Croton Ave. – Cortlandt | 4.87 mi | E |
| DR22 | 67 | Colabaugh Pond Rd. – Cortlandt | 4.5 mi | ESE |
| DR23 | 69 | Mt. Airy & Windsor Road | 4.97 mi | SE |
| DR24 | 92 | Warren Rd. – Cortlandt | 3.84 mi | SSE |
| DR25 | 71 | Warren Ave. – Haverstraw | 4.83 mi | S |
| DR26 | 72 | Railroad Ave. & 9W Haverstraw | 4.53 mi | SSW |
| DR27 | 73 | Willow Grove Rd. & Captain Faldermeyer Drive | 4.97 mi | SW |
| DR28 | 81 | Palisades Parkway, Lake Welch Exit | 4.96 mi | WSW |
| DR29 | 77 | Palisades Parkway | 4.15 mi | W |
| DR30 | 79 | Anthony Wayne Park | 4.57 mi | WNW |
| DR31 | 75 | Palisades Parkway | 4.65 mi | NW |
| DR32 | 83 | Rt. 9W Fort Montgomery | 4.82 mi | NNW |
| DR33 | 33 | Hamilton Street (Substation) | 2.88 mi | NE |
| DR34 | 38 | Furnace Dock (Substation) | 3.43 mi | SE |
| DR35 | 89 | Highland Ave. & Sprout Brook Rd. (near Rock Cut) | 2.89 mi | NNE |
| DR36 | 61 | Lower South Street and Franklin Street | 1.3 mi | NE |
| DR37 | 56 | Verplanck – Broadway & 6th St. | 1.25 mi | SSW |
| DR38 | 20 | Cortlandt Yacht Club (aka Montrose Marina) | 1.5 mi | S |
| DR39 | 29 | Grassy Point | 3.37 mi | SSW |
| DR40 | 23 | *Roseton | 20.7 mi | N |
| DR41 | 27 | Croton Point | 6.36 mi | SSE |

* Control Station

## ENVIRONMENTAL SAMPLING POINTS

| Sample Designation | IPEC Station Number | Location | Distance | Direction from U1 Stack |
|---|---|---|---|---|
| **Airborne** | | | | |
| A1 | 4 | Algonquin Gas Line | 0.28 mi | SW |
| A2 | 94 | IPEC Training Center | 0.38 mi | S |
| A3 | 95 | Meteorological Tower | 0.46 mi | SSW |
| A4 | 5 | NYU Tower | 0.88 mi | SSW |
| A5 | 23 | *Roseton | 20.7 mi | N |
| **Waterborne – Surface (Hudson River Water)** | | | | |
| Wa1 | 9 | *Roseton 20.7 miles N | | |
| Wa2 | 10 | Discharge Canal (Mixing Zone) 0.3 mi - WSW | | |
| **Waterborne – Drinking** | | | | |
| Wb1 | 7 | Camp Field Reservoir | 3.4 mi | NE |
| **Soil From Shoreline** | | | | |
| Wc1 | 53 | White Beach | 0.92 mi | SW |
| Wc2 | 50 | *Manitou Inlet | 4.48 mi | NNW |
| **Ingestion-Food Products (Broad Leaf Vegetation)** | | | | |
| Ic1 | 95 | Meteorological Tower | 0.46 mi | SSW |
| Ic2 | 94 | IPEC Training Center | 0.39 mi | S |
| Ic3 | 23 | *Roseton | 20.7 mi | N |

Exposure Pathway/Sample Designation: Milk

There are no milch animals whose milk is used for human consumption within 8 km distance of Indian Point; therefore, no milk samples are taken (Ia1 – Ia4).

Exposure Pathway/Sample Designation: Ingestion-Fish and Invertebrates

The RECS designate three required sample locations labeled Ib1/25, Ib2/23 and Ib3/107. The downstream Ib1 location and samples will be chosen where it is likely to be affected by plant discharge. Ib2 will be a location upstream that is not likely to be affected by plant discharge. The following species along with other commercially/recreationally important species are considered acceptable:

Striped Bass
Bluegill Sunfish
White Perch
Pumpkin Seed
White Catfish
Blueback Herring
American Eel
Crabs

*Control Station

## APPENDIX G



## ENVIRONMENTAL SAMPLING POINTS

| Sample Designation | IPEC Station Number | Location | Distance | Direction from U1 Stack | Sample Types |
|---|---|---|---|---|---|
| DR8 | 3 | Service Center Building | 0.35 mi | SSE | 3 |
| A1 | 4 | Algonquin Gas Line | 0.28 mi | SW | 1,2 |
| A4, DR10 | 5 | NYU Tower | 0.88 mi | SSW | 1,2,3 |
| Wb1 | 7 | Camp Field Reservoir | 3.4 mi | NE | 6 |
| Wa1 | 9 | *Roseton | 20.7 mi | N | 7 |
| Wa2 | 10 | Discharge Canal (Mixing Zone) | 0.3 mi | WSW | 7 |
| DR7 | 14 | Water Meter House | 0.3 mi | SE | 3 |
| DR38 | 20 | Cortlandt Yacht Club (AKA Montrose Marina) | 1.5 mi | S | 3 |
| Ib2,A5,DR40,Ic3 | 23 | *Roseton | 20.7 mi | N | 1,2,3,4,12 |
| Ib1 | 25 | where available, downstream | N/A | N/A | 12 |
| DR41 | 27 | Croton Point | 6.36 mi | SSE | 1,2,3 |
| DR4 | 28 | Lents Cove | 0.45 mi | ENE | 3 |
| DR39 | 29 | Grassy Point | 3.37 mi | SSW | 1,2,3 |
| DR33 | 33 | Hamilton Street (Substation) | 2.88 mi | NE | 3 |
| DR9 | 34 | South East Corner of Site | 0.52 mi | S | 3 |
| DR5 | 35 | Broadway & Bleakley Avenue | 0.37 mi | E | 3 |
| DR34 | 38 | Furnace Dock (Substation) | 3.43 mi | SE | 3 |
| Wc2 | 50 | *Manitou Inlet | 4.48 mi | NNW | 10 |
| Wc1, DR11 | 53 | White Beach | 0.92 mi | SW | 3,10 |
| DR37 | 56 | Verplanck – Broadway & 6th Street | 1.25 mi | SSW | 3 |
| DR1 | 57 | Roa Hook | 2.0 mi | N | 3 |
| DR17 | 58 | Rt. 9D Garrison | 5.41 mi | N | 3 |
| DR2 | 59 | Old Pemart Ave. | 1.8 mi | NNE | 3 |
| DR18 | 60 | Gallows Hill Road and Sprout Brook Road | 5.02 mi | NNE | 3 |
| DR36 | 61 | Lower South Street and Franklin Street | 1.3 mi | NE | 3 |
| DR19 | 62 | West Brook Drive (near the Community Center) | 5.03 mi | NE | 3 |
| DR20 | 64 | Lincoln Road – Cortlandt (School Parking Lot) | 4.6 mi | ENE | 3 |
| DR21 | 66 | Croton Ave. – Cortlandt | 4.87 mi | E | 3 |
| DR22 | 67 | Colabaugh Pond Rd. – Cortlandt | 4.5 mi | ESE | 3 |
| DR23 | 69 | Mt. Airy & Windsor Road | 4.97 mi | SE | 3 |

* Control Station

**APPENDIX G** 

**ENVIRONMENTAL SAMPLING POINTS**

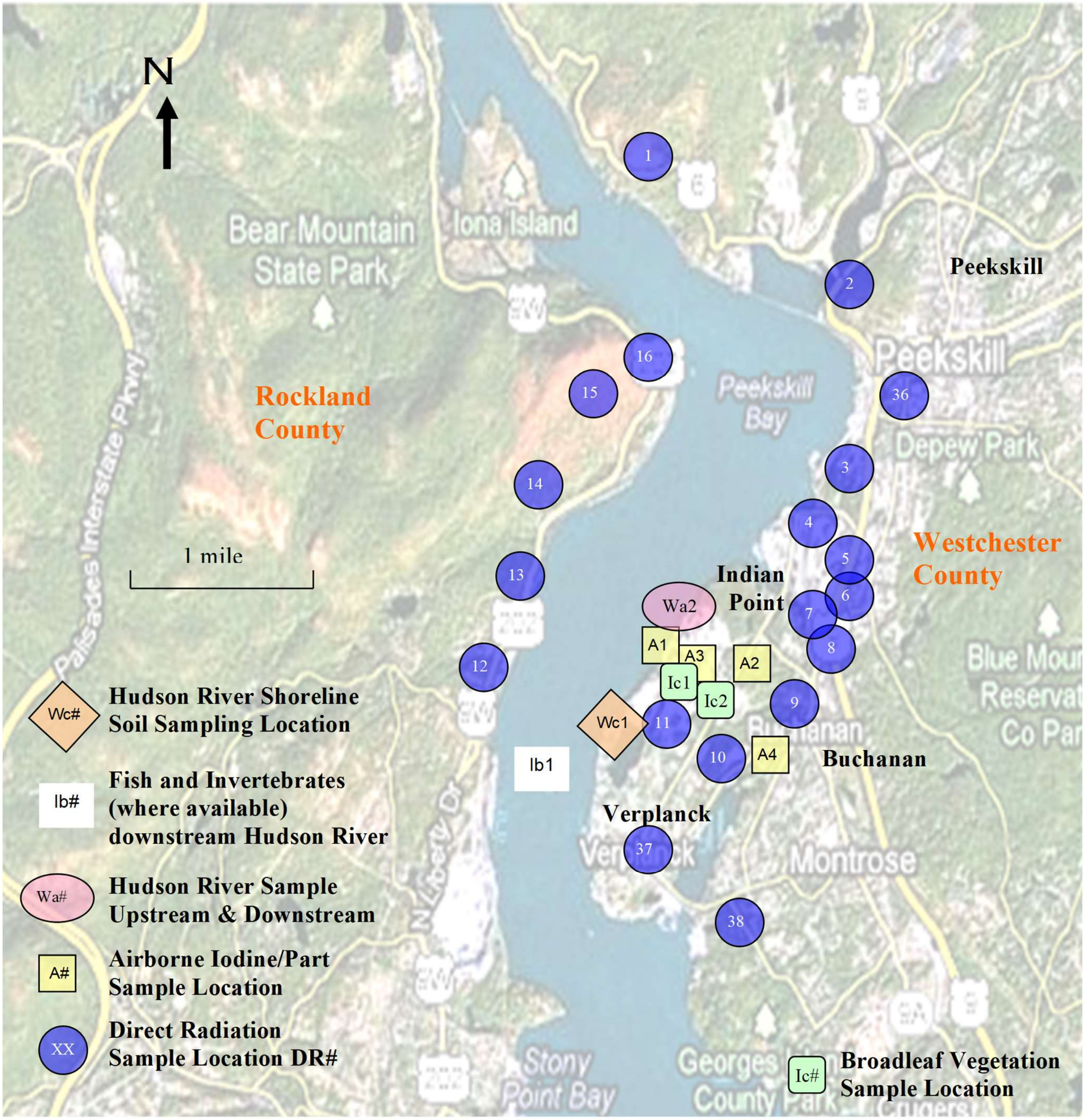
| Sample Designation | IPEC Station # | Location | Distance | Direction from U1 Stack | Sample Types |
|---|---|---|---|---|---|
| DR25 | 71 | Warren Avenue – Haverstraw | 4.83 mi | S | 3 |
| DR26 | 72 | Railroad Ave. & 9W – Haverstraw | 4.53 mi | SSW | 3 |
| DR27 | 73 | Willow Grove Rd. & Captain Faldermeyer Dr | 4.97 mi | SW | 3 |
| DR12 | 74 | West Shore Drive – South | 1.59 mi | WSW | 3 |
| DR31 | 75 | Palisades Parkway | 4.65 mi | NW | 3 |
| DR13 | 76 | West Shore Drive – North | 1.21 mi | W | 3 |
| DR29 | 77 | Palisades Parkway | 4.15 mi | W | 3 |
| DR14 | 78 | Rte. 9W, across from R/S #14 | 1.2 mi | WNW | 3 |
| DR30 | 79 | Anthony Wayne Park | 4.57 mi | WNW | 3 |
| DR15 | 80 | Rte. 9W – South of Ayers Road | 1.02 mi | NW | 3 |
| DR28 | 81 | Palisades Parkway, Lake Welch Exit | 4.96 mi | WSW | 3 |
| DR16 | 82 | Ayers Road | 1.01 mi | NNW | 3 |
| DR32 | 83 | Rte. 9W – Fort Montgomery | 4.82 mi | NNW | 3 |
| DR6 | 88 | Reuter-Stokes Pole #6 | 0.32 mi | ESE | 3 |
| DR35 | 89 | Highland Ave. & Sprout Brook Road (near rock cut) | 2.89 mi | NNE | 3 |
| DR3 | 90 | Charles Point | 0.88 mi | NE | 3 |
| DR24 | 92 | Warren Rd. – Cortlandt | 3.84 mi | SSE | 3 |
| A2, Ic2 | 94 | IPEC Training Center | 0.39 mi | S | 1,2,4 |
| A3, Ic1 | 95 | Meteorological Tower | 0.46 mi | SSW | 1,2,4 |
| Ib3 | 107 | Vicinity of Haverstraw Bay | 2.50 mi | SSW | 12 |

* Control Station

Sample types are:

| | | | |
|---|---|---|---|
| 1 | Air particulates | 9 | H.R. aquatic vegetation |
| 2 | Radioiodine | 10 | H.R. shoreline soil |
| 3 | Direct gamma | 12 | Fish and invertebrates |
| 4 | Broadleaf vegetation | 13 | Groundwater well |
| 6 | Drinking water | | |
| 7 | Hudson River (H.R.) water | | |

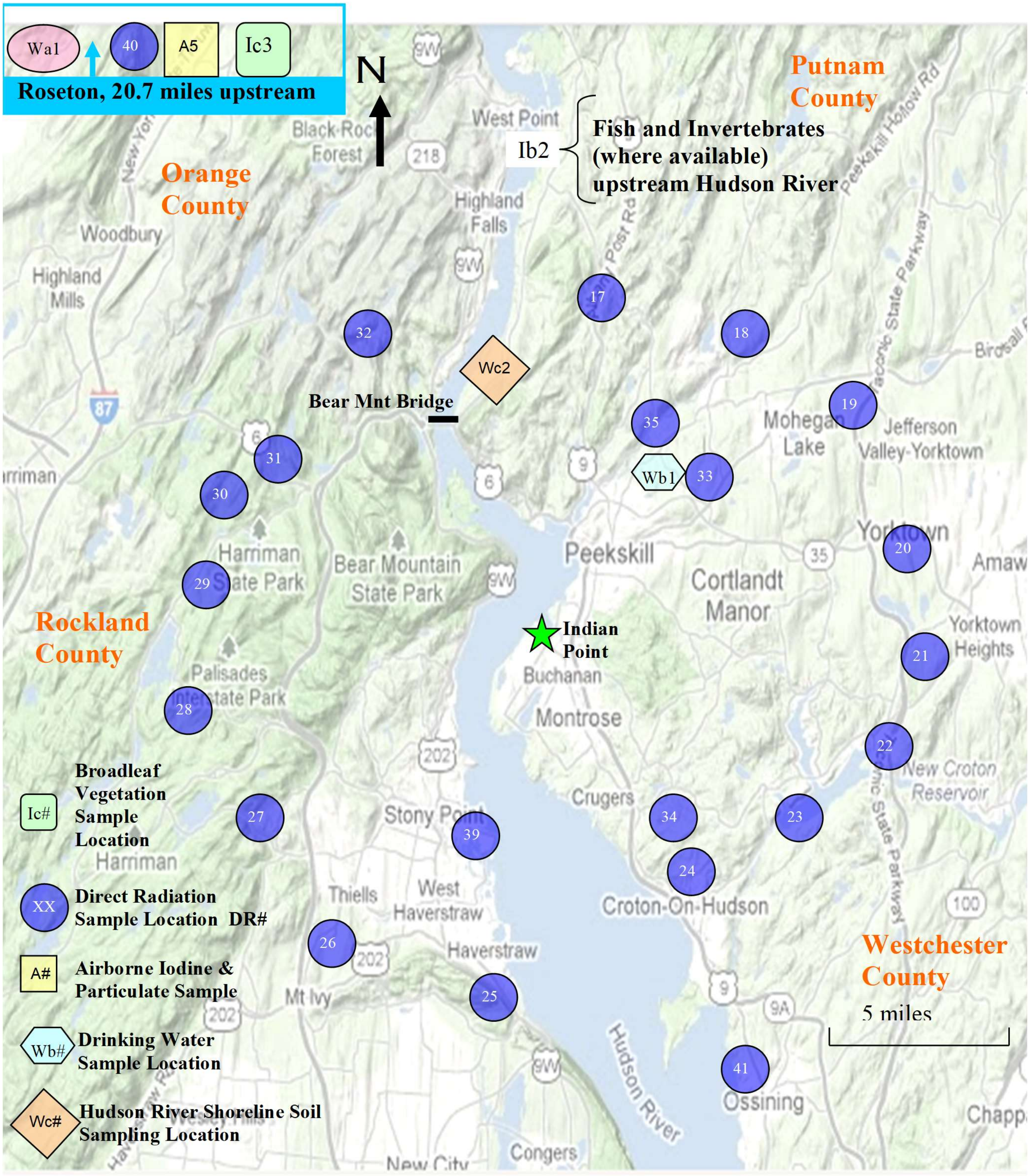
**APPENDIX G**
(Page 5 of 7)
**Environmental Sampling Points Within Two Miles of Indian Point**



**APPENDIX G**

(Page 6 of 7)

**Environmental Sampling Points Greater Than Two Miles from Indian Point**



**APPENDIX G**

(Page 7 of 7)

**ENVIRONMENTAL SAMPLING POINTS**

ADDITIONAL SAMPLING LOCATIONS, by IPEC Station Number

**Deleted**

**APPENDIX H**

## INTERLABORATORY COMPARISON PROGRAM

Laboratories used for analysis of samples to support the Radiological Environmental Monitoring Program (REMP) participate in an Interlaboratory Comparison Program or comparable program with an approved vendor (EPA, NIST, etc).

Samples of various media containing known activities of radionuclides are sent to participating laboratories for analyses. Results of the analyses are compared to the known values.

While laboratory results may be reported in terms of normalized deviations from a known value (generally ± 3 sigma), the results are evaluated for acceptance criteria using the NRC's standardized comparison requirements for agreement found in the site quality control procedures (as a function of resolution).

Annual results of the interlab participation, along with resolution and agreement criteria, are summarized in the Annual Environmental Operating Report.

## CALCULATION OF ALLOWABLE RELEASE RATES FOR INDIAN POINT UNITS 2 and 3

Primary Assumptions:

- Units 2 and 3 effective dose factors (KLMN) are equivalent, except for unit-specific finite cloud correction factors, which represent different recirculation contribution, as required.
- For instantaneous release calculations, the default (initial) condition is for each unit to share (50-50) in the application of the site's 10CFR20 limit (converted to uCi/sec from mrem/yr).
- The following data represent long-term meteorological factors. Short term correction, if applicable, should be applied to these values, as discussed in Section 3.5, and Reference 17.

| Unit 1 or 2 Release Points | Receptor | Site Boundary | Nearest Resident | 5-miles Down Valley, Haverstraw |
|---|---|---|---|---|
| Primary Vent Releases | Concentration X/Q (sec/$m^3$) | 2.219E-06 [SSW, 755 m] | 1.030E-06 [SSW, 1574 m] | 7.22E-07 |
| | Deposition D/Q ($m^{-2}$) | 1.407E-08 [SSW, 755 m | 7.517E-09 [S, 1133 m] | 1.35E-09 |
| Ground Level Releases | Concentration X/Q (sec/$m^3$) | 4.585E-05* [SSW, 440 m] | 1.448E-05* [ESE, 515 m] | 7.22E-07 |
| | Deposition D/Q ($m^{-2}$) | 8.759E-08 [SSW, 440 m | 3.439E-08* [ESE, 515 m] | 1.35E-09 |

| Unit 3 Release Point | Receptor | Site Boundary | Nearest Resident | 5-miles Down Valley, Haverstraw |
|---|---|---|---|---|
| Primary Vent Releases | Concentration X/Q (sec/$m^3$) | 4.473E-06 [SW, 350 m] | 1.016E-06 [SSW, 1574 m] | 7.22E-07 |
| | Deposition D/Q ($m^{-2}$) | 2.599E-08 [SSW, 480 m] | 7.451E-09 [S, 1133 m] | 1.35E-09 |
| Ground Level Releases | Concentration X/Q (sec/$m^3$) | 1.114E-4* [SSW, 250 m] | 1.448E-05* [ESE, 515 m] | 7.22E-07 |
| | Deposition D/Q ($m^{-2}$) | 2.012E-07 [SSW, 250 m] | 3.439E-08* [ESE, 515 m] | 1.35E-09 |

*Data from Reference 50, 2006 to 2015 Site Meterology

## CALCULATION OF ALLOWABLE RELEASE RATES FOR INDIAN POINT UNITS 2 and 3

Instantaneous Release Rates vs Dose Rates

Indian Point units 2 and 3 share a common site boundary limit of 500 mrem/yr. This 500 mrem/yr limit was divided between the units based upon a 50-50 split of the release rate in μCi/sec. Because each unit has its own X/Q and K-bar, equal μCi/sec discharges from each plant will result in different dose rates for each plant at the most restrictive site boundary location. In order to define the split of the 500 mrem/yr limit, IPEC units 2 and 3 must base the dose split on the mixture presented in Table 3-8.

***Dose Split Between IP2 and IP3***

A. Instantaneous Dose Rates and Calculation of Allowable Release Rate in uCi/sec:

i. Whole Body Dose Rate Calculations:

Given:

a) site limit is 500 mrem/yr

b) IP3 worst sector X/Q = 4.47E-6 sec/$m^3$

c) IP3 K-bar for instantaneous mixture = 849 $\frac{mrem \bullet m^3}{\mu Ci \bullet yr}$

d) IP2 worst sector X/Q = 2.22E-6 sec/$m^3$

e) IP2 K-bar for instantaneous mixture = 1507 $\frac{mrem \bullet m^3}{\mu Ci \bullet yr}$

f) $\dot{Q}$ = μCi/sec

> Note:
>
> Units 2 and 3 effective dose factors (KLMN) are equivalent, except for site-specific finite cloud correction, as defined in Table 3-8.

Solve for $\dot{Q}$:

$\dot{Q}$ [ $(X/Q_3)$ $(K\ bar_3)$ + $(X/Q_2)$ $(K\ bar_2)$ ] = 500 mrem/yr
$\dot{Q}$ [ (4.47E-6) (849) + (2.22E-6) (1507) ] = 500 mrem/yr

Therefore, without performing any specific calculations for an actual release, the default back-calculated instantaneous release rate ($\dot{Q}$) ***for either unit*** = **7.00E+4 μCi/sec.**

In other words, if both units were releasing at this rate, with the default instantaneous mixture identified in Table 3-8, IPEC would be releasing at 500 mrem/yr (the RECS and 10CFR20 release rate limit).

Since this value assumes ALL releases are included (per unit), a partitioning factor should be applied for each applicable release point when this limit is used. Should it become necessary to "borrow" from the other unit , isotopic mixtures from specific sample results should replace the dose factors used in this default calculation.

Without specific sample data, the default ***SITE*** release rate limit is then: **1.40E5 uCi/sec**.

**CALCULATION OF ALLOWABLE RELEASE RATES FOR INDIAN POINT UNITS 2 and 3**

ii. Skin Dose Rate Calculations:

Given:

a) site limit is 3,000 mrem/yr

b) IP3 worst sector X/Q = 4.47E-6 sec/$m^3$

c) IP3 (Li + 1.1 Mi) = 2306 $\frac{mrem \bullet m^3}{\mu Ci \bullet yr}$

d) IP2 X/Q for SSW sector = 2.22E-6 sec/$m^3$

e) IP2 (Li + 1.1 Mi) = 3071 $\frac{mrem \bullet m^3}{\mu Ci \bullet yr}$

f) $\dot{Q}$ = uCi/sec

Solve for $\dot{Q}$:

$\dot{Q}$ [$(X/Q)_3$ $(Li + 1.1\ Mi)_3$ + $(X/Q)_2$ $(Li + 1.1\ Mi)_2$] = 3,000 mrem/yr

$\dot{Q}$ [(4.47E-6) (2306) + (2.22E-6) (3071)] = 3,000 mrem/yr

$\dot{Q}$ = 1.75E+5 μCi/sec (less restrictive than Whole Body)

iii. Solve for WB dose rate commitments per site (with $\dot{Q}$ = 7.00E+4 uCi/sec)

Indian Point 2:

(7.00E+4 μCi/sec) (2.22E-6 sec/$m^3$) (1507 $\frac{mrem \bullet m^3}{\mu Ci \bullet yr}$) = **234 mrem/yr**

Indian Point 3:

(7.00E+4 μCi/sec) (4.47E-6 sec/$m^3$) (849 $\frac{mrem \bullet m^3}{\mu Ci \bullet yr}$) = **266 mrem/yr**

The less restrictive skin dose rate limit for each unit (information only):

Unit 2: (1.75E+5 uCi/sec) (2.22E-6 sec/$m^3$) (3071 $\frac{mrem \bullet m^3}{\mu Ci \bullet yr}$) = 1194 mrem/yr

Unit 3: (1.75E+5 uCi/sec) (4.47E-6 sec/$m^3$) (2306 $\frac{mrem \bullet m^3}{\mu Ci \bullet yr}$) = 1806 mrem/yr

## CALCULATION OF ALLOWABLE RELEASE RATES FOR INDIAN POINT UNITS 2 and 3

RELEASE RATE LIMITS FOR QUARTERLY AND ANNUAL AVERAGE NOBLE GAS RELEASES

| | For a Calendar Quarter | For a Calendar Year |
|---|---|---|
| Gamma air dose | 5 mrad limit | 10 mrad limit |
| Beta air dose | 10 mrad limit | 20 mrad limit |

I. Assumptions:

1. Doses are delivered to the air at the site boundary.
2. Finite cloud geometry is assumed for noble gas releases at site boundary.
3. X/Q for Unit 2 = 2.22E-6 sec/m$^3$, ($\dot{Q}$ = release rate uCi/sec)
4. X/Q for Unit 3 = 4.47E-6 sec/m$^3$, ($\dot{Q}$ = release rate uCi/sec)
5. Gamma and Beta air dose factors (M and N), Corrected for finite cloud geometry (as described on Table 3-8) are as follows:

| Unit 2 effective average dose factors | Unit 3 effective average dose factors | Units |
|---|---|---|
| $\overline{M}$ = 281 | $\overline{M}$ = 181 | mrad/yr per uCi/m$^3$ |
| $\overline{N}$ = 1254 | $\overline{N}$ = 1254 | mrad/yr per uCi/m$^3$ |

II. Calculation of Quarterly Release Rates:

a) for gamma dose: ($\dot{Q}$)*[(M)(X/Q)] less than or equal to 5 mrad/qtr

b) for beta dose: ($\dot{Q}$)*[(N)(X/Q)] less than or equal to 10 mrad/qtr

| | | unit 2 | unit 3 |
|---|---|---|---|
| gamma dose rate | $\dot{Q} = \dfrac{5 mrad / qtr}{(1/4 yr)(M)(X/Q)}$ = | 3.21E+4 μCi/sec | 2.47E+4 μCi/sec |
| beta dose rate | $\dot{Q} = \dfrac{10 mrad / qtr}{(1/4 yr)(N)(X/Q)}$ = | 1.44E+4 μCi/sec | 7.14E+3 μCi/sec |

Based on the above analysis, the beta dose is limiting for time average doses. Therefore, the allowable quarterly average release rates are 1.44E+4 μCi/sec for unit 2 and 7.14E+3 μCi/sec for unit 3.

III. Calculation of Calendar Year Release Rate

Annual limits are one half of quarterly limits. Therefore, using Beta air dose as most limiting, the maximum annual average release rates are 7.20E+3 μCi/sec for unit 2 and 3.57E+3 μCi/sec for unit 3.

**CALCULATION OF ALLOWABLE RELEASE RATES FOR INDIAN POINT UNITS 2 and 3**

ALLOWABLE INSTANTANEOUS RELEASE RATE for I-131 & Particulates w/ T½ > 8 DAYS)

Given: Wv(in): X/Q at the Site Boundary for IP3 = 4.47E-6 sec/$m^3$

Wv(in): X/Q at the Site Boundary for IP2 = 2.22E-6 sec/$m^3$

PI(c) = 1.62 E7 $\frac{mrem/yr}{\mu Ci/m^3}$

Assumed Pathway: Child Inhalation at Unrestricted Area Boundary

Solve the following equation for $\dot{Q}$:

[($\dot{Q}$)PI(c)(Wv(in)) Unit 3] + [($\dot{Q}$)PI(c)(Wv(in)) Unit 2] = 1500 mrem/yr

IP3: ($\dot{Q}$)PI(c)(Wv(in))3 = $\dot{Q}$ * 1.62E7 $\frac{mrem/yr}{\mu Ci/m^3}$ 4.47E-6 s/$m^3$ = $\dot{Q}$ * 72.4 $\frac{mrem/yr}{\mu Ci/\sec}$

IP2: ($\dot{Q}$)PI(c)(Wv(in))2 = $\dot{Q}$ * 1.62E7 $\frac{mrem/yr}{\mu Ci/m^3}$ 2.22E-6 s/$m^3$ = $\dot{Q}$ * 36.0 $\frac{mrem/yr}{\mu Ci/\sec}$

The sum equals : (108) ( $\dot{Q}$) mrem/yr per uCi/sec

Limit is 1500 mrem/yr per site:

Therefore: 108 * $\dot{Q}$ $\frac{mrem/yr}{\mu Ci/\sec}$ = 1500 mrem/yr

**$\dot{Q}$ = 1.38E+1 μCi/sec** (for each unit)

IP3 Dose Contribution: 1.38E+1 $\frac{\mu Ci}{\sec} * 1.62E7 \frac{mrem}{yr} \frac{m^3}{\mu Ci} * 4.47E-6 \frac{\sec}{m^3}$ = 1003 mrem/yr

IP2 Dose Contribution: 1.38E+1 $\frac{\mu Ci}{\sec} * 1.62E7 \frac{mrem}{yr} \frac{m^3}{\mu Ci} * 2.22E-6 \frac{\sec}{m^3}$ = 497 mrem/yr

Sum = 1500 mrem/yr

(Approximately a 67 / 33 percent dose split for IP3 and IP2 respectively).

## ALLOWABLE QUARTERLY and ANNUAL IODINE/PARTICULATE RELEASE RATES

### DOSE LIMITS AT THE NEAREST RESIDENT

Dose factors for the child, thyroid (for Iodine 131) are used for this category as a conservative assumption since this nuclide has the highest thyroid dose factor of all iodines and particulates, and its most significant effect in on the child age group. The H-3 dose factor is about 4 orders of magnitude less significant and its contribution to the total dose is considered negligible.

The back-calculated release rate for Iodine and Particulate is as follows:

| | Unit 2 | Unit 3 |
|---|---|---|
| X/Q (in sec/$m^3$ at the nearest resident) | 1.03E-6 | 1.02E-6 |
| D/Q (in $m^{-2}$ at the nearest resident) | 7.52E-9 | 7.45E-9 |

RI(c) = 1.62E+7 $\frac{mrem/yr}{\mu Ci/m^3}$, child thyroid inhalation dose factor for I-131 (for both units)

RG = 1.72E+7 $m^2$ $\frac{mrem/yr}{\mu Ci/\sec}$, ground plane dose factor for I-131 (for both units)

RV(c) = 4.75E+10 $m^2$ $\frac{mrem/yr}{\mu Ci/\sec}$, child thyroid vegetation dose factor for I-131 (for both units)

Calculating the allowable time average release rate by solving the following equation for $\dot{Q}$:

$\dot{Q}$ [(RIc)(X/Q) + (RG)(D/Q) + (RVc)(D/Q)] = limit in mrem/yr

| | Unit 2 | Unit 3 |
|---|---|---|
| $\dot{Q}$ (RIc)(X/Q) in mrem/yr per uCi/sec = | 16.7 * $\dot{Q}$ | 16.5 * $\dot{Q}$ |
| $\dot{Q}$ (RG) (D/Q) in mrem/yr per uCi/sec = | 0.129 * $\dot{Q}$ | 0.128 * $\dot{Q}$ |
| $\dot{Q}$ (RVc)(D/Q) in mrem/yr per uCi/sec = | 357 * $\dot{Q}$ | 354 * $\dot{Q}$ |
| The sum for each unit ( X * $\dot{Q}$ ) in mrem/yr per uCi/sec. | **374** * $\dot{Q}$ | **371** * $\dot{Q}$ |

Quarterly time average limit is 7.5 mrem to any organ (or 30 mrem/yr). Solving for $\dot{Q}$ yields:

| | | (Quarterly Limit) | (Annual Limit) |
|---|---|---|---|
| (IP2) | $\dot{Q} * 374 \frac{mrem/yr}{\mu Ci/\sec}$ = 30 mrem/yr; | 8.02E-2 μCi/sec | 4.01E-2 μCi/sec |
| (IP3) | $\dot{Q} * 371 \frac{mrem/yr}{\mu Ci/\sec}$ = 30 mrem/yr; | 8.10E-2 μCi/sec | 4.05E-2 μCi/sec |

(Annual limits are ½ quarterly limits, or 15 mrem to any organ/yr)

## ALLOWABLE QUARTERLY and ANNUAL IODINE/PARTICULATE RELEASE RATES

### DOSE LIMITS AT THE 5-MILE SECONDARY RECEPTOR (when applied)

Dose factors for the infant, thyroid (for Iodine 131) are used for this category as a conservative assumption since this nuclide has the highest thyroid dose factor of all iodines and particulates, and its most significant effect is on the infant age group at this location. When applied (as required by the applicable current Land Use Census), this pathway may be approximately four times more limiting than the Primary Receptor. The back-calculated release rate for Iodine and Particulate are as follows:

| | Units 2 or 3 |
|---|---|
| X/Q (in sec/$m^3$ at 5-miles down valley) | 7.22E-7 |
| D/Q (in $m^{-2}$ at 5-miles down valley) | 1.35E-9 |

RI(i) = 1.48E+7 $\frac{mrem/yr}{\mu Ci/m^3}$, infant thyroid inhalation dose factor for I-131 (for both units)

RG = 2.10E+7 $m^2$ $\frac{mrem/yr}{\mu Ci/\sec}$, ground plane dose factor for I-131 (for both units)

RC(i) = 1.05E+12 $m^2$ $\frac{mrem/yr}{\mu Ci/\sec}$, infant thyroid cow-milk dose factor for I-131 (for both units)

(there is no vegetative pathway for the infant)

Calculating the allowable time average release rate by solving the following equation for $\dot{Q}$:

$\dot{Q}$ [(RIi)(X/Q) + (RG)(D/Q) + (RCi)(D/Q)] = limit in mrem/yr

| | Units 2 or 3 |
|---|---|
| $\dot{Q}$ (RIi)(X/Q) in mrem/yr per uCi/sec = | 10.7 * $\dot{Q}$ |
| $\dot{Q}$ (RG) (D/Q) in mrem/yr per uCi/sec = | 0.028 * $\dot{Q}$ |
| $\dot{Q}$ (RCi)(D/Q) in mrem/yr per uCi/sec = | 1412 * $\dot{Q}$ |
| The sum for each unit ( X * $\dot{Q}$ ) in mrem/yr per uCi/sec. | **1428** * $\dot{Q}$ |

Quarterly time average limit is 7.5 mrem to any organ (or 30 mrem/yr).

Solving for $\dot{Q}$ yields the following limits, at either unit:

| | **(Quarterly Limit)** | **(Annual Limit)** |
|---|---|---|
| $\dot{Q}$ * 1428 $\frac{mrem/yr}{\mu Ci/\sec}$ = 30 mrem/yr; | 2.10E-2 μCi/sec | 1.05E-2 μCi/sec |

(Annual limits are ½ quarterly limits, or 15 mrem to any organ/yr)

## GROUNDWATER AND STORMWATER FLOW AND OFFSITE DOSE CALCULATION DETAILS

**Overview:**

Site hydrologists have verified the overall direction of groundwater flow at IPEC to be ultimately into the Hudson River. From this established understanding, two independent models have been applied to determine groundwater flowrates from the site into the river, the precipitation mass balance and the Darcy's Law models.

The precipitation mass balance model, exclusively relied upon prior to 2007, was enhanced and further validated for 2007 and beyond using a calibration process involving Darcy's Law. A total of six zones on site (described below) were evaluated to better partition the distribution of flow across the site. Each zone was also further subdivided into a shallow flow regime and a deeper flow regime based on the depth-specific differences in formation hydraulic conductivity. In addition, the groundwater flow values before and after the Discharge Canal were computed and compared to estimate the amount of groundwater flowing into the canal as well as that discharging directly to the river. This flow discretization was conducted using a 3-dimensional numerical model based on Dary's Law (Darcy's Law model). The overall flow values generated by the precipitation mass balance model were also validated through calibration against the Darcy's Law model.

The evaluation method for radionuclide activities at groundwater to surface water discharge points was updated using wells specifically drilled proximate to these points, thus allowing more accurate assessment of these activities at these plume boundaries. Average activities are used, and based on multiple samples, generally four, but at least one, per quarter per elevation per well. The additional wells, and the instrumentation installed therein, also provides further definition of groundwater elevations to enhance the Darcy's Law calibration of the precipitation mass balance model. The hydrogeology portion of the model was produced by IPEC's consultant, GZA GeoEnvironmental, Inc. The specific processes for release and dilution flow evaluation are defined in the following text.

The precipitation mass balance model partitions the precipitation falling on the watershed catchment area (i.e., that portion of the Facility area where the surface topography is sloped towards the river) into water that: 1) infiltrates through the ground surface to become groundwater (GW); 2) water which infiltrates but then moves back into the atmosphere via evaporation / transpiration and other processes; and 3) water that flows off the surface as storm water (SW).

There are five primary parameters required by the precipitation mass balance method of computing radionuclide release rate to the Hudson River via the groundwater pathway.

1. Overall direction of groundwater flow - The surface topography shows that the IPEC facility is located in a significant depression in the eastern bank of the Hudson River. Given that groundwater elevations generally mirror ground surface topography and groundwater flow is from high elevations to lower elevations, the groundwater flows from the north, east and south towards the facility, with ultimate discharge to the Hudson River to the west (as generally confirmed for the IPEC site by the monitoring network).

2. Facility-specific groundwater flow paths - To establish facility-specific groundwater flow paths relative to on-site release areas, facility ground surface topography mapping was used. These flow paths were refined based on groundwater contours developed from the groundwater elevations measured with transducers installed in groundwater monitoring installations. The groundwater flow in each zone was then proportioned into shallow flow and deeper flow regimes based on relative hydraulic conductivities measured for the geologic deposits in each zone.

3. Rate of groundwater flow - The groundwater flow rates through the individual zones were computed using mass-balance relationships that begin with the overall average yearly precipitation for the watershed area and then subtract out precipitation volumes reflecting removal mechanisms such as:

   - Direct evaporation;
   - Vegetative transpiration;
   - Paved and roof surfaces - transport precipitation directly to the river via storm drains;
   - Footing drains.

   Prior to 2007, the net precipitation infiltration rates resulting in groundwater flow were adopted directly from a USGS study performed specifically for the Westchester County area, the location in which the facility is sited (USGS report: *Water Use, Groundwater Recharge and Availability, and Quality in the Greenwich Area, Fairfield County, CT and Westchester County, NY, 2000 – 2002*). The total groundwater flow rate was initially proportioned relative to the catchment areas associated with general groundwater flow areas.

   These groundwater flow values were subsequently refined in 2007 and 2010 using the relative flow values computed with the Darcy's Law model. The gradients (changes in hydraulic pressure with distance) throughout the site were computed from the groundwater elevation contours. For this computation, each flow zone was segregated into two depth regimes; a higher hydraulic conductivity shallow regime and a lower conductivity deeper regime. Finally, the zone-specific flow rates before the Discharge Canal were compared to those after the canal to evaluate the groundwater flux to the river via the Discharge Canal as compared to that discharging directly to the river.

4. Groundwater radionuclideactivity - A number of multi-level groundwater monitoring installations are in place up-gradient of the Discharge Canal and along the waterfront, thus allowing the radionuclide activities to be measured for groundwater flowing into the canal as well as proximate totthe groundwater/river interface.

5. Radionuclide release rate to river - Once the groundwater flow rates were established, the zone-specific radionuclide release rates to the Hudson River were computed by multiplying the area/depth-specific groundwater flow rates times the associated radionuclide activities; these individual zone-specific values were then summed to arrive at the total radionuclide release rate to the river.

## GROUNDWATER AND STORMWATER FLOW AND OFFSITE DOSE CALCULATION DETAILS

Over the entire watershed catchment area of 3.2 million $ft^2$, the GW and SW has been segmented relative to areas of the facility through which it flows (primarily established based on the relative activities and types of contaminants in the various facility areas). The bulk of the GW activity has been identified down gradient of the Unit 2 transformer yard. While tritium is suspected to have originated at both Unit 2 and Unit 1 leaks, most of the offsite dose has been demonstrated to originate from Unit 1 contamination from Sr-90 and other radionuclides (tritium has little dose effect). Stream tubes have been drawn through the boundaries of these areas to define six individual groundwater flow zones:

- **Northern Clean Zone**, the area north of Unit 2;
- **Unit 2 North Zone**, the northern areas of Unit 2, including some low levels of tritium;
- **Unit 1 / 2 Zone**, the area encompassing most of the known plume, between units 1 and 2;
- **Unit 3 North Zone**, the area between Unit 1 and Unit 3;
- **Unit 3 South Zone**, the area that primarily includes operating areas of Unit 3;
- **Southern Clean Zone**, south of Unit 3 to the edge of the property line.

Overall, the partitioning is established for groundwater and storm water, including recharge rates where storm drains and ground water communicate. In each zone, the groundwater flow is further subdivided into a shallow flow regime and a deeper flow regime based on the depth-specific differences in formation hydraulic conductivity. In addition, the groundwater flow values, determined from hydraulic pressure differences before and after the Discharge Canal, were computed and compared to estimate the amount of groundwater flowing into the canal as well as that discharging directly to the river.

**Source Terms:**

Activities of identified radionuclides for all Zones (from quarterly groundwater sampling data from Monitoring Wells and the accumulated Storm Drain sample data) are then applied for routine offsite dose cacluations per ODCM Part II, Section 2. All wells and storm drains are analyzed for gamma spectroscopy and tritium by liquid scintillation. Additionally, groundwater analyses are completed for beta emitters, such as Ni-63 and Sr-90. Four sets of quarterly results for each year from effected wells in the effluent locations are evaluated to compute a spatial and temporal average source term for each area or zone.

> If a result is *below MDC* (whether positive or negative) it was *not* included in the computed average. This computed average is therefore biased high (more conservative from a dose computation perspective) relative to an average computed using all of the data, which would be more representative of actual conditions (values below MDC and non-detected “zero values” are equally valid results for the groundwater activity levels at certain locations/times). In cases where all the sampling locations assigned to a given stream tube provided results below the MDC, then an average activity value of zero was assigned to the effected portion of the stream tube. (This mathematically allows the calculation to proceed in the absence of positive detections).

**GROUNDWATER AND STORMWATER FLOW AND OFFSITE DOSE CALCULATION DETAILS**

Ground Water and Storm Drain Source Term selection for flow to the canal is as follows:

| Streamtube | Manholes (Storm Drains) | Monitoring Wells, upper zone | Monitoring Wells, lower zone |
|---|---|---|---|
| Northern Clean Zone | NA | *Background* | *Background* |
| Unit 2 North | None | *MW-52-11 MW-52-18 MW-52-48* | *MW-52-64 MW-52-122 MW-52-162 MW-52-181* |
| Units 1/ 2 | MH-4A | *MW-36-24 MW-36-41 MW-36-52 MW-50-42 MW-50-66 MW-54-37 MW-57-11 MW-57-20 MW-57-45* | *MW-32-85 MW-32-149 MW-32-173 MW-32-190 MW-53-120 MW-54-58 MW-54-123 MW-54-144 MW-54-173 MW-54-190* |
| Unit 3 North | CB-14, CB-34 | *MW-58-26 MW-58-65* | *MW-54-58 MW-54-123 MW-54-144 MW-54-173 MW-54-190* |
| Unit 3 South | B8 | *U3-T2 U3-T1 U3-4S MW-68-19 MW-68-29 MW-68-57* | *MW-44-102 U3-4D MW-68-103 MW-68-132* |
| Southern Clean Zone | C1, D1, E6, E10 | *MW-40-27 MW-40-46 MW-51-40 MW-51-79* | *MW-40-81 MW-40-100 MW-40-127 MW-40-162 MW-51-104 MW-51-135 MW-51-163 MW-51-189* |

Ground Water and Storm Drain Source Term selection for flow directly to the river is as follows:

| Streamtube | Manholes (Storm Drains) | Monitoring Wells, upper zone | Monitoring Wells, lower zone |
|---|---|---|---|
| Northern Clean Zone | NA | *Background* | *Background* |
| Unit 2 North | MH-1 MH-12 | *MW-60-35* | *MW-60-53 MW-60-72 MW-60-135 MW-60-154 MW-60-176* |
| Units 1and 2 | MH-14 | *MW-37-22 MW-37-32 MW-49-26 MW-49-42 MW-49-65 MW-66-21 MW-66-36 MW-67-39* | *MW-67-105 MW-67-173 MW-67-219 MW-67-276 MW-67-323 MW-67-340* |
| Unit 3 North | CB-15 | *MW-62-18 MW-62-37 MW-62-53 MW-62-71 MW-63-18 MW-63-34 MW-63-50 MW-63-93* | *MW-62-92 MW-62-138 MW-62-182 MW-63-112 MW-63-121 MW-63-163 MW-63-174* |
| Unit 3 South | none | *U3-T1 U3-T2 U3-4S MW-68-19 MW-68-29 MW-68-57* | *MW-68-103 MW-68-132 MW-44-102 U3-4D* |
| Southern Clean Zone | C2, E13 | *MW-40-27 MW-40-46 MW-51-40 MW-51-79* | *MW-40-81 MW-40-100 MW-40-127 MW-40-162 MW-51-104 MW-51-135 MW-51-163 MW-51-189* |

## GROUNDWATER AND STORMWATER FLOW AND OFFSITE DOSE CALCULATION DETAILS

**Flow Rates:**
Determination of groundwater flow rates to the canal and the river through each zone depend on infiltration rates as well as rainfall and measured hydraulic pressure differences. The infiltration rate in non-paved areas (or building areas) was computed as approximately 25 percent of the total precipitation for the previous year, as is consistent with the final Darcy's law calibration of the Precipitation Mass Balance Model (as described below).

The precipitation rate for the IPEC area is recorded each year, and averages approximately 3 feet per year. All precipitation falling on paved/building areas is assumed to result in stormwater flow. Although some of this water actually evaporates directly to atmosphere from pavement and building roofs, no credit for this evaporation is taken to enhance conservativism in the model. Model conservatism relative to stormwater dose computation is further enhanced through the use of activities which are inherently baised high due to the typical timing of sample collection which favors low flow conditions[1]. Finally, it is noted that a portion of the Stormwater also ultimately recharges the groundwater.

The following values are currently applied in the flow model:

| Streamtube | Percent of Stormwater Flow Recharging Groundwater |
|---|---|
| Northern Clean Zone | 0% |
| Unit 2 North | 50% |
| Unit 1/2 | 30% |
| Unit 3 North | 60% |
| Unit 3 South | 10% |
| Southern Clean Zone | 40% |

Known subsurface drain extration rates from existing groundwater pathways need to be subtracted from the zones applicable to these specific pathways, as follows:

- Five gallons per minute (gpm) from the Unit 2 Footing Drain is removed from the Unit 2 North streamtube.
- Five gpm from the Unit 1 North Curtain Drain and 2.5 gpm from the Unit 1 Chemical Systems Building Foundation Drain are removed from the Unit 1/2 streamtube.
- Seven and a half gpm from the Unit 1 Chemical Systems Building Foundation Drain are removed from the Unit 3 North streamtube.

[1] Samples are typically obtained from the storm drain manholes when it's not raining so as to facilitate field work. As such, there is generally little to no stormwater flow during sampling, with the majority of the flow then contributed by groundwater infiltration. Therefore, the activities are biased high relative to those which would be obtained during precipitation events when the storm drains are carrying much higher flow rates, and thus the majority of their flow contribution to the dose computation. These relatively high activities are then applied to the full yearly average stormwater flow, resulting in: 1) a substantial overstatement of the dose to the river; and 2) high computed variability in the dose due to stormwater flow induced variability in the measured activity.

**GROUNDWATER AND STORMWATER FLOW AND OFFSITE DOSE CALCULATION DETAILS**

Beyond the known extraction rates, the Precipitation Mass Balance Model was calibrated using Darcy's Law with the groundwater elevation contours for each of the six zones. The contours and measurements of hydraulic conductivity were developed from the wells on site, recognizing that flow is perpendicular to the contours. This effort also provides knowledge of facility-specific flow paths. Measurments of pressure differential were then applied (per Darcy's Law) to determine flow rate for use in the calibration process:

$$Q = K * i * A$$

Where:

*Q* is groundwater flow (cubic feet/day). This value is calculated.

*K* is the hydraulic conductivity (ft/day). This value is a log normal average of hydraulic conductivity values measured within the appropriate portion of the streamtube. In other words, the ease of which flow can be forced through sub-surface media.

*A* is the cross sectional area through which groundwater is moving ($ft^2$).

*i* is the change in head over a distance (ft/ft), or a measure of the pressure driving the flow. This value is calculated for the shallow and deep zones both upgradient and downgradient of the canal.

The parameters above were originally developed from the Quarter 2 2007 data set and applied to calibrate the precipitation mass balance model; subsequent data was used to verify the applicability of this calibration on a quarterly basis. After collection of nine quarterly rounds of data, a final recalibration of the model was performed using the quarterly data set yielding the most conservative groundwater flow values (Quarter 4 2008).

The calibration routine generally consisted of the following steps:

1) Groundwater elevation data was downloaded from transducers and/or recorded manually with an electronic water level indicator or equivalent. Following download, the data was reduced and evaluated by the site Hydrologists.
2) A period of time was selected to evaluate the groundwater at key elevations and positions along all three axes, such that the maximum number of working transducers were included. Flow evaluations were biased high (overstates dose) by selecting readings during low tide on the targeted day, and targeting a day when the tides are particularly low.
3) Two sets of groundwater contours were prepared. Shallow groundwater contours were drawn based on groundwater elevation data collected generally at elevations higher than 40 feet below top of bedrock. Deep groundwater contours were drawn based on groundwater elevation data from sampling locations deeper than 40 feet below the top of rock, although preference was given to data from the upper portion of that zone.
4) Using the groundwater contours within each streamtube, the shallow and deep groundwater flux was calculated within each zone using Darcy's Law as described above.
5) The total flow, both upgradient and downgradient of the Discharge Canal, was summed separately. The difference between these flows yields the groundwater flow which is recharging the Discharge Canal.

**GROUNDWATER AND STORMWATER FLOW AND OFFSITE DOSE CALCULATION DETAILS**

6) The total flow downgradient of the Discharge Canal discharges into the Hudson river.

7) The percentage of groundwater flow in the upper and lower zones of each streamtube was calculated for proportioning of groundwater flow in the upper and lower zones in the Precipitation Mass Balance Model.

NOTE:

The groundwater contours used for the Darcy's Law calibration of the Precipitation Mass Balance Model had originally been based on data collected during Quarter 2 of calendar year 2007; this calibration was used for dose computations through 2009.

Given that seasonal and yearly variations in precipitation and runoff cause changes in the groundwater contours for individual quarterly monitoring rounds, quarterly groundwater elevation data was collected for nine quarters between Q2 2007 to Q2 2009. These data were reviewed to evaluate the magnitude of variation in the computed groundwater flows due to precipitation variability. It was concluded that sufficient seasonal data had been collected to encompass the majority of the precipitation variability observed over the last fourteen years (fifty-six quarters); see analysis in Section 3.1.2 of the Quarter 2 2009 monitoring report. The Precipitation Mass Balance Model was therefore recalibrated in Quarter 2 of 2009 (shown on the following 2 pages).

To be conservative, the model was recalibrated to the quarterly data set that yielded the largest total and/or Unit 1/2 Zone[2] groundwater flows from the Darcy's Law Model. Based on these analyses, the model was recalibrated to the groundwater fluxes from Quarter 4 2008. While this quarter did not yield the highest total flow through the entire site, it did provide a high total flow and the highest flow through the Unit 1/2 Zone, and thus the highest computed dose. This calibration to Quarter 4 2008 groundwater elevations has therefore been used from 2010 going forward.

8) A final determination of offsite dose can be performed with the previously compiled data (dilution flow, effluent flow rates, and source terms) using an integrated dose calculation model (electronic Excel spreadsheet) identified in Reference 44. This spreadsheet, called the Master Groundwater Dose Calculator, is available from Chemistry Management.

   - The distribution of flow rates to the canal and the river, from each zone, is determined within this asset as a result of calibrations of the rainfall model with Darcy's Law and transducer data. Its purpose is to bound the effluent flow rate in a conservative fashion.
   - Averaged or conservative assessments of source term are entered for each zone from a list of required input locations (wells or drains in each effected area).
   - Dose calculations are performed with this information per ODCM Part II, Section 2.4, in the same fashion as other liquid effluents.

2 In order to approach the recalibration conservatively, GZA not only reviewed the groundwater flux across the entire site but also the flux in the Unit 1/2 Zone because the majority of the radionuclide dose is located within this Zone.

# GROUNDWATER AND STORMWATER FLOW AND OFFSITE DOSE CALCULATION DETAILS

**Example of the Precipitation Mass Balance Calibration 2009, Q2**

**Facility Groundwater Flux Calculation**

**Site** Indian Point
**Job No.** 17869.91

**Prepared By:** JAS
**Reviewed By:** mjb

**Parameter Values:**

| | | | | | | |
|---|---|---|---|---|---|---|
| | ***Totals*** | | | | | |
| | | **Total Catchment Zone (ft^2)** | **Total Improved Zone (ft^2)** | **Recharge (ft/yr)** | **Precipitation (ft/yr)** | |
| | | 3,969,765 | 1,432,972 | 0.70 | 2.69 | |
| year | ***Surface Area*** | | | | | |
| **2009** | **Improved (ft^2)** | **Unit 2 North Improved Zone (ft^2)** | **Unit 1/2 Improved Zone (ft^2)** | **Unit 3 North Improved Zone (ft^2)** | **Unit 3 South Improved Zone (ft^2)** | **Southern Clean Improved Zone (ft^2)** |
| | 0 | 148,214 | 433,904 | 316,210 | 321,290 | 213,354 |
| | **Northern Clean Unimproved Zone (ft^2)** | **Unit 2 North Unimproved Zone (ft^2)** | **Unit 1/2 Unimproved Zone (ft^2)** | **Unit 3 North Unimproved Zone (ft^2)** | **Unit 3 South Unimproved Zone (ft^2)** | **Southern Clean Zone Unimproved (ft^2)** |
| | 106,429 | 204,317 | 438,221 | 323,116 | 268,862 | 585,600 |
| | **Discounted Area Within Zone** | **Discounted Area Within Zone** | **Discounted Area Within Zone** | **Discounted Area Within Zone** | **Within Zone** | **Zone** |
| | 50,265 | 0 | 291,186 | 106,718 | 17,730 | 144,347 |
| | **Catchment (ft^2)** | **Unit 2 North Catchment Zone (ft^2)** | **Unit 1/2 Catchment Zone (ft^2)** | **Unit 3 North Catchment Zone (ft^2)** | **Unit 3 South Zone (ft^2)** | **Southern Clean Zone (ft^2)** |
| | 156,694 | 352,531 | 1,163,311 | 746,044 | 607,882 | 943,302 |
| | ***Activity (pCi/L)*** | | | | | |
| | ***Groundwater*** | | | | | |
| | **Catchment** | **Unit 2 North** | **Unit 1/2** | **Unit 3 North** | **Unit 3 South Zone** | **Southern Clean Zone** |
| **Upper Zone Before Canal** | 150 | 297 | 3,031 | 327 | 778 | 227 |
| **Lower Zone Before Canal** | 150 | 251 | 2,750 | 1,143 | 480 | 210 |
| | | **Unit 2 North** | **Unit 1/2** | **Unit 3 North** | **Unit 3 South Zone** | **Southern Clean Zone** |
| **Upper Zone After Canal** | 150 | 198 | 3,121 | 376 | 778 | 227 |
| **Lower Zone After Canal** | 150 | 575 | 1,061 | 511 | 480 | 210 |
| | ***Stormwater Discharging to Canal (pCi/L)*** | | | | | |
| | **Storm Water for Northern Clean Zone** | **Storm Water for Unit 2 North** | **Storm Water for Unit 1/2** | **Storm Water for Unit 3 North** | **Storm Water for Unit 3 South** | **Storm Water for Southern Clean Zone** |
| | | 1,276 | | 0 | 0 | 0 |
| | *NA* | *Avg MH-4a* | *NA* | *Avg CB-14 and CB-34* | *Avg U3-CB-B8* | *Avg D1, C3, E6, & E10* |
| | ***Stormwater Discharging to River (pCi/L)*** | | | | | |
| | **Storm Water for Northern Clean Zone** | **Storm Water for Unit 2 North** | **Storm Water for Unit 1/2** | **Storm Water for Unit 3 North** | **Storm Water for Unit 3 South** | **Storm Water for Southern Clean Zone** |
| | | 613 | 0 | 683 | | 251 |
| | *NA* | *Avg. MH-1 and MH-12* | *Avg MH-14* | *Avg CB-15* | *NA* | *Avg E13,CB-C2* |

**Potential Water Received by Storm Drain System**

**=(Improved Area) x Precipitation**

| **Northern Clean Area** | **Unit 2 North** | **Unit 1/2** | **Unit 3 North** | **Unit 3 South** | **Southern Clean Zone** | |
|---|---|---|---|---|---|---|
| 0 | 398,572 | 1,166,841 | 850,342 | 864,001 | 573,746 | ft^3/yr |
| 0 | 1,092 | 3,197 | 2,330 | 2,367 | 1,572 | ft^3/day |
| 0.00 | 5.67 | 16.61 | 12.10 | 12.30 | 8.17 | GPM |
| 0 | 11,286,298 | 33,041,245 | 24,079,009 | 24,465,788 | 16,246,670 | L/Yr |

The total amount of water available to be received by the storm system is computed as the combined area of buildings and paved areas in the catchment multiplied by the annual precipitation rate. Note this conservatively assumes that the amount of water lost to the atmosphere or other sinks after preci

## GROUNDWATER AND STORMWATER FLOW AND OFFSITE DOSE CALCULATION DETAILS

**Water Directly Recharged to Aquifer from Precipitation**

**=Unimproved Area x Recharge**

| Northern Clean Area | Unit 2 North | Unit 1/2 | Unit 3 North | Unit 3 South | Southern Clean Zone | Units |
|---|---|---|---|---|---|---|
| 74,414 | 142,855 | 306,397 | 225,917 | 187,984 | 409,442 | ft^3/yr |
| 204 | 391 | 839 | 619 | 515 | 1,122 | ft^3/day |
| 1.06 | 2.03 | 4.36 | 3.22 | 2.68 | 5.83 | GPM |
| 2,107,156 | 4,045,210 | 8,676,196 | 6,397,256 | 5,323,118 | 11,594,104 | L/Yr |

Note that this calculation reflects recharge to the aquifer in non-paved areas. The Recharge value listed above and used in this calculation reflects only that portion of precipitation that actually recharges the aquifer.

**Water Recharged to Aquifer (Direct Recharge Plus Storm Water Leakage Minus Building Drain Removal)**

**=(Direct Recharge + X% Water Received by Storm System) - (Y% x Water Removed by Building Drains)**

**Total Water Discharged to Aquifer**

| | [Northern Clean Area Catchment + (0% Storm Drain Water)][1] | [Unit 2 North + (50% Storm Drain Water)]-[5gpm] | [Unit 1/2 Area Catchment + (30% Storm Drain Water)]-[7.5 gpm] | [Unit 3 North Area Catchment + (60% Storm Drain Water)]-[7.5gpm] | [Unit 3 South Area + (10% Storm Drain Water)] | [Southern Clean Zone Area + (40% Storm Drain Water)] | Units |
|---|---|---|---|---|---|---|---|
| Upper and Lower Zone | 74,414 | -9,171 | 129,480 | 209,154 | 274,384 | 638,940 | ft^3/yr |
| | 204 | -25 | 355 | 573 | 752 | 1,751 | ft^3/day |
| | 1.06 | -0.13 | 1.84 | 2.98 | 3.91 | 9.09 | GPM |
| | 2,107,156 | -259,703 | 3,666,477 | 5,922,569 | 7,769,697 | 18,092,772 | L/Yr |

[1] There are no improved surfaces in Northern Clean Zone.

**Groundwater Discharged to Canal**

**=Water Recharged to Aquifer x X% flowing to Canal**

| | Northern Clean Area Catchment x 0% | Unit 2 North x 15.2% | Unit 1/2 Area Catchment 24.2% | Unit 3 North Area Catchment x 22.9% | Unit 3 South Area x68.4% | Southern Clean Zone Area x 0% | Units |
|---|---|---|---|---|---|---|---|
| Upper and Lower Zone | 0 | -1,394 | 31,334 | 47,896 | 187,679 | 0 | ft^3/yr |
| | 0 | -4 | 86 | 131 | 514 | 0 | ft^3/day |
| | 0.00 | -0.02 | 0.45 | 0.68 | 2.67 | 0.00 | GPM |
| | 0 | -39,475 | 887,287 | 1,356,268 | 5,314,473 | 0 | L/Yr |

**Groundwater Discharged to River**

**=Water Recharged to Aquifer x X% flowing to River x Y% Flowing in Appropriate Vertical Zone**

| | Northern Clean Area Catchment x 100% x 59.3% | Unit 2 North x 84.8% x 15.1% | Unit 1/2 Area Catchment x 75.8% x 11.7% | Unit 3 North Area Catchment x 77.1% x 47.9% | Unit 3 South Area x 31.6% x 31.3% | Southern Clean Zone Area x 100% x 55.2% | Units |
|---|---|---|---|---|---|---|---|
| Upper Zone | 44,127 | -1,174 | 11,483 | 77,242 | 27,139 | 352,695 | ft^3/yr |
| | 121 | -3 | 31 | 212 | 74 | 966 | ft^3/day |
| | 0.63 | -0.02 | 0.16 | 1.10 | 0.39 | 5.02 | GPM |
| | 1,249,543 | -33,254 | 325,165 | 2,187,258 | 768,485 | 9,987,210 | L/Yr |
| | **Northern Clean Area Catchment x 100% x 40.7%** | **Unit 2 North x 84.8% x 84.9%** | **Unit 1/2 Area Catchment 75.8% x 88.3%** | **Unit 3 North Area Catchment x 77.1% x 52.1%** | **Unit 3 South Area x 31.6% x 68.7%** | **Southern Clean Zone Area x 100% x 44.8%** | **Units** |
| Lower Zone | 30,286 | -6,603 | 86,663 | 84,015 | 59,567 | 286,245 | ft^3/yr |
| | 83 | -18 | 237 | 230 | 163 | 784 | ft^3/day |
| | 0.43 | -0.09 | 1.23 | 1.20 | 0.85 | 4.07 | GPM |
| | 857,612 | -186,974 | 2,454,024 | 2,379,043 | 1,686,739 | 8,105,562 | L/Yr |

**Water Remaining in Storm Drains and Discharged to Canal**

**=Storm Drain Water x X% Not Leaking to Groundwater and Not Discharging to River**

| Northern Clean Area Catchment (0% Storm Drain Water) | Unit 2 North (45% Unit 2 North and 30% of Unit 1/2 Storm Drain Water). Plus 5 gpm (351k cf/yr) from U2 footing drain. | Unit 1/2 Area Catchment (0% Storm Drain Water) | Unit 3 North Area Catchment (3% Unit 3 North Storm Drain Water) | Unit 3 South Area (3% Unit 3 North and 42% Unit 3 South Storm Drain Water) | Southern Clean Zone Area (30% Unit 1/2, 27% Unit 3 North, 43% Unit 3 South, and 55% Southern Clean Zone Storm Drain Water) | Units |
|---|---|---|---|---|---|---|
| 0 | 880,410 | 0 | 25,510 | 388,391 | 1,266,725 | ft^3/yr |
| 0 | 2,412 | 0 | 70 | 1,064 | 3,470 | ft^3/day |
| 0 | 12.53 | 0.00 | 0.36 | 5.53 | 18.03 | GPM |
| 0 | 24,931,628 | 0 | 722,370 | 10,998,001 | 35,869,663 | L/Yr |

## GROUNDWATER AND STORMWATER FLOW AND OFFSITE DOSE CALCULATION DETAILS

**Water Remaining in Storm Drains and Discharged to River**

| Northern Clean Area Catchment (0% Storm Drain Water) | Unit 2 North (5% Storm Drain Water) | Unit 1/2 Area Catchment (10% Storm Drain Water) | Unit 3 North Area Catchment (7% Storm Drain Water) | Unit 3 South Area (5% Storm Drain Water) | Southern Clean Zone Area (5% Storm Drain Water) | Units |
|---|---|---|---|---|---|---|
| 0 | 19,929 | 116,684 | 59,524 | 43,200 | 28,687 | ft^3/yr |
| 0 | 55 | 320 | 163 | 118 | 79 | ft^3/day |
| 0 | 0.28 | 1.66 | 0.85 | 0.61 | 0.41 | GPM |
| 0 | 564,315 | 3,304,125 | 1,685,531 | 1,223,289 | 812,334 | L/Yr |

**Flux Calculations**

**Conceptual Model: Migration Pathway Summary**

| | Northern Clean Area | Unit 2 North | Unit 1/2 | Unit 3 North | Unit 3 South | Southern Clean Zone |
|---|---|---|---|---|---|---|
| GW | 100% Upper and Lower Zone To River | 84.8% Upper Zone and Lower Zone Flow To River. 15.2% Upper Zone and Lower Zone Flow to Canal | 75.8% Upper Zone and Lower Zone To River. 24.2% Upper Zone and Lower Zone to Canal | 77.1% Upper Zone and Lower Zone To River. 22.9% Upper Zone and Lower Zone to Canal | 31.6% Upper Zone and Lower Zone To River. 68.4% Upper Zone and Lower Zone to Canal | 100% Upper and Lower Zone To River |
| SW | NA | To Canal (Storm Water Considered Clean; Estimated at 5.5 GPM) and To River (5% Storm Water) | To Canal (60% Storm Water) and To River (10% Storm Water) | To Canal (33% Storm Water) and To River (7% Storm Water) | To Canal (85% Storm Water) and To River (5% Storm Water) | To Canal (55% Storm Water) and To River (5% Storm Water) |

**Flux (pCi/Yr)**

| | North Clean Area | Unit 2 North | Unit 1/2 | Unit 3 North | Unit 3 South | South Clean Zone | Total |
|---|---|---|---|---|---|---|---|
| **GW to River-Upper Zone** | 1.87E+08 | 0.00E+00 | 1.01E+09 | 8.23E+08 | 5.98E+08 | 2.26E+09 | **4.88E+09** |
| **GW to River-Lower Zone** | 1.29E+08 | 0.00E+00 | 2.60E+09 | 1.22E+09 | 8.09E+08 | 1.71E+09 | **6.46E+09** |
| **GW to Canal** | 0.00E+00 | 0.00E+00 | 2.69E+09 | 4.43E+08 | 4.13E+09 | 0.00E+00 | **7.27E+09** |
| **SW to Canal** | NA | 3.18E+10 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | **3.18E+10** |
| **SW to River** | NA | 3.46E+08 | 0.00E+00 | 1.15E+09 | 0.00E+00 | 2.04E+08 | **1.70E+09** |
| | | | | | | **Curies/Yr ==>** | **0.05** |

**Notes:**

The recharge rate used herein, 26% of precipitation (~7 in/yr), is within the range of values discussed in the USGS modeling report[1]. The reported recharge ranged from 3.6 inches/year to 7.5 inches/year for a till to 20 inches per year for coarse grained glacially stratified deposits. A yearly rolling average precipitation value measured at the Facility meteorological station is also used in the computations. The catchment area was defined using an AutoCAD topo map for the Site and surrounding area. The catchment was defined by starting at the area marked "line of water grant" and tracking east, away from the River, to define portions of the land surface contributing water to the selected discharge zone. Calculations assume that run-off or overland flow in unimproved areas of the Site is negligible, there are no changes in storage and the Hudson River is a gaining stream.

1. USGS. Water Use, Ground-Water Recharge and Availability, and Quality of Water in the Greenwich Area, Fairfield County, Connecticut and Westchester County, New York, 2000-2002

## APPENDIX K

## QUANTIFICATION AND REPORTING of C-14 in IPEC RELEASES



Effluent Curie Determination:

In the early 1980s, the NYSDOH conducted experiments at IP3 to quantify C-14 releases (Ref. 48). This data was summarized and incorporated into station procedures and annual effluent reports after 1983. In 2009, EPRI began working with licensees to develop a modern model to generate a good estimate of C-14 curies released from American nuclear power plants.

> EPRI's project "Estimation of Carbon-14 in Nuclear Power Plant Gaseous Effluents" was completed and published in December 2010 as document # 1021106.

Applying the EPRI model (Ref. 47) at IPEC resulted in closely matched values from those of the earlier work by NYSDOH. EPRI's calculation involves using the unit-specific average neutron flux (averaged values for beginning and end of core life), and the active core coolant mass in the reactor vessel area. From this data, the C-14 production rates from both the Oxygen and Nitrogen generation methods were computed ($^{17}O(n,\alpha)^{14}C$ and $^{14}N(n,p)^{14}C$).

The Nitrogen generation model requires the additional input of the average Nitrogen content in the reactor coolant, as described in References 47 and 48. Old and new values for C-14 released via airborne pathways annually is summarized below:

| | Curies C-14 released per NYSDOH, 1983 | Curies C-14 released per EPRI, 2010 | $CO_2$ fraction | Annual Curies causing dose |
|---|---|---|---|---|
| IP 2 | **N/A** | **10.5** | **N/A** | **2.73** |
| IP 3 | **9.6** | **10.4** | **26%** | **2.72** |

Liquid effluent C-14 was evaluated in 1982 and determined to be insignificant. However, since it has been reported since 1983, all liquid effluent data will continue to be reported for comparison purposes in the annual effluent report to the NRC. Annual curie and dose values for liquid C-14 releases are unchanged from Reference 48 and will continue:

*0.07 Ci, 1.17E-3 mrem Child Total Body, and 5.83E-3 mrem Child Bone dose, per unit.*

For 2010 and beyond, the curies of airborne effluent C-14 are determined from the EPRI model and used in conjunction with the defined fraction of $CO_2$ from the NYSDOH studies (Ref. 48), to establish the source term for offsite dose calculations from C-14.

*Determination of Curies, Appendix D of the EPRI model (Unit 2, 2009-2010 data shown)*

Note: Details of this calculation are provided in References 47 and 48 and are only summarized below:

Indian Point Unit-2 is a Westinghouse 4 loop PWR rated at 3216 MWth with a net electrical rating of 1032 MWe. Active core mass and core average neutron flux data is supplied by Reactor Engineering (and may be modified from cycle to cycle). However the following calculation serves as a template for an annual assessment of C-14 at either IPEC unit:

**"Core Average" Neutron Flux, n/cm$^2$-sec**

| | ≤0.625 eV | >0.625 eV |
|---|---|---|
| BOC | 3.18E13 | 2.78E14 |
| EOC | 3.96E13 | 2.90E14 |

| **Reaction** | **"Effective" Cross-Section, b** | |
|---|---|---|
| 17O(n,α)14C | 0.119 | 0.0482 |
| 14N(n,p)14C | 0.951 | 0.0393 |

## APPENDIX K

## QUANTIFICATION AND REPORTING of C-14 in IPEC RELEASES



The following equation was used to calculate the production rate in units of μCi/sec-kg for the $^{17}O(n,\alpha)^{14}C$ reaction.

$$\text{Production Rate } (\mu Ci/sec\text{-}kg) = \frac{N \cdot [\sigma th \cdot \varphi th + \sigma f \cdot \varphi f] \cdot 1.0E\text{-}24 \cdot \lambda}{3.7E4}$$

where:

| | | |
|---|---|---|
| N | = | 1.27E22 atoms $^{17}O/kg\ H_2O$ |
| σth | = | "effective" thermal cross-section, b |

**Indian Point Unit 2 Cycle 20 Average Production Rates for Oxygen Reaction**

| | Production Rate, μCi/sec-kg |
|---|---|
| BOC | 2.261E-5 |
| EOC | 2.459E-5 |
| Average: | 2.36E-5 |

| | | |
|---|---|---|
| φth | = | thermal neutron flux (≤0.625 eV), $n/cm^2$-sec |
| σf | = | "effective" fast cross-section, b |
| φf | = | fast neutron flux (>0.625 eV), $n/cm^2$-sec |
| 1.0E-24 | = | Conversion factor, 1.0E-24 $cm^2/b$ |
| λ | = | $^{14}C$ decay constant, 3.833E-12/sec |
| 3.7E4 | = | Conversion factor, 3.7E4 d/sec-μCi |

The effective cross section data were obtained from site Reactor Engineering, from Westinghouse documents.

BOC calculation:

$$PR = \frac{1.27E22 \cdot [0.119 \cdot 3.18E13 + 0.0482 \cdot 2.78E14] \cdot 1.0E\text{-}24 \cdot 3.833E\text{-}12}{3.7E4} = 2.261E\text{-}5\ \mu Ci/sec\text{-}kg$$

EOC calculation:

$$PR = \frac{1.27E22 \cdot [0.119 \cdot 3.96E13 + 0.0482 \cdot 2.90E14] \cdot 1.0E\text{-}24 \cdot 3.833E\text{-}12}{3.7E4} = 2.459E\text{-}5\ \mu Ci/sec\text{-}kg$$

The cycle average $^{14}C$ production rates for the $^{17}O(n,\alpha)^{14}C$ reaction were as follows:

Given an "active core" mass of 13,498 kg (from site Reactor Engineering), the total $^{14}C$ produced by the $^{17}O(n,\alpha)^{14}C$ reaction is:

2.36E-5 μCi/sec-kg • 13,498 kg • 3.156E7 sec/yr = 1.01E7 μCi/yr (**10.1 Ci/yr**)
or
2.36E-5 μCi/sec-kg • 13,498 kg • 3.6E3 sec/hr]/3216 MWth = 0.357 μCi/MWth-h

To calculate the production rate in units of μCi/sec-kg-ppm N for the $^{14}N(n,p)^{14}C$ reaction, the following equation is employed:

$$\text{Production Rate } (\mu\text{Ci/sec-kg-ppm N}) = \frac{N \cdot [\sigma th \cdot \varphi th + \sigma f \cdot \varphi f\,] \cdot 1.0\text{E-}24 \cdot \lambda}{3.7\text{E}4}$$

where:

| | | |
|---|---|---|
| N | = | 4.284E19 atoms $^{14}N$/kg-ppm N |
| σth | = | "effective" thermal cross-section, b |
| φth | = | thermal neutron flux, n/cm$^2$-sec |
| σf | = | "effective" fast cross-section, b |
| φf | = | fast neutron flux, n/cm$^2$-sec |
| 1.0E-24 | = | conversion factor, 1.0E-24 cm$^2$/b |
| λ | = | $^{14}C$ decay constant, 3.833E-12/sec |
| 3.7E4 | = | conversion factor, 3.7E4 d/sec-μCi |

The effective cross section data were obtained from site Reactor Engineering, from Westinghouse documents.

BOC calculation:

$$PR = \frac{4.284\text{E}19 \cdot [0.951 \cdot 3.18\text{E}13 + 0.0393 \cdot 2.78\text{E}14] \cdot 1.0\text{E-}24 \cdot 3.833\text{E-}12}{3.7\text{E}4} = 1.827\text{E-}7\ \mu\text{Ci/sec-kg-ppm } N_2$$

EOC calculation:

$$PR = \frac{4.284\text{E}19 \cdot [0.951 \cdot 3.96\text{E}13 + 0.0393 \cdot 2.90\text{E}14] \cdot 1.0\text{E-}24 \cdot 3.833\text{E-}12}{3.7\text{E}4} = 2.177\text{E-}7\ \mu\text{Ci/sec-kg-ppm } N_2$$

## APPENDIX K

## QUANTIFICATION AND REPORTING of C-14 in IPEC RELEASES



The production rates are summarized below:

**Indian Point Unit 2 Cycle 20 Average Production Rates for Nitrogen Reaction**

| | Production Rate, μCi/sec-kg-ppm $N_2$ |
|---|---|
| BOC | 1.827E-7 |
| EOC | 2.177E-7 |
| Average: | 2.00E-7 |

Given an "active core" mass of 13,498 kg (from site Reactor Engineering), the total $^{14}C$ produced by the $^{14}N(n,p)^{14}C$ reaction is:

2.00E-7 μCi/sec-kg-ppm N • 13,498 kg • 3.156E7 sec/yr = 8.52E4 μCi/yr-ppm N = **0.0852 Ci/yr-ppm-$N_2$**

or

[2.00E-7 μCi/sec-kg-ppm N • 13,498 kg • 3.6E3 sec/hr]/3216 MWth = 3.02E-3 μCi/MWth-h–ppm $N_2$

The ppm $N_2$ in the coolant is determined from VCT conditions per EPRI's model, Appendix E. Indian Point Unit 2 averages approximately 90% Hydrogen, and conservatively 30 psig pressure in the VCT. Accounting for a slight reduction in pressure due to the water vapor, the partial pressure of Nitrogen is then:

$$P(N_2) = 0.10 * 29.7 = 0.302 \text{ atm}$$

Assuming 9.88E4 atm/mole-fraction at average operating temperature (from Appendix E), the mole fraction of $N_2$ in the VCT liquid phase is:

$$0.302 \text{ atm} / 9.88E4 \text{ atm/mole fraction} = 3.06E-6$$

Converting to ppm $N_2$:

$$\frac{3.06E-6 \text{ moles } N_2}{\text{mole } H_20} * \frac{\text{mole } H_20}{18.02 \text{ g } H_20} * \frac{28.01 \text{ g } N_2}{\text{mole } N_2} = 4.76E-6 \text{ g } N_2 / \text{g } H_20 = \mathbf{\textit{4.76 ppm}}$$

The resulting curies from the $N_2$ reaction would then be:

$$0.0852 \text{ Ci/yr-ppm } N_2 * 4.76 \text{ ppm} = 0.405 \text{ Ci/yr}$$

Adding the curies determined from the$O_2$ reaction, earlier (10.1 Ci/yr):

Total Curies of C-14 released from a single IPEC unit = **10.5 Ci**/full power year

Applying a correction factor for effective full power days (EFPD, obtained from Programs and Components) provides actual curies for each year. For example, if a unit's EFPD for a given year was 299, the factor would be 299/365 or 0.819. In the above example, this would result in actual curies of C-14 for the given year to be: 0.819 * 10.5, or 8.60 Curies total C-14.

**APPENDIX K**

**QUANTIFICATION AND REPORTING of C-14 in IPEC RELEASES** 

Effluent Dose Determination:

Comparing the EPRI model curie calculations with the work compiled at IP3 in 1982:

| | Measurements at IP3, 1982 | EPRI model, 2010 | Percent Difference |
|---|---|---|---|
| Curies of C-14 released, per unit | **9.6** | **10.5** | *8.57% increase* |

The EPRI model compares favorably (slightly in the conservative direction) with sample data results obtained at IP3 in the 1980s. For conservativism and industry standardization, IPEC uses the EPRI model for determining curies released, as of 2010.

Offsite doses from C-14 emissions are calculated in the same manner as all other isotopes at IPEC, using Reg Guide 1.109 and associated dose factors, with details identified in Ref 48. As the release is in the form of $CO_2$, the X/Q dispersion constant is used. Whole Body and Critical Organ doses are calculated for the critical age group (child) at the Primary Receptor, from ingestion (vegetative) and inhalation pathways.

Adding the liquid effluent data, and attributing dose to each unit (as is required by 10CFR50), results in annual totals that can be used as a bounding calculation from maximum rated output and core size. See the summary table at the end of this section.

Liquid:

Liquid effluent curies and doses from C-14 were determined to be relatively insignificant in the 1982 study. The EPRI model in 2010 also identified liquid pathways to be insignificant, and specifically mentions only airborne pathways need to be evaluated. However, since liquid effluent values were determined from actual sampling in 1982, the historical curies and doses (determined from standard Reg Guide 1.109 modeling) will continue to be reported in annual reports, as shown in the table at the end of this section. Details of both liquid and airborne dose calculations are provided in Reference 48.

Airborne:

1. Assumptions

   a. 21 Ci/yr released from IPEC, per EPRI model (10.5 Ci/yr per operating unit)
   b. Q=5.46 Ci/yr (26% as $CO_2$, the only dose contributor, 2.73 Ci/yr per unit)
   c. p= ratio of C-14 releases to total release time = 1 (very conservative)
   d. X/Q @ Primary Receptor (U2 = 1.03E-6 sec/$m^3$ , U3 = 1.02E-6 sec/$m^3$ )
   e. Fraction of total plant mass that is natural carbon = 0.11 (RG 1.109, C-8)
   f. Concentration (g/$m^3$) of natural carbon in atmosphere = 0.16 (RG 1.109, C-8)
   g. Child dose at the Primary Receptor is most limiting
   h. Dose Factors used from Reg Guide 1.109

   Note: Values for c, e, and f are conservative and offered by RG 1.109. Better (site-specific) data is being evaluated at IPEC and throughout the industry for application in the future.

2. Vegetative Pathway Calculation from Reg Guide (see RG 1.109, equation C-8)

   C14 pCi/kg = 3.17E7 * p * Q * X/Q * (0.11/0.16) *[3.17E7 = (pCi-g-yr)/(Ci-kg-sec)]*

   C14 pCi/kg = **122.6 pCi/kg ingested** (veg) *(conservatively using U2's X/Q)*

## APPENDIX K

## QUANTIFICATION AND REPORTING of C-14 in IPEC RELEASES



3. Child Ingestion *(uses 26% of total C-14 released, or just the $CO_2$ portion)*

Dose = DF * [ $u^v * f_g + u^L$] * 122.6 pCi/kg

DF = 1.21E-5 mrem/pCi Bone Child *[RG 1.109, E-13]*
2.42E-6 mrem/pCi TB Child *[RG 1.109, E-13]*

*$u^v$=520 kg/yr (child ; $u^L$=26 kg/yr [usage factors, RG 1.109, E-5]*

*$f_g$ = 0.76 [ fraction of produce ingested in garden of interest, E-15]*

Annual Child Bone Dose = 1.21E-5 * 51639 = **0.625 mrem**

Annual Child TB Dose = 2.42E-6 * 51639 = **0.125 mrem**

4. Child Inhalation *(uses all released C-14, not just $CO_2$)*

C14 pCi/m$^3$ = 3.17E+4 * (Q) * (X/Q) [*3.17E+4 = (pCi-yr) / (Ci-sec)*]

C14 pCi/m$^3$ = 3.17E+4 pCi-yr/Ci-sec * 21 Ci * 1.03E-6 sec/m$^3$ = 0.686 pCi/m$^3$

C14 Dose = BR * pCi/m$^3$ * DFi

$BR_{child}$ = 3700 m$^3$/yr ; Conc = 0.686 pCi/m$^3$ ; DFI = 9.70E-6 mrem/pCi $_{\text{Child Bone}}$
= 1.82E-6 mrem/pCi $_{\text{Child TB}}$

Annual Child Inh Bone Dose = 3700 * 0.686 * 9.70E-6 = **2.46E-3 mrem**

Annual Child Inh Tot Body Dose = 3700 * 0.686 * 1.82E-6 = **4.62E-3 mrem**

5. The doses above apply to IPEC. Individual unit doses are half the total, as follows:

One IPEC Unit **Child Bone** Dose = (0.625 + 2.46E-3) / 2 = **0.325 mrem**

One IPEC Unit **Child Tot Body** Dose = (0.125 + 4.62E-3) / 2 = **0.0648 mrem**

6. The Annual Radioactive Effluent Release Report (ARERR, per RG 1.21), includes data similar to the following table, as determined for each year, corrected for effective full power days. The percentage of total C-14 that is $CO_2$ should also be identified.

7. C-14 curies and doses should be reported separately from other isotopes because:

- C-14's measurement and quantification methods are unique,
- Trending/representation of C-14 and other isotopes will remain unchanged, and,
- This method precludes any confusion or inappropriate comparison between C-14 and isotopes that are categorized as Noble Gas, Iodine, or Particulate (as C-14 cannot be accurately grouped with any of these).

| Typical Annual C-14 reporting from IPEC | | Unit 2 | Unit 3 |
|---|---|---|---|
| Liquid Effluent $C^{14}$ Released | Curies | **0.07** | **0.07** |
| Total Airborne $C^{14}$ Released | Curies | **10.5** | **10.5** |
| Airborne $C^{14}$ as $CO_2$ | Curies | **2.73** | **2.73** |

| | | | |
|---|---|---|---|
| Airborne Eff Child TB Dose, $C^{14}$ | mrem | **0.0648** | **0.0648** |
| Airborne Eff Child Bone Dose, $C^{14}$ | mrem | **0.325** | **0.325** |
| Liquid Eff Child TB Dose, $C^{14}$ | mrem | **0.00117** | **0.00117** |
| Liquid Eff Child Bone Dose, $C^{14}$ | mrem | **0.00583** | **0.00583** |