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NL-20-040

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

SUBJECT: 2019 Annual Radiological Environmental Operating Report
Indian Point Unit Nos. 1, 2 and 3
Docket Nos. 50-03, 50-247, 50-286
License Nos. DPR-5. DPR-26, DPR-64

This letter provides Entergy Nuclear Operations, Inc. Indian Point Energy Center Annual Radiological Environmental Operating Report for the period January 1, 2019 through December 31, 2019.

This report is submitted in accordance with facility Technical Specification, Appendix A, Section 5.6.2 associated with License Numbers DPR-5, DPR-26 and DPR-64, for Indian Points Units 1, 2 and 3 respectively. There are no new regulatory commitments being made by Entergy in this correspondence.

If you have any questions or require additional information, please Mahvash Mirzai at 914-254-7714

Sincerely,

AJV/trj

Enclosure: 2019 Annual Radiological Environmental Operating Report

IE25
NMSS01
NRR
NMSS

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ENCLOSURE TO NL-20-040

2019 Annual Radiological Environmental Operating Report

ENTERGY NUCLEAR OPERATIONS, INC.
INDIAN POINT UNIT 1, 2, and 3 NUCLEAR POWER PLANTS
DOCKET Nos. 50-03, 50-247, and 50-286

Entergy

Plant: Indian Point Energy Center	Page 1 of 126 YEAR: 2019
Docket Number: 50-003 (IP1), 50-247 (IP2), 50-286 (IP3)	
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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, 2019. The Indian Point site consists of Units 1, 2 and 3, which are operated by Entergy Nuclear Operations Inc. Unit 1 was retired as a generating facility in 1974, and its reactor is no longer operated.

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, ground water, broadleaf vegetation, river water, shoreline sediment, bottom sediment, aquatic vegetation, fish, and invertebrates.

During 2019 there were 1145 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 2019 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 1297 analyses performed on the environmental media samples. The analyzes of the 2019 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 2019. 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, broadleaf 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 45 and 64 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 and at the Hudson River intake 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 as well as one soil and one shoreline soil sample. 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 2019 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.

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 2019 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 2019 performed by Entergy 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, 2019.

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.

The ground water table is listed after the rainwater and drinking water tables for ease of data comparison. However, ground water is not a dose pathway since it is not a drinking water pathway at IPEC.

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 2019 as required by the IPEC ODCM. Also included are summaries and discussions of the results of the 2019 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 Entergy Nuclear Indian Point 2, LLC and Unit 3 is owned by Entergy Nuclear Indian Point 3 LLC. All three units are operated by Entergy Nuclear, although only Units 2 and 3 continue to operate.

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 2019 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 2019 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

Entergy 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 2019 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 2019 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, 44, 94 (A2), and 95 (A3). 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 Precipitation

Precipitation sampling was discontinued in 2019 due to not being required by the ODCM and not recommended in NUREG 1301.

3.3.4 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.

3.3.5 Groundwater Water

Groundwater samples are obtained semi-annually at Lafarge (106). Samples are analyzed for tritium, strontium-90, nickel-63 and by gamma spectroscopy.

3.3.6 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.

3.3.7 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.

3.3.8 Hudson River Water

Hudson River water sampling is performed continuously at the intake structure (sampling station 9, Wa1) and 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. 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.

3.3.9 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.

3.3.10 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.

3.3.11 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.

3.3.12 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.

3.3.13 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 is discussed in Section 4.13.

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)

λ = 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 2009 through 2019. The historical averages are calculated using only the positive values presented for 2009 through 2018. The 2019 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
9	Wa1	Plant Inlet (Hudson River Intake)*	Onsite - 0.16 Mi (W) at 273°	HR 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	**	Roseton*	20.7 Mi (N) at 357°	Precipitation
	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

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°	Precipitation
	**			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

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
106	**	Lafarge Monitoring Well	0.63 mi SW	Groundwater
107	**	Vicinity of Haverstraw Bay	2.5 mi SSW (downstream)	Fish & Invertebrates

* = Control location

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

HR = Hudson River

FIGURE A-1

SAMPLING LOCATIONS
Within Two Miles of Indian Point

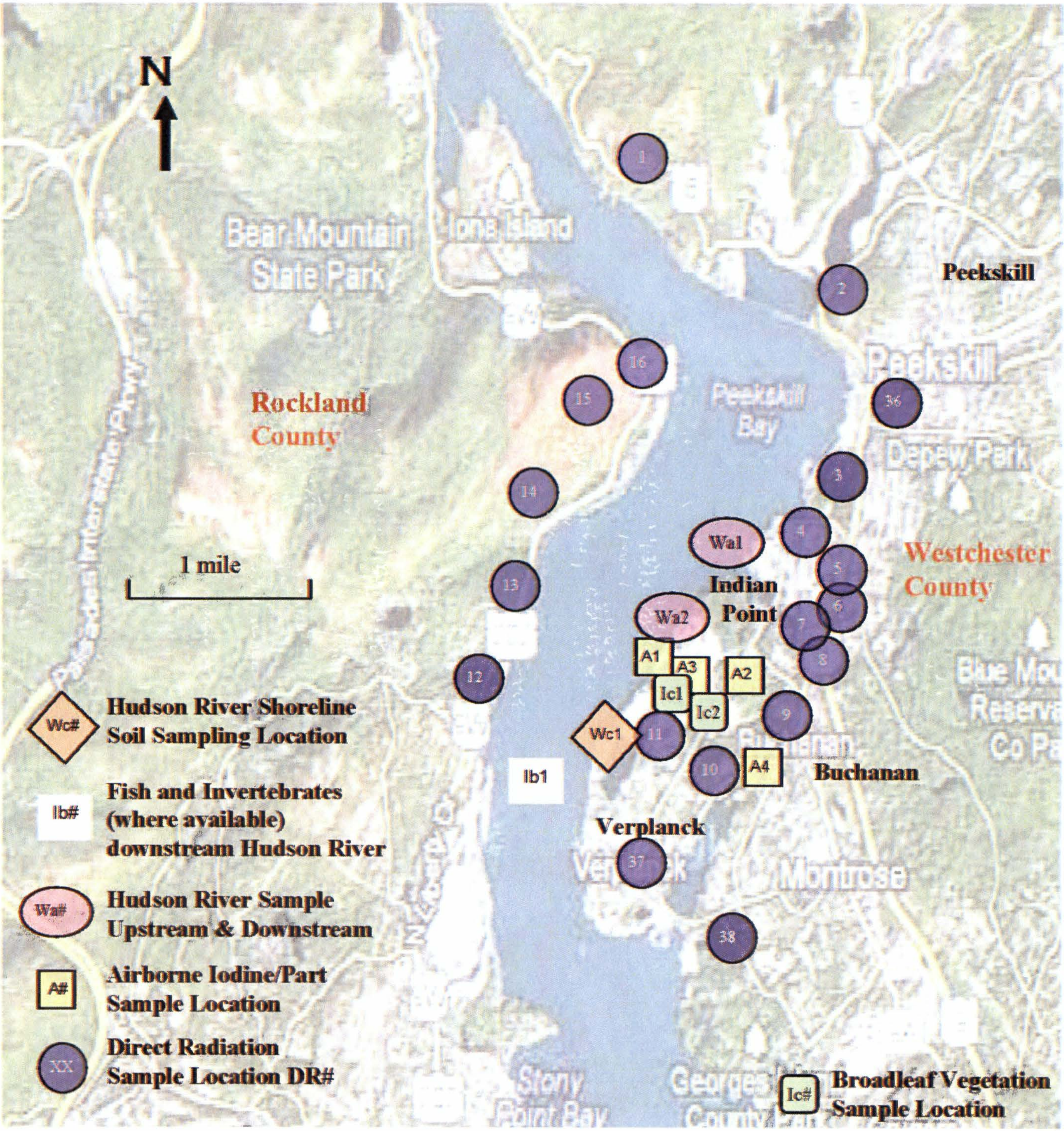


FIGURE A-2

SAMPLING LOCATIONS
Greater than Two Miles from Indian Point

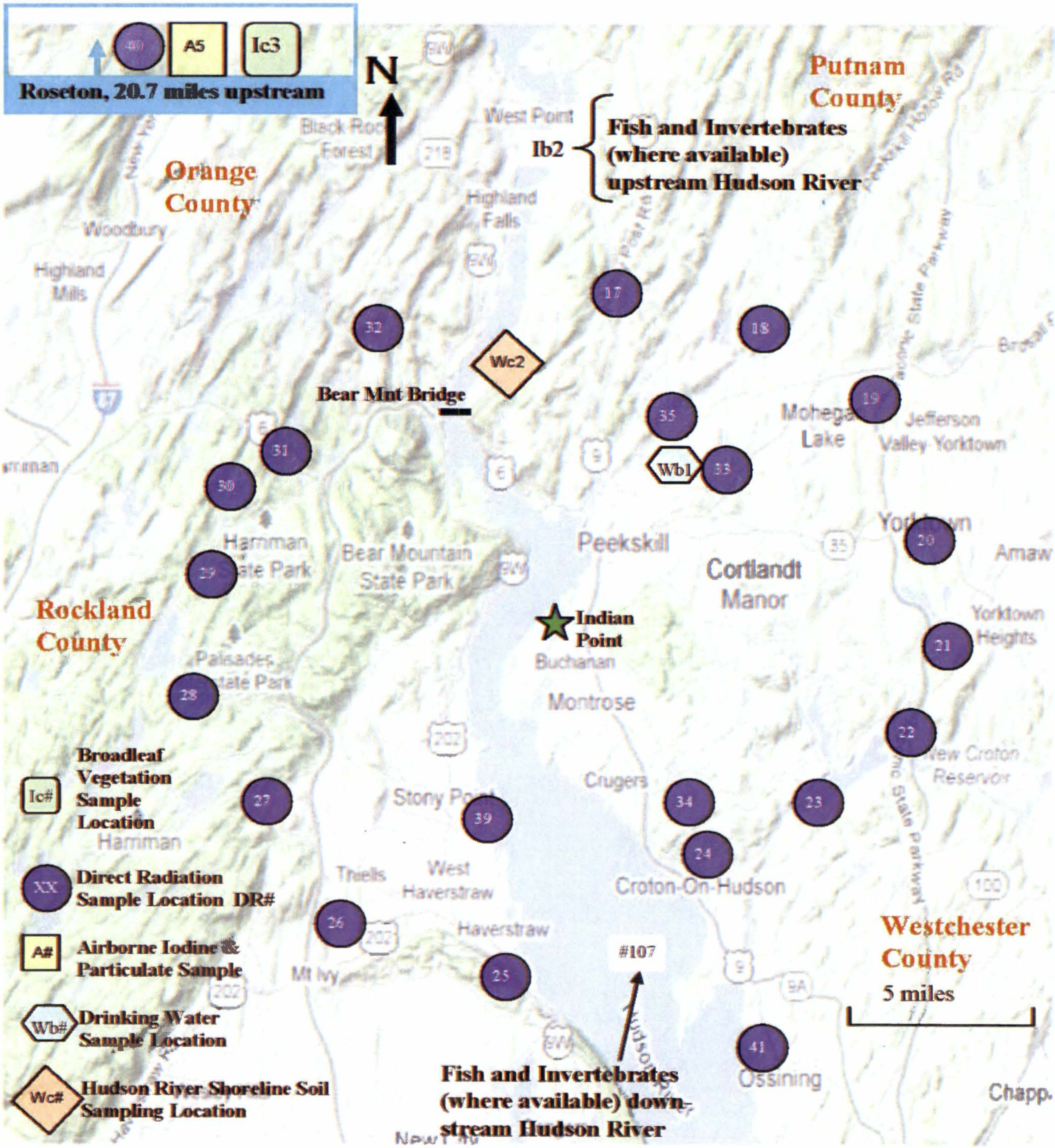


FIGURE A-3

SAMPLING LOCATIONS
Additional Sampling Locations

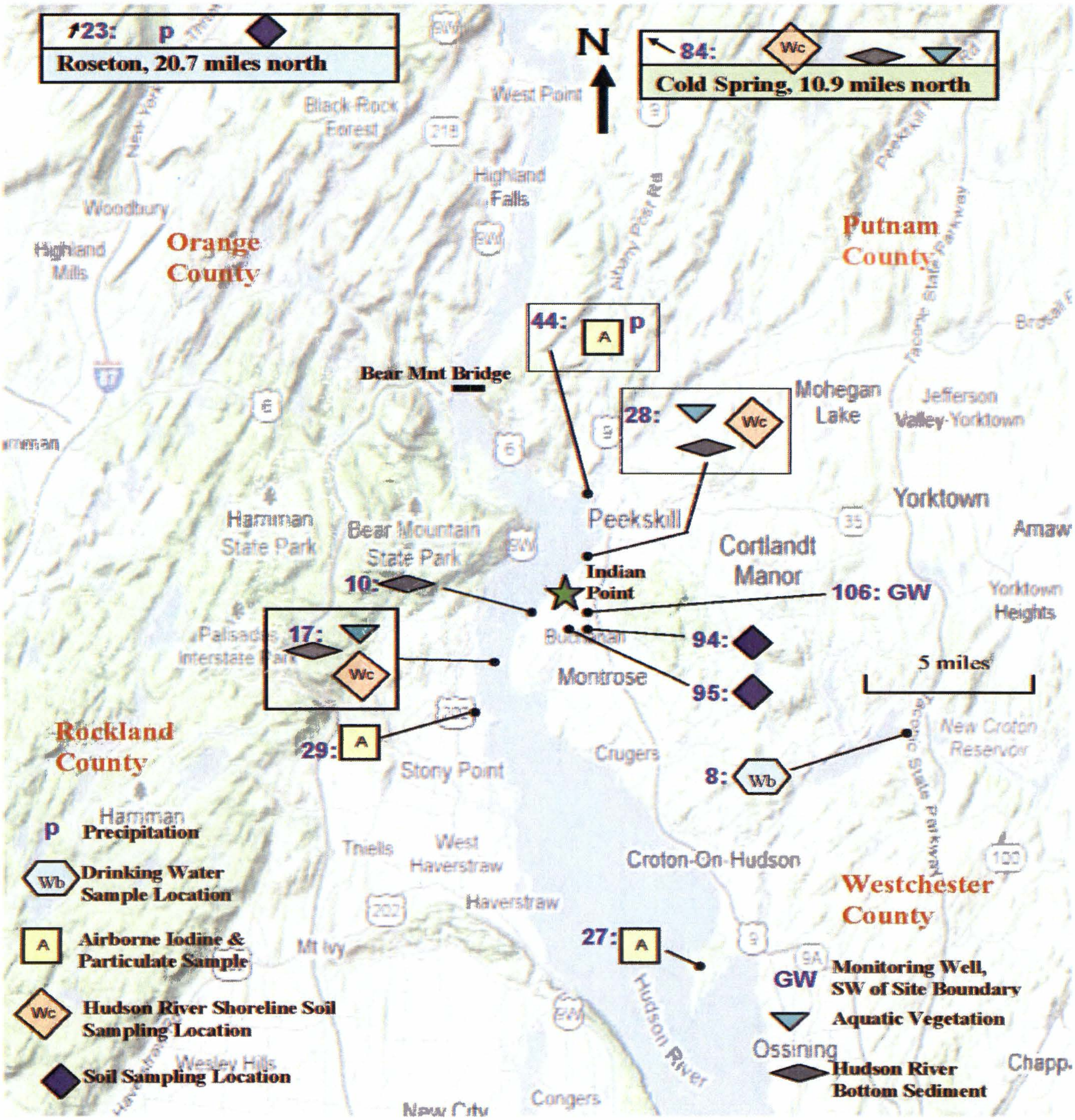


TABLE A-2

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			5000
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 2019 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	Airborne Particulates and Radioiodine
Precipitation	Drinking Water
Groundwater	Soil
Broad Leaf Vegetation	Hudson River Water
Bottom Sediment	Shoreline Soil
Aquatic Vegetation	Fish and Invertebrates

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 2019 and assessed the significance of the findings.

A summary of the results of the 2019 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 2019 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 2019, 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 2019 REMP comprises those that may be attributable to current plant operations. During 2019, 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 2019, 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 2019, there were seven detections of Cs-137 in bottom sediment and shoreline soil at indicator locations. Cs-137 was also detected in one soil samples obtained. In all cases, the Cs-137 concentrations, when detected, were consistent with historical values.

The fact that there was no Cs-134 present (recent plant releases would contain Cs-134) and that the levels detected were consistent with historical values indicates that the activity may be due to atmospheric weapons testing, with some contribution from plant releases from the past years. None of the fish samples indicated any detectable levels of these isotopes.

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, shoreline soil, or REMP groundwater samples.

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 2019 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 2019 REMP, although they were observed in historical data.

In the following sections, a summary of the results of the 2019 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 2019, 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 2010 through 2018. The 2019 means are also presented in Table B-4. Table B-5 presents the 2019 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 2019 mean value for the indicator direct radiation sample points was 13.7 mR per standard quarter – which is consistent with historical values. At those locations where the 2019 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 13.7 mR per standard quarter and also average for the outer ring was 13.9 mR per standard quarter. The control location average for 2019 was 15.0 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 2019 averages are consistent with the historical data. The 2019 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 eight indicator air sample locations was 0.012 pCi/m^3 and the average for the control location was 0.012 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 2019 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 2019.

4.3 Precipitation

Precipitation collection was discontinued in 2019 due to sampling not being required by the ODCM and not recommended in NUREG 1301. Discontinuation of precipitation is noted in Table B-9.

4.4 Drinking Water

Results of the gross beta, tritium and gamma spectroscopy analyses of the monthly drinking water samples are in Table B-10. 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.

4.5 Ground Water

Data resulting from analysis of the groundwater samples for gamma emitters, tritium analysis, Ni-63 and Sr-90 are given in Table B-11. No plant related nuclides were noted in any of the samples.

4.6 Soil

Table B-12 contains the results of the soil samples for 2019. Other than naturally occurring radionuclides, very low levels of Cs-137 were detected in some soil samples consistent with historical results.

4.7 Broad Leaf Vegetation

Data from analysis of the 2019 samples are presented in Table B-13. 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 2019 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.

4.8 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-14.

The only plant related activity detected was H-3; detected at low levels in two indicator samples and one control sample. 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.

4.9 Hudson River Bottom Sediment

Table B-15 contains the results of the analysis of bottom sediment samples for 2019. Cesium-137 was detected in four of the indicator station samples, and both of the control location samples. Detection of positive levels of Cs-137 in river bottom sediment is not unusual. Cs-134 was not detected in any bottom sediment samples. The lack of Cs-134 points to the primary source of the Cs-137 in bottom sediment as being from prior historical plant releases over the years and from residual weapons test fallout.

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 2019 sampling are within the range of levels identified in historical samples.

4.10 Hudson River Shoreline Soil

Table B-16 contains the results of the gamma spectroscopic and strontium-90 analyses of the shoreline soil samples. In addition to the naturally occurring radionuclides, Cs-137 was identified in one of the Hudson River shoreline soil samples in 2019.

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.

4.11 Hudson River Aquatic Vegetation

Table B-17 results show no plant related radionuclides were detected in any indicator or control aquatic vegetation samples in 2019. This is consistent with historical findings.

4.12 Fish and Invertebrates

Table B-18 contains the results of the analysis of fish and invertebrate samples for 2019. No plant related radionuclides were detected. This is consistent with historical results which are shown in table and figure C-7.

4.13 Land Use Census

A census was performed in the vicinity of Indian Point in 2019. This census consisted of a milch animal and a residence census. Results of this census are presented in Tables B-19 and B-20.

The results of the 2019 census were generally same as the 2018 census results, in 2018 the presence of goats was noted on a property located less than 5.0 miles SSE of IPEC. However, discussions with the owner for the 2019 land use surveys confirmed that the goats did not produce milk for human consumption and are therefore not milch animals.

The 2019 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 4.7 and presented in Table B-13, Table C-6 and Figure C-6.

4.14 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 2019 REMP reveal that operations at the station did not result in an impact on the environment.

The 2019 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 2019 Annual Radiological Environmental Monitoring Program Summary

The results of the 2019 radiological environmental sampling program are presented in Tables B-2 through B-18. Table B-2 is a summary table of the sample results for 2019. 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-18.

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-19 and B-20, 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-13).

5.3 Sampling Deviations

During 2019, environmental sampling was performed for 11 unique media types addressed in the ODCM and for direct radiation. A total of 1145 samples of 1151 scheduled were obtained. Of the scheduled samples, 99.5% 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 and Table B-1b for other media.

5.4 Analytical Deviations

No analytical deviations were found in 2019.

5.5 Special Reports

No special reports were required under the REMP.

TABLE B-1

Summary of Sampling Deviations - 2019

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	416	0	100%	448	N/A
CHARCOAL FILTER	416	0	100%	416	N/A
PRECIPITATION	N/A	N/A	N/A	N/A	See Table B-1b
DRINKING WATER	24	2	92%	52	See Table B-1b
GROUNDWATER SAMPLES	2	0	100%	8	N/A
SOIL	3	0	100%	3	N/A
BROAD LEAF VEGETATION	45	0	100%	45	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	4	33%	2	See Table B-1b
FISH & INVERTEBRATES	33	0	100%	99	N/A
TOTALS	1151	6	99.5%	1297	

TOTAL NUMBER OF SAMPLES COLLECTED = 1145

* Samples not collected or unable to be analyzed.

** Several sample types require more than one analysis

TABLE B-1a

2019 Air Sampling Deviations

LOCATION	DATE	PROBLEM / ACTIONS TO PREVENT RECURRENCE
23 Roseton	2/27/2019	Air sampler lost 37 hours of run time due to a power outage. CR-IP2-2019-1029
22 Roseton	6/5/2019	Sample volume of 13,300 ft^3 noted for the week, versus an expected volume of 17,970 ft^3, resulting in a calculated sample pump outage time of 37 hrs. CR-IP2-2019-1029.
94 Training Building	6/5/2019	Sample volume of 8,400 ft^3 noted for the week, versus an expected volume of 18,344 ft^3 resulting in a calculated sample pump outage time of 91 hours. Electrical service interrupted by feeder switching and incomplete power restoration. CP-IP2-2019-2405.
44 Gas Holder	11/25/2019	Evidence of equipment tampering was observed at Station 44. Location is extra location, not required by the ODCM. Elapsed time/total volume collected calculation shows no lost sample time or less-than-expected sample volume. CR-IP2-4890.

TABLE B-1b

2019 Other Media Deviations

LOCATION	DATE	PROBLEM / ACTIONS TO PREVENT RECURRENCE
09 Hudson River Intake	1/23/2019	Unable to collect the weekly Hudson river intake water sample due to unsafe conditions on the Unit 1 dock. Sample from automatic compositor scheduled to be collected the following week. CR-IP2-2019-0379.
09 Hudson River Intake	1/29/2019	While collecting the water sample it was discovered that the sample strainer was missing from the sample hose due to ice in the river. Both of the conditions identified in this CR have been corrected. The snow and ice have been removed. The sample tube and filter have been replaced. CR-IP2-2019-0493.
23 Roseton Fish	4/30/2019	Laboratory failed to update collection date for sample added to work order. Gamma nuclide Fe-59 results exceed the LLD requirements. Lab initiated corrective action.

TABLE B-1b cont'd

2019 Other Media Deviations

LOCATION	DATE	PROBLEM / ACTIONS TO PREVENT RECURRENCE
09 Hudson River Intake	4/16/2019 5/2/2019 5/8/2019 5/15/2019 5/21/2019 5/30/2019 12/26/2019	Unable to collect the weekly Hudson River intake water sample from the auto-compositor due to lack of power for the sample pump (and line freezing during cold weather). Weekly grabs were performed as a replacement for the compositor. This sample location is a "Control Location" which is intended to provide "background" information from potential up-river sources. CR-IP2-2019-1742, 1936, 2013, 2116, 2184, 2322, and 5167. This location is not the preferred control location due to upstream flow from the discharge area since the Hudson is a tidal river. Replacement of this location further upstream is being proposed in a revision of the ODCM.
07 Camp Field, 08 Croton Drinking Water	7/11/2019	July Drinking water sample were lost in transit by the shipping company. CR-IP2-2019-3275
28, 17 & 84 for HR Aquatic Vegetation	Spring 2019	Aquatic Vegetation Samples were not available in the river bed areas designated for these samples during the Spring sampling event.
84 for HR Aquatic Vegetation	Summer 2019	Aquatic Vegetation Sample was not available in the river bed areas designated for these samples during the Summer sampling event.
23 Roseton Rainwater	2019	Rainwater Sampling was discontinued in 2019 due to sampling not being required by the ODCM and not recommended in NUREG 1301.
44 Peekskill Rainwater	2019	Rainwater Sampling was discontinued in 2019 due to sampling not being required by the ODCM and not recommended in NUREG 1301

TABLE B-2 RADIOLOGICIAL ENVIRONMENT MONITORING PROGRAM SUMMARY
INDIAN POINT ENERGY CENTER - 2019
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	NA	13.7 (160/160) (9.9-17.1)	DR-31	4.65 Mi. NW	16.0 (4/4) (14.9-16.8)	15.0 (4/4) (14.4-15.7)	0
Air Particulate (pCi/m^3)	Gr-B	416	0.01	.012 (364/364) (.006-.022)	29	3.37 Mi. SSW	.013 (52/52) (.007-.022)	.012 (52/52) (.005-.020)	0
Air Iodine (pCi/m^3)	GAMMA I-131	416	0.07	<LLD			-	<LLD	0
Air Particulate (10^{-3} pCi/m^3)	GAMMA	32							
	Be-7		NA	112.8 (28/28) (78.3-151.2)	95	0.46 Mi. SSW	116.8 (4/4) (95.8-129.9)	108.8 (4/4) (76.1-127.9)	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
Rainwater* (pCi/L)	H-3	0	200	NA			-	NA	0
	GAMMA	0							
	Co-60		15	NA			-	NA	0
	Cs-134		15	NA			-	NA	0
	Cs-137		18	NA			-	NA	0

*Rainwater collection was discontinued in 2019.

Medium or Pathway Sampled (Units)	Analysis Type	Total Number	LLD*	Indicator Locations Mean ** (Range)	Location Number	Distance Direction	Mean** (Range)	Control Locations Mean** (Range)	Non-Routine Reported Measurements
Drinking Water (pCi/L)	Gr-B	22	4	3.21 (7/22) (2.02-5.85)	07	3.4 Mi. NE	3.38 (4/11) (2.27-5.85)	NA	0
	H-3	8	200	<LLD			-	NA	0
	GAMMA	22							
	Mn-54		15	<LLD			-	NA	0
	Co-58		15	<LLD			-	NA	0
	Fe-59		30	<LLD			-	NA	0

TABLE B-2 RADIOLOGICIAL ENVIRONMENT MONITORING PROGRAM SUMMARY
INDIAN POINT ENERGY CENTER - 2019
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)	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
	Cs-137		18	<LLD			-	NA	0
	Ba-140		60	<LLD			-	NA	0
	La-140		15	<LLD			-	NA	0
Groundwater (pCi/L)	H-3	2	200	<LLD			-	NA	0
	Ni-63	2	30	<LLD			-	NA	0
	Sr-90	2	1	<LLD			-	NA	0
	GAMMA	2							
	Mn-54		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

TABLE B-2 RADIOLOGICIAL ENVIRONMENT MONITORING PROGRAM SUMMARY
INDIAN POINT ENERGY CENTER - 2019
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
Groundwater (cont'd) (pCi/L)	Zr-95		30	<LLD			-	NA	0
	I-131		15	<LLD			-	NA	0
	Cs-134		15	<LLD			-	NA	0
	Cs-137		18	<LLD			-	NA	0
	Ba-140		60	<LLD			-	NA	0
	La-140		15	<LLD			-	NA	0
Soil (pCi/kg dry)	GAMMA Be-7	3	NA	<LLD			-	<LLD	0
	K-40		NA	13285 (2/2) (11950-14620)	23	20.7 Mi. N	17270 (1/1)	17270 (1/1)	0
	Co-60		NA	<LLD			-	<LLD	0
	Cs-134		150	<LLD			-	<LLD	0
	Cs-137		180	445.3 (1/2)	94	0.39 Mi. S	445.3 (1/1)	<LLD	0
	Ra-226		NA	<LLD			-	<LLD	0
	Th-228		NA	527.1 (2/2) (483.3-570.9)	23	20.7 Mi. N	986.6 (1/1)	986.6 (1/1)	0
Broadleaf Vegetation (pCi/kg wet)	GAMMA Be-7	45	NA	1825.1 (28/30) (433.3-3730)	95	0.46 Mi. SSW	1923.0 (15/15) (621.0-3730)	1189.3 (14/15) (607.4-2074)	0
	K-40		NA	5097.6 (30/30) (1888-8869)	94	0.39 Mi. S	5406.6 (15/15) (1888-8869)	4560.0 (15/15) (2482-8029)	0
	Co-60		NA	<LLD			-	<LLD	0
	I-131		60	<LLD			-	<LLD	0
	Cs-134		60	<LLD			-	<LLD	0

TABLE B-2 RADIOLOGICIAL ENVIRONMENT MONITORING PROGRAM SUMMARY
INDIAN POINT ENERGY CENTER - 2019
Dockets 50-003, 50-247 & 50-286

Medium or Pathway Sampled (Units)	Analysis Type	Total Number	LLD*	Indicator Locations	Location with Highest Mean			Control Locations	Non-Routine Reported Measurements
				Mean ** (Range)	Location Number	Distance Direction	Mean** (Range)	Mean** (Range)	
Broadleaf Vegetation (cont'd) (pCi/kg wet)	Cs-137		80	<LLD			-	<LLD	0
	Th-228		NA	66.46 (1/30)	95	0.46 Mi. SSW	66.46 (1/15)	<LLD	0
River Water (pCi/L)	H-3	8	200	295 (2/4) (294-296)	10	0.3 Mi. WSW	295 (2/4) (294-296)	273 (1/4)	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	7.26 (1/24)	10	0.3 Mi. WSW	7.26 (1/24)	<LLD	0
Bottom Sediment (pCi/kg dry)	GAMMA	8							
	K-40		NA	17761.7 (6/6) (14870-19760)	84	10.88 Mi. N	21045 (2/2) (20120-21970)	21045 (2/2) (20120-21970)	0
	Co-60		NA	<LLD			-	<LLD	0

TABLE B-2 RADIOLOGICIAL ENVIRONMENT MONITORING PROGRAM SUMMARY
INDIAN POINT ENERGY CENTER - 2019
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)	Cs-134		150	<LLD			-	<LLD	0
	Cs-137		180	190.3 (4/6) (114.8-274.4)	17	1.5 Mi. SSW	274.4 (1/2)	176.3 (2/2) (162.1-190.5)	0
	Ra-226		NA	2551 (1/6)	84	10.88 Mi. N	3109 (1/2)	3109 (1/2)	0
	Th-228		NA	650.8 (6/6) (293-1035)	84	10.88 Mi. N	1230.5 (2/2) (1030-1431)	1230.5 (2/2) (1030-1431)	0
Shoreline Soil (pCi/kg dry)	Sr-90	10	5000	<LLD			-	<LLD	0
	GAMMA	10							
	K-40		NA	12767.2 (6/6) (6613-17070)	84	10.88 Mi. N	29435 (2/2) (27900-30970)	21745 (4/4) (14030-30970)	0
	Cs-134		150	<LLD			-	<LLD	0
	Cs-137		180	103.6 (1/6)	17	1.5 Mi. SSW	103.6 (1/2)	<LLD	0
	Ra-226		NA	2155 (1/6)	50	4.48 Mi. NNW	2751 (2/2) (2490-3012)	2751 (2/4) (2490-3012)	0
	Th-228		NA	621.0 (5/6) (148.0-950.1)	28	0.45 Mi. ENE	827.5 (2/2) (704.9-950.1)	807.1 (4/4) (651.3-961.1)	0
Aquatic Vegetation (pCi/kg wet)	GAMMA	2							
	Be-7		NA	<LLD			-	NA	0
	K-40		NA	1986 (2/2) (1736-2236)	28	0.45 Mi. ENE	2236 (1/1)	NA	0
	Co-60		NA	<LLD			-	NA	0
	I-131		60	<LLD			-	NA	0
	Cs-134		60	<LLD			-	NA	0
	Cs-137		80	<LLD			-	NA	0
	Ra-226		NA	<LLD			-	NA	0
	Ac-228		NA	135.6 (2/2) (121.4-149.8)	17	1.5 Mi. SSW	149.8 (1/1)	NA	0

TABLE B-2 RADIOLOGICIAL ENVIRONMENT MONITORING PROGRAM SUMMARY
INDIAN POINT ENERGY CENTER - 2019
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
Aquatic Vegetation (cont'd) (pCi/kg wet)	Th-228		NA	64.4 (2/2) (59.7-69.0)	28	0.45 Mi. ENE	69.0 (1/1)	NA	0
Fish (pCi/kg wet)	Ni-63	33	100	<LLD			-	<LLD	0
	Sr-90	33	5	<LLD			-	<LLD	0
	GAMMA	33							
	K-40		NA	2311 (22/22) (1378-3032)	23	20.7 Mi. N	2406 (11/11) (1985-3109)	2406 (11/11) (1985-3109)	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	<LLD			-	<LLD	0

Environment Samples 1145
Analysis 1297

* 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 - 2019

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	14.8 ± 0.7	15.5 ± 0.5	16.0 ± 0.8	16.4 ± 1.1	15.7 ± 0.7	62.7
	DR-02	13.8 ± 0.6	14.7 ± 0.8	14.4 ± 0.9	15.8 ± 1.0	14.7 ± 0.8	58.7
	DR-03	11.1 ± 0.6	11.8 ± 0.5	12.6 ± 0.6	13.8 ± 1.0	12.3 ± 1.2	49.2
	DR-04	12.2 ± 0.5	12.7 ± 0.7	13.2 ± 0.6	14.0 ± 0.7	13.0 ± 0.7	52.1
	DR-05	12.1 ± 0.6	13.7 ± 0.7	13.9 ± 0.8	14.5 ± 0.8	13.6 ± 1.0	54.2
	DR-06	12.7 ± 0.6	14.2 ± 0.9	13.9 ± 0.5	15.6 ± 1.0	14.1 ± 1.2	56.4
	DR-07	14.4 ± 0.7	15.5 ± 0.7	15.6 ± 0.8	16.6 ± 0.8	15.5 ± 0.9	62.1
	DR-08	11.1 ± 0.6	11.7 ± 0.8	11.9 ± 0.6	13.0 ± 0.7	11.9 ± 0.8	47.6
	DR-09	12.3 ± 0.6	13.4 ± 0.7	13.3 ± 0.6	14.5 ± 0.9	13.4 ± 0.9	53.5
	DR-10	12.4 ± 0.5	13.3 ± 0.5	13.3 ± 0.7	13.9 ± 0.7	13.2 ± 0.6	53.0
	DR-11	9.9 ± 0.7	10.7 ± 0.6	10.5 ± 0.6	11.6 ± 0.5	10.7 ± 0.7	42.8
	DR-12	14.5 ± 0.6	15.7 ± 1.0	15.0 ± 0.6	16.2 ± 0.8	15.3 ± 0.7	61.4
	DR-13	14.8 ± 0.6	15.4 ± 0.4	15.6 ± 0.9	17.1 ± 0.9	15.7 ± 1.0	62.9
	DR-14	12.2 ± 0.4	12.7 ± 0.4	12.6 ± 0.5	13.7 ± 0.8	12.8 ± 0.6	51.3
	DR-15	12.3 ± 0.5	12.7 ± 0.4	12.6 ± 0.5	13.7 ± 0.7	12.8 ± 0.6	51.3
	DR-16	13.4 ± 0.5	14.1 ± 0.6	14.3 ± 0.5	15.1 ± 0.7	14.2 ± 0.7	56.8
	DR-17	13.5 ± 0.5	14.5 ± 0.5	14.4 ± 0.7	14.2 ± 1.1	14.2 ± 0.5	56.6
	DR-18	13.3 ± 0.6	13.7 ± 0.5	14.0 ± 0.5	15.1 ± 0.7	14.0 ± 0.8	56.1
	DR-19	13.4 ± 0.5	14.1 ± 0.6	14.7 ± 0.6	15.0 ± 0.6	14.3 ± 0.7	57.2
	DR-20	12.9 ± 0.7	13.3 ± 0.6	14.0 ± 0.5	14.5 ± 0.8	13.7 ± 0.7	54.7
	DR-21	13.1 ± 0.6	13.7 ± 0.4	14.1 ± 0.7	15.2 ± 0.7	14.0 ± 0.9	56.1
	DR-22	10.5 ± 0.4	11.2 ± 0.5	10.9 ± 0.5	12.2 ± 0.7	11.2 ± 0.7	44.8
	DR-23	12.7 ± 0.6	13.7 ± 0.4	13.6 ± 0.7	14.5 ± 0.8	13.6 ± 0.7	54.4
	DR-24	13.8 ± 0.6	14.2 ± 0.7	14.5 ± 0.8	15.5 ± 0.7	14.5 ± 0.7	58.0
	DR-25	11.2 ± 0.5	11.8 ± 0.4	11.6 ± 0.5	12.8 ± 0.7	11.8 ± 0.7	47.3
	DR-26	12.8 ± 0.7	13.7 ± 0.5	12.9 ± 0.7	14.3 ± 1.0	13.4 ± 0.7	53.6
	DR-27	12.6 ± 0.5	13.3 ± 0.4	12.7 ± 0.9	13.7 ± 0.7	13.1 ± 0.5	52.3
	DR-28	14.5 ± 0.9	15.2 ± 0.6	15.0 ± 0.6	16.2 ± 0.8	15.2 ± 0.7	60.9
	DR-29	12.7 ± 0.7	13.6 ± 0.5	14.1 ± 0.6	14.5 ± 0.7	13.7 ± 0.8	54.9
	DR-30	13.6 ± 0.5	14.2 ± 0.4	14.0 ± 0.7	14.5 ± 0.7	14.1 ± 0.4	56.2
	DR-31	14.9 ± 0.6	15.7 ± 0.4	16.5 ± 0.7	16.8 ± 0.7	16.0 ± 0.8	64.0
	DR-32	15.1 ± 0.8	16.2 ± 0.9	15.9 ± 0.8	16.1 ± 0.8	15.8 ± 0.5	63.3
	DR-33	12.3 ± 0.7	13.3 ± 0.7	13.1 ± 0.6	14.1 ± 0.9	13.2 ± 0.7	52.7
	DR-34	12.4 ± 0.7	13.0 ± 0.4	12.9 ± 0.7	13.4 ± 0.8	12.9 ± 0.4	51.8
	DR-35	13.2 ± 0.7	13.9 ± 0.6	12.9 ± 0.5	14.2 ± 0.9	13.5 ± 0.6	54.1
	DR-36	13.7 ± 0.6	14.4 ± 0.6	14.3 ± 0.8	15.1 ± 0.7	14.3 ± 0.6	57.4
	DR-37	13.0 ± 0.5	13.9 ± 0.4	13.4 ± 0.7	14.5 ± 1.0	13.7 ± 0.7	54.8
	DR-38	11.9 ± 0.7	12.6 ± 0.5	12.3 ± 0.6	13.2 ± 0.5	12.5 ± 0.5	49.9
	DR-39	14.5 ± 0.6	15.1 ± 0.4	14.7 ± 0.7	15.0 ± 0.8	14.8 ± 0.3	59.4
	DR-40*	14.4 ± 0.5	15.7 ± 0.9	14.7 ± 0.6	15.4 ± 0.8	15.0 ± 0.6	60.1
	DR-41	12.5 ± 0.4	13.2 ± 0.7	13.1 ± 0.8	13.5 ± 0.8	13.1 ± 0.4	52.3
AVERAGE (Indicator Locations)		12.9 ± 1.2	13.7 ± 1.3	13.7 ± 1.3	14.6 ± 1.2	13.7 ± 1.2	55.0

* Control location

INDIAN POINT ENERGY CENTER

TABLE B-4

DIRECT RADIATION, 2010 THROUGH 2019 DATA

mR per Year

Station Number	Mean (2010-2018)	Standard Deviation (2010-2018)	Minimum Value (2010-2018)	Maximum Value (2010-2018)	2019 Annual Total
DR-01	61.4	3.3	55.6	65.6	62.7
DR-02	58.0	1.7	55.9	60.4	58.7
DR-03	46.2	4.7	35.0	50.8	49.2
DR-04	53.3	0.9	52.2	54.8	52.1
DR-05	55.0	1.7	53.3	58.2	54.2
DR-06	56.1	1.4	54.7	58.0	56.4
DR-07	62.7	1.5	60.7	64.6	62.1
DR-08	47.0	1.4	45.1	48.9	47.6
DR-09	52.8	2.1	50.0	55.8	53.5
DR-10	57.5	4.5	54.4	67.7	53.0
DR-11	43.3	1.1	41.4	44.6	42.8
DR-12	60.5	4.5	49.2	64.8	61.4
DR-13	65.7	2.6	62.3	70.6	62.9
DR-14	52.5	1.4	50.5	54.1	51.3
DR-15	52.5	1.4	50.3	54.1	51.3
DR-16	57.5	1.6	55.1	59.3	56.8
DR-17	58.1	1.7	55.6	60.1	56.6
DR-18	56.6	1.5	54.4	59.1	56.1
DR-19	58.7	1.5	55.9	60.4	57.2
DR-20	55.2	1.5	53.0	57.5	54.7
DR-21	54.9	2.4	51.9	58.4	56.1
DR-22	45.1	1.7	42.6	47.7	44.8
DR-23	55.7	1.2	53.6	57.4	54.4
DR-24	58.2	1.6	55.8	60.2	58.0
DR-25	48.7	1.4	45.7	50.5	47.3
DR-26	55.6	1.3	53.0	57.4	53.6
DR-27	54.3	1.5	51.5	56.5	52.3
DR-28	73.2	10.8	51.3	80.6	60.9
DR-29	56.5	1.1	54.8	58.3	54.9
DR-30	57.7	2.1	54.7	61.9	56.2
DR-31	65.0	1.9	61.5	67.4	64.0
DR-32	52.5	2.1	48.7	55.4	63.3
DR-33	53.9	1.1	52.3	55.6	52.7
DR-34	52.2	1.9	50.2	55.0	51.8
DR-35	52.4	2.6	49.9	56.3	54.1
DR-36	58.2	1.7	55.9	60.2	57.4
DR-37	55.0	1.4	53.3	57.0	54.8
DR-38	48.6	1.5	46.6	50.9	49.9
DR-39	58.2	2.3	54.8	61.7	59.4
DR-40*	56.9	4.6	49.3	62.4	60.1
DR-41	51.7	1.6	49.7	53.9	52.3
AVERAGE (Indicator Locations)	55.5				55.0

* Control location

INDIAN POINT ENERGY CENTER

TABLE B-5

DIRECT RADIATION, INNER AND OUTER RINGS - 2019

(mR per Year)

Inner Ring ID	Outer Ring ID	Sector	Inner Ring Annual Total	Outer Ring Annual Total
DR-01	DR-17	N	62.65	56.62
DR-02	DR-18	NNE	58.70	56.11
DR-03	DR-19	NE	49.22	57.23
DR-04	DR-20	ENE	52.06	54.67
DR-05	DR-21	E	54.22	56.09
DR-06	DR-22	ESE	56.42	44.83
DR-07	DR-23	SE	62.10	54.44
DR-08	DR-24	SSE	47.62	58.05
DR-09	DR-25	S	53.49	47.27
DR-10	DR-26	SSW	52.96	53.57
DR-11	DR-27	SW	42.79	52.34
DR-12	DR-28	WSW	61.38	60.87
DR-13	DR-29	W	62.92	54.88
DR-14	DR-30	WNW	51.26	56.23
DR-15	DR-31	NW	51.27	63.97
DR-16	DR-32	NNW	56.83	63.33
		Average	54.74	55.66

INDIAN POINT ENERGY CENTER

TABLE B-6

GROSS BETA ACTIVITY IN AIRBORNE PARTICULATE SAMPLES - 2019

pCi/m^3 ± 2 Sigma

PERIOD ENDING	Algonquin 4	NYU Tower 5	Roseton 23*	Croton Point 27	Grassy Point 29	Peekskill 44	Training Building 94	Met Tower 95
01/07/19	0.014 ± 0.002	0.015 ± 0.002	0.013 ± 0.002	0.013 ± 0.002	0.013 ± 0.002	0.015 ± 0.002	0.013 ± 0.002	0.015 ± 0.002
01/14/19	0.009 ± 0.002	0.010 ± 0.002	0.011 ± 0.002	0.011 ± 0.002	0.009 ± 0.002	0.011 ± 0.002	0.011 ± 0.002	0.009 ± 0.002
01/22/19	0.010 ± 0.002	0.010 ± 0.002	0.012 ± 0.002	0.011 ± 0.002	0.013 ± 0.002	0.011 ± 0.002	0.012 ± 0.002	0.012 ± 0.002
01/28/19	0.015 ± 0.003	0.012 ± 0.002	0.011 ± 0.002	0.011 ± 0.002	0.013 ± 0.003	0.014 ± 0.003	0.014 ± 0.003	0.011 ± 0.002
02/04/19	0.016 ± 0.003	0.016 ± 0.003	0.017 ± 0.003	0.017 ± 0.003	0.014 ± 0.003	0.015 ± 0.003	0.017 ± 0.003	0.015 ± 0.002
02/11/19	0.015 ± 0.003	0.012 ± 0.002	0.012 ± 0.002	0.014 ± 0.003	0.013 ± 0.002	0.012 ± 0.002	0.012 ± 0.002	0.014 ± 0.002
02/19/19	0.014 ± 0.002	0.014 ± 0.002	0.015 ± 0.002	0.014 ± 0.002	0.013 ± 0.002	0.013 ± 0.002	0.016 ± 0.002	0.014 ± 0.002
02/25/19	0.013 ± 0.003	0.012 ± 0.002	0.015 ± 0.003	0.013 ± 0.003	0.014 ± 0.003	0.015 ± 0.003	0.013 ± 0.003	0.015 ± 0.003
03/04/19	0.016 ± 0.003	0.016 ± 0.002	0.016 ± 0.003	0.014 ± 0.002	0.015 ± 0.002	0.015 ± 0.002	0.015 ± 0.003	0.016 ± 0.002
03/11/19	0.016 ± 0.002	0.013 ± 0.002	0.014 ± 0.002	0.015 ± 0.002	0.017 ± 0.003	0.013 ± 0.002	0.013 ± 0.002	0.014 ± 0.002
03/18/19	0.016 ± 0.003	0.018 ± 0.003	0.020 ± 0.003	0.019 ± 0.003	0.019 ± 0.003	0.017 ± 0.003	0.017 ± 0.002	0.020 ± 0.003
03/25/19	0.014 ± 0.002	0.014 ± 0.002	0.010 ± 0.002	0.009 ± 0.002	0.010 ± 0.002	0.011 ± 0.002	0.012 ± 0.002	0.010 ± 0.002
04/02/19	0.013 ± 0.002	0.012 ± 0.002	0.010 ± 0.002	0.011 ± 0.002	0.008 ± 0.002	0.011 ± 0.002	0.012 ± 0.002	0.011 ± 0.002
04/08/19	0.012 ± 0.002	0.011 ± 0.002	0.012 ± 0.002	0.013 ± 0.002	0.014 ± 0.003	0.012 ± 0.003	0.013 ± 0.002	0.012 ± 0.002
04/15/19	0.009 ± 0.002	0.010 ± 0.002	0.009 ± 0.002	0.006 ± 0.002	0.009 ± 0.002	0.008 ± 0.002	0.009 ± 0.002	0.008 ± 0.002
04/22/19	0.009 ± 0.002	0.012 ± 0.002	0.007 ± 0.002	0.009 ± 0.002	0.010 ± 0.002	0.010 ± 0.002	0.009 ± 0.002	0.009 ± 0.002
04/29/19	0.007 ± 0.002	0.007 ± 0.002	0.009 ± 0.002	0.007 ± 0.002	0.008 ± 0.002	0.007 ± 0.002	0.009 ± 0.002	0.009 ± 0.002
05/06/19	0.007 ± 0.002	0.011 ± 0.002	0.008 ± 0.002	0.009 ± 0.002	0.008 ± 0.002	0.008 ± 0.002	0.008 ± 0.002	0.010 ± 0.002
05/13/19	0.010 ± 0.002	0.011 ± 0.002	0.009 ± 0.002	0.008 ± 0.002	0.011 ± 0.002	0.010 ± 0.002	0.013 ± 0.002	0.011 ± 0.002
05/20/19	0.011 ± 0.002	0.011 ± 0.002	0.011 ± 0.002	0.011 ± 0.002	0.011 ± 0.002	0.011 ± 0.002	0.011 ± 0.002	0.013 ± 0.002
05/28/19	0.007 ± 0.002	0.008 ± 0.002	0.005 ± 0.002	0.007 ± 0.002	0.007 ± 0.002	0.009 ± 0.002	0.007 ± 0.002	0.007 ± 0.002
06/04/19	0.009 ± 0.002	0.011 ± 0.002	0.007 ± 0.002	0.009 ± 0.002	0.010 ± 0.002	0.009 ± 0.002	0.006 ± 0.004	0.009 ± 0.002
06/10/19	0.011 ± 0.003	0.010 ± 0.003	0.013 ± 0.003	0.010 ± 0.003	0.012 ± 0.003	0.011 ± 0.003	0.010 ± 0.003	0.011 ± 0.003
06/17/19	0.011 ± 0.002	0.010 ± 0.002	0.010 ± 0.002	0.011 ± 0.002	0.011 ± 0.002	0.011 ± 0.002	0.009 ± 0.002	0.010 ± 0.002
06/25/19	0.007 ± 0.002	0.008 ± 0.002	0.007 ± 0.002	0.009 ± 0.002	0.010 ± 0.002	0.009 ± 0.002	0.007 ± 0.002	0.009 ± 0.002

*Control Location

INDIAN POINT ENERGY CENTER

TABLE B-6

GROSS BETA ACTIVITY IN AIRBORNE PARTICULATE SAMPLES - 2019

pCi/m^3 ± 2 Sigma

PERIOD ENDING	Algonquin 4	NYU Tower 5	Roseton 23*	Croton Point 27	Grassy Point 29	Peekskill 44	Training Building 94	Met Tower 95
07/01/19	0.010 ± 0.002	0.012 ± 0.002	0.010 ± 0.002	0.012 ± 0.002	0.011 ± 0.002	0.012 ± 0.002	0.011 ± 0.002	0.012 ± 0.002
07/08/19	0.014 ± 0.002	0.014 ± 0.002	0.012 ± 0.002	0.013 ± 0.002	0.013 ± 0.002	0.015 ± 0.002	0.013 ± 0.002	0.012 ± 0.002
07/15/19	0.012 ± 0.002	0.012 ± 0.002	0.012 ± 0.002	0.015 ± 0.003	0.013 ± 0.002	0.014 ± 0.002	0.013 ± 0.002	0.011 ± 0.002
07/22/19	0.013 ± 0.002	0.015 ± 0.002	0.013 ± 0.002	0.013 ± 0.002	0.013 ± 0.002	0.013 ± 0.002	0.013 ± 0.002	0.013 ± 0.002
07/29/19	0.014 ± 0.002	0.012 ± 0.002	0.013 ± 0.002	0.014 ± 0.002	0.013 ± 0.002	0.011 ± 0.002	0.013 ± 0.002	0.013 ± 0.002
08/05/19	0.020 ± 0.003	0.021 ± 0.003	0.017 ± 0.003	0.020 ± 0.003	0.022 ± 0.003	0.019 ± 0.003	0.019 ± 0.003	0.020 ± 0.003
08/12/19	0.012 ± 0.002	0.013 ± 0.002	0.014 ± 0.003	0.012 ± 0.002	0.013 ± 0.003	0.015 ± 0.003	0.013 ± 0.003	0.010 ± 0.002
08/20/19	0.019 ± 0.003	0.019 ± 0.003	0.016 ± 0.002	0.018 ± 0.003	0.018 ± 0.002	0.016 ± 0.002	0.017 ± 0.002	0.018 ± 0.002
08/26/19	0.013 ± 0.003	0.014 ± 0.003	0.013 ± 0.003	0.014 ± 0.003	0.011 ± 0.003	0.014 ± 0.003	0.013 ± 0.003	0.013 ± 0.003
09/03/19	0.012 ± 0.002	0.014 ± 0.002	0.013 ± 0.002	0.010 ± 0.002	0.012 ± 0.002	0.010 ± 0.002	0.009 ± 0.002	0.011 ± 0.002
09/09/19	0.011 ± 0.003	0.011 ± 0.003	0.012 ± 0.003	0.011 ± 0.003	0.011 ± 0.003	0.012 ± 0.003	0.012 ± 0.003	0.011 ± 0.003
09/16/19	0.013 ± 0.002	0.015 ± 0.003	0.016 ± 0.003	0.014 ± 0.002	0.017 ± 0.003	0.015 ± 0.003	0.014 ± 0.002	0.015 ± 0.003
09/23/19	0.016 ± 0.003	0.013 ± 0.002	0.016 ± 0.003	0.016 ± 0.003	0.016 ± 0.003	0.015 ± 0.002	0.014 ± 0.002	0.016 ± 0.003
09/30/19	0.017 ± 0.002	0.019 ± 0.003	0.013 ± 0.002	0.015 ± 0.002	0.017 ± 0.002	0.016 ± 0.003	0.016 ± 0.002	0.015 ± 0.002
10/07/19	0.009 ± 0.002	0.011 ± 0.002	0.012 ± 0.002	0.010 ± 0.002	0.012 ± 0.002	0.013 ± 0.002	0.012 ± 0.002	0.009 ± 0.002
10/15/19	0.015 ± 0.002	0.014 ± 0.002	0.013 ± 0.002	0.014 ± 0.002	0.016 ± 0.002	0.014 ± 0.002	0.016 ± 0.002	0.014 ± 0.002
10/21/19	0.010 ± 0.002	0.011 ± 0.002	0.011 ± 0.002	0.008 ± 0.002	0.012 ± 0.002	0.010 ± 0.002	0.009 ± 0.002	0.010 ± 0.002
10/28/19	0.011 ± 0.002	0.013 ± 0.002	0.011 ± 0.002	0.011 ± 0.002	0.015 ± 0.002	0.013 ± 0.002	0.013 ± 0.002	0.013 ± 0.002
11/04/19	0.007 ± 0.002	0.006 ± 0.002	0.007 ± 0.002	0.006 ± 0.002	0.007 ± 0.002	0.007 ± 0.002	0.006 ± 0.002	0.007 ± 0.002
11/12/19	0.015 ± 0.002	0.012 ± 0.002	0.012 ± 0.002	0.013 ± 0.002	0.011 ± 0.002	0.012 ± 0.002	0.013 ± 0.002	0.013 ± 0.002
11/18/19	0.012 ± 0.002	0.010 ± 0.002	0.014 ± 0.003	0.012 ± 0.003	0.013 ± 0.002	0.013 ± 0.003	0.012 ± 0.003	0.012 ± 0.002
11/25/19	0.012 ± 0.002	0.011 ± 0.002	0.009 ± 0.002	0.010 ± 0.002	0.011 ± 0.002	0.012 ± 0.002	0.010 ± 0.002	0.010 ± 0.002
12/02/19	0.011 ± 0.002	0.013 ± 0.002	0.010 ± 0.002	0.010 ± 0.002	0.011 ± 0.002	0.012 ± 0.002	0.012 ± 0.002	0.011 ± 0.002
12/09/19	0.011 ± 0.002	0.009 ± 0.002	0.013 ± 0.003	0.010 ± 0.002	0.012 ± 0.002	0.009 ± 0.002	0.008 ± 0.002	0.009 ± 0.002
12/16/19	0.010 ± 0.002	0.010 ± 0.002	0.009 ± 0.002	0.011 ± 0.002	0.012 ± 0.002	0.010 ± 0.002	0.009 ± 0.002	0.008 ± 0.002
12/23/19	0.019 ± 0.003	0.020 ± 0.003	0.020 ± 0.003	0.019 ± 0.003	0.018 ± 0.003	0.017 ± 0.003	0.019 ± 0.003	0.020 ± 0.003
12/30/19	0.019 ± 0.003	0.020 ± 0.003	0.016 ± 0.002	0.020 ± 0.003	0.021 ± 0.003	0.019 ± 0.003	0.021 ± 0.003	0.018 ± 0.003

*Control Location

INDIAN POINT ENERGY CENTER

TABLE B-7

IODINE-131 ACTIVITY IN AIRBORNE CHARCOAL SAMPLES - 2019

pCi/m^3 ± 2 Sigma

PERIOD ENDING	Algonquin 4	NYU Tower 5	Roseton 23*	Croton Point 27	Grassy Point 29	Peekskill 44	Training Building 94	Met Tower 95
01/07/19	< 0.023	< 0.024	< 0.039	< 0.022	< 0.039	< 0.041	< 0.026	< 0.038
01/14/19	< 0.037	< 0.035	< 0.045	< 0.038	< 0.044	< 0.046	< 0.038	< 0.043
01/22/19	< 0.021	< 0.019	< 0.028	< 0.021	< 0.027	< 0.029	< 0.021	< 0.027
01/28/19	< 0.034	< 0.030	< 0.027	< 0.032	< 0.026	< 0.027	< 0.034	< 0.027
02/04/19	< 0.037	< 0.014	< 0.019	< 0.036	< 0.019	< 0.019	< 0.037	< 0.019
02/11/19	< 0.023	< 0.021	< 0.020	< 0.023	< 0.019	< 0.020	< 0.024	< 0.019
02/19/19	< 0.023	< 0.021	< 0.032	< 0.022	< 0.013	< 0.032	< 0.023	< 0.030
02/25/19	< 0.026	< 0.019	< 0.045	< 0.025	< 0.035	< 0.036	< 0.026	< 0.035
03/04/19	< 0.039	< 0.033	< 0.025	< 0.036	< 0.023	< 0.023	< 0.037	< 0.022
03/11/19	< 0.036	< 0.033	< 0.033	< 0.036	< 0.033	< 0.014	< 0.036	< 0.031
03/18/19	< 0.025	< 0.009	< 0.022	< 0.024	< 0.022	< 0.022	< 0.023	< 0.022
03/25/19	< 0.020	< 0.019	< 0.019	< 0.021	< 0.015	< 0.018	< 0.018	< 0.017
04/02/19	< 0.023	< 0.021	< 0.027	< 0.021	< 0.026	< 0.026	< 0.021	< 0.025
04/08/19	< 0.021	< 0.021	< 0.014	< 0.021	< 0.034	< 0.037	< 0.022	< 0.034
04/15/19	< 0.051	< 0.051	< 0.033	< 0.051	< 0.035	< 0.034	< 0.053	< 0.034
04/22/19	< 0.020	< 0.020	< 0.020	< 0.020	< 0.021	< 0.020	< 0.020	< 0.021
04/29/19	< 0.010	< 0.025	< 0.017	< 0.025	< 0.019	< 0.018	< 0.025	< 0.017
05/06/19	< 0.023	< 0.023	< 0.011	< 0.023	< 0.012	< 0.011	< 0.024	< 0.012
05/13/19	< 0.025	< 0.026	< 0.021	< 0.026	< 0.022	< 0.021	< 0.026	< 0.019
05/20/19	< 0.013	< 0.013	< 0.019	< 0.013	< 0.020	< 0.019	< 0.014	< 0.019
05/28/19	< 0.032	< 0.033	< 0.022	< 0.033	< 0.022	< 0.024	< 0.035	< 0.021
06/04/19	< 0.019	< 0.019	< 0.030	< 0.020	< 0.030	< 0.029	< 0.044	< 0.030
06/10/19	< 0.031	< 0.032	< 0.019	< 0.032	< 0.018	< 0.017	< 0.033	< 0.013
06/17/19	< 0.028	< 0.029	< 0.023	< 0.030	< 0.024	< 0.023	< 0.030	< 0.022
06/25/19	< 0.011	< 0.011	< 0.019	< 0.011	< 0.021	< 0.019	< 0.010	< 0.019

*Control Location

INDIAN POINT ENERGY CENTER

TABLE B-7

IODINE-131 ACTIVITY IN AIRBORNE CHARCOAL SAMPLES - 2019

pCi/m^3 ± 2 Sigma

PERIOD ENDING	Algonquin 4	NYU Tower 5	Roseton 23*	Croton Point 27	Grassy Point 29	Peekskill 44	Training Building 94	Met Tower 95
07/01/19	< 0.010	< 0.010	< 0.015	< 0.010	< 0.015	< 0.015	< 0.010	< 0.008
07/08/19	< 0.019	< 0.019	< 0.028	< 0.019	< 0.028	< 0.027	< 0.019	< 0.028
07/15/19	< 0.012	< 0.012	< 0.015	< 0.013	< 0.015	< 0.015	< 0.012	< 0.014
07/22/19	< 0.028	< 0.029	< 0.018	< 0.030	< 0.018	< 0.015	< 0.029	< 0.017
07/29/19	< 0.026	< 0.026	< 0.030	< 0.026	< 0.030	< 0.030	< 0.026	< 0.029
08/05/19	< 0.025	< 0.026	< 0.024	< 0.026	< 0.025	< 0.024	< 0.026	< 0.013
08/12/19	< 0.023	< 0.023	< 0.029	< 0.024	< 0.029	< 0.030	< 0.024	< 0.028
08/20/19	< 0.026	< 0.026	< 0.020	< 0.026	< 0.022	< 0.022	< 0.024	< 0.023
08/26/19	< 0.023	< 0.022	< 0.012	< 0.022	< 0.013	< 0.012	< 0.021	< 0.010
09/03/19	< 0.029	< 0.027	< 0.024	< 0.028	< 0.013	< 0.025	< 0.027	< 0.009
09/09/19	< 0.032	< 0.030	< 0.027	< 0.030	< 0.025	< 0.026	< 0.029	< 0.013
09/16/19	< 0.020	< 0.020	< 0.017	< 0.020	< 0.016	< 0.017	< 0.020	< 0.016
09/23/19	< 0.014	< 0.014	< 0.023	< 0.014	< 0.023	< 0.023	< 0.014	< 0.023
09/30/19	< 0.025	< 0.026	< 0.018	< 0.026	< 0.017	< 0.018	< 0.026	< 0.017
10/07/19	< 0.033	< 0.033	< 0.021	< 0.033	< 0.019	< 0.010	< 0.014	< 0.032
10/15/19	< 0.017	< 0.016	< 0.025	< 0.017	< 0.025	< 0.026	< 0.017	< 0.025
10/21/19	< 0.019	< 0.018	< 0.031	< 0.018	< 0.031	< 0.033	< 0.019	< 0.032
10/28/19	< 0.026	< 0.026	< 0.026	< 0.027	< 0.025	< 0.027	< 0.028	< 0.025
11/04/19	< 0.028	< 0.027	< 0.020	< 0.027	< 0.018	< 0.020	< 0.029	< 0.018
11/12/19	< 0.062	< 0.062	< 0.020	< 0.064	< 0.019	< 0.021	< 0.066	< 0.019
11/18/19	< 0.018	< 0.019	< 0.024	< 0.019	< 0.023	< 0.022	< 0.020	< 0.023
11/25/19	< 0.023	< 0.023	< 0.024	< 0.023	< 0.022	< 0.022	< 0.025	< 0.023
12/02/19	< 0.021	< 0.018	< 0.030	< 0.021	< 0.027	< 0.027	< 0.021	< 0.021
12/09/19	< 0.014	< 0.015	< 0.012	< 0.014	< 0.010	< 0.011	< 0.014	< 0.009
12/16/19	< 0.018	< 0.019	< 0.016	< 0.019	< 0.015	< 0.016	< 0.019	< 0.016
12/23/19	< 0.011	< 0.011	< 0.011	< 0.011	< 0.008	< 0.010	< 0.011	< 0.010
12/30/19	< 0.014	< 0.006	< 0.009	< 0.014	< 0.008	< 0.007	< 0.014	< 0.013

*Control Location

INDIAN POINT ENERGY CENTER

TABLE B-8

GAMMA EMITTERS IN AIRBORNE PARTICULATE SAMPLES - 2019

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	124 ± 22	108 ± 19	127 ± 27	90 ± 19	102 ± 18	112 ± 28	113 ± 19	89 ± 21
K-40	< 25	< 19	< 26	< 29	< 14	< 15	< 16	< 17
Mn-54	< 2	< 1	< 2	< 1	< 1	< 2	< 1	< 1
Co-58	< 3	< 1	< 2	< 2	< 2	< 3	< 2	< 2
Fe-59	< 7	< 4	< 5	< 7	< 5	< 8	< 3	< 5
Co-60	< 2	< 1	< 1	< 1	< 1	< 2	< 1	< 1
Zn-65	< 4	< 3	< 5	< 3	< 3	< 4	< 3	< 3
Nb-95	< 3	< 2	< 3	< 2	< 2	< 3	< 2	< 2
Zr-95	< 4	< 3	< 4	< 3	< 2	< 5	< 3	< 2
Ru-103	< 3	< 2	< 3	< 3	< 2	< 3	< 2	< 2
Ru-106	< 14	< 7	< 12	< 13	< 9	< 15	< 8	< 9
I-131	< 265	< 158	< 203	< 172	< 158	< 249	< 134	< 169
Cs-134	< 2	< 1	< 2	< 1	< 1	< 2	< 1	< 1
Cs-137	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Ba-140	< 112	< 78	< 132	< 77	< 65	< 115	< 72	< 89
La-140	< 43	< 19	< 38	< 46	< 33	< 62	< 38	< 29
Ce-141	< 7	< 4	< 5	< 4	< 3	< 5	< 3	< 3
Ce-144	< 9	< 6	< 6	< 5	< 4	< 7	< 5	< 4
Ra-226	< 28	< 19	< 22	< 21	< 16	< 24	< 15	< 14
Ac-228	< 6	< 4	< 5	< 5	< 3	< 6	< 4	< 3
Th-228	< 3	< 2	< 2	< 2	< 2	< 2	< 2	< 1

INDIAN POINT ENERGY CENTER

TABLE B-8

GAMMA EMITTERS IN AIRBORNE PARTICULATE SAMPLES - 2019

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	123 ± 20	109 ± 19	128 ± 23	76 ± 15	112 ± 23	123 ± 23	121 ± 23	98 ± 21
K-40	< 16	< 25	< 26	< 19	< 23	< 16	< 22	< 19
Mn-54	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Co-58	< 2	< 2	< 3	< 1	< 2	< 2	< 2	< 2
Fe-59	< 6	< 6	< 7	< 6	< 4	< 7	< 5	< 6
Co-60	< 1	< 1	< 2	< 1	< 1	< 1	< 2	< 2
Zn-65	< 2	< 3	< 3	< 2	< 3	< 3	< 3	< 3
Nb-95	< 2	< 2	< 3	< 2	< 2	< 2	< 2	< 2
Zr-95	< 4	< 3	< 4	< 3	< 4	< 3	< 3	< 3
Ru-103	< 3	< 3	< 3	< 3	< 3	< 2	< 3	< 3
Ru-106	< 9	< 9	< 13	< 9	< 14	< 9	< 12	< 13
I-131	< 184	< 158	< 189	< 121	< 216	< 175	< 177	< 180
Cs-134	< 1	< 1	< 1	< 1	< 2	< 1	< 1	< 1
Cs-137	< 1	< 1	< 2	< 1	< 1	< 1	< 1	< 1
Ba-140	< 83	< 96	< 113	< 57	< 86	< 93	< 83	< 97
La-140	< 34	< 48	< 42	< 20	< 42	< 34	< 42	< 42
Ce-141	< 4	< 4	< 4	< 3	< 4	< 4	< 4	< 4
Ce-144	< 6	< 5	< 5	< 5	< 5	< 4	< 6	< 6
Ra-226	< 19	< 19	< 24	< 18	< 20	< 19	< 21	< 21
Ac-228	< 3	< 5	< 6	< 2	< 5	< 4	< 6	< 4
Th-228	< 1	< 2	< 2	< 2	< 2	< 2	< 2	< 2

* Control Location

INDIAN POINT ENERGY CENTER

TABLE B-8

GAMMA EMITTERS IN AIRBORNE PARTICULATE SAMPLES - 2019

10^{-3} pCi/m^3 ± 2 Sigma

	Grassy Point 29				Peekskill 44			
DATE	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
Be-7	116 ± 22	106 ± 21	151 ± 22	84 ± 18	145 ± 28	132 ± 22	111 ± 23	78 ± 18
K-40	< 19	< 9	< 21	< 13	< 28	< 21	< 21	< 25
Mn-54	< 1	< 1	< 1	< 1	< 2	< 1	< 1	< 1
Co-58	< 3	< 2	< 2	< 1	< 3	< 2	< 2	< 1
Fe-59	< 5	< 7	< 6	< 4	< 7	< 4	< 5	< 4
Co-60	< 2	< 0	< 1	< 1	< 2	< 1	< 1	< 1
Zn-65	< 3	< 3	< 4	< 2	< 4	< 4	< 3	< 2
Nb-95	< 2	< 1	< 2	< 2	< 3	< 2	< 2	< 2
Zr-95	< 4	< 3	< 4	< 3	< 5	< 2	< 4	< 2
Ru-103	< 3	< 3	< 3	< 2	< 4	< 2	< 2	< 2
Ru-106	< 12	< 7	< 10	< 11	< 15	< 11	< 13	< 9
I-131	< 239	< 148	< 218	< 125	< 253	< 145	< 208	< 156
Cs-134	< 2	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Cs-137	< 1	< 1	< 1	< 1	< 2	< 1	< 1	< 1
Ba-140	< 123	< 77	< 102	< 70	< 152	< 76	< 105	< 81
La-140	< 47	< 25	< 43	< 26	< 33	< 32	< 30	< 23
Ce-141	< 5	< 4	< 4	< 3	< 5	< 4	< 5	< 3
Ce-144	< 7	< 6	< 6	< 5	< 6	< 5	< 6	< 4
Ra-226	< 22	< 20	< 21	< 15	< 28	< 19	< 21	< 16
Ac-228	< 4	< 4	< 5	< 4	< 7	< 4	< 5	< 5
Th-228	< 2	< 2	< 2	< 1	< 2	< 2	< 2	< 2

INDIAN POINT ENERGY CENTER

TABLE B-8

GAMMA EMITTERS IN AIRBORNE PARTICULATE SAMPLES - 2019

10^{-3} pCi/m^3 ± 2 Sigma

	Training Building 94				Met Tower 95			
DATE	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
Be-7	111 ± 35	112 ± 20	123 ± 27	103 ± 24	113 ± 20	129 ± 26	130 ± 21	96 ± 17
K-40	< 28	< 18	< 26	< 25	< 16	< 17	< 15	< 14
Mn-54	< 2	< 1	< 2	< 2	< 1	< 1	< 1	< 1
Co-58	< 2	< 2	< 3	< 3	< 2	< 1	< 2	< 2
Fe-59	< 8	< 6	< 6	< 7	< 5	< 4	< 5	< 3
Co-60	< 1	< 1	< 3	< 2	< 1	< 1	< 1	< 1
Zn-65	< 4	< 2	< 10	< 5	< 2	< 3	< 5	< 3
Nb-95	< 3	< 2	< 5	< 3	< 2	< 3	< 3	< 2
Zr-95	< 4	< 4	< 5	< 7	< 2	< 4	< 2	< 3
Ru-103	< 4	< 3	< 4	< 4	< 2	< 3	< 2	< 2
Ru-106	< 15	< 11	< 17	< 17	< 8	< 12	< 12	< 7
I-131	< 268	< 147	< 280	< 237	< 135	< 177	< 143	< 132
Cs-134	< 2	< 1	< 2	< 3	< 1	< 1	< 1	< 1
Cs-137	< 1	< 1	< 2	< 2	< 1	< 1	< 1	< 1
Ba-140	< 153	< 95	< 122	< 131	< 83	< 102	< 89	< 58
La-140	< 46	< 45	< 80	< 60	< 36	< 31	< 23	< 36
Ce-141	< 5	< 3	< 7	< 5	< 3	< 4	< 4	< 3
Ce-144	< 6	< 5	< 9	< 6	< 4	< 6	< 5	< 4
Ra-226	< 28	< 18	< 31	< 26	< 14	< 23	< 19	< 15
Ac-228	< 6	< 4	< 7	< 6	< 3	< 4	< 4	< 3
Th-228	< 2	< 2	< 4	< 2	< 1	< 2	< 2	< 1

INDIAN POINT ENERGY CENTER

TABLE B-9

RADIONUCLIDES IN RAINWATER SAMPLES - 2019

pCi/L ± 2 Sigma

	Roseton 23*				Peekskill 44			
DATE	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
RADIOCHEMICAL								
H-3								
GAMMA								
Be-7								
K-40								
Mn-54								
Co-58								
Fe-59								
Co-60								
Zn-65	Rainwater collection was discontinued in 2019							
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								

* Control Location

INDIAN POINT ENERGY CENTER
TABLE B-10
RADIONUCLIDES IN DRINKING WATER SAMPLES - 2019

pCi/L ± 2 Sigma

Camp Field
7

DATE	01/15/19	02/20/19	03/12/19	04/09/19	05/15/19	06/10/19
RADIOCHEMICAL						
Gr-B	< 2	< 2	< 2	6 ± 2	3 ± 2	< 2
H-3 (a)			< 196			< 195
GAMMA						
Be-7	< 40	< 58	< 57	< 36	< 59	< 51
K-40	< 53	< 113	< 63	< 92	< 125	< 111
Mn-54	< 4	< 6	< 7	< 4	< 6	< 5
Co-58	< 5	< 7	< 5	< 4	< 6	< 7
Fe-59	< 11	< 15	< 16	< 9	< 11	< 14
Co-60	< 6	< 7	< 7	< 4	< 5	< 7
Zn-65	< 8	< 11	< 15	< 9	< 12	< 16
Nb-95	< 5	< 8	< 6	< 5	< 7	< 6
Zr-95	< 8	< 14	< 10	< 8	< 10	< 9
Ru-103	< 5	< 8	< 7	< 4	< 6	< 5
Ru-106	< 47	< 65	< 59	< 43	< 56	< 55
I-131	< 6	< 10	< 12	< 5	< 7	< 7
Cs-134	< 6	< 6	< 7	< 5	< 7	< 7
Cs-137	< 6	< 7	< 7	< 5	< 7	< 7
Ba-140	< 15	< 33	< 29	< 18	< 24	< 26
La-140	< 7	< 7	< 11	< 5	< 7	< 5
Ce-141	< 7	< 10	< 11	< 7	< 12	< 11
Ce-144	< 31	< 44	< 42	< 34	< 48	< 48
Ra-226	< 122	< 136	< 142	< 125	< 134	< 143
Ac-228	< 15	< 24	< 21	< 19	< 23	< 31
Th-228	< 9	< 13	< 11	< 10	< 12	< 13

(a) Quarterly Composite

INDIAN POINT ENERGY CENTER
TABLE B-10
RADIONUCLIDES IN DRINKING WATER SAMPLES - 2019

pCi/L ± 2 Sigma

	Camp Field 7					
DATE	07/11/19	08/14/19	09/05/19	10/15/19	11/13/19	12/10/19
RADIOCHEMICAL						
Gr-B	(b)	3 ± 2	< 2	< 2	2 ± 1	< 2
H-3 (a)			< 188			< 183
GAMMA						
Be-7		< 52	< 46	< 53	< 53	< 52
K-40		< 68	< 109	< 121	< 117	< 129
Mn-54		< 7	< 6	< 6	< 6	< 6
Co-58		< 6	< 6	< 7	< 5	< 7
Fe-59		< 15	< 12	< 13	< 11	< 11
Co-60		< 9	< 6	< 7	< 6	< 6
Zn-65		< 15	< 10	< 15	< 12	< 12
Nb-95		< 7	< 6	< 5	< 6	< 8
Zr-95		< 13	< 10	< 12	< 10	< 12
Ru-103		< 7	< 6	< 5	< 6	< 8
Ru-106		< 62	< 43	< 41	< 59	< 63
I-131		< 10	< 11	< 8	< 7	< 9
Cs-134		< 7	< 7	< 8	< 6	< 7
Cs-137		< 7	< 7	< 6	< 7	< 8
Ba-140		< 32	< 22	< 21	< 20	< 29
La-140		< 11	< 9	< 9	< 7	< 8
Ce-141		< 13	< 10	< 10	< 10	< 12
Ce-144		< 51	< 44	< 38	< 43	< 47
Ra-226		< 200	< 158	< 162	< 149	< 189
Ac-228		< 29	< 25	< 24	< 25	< 28
Th-228		< 13	< 13	< 12	< 13	< 14

(a) Quarterly Composite
(b) Refer deviation table B-1b.

INDIAN POINT ENERGY CENTER

TABLE B-10

RADIONUCLIDES IN DRINKING WATER SAMPLES - 2019

pCi/L ± 2 Sigma

	Croton 8					
DATE	01/15/19	02/20/19	03/12/19	04/09/19	05/15/19	06/10/19
RADIOCHEMICAL						
Gr-B	< 2	< 2	2 ± 1	< 2	< 2	< 2
H-3 (a)			< 196			< 191
GAMMA						
Be-7	< 54	< 54	< 58	< 31	< 25	< 59
K-40	< 102	< 120	< 67	< 33	< 67	< 131
Mn-54	< 7	< 6	< 6	< 4	< 3	< 7
Co-58	< 6	< 7	< 8	< 4	< 3	< 7
Fe-59	< 13	< 14	< 16	< 8	< 6	< 13
Co-60	< 7	< 6	< 7	< 4	< 4	< 8
Zn-65	< 13	< 12	< 12	< 8	< 5	< 15
Nb-95	< 6	< 8	< 6	< 4	< 3	< 8
Zr-95	< 12	< 9	< 12	< 7	< 6	< 10
Ru-103	< 6	< 6	< 7	< 4	< 3	< 7
Ru-106	< 60	< 70	< 71	< 33	< 29	< 68
I-131	< 7	< 10	< 14	< 4	< 4	< 9
Cs-134	< 6	< 5	< 7	< 4	< 3	< 9
Cs-137	< 7	< 6	< 8	< 4	< 3	< 8
Ba-140	< 23	< 29	< 35	< 15	< 12	< 34
La-140	< 8	< 9	< 12	< 4	< 4	< 8
Ce-141	< 10	< 10	< 14	< 6	< 5	< 13
Ce-144	< 45	< 46	< 53	< 28	< 24	< 64
Ra-226	< 144	< 174	< 181	< 100	< 86	< 214
Ac-228	< 27	< 28	< 21	< 16	< 14	< 34
Th-228	< 12	< 13	< 15	< 7	< 6	< 15

(a) Quarterly Composite

INDIAN POINT ENERGY CENTER
TABLE B-10
RADIONUCLIDES IN DRINKING WATER SAMPLES - 2019

pCi/L ± 2 Sigma

	Croton 8					
DATE	07/11/19	08/14/19	09/05/19	10/15/19	11/13/19	12/10/19
RADIOCHEMICAL						
Gr-B	(b)	< 2	< 2	4 ± 2	3 ± 2	< 2
H-3 (a)			< 186			< 179
GAMMA						
Be-7		< 68	< 48	< 81	< 42	< 45
K-40		< 66	< 86	< 131	< 52	< 127
Mn-54		< 6	< 6	< 9	< 4	< 6
Co-58		< 7	< 6	< 9	< 4	< 8
Fe-59		< 16	< 14	< 18	< 9	< 12
Co-60		< 6	< 5	< 12	< 6	< 9
Zn-65		< 12	< 14	< 19	< 10	< 17
Nb-95		< 9	< 6	< 10	< 5	< 6
Zr-95		< 16	< 9	< 17	< 9	< 11
Ru-103		< 9	< 6	< 10	< 5	< 9
Ru-106		< 71	< 65	< 92	< 48	< 54
I-131		< 13	< 10	< 12	< 8	< 9
Cs-134		< 7	< 7	< 11	< 5	< 9
Cs-137		< 9	< 6	< 11	< 4	< 9
Ba-140		< 30	< 26	< 40	< 23	< 27
La-140		< 15	< 5	< 9	< 8	< 9
Ce-141		< 15	< 11	< 17	< 9	< 10
Ce-144		< 59	< 44	< 77	< 35	< 44
Ra-226		< 211	< 165	< 238	< 131	< 182
Ac-228		< 26	< 24	< 36	< 21	< 31
Th-228		< 16	< 11	< 19	< 10	< 13

(a) Quarterly Composite
(b) Refer deviation table B-1b.

INDIAN POINT ENERGY CENTER

TABLE B-11

RADIONUCLIDES IN GROUNDWATER SAMPLES - 2019

pCi/L ± 2 Sigma

	Lafarge Monitoring Well 106	
DATE	05/16/19	10/23/19
RADIOCHEMICAL		
H-3	< 196	< 192
Ni-63	< 30	< 28
Sr-90	< 1	< 1
GAMMA		
Be-7	< 56	< 64
K-40	< 128	< 65
Mn-54	< 5	< 6
Co-58	< 6	< 7
Fe-59	< 13	< 13
Co-60	< 6	< 9
Zn-65	< 13	< 14
Nb-95	< 7	< 7
Zr-95	< 11	< 13
Ru-103	< 7	< 8
Ru-106	< 61	< 55
Cs-134	< 6	< 9
Cs-137	< 7	< 10
Ba-140	< 25	< 35
La-140	< 9	< 11
Ce-141	< 11	< 13
Ce-144	< 45	< 51
Ac-228	< 34	< 32

INDIAN POINT ENERGY CENTER
TABLE B-12
GAMMA EMITTERS IN SOIL SAMPLES - 2019

pCi/kg dry ± 2 Sigma

	Roseton 23*	Training Building 94	Met Tower 95
DATE	09/06/19	09/06/19	09/06/19
Be-7	< 624	< 950	< 595
K-40	17270 ± 1569	14620 ± 2013	11950 ± 1505
Mn-54	< 81	< 73	< 58
Co-58	< 85	< 92	< 54
Fe-59	< 182	< 225	< 154
Co-60	< 89	< 70	< 71
Zn-65	< 197	< 172	< 172
Nb-95	< 93	< 109	< 61
Zr-95	< 145	< 160	< 97
Ru-103	< 78	< 92	< 65
Ru-106	< 660	< 771	< 503
I-131	< 150	< 212	< 125
Cs-134	< 93	< 101	< 65
Cs-137	< 82	445 ± 115	< 70
Ba-140	< 379	< 567	< 313
La-140	< 114	< 113	< 77
Ce-141	< 125	< 154	< 91
Ce-144	< 469	< 564	< 330
Ra-226	< 1823	< 1799	< 1314
Th-228	987 ± 125	571 ± 192	483 ± 92

* Control Location

INDIAN POINT ENERGY CENTER

TABLE B-13

GAMMA EMITTERS IN BROAD LEAF VEGETATION SAMPLES - 2019

pCi/kg wet ± 2 Sigma

	Roseton 23*					
DATE	05/20/19	05/20/19	05/20/19	06/27/19	06/27/19	06/27/19
GAMMA						
Be-7	607 ± 180	1372 ± 227	1483 ± 289	< 291	1524 ± 339	2049 ± 324
K-40	3660 ± 483	4249 ± 513	3009 ± 453	3016 ± 615	8029 ± 888	4475 ± 574
Mn-54	< 22	< 19	< 23	< 33	< 28	< 27
Co-58	< 16	< 22	< 20	< 34	< 25	< 26
Fe-59	< 43	< 50	< 43	< 52	< 50	< 65
Co-60	< 20	< 15	< 21	< 32	< 35	< 33
Zn-65	< 38	< 46	< 47	< 79	< 73	< 66
Nb-95	< 23	< 22	< 24	< 44	< 31	< 31
Zr-95	< 38	< 36	< 43	< 48	< 45	< 46
Ru-103	< 20	< 18	< 23	< 34	< 31	< 26
Ru-106	< 196	< 170	< 181	< 256	< 229	< 287
I-131	< 26	< 33	< 30	< 54	< 34	< 44
Cs-134	< 22	< 26	< 22	< 38	< 32	< 28
Cs-137	< 20	< 23	< 21	< 36	< 23	< 30
Ba-140	< 72	< 86	< 88	< 156	< 102	< 116
La-140	< 24	< 27	< 28	< 44	< 21	< 24
Ce-141	< 33	< 38	< 33	< 52	< 41	< 42
Ce-144	< 142	< 152	< 134	< 223	< 145	< 164
Ra-226	< 516	< 601	< 484	< 722	< 617	< 668
Th-228	< 39	< 39	< 43	< 63	< 50	< 53

* Control Location

INDIAN POINT ENERGY CENTER

TABLE B-13

GAMMA EMITTERS IN BROAD LEAF VEGETATION SAMPLES - 2019

pCi/kg wet ± 2 Sigma

	Roseton 23*					
DATE	07/14/19	07/14/19	07/14/19	08/08/19	08/08/19	08/08/19
GAMMA						
Be-7	680 ± 220	653 ± 200	971 ± 289	2074 ± 318	1172 ± 258	967 ± 267
K-40	3547 ± 625	7127 ± 693	3636 ± 614	7112 ± 775	2482 ± 395	3996 ± 571
Mn-54	< 18	< 23	< 27	< 27	< 23	< 19
Co-58	< 22	< 28	< 28	< 23	< 19	< 24
Fe-59	< 68	< 50	< 64	< 55	< 43	< 57
Co-60	< 21	< 27	< 33	< 30	< 23	< 31
Zn-65	< 65	< 62	< 67	< 56	< 62	< 59
Nb-95	< 30	< 30	< 32	< 23	< 24	< 26
Zr-95	< 48	< 54	< 47	< 37	< 43	< 40
Ru-103	< 23	< 23	< 34	< 25	< 23	< 25
Ru-106	< 240	< 222	< 280	< 231	< 219	< 224
I-131	< 41	< 35	< 46	< 34	< 34	< 34
Cs-134	< 26	< 27	< 37	< 26	< 23	< 29
Cs-137	< 21	< 29	< 32	< 27	< 26	< 25
Ba-140	< 87	< 107	< 145	< 91	< 96	< 96
La-140	< 24	< 35	< 38	< 20	< 30	< 27
Ce-141	< 49	< 41	< 47	< 37	< 42	< 41
Ce-144	< 203	< 160	< 202	< 154	< 173	< 155
Ra-226	< 817	< 549	< 802	< 627	< 615	< 626
Th-228	< 55	< 52	< 59	< 51	< 45	< 51

* Control Location

INDIAN POINT ENERGY CENTER

TABLE B-13

GAMMA EMITTERS IN BROAD LEAF VEGETATION SAMPLES - 2019

pCi/kg wet ± 2 Sigma

	Roseton 23*		
DATE	09/10/19	09/10/19	09/10/19
GAMMA			
Be-7	984 ± 338	722 ± 347	1391 ± 372
K-40	4920 ± 681	4570 ± 781	4572 ± 775
Mn-54	< 31	< 27	< 34
Co-58	< 25	< 25	< 26
Fe-59	< 53	< 67	< 72
Co-60	< 36	< 32	< 38
Zn-65	< 58	< 78	< 84
Nb-95	< 30	< 26	< 37
Zr-95	< 53	< 44	< 47
Ru-103	< 28	< 26	< 31
Ru-106	< 274	< 309	< 296
I-131	< 37	< 38	< 50
Cs-134	< 29	< 31	< 42
Cs-137	< 33	< 24	< 30
Ba-140	< 125	< 127	< 167
La-140	< 40	< 23	< 41
Ce-141	< 49	< 47	< 52
Ce-144	< 196	< 151	< 201
Ra-226	< 720	< 711	< 757
Th-228	< 61	< 50	< 65

* Control Location

INDIAN POINT ENERGY CENTER

TABLE B-13

GAMMA EMITTERS IN BROAD LEAF VEGETATION SAMPLES - 2019

pCi/kg wet ± 2 Sigma

	Training Center 94					
DATE	05/21/19	05/21/19	05/21/19	06/27/19	06/27/19	06/27/19
GAMMA						
Be-7	2187 ± 269	< 204	1943 ± 254	1926 ± 319	< 213	2156 ± 303
K-40	7769 ± 591	6422 ± 671	5450 ± 609	8277 ± 801	1915 ± 523	5565 ± 646
Mn-54	< 23	< 29	< 28	< 32	< 21	< 30
Co-58	< 20	< 21	< 24	< 27	< 23	< 27
Fe-59	< 53	< 40	< 54	< 68	< 56	< 74
Co-60	< 22	< 28	< 25	< 33	< 23	< 33
Zn-65	< 49	< 52	< 57	< 51	< 72	< 81
Nb-95	< 24	< 21	< 26	< 34	< 28	< 37
Zr-95	< 40	< 40	< 31	< 46	< 56	< 48
Ru-103	< 18	< 23	< 24	< 27	< 26	< 27
Ru-106	< 178	< 184	< 197	< 272	< 256	< 266
I-131	< 22	< 25	< 28	< 47	< 42	< 42
Cs-134	< 23	< 22	< 30	< 32	< 31	< 27
Cs-137	< 21	< 21	< 21	< 27	< 29	< 36
Ba-140	< 74	< 81	< 94	< 149	< 115	< 131
La-140	< 25	< 17	< 26	< 27	< 37	< 39
Ce-141	< 31	< 33	< 33	< 46	< 35	< 45
Ce-144	< 136	< 127	< 146	< 201	< 157	< 177
Ra-226	< 516	< 375	< 521	< 699	< 626	< 668
Th-228	< 38	< 43	< 46	< 58	< 40	< 56

INDIAN POINT ENERGY CENTER

TABLE B-13

GAMMA EMITTERS IN BROAD LEAF VEGETATION SAMPLES - 2019

pCi/kg wet ± 2 Sigma

	Training Center 94					
DATE	07/15/19	07/15/19	07/15/19	08/08/19	08/08/19	08/08/19
GAMMA						
Be-7	1484 ± 304	433 ± 156	2031 ± 379	1726 ± 315	1376 ± 274	608 ± 223
K-40	7747 ± 739	8869 ± 540	4359 ± 778	1888 ± 456	5563 ± 637	5922 ± 727
Mn-54	< 28	< 22	< 31	< 21	< 23	< 29
Co-58	< 32	< 22	< 39	< 18	< 20	< 32
Fe-59	< 78	< 50	< 83	< 40	< 50	< 67
Co-60	< 41	< 21	< 36	< 26	< 27	< 22
Zn-65	< 82	< 57	< 48	< 59	< 57	< 59
Nb-95	< 31	< 23	< 31	< 28	< 27	< 29
Zr-95	< 58	< 35	< 70	< 45	< 47	< 48
Ru-103	< 28	< 21	< 27	< 24	< 23	< 27
Ru-106	< 303	< 216	< 280	< 141	< 267	< 259
I-131	< 36	< 28	< 40	< 32	< 36	< 39
Cs-134	< 37	< 26	< 38	< 24	< 24	< 33
Cs-137	< 29	< 23	< 30	< 24	< 27	< 31
Ba-140	< 118	< 91	< 119	< 86	< 124	< 127
La-140	< 17	< 26	< 34	< 28	< 18	< 23
Ce-141	< 45	< 31	< 40	< 38	< 41	< 43
Ce-144	< 171	< 134	< 159	< 148	< 166	< 173
Ra-226	< 668	< 495	< 661	< 621	< 606	< 692
Th-228	< 46	< 35	< 55	< 46	< 51	< 56

INDIAN POINT ENERGY CENTER

TABLE B-13

GAMMA EMITTERS IN BROAD LEAF VEGETATION SAMPLES - 2019

pCi/kg wet ± 2 Sigma

	Training Center 94		
DATE	09/10/19	09/10/19	09/10/19
GAMMA			
Be-7	2298 ± 381	2589 ± 401	1502 ± 357
K-40	5828 ± 728	3634 ± 619	1891 ± 484
Mn-54	< 30	< 31	< 26
Co-58	< 24	< 25	< 33
Fe-59	< 40	< 55	< 58
Co-60	< 31	< 35	< 38
Zn-65	< 61	< 61	< 81
Nb-95	< 28	< 32	< 24
Zr-95	< 45	< 48	< 49
Ru-103	< 25	< 23	< 29
Ru-106	< 170	< 288	< 260
I-131	< 39	< 37	< 46
Cs-134	< 36	< 35	< 28
Cs-137	< 28	< 34	< 25
Ba-140	< 113	< 90	< 99
La-140	< 37	< 33	< 39
Ce-141	< 41	< 47	< 37
Ce-144	< 164	< 182	< 161
Ra-226	< 749	< 712	< 650
Th-228	< 60	< 61	< 52

INDIAN POINT ENERGY CENTER
TABLE B-13
GAMMA EMITTERS IN BROAD LEAF VEGETATION SAMPLES - 2019

pCi/kg wet ± 2 Sigma

	Met Tower 95					
DATE	05/21/19	05/21/19	05/21/19	06/27/19	06/27/19	06/27/19
GAMMA						
Be-7	1263 ± 255	2236 ± 298	716 ± 153	2006 ± 374	3730 ± 513	1207 ± 338
K-40	5995 ± 602	4718 ± 644	4433 ± 484	8288 ± 877	3480 ± 649	5208 ± 803
Mn-54	< 20	< 24	< 21	< 23	< 26	< 29
Co-58	< 20	< 21	< 20	< 27	< 26	< 23
Fe-59	< 45	< 49	< 41	< 84	< 47	< 54
Co-60	< 24	< 25	< 18	< 31	< 39	< 27
Zn-65	< 48	< 46	< 42	< 74	< 80	< 63
Nb-95	< 21	< 19	< 17	< 33	< 26	< 25
Zr-95	< 35	< 27	< 32	< 45	< 59	< 43
Ru-103	< 19	< 20	< 19	< 28	< 27	< 31
Ru-106	< 207	< 176	< 182	< 274	< 294	< 273
I-131	< 25	< 28	< 21	< 37	< 37	< 43
Cs-134	< 24	< 25	< 23	< 32	< 36	< 25
Cs-137	< 24	< 26	< 22	< 29	< 32	< 27
Ba-140	< 83	< 85	< 70	< 129	< 108	< 130
La-140	< 18	< 27	< 16	< 23	< 28	< 31
Ce-141	< 33	< 29	< 37	< 46	< 37	< 44
Ce-144	< 154	< 125	< 163	< 169	< 143	< 170
Ra-226	< 566	< 470	< 545	< 658	< 740	< 762
Th-228	< 40	< 42	< 42	< 55	< 54	< 57

INDIAN POINT ENERGY CENTER

TABLE B-13

GAMMA EMITTERS IN BROAD LEAF VEGETATION SAMPLES - 2019

pCi/kg wet ± 2 Sigma

	Met Tower 95					
DATE	07/15/19	07/15/19	07/15/19	08/08/19	08/08/19	08/08/19
GAMMA						
Be-7	1050 ± 339	1111 ± 301	621 ± 231	1890 ± 294	3190 ± 389	2935 ± 308
K-40	7004 ± 846	4194 ± 790	4425 ± 718	3642 ± 560	3137 ± 535	2901 ± 440
Mn-54	< 37	< 37	< 30	< 30	< 23	< 24
Co-58	< 23	< 36	< 24	< 22	< 25	< 23
Fe-59	< 68	< 68	< 67	< 44	< 47	< 49
Co-60	< 36	< 41	< 26	< 25	< 22	< 32
Zn-65	< 91	< 70	< 78	< 56	< 51	< 56
Nb-95	< 32	< 33	< 33	< 23	< 26	< 25
Zr-95	< 47	< 54	< 33	< 38	< 44	< 45
Ru-103	< 24	< 31	< 27	< 24	< 24	< 25
Ru-106	< 357	< 260	< 341	< 207	< 230	< 221
I-131	< 45	< 43	< 36	< 31	< 31	< 35
Cs-134	< 37	< 51	< 33	< 26	< 26	< 26
Cs-137	< 30	< 36	< 35	< 20	< 26	< 26
Ba-140	< 134	< 133	< 122	< 73	< 110	< 106
La-140	< 34	< 42	< 25	< 33	< 33	< 26
Ce-141	< 51	< 51	< 47	< 36	< 42	< 47
Ce-144	< 219	< 225	< 185	< 123	< 184	< 178
Ra-226	< 809	< 886	< 779	< 600	< 710	< 673
Th-228	< 71	< 67	< 58	< 42	< 54	< 52

INDIAN POINT ENERGY CENTER

TABLE B-13

GAMMA EMITTERS IN BROAD LEAF VEGETATION SAMPLES - 2019

pCi/kg wet ± 2 Sigma

	Met Tower 95		
DATE	09/10/19	09/10/19	09/10/19
GAMMA			
Be-7	1413 ± 383	2444 ± 386	3032 ± 472
K-40	4586 ± 707	5402 ± 621	4416 ± 720
Mn-54	< 36	< 32	< 33
Co-58	< 29	< 29	< 32
Fe-59	< 74	< 62	< 65
Co-60	< 43	< 33	< 32
Zn-65	< 99	< 69	< 85
Nb-95	< 36	< 39	< 29
Zr-95	< 61	< 62	< 46
Ru-103	< 33	< 29	< 24
Ru-106	< 262	< 255	< 251
I-131	< 39	< 57	< 40
Cs-134	< 39	< 28	< 32
Cs-137	< 38	< 33	< 49
Ba-140	< 142	< 154	< 92
La-140	< 32	< 35	< 17
Ce-141	< 49	< 52	< 44
Ce-144	< 211	< 202	< 170
Ra-226	< 715	< 713	< 688
Th-228	< 67	66 ± 39	< 66

INDIAN POINT ENERGY CENTER
TABLE B-14
RADIONUCLIDES IN RIVER WATER SAMPLES - 2019

pCi/L ± 2 Sigma

Plant Inlet Hudson River Intake
9*

DATE	01/29/19	02/26/19	03/26/19	04/30/19	05/29/19	06/26/19
RADIOCHEMICAL						
H-3 (a)			273 ± 135			< 191
GAMMA						
K-40	< 50	< 14	< 13	< 29	< 31	< 34
Mn-54	< 3	< 2	< 2	< 2	< 2	< 2
Co-58	< 3	< 2	< 2	< 2	< 2	< 2
Fe-59	< 9	< 5	< 4	< 5	< 4	< 5
Co-60	< 4	< 2	< 1	< 2	< 2	< 2
Zn-65	< 7	< 4	< 3	< 3	< 3	< 4
Nb-95	< 3	< 2	< 2	< 2	< 2	< 2
Zr-95	< 5	< 4	< 3	< 4	< 3	< 4
Ru-103	< 4	< 2	< 2	< 2	< 2	< 2
Ru-106	< 25	< 16	< 14	< 17	< 15	< 16
I-131	< 14	< 10	< 8	< 12	< 9	< 10
Cs-134	< 3	< 2	< 2	< 2	< 2	< 2
Cs-137	< 3	< 2	< 2	< 2	< 2	< 2
Ba-140	< 25	< 18	< 15	< 21	< 16	< 17
La-140	< 9	< 6	< 5	< 6	< 5	< 6
Ce-141	< 6	< 4	< 4	< 4	< 4	< 4
Ce-144	< 19	< 12	< 12	< 13	< 13	< 14
Ra-226	< 62	< 45	< 38	< 46	< 42	< 49
Ac-228	< 12	< 8	< 6	< 7	< 6	< 8
Th-228	< 5	< 4	< 3	< 3	< 3	< 4

* Control Location
(a) Quarterly Composite

INDIAN POINT ENERGY CENTER

TABLE B-14

RADIONUCLIDES IN RIVER WATER SAMPLES - 2019

pCi/L ± 2 Sigma

Plant Inlet Hudson River Intake

9*

DATE	07/30/19	08/27/19	09/23/19	10/29/19	11/26/19	12/31/19
RADIOCHEMICAL						
H-3 (a)			< 191			< 185
GAMMA						
K-40	< 17	< 17	64 ± 26	45 ± 24	< 16	< 18
Mn-54	< 2	< 2	< 2	< 2	< 2	< 2
Co-58	< 2	< 2	< 2	< 2	< 2	< 2
Fe-59	< 5	< 4	< 5	< 4	< 5	< 5
Co-60	< 2	< 2	< 2	< 2	< 2	< 2
Zn-65	< 4	< 4	< 4	< 3	< 4	< 4
Nb-95	< 2	< 2	< 2	< 2	< 2	< 2
Zr-95	< 4	< 3	< 4	< 3	< 3	< 4
Ru-103	< 3	< 2	< 2	< 2	< 2	< 2
Ru-106	< 17	< 15	< 18	< 14	< 16	< 17
I-131	< 13	< 7	< 7	< 12	< 10	< 14
Cs-134	< 2	< 2	< 2	< 2	< 2	< 2
Cs-137	< 2	< 2	< 2	< 2	< 2	< 2
Ba-140	< 22	< 15	< 16	< 20	< 17	< 22
La-140	< 7	< 5	< 5	< 6	< 6	< 7
Ce-141	< 5	< 4	< 5	< 4	< 4	< 4
Ce-144	< 14	< 13	< 15	< 11	< 12	< 12
Ra-226	< 54	< 44	< 52	< 38	< 38	< 37
Ac-228	< 6	< 7	< 8	< 6	< 6	< 8
Th-228	< 4	< 4	< 4	< 3	< 3	< 3

* Control Location

(a) Quarterly Composite

INDIAN POINT ENERGY CENTER
TABLE B-14
RADIONUCLIDES IN RIVER WATER SAMPLES - 2019

pCi/L ± 2 Sigma

Discharge Canal
10

DATE	01/29/19	02/26/19	03/26/19	04/30/19	05/29/19	06/26/19
RADIOCHEMICAL						
H-3 (a)			296 ± 136			294 ± 132
GAMMA						
K-40	< 13	< 34	< 16	< 15	79 ± 21	42 ± 25
Mn-54	< 1	< 2	< 2	< 1	< 1	< 2
Co-58	< 2	< 2	< 2	< 2	< 2	< 2
Fe-59	< 4	< 5	< 4	< 5	< 3	< 4
Co-60	< 2	< 2	< 2	< 2	< 1	< 2
Zn-65	< 3	< 4	< 4	< 4	< 3	< 4
Nb-95	< 2	< 2	< 2	< 2	< 2	< 2
Zr-95	< 3	< 3	< 3	< 3	< 3	< 4
Ru-103	< 2	< 2	< 2	< 2	< 2	< 2
Ru-106	< 14	< 15	< 15	< 14	< 12	< 17
I-131	< 8	< 10	< 9	< 12	< 7	< 9
Cs-134	< 2	< 2	< 2	< 2	< 2	< 2
Cs-137	< 2	< 2	< 2	< 2	< 1	< 2
Ba-140	< 14	< 18	< 17	< 20	< 13	< 17
La-140	< 4	< 6	< 6	< 7	< 4	< 6
Ce-141	< 4	< 4	< 4	< 4	< 3	< 4
Ce-144	< 12	< 11	< 11	< 12	< 10	< 13
Ra-226	< 35	< 41	< 37	< 35	< 40	< 40
Ac-228	< 6	< 6	< 6	< 6	< 5	< 7
Th-228	< 3	7 ± 3	< 3	< 3	< 2	< 3

(a) Quarterly Composite

INDIAN POINT ENERGY CENTER
TABLE B-14
RADIONUCLIDES IN RIVER WATER SAMPLES - 2019

pCi/L ± 2 Sigma

Discharge Canal
10

DATE	07/30/19	08/27/19	09/23/19	10/29/19	11/26/19	12/31/19
RADIOCHEMICAL						
H-3 (a)			< 187			< 181
GAMMA						
K-40	< 17	61 ± 26	52 ± 29	< 14	< 18	< 15
Mn-54	< 2	< 2	< 2	< 1	< 2	< 2
Co-58	< 2	< 2	< 2	< 2	< 2	< 2
Fe-59	< 5	< 4	< 5	< 4	< 5	< 4
Co-60	< 2	< 2	< 2	< 1	< 2	< 2
Zn-65	< 4	< 4	< 4	< 3	< 4	< 4
Nb-95	< 2	< 2	< 2	< 2	< 2	< 2
Zr-95	< 4	< 4	< 4	< 3	< 4	< 4
Ru-103	< 3	< 2	< 2	< 2	< 2	< 2
Ru-106	< 17	< 16	< 18	< 14	< 15	< 15
I-131	< 12	< 7	< 7	< 12	< 9	< 12
Cs-134	< 2	< 2	< 2	< 2	< 2	< 2
Cs-137	< 2	< 2	< 2	< 2	< 2	< 2
Ba-140	< 21	< 14	< 14	< 19	< 17	< 20
La-140	< 7	< 5	< 5	< 6	< 7	< 6
Ce-141	< 4	< 4	< 4	< 4	< 4	< 4
Ce-144	< 12	< 13	< 12	< 12	< 12	< 11
Ra-226	< 38	< 41	< 44	< 35	< 36	< 44
Ac-228	< 7	< 7	< 8	< 6	< 7	< 7
Th-228	< 3	< 3	< 3	< 3	< 3	< 3

(a) Quarterly Composite

INDIAN POINT ENERGY CENTER

TABLE B-15

GAMMA EMITTERS IN BOTTOM SEDIMENT SAMPLES - 2019

pCi/kg dry ± 2 Sigma

	Discharge Canal 10		Off Verplanck 17	
DATE	06/14/19	09/19/19	06/14/19	09/19/19
GAMMA				
Be-7	< 470	< 471	< 1062	< 809
K-40	14870 ± 1617	15760 ± 1832	19680 ± 2359	19760 ± 2080
Mn-54	< 60	< 59	< 97	< 91
Co-58	< 49	< 55	< 104	< 82
Fe-59	< 123	< 153	< 218	< 193
Co-60	< 62	< 60	< 113	< 87
Zn-65	< 141	< 128	< 245	< 180
Nb-95	< 55	< 69	< 128	< 102
Zr-95	< 117	< 99	< 196	< 173
Ru-103	< 57	< 63	< 118	< 83
Ru-106	< 429	< 407	< 983	< 814
I-131	< 138	< 99	< 322	< 149
Cs-134	< 53	< 68	< 133	< 100
Cs-137	158 ± 67	115 ± 73	< 166	274 ± 114
Ba-140	< 359	< 286	< 717	< 442
Ce-141	< 81	< 78	< 202	< 134
Ce-144	< 267	< 295	< 675	< 474
Ra-226	< 879	< 1223	< 2808	< 1743
Th-228	293 ± 89	327 ± 125	765 ± 286	1035 ± 216

INDIAN POINT ENERGY CENTER

TABLE B-15

GAMMA EMITTERS IN BOTTOM SEDIMENT SAMPLES - 2019

pCi/kg dry ± 2 Sigma

	Lent's Cove 28		Cold Spring 84*	
DATE	06/24/19	09/19/19	06/24/19	09/18/19
GAMMA				
Be-7	< 699	< 891	< 779	< 732
K-40	17320 ± 1969	19180 ± 2407	21970 ± 2588	20120 ± 2311
Mn-54	< 87	< 106	< 102	< 93
Co-58	< 59	< 85	< 88	< 79
Fe-59	< 164	< 239	< 192	< 183
Co-60	< 71	< 106	< 111	< 92
Zn-65	< 184	< 216	< 274	< 225
Nb-95	< 91	< 108	< 85	< 106
Zr-95	< 157	< 172	< 136	< 198
Ru-103	< 82	< 88	< 101	< 83
Ru-106	< 750	< 723	< 1020	< 828
I-131	< 106	< 124	< 127	< 163
Cs-134	< 107	< 118	< 129	< 117
Cs-137	< 118	214 ± 127	191 ± 95	162 ± 90
Ba-140	< 348	< 421	< 367	< 495
Ce-141	< 143	< 106	< 144	< 115
Ce-144	< 562	< 449	< 599	< 447
Ra-226	< 1895	2551 ± 1511	< 2086	3109 ± 1754
Th-228	582 ± 168	903 ± 148	1431 ± 256	1030 ± 152

* Control Location

INDIAN POINT ENERGY CENTER

TABLE B-16

RADIONUCLIDES IN SHORELINE SOIL SAMPLES - 2019

pCi/kg dry ± 2 Sigma

	Off Verplanck 17		Lent's Cove 28	
DATE	06/06/19	09/06/19	06/06/19	09/06/19
RADIOCHEMICAL				
Sr-90	< 19	< 218	< 42	< 189
GAMMA				
Be-7	< 435	< 488	< 368	< 573
K-40	16250 ± 1528	17070 ± 1896	13690 ± 1086	11760 ± 1348
Mn-54	< 56	< 69	< 47	< 65
Co-58	< 49	< 61	< 40	< 65
Fe-59	< 107	< 134	< 92	< 144
Co-60	< 62	< 63	< 45	< 63
Zn-65	< 145	< 169	< 79	< 142
Nb-95	< 47	< 84	< 49	< 66
Zr-95	< 71	< 138	< 83	< 135
Ru-103	< 41	< 63	< 35	< 64
Ru-106	< 449	< 680	< 359	< 609
I-131	< 66	< 131	< 70	< 129
Cs-134	< 68	< 80	< 56	< 70
Cs-137	104 ± 56	< 88	< 52	< 67
Ba-140	< 221	< 381	< 193	< 350
La-140	< 68	< 89	< 49	< 93
Ce-141	< 66	< 114	< 68	< 122
Ce-144	< 262	< 386	< 256	< 407
Ra-226	< 1090	< 1317	2155 ± 898	< 1616
Ac-228	< 160	< 249	< 161	< 432
Th-228	630 ± 79	672 ± 102	950 ± 74	705 ± 110

INDIAN POINT ENERGY CENTER
TABLE B-16
RADIONUCLIDES IN SHORELINE SOIL SAMPLES - 2019

pCi/kg dry ± 2 Sigma

	Manitou Inlet 50*		White Beach 53	
DATE	06/06/19	09/06/19	06/06/19	09/06/19
RADIOCHEMICAL				
Sr-90	< 45	< 208	< 35	< 143
GAMMA				
Be-7	< 429	< 453	< 481	< 282
K-40	14030 ± 1144	14080 ± 1499	11220 ± 1354	6613 ± 1042
Mn-54	< 46	< 64	< 55	< 48
Co-58	< 47	< 55	< 50	< 42
Fe-59	< 94	< 137	< 118	< 100
Co-60	< 51	< 51	< 51	< 37
Zn-65	< 117	< 127	< 130	< 85
Nb-95	< 58	< 72	< 44	< 29
Zr-95	< 90	< 98	< 99	< 75
Ru-103	< 51	< 55	< 58	< 31
Ru-106	< 401	< 517	< 391	< 367
I-131	< 83	< 118	< 89	< 80
Cs-134	< 54	< 86	< 60	< 40
Cs-137	< 60	< 64	< 57	< 38
Ba-140	< 215	< 268	< 244	< 214
La-140	< 65	< 133	< 64	< 51
Ce-141	< 86	< 91	< 65	< 51
Ce-144	< 327	< 327	< 251	< 181
Ra-226	2490 ± 1196	3012 ± 1364	< 1084	< 772
Ac-228	< 176	< 374	< 200	< 158
Th-228	961 ± 102	692 ± 96	148 ± 64	< 66

* Control Location

INDIAN POINT ENERGY CENTER

TABLE B-16

RADIONUCLIDES IN SHORELINE SOIL SAMPLES - 2019

pCi/kg dry ± 2 Sigma

	Cold Spring 84*	
DATE	06/06/19	09/06/19
RADIOCHEMICAL		
Sr-90	< 25	< 225
GAMMA		
Be-7	< 427	< 412
K-40	30970 ± 1662	27900 ± 1767
Mn-54	< 51	< 50
Co-58	< 52	< 51
Fe-59	< 144	< 119
Co-60	< 60	< 49
Zn-65	< 140	< 116
Nb-95	< 52	< 59
Zr-95	< 104	< 101
Ru-103	< 49	< 52
Ru-106	< 443	< 439
I-131	< 72	< 104
Cs-134	< 60	< 62
Cs-137	< 59	< 69
Ba-140	< 223	< 287
La-140	< 53	< 83
Ce-141	< 66	< 80
Ce-144	< 256	< 296
Ra-226	< 882	< 1166
Ac-228	< 209	< 198
Th-228	651 ± 100	924 ± 89

* Control Location

INDIAN POINT ENERGY CENTER

TABLE B-17

GAMMA EMITTERS IN AQUATIC VEGETATION SAMPLES - 2019

pCi/kg wet ± 2 Sigma

	Lent's Cove 28	
DATE	06/15/19 Myriophyllium	09/19/19 Myriophyllium
Be-7	(a)	< 196
K-40		2236 ± 323
Mn-54		< 18
Co-58		< 16
Fe-59		< 40
Co-60		< 19
Zn-65		< 30
Nb-95		< 21
Zr-95		< 25
Ru-103		< 19
Ru-106		< 159
I-131		< 31
Cs-134		< 22
Cs-137		< 23
Ba-140		< 87
La-140		< 19
Ce-141		< 30
Ce-144		< 118
Ra-226		< 456
Ac-228		121 ± 68
Th-228		69 ± 40

(a) Unable to locate and collect samples at this location

INDIAN POINT ENERGY CENTER

TABLE B-17

GAMMA EMITTERS IN AQUATIC VEGETATION SAMPLES - 2019

pCi/kg wet ± 2 Sigma

	Off Verplanck 17	
DATE	06/15/19 Myriophyllium	09/19/19 Myriophyllium
Be-7	(a)	< 178
K-40		1736 ± 380
Mn-54		< 16
Co-58		< 21
Fe-59		< 39
Co-60		< 15
Zn-65		< 42
Nb-95		< 21
Zr-95		< 41
Ru-103		< 17
Ru-106		< 172
I-131		< 30
Cs-134		< 25
Cs-137		< 24
Ba-140		< 73
La-140		< 34
Ce-141		< 24
Ce-144		< 100
Ra-226		< 432
Ac-228		150 ± 94
Th-228		60 ± 32

(a) Unable to locate and collect samples at this location

INDIAN POINT ENERGY CENTER

TABLE B-17

GAMMA EMITTERS IN AQUATIC VEGETATION SAMPLES - 2019

pCi/kg wet ± 2 Sigma

	Cold Spring 84*	
DATE	06/15/19 Myriophyllium	09/18/19 Myriophyllium
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		

* Control Location

(a) Unable to locate and collect samples at this location

INDIAN POINT ENERGY CENTER

TABLE B-18

RADIONUCLIDES IN FISH / INVERTEBRATES - 2019

pCi/kg wet ± 2 Sigma

	Downstream 107					
DATE	05/29/19 Eels	05/29/19 Striped Bass	05/30/19 White Perch	06/04/19 Catfish	06/10/19 Blue Crab	06/18/19 Sunfish
RADIOCHEMICAL						
Ni-63	< 83	< 100	< 76	< 62	< 75	< 97
Sr-90	< 3	< 4	< 4	< 4	< 4	< 4
GAMMA						
Be-7	< 766	< 912	< 546	< 519	< 876	< 780
K-40	1485 ± 671	2843 ± 852	2504 ± 716	1713 ± 622	2217 ± 931	2327 ± 1084
Mn-54	< 52	< 62	< 38	< 37	< 65	< 72
Co-58	< 60	< 91	< 66	< 45	< 86	< 79
Fe-59	< 158	< 219	< 181	< 144	< 212	< 185
Co-60	< 41	< 22	< 50	< 48	< 82	< 87
Zn-65	< 88	< 128	< 115	< 82	< 136	< 154
Nb-95	< 76	< 94	< 73	< 48	< 81	< 87
Zr-95	< 126	< 146	< 121	< 92	< 114	< 174
Ru-103	< 100	< 103	< 73	< 75	< 116	< 97
Ru-106	< 442	< 560	< 492	< 472	< 586	< 774
I-131	< 2624	< 2876	< 1946	< 1064	< 1323	< 724
Cs-134	< 54	< 60	< 49	< 38	< 67	< 83
Cs-137	< 50	< 57	< 44	< 37	< 67	< 77
Ba-140	< 2095	< 2508	< 1717	< 1293	< 1547	< 997
La-140	< 436	< 521	< 538	< 500	< 369	< 261
Ce-141	< 170	< 201	< 134	< 98	< 179	< 164
Ce-144	< 284	< 365	< 251	< 200	< 362	< 448
Ra-226	< 1097	< 1303	< 923	< 645	< 1697	< 1696
Th-228	< 92	< 115	< 78	< 68	< 102	< 144

INDIAN POINT ENERGY CENTER
TABLE B-18
RADIONUCLIDES IN FISH / INVERTEBRATES - 2019

pCi/kg wet ± 2 Sigma

	Downstream 107				
DATE	08/06/19 Blue Crabs	08/07/19 Eels	09/10/19 Sunfish	09/10/19 White Perch	09/10/19 Catfish
RADIOCHEMICAL					
Ni-63	< 82	< 92	< 58	< 85	< 49
Sr-90	< 4	< 5	< 5	< 4	< 4
GAMMA					
Be-7	< 648	< 817	< 604	< 511	< 561
K-40	1739 ± 642	2755 ± 853	2686 ± 784	1925 ± 667	2295 ± 783
Mn-54	< 57	< 18	< 61	< 50	< 62
Co-58	< 67	< 56	< 47	< 50	< 52
Fe-59	< 216	< 248	< 157	< 162	< 133
Co-60	< 52	< 42	< 59	< 50	< 50
Zn-65	< 83	< 128	< 139	< 117	< 129
Nb-95	< 70	< 58	< 60	< 60	< 60
Zr-95	< 111	< 50	< 128	< 94	< 131
Ru-103	< 102	< 117	< 64	< 66	< 67
Ru-106	< 431	< 359	< 447	< 417	< 438
I-131	< 12040	< 7489	< 566	< 566	< 522
Cs-134	< 52	< 40	< 61	< 57	< 48
Cs-137	< 43	< 38	< 56	< 49	< 60
Ba-140	< 4473	< 4147	< 875	< 768	< 870
La-140	< 940	< 1340	< 300	< 281	< 402
Ce-141	< 192	< 137	< 99	< 116	< 115
Ce-144	< 253	< 176	< 214	< 264	< 247
Ra-226	< 994	< 677	< 956	< 1073	< 883
Th-228	< 70	< 67	< 83	< 81	< 75

INDIAN POINT ENERGY CENTER

TABLE B-18

RADIONUCLIDES IN FISH / INVERTEBRATES - 2019

pCi/kg wet ± 2 Sigma

	Roseton 23*					
DATE	04/30/19 Striped Bass	06/04/19 White Perch	06/04/19 Catfish	06/05/19 Sunfish	06/05/19 Eels	06/19/19 Blue Crab
RADIOCHEMICAL						
Ni-63	< 91	< 91	< 71	< 93	< 58	< 100
Sr-90	< 4	< 4	< 4	< 4	< 4	< 3
GAMMA						
Be-7	< 978	< 397	< 780	< 607	< 349	< 562
K-40	3109 ± 694	2382 ± 443	1985 ± 902	2407 ± 791	2068 ± 499	2215 ± 788
Mn-54	< 54	< 34	< 64	< 37	< 31	< 50
Co-58	< 87	< 34	< 76	< 54	< 36	< 66
Fe-59	< 266	< 108	< 183	< 137	< 84	< 164
Co-60	< 42	< 30	< 82	< 41	< 37	< 63
Zn-65	< 112	< 70	< 117	< 85	< 52	< 147
Nb-95	< 97	< 41	< 114	< 54	< 38	< 74
Zr-95	< 145	< 70	< 169	< 106	< 72	< 125
Ru-103	< 170	< 60	< 116	< 80	< 56	< 73
Ru-106	< 469	< 269	< 614	< 415	< 269	< 468
I-131	< 30600	< 1076	< 2038	< 1188	< 840	< 498
Cs-134	< 58	< 33	< 75	< 44	< 31	< 53
Cs-137	< 46	< 30	< 77	< 46	< 25	< 53
Ba-140	< 9354	< 884	< 2217	< 1085	< 779	< 764
La-140	< 2518	< 323	< 454	< 395	< 283	< 277
Ce-141	< 262	< 101	< 197	< 120	< 81	< 114
Ce-144	< 300	< 207	< 361	< 234	< 164	< 296
Ra-226	< 993	< 760	< 1317	< 835	< 626	< 1227
Th-228	< 94	< 51	< 138	< 83	< 46	< 99

* Control Location

INDIAN POINT ENERGY CENTER

TABLE B-18

RADIONUCLIDES IN FISH / INVERTEBRATES - 2019

pCi/kg wet ± 2 Sigma

	Roseton 23*				
DATE	07/30/19 White Perch	08/12/19 Sunfish	08/12/19 Eels	08/12/19 Catfish	08/13/19 Blue Crabs
RADIOCHEMICAL					
Ni-63	< 94	< 76	< 81	< 70	< 67
Sr-90	< 5	< 5	< 4	< 4	< 4
GAMMA					
Be-7	< 362	< 807	< 283	< 210	< 277
K-40	2593 ± 344	2351 ± 650	2101 ± 256	2806 ± 286	2451 ± 299
Mn-54	< 22	< 54	< 21	< 16	< 19
Co-58	< 36	< 86	< 28	< 21	< 27
Fe-59	< 108	< 239	< 87	< 64	< 71
Co-60	< 19	< 57	< 20	< 16	< 19
Zn-65	< 49	< 141	< 48	< 35	< 40
Nb-95	< 40	< 86	< 32	< 26	< 29
Zr-95	< 72	< 149	< 54	< 42	< 49
Ru-103	< 63	< 125	< 44	< 35	< 44
Ru-106	< 189	< 427	< 169	< 140	< 171
I-131	< 9814	< 7530	< 2916	< 2079	< 2608
Cs-134	< 23	< 54	< 19	< 15	< 20
Cs-137	< 21	< 51	< 18	< 14	< 17
Ba-140	< 3200	< 3983	< 1534	< 1183	< 1430
La-140	< 994	< 1433	< 564	< 391	< 398
Ce-141	< 99	< 203	< 72	< 48	< 71
Ce-144	< 107	< 271	< 99	< 68	< 101
Ra-226	< 440	< 989	< 357	< 243	< 343
Th-228	< 30	< 81	< 30	< 21	< 27

* Control Location

INDIAN POINT ENERGY CENTER
TABLE B-18
RADIONUCLIDES IN FISH / INVERTEBRATES - 2019

pCi/kg wet ± 2 Sigma

	Downstream 25					
DATE	05/29/19 Eels	05/29/19 Striped Bass	05/29/19 Catfish	06/03/19 Sunfish	06/03/19 White Perch	06/17/19 Blue Crab
RADIOCHEMICAL						
Ni-63	< 80	< 97	< 93	< 96	< 96	< 86
Sr-90	< 4	< 3	< 3	< 4	< 3	< 4
GAMMA						
Be-7	< 662	< 780	< 538	< 841	< 729	< 677
K-40	1378 ± 647	2780 ± 811	2211 ± 740	2730 ± 951	2061 ± 737	2118 ± 857
Mn-54	< 43	< 56	< 49	< 67	< 46	< 72
Co-58	< 38	< 71	< 93	< 89	< 72	< 49
Fe-59	< 103	< 151	< 166	< 247	< 168	< 156
Co-60	< 58	< 60	< 47	< 63	< 72	< 79
Zn-65	< 111	< 129	< 137	< 162	< 129	< 107
Nb-95	< 78	< 73	< 78	< 107	< 77	< 75
Zr-95	< 138	< 126	< 141	< 167	< 122	< 118
Ru-103	< 78	< 104	< 93	< 110	< 94	< 82
Ru-106	< 449	< 558	< 441	< 628	< 415	< 420
I-131	< 2884	< 2400	< 2410	< 2511	< 2057	< 619
Cs-134	< 35	< 55	< 58	< 71	< 49	< 49
Cs-137	< 42	< 56	< 55	< 70	< 47	< 69
Ba-140	< 1855	< 1977	< 2162	< 2389	< 1593	< 968
La-140	< 423	< 785	< 782	< 645	< 362	< 188
Ce-141	< 123	< 175	< 152	< 210	< 191	< 149
Ce-144	< 249	< 305	< 246	< 388	< 398	< 358
Ra-226	< 893	< 1132	< 1006	< 1631	< 1262	< 1314
Th-228	< 70	< 89	< 83	< 135	< 99	< 120

INDIAN POINT ENERGY CENTER

TABLE B-18

RADIONUCLIDES IN FISH / INVERTEBRATES - 2019

pCi/kg wet ± 2 Sigma

	Downstream 25				
DATE	08/06/19 Eels	08/07/19 Blue Crabs	08/12/19 Sunfish	08/13/19 White Perch	09/10/19 Catfish
RADIOCHEMICAL					
Ni-63	< 73	< 83	< 70	< 75	< 48
Sr-90	< 4	< 4	< 4	< 4	< 4
GAMMA					
Be-7	< 732	< 855	< 675	< 230	< 849
K-40	2173 ± 682	3032 ± 722	2325 ± 762	2611 ± 293	2926 ± 929
Mn-54	< 52	< 55	< 57	< 17	< 62
Co-58	< 77	< 80	< 95	< 24	< 76
Fe-59	< 229	< 223	< 237	< 68	< 216
Co-60	< 36	< 48	< 66	< 18	< 76
Zn-65	< 101	< 120	< 165	< 36	< 105
Nb-95	< 84	< 90	< 98	< 27	< 80
Zr-95	< 153	< 133	< 132	< 45	< 149
Ru-103	< 117	< 120	< 140	< 39	< 95
Ru-106	< 466	< 453	< 538	< 144	< 631
I-131	< 10700	< 10350	< 7879	< 2069	< 734
Cs-134	< 48	< 57	< 53	< 17	< 65
Cs-137	< 48	< 51	< 43	< 15	< 70
Ba-140	< 4575	< 4815	< 4249	< 1114	< 1218
La-140	< 1800	< 1225	< 1408	< 435	< 259
Ce-141	< 217	< 191	< 188	< 52	< 148
Ce-144	< 262	< 267	< 281	< 70	< 335
Ra-226	< 962	< 1003	< 942	< 283	< 1189
Th-228	< 81	< 87	< 87	< 20	< 117

TABLE B-19

LAND USE CENSUS - RESIDENCE AND MILCH ANIMAL RESULTS 2019

The 2019 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-20
LAND USE CENSUS
2019

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	735	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 2019 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
2009-2019

Average Quarterly Dose (mR/Quarter)			
Year	Inner Ring	Outer Ring	Control Location
2009	14.5	14.2	17.3
2010	14.0	14.3	13.0
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	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

Historical Average 2009-2018	13.9	14.1	14.5

Figure C-1

DIRECT RADIATION, ANNUAL SUMMARY 2009-2019

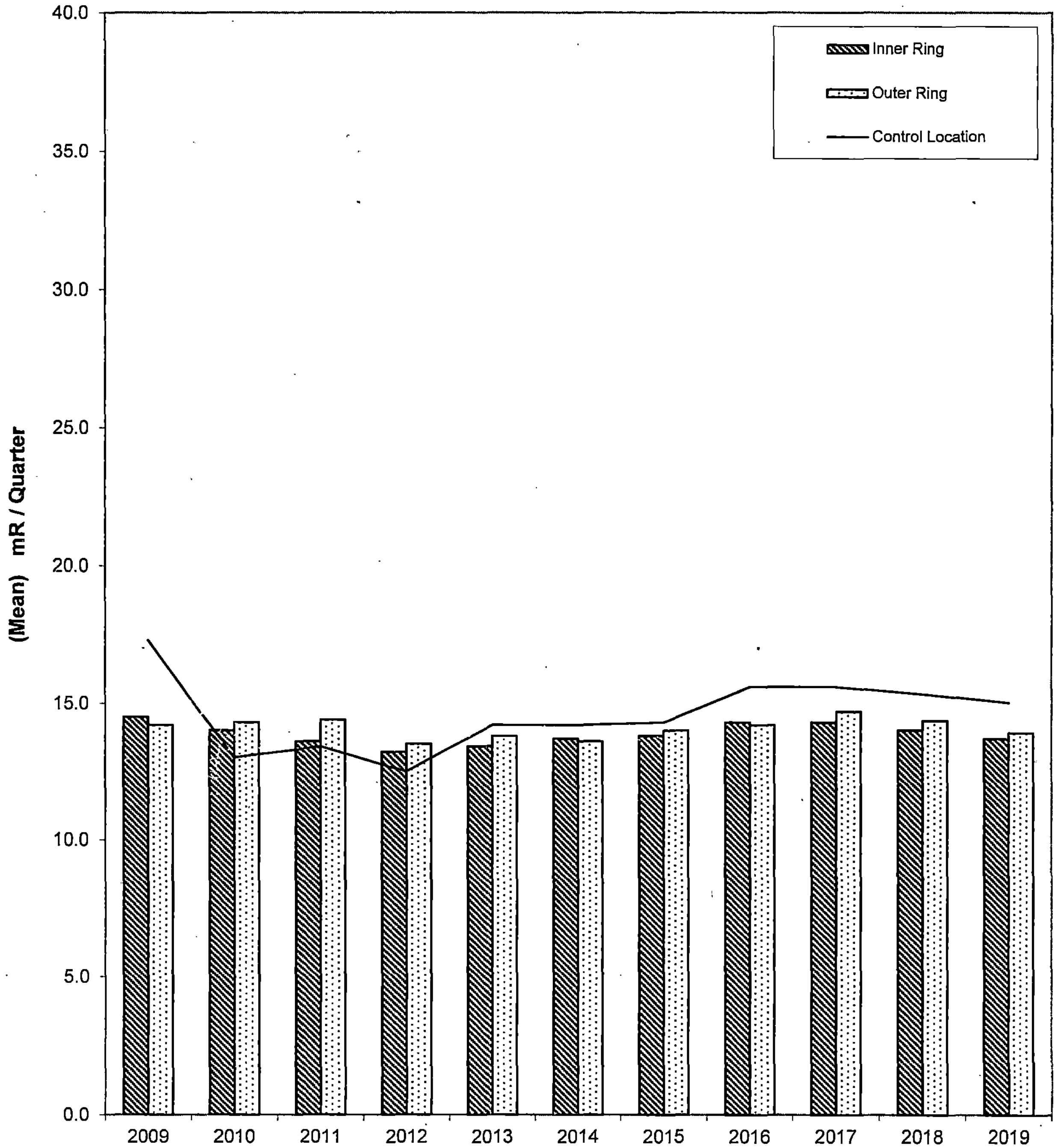


TABLE C-2
RADIONUCLIDES IN AIR
2009-2019
(pCi/m^3)

Year	Gross Beta		Cs-137	
	All Indicator Locations	Control Location	All Indicator Locations	Control Location
2009	0.01	0.01	$< L_C$	$< L_C$
2010	0.01	0.01	$< L_C$	$< L_C$
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	< Lc	< Lc
2019	0.012	0.012	< Lc	< Lc

Historical Average 2009-2018	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 2009-2019

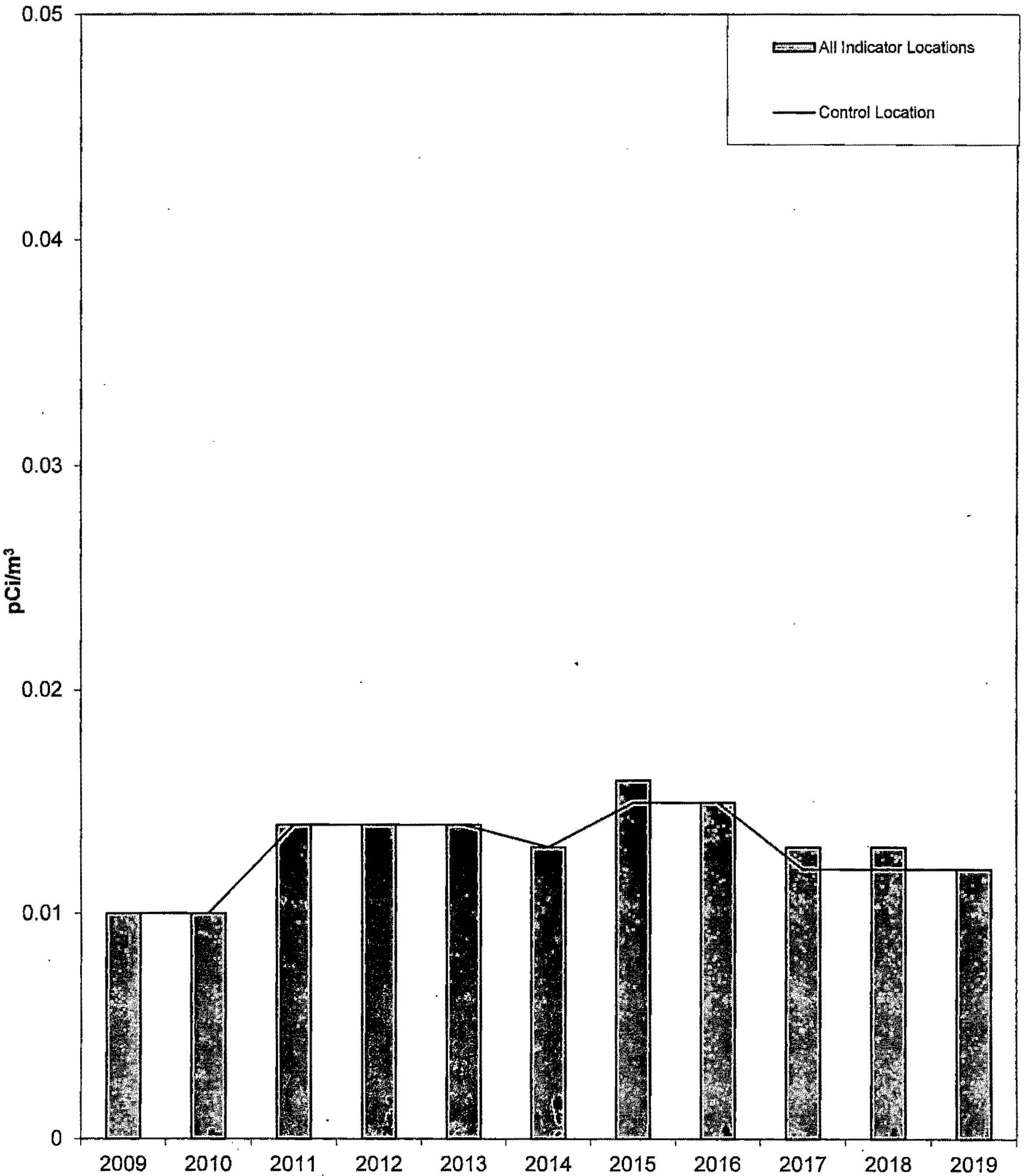


TABLE C-3
RADIONUCLIDES IN HUDSON RIVER WATER-TRITIUM
2009-2019
(pCi/L)

	Tritium (H-3)		Cs-137	
Year	Inlet	Discharge	Inlet	Discharge
2009	< Lc	< Lc	< Lc	< Lc
2010	428	< Lc	< Lc	< Lc
2011	< Lc	661	< Lc	< Lc
2012	< Lc	539	< Lc	< Lc
2013	241	462	< Lc	< Lc
2014	224	253	< Lc	< Lc
2015	188	341	< Lc	< Lc
2016	< Lc	415	< Lc	< Lc
2017	< Lc	299	< Lc	< Lc
2018	236	266	< Lc	< Lc
2019	273	295	< Lc	< Lc
Historical Average 2009-2018	263	405	< 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-3

RADIONUCLIDES IN HUDSON RIVER WATER - TRITIUM
2009-2019

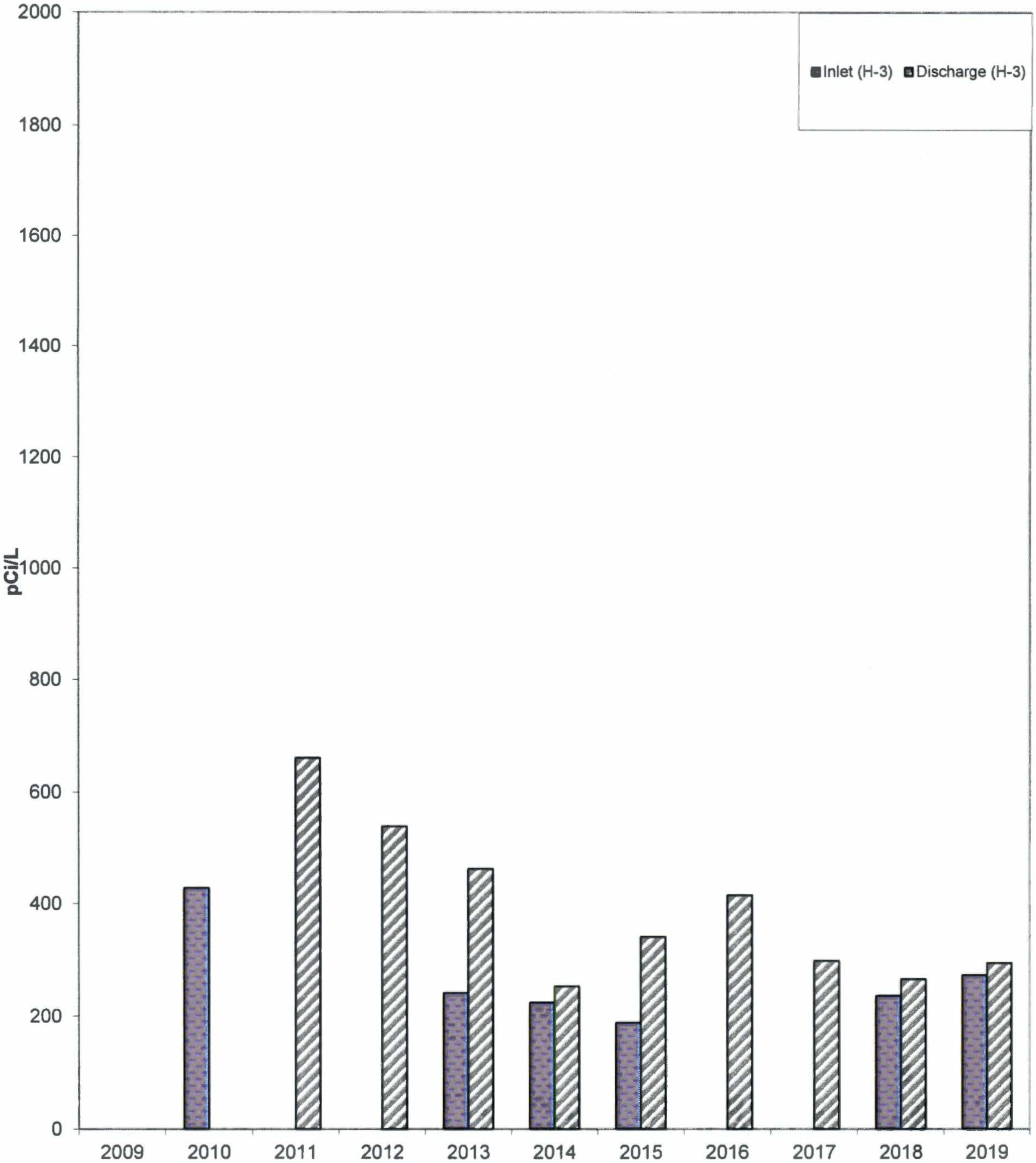


TABLE C-4
RADIONUCLIDES IN DRINKING WATER
2009-2019
(pCi/L)

Year	Tritium (H-3)	Cs-137
2009	< Lc	< Lc
2010	< Lc	< Lc
2011	< Lc	< Lc
2012	< Lc	< Lc
2013	< Lc	< Lc
2014	< Lc	< Lc
2015	< Lc	< Lc
2016	< Lc	< Lc
2017	< Lc	< Lc
2018	< Lc	< Lc
2019	< Lc	< Lc
Historical Average 2009-2018	< 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 2009-2019

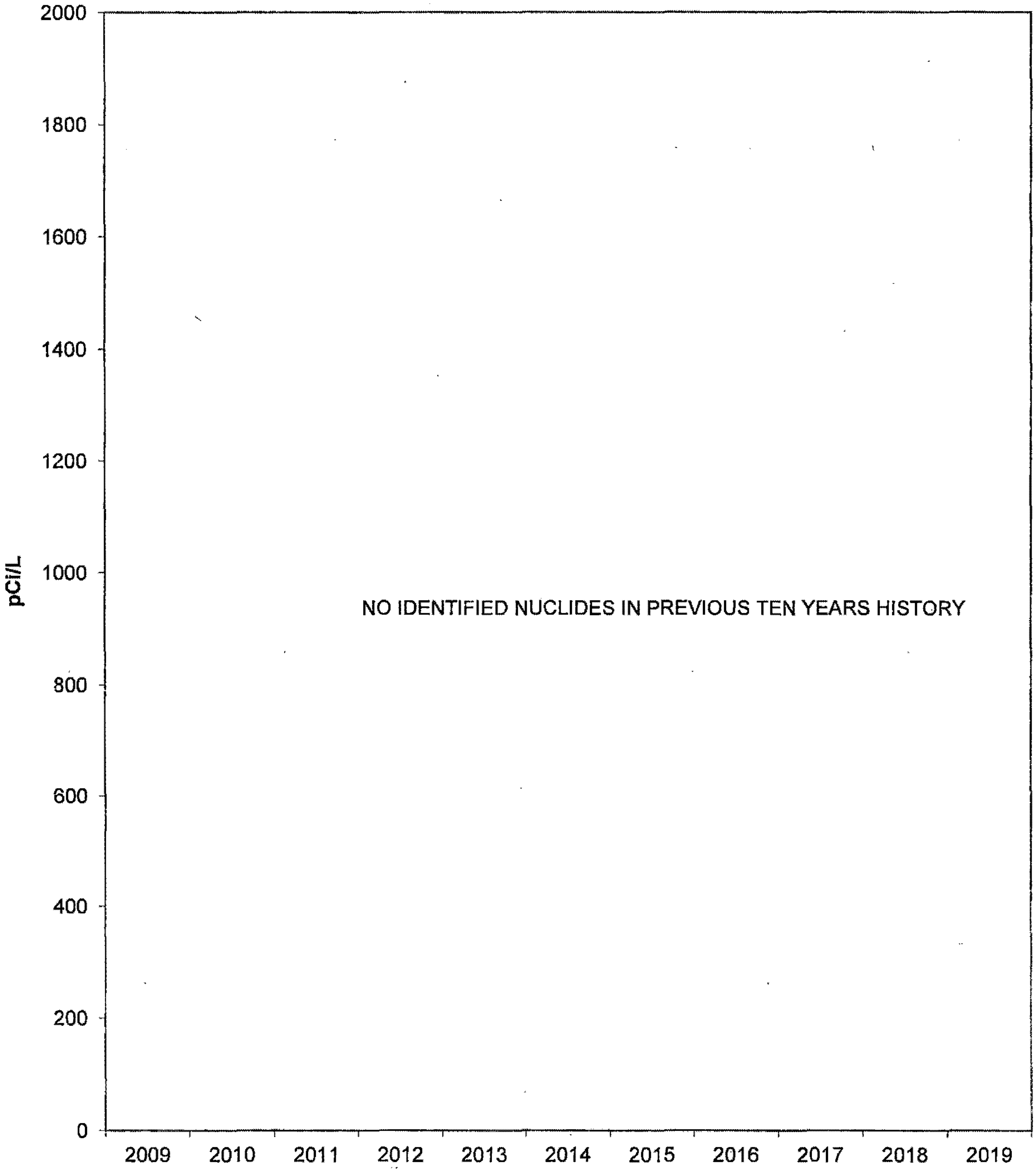


TABLE C-5
RADIONUCLIDES IN SHORELINE SOIL
2009-2019
(pCi/Kg, dry)

	Cs-134		Cs-137	
Year	Indicator	Control	Indicator	Control
2009	< Lc	< Lc	149	< Lc
2010	< Lc	< Lc	154	63
2011	< Lc	< Lc	108	< Lc
2012	< Lc	< Lc	141	< Lc
2013	< Lc	< Lc	133	< Lc
2014	< Lc	< Lc	327	< Lc
2015	< Lc	< Lc	110	< Lc
2016	< Lc	< Lc	< Lc	< Lc
2017	< Lc	< Lc	151	< Lc
2018	< Lc	< Lc	129	< Lc
2019	< Lc	< Lc	104	< Lc
Historical Average 2009-2018	< Lc	< Lc	156	63

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 SEDIMENT 2009-2019

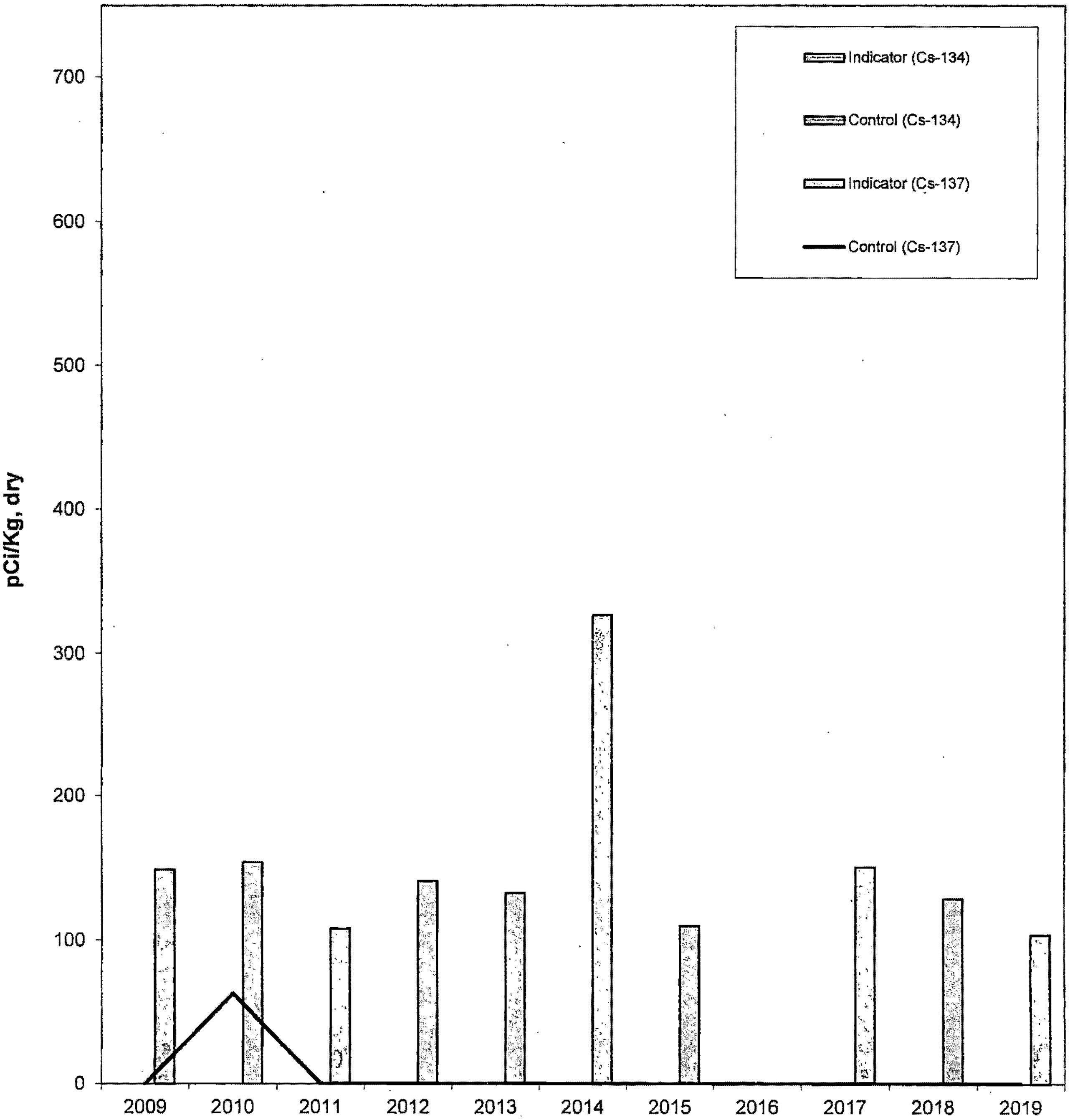


TABLE C-6
RADIONUCLIDES IN BROAD LEAF VEGETATION 2009-2019
(pCi/Kg, wet)

	Cs-137	
Year	**Indicator**	**Control**
2009	< Lc	< Lc
2010	31	< Lc
2011	< Lc	< Lc
2012	44	< Lc
2013	< Lc	< Lc
2014	< Lc	< Lc
2015	< Lc	< Lc
2016	< Lc	< Lc
2017	< Lc	< Lc
2018	< Lc	< Lc
2019	< Lc	< Lc
Historical Average 2009-2018	38	< Lc

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 2009-2019

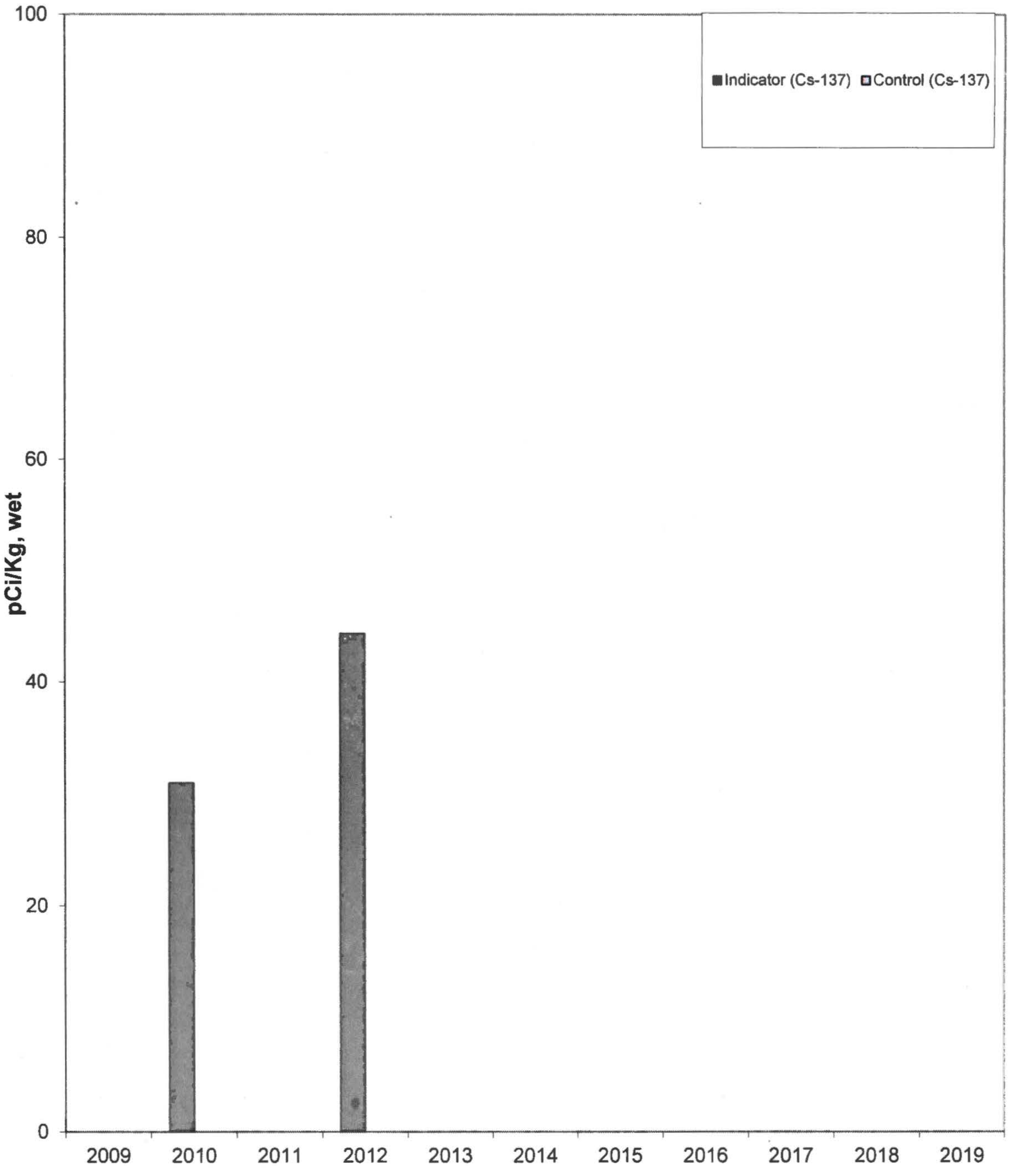


TABLE C-7
RADIONUCLIDE IN FISH AND INVERTEBRATES
2009-2019
(pCi/Kg, dry)

	Cs-137	
Year	**Indicator**	**Control**
2009	< Lc	< Lc
2010	< Lc	< Lc
2011	< Lc	< Lc
2012	< Lc	< Lc
2013	< Lc	< Lc
2014	< Lc	< Lc
2015	< Lc	< Lc
2016	< Lc	< Lc
2017	< Lc	< Lc
2018	< Lc	< Lc
2019	< Lc	< Lc
Historical Average 2009-2018	< Lc	< Lc

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 2009-2019

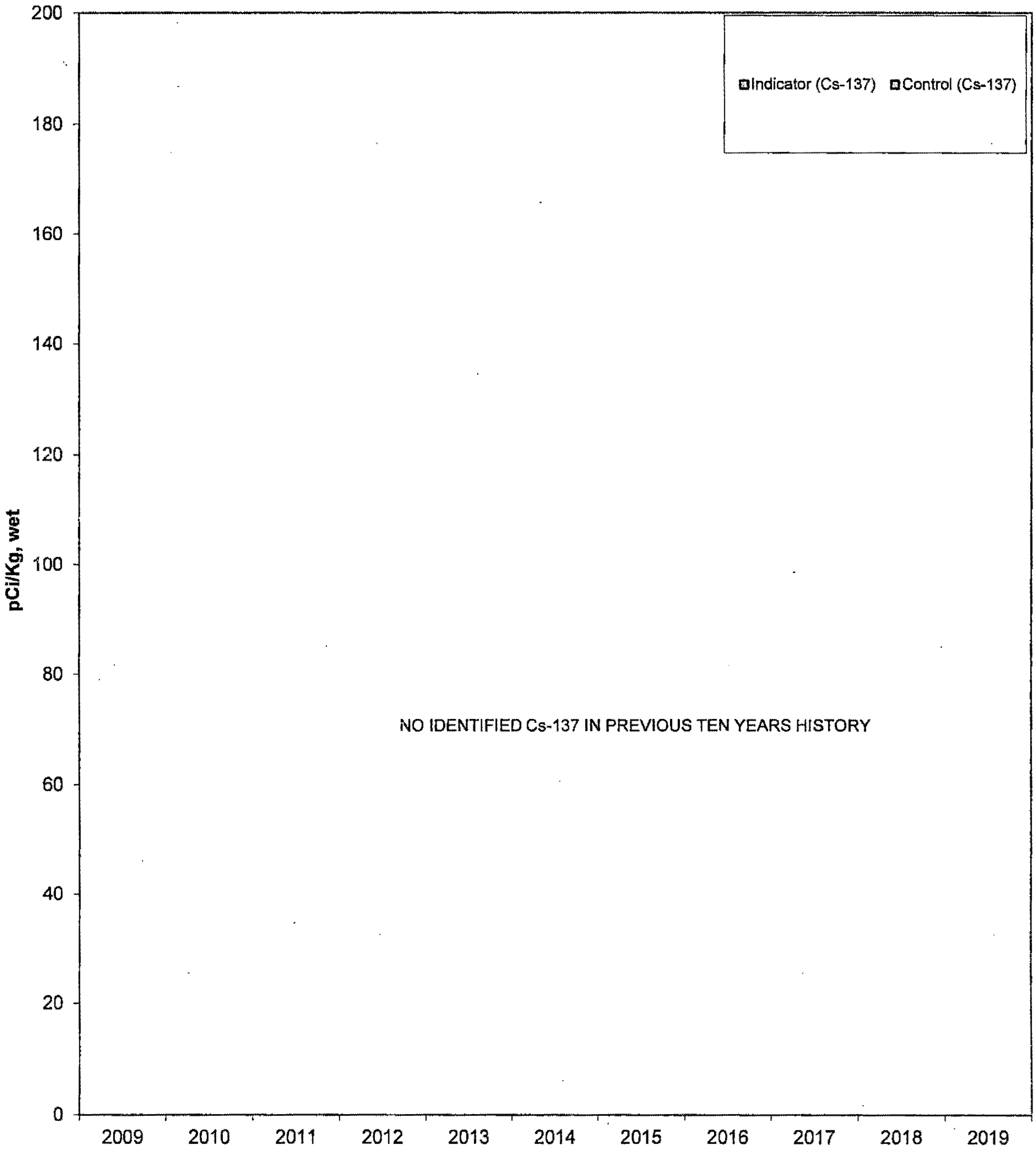


TABLE C-8
RIVER WATER - Discharge Area - Tritium
REMP vs. EFFLUENT
(pCi/L)

Year	REMP*	EFFLUENT **
1Q 2016	572	830
2Q 2016	257	762
3Q 2016	177	55
4Q 2016	195	253
1Q 2017	216	912
2Q 2017	<191	372
3Q 2017	<179	51
4Q 2017	381	665
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	8
Four Year Average, by Quarter, 2016 - 2019	290	432

* 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
2009-2019
(pCi/Kg, dry)

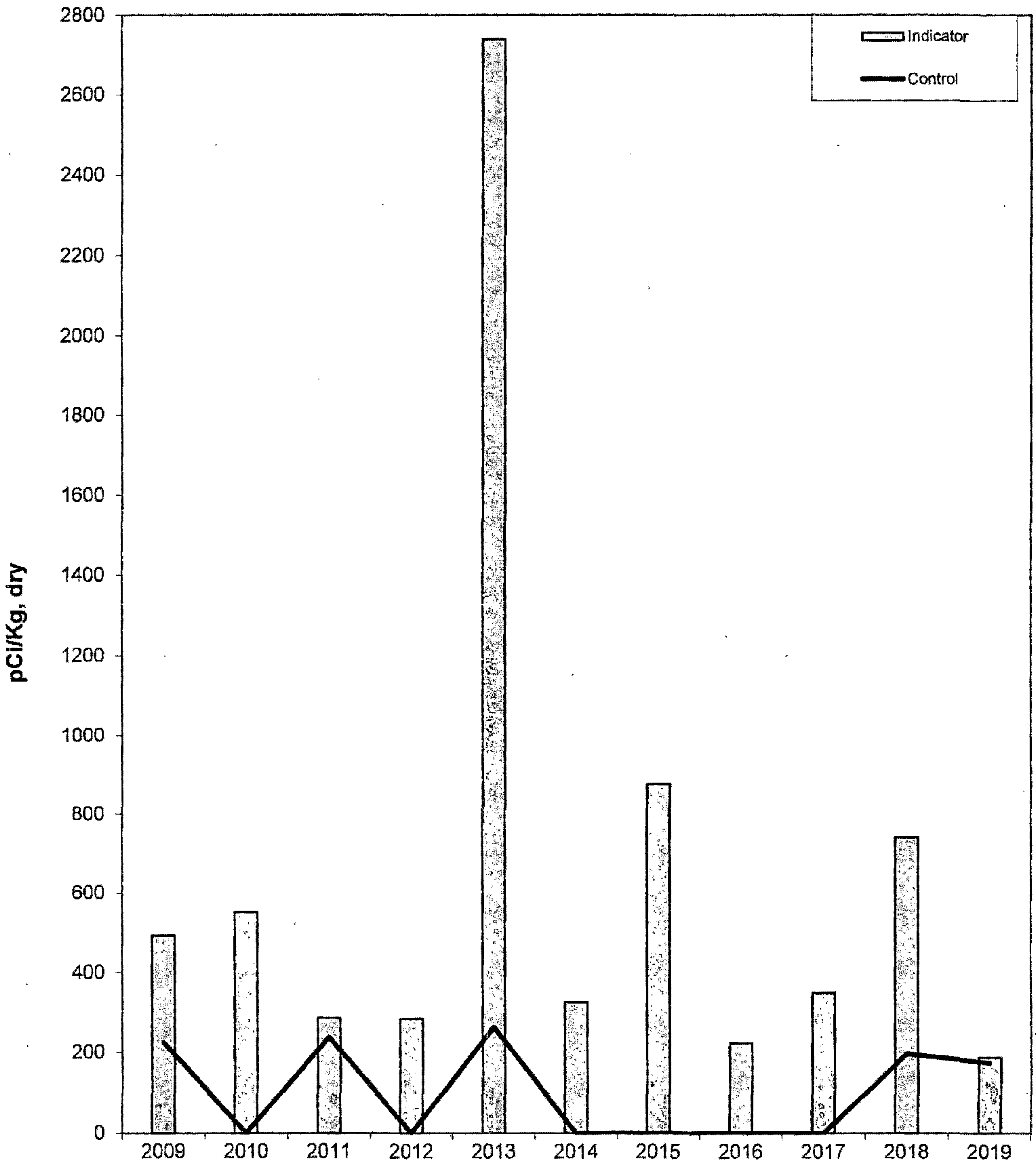
	Cs-137	
Year	**Indicator**	**Control**
2009	493	225
2010	552	< Lc
2011	287	238
2012	284	< Lc
2013	2738	264
2014	327	< Lc
2015	876	< Lc
2016	224	< Lc
2017	350	< Lc
2018	741	198
2019	190	176
Historical Average 2009-2018	687	231

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 2009-2019



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 2019	E12468A	Milk	Sr-89	pCi/L	87.1	96	0.91	A
			Sr-90	pCi/L	12.6	12.6	1.00	A
	E12469A	Milk	Ce-141	pCi/L	113	117	0.97	A
			Co-58	pCi/L	153	143	1.07	A
			Co-60	pCi/L	289	299	0.97	A
			Cr-51	pCi/L	233	293	0.80	A
			Cs-134	pCi/L	147	160	0.92	A
			Cs-137	pCi/L	193	196	0.98	A
			Fe-59	pCi/L	153	159	0.96	A
			I-131	pCi/L	91.5	89.5	1.02	A
			Mn-54	pCi/L	149	143	1.04	A
			Zn-65	pCi/L	209	220	0.95	A
	E12470	Charcoal	I-131	pCi	77.5	75.2	1.03	A
	E12471	AP	Ce-141	pCi	60.7	70.2	0.87	A
			Co-58	pCi	87.9	85.8	1.02	A
			Co-60	pCi	175	179	0.98	A
			Cr-51	pCi	165	176	0.94	A
			Cs-134	pCi	91.2	95.9	0.95	A
			Cs-137	pCi	120	118	1.02	A
			Fe-59	pCi	108	95.3	1.13	A
			Mn-54	pCi	94.2	85.7	1.10	A
			Zn-65	pCi	102	132	0.77	W
	E12472	Water	Fe-55	pCi/L	2230	1920	1.16	A
	E12473	Soil	Ce-141	pCi/g	0.189	0.183	1.03	A
			Co-58	pCi/g	0.209	0.224	0.93	A
			Co-60	pCi/g	0.481	0.466	1.03	A
			Cr-51	pCi/g	0.522	0.457	1.14	A
			Cs-134	pCi/g	0.218	0.250	0.87	A
			Cs-137	pCi/g	0.370	0.381	0.97	A
			Fe-59	pCi/g	0.263	0.248	1.06	A
			Mn-54	pCi/g	0.248	0.223	1.11	A
			Zn-65	pCi/g	0.371	0.344	1.08	A
	E12474	AP	Sr-89	pCi	88.3	95.2	0.93	A
			Sr-90	pCi	11.7	12.5	0.94	A
August 2019	E12562	Soil	Sr-90	pCi/g	4.710	6.710	0.70	W

(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 Analytics Result	Evaluation (b)
September 2019	E12475	Milk	Sr-89	pCi/L	70.0	93.9	0.75	W
			Sr-90	pCi/L	12.0	12.9	0.93	A
	E12476	Milk	Ce-141	pCi/L	150	167	0.90	A
			Co-58	pCi/L	170	175	0.97	A
			Co-60	pCi/L	211	211	1.00	A
			Cr-51	pCi/L	323	331	0.98	A
			Cs-134	pCi/L	180	207	0.87	A
			Cs-137	pCi/L	147	151	0.97	A
			Fe-59	pCi/L	156	148	1.05	A
			I-131	pCi/L	81.1	92.1	0.88	A
			Mn-54	pCi/L	160	154	1.04	A
			Zn-65	pCi/L	303	293	1.03	A
	E12477	Charcoal	I-131	pCi	95.9	95.1	1.01	A
	E12478	AP	Ce-141	pCi	129	138	0.93	A
			Co-58	pCi	128	145	0.88	A
			Co-60	pCi	181	174	1.04	A
			Cr-51	pCi	292	274	1.07	A
			Cs-134	pCi	166	171	0.97	A
			Cs-137	pCi	115	125	0.92	A
			Fe-59	pCi	119	123	0.97	A
			Mn-54	pCi	129	128	1.01	A
			Zn-65	pCi	230	242	0.95	A
	E12479	Water	Fe-55	pCi/L	1810	1850	0.98	A
	E12480	Soil	Ce-141	pCi/g	0.305	0.276	1.10	A
			Co-58	pCi/g	0.270	0.289	0.93	A
			Co-60	pCi/g	0.358	0.348	1.03	A
			Cr-51	pCi/g	0.765	0.547	1.40	N(1)
			Cs-134	pCi/g	0.327	0.343	0.95	A
			Cs-137	pCi/g	0.308	0.321	0.96	A
			Fe-59	pCi/g	0.257	0.245	1.05	A
			Mn-54	pCi/g	0.274	0.255	1.07	A
			Zn-65	pCi/g	0.536	0.485	1.11	A
	E12481	AP	Sr-89	pCi	95.9	91.9	1.04	A
			Sr-90	pCi	12.3	12.6	0.97	A
	E12563	Soil	Sr-90	pCi/g	0.392	0.360	1.09	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*

*(1) See **NCR 19-27***

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 2019	19-GrF40	AP	Gross Alpha	Bq/sample	0.184	0.528	0.158 - 0.898	A
			Gross Beta	Bq/sample	0.785	0.948	0.474 - 1.422	A
	19-MaS40	Soil	Ni-63	Bq/kg	420	519.0	363 - 675	A
			Sr-90	Bq/kg			*(1)*	NR(3)
	19-MaW40	Water	Am-241	Bq/L	0.764	0.582	0.407 - 0.757	N(4)
			Ni-63	Bq/L	4.72	5.8	4.1 - 7.5	A
			Pu-238	Bq/L	0.443	0.451	0.316 - 0.586	A
			Pu-239/240	Bq/L	-0.00161	0.0045	*(2)*	A
	19-RdF40	AP	U-234/233	Bq/sample	0.1138	0.106	0.074 - 0.138	A
			U-238	Bq/sample	0.107	0.110	0.077 - 0.143	A
	19-RdV40	Vegetation	Cs-134	Bq/sample	2.14	2.44	1.71 - 3.17	A
			Cs-137	Bq/sample	2.22	2.30	1.61 - 2.99	A
			Co-57	Bq/sample	2.16	2.07	1.45 - 2.69	A
			Co-60	Bq/sample	0.02382		*(1)*	A
			Mn-54	Bq/sample	-0.03607		*(1)*	A
			Sr-90	Bq/sample	-0.1060		*(1)*	N(5)
			Zn-65	Bq/sample	1.35	1.71	1.20 - 2.22	W
August 2019	19-GrF41	AP	Gross Alpha	Bq/sample	0.192	0.528	0.158 - 0.898	W
			Gross Beta	Bq/sample	0.722	0.937	0.469 - 1.406	A
	19-MaS41	Soil	Ni-63	Bq/kg	436	629	440 - 818	N(6)
			Sr-90	Bq/kg	444	572	400 - 744	W
	19-MaW41	Water	Am-241	Bq/L				NR(7)
			Ni-63	Bq/L	7.28	9.7	6.8 - 12.6	W
			Pu-238	Bq/L	0.0207	0.0063	*(2)*	A
			Pu-239/240	Bq/L	0.741	0.727	0.509 - 0.945	A
	19-RdF41	AP	U-234/233	Bq/sample	0.0966	0.093	0.065 - 0.121	A
			U-238	Bq/sample	0.0852	0.096	0.067-0.125	A
	19-RdV41	Vegetation	Cs-134	Bq/sample	0.0197		*(1)*	A
			Cs-137	Bq/sample	3.21	3.28	2.30 - 4.26	A
			Co-57	Bq/sample	4.62	4.57	3.20 - 5.94	A
			Co-60	Bq/sample	4.88	5.30	3.71 - 6.89	A
			Mn-54	Bq/sample	4.54	4.49	3.14 - 5.84	A
			Sr-90	Bq/sample	0.889	1.00	0.70 - 1.30	A
			Zn-65	Bq/sample	2.78	2.85	2.00 - 3.71	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 19-12***
(4) See ***NCR 19-13***
(5) See ***NCR 19-14***
(6) See ***NCR 19-25***
(7) See ***NCR 19-26***

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)
April 2019	Rad-117	Water	Ba-133	pCi/L	26.3	24.1	18.6 - 27.8	A
			Cs-134	pCi/L	15.2	12.1	8.39 - 14.4	N(1)
			Cs-137	pCi/L	33.6	33.1	28.8 - 39.4	A
			Co-60	pCi/L	11.9	11.5	8.67 - 15.5	A
			Zn-65	pCi/L	87.1	89.2	80.3 - 107	A
			GR-A	pCi/L	19	19.3	9.56 - 26.5	A
			GR-B	pCi/L	20.2	29.9	19.1 - 37.7	A
			U-Nat	pCi/L	55.5	55.9	45.6 - 61.5	A
			H-3	pCi/L	21500	21400	18700 - 23500	A
			Sr-89	pCi/L	44.9	33.3	24.5 - 40.1	N(2)
			Sr-90	pCi/L	24.5	26.3	19.0 - 30.7	A
			I-131	pCi/L	28.9	28.4	23.6 - 33.3	A
October 2019	Rad-119	Water	Ba-133	pCi/L	42.7	43.8	35.7 - 48.8	A
			Cs-134	pCi/L	53.5	55.9	45.2 - 61.5	A
			Cs-137	pCi/L	77.7	78.7	70.8 - 89.2	A
			Co-60	pCi/L	51.5	53.4	48.1 - 61.3	A
			Zn-65	pCi/L	36.6	34.0	28.5 - 43.1	A
			GR-A	pCi/L	40.5	27.6	14.0 - 36.3	N(3)
			GR-B	pCi/L	36.3	39.8	26.4 - 47.3	A
			U-Nat	pCi/L	27.66	28.0	22.6 - 31.1	A
			H-3	pCi/L	22800	23400	20500 - 25700	A
			Sr-89	pCi/L	47.1	45.5	35.4 - 52.7	A
			Sr-90	pCi/L	32.5	26.5	19.2 - 30.9	N(4)
			I-131	pCi/L	26.0	23.9	19.8 - 28.4	A
December 2019	QR 120419D	Water	Sr-90	pCi/L	20.1	18.6	13.2 - 22.1	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 19-10***

(2) See ***NCR 19-11***

(3) See ***NCR 19-23***

(4) See ***NCR 19-24***

7.4 Environmental TLD Quality Assurance

Environmental dosimetry services for the reporting period of January – December, 2019 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 2019 [(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 2019 [(1), (2)]

Process Date	Mean Bias %	Standard Deviation %	Tolerance Limit +/-15%
4/25/2019	1.8	1.7	Pass
4/29/2019	3.1	1.5	Pass
5/04/2019	-0.4	1.4	Pass
7/28/2019	5.9	1.1	Pass
7/30/2019	2.8	1.2	Pass
8/4/2019	-0.7	1.2	Pass
10/25/2019	1.8	1.2	Pass
11/04/2019	-0.5	1.8	Pass
11/05/2019	3.0	1.7	Pass
01/20/2020	1.0	2.0	Pass
01/30/2020	1.8	2.6	Pass
02/17/2020	-2.6	2.4	Pass

(1) This table summarizes results of tests conducted by EDC for TLDs issued in 2019.
(2) Environmental dosimeter results are free in air.

TABLE D-4.3
SUMMARY OF INDEPENDENT DOSIMETER TESTING
JANUARY – DECEMBER 2019 [(1), (2)]

Issuance Period	Client	Mean Bias %	Standard Deviation %	Pass / Fail
1st Qtr. 2019	Millstone	0.6	2.6	Pass
2nd Qtr.2019	Seabrook	7.8	2.0	Pass
3rd Qtr. 2019	SONGS	0.1	2.4	Pass
3rd Qtr. 2019	Millstone	1.1	1.9	Pass
4th Qtr.2019	PSEG(PNNL)	-3.2	0.9	Pass
4th Qtr.2019	Seabrook	0.9	1.0	Pass

(1) Performance criteria are +/- 15%.
(2) Blind spike irradiations using Cs-137

SECTION 8.0

REFERENCES

8.0 REFERENCES

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