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NL-17-066

May 15, 2017

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
11555 Rockville Pike
Rockville, MS 20852

Subject: 2016 Annual Radiological Environmental Operating Report
Indian Point Unit Nos. 1, 2 and 3
Docket Nos. 50-003, 50-247, and DPR-64

Dear Sir or Madam:

Enclosed pleased find one copy of the Entergy Nuclear Operations, Inc. Indian Point Energy Center Annual Radiological Environmental Operating Report for the period January 1, 2016 to December 31, 2016.

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 Point Unit Nos. 1, 2 and 3 respectively. There are no new regulatory commitments being by Entergy in this correspondence.

IE25
NMSS01
NRR
NMSS

Should you or your staff have any questions regarding this matter, please contact me.

Sincerely,

RWW/trj

Enclosures: 2016 Annual Radiological Environmental Operating Report

cc: Mr. Daniel H. Dorman, Regional Administrator, NRC Region I
Mr. Richard V. Guzman, Senior Project Manager, NRC NRR DORL
NRC Resident Inspectors Office, Indian Point Energy Center
Ms. Kimberly Conway, IPEC NRC Unit 1 Project Manager
Mr. Timothy Rice, Bureau of Hazardous Waste & Radiation Management, NYSDEC
Ms. Bridget Frymire, New York State Public Service Commission
Mr. John B. Rhodes, President and CEO, NYSERDA

ENCLOSURE TO NL-17-066

2016 Annual Radiological Environmental Operating Report

Entergy Nuclear Operating, Inc.
Indian Point Unit Nos. 1, 2, and 3
Docket Nos. 50-003, 50-247, and 50-286

ANNUAL RADIOLOGICAL ENVIRONMENTAL OPERATING REPORT

ENTERGY NUCLEAR

INDIAN POINT NUCLEAR GENERATING STATION
UNITS 1, 2, AND 3

Docket No. 50-003 Indian Point Unit 1 (IP1)
Docket No. 50-247 Indian Point Unit 2 (IP2)
Docket No. 50-286 Indian Point Unit 3 (IP3)

January 1 - December 31, 2016

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EXECUTIVE SUMMARY

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, 2016. 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.

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, precipitation, shoreline sediment, bottom sediment, aquatic vegetation, fish, and invertebrates.

During 2016, there were 1169 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 2016 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 1469 analyses performed on the environmental media samples. The analysis of the 2016 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 for 2016. Samples were analyzed as required by the IPEC ODCM.

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.

SUMMARY OF RESULTS

Most samples collected as part of the IPEC REMP continued to contain detectable amounts of naturally-occurring and man-made radioactive materials. Offsite ambient radiation measurements using environmental TLDs beyond the site boundary ranged between 47 and 80 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 reactivity, tritium and cesium-137. The tritium was found in river water at the downstream mixing zone of the discharge 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 two soil samples. 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.

CONCLUSIONS

The 2016 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 2016 did not result in exposure to the public greater than environmental background levels.

SECTION 1.0

INTRODUCTION

1.1 Overview

The Radiological Environmental Monitoring Program (REMP) for 2016 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, 2016.

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, precipitation, 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 rain water 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 2016 as required by the IPEC ODCM. Also included are summaries and discussions of the results of the 2016 program, trend analyses (where appropriate), comparison to historical results and trend analyses (where appropriate) 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.

SECTION 2

BACKGROUND

2.0 BACKGROUND

2.1 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.

2.2 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.

2.3 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 objective described above. Verifying projected concentrations through the REMP is difficult since the environmental concentrations resulting from plant releases are typically too small to be detected. Plant related radionuclides were detected in 2016 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 2016 REMP sample results confirms that environmental concentrations which could be attributed to radiological effluents were well below regulatory limits.

SECTION 3

PROGRAM DESCRIPTION

3.0 PROGRAM DESCRIPTION

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.

3.2 Sample Analysis

The analysis of the 2016 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 (0.4 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 samples are continuously collected at one indicator location (sampling station 44) and one control location (23); see Figure A-3. They are collected in sample bottles designed to hinder evaporation. They are composited quarterly and analyzed by gamma spectroscopy and for tritium.

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-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, and 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 point 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

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.

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 (See Tables B-21 and B-22).

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.

Although there are presently no animals producing milk for human consumption within 5 miles (8 km) of the site, the census is performed to determine if a milk-sampling program needs to be conducted.

A residence census is also performed to identify the nearest residence(s) to the site in each of the 16 sectors surrounding Indian Point. See Table B-22.

A garden census was not performed, 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 $3.29\ \sigma_b * [(1 + (T_b / T_s))^{1/2}] = 4.66\ \sigma_b$).

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. The historical averages are calculated using only the positive values presented for 2006 through 2015. The 2016 average values are included in these historic tables for purposes of comparison.

SECTION 4

RESULTS AND DISCUSSION

4.0 RESULTS AND DISCUSSION

The 2016 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 2014 and assessed the significance of the findings.

A summary of the results of the 2016 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, H-3) 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 2016 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 2016, 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 2016 REMP comprises those that may be attributable to current plant operations. During 2016, 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 2016, very low levels of H-3 were detected in two river water samples.

Cs-137 is ubiquitous in the environment from atmospheric testing debris and a lesser amount from the Chernobyl accident. In 2016, there were two detections of Cs-137 in bottom sediment and shoreline soil at both control and indicator locations. Cs-137 was also detected in one aquatic vegetation sample obtained at an upstream (control) location at very low levels but none was detected in downstream (indicator) locations. As described in section 4.6, Cs-137 was initially detected in one groundwater sample but that is not indicative of impact as a result from plant operations. 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. No Sr-90 was detected in any of the fish or shoreline soil samples. Sr-90 was found in one groundwater sample with an average of 0.8 pCi/L. As described in section 4.2 this anomalous reading is not indicative of impact from plant operations.

I-131 is also produced in fission reactors, but can result from non-plant related anthropogenic sources, e.g., medical administrations, such as in previous years. I-131 was not detected in 2016 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 2016 REMP, although they were observed in historical data.

In the following sections, a summary of the results of the 2016 REMP is presented by sample medium and the significance of any positive findings discussed. It should be noted that naturally occurring radionuclides are omitted from the summary table (Table B-2) and further discussion.

4.1 Direct Radiation

The environmental TLDs used to measure the direct radiation were TLDs supplied and processed by Environmental Dosimetry Company. In 2016, 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 standard quarter for the years 2003 through 2016. The 2016 means are also presented in Table B-4. Table B-5 presents the 2016 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 2016 mean value for the indicator direct radiation sample points was 14.2 mR per standard quarter – which is consistent with historical values. At those locations where the 2016 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 for these two rings of TLDs are provided in Table B-5. The annual average for the inner ring was 14.0 mR per standard quarter and also average for the outer ring was 14.3 mR per standard quarter. The control location average for 2015 was 15.6 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 2016 averages are consistent with the historical data. The 2016 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

An annual summary of the results of the 2016 air particulate filter and charcoal cartridge analyses is presented in Table B-2. As shown, there were no radionuclides detected in the air attributable to plant operations.

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 0.015 pCi/m^3 and the average for the control location was 0.015 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 GSA of the quarterly composites of these samples are in Table B-8. These quarterly composite air samples showed that no reactor-related radionuclides were detected and that only naturally-occurring radionuclides were 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 2016 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 2016.

4.3 Precipitation

A summary of the precipitation sample analysis results is presented in Table B-2. Table B-9 contains the results of the precipitation samples for 2016. Only one naturally occurring radionuclide was detected in the precipitation samples.

A review of historical data over the last 10 years indicates tritium had been detected in one indicator precipitation sample in 2010 and both indicator and control locations in 2010; however, there have been no instances of positive values in 2016.

4.4 Drinking Water

The annual program summary table (Table B-2) contains a summary of the 2016 drinking water sample analysis results. Results of the gross beta, tritium and gamma spectroscopy analyses of the monthly drinking water samples are in Table B-10. Other than naturally occurring radionuclides, 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

A summary of the groundwater samples for 2016 is contained in Table B-2. Data resulting from analysis of the groundwater samples for gamma emitters, tritium analysis, Ni-63 and Sr-90 are given in Table B-11. An initial sample indicated the presence of Cs-137 and Sr-90. Due to low levels and absence of other plant related nuclides, a new sample was obtained and analyzed revealing the first sample results to be an anomaly and that those results could not be relied on. No plant related nuclides were noted in any acceptable samples.

4.6 Soil

A summary of the soil sample analysis results is presented in Table B-2. Table B-12 contains the results of the soil samples for 2016. 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

Table B-2 contains a summary of the broad leaf vegetation sample analysis results. Data from analysis of the 2016 samples are presented in Table B-13.

Table C-3 contains an historical summary and Figure C-3 is an illustration of the broad leaf vegetation analysis results. There were no plant related nuclides detected in the 2016 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

A summary of the radionuclides detected in the Hudson River water is contained in Table B-2. 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, and it was detected at low levels in two indicator samples. The levels are consistent with occasional historical detection of H-3. 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 calculation of radionuclide concentrations resulting from effluent releases attributable to the site.

4.9 Hudson River Bottom Sediment

A summary of the Hudson River bottom sediment analysis results is included in Table B-2. Table B-15 contains the results of the analysis of bottom sediment samples for 2016. Cesium-137 was detected in four of the indicator station samples, and none 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-8. This data shows the continued detection of Cs-137 in bottom sediment samples at varying levels, and demonstrates that the levels observed during 2016 sampling are within the range of levels identified in historical samples.

4.10 Hudson River Shoreline Soil

A summary of the radionuclide concentrations detected in the shoreline soil samples is contained in Table B-2. 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 not identified in the Hudson River shoreline soil samples in 2016.

An historical look at Cs-137 detected in shoreline soil at indicator and control locations can be viewed in Table C-6 and Figure C-6. 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 8 indicator location samples or any of the control location samples.

4.11 Aquatic Vegetation

A summary of the aquatic sample analysis results is presented in Table B-2. Table B-17 contains the results of the analysis of aquatic vegetation samples for 2016. No plant related radionuclides were detected in any indicator samples. This is consistent with historical findings.

4.12 Fish and Invertebrates

A summary of the fish and invertebrate sample analysis results is presented in Table B-2. Table B-18 contains the results of the analysis of fish and invertebrate samples for 2016. 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 2016. This census consisted of a milch animal and a residence census. Results of this census are presented in Tables B-21 and B-22.

The results of the 2016 census were generally same as the 2015 census results, in 2015 the presence of goats was noted on a property located approximately 4.99 miles NNW of IPEC. However, discussions with the owner for both the 2015 and 2016 land use surveys confirmed that the goats did not produce milk for human consumption and are therefore not milk animals.

The census revealed that the two nearest residences in different sectors are located 0.44 miles (0.71 km) ESE and 0.73 miles (1.13 km) S of the plant. The 2015 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 4.6 and presented in Table B-14, 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 2016 REMP reveal that operations at the station did not result in an impact on the environment.

The 2016 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

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5.0 REFERENCES

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APPENDIX A

ENVIRONMENTAL SAMPLING AND ANALYSIS REQUIREMENTS

APPENDIX A

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 2016 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.

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.

In addition to the sampling outlined in Table A-1, there is an environmental surveillance requirement that an annual land use and milch animal census be performed. See Tables B-19 and B-20 for the milch animal and land use census.

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 R/S = Reuter Stokes

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		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 R/S = Reuter Stokes

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 R/S = Reuter Stokes

FIGURE A-1

SAMPLING LOCATIONS
Within Two Miles of Indian Point

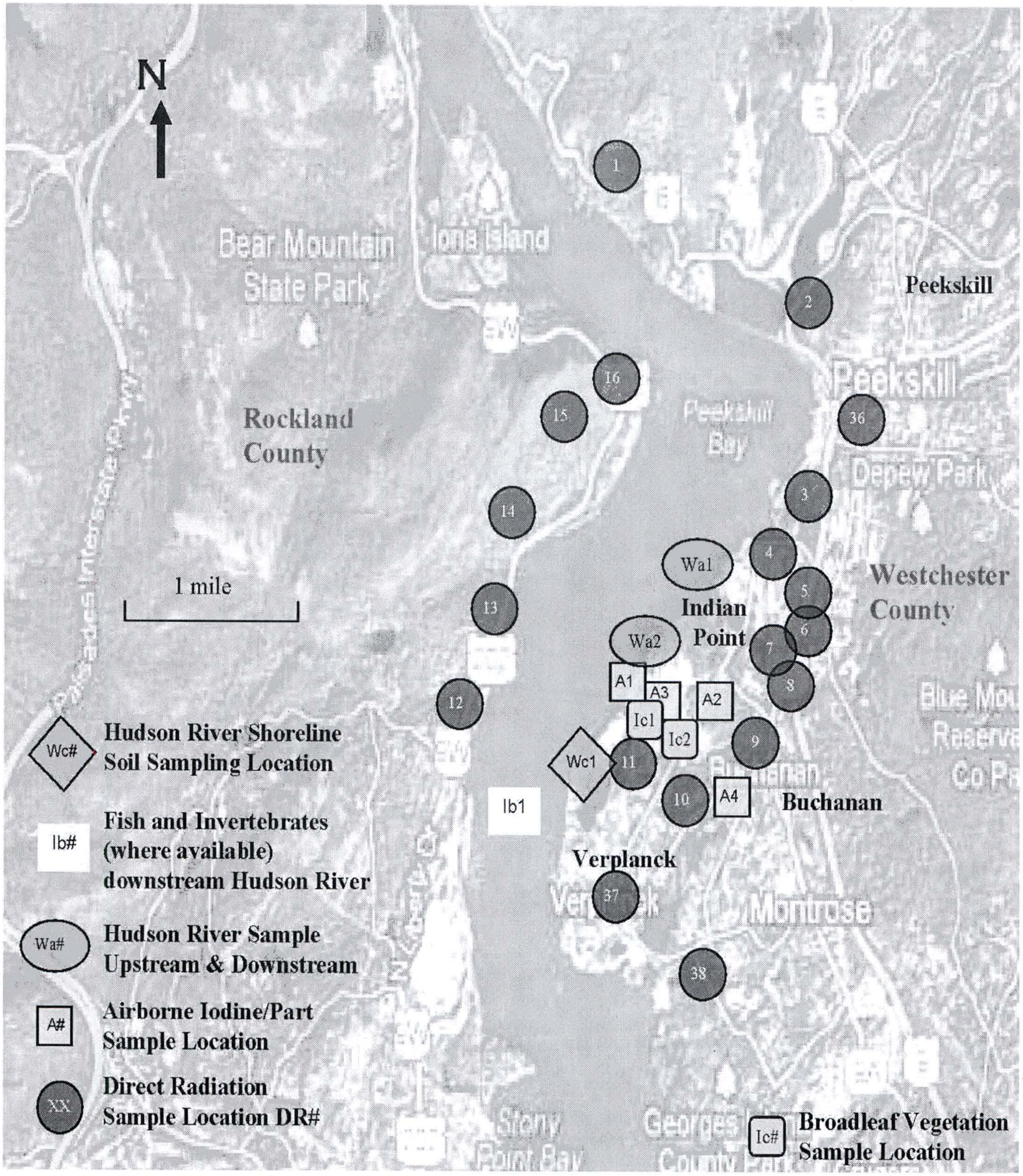


FIGURE A-2

SAMPLING LOCATIONS
Greater than Two Miles from Indian Point

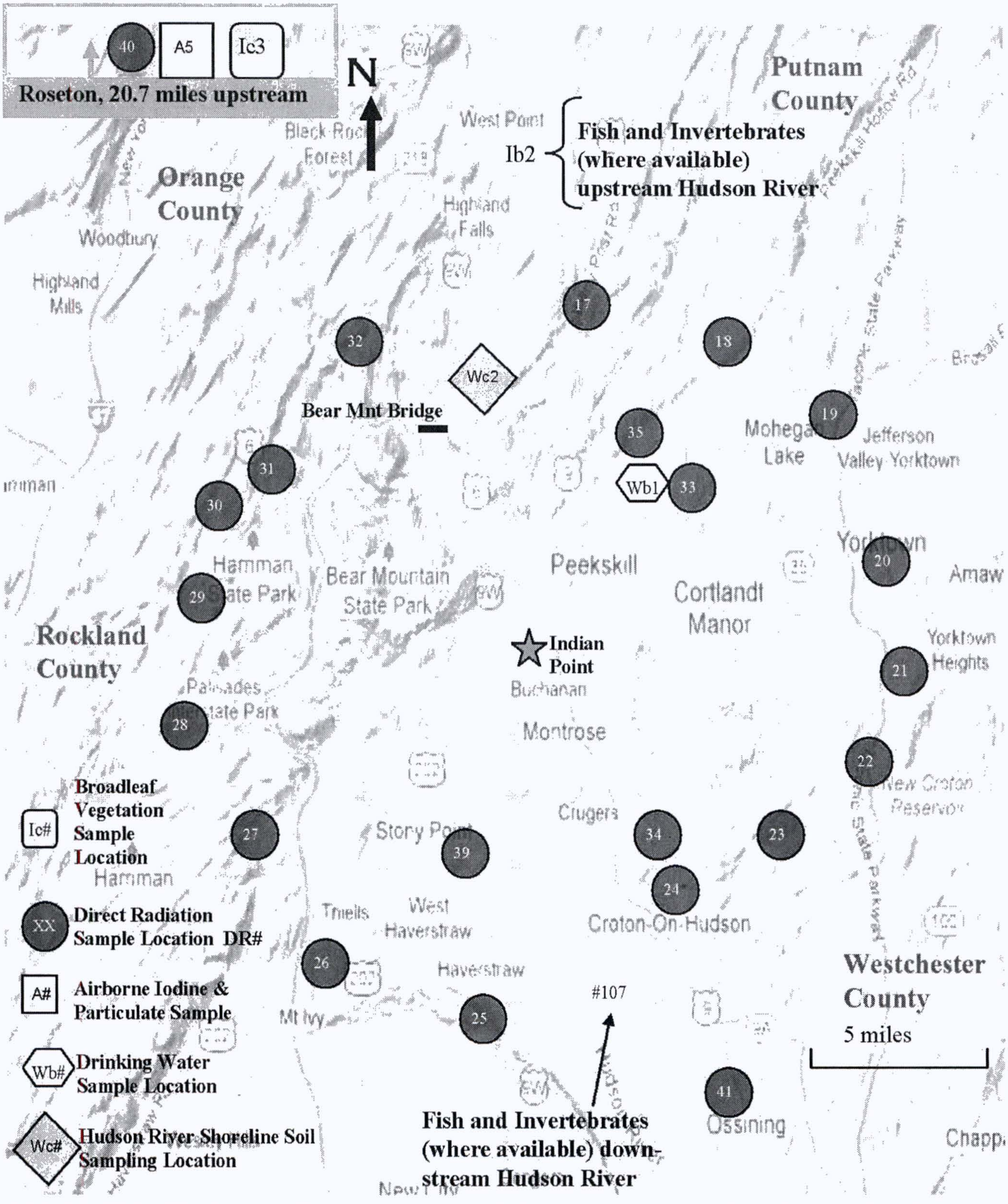


FIGURE A-3

SAMPLING LOCATIONS
Additional Sampling Locations

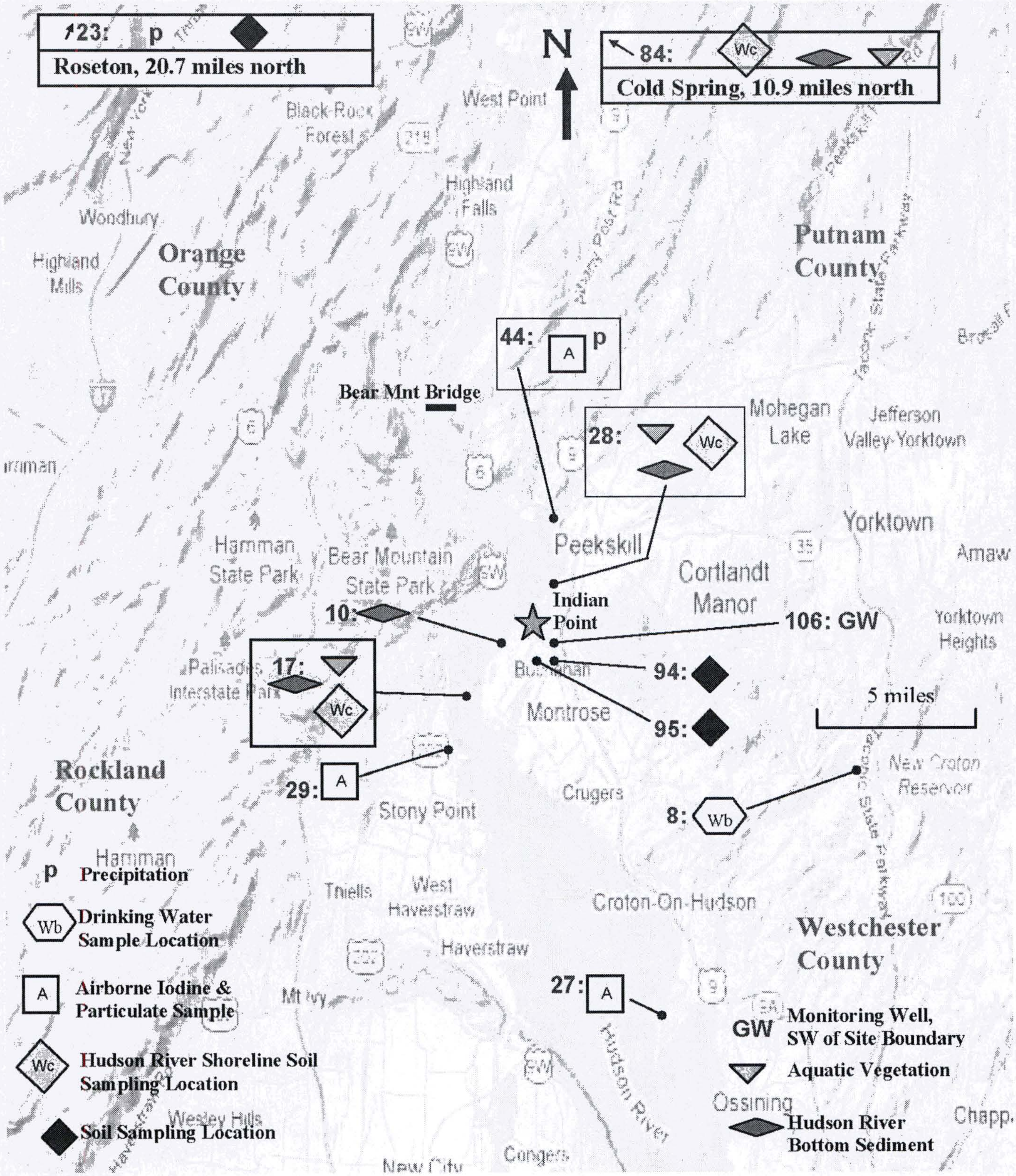


TABLE A-2

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 for H-3 and 15 for I-131.

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

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

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.

APPENDIX B

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM RESULTS SUMMARY

APPENDIX B

B.1 2016 Annual Radiological Environmental Monitoring Program Summary

The results of the 2016 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 2016. 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 the following radionuclides; 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.

B.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).

B.3 Sampling Deviations

During 2016, environmental sampling was performed for 12 unique media types addressed in the ODCM and for direct radiation. A total of 1169 samples of 1170 scheduled were obtained. Of the scheduled samples, 99.9% 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.

B.4 Analytical Deviations

No analytical deviations were found in 2016.

B.5 Special Reports

No special reports were required under the REMP.

TABLE B-1

Summary of Sampling Deviations - 2016

MEDIA	TOTAL SCHEDULED SAMPLES	NUMBER OF DEVIATIONS*	SAMPLING EFFICIENCY %	NUMBER OF ANALYSES**	REASON FOR DEVIATION
MEDIA					
TLD	164	1	99%	326	See Table B-1c
PARTICULATES IN AIR	416	0	100%	416	N/A
CHARCOAL FILTER	416	0	100%	416	N/A
PRECIPITATION	8	0	100%	16	N/A
DRINKING WATER	24	0	100%	56	N/A
GROUNDWATER SAMPLES	3	0	100%	12	N/A
SOIL	3	0	100%	3	N/A
BROAD LEAF VEGETATION	53	0	100%	53	N/A
HUDSON RIVER WATER	24	0	100%	33	N/A
SHORELINE SOIL	10	0	100%	20	N/A
HUDSON RIVER BOTTOM SEDIMENT	8	0	100%	8	N/A
AQUATIC VEGETATION	5	0	100%	5	N/A
FISH & INVERTEBRATES	35	0	100%	105	N/A
TOTALS	1169	1	99.9%	1469	

TOTAL NUMBER OF SAMPLES COLLECTED = 1168

* Samples not collected or unable to be analyzed.

** Several sample types require more than one analysis

TABLES B-1a / B-1b / B-1c

TABLE B-1a
2016 Air Sampling Deviations

LOCATION	DATE	PROBLEM / ACTIONS TO PREVENT RECURRENCE
Algonquin	5/31/2016	Delivered sample volume 7,300 ft3 vs. expected volume of >22,400 ft3 due to a tripped GFCI w/ 130 hrs outage time.(CR-IP2-2016-03486)
Meteorological Tower 95	6/13/2016	Actual sample volume of 17,300 ft3, versus an expected volume of 20,180ft3, due to electrical repair activity w/ 23.5 hrs outage time.(CR-IP2-2016-03853)
Roseton	10/24/2016	Particulate filter found mis-aligned in sample head.(CR-IP2-2016-06532)
Grassy Point 29	11/14/2016	Delivered sample volume 3,500 ft3 vs. expected volume of 20,854 ft3 due to a tripped GFCI w/ 139.1 hrs outage time.(CR-IP2-2016-06816)
Grassy Point 29	11/28/2016	Delivered sample volume 9,200 ft3 vs. expected volume of 20,493 ft3 due to a tripped GFCI w/ 91.2 hrs outage time.(CR-IP2-2016-07064)
Grassy Point 29	12/12/2016	Delivered sample volume 13,600 ft3 vs. expected volume of 20,362 ft3 due to a tripped GFCI w/ 56.0 hrs outage time.(CR-IP2-2016-07253)

TABLE B-1b
2016 Other Media Deviations

LOCATION	Date3	PROBLEM / ACTIONS TO PREVENT RECURRENCE
Met/Training	10/17/2016	Insufficient amount of broadleaf vegetation available for 2 of 6 species required.[CR-IP2-2016-02652] cb.
74 West Shore Drive-South	1/12/2017	Cupset and TLDs it contained were found to be missing during collection of 4th quarter 2016 TLDs. New cupset and TLDs were installed. cb. [CR IP2-2017-00319]

INDIAN POINT ENERGY CENTER
TABLE B-3
DIRECT RADIATION, QUARTERLY DATA - 2016

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	16.48 ± 0.9	16.9 ± 0.7	16.3 ± 0.8	14.8 ± 0.6	16.1 ± 0.1	
	DR-02	14.85 ± 0.6	15.8 ± 1.1	14.8 ± 0.7	14.3 ± 0.6	14.9 ± 0.2	
	DR-03	12.33 ± 0.6	13.2 ± 0.6	12.4 ± 0.6	11.9 ± 0.6	12.4 ± 0.0	
	DR-04	13.53 ± 0.8	14.7 ± 1.0	13.9 ± 0.6	12.3 ± 0.6	13.6 ± 0.2	
	DR-05	13.85 ± 0.9	14.8 ± 0.6	14.2 ± 0.6	13.3 ± 0.5	14.1 ± 0.2	
	DR-06	14.0 ± 0.7	15.5 ± 0.6	14.5 ± 0.6	13.9 ± 0.7	14.5 ± 0.1	
	DR-07	15.82 ± 0.9	17.2 ± 0.7	16.2 ± 0.7	15.3 ± 0.9	16.1 ± 0.1	
	DR-08	12.22 ± 0.7	13.2 ± 0.7	11.9 ± 0.5	11.3 ± 0.5	12.2 ± 0.1	
	DR-09	13.64 ± 0.5	14.6 ± 0.7	13.3 ± 0.6	13.6 ± 0.6	13.8 ± 0.1	
	DR-10	15.06 ± 0.8	15.1 ± 0.6	17.3 ± 0.8	14.1 ± 0.7	15.4 ± 0.1	
	DR-11	10.47 ± 0.8	11.9 ± 0.7	11.3 ± 0.7	10.1 ± 0.4	10.9 ± 0.1	
	DR-12	15.57 ± 0.9	17.6 ± 0.6	16.0 ± 0.7	(a)	16.4 ± 0.1	
	DR-13	16.65 ± 0.8	17.3 ± 1.0	16.3 ± 0.7	15.7 ± 1.0	16.5 ± 0.1	
	DR-14	13.0 ± 0.8	14.3 ± 0.6	13.5 ± 0.7	12.7 ± 0.6	13.4 ± 0.1	
	DR-15	12.62 ± 0.8	14.4 ± 0.8	13.6 ± 0.7	12.5 ± 0.6	13.3 ± 0.1	
	DR-16	14.29 ± 0.6	16.2 ± 0.9	14.6 ± 0.7	14.2 ± 0.6	14.8 ± 0.1	
	DR-17	14.84 ± 0.8	16.7 ± 1.4	14.8 ± 0.8	13.8 ± 0.7	15.1 ± 0.3	
	DR-18	14.61 ± 0.8	15.2 ± 0.7	14.0 ± 0.7	13.2 ± 0.7	14.3 ± 0.1	
	DR-19	14.62 ± 0.8	16.2 ± 0.8	15.0 ± 0.6	13.6 ± 0.5	14.8 ± 0.1	
	DR-20	13.91 ± 0.7	14.8 ± 0.5	14.4 ± 0.6	13.2 ± 0.5	14.1 ± 0.1	
	DR-21	13.82 ± 0.7	14.6 ± 0.7	14.4 ± 0.8	13.3 ± 0.7	14.0 ± 0.0	
	DR-22	11.47 ± 0.8	12.6 ± 0.5	11.6 ± 0.5	11.1 ± 0.5	11.7 ± 0.1	
	DR-23	14.11 ± 0.8	14.8 ± 0.7	14.9 ± 0.9	13.5 ± 0.6	14.3 ± 0.2	
	DR-24	14.81 ± 0.9	15.8 ± 0.8	15.1 ± 1.0	14.0 ± 0.7	14.9 ± 0.1	
	DR-25	11.77 ± 0.7	13.3 ± 0.6	12.3 ± 0.9	11.7 ± 0.5	12.3 ± 0.2	
	DR-26	13.75 ± 0.8	15.0 ± 0.8	14.3 ± 0.7	13.4 ± 0.7	14.1 ± 0.1	
	DR-27	13.38 ± 0.7	14.9 ± 0.5	14.0 ± 0.7	13.1 ± 0.7	13.9 ± 0.1	
	DR-28	20.24 ± 1.1	20.6 ± 0.9	20.6 ± 0.8	19.0 ± 0.7	20.1 ± 0.2	
	DR-29	13.63 ± 0.6	15.1 ± 0.8	14.7 ± 0.6	14.0 ± 0.7	14.4 ± 0.1	
	DR-30	14.17 ± 0.7	15.6 ± 0.8	14.6 ± 0.6	14.0 ± 0.7	14.6 ± 0.1	
	DR-31	16.24 ± 0.8	17.3 ± 0.8	17.0 ± 0.8	16.1 ± 0.6	16.7 ± 0.1	
	DR-32	13.48 ± 0.6	14.3 ± 0.7	13.6 ± 0.6	13.0 ± 0.9	13.6 ± 0.1	
	DR-33	13.72 ± 0.7	14.7 ± 0.7	13.9 ± 0.6	13.3 ± 0.5	13.9 ± 0.1	
	DR-34	13.0 ± 0.7	14.2 ± 0.6	13.3 ± 0.7	13.2 ± 0.5	13.4 ± 0.1	
	DR-35	13.45 ± 0.7	14.4 ± 0.6	13.5 ± 0.7	13.8 ± 0.6	13.8 ± 0.1	
	DR-36	14.16 ± 0.7	15.3 ± 0.5	14.8 ± 0.7	15.3 ± 0.6	14.9 ± 0.1	
	DR-37	13.61 ± 0.6	14.5 ± 0.7	14.1 ± 0.8	13.8 ± 0.7	14.0 ± 0.1	
	DR-38	11.89 ± 0.8	12.7 ± 0.6	12.6 ± 0.7	12.0 ± 0.7	12.3 ± 0.1	
	DR-39	14.11 ± 0.6	15.1 ± 0.7	15.4 ± 1.0	14.3 ± 0.6	14.7 ± 0.2	
	DR-40	14.71 ± 0.6	16.6 ± 0.9	16.7 ± 0.8	14.2 ± 1.0	15.5 ± 0.1	
	DR-41	13.21 ± 0.9	14.0 ± 0.9	13.8 ± 0.6	12.9 ± 0.6	13.5 ± 0.2	
AVERAGE (Indicator Locations)		14.0	15.1	14.5	13.6	14.3	

* Control location

(a) TLD missing, the annual total is based on using the 3 quarters average for the fourth quarter.

INDIAN POINT ENERGY CENTER
TABLE B-4
DIRECT RADIATION, 2005 THROUGH 2016 DATA

mR per Year

Station Number	Mean (2005-2015)	Standard Deviation (2005-2015)	Minimum Value (2005-2015)	Maximum Value (2005-2015)	2016 Annual Total
DR-01	60.4	2.2	55.6	63.6	64.5
DR-02	57.4	1.3	56.0	60.0	59.8
DR-03	46.8	1.4	44.4	48.8	49.8
DR-04	53.4	1.1	52.0	55.6	54.4
DR-05	54.6	1.2	53.2	56.8	56.2
DR-06	55.7	1.4	54.0	57.6	57.9
DR-07	63.1	1.8	61.2	66.4	64.5
DR-08	48.1	2.1	45.2	50.8	48.6
DR-09	52.3	1.5	50.0	54.8	55.1
DR-10	56.5	1.5	54.4	58.8	61.6
DR-11	43.3	1.2	41.6	45.6	43.8
DR-12	63.3	3.2	59.6	68.4	49.2
DR-13	72.2	7.3	62.4	82.0	66.0
DR-14	52.9	1.6	50.4	55.2	53.5
DR-15	52.6	1.3	50.4	54.8	53.1
DR-16	58.1	1.5	55.2	60.8	59.3
DR-17	58.4	1.8	55.6	61.2	60.1
DR-18	56.9	1.4	54.4	59.2	57.0
DR-19	59.1	1.4	56.0	60.8	59.4
DR-20	53.8	1.2	52.4	55.2	56.3
DR-21	54.7	1.8	52.0	57.6	56.1
DR-22	44.7	1.2	42.4	46.4	46.8
DR-23	55.5	1.2	53.6	58.0	57.3
DR-24	57.6	1.0	56.0	58.8	59.7
DR-25	49.1	1.8	45.6	52.4	49.1
DR-26	55.4	1.8	52.8	58.8	56.5
DR-27	53.8	1.3	51.6	56.4	55.4
DR-28	77.3	1.9	72.4	79.2	80.4
DR-29	56.6	1.2	54.8	58.8	57.4
DR-30	58.1	2.1	54.8	62.0	58.4
DR-31	65.9	2.6	61.6	70.0	66.6
DR-32	51.8	1.6	48.8	54.8	54.4
DR-33	54.0	0.9	52.4	55.2	55.6
DR-34	50.9	0.4	50.4	51.2	53.7
DR-35	52.5	2.1	50.0	56.4	55.2
DR-36	58.4	1.6	56.0	60.0	59.6
DR-37	54.4	1.9	52.0	58.0	56.0
DR-38	49.9	3.0	46.8	56.0	49.2
DR-39	58.9	2.5	54.8	61.6	58.9
DR-40	60.8	8.6	49.2	75.2	62.2
DR-41	50.8	1.2	48.4	52.4	53.9
					56.9
AVERAGE (Indicator Locations)	55.9				

* Control location

INDIAN POINT ENERGY CENTER
TABLE B-5
DIRECT RADIATION, INNER AND OUTER RINGS - 2016
(mR per Year)

Inner Ring	Outer Ring	Sector	Inner Ring	Outer Ring
ID	ID		Annual Average	Annual Average
DR-01	DR-17	N	64.48	60.14
DR-02	DR-18	NNE	59.75	57.01
DR-03	DR-19	NE	49.83	59.42
DR-04	DR-20	ENE	54.43	56.31
DR-05	DR-21	E	56.15	56.12
DR-06	DR-22	ESE	57.90	46.77
DR-07	DR-23	SE	64.52	57.31
DR-08	DR-24	SSE	48.62	59.71
DR-09	DR-25	S	55.14	49.07
DR-10	DR-26	SSW	61.56	56.45
DR-11	DR-27	SW	43.77	55.38
DR-12	DR-28	WSW	49.17	80.44
DR-13	DR-29	W	65.95	57.43
DR-14	DR-30	WNW	53.50	58.37
DR-15	DR-31	NW	53.12	66.64
DR-16	DR-32	NNW	59.29	54.38
Average			56.07	58.18

INDIAN POINT ENERGY CENTER
TABLE B-6
GROSS BETA ACTIVITY IN AIRBORNE PARTICULATE SAMPLES - 2016

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
01/04/16	0.015 ± 0.002	0.016 ± 0.002	0.014 ± 0.002	0.013 ± 0.002	0.011 ± 0.002	0.014 ± 0.002	0.014 ± 0.002	0.013 ± 0.002
01/11/16	0.016 ± 0.002	0.015 ± 0.002	0.017 ± 0.002	0.015 ± 0.002	0.017 ± 0.002	0.016 ± 0.002	0.017 ± 0.002	0.014 ± 0.002
01/19/16	0.020 ± 0.003	0.018 ± 0.002	0.018 ± 0.002	0.018 ± 0.002	0.019 ± 0.002	0.015 ± 0.002	0.018 ± 0.002	0.018 ± 0.002
01/25/16	0.009 ± 0.002	0.011 ± 0.002	0.013 ± 0.002	0.012 ± 0.002	0.012 ± 0.003	0.012 ± 0.003	0.008 ± 0.002	0.009 ± 0.002
02/01/16	0.017 ± 0.002	0.014 ± 0.002	0.017 ± 0.002	0.016 ± 0.002	0.016 ± 0.002	0.015 ± 0.002	0.016 ± 0.002	0.014 ± 0.002
02/08/16	0.014 ± 0.002	0.011 ± 0.002	0.016 ± 0.002	0.015 ± 0.002	0.013 ± 0.002	0.016 ± 0.002	0.013 ± 0.002	0.017 ± 0.002
02/16/16	0.014 ± 0.002	0.015 ± 0.002	0.015 ± 0.002	0.015 ± 0.002	0.016 ± 0.002	0.017 ± 0.002	0.014 ± 0.002	0.015 ± 0.002
02/22/16	0.013 ± 0.003	0.013 ± 0.002	0.013 ± 0.002	0.014 ± 0.003	0.013 ± 0.003	0.015 ± 0.003	0.013 ± 0.002	0.016 ± 0.003
02/29/16	0.013 ± 0.002	0.013 ± 0.002	0.015 ± 0.002	0.015 ± 0.002	0.014 ± 0.002	0.014 ± 0.002	0.012 ± 0.002	0.014 ± 0.002
03/07/16	0.020 ± 0.003	0.016 ± 0.002	0.015 ± 0.002	0.016 ± 0.002	0.019 ± 0.003	0.017 ± 0.003	0.014 ± 0.002	0.016 ± 0.002
03/14/16	0.018 ± 0.003	0.016 ± 0.002	0.018 ± 0.003	0.016 ± 0.002	0.019 ± 0.003	0.017 ± 0.003	0.016 ± 0.002	0.017 ± 0.003
03/21/16	0.013 ± 0.002	0.013 ± 0.002	0.010 ± 0.002	0.010 ± 0.002	0.012 ± 0.002	0.013 ± 0.002	0.012 ± 0.002	0.014 ± 0.002
03/28/16	0.016 ± 0.003	0.015 ± 0.002	0.014 ± 0.002	0.016 ± 0.002	0.016 ± 0.003	0.018 ± 0.003	0.015 ± 0.002	0.014 ± 0.002
04/04/16	0.015 ± 0.002	0.016 ± 0.002	0.016 ± 0.003	0.018 ± 0.003	0.017 ± 0.003	0.017 ± 0.003	0.017 ± 0.003	0.014 ± 0.002
04/11/16	0.015 ± 0.002	0.015 ± 0.002	0.015 ± 0.002	0.017 ± 0.003	0.015 ± 0.002	0.016 ± 0.002	0.017 ± 0.002	0.012 ± 0.002
04/18/16	0.018 ± 0.003	0.014 ± 0.002	0.018 ± 0.003	0.018 ± 0.003	0.017 ± 0.003	0.018 ± 0.003	0.017 ± 0.002	0.019 ± 0.003
04/25/16	0.017 ± 0.003	0.016 ± 0.002	0.017 ± 0.003	0.017 ± 0.003	0.016 ± 0.002	0.017 ± 0.003	0.016 ± 0.002	0.015 ± 0.002
05/02/16	0.015 ± 0.003	0.015 ± 0.002	0.019 ± 0.003	0.018 ± 0.003	0.016 ± 0.002	0.015 ± 0.002	0.014 ± 0.002	0.017 ± 0.003
05/09/16	0.008 ± 0.002	0.007 ± 0.002	0.006 ± 0.002	0.007 ± 0.002	0.008 ± 0.002	0.007 ± 0.002	0.007 ± 0.002	0.006 ± 0.002
05/16/16	0.016 ± 0.002	0.013 ± 0.002	0.012 ± 0.002	0.014 ± 0.002	0.014 ± 0.002	0.013 ± 0.002	0.014 ± 0.002	0.014 ± 0.002
05/23/16	0.014 ± 0.002	0.015 ± 0.002	0.011 ± 0.002	0.012 ± 0.002	0.014 ± 0.002	0.013 ± 0.002	0.014 ± 0.002	0.015 ± 0.002
05/31/16	0.030 ± 0.006	0.017 ± 0.002	0.019 ± 0.002	0.019 ± 0.003	0.020 ± 0.002	0.018 ± 0.002	0.019 ± 0.002	0.019 ± 0.002
06/06/16	0.014 ± 0.003	0.016 ± 0.003	0.015 ± 0.003	0.017 ± 0.003	0.015 ± 0.003	0.016 ± 0.003	0.015 ± 0.003	0.014 ± 0.003
06/13/16	0.013 ± 0.002	0.012 ± 0.002	0.011 ± 0.002	0.011 ± 0.002	0.012 ± 0.002	0.012 ± 0.002	0.013 ± 0.002	0.015 ± 0.003
06/20/16	0.014 ± 0.002	0.013 ± 0.002	0.012 ± 0.002	0.011 ± 0.002	0.012 ± 0.002	0.013 ± 0.002	0.012 ± 0.002	0.012 ± 0.002

INDIAN POINT ENERGY CENTER
TABLE B-6
GROSS BETA ACTIVITY IN AIRBORNE PARTICULATE SAMPLES - 2016

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
06/27/16	0.017 ± 0.003	0.014 ± 0.002	0.016 ± 0.003	0.017 ± 0.003	0.016 ± 0.002	0.016 ± 0.003	0.016 ± 0.003	0.014 ± 0.002
07/05/16	0.017 ± 0.002	0.018 ± 0.002	0.015 ± 0.002	0.018 ± 0.002	0.017 ± 0.002	0.016 ± 0.002	0.017 ± 0.002	0.016 ± 0.002
07/12/16	0.019 ± 0.003	0.018 ± 0.003	0.017 ± 0.002	0.017 ± 0.003	0.016 ± 0.002	0.018 ± 0.003	0.018 ± 0.003	0.015 ± 0.002
07/18/16	0.017 ± 0.003	0.020 ± 0.003	0.021 ± 0.003	0.021 ± 0.003	0.017 ± 0.003	0.020 ± 0.003	0.021 ± 0.003	0.016 ± 0.003
07/25/16	0.015 ± 0.003	0.018 ± 0.003	0.016 ± 0.003	0.015 ± 0.003	0.016 ± 0.003	0.013 ± 0.002	0.018 ± 0.003	0.017 ± 0.003
08/01/16	0.017 ± 0.003	0.017 ± 0.003	0.014 ± 0.002	0.016 ± 0.003	0.015 ± 0.002	0.015 ± 0.002	0.014 ± 0.002	0.015 ± 0.002
08/08/16	0.014 ± 0.003	0.016 ± 0.002	0.016 ± 0.002	0.016 ± 0.003	0.014 ± 0.002	0.014 ± 0.002	0.014 ± 0.002	0.013 ± 0.002
08/15/16	0.013 ± 0.002	0.013 ± 0.002	0.013 ± 0.002	0.016 ± 0.003	0.013 ± 0.002	0.013 ± 0.002	0.012 ± 0.002	0.013 ± 0.002
08/22/16	0.015 ± 0.002	0.013 ± 0.002	0.013 ± 0.002	0.015 ± 0.002	0.015 ± 0.002	0.015 ± 0.002	0.015 ± 0.002	0.015 ± 0.002
08/29/16	0.018 ± 0.003	0.018 ± 0.003	0.025 ± 0.003	0.018 ± 0.003	0.019 ± 0.003	0.021 ± 0.003	0.020 ± 0.003	0.022 ± 0.003
09/06/16	0.019 ± 0.003	0.018 ± 0.002	0.020 ± 0.003	0.016 ± 0.002	0.017 ± 0.002	0.018 ± 0.002	0.021 ± 0.003	0.017 ± 0.002
09/12/16	0.011 ± 0.002	0.010 ± 0.002	0.012 ± 0.002	0.011 ± 0.002	0.011 ± 0.002	0.012 ± 0.002	0.012 ± 0.002	0.012 ± 0.002
09/19/16	0.017 ± 0.003	0.015 ± 0.002	0.015 ± 0.002	0.014 ± 0.002	0.016 ± 0.002	0.016 ± 0.002	0.017 ± 0.003	0.019 ± 0.003
09/26/16	0.017 ± 0.003	0.014 ± 0.002	0.015 ± 0.002	0.016 ± 0.003	0.016 ± 0.002	0.015 ± 0.002	0.016 ± 0.003	0.016 ± 0.003
10/03/16	0.012 ± 0.002	0.011 ± 0.002	0.011 ± 0.002	0.012 ± 0.002	0.013 ± 0.002	0.012 ± 0.002	0.013 ± 0.002	0.013 ± 0.002
10/11/16	0.015 ± 0.002	0.015 ± 0.002	0.015 ± 0.002	0.016 ± 0.002	0.016 ± 0.002	0.020 ± 0.002	0.016 ± 0.002	0.014 ± 0.002
10/17/16	0.016 ± 0.003	0.015 ± 0.003	0.017 ± 0.003	0.016 ± 0.003	0.015 ± 0.003	0.014 ± 0.003	0.015 ± 0.003	0.015 ± 0.003
10/24/16	0.017 ± 0.003	0.018 ± 0.003	0.005 ± 0.002	0.016 ± 0.003	0.018 ± 0.003	0.018 ± 0.003	0.016 ± 0.003	0.016 ± 0.003
10/31/16	0.013 ± 0.002	0.010 ± 0.002	0.012 ± 0.002	0.015 ± 0.003	0.011 ± 0.002	0.013 ± 0.002	0.013 ± 0.002	0.014 ± 0.003
11/07/16	0.016 ± 0.002	0.016 ± 0.002	0.016 ± 0.002	0.017 ± 0.003	0.015 ± 0.002	0.017 ± 0.003	0.016 ± 0.002	0.016 ± 0.003
11/14/16	0.014 ± 0.002	0.016 ± 0.002	0.014 ± 0.002	0.014 ± 0.002	0.025 ± 0.009	0.016 ± 0.002	0.013 ± 0.002	0.015 ± 0.002
11/21/16	0.022 ± 0.003	0.024 ± 0.003	0.022 ± 0.003	0.024 ± 0.003	0.022 ± 0.003	0.024 ± 0.003	0.028 ± 0.003	0.025 ± 0.003
11/28/16	0.013 ± 0.002	0.014 ± 0.002	0.012 ± 0.002	0.013 ± 0.002	0.015 ± 0.004	0.014 ± 0.002	0.013 ± 0.002	0.013 ± 0.002
12/05/16	0.013 ± 0.002	0.015 ± 0.002	0.013 ± 0.002	0.016 ± 0.002	0.012 ± 0.002	0.012 ± 0.002	0.014 ± 0.002	0.013 ± 0.002
12/12/16	0.013 ± 0.002	0.013 ± 0.002	0.013 ± 0.002	0.012 ± 0.002	0.013 ± 0.003	0.011 ± 0.002	0.012 ± 0.002	0.013 ± 0.002
12/19/16	0.017 ± 0.003	0.015 ± 0.002	0.017 ± 0.002	0.018 ± 0.003	0.016 ± 0.002	0.016 ± 0.002	0.016 ± 0.002	0.016 ± 0.003
12/27/16	0.019 ± 0.003	0.018 ± 0.002	0.021 ± 0.003	0.021 ± 0.003	0.017 ± 0.002	0.017 ± 0.002	0.016 ± 0.002	0.018 ± 0.003

*Control Location

INDIAN POINT ENERGY CENTER
TABLE B-7
IODINE-131 ACTIVITY IN AIRBORNE CHARCOAL SAMPLES - 2016

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
01/04/16	< 0.053	< 0.050	< 0.055	< 0.050	< 0.055	< 0.057	< 0.050	< 0.055
01/11/16	< 0.038	< 0.015	< 0.031	< 0.036	< 0.017	< 0.032	< 0.035	< 0.037
01/19/16	< 0.047	< 0.043	< 0.043	< 0.044	< 0.044	< 0.046	< 0.044	< 0.045
01/25/16	< 0.039	< 0.015	< 0.027	< 0.036	< 0.028	< 0.029	< 0.037	< 0.038
02/01/16	< 0.032	< 0.029	< 0.043	< 0.030	< 0.043	< 0.045	< 0.030	< 0.044
02/08/16	< 0.024	< 0.022	< 0.032	< 0.022	< 0.032	< 0.033	< 0.022	< 0.034
02/16/16	< 0.011	< 0.004	< 0.016	< 0.011	< 0.016	< 0.016	< 0.011	< 0.011
02/22/16	< 0.031	< 0.011	< 0.030	< 0.030	< 0.031	< 0.032	< 0.030	< 0.033
02/29/16	< 0.042	< 0.039	< 0.038	< 0.040	< 0.039	< 0.040	< 0.040	< 0.040
03/07/16	< 0.032	< 0.029	< 0.029	< 0.030	< 0.029	< 0.030	< 0.031	< 0.031
03/14/16	< 0.025	< 0.024	< 0.024	< 0.025	< 0.024	< 0.025	< 0.025	< 0.025
03/21/16	< 0.016	< 0.008	< 0.011	< 0.015	< 0.011	< 0.012	< 0.016	< 0.017
03/28/16	< 0.022	< 0.020	< 0.022	< 0.021	< 0.022	< 0.023	< 0.021	< 0.023
04/04/16	< 0.035	< 0.034	< 0.047	< 0.036	< 0.047	< 0.048	< 0.034	< 0.044
04/11/16	< 0.040	< 0.039	< 0.044	< 0.040	< 0.043	< 0.044	< 0.040	< 0.043
04/18/16	< 0.034	< 0.033	< 0.059	< 0.034	< 0.062	< 0.064	< 0.013	< 0.060
04/25/16	< 0.026	< 0.026	< 0.034	< 0.027	< 0.013	< 0.032	< 0.026	< 0.033
05/02/16	< 0.027	< 0.026	< 0.043	< 0.027	< 0.040	< 0.041	< 0.028	< 0.042
05/09/16	< 0.023	< 0.023	< 0.041	< 0.023	< 0.037	< 0.039	< 0.023	< 0.039
05/16/16	< 0.034	< 0.033	< 0.029	< 0.034	< 0.026	< 0.027	< 0.034	< 0.028
05/23/16	< 0.033	< 0.033	< 0.033	< 0.034	< 0.031	< 0.031	< 0.033	< 0.031
05/31/16	< 0.053	< 0.018	< 0.025	< 0.018	< 0.025	< 0.026	< 0.018	< 0.026
06/06/16	< 0.059	< 0.056	< 0.032	< 0.059	< 0.032	< 0.033	< 0.057	< 0.024
06/13/16	< 0.031	< 0.030	< 0.021	< 0.031	< 0.052	< 0.053	< 0.031	< 0.060
06/20/16	< 0.044	< 0.043	< 0.035	< 0.045	< 0.035	< 0.036	< 0.044	< 0.034
06/27/16	< 0.029	< 0.029	< 0.024	< 0.030	< 0.024	< 0.011	< 0.028	< 0.011

*Control Location

INDIAN POINT ENERGY CENTER
TABLE B-7
IODINE-131 ACTIVITY IN AIRBORNE CHARCOAL SAMPLES - 2016

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
01/04/16	< 0.053	< 0.050	< 0.055	< 0.050	< 0.055	< 0.057	< 0.050	< 0.055
07/05/16	< 0.035	< 0.033	< 0.040	< 0.034	< 0.040	< 0.041	< 0.035	< 0.039
07/12/16	< 0.057	< 0.053	< 0.053	< 0.056	< 0.053	< 0.054	< 0.056	< 0.021
07/18/16	< 0.027	< 0.026	< 0.037	< 0.027	< 0.036	< 0.036	< 0.027	< 0.036
07/25/16	< 0.038	< 0.036	< 0.035	< 0.041	< 0.039	< 0.040	< 0.038	< 0.039
08/01/16	< 0.045	< 0.045	< 0.055	< 0.046	< 0.055	< 0.056	< 0.045	< 0.053
08/08/16	< 0.023	< 0.021	< 0.025	< 0.022	< 0.025	< 0.025	< 0.023	< 0.026
08/15/16	< 0.016	< 0.015	< 0.013	< 0.015	< 0.013	< 0.013	< 0.016	< 0.013
08/22/16	< 0.018	< 0.017	< 0.019	< 0.017	< 0.019	< 0.019	< 0.018	< 0.020
08/29/16	< 0.058	< 0.055	< 0.043	< 0.057	< 0.044	< 0.044	< 0.058	< 0.022
09/06/16	< 0.037	< 0.034	< 0.033	< 0.036	< 0.034	< 0.034	< 0.037	< 0.035
09/12/16	< 0.048	< 0.046	< 0.031	< 0.048	< 0.032	< 0.032	< 0.048	< 0.012
09/19/16	< 0.041	< 0.038	< 0.035	< 0.040	< 0.035	< 0.035	< 0.041	< 0.037
09/26/16	< 0.034	< 0.032	< 0.027	< 0.034	< 0.027	< 0.028	< 0.035	< 0.028
10/03/16	< 0.037	< 0.034	< 0.044	< 0.036	< 0.044	< 0.046	< 0.037	< 0.047
10/11/16	< 0.038	< 0.037	< 0.011	< 0.038	< 0.030	< 0.031	< 0.039	< 0.030
10/17/16	< 0.038	< 0.034	< 0.028	< 0.036	< 0.028	< 0.029	< 0.038	< 0.030
10/24/16	< 0.059	< 0.056	< 0.038	< 0.059	< 0.014	< 0.037	< 0.055	< 0.039
10/31/16	< 0.047	< 0.044	< 0.038	< 0.046	< 0.039	< 0.040	< 0.045	< 0.040
11/07/16	< 0.032	< 0.031	< 0.025	< 0.031	< 0.025	< 0.026	< 0.030	< 0.027
11/14/16	< 0.026	< 0.010	< 0.025	< 0.027	< 0.057	< 0.026	< 0.025	< 0.026
11/21/16	< 0.044	< 0.042	< 0.045	< 0.044	< 0.043	< 0.044	< 0.017	< 0.046
11/28/16	< 0.010	< 0.016	< 0.023	< 0.018	< 0.054	< 0.025	< 0.017	< 0.026
12/05/16	< 0.031	< 0.029	< 0.023	< 0.031	< 0.023	< 0.025	< 0.029	< 0.025
12/12/16	< 0.028	< 0.030	< 0.021	< 0.028	< 0.033	< 0.023	< 0.027	< 0.023
12/19/16	< 0.035	< 0.037	< 0.039	< 0.035	< 0.040	< 0.043	< 0.034	< 0.043
12/27/16	< 0.032	< 0.032	< 0.011	< 0.031	< 0.020	< 0.021	< 0.030	< 0.022

*Control Location

INDIAN POINT ENERGY CENTER
TABLE B-8
GAMMA EMITTERS IN AIRBORNE PARTICULATE SAMPLES - 2016

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	90 ± 22	191 ± 36	68 ± 26	103 ± 20	123 ± 27	145 ± 34	105 ± 30	80 ± 16
K-40	< 10	< 6	< 26	< 28	< 21	< 12	< 24	< 23
Mn-54	< 1	< 2	< 2	< 2	< 1	< 2	< 2	< 1
Co-58	< 2	< 3	< 3	< 2	< 2	< 3	< 3	< 2
Fe-59	< 4	< 7	< 10	< 5	< 8	< 11	< 8	< 6
Co-60	< 1	< 1	< 1	< 1	< 1	< 2	< 2	< 1
Zn-65	< 3	< 4	< 3	< 3	< 2	< 4	< 5	< 4
Nb-95	< 2	< 2	< 3	< 2	< 2	< 3	< 4	< 2
Zr-95	< 5	< 5	< 5	< 4	< 4	< 7	< 7	< 3
Ru-103	< 3	< 4	< 5	< 3	< 3	< 5	< 5	< 3
Ru-106	< 7	< 14	< 10	< 12	< 10	< 18	< 15	< 13
I-131	< 1020	< 881	< 1030	< 169	< 1190	< 956	< 1090	< 169
Cs-134	< 1	< 2	< 1	< 1	< 1	< 2	< 2	< 1
Cs-137	< 1	< 1	< 1	< 1	< 1	< 2	< 2	< 1
Ba-140	< 258	< 303	< 271	< 85	< 293	< 292	< 339	< 101
La-140	< 136	< 108	< 115	< 46	< 89	< 127	< 102	< 40
Ce-141	< 7	< 8	< 6	< 6	< 5	< 9	< 9	< 5
Ce-144	< 6	< 7	< 6	< 8	< 5	< 8	< 8	< 8
Ra-226	< 19	< 24	< 20	< 21	< 17	< 29	< 26	< 26
Ac-228	< 4	< 5	< 4	< 5	< 3	< 6	< 6	< 5
Th-228	< 1	< 2	< 2	< 2	< 2	< 2	< 2	< 2

INDIAN POINT ENERGY CENTER
TABLE B-8
GAMMA EMITTERS IN AIRBORNE PARTICULATE SAMPLES - 2016

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	120 ± 27	172 ± 40	130 ± 24	62 ± 18	94 ± 32	139 ± 29	119 ± 22	74 ± 16
K-40	< 13	23 ± 14	< 18	< 29	< 29	< 10	< 29	< 18
Mn-54	< 1	< 2	< 1	< 1	< 1	< 1	< 2	< 1
Co-58	< 3	< 3	< 2	< 2	< 3	< 3	< 3	< 1
Fe-59	< 9	< 7	< 6	< 5	< 8	< 11	< 8	< 3
Co-60	< 1	< 2	< 1	< 1	< 1	< 2	< 1	< 1
Zn-65	< 4	< 5	< 3	< 4	< 3	< 6	< 4	< 2
Nb-95	< 3	< 4	< 2	< 2	< 3	< 2	< 4	< 2
Zr-95	< 4	< 4	< 4	< 3	< 5	< 6	< 6	< 2
Ru-103	< 5	< 6	< 4	< 3	< 4	< 4	< 5	< 2
Ru-106	< 13	< 13	< 9	< 11	< 13	< 12	< 14	< 9
I-131	< 1420	< 1120	< 984	< 152	< 1210	< 757	< 1340	< 135
Cs-134	< 1	< 2	< 1	< 1	< 1	< 1	< 2	< 1
Cs-137	< 1	< 2	< 1	< 1	< 1	< 1	< 1	< 1
Ba-140	< 388	< 352	< 119	< 95	< 294	< 315	< 304	< 64
La-140	< 138	< 146	< 67	< 37	< 123	< 126	< 89	< 20
Ce-141	< 7	< 9	< 7	< 4	< 7	< 7	< 10	< 4
Ce-144	< 8	< 10	< 6	< 5	< 6	< 7	< 9	< 5
Ra-226	< 25	< 29	< 18	< 19	< 21	< 25	< 30	< 15
Ac-228	< 5	< 6	< 3	< 5	< 4	< 6	< 6	< 3
Th-228	< 2	< 3	< 2	< 2	< 2	< 2	< 2	< 1

* Control Location

INDIAN POINT ENERGY CENTER
TABLE B-8
GAMMA EMITTERS IN AIRBORNE PARTICULATE SAMPLES - 2016

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	89 ± 24	147 ± 31	84 ± 19	84 ± 31	122 ± 29	144 ± 27	98 ± 36	69 ± 17
K-40	< 12	< 14	< 22	< 34	< 36	< 15	< 28	< 11
Mn-54	< 1	< 2	< 1	< 2	< 2	< 1	< 2	< 1
Co-58	< 2	< 3	< 3	< 3	< 3	< 2	< 3	< 2
Fe-59	< 7	< 7	< 8	< 6	< 13	< 8	< 10	< 6
Co-60	< 1	< 1	< 2	< 2	< 2	< 1	< 1	< 1
Zn-65	< 4	< 4	< 4	< 5	< 5	< 2	< 4	< 3
Nb-95	< 3	< 3	< 3	< 3	< 4	< 2	< 4	< 2
Zr-95	< 4	< 3	< 4	< 5	< 8	< 4	< 6	< 3
Ru-103	< 4	< 5	< 3	< 5	< 5	< 3	< 4	< 3
Ru-106	< 11	< 12	< 13	< 18	< 17	< 12	< 17	< 12
I-131	< 1130	< 869	< 974	< 263	< 1790	< 760	< 1290	< 208
Cs-134	< 1	< 1	< 1	< 2	< 2	< 1	< 2	< 1
Cs-137	< 1	< 1	< 1	< 2	< 2	< 1	< 2	< 1
Ba-140	< 189	< 259	< 331	< 164	< 475	< 255	< 355	< 92
La-140	< 122	< 130	< 95	< 41	< 179	< 124	< 123	< 50
Ce-141	< 6	< 7	< 6	< 6	< 10	< 8	< 8	< 5
Ce-144	< 6	< 7	< 6	< 10	< 9	< 7	< 8	< 7
Ra-226	< 20	< 23	< 18	< 33	< 31	< 22	< 26	< 25
Ac-228	< 4	< 5	< 4	< 9	< 7	< 4	< 6	< 5
Th-228	< 2	< 2	< 2	< 3	< 2	< 2	< 3	< 2

INDIAN POINT ENERGY CENTER

TABLE B-8

GAMMA EMITTERS IN AIRBORNE PARTICULATE SAMPLES - 2016

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	76 ± 24	164 ± 27	139 ± 27	64 ± 26	91 ± 39	192 ± 32	104 ± 33	74 ± 20
K-40	< 21	< 16	< 20	< 26	< 40	< 13	< 13	< 21
Mn-54	< 1	< 1	< 1	< 2	< 2	< 2	< 2	< 1
Co-58	< 3	< 1	< 3	< 3	< 5	< 3	< 4	< 2
Fe-59	< 9	< 7	< 9	< 5	< 11	< 9	< 13	< 6
Co-60	< 2	< 1	< 1	< 2	< 2	< 2	< 2	< 1
Zn-65	< 3	< 3	< 3	< 5	< 6	< 4	< 5	< 3
Nb-95	< 3	< 2	< 3	< 4	< 5	< 3	< 4	< 2
Zr-95	< 4	< 3	< 4	< 5	< 9	< 6	< 4	< 4
Ru-103	< 4	< 4	< 4	< 4	< 8	< 4	< 5	< 3
Ru-106	< 11	< 11	< 12	< 18	< 19	< 13	< 15	< 12
I-131	< 1240	< 756	< 1020	< 234	< 2160	< 933	< 1300	< 145
Cs-134	< 1	< 1	< 2	< 2	< 2	< 1	< 2	< 1
Cs-137	< 1	< 1	< 1	< 2	< 2	< 1	< 1	< 1
Ba-140	< 347	< 241	< 200	< 125	< 524	< 250	< 461	< 100
La-140	< 135	< 75	< 127	< 42	< 203	< 80	< 134	< 37
Ce-141	< 7	< 6	< 7	< 5	< 11	< 8	< 8	< 4
Ce-144	< 7	< 7	< 6	< 7	< 9	< 8	< 7	< 6
Ra-226	< 19	< 22	< 24	< 26	< 34	< 25	< 27	< 21
Ac-228	< 5	< 4	< 5	< 5	< 8	< 5	< 5	< 3
Th-228	< 2	< 2	< 2	< 2	< 3	< 2	< 2	< 2

INDIAN POINT ENERGY CENTER
TABLE B-9
RADIONUCLIDES IN RAINWATER SAMPLES - 2016

10^{-3} pCi/m^{3} ± 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	< 189	< 191	< 188	< 196	< 188	< 191	< 189	< 190
GAMMA								
Be-7	< 9	32 ± 15	< 10	< 10	< 13	< 17	< 10	< 13
K-40	< 6	< 31	< 7	< 7	< 5	< 10	< 6	52 ± 26
Mn-54	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Co-58	< 1	< 2	< 1	< 1	< 1	< 2	< 1	< 1
Fe-59	< 2	< 5	< 3	< 2	< 3	< 4	< 2	< 2
Co-60	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Zn-65	< 1	< 3	< 2	< 1	< 1	< 2	< 1	< 1
Nb-95	< 1	< 2	< 1	< 1	< 1	< 2	< 1	< 1
Zr-95	< 2	< 4	< 2	< 1	< 2	< 3	< 2	< 2
Ru-103	< 1	< 3	< 1	< 1	< 1	< 2	< 1	< 2
Ru-106	< 5	< 13	< 7	< 6	< 7	< 11	< 7	< 7
I-131	< 37	< 91	< 43	< 53	< 45	< 79	< 46	< 63
Cs-134	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Cs-137	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Ba-140	< 29	< 64	< 35	< 35	< 32	< 56	< 34	< 41
La-140	< 9	< 20	< 9	< 12	< 10	< 17	< 10	< 15
Ce-141	< 3	< 6	< 3	< 3	< 3	< 5	< 3	< 3
Ce-144	< 5	< 10	< 5	< 5	< 6	< 9	< 6	< 6
Ra-226	< 19	< 37	< 15	< 16	< 18	< 25	< 16	< 19
Ac-228	< 3	< 5	< 3	< 3	< 3	< 5	< 2	< 4
Th-228	< 1	4 ± 3	< 1	< 2	< 2	< 2	< 1	< 2

* Control Location

INDIAN POINT ENERGY CENTER
TABLE B-10
RADIONUCLIDES IN DRINKING WATER SAMPLES - 2016

pCi/L ± 2 Sigma

Camp Field
7

DATE	1/12/2016	2/17/2016	3/15/2016	4/12/2016	5/10/2016	6/13/2016
RADIOCHEMICAL						
Gr-B	4 ± 2	3 ± 2	< 2	< 3	4 ± 2	2 ± 2
H-3 (a)			< 196			< 194
GAMMA						
Be-7	< 43	< 28	< 48	< 75	< 37	< 51
K-40	< 100	< 27	< 103	< 128	< 95	< 51
Mn-54	< 6	< 2	< 7	< 7	< 5	< 6
Co-58	< 6	< 3	< 6	< 8	< 4	< 7
Fe-59	< 14	< 4	< 12	< 17	< 11	< 13
Co-60	< 7	< 3	< 5	< 7	< 5	< 7
Zn-65	< 11	< 5	< 13	< 20	< 8	< 14
Nb-95	< 5	< 3	< 5	< 8	< 5	< 6
Zr-95	< 17	< 5	< 9	< 14	< 8	< 12
Ru-103	< 5	< 3	< 6	< 9	< 5	< 7
Ru-106	< 49	< 26	< 48	< 73	< 49	< 58
I-131	< 11	< 5	< 6	< 15	< 8	< 9
Cs-134	< 6	< 3	< 5	< 9	< 5	< 7
Cs-137	< 4	< 3	< 5	< 10	< 5	< 7
Ba-140	< 27	< 15	< 23	< 38	< 22	< 27
La-140	< 12	< 4	< 8	< 7	< 6	< 12
Ce-141	< 10	< 6	< 10	< 18	< 10	< 9
Ce-144	< 48	< 25	< 41	< 78	< 39	< 37
Ra-226	< 180	< 77	< 164	< 241	< 137	< 137
Ac-228	< 34	< 9	< 16	< 26	< 16	< 22
Th-228	< 14	< 6	< 14	< 20	< 11	< 11

(a) Quarterly Composite

INDIAN POINT ENERGY CENTER
TABLE B-10
RADIONUCLIDES IN DRINKING WATER SAMPLES - 2016

pCi/L ± 2 Sigma

	Camp Field 7					
DATE	7/11/2016	8/10/2016	9/12/2016	10/12/2016	11/15/2016	12/12/2016
RADIOCHEMICAL						
Gr-B	< 3	2 ± 1	< 2	3 ± 2	< 2	3 ± 2
H-3 (a)			< 149			< 189
GAMMA						
Be-7	< 61	< 38	< 58	< 46	< 62	< 32
K-40	< 159	< 47	< 42	< 38	< 106	< 92
Mn-54	< 8	< 6	< 8	< 6	< 5	< 3
Co-58	< 6	< 5	< 9	< 5	< 7	< 4
Fe-59	< 13	< 11	< 14	< 11	< 12	< 8
Co-60	< 7	< 7	< 7	< 5	< 8	< 4
Zn-65	< 16	< 10	< 13	< 11	< 10	< 8
Nb-95	< 7	< 5	< 8	< 6	< 5	< 4
Zr-95	< 12	< 10	< 13	< 9	< 8	< 7
Ru-103	< 7	< 6	< 9	< 5	< 7	< 4
Ru-106	< 52	< 54	< 76	< 47	< 62	< 34
I-131	< 11	< 9	< 11	< 8	< 8	< 4
Cs-134	< 7	< 6	< 8	< 5	< 6	< 3
Cs-137	< 8	< 5	< 8	< 5	< 7	< 4
Ba-140	< 32	< 19	< 32	< 26	< 29	< 14
La-140	< 8	< 7	< 15	< 9	< 6	< 4
Ce-141	< 13	< 10	< 14	< 9	< 13	< 7
Ce-144	< 51	< 47	< 58	< 41	< 54	< 27
Ra-226	< 202	< 161	< 222	< 144	< 211	< 109
Ac-228	< 31	< 23	< 18	< 22	< 23	< 17
Th-228	< 13	< 12	< 16	< 11	< 14	< 7

(a) Quarterly Composite

INDIAN POINT ENERGY CENTER
TABLE B-10
RADIONUCLIDES IN DRINKING WATER SAMPLES - 2016

pCi/L ± 2 Sigma

	Croton 8					
DATE	1/12/2016	2/17/2016	3/15/2016	4/12/2016	5/10/2016	6/8/2015
RADIOCHEMICAL						
Gr-B	3 ± 2	4 ± 2	< 2	< 2	3 ± 1	< 2
H-3 (a)			< 198			< 191
GAMMA						
Be-7	< 56	< 30	< 51	< 52	< 31	< 11
K-40	< 56	< 80	< 181	< 43	< 65	< 26
Mn-54	< 7	< 4	< 7	< 5	< 3	< 1
Co-58	< 6	< 4	< 6	< 6	< 4	< 1
Fe-59	< 15	< 8	< 16	< 12	< 6	< 2
Co-60	< 11	< 4	< 7	< 5	< 3	< 1
Zn-65	< 16	< 8	< 17	< 11	< 7	< 2
Nb-95	< 6	< 4	< 8	< 5	< 3	< 1
Zr-95	< 15	< 7	< 12	< 11	< 5	< 2
Ru-103	< 7	< 5	< 7	< 6	< 4	< 1
Ru-106	< 65	< 37	< 74	< 52	< 30	< 11
I-131	< 10	< 6	< 9	< 9	< 4	< 2
Cs-134	< 6	< 4	< 6	< 6	< 3	< 1
Cs-137	< 7	< 4	< 6	< 6	< 4	< 2
Ba-140	< 37	< 18	< 28	< 24	< 13	< 6
La-140	< 15	< 6	< 11	< 9	< 4	< 2
Ce-141	< 12	< 6	< 12	< 12	< 6	< 2
Ce-144	< 45	< 23	< 48	< 40	< 28	< 10
Ra-226	< 190	< 76	< 199	< 136	< 86	< 38
Ac-228	< 36	< 16	< 28	< 24	< 10	< 6
Th-228	< 16	< 7	< 16	< 11	< 7	< 3

(a) Quarterly Composite

INDIAN POINT ENERGY CENTER
TABLE B-10
RADIONUCLIDES IN DRINKING WATER SAMPLES - 2016

pCi/L ± 2 Sigma

	Croton 8					
DATE	7/11/2016	8/10/2016	9/12/2016	10/12/2016	11/15/2016	12/12/2016
RADIOCHEMICAL						
Gr-B	< 3	4 ± 2	< 2	3 ± 2	3 ± 2	< 2
H-3 (a)			< 148			< 189
GAMMA						
Be-7	< 50	< 47	< 40	< 53	< 77	< 33
K-40	< 110	< 96	< 88	< 55	< 179	< 73
Mn-54	< 6	< 5	< 4	< 6	< 9	< 4
Co-58	< 5	< 6	< 5	< 6	< 9	< 3
Fe-59	< 8	< 11	< 8	< 13	< 20	< 8
Co-60	< 7	< 5	< 5	< 7	< 8	< 4
Zn-65	< 15	< 11	< 9	< 11	< 17	< 8
Nb-95	< 7	< 5	< 4	< 6	< 10	< 4
Zr-95	< 10	< 9	< 7	< 9	< 16	< 6
Ru-103	< 6	< 5	< 4	< 7	< 11	< 4
Ru-106	< 48	< 43	< 39	< 66	< 83	< 37
I-131	< 9	< 8	< 6	< 10	< 12	< 4
Cs-134	< 7	< 5	< 5	< 6	< 11	< 4
Cs-137	< 8	< 4	< 4	< 7	< 9	< 4
Ba-140	< 23	< 25	< 16	< 27	< 37	< 15
La-140	< 10	< 6	< 8	< 10	< 8	< 5
Ce-141	< 12	< 9	< 8	< 11	< 20	< 7
Ce-144	< 55	< 37	< 35	< 49	< 94	< 31
Ra-226	< 153	< 129	< 113	< 181	< 277	< 103
Ac-228	< 23	< 20	< 18	< 26	< 33	< 16
Th-228	< 12	< 10	< 9	< 14	< 22	< 8

(a) Quarterly Composite

INDIAN POINT ENERGY CENTER
TABLE B-11
RADIONUCLIDES IN GROUNDWATER SAMPLES - 2016

pCi/L ± 2 Sigma

	Lafarge Monitoring Well 106		
DATE	5/12/2016	6/29/2016	11/2/2016
RADIOCHEMICAL			
H-3	< 180	< 180	< 191
Ni-63	< 11	< 11	< 12
Sr-90	0.8 ± 1	< 0.5	< 1
GAMMA			
Be-7	< 27	< 48	< 68
K-40	< 66	< 137	< 82
Mn-54	< 3	< 6	< 6
Co-58	< 3	< 7	< 8
Fe-59	< 6	< 11	< 17
Co-60	< 3	< 7	< 7
Zn-65	< 6	< 17	< 15
Nb-95	< 3	< 9	< 8
Zr-95	< 5	< 10	< 12
Ru-103	< 4	< 7	< 9
Ru-106	< 28	< 51	< 59
Cs-134	< 3	< 6	< 7
Cs-137	13 ± 3	< 7	< 9
Ba-140	< 16	< 29	< 36
La-140	< 5	< 8	< 13
Ce-141	< 6	< 13	< 16
Ce-144	< 24	< 49	< 66
Ac-228	< 13	< 33	< 36

INDIAN POINT ENERGY CENTER
TABLE B-12
GAMMA EMITTERS IN SOIL SAMPLES, 2016

pCi/kg dry ± 2 Sigma

	Roseton 23*	Training Building 94	Met Tower 95
DATE	9/12/2016	9/12/2016	9/12/2016
Be-7	< 497	< 392	< 447
K-40	28600 ± 1610	13200 ± 1140	13900 ± 1210
Mn-54	< 64	< 42	< 51
Co-58	< 58	< 44	< 51
Fe-59	< 129	< 108	< 118
Co-60	< 57	< 45	< 47
Zn-65	< 145	< 104	< 96
Nb-95	< 69	< 49	< 58
Zr-95	< 105	< 80	< 84
Ru-103	< 59	< 45	< 52
Ru-106	< 532	< 375	< 397
I-131	< 102	< 79	< 86
Cs-134	< 55	< 41	< 44
Cs-137	< 63	142 ± 60	242 ± 55
Ba-140	< 315	< 220	< 242
La-140	< 79	< 62	< 66
Ce-141	< 100	< 76	< 73
Ce-144	< 372	< 285	< 288
Ra-226	< 1240	< 932	< 899
Th-228	1260 ± 101	495 ± 59	776 ± 86

* Control Location

INDIAN POINT ENERGY CENTER
TABLE B-13
GAMMA EMITTERS IN BROADLEAF VEGETATION SAMPLES - 2016

pCi/kg wet ± 2 Sigma

	Roseton 23*					
DATE	05/18/16	05/18/16	05/18/16	06/27/16	06/27/16	06/27/16
GAMMA						
Be-7	< 301	438 ± 224	1580 ± 308	872 ± 223	1290 ± 257	862 ± 255
K-40	3870 ± 694	3700 ± 542	6280 ± 626	3150 ± 528	7270 ± 689	5910 ± 645
Mn-54	< 26	< 25	< 24	< 27	< 21	< 34
Co-58	< 27	< 22	< 22	< 26	< 27	< 30
Fe-59	< 53	< 60	< 59	< 53	< 61	< 77
Co-60	< 28	< 21	< 25	< 25	< 29	< 34
Zn-65	< 71	< 51	< 45	< 60	< 61	< 73
Nb-95	< 31	< 25	< 22	< 27	< 27	< 33
Zr-95	< 52	< 48	< 48	< 45	< 46	< 59
Ru-103	< 28	< 23	< 22	< 28	< 28	< 30
Ru-106	< 251	< 207	< 233	< 209	< 244	< 278
I-131	< 42	< 46	< 38	< 59	< 57	< 58
Cs-134	< 28	< 24	< 27	< 23	< 23	< 26
Cs-137	< 28	< 25	< 23	< 28	< 25	< 26
Ba-140	< 124	< 105	< 107	< 146	< 146	< 162
La-140	< 41	< 18	< 29	< 36	< 25	< 45
Ce-141	< 44	< 40	< 44	< 51	< 53	< 51
Ce-144	< 159	< 153	< 171	< 186	< 172	< 192
Ra-226	< 642	< 503	< 579	< 625	< 629	< 670
Th-228	< 48	< 46	< 52	< 50	< 50	< 54

* Control Location

INDIAN POINT ENERGY CENTER

TABLE B-13

GAMMA EMITTERS IN BROADLEAF VEGETATION SAMPLES - 2016

pCi/kg wet ± 2 Sigma

	Roseton 23*					
DATE	07/29/16	07/29/16	07/29/16	08/18/16	08/18/16	08/18/16
GAMMA						
Be-7	604 ± 115	< 112	818 ± 125	1170 ± 339	2140 ± 385	2460 ± 361
K-40	4340 ± 243	< 123	4810 ± 288	5490 ± 682	7740 ± 763	4840 ± 622
Mn-54	< 10	< 13	< 12	< 22	< 28	< 23
Co-58	< 11	< 14	< 12	< 25	< 24	< 21
Fe-59	< 23	< 27	< 29	< 65	< 66	< 53
Co-60	< 10	< 11	< 13	< 32	< 31	< 33
Zn-65	< 23	< 29	< 28	< 64	< 54	< 59
Nb-95	< 11	< 16	< 13	< 28	< 29	< 23
Zr-95	< 19	< 26	< 23	< 55	< 51	< 33
Ru-103	< 11	< 15	< 13	< 26	< 25	< 25
Ru-106	< 84	< 110	< 101	< 226	< 245	< 244
I-131	< 27	< 37	< 32	< 44	< 47	< 40
Cs-134	< 9	< 12	< 10	< 27	< 26	< 22
Cs-137	< 11	< 14	< 13	< 32	< 27	< 22
Ba-140	< 63	< 84	< 74	< 116	< 134	< 99
La-140	< 18	< 29	< 20	< 43	< 30	< 33
Ce-141	< 18	< 21	< 19	< 43	< 43	< 38
Ce-144	< 61	< 71	< 69	< 169	< 155	< 157
Ra-226	< 197	< 265	< 225	< 602	< 585	< 496
Th-228	< 16	< 19	< 19	< 50	< 55	< 49

* Control Location

INDIAN POINT ENERGY CENTER
TABLE B-13
GAMMA EMITTERS IN BROADLEAF VEGETATION SAMPLES - 2016

pCi/kg wet ± 2 Sigma

	Roseton 23*					
DATE	09/19/16	09/19/16	09/19/16	10/17/16	10/17/16	10/17/16
GAMMA						
Be-7	1250 ± 346	1180 ± 280	997 ± 270	1910 ± 330	1430 ± 332	1790 ± 262
K-40	2340 ± 543	3610 ± 636	1890 ± 384	3750 ± 544	6770 ± 654	2330 ± 398
Mn-54	< 30	< 25	< 29	< 24	< 31	< 25
Co-58	< 27	< 28	< 31	< 25	< 33	< 22
Fe-59	< 61	< 62	< 61	< 53	< 71	< 58
Co-60	< 28	< 32	< 26	< 26	< 30	< 21
Zn-65	< 59	< 64	< 75	< 54	< 69	< 57
Nb-95	< 31	< 32	< 37	< 26	< 32	< 25
Zr-95	< 60	< 44	< 58	< 50	< 60	< 45
Ru-103	< 30	< 27	< 33	< 30	< 31	< 27
Ru-106	< 275	< 250	< 299	< 226	< 307	< 220
I-131	< 40	< 36	< 51	< 57	< 59	< 60
Cs-134	< 27	< 30	< 41	< 26	< 28	< 25
Cs-137	< 34	< 30	< 36	< 28	< 30	< 24
Ba-140	< 120	< 133	< 151	< 152	< 176	< 143
La-140	< 24	< 34	< 25	< 28	< 54	< 44
Ce-141	< 51	< 38	< 63	< 49	< 42	< 43
Ce-144	< 168	< 174	< 273	< 188	< 150	< 153
Ra-226	< 581	< 627	< 897	< 693	< 603	< 628
Th-228	< 54	< 54	< 66	90 ± 54	< 48	< 51

* Control Location

INDIAN POINT ENERGY CENTER

TABLE B-13

GAMMA EMITTERS IN BROADLEAF VEGETATION SAMPLES - 2016

pCi/kg wet ± 2 Sigma

	Training Center 94					
DATE	05/18/16	05/18/16	05/18/16	06/28/16	06/28/16	06/28/16
GAMMA						
Be-7	929 ± 213	1740 ± 258	1200 ± 251	314 ± 170	1050 ± 218	606 ± 264
K-40	6200 ± 642	5390 ± 551	6380 ± 578	2680 ± 488	6420 ± 586	4020 ± 619
Mn-54	< 25	< 24	< 24	< 21	< 22	< 28
Co-58	< 21	< 24	< 24	< 24	< 22	< 29
Fe-59	< 50	< 47	< 52	< 45	< 57	< 67
Co-60	< 29	< 31	< 26	< 31	< 20	< 26
Zn-65	< 42	< 56	< 51	< 72	< 44	< 54
Nb-95	< 21	< 25	< 25	< 23	< 23	< 29
Zr-95	< 33	< 48	< 39	< 38	< 40	< 50
Ru-103	< 23	< 28	< 24	< 30	< 19	< 27
Ru-106	< 231	< 222	< 196	< 236	< 157	< 255
I-131	< 41	< 40	< 40	< 47	< 43	< 50
Cs-134	< 20	< 25	< 22	< 21	< 19	< 29
Cs-137	< 24	< 32	< 26	< 24	< 23	< 30
Ba-140	< 105	< 111	< 99	< 140	< 116	< 154
La-140	< 31	< 24	< 31	< 32	< 22	< 7
Ce-141	< 37	< 44	< 40	< 46	< 38	< 44
Ce-144	< 150	< 168	< 139	< 166	< 143	< 165
Ra-226	< 595	< 625	< 585	< 606	< 474	< 561
Th-228	< 44	< 52	< 37	< 47	< 40	< 40

INDIAN POINT ENERGY CENTER

TABLE B-13

GAMMA EMITTERS IN BROADLEAF VEGETATION SAMPLES - 2016

pCi/kg wet ± 2 Sigma

Training Center 94

DATE	07/27/16	07/27/16	07/27/16	08/18/16	08/18/16	08/18/16
GAMMA						
Be-7	539 ± 73	999 ± 110	684 ± 88	1410 ± 329	1570 ± 365	1400 ± 331
K-40	2330 ± 136	6510 ± 246	4660 ± 203	2660 ± 537	6760 ± 844	5640 ± 714
Mn-54	< 6	< 10	< 8	< 25	< 31	< 27
Co-58	< 6	< 11	< 9	< 28	< 32	< 28
Fe-59	< 15	< 25	< 21	< 49	< 59	< 77
Co-60	< 6	< 10	< 9	< 27	< 40	< 32
Zn-65	< 13	< 22	< 19	< 69	< 77	< 74
Nb-95	< 7	< 10	< 9	< 32	< 37	< 37
Zr-95	< 11	< 17	< 17	< 49	< 50	< 53
Ru-103	< 8	< 11	< 10	< 27	< 37	< 28
Ru-106	< 57	< 83	< 78	< 258	< 311	< 270
I-131	< 22	< 32	< 29	< 50	< 45	< 38
Cs-134	< 6	< 9	< 8	< 24	< 27	< 28
Cs-137	< 7	< 10	< 9	< 36	< 40	< 31
Ba-140	< 44	< 68	< 63	< 140	< 160	< 144
La-140	< 10	< 19	< 18	< 36	< 39	< 25
Ce-141	< 14	< 18	< 18	< 48	< 53	< 49
Ce-144	< 46	< 59	< 61	< 193	< 204	< 198
Ra-226	< 146	< 228	< 187	< 737	< 861	< 806
Th-228	15 ± 8	< 16	< 15	< 46	< 57	< 46

INDIAN POINT ENERGY CENTER

TABLE B-13

GAMMA EMITTERS IN BROADLEAF VEGETATION SAMPLES - 2016

pCi/kg wet ± 2 Sigma

	Training Center 94					
DATE	9/19/201	09/19/16	09/19/16	10/17/16	10/17/16	10/17/16
GAMMA						
Be-7	1710 ± 437	1230 ± 353	904 ± 401	2450 ± 284	2980 ± 277	1980 ± 236
K-40	1850 ± 464	4680 ± 822	6750 ± 945	2240 ± 387	7370 ± 602	9890 ± 537
Mn-54	< 38	< 36	< 36	< 24	< 25	< 26
Co-58	< 29	< 46	< 37	< 25	< 28	< 23
Fe-59	< 67	< 91	< 88	< 55	< 60	< 54
Co-60	< 35	< 39	< 32	< 24	< 27	< 25
Zn-65	< 70	< 101	< 88	< 48	< 66	< 55
Nb-95	< 35	< 48	< 46	< 24	< 32	< 30
Zr-95	< 56	< 75	< 60	< 45	< 45	< 43
Ru-103	< 30	< 45	< 32	< 29	< 28	< 28
Ru-106	< 325	< 371	< 387	< 200	< 240	< 224
I-131	< 54	< 57	< 50	< 58	< 57	< 60
Cs-134	< 36	< 55	< 43	< 26	< 26	< 25
Cs-137	< 35	< 44	< 45	< 26	< 26	< 27
Ba-140	< 155	< 182	< 128	< 145	< 158	< 134
La-140	< 40	< 33	< 48	< 30	< 39	< 38
Ce-141	< 65	< 48	< 75	< 52	< 47	< 45
Ce-144	< 234	< 200	< 281	< 178	< 174	< 166
Ra-226	< 887	< 819	< 1080	< 673	< 603	< 540
Th-228	< 75	< 65	< 81	< 45	< 52	148 ± 36

INDIAN POINT ENERGY CENTER
TABLE B-13
GAMMA EMITTERS IN BROADLEAF VEGETATION SAMPLES - 2016

pCi/kg wet ± 2 Sigma

	Met Tower 95					
DATE	05/18/16	05/18/16	05/18/16	06/28/16	06/28/16	06/28/16
GAMMA						
Be-7	767 ± 309	< 260	883 ± 352	933 ± 344	634 ± 245	1110 ± 209
K-40	4620 ± 613	4090 ± 558	4560 ± 662	3520 ± 558	5410 ± 755	7510 ± 574
Mn-54	< 27	< 31	< 30	< 27	< 25	< 20
Co-58	< 28	< 27	< 28	< 32	< 26	< 22
Fe-59	< 56	< 67	< 69	< 63	< 61	< 49
Co-60	< 30	< 32	< 21	< 34	< 26	< 22
Zn-65	< 64	< 60	< 79	< 67	< 65	< 59
Nb-95	< 36	< 28	< 31	< 31	< 23	< 19
Zr-95	< 49	< 58	< 47	< 53	< 39	< 33
Ru-103	< 32	< 26	< 26	< 34	< 29	< 20
Ru-106	< 289	< 266	< 287	< 251	< 251	< 179
I-131	< 59	< 48	< 54	< 58	< 55	< 39
Cs-134	< 30	< 28	< 23	< 31	< 24	< 17
Cs-137	< 33	< 30	< 28	< 26	< 23	< 20
Ba-140	< 150	< 141	< 158	< 156	< 125	< 93
La-140	< 37	< 37	< 50	< 36	< 32	< 24
Ce-141	< 52	< 38	< 50	< 56	< 50	< 34
Ce-144	< 223	< 143	< 198	< 209	< 211	< 130
Ra-226	< 640	< 564	< 678	< 755	< 659	< 534
Th-228	< 53	< 44	< 56	< 50	< 53	< 34

INDIAN POINT ENERGY CENTER
TABLE B-13
GAMMA EMITTERS IN BROADLEAF VEGETATION SAMPLES - 2016

pCi/kg wet ± 2 Sigma

	Met Tower 95					
DATE	07/27/16	07/27/16	07/27/16	08/18/16	08/18/16	08/18/16
GAMMA						
Be-7	465 ± 60	1450 ± 112	938 ± 89	1060 ± 213	1780 ± 313	2280 ± 252
K-40	3830 ± 148	4160 ± 188	6150 ± 190	3250 ± 458	4090 ± 498	6520 ± 489
Mn-54	< 6	< 10	< 9	< 19	< 21	< 23
Co-58	< 6	< 11	< 9	< 23	< 22	< 24
Fe-59	< 15	< 25	< 21	< 47	< 56	< 48
Co-60	< 6	< 11	< 8	< 25	< 26	< 25
Zn-65	< 13	< 24	< 20	< 44	< 59	< 65
Nb-95	< 7	< 11	< 10	< 21	< 26	< 29
Zr-95	< 12	< 20	< 17	< 36	< 43	< 45
Ru-103	< 7	< 12	< 10	< 21	< 23	< 25
Ru-106	< 55	< 94	< 81	< 181	< 223	< 241
I-131	< 19	< 34	< 31	< 32	< 41	< 43
Cs-134	< 6	< 11	< 9	< 20	< 25	< 30
Cs-137	< 6	< 10	< 9	< 21	< 25	< 27
Ba-140	< 43	< 71	< 62	< 100	< 102	< 115
La-140	< 11	< 20	< 13	< 32	< 26	< 32
Ce-141	< 11	< 19	< 21	< 32	< 36	< 51
Ce-144	< 38	< 65	< 73	< 123	< 153	< 209
Ra-226	< 157	< 224	< 238	< 433	< 517	< 704
Th-228	< 10	< 16	< 16	< 34	< 40	< 52

INDIAN POINT ENERGY CENTER

TABLE B-13

GAMMA EMITTERS IN BROADLEAF VEGETATION SAMPLES - 2016

pCi/kg wet ± 2 Sigma

	Met Tower 95				
DATE	09/19/16	09/19/16	09/19/16	10/17/16	10/17/16
GAMMA					
Be-7	1120 ± 504	< 256	1620 ± 409	813 ± 250	2660 ± 347
K-40	2410 ± 798	4150 ± 696	6210 ± 841	8290 ± 518	7400 ± 597
Mn-54	< 45	< 31	< 40	< 28	< 29
Co-58	< 38	< 32	< 32	< 28	< 28
Fe-59	< 94	< 66	< 78	< 58	< 60
Co-60	< 44	< 29	< 28	< 24	< 25
Zn-65	< 90	< 77	< 89	< 64	< 64
Nb-95	< 42	< 32	< 39	< 34	< 32
Zr-95	< 71	< 48	< 59	< 48	< 49
Ru-103	< 38	< 31	< 34	< 28	< 28
Ru-106	< 411	< 315	< 321	< 235	< 250
I-131	< 56	< 48	< 45	< 58	< 57
Cs-134	< 43	< 30	< 34	< 27	< 24
Cs-137	< 45	< 30	< 40	< 29	< 28
Ba-140	< 163	< 123	< 142	< 138	< 145
La-140	< 62	< 39	< 31	< 46	< 46
Ce-141	< 57	< 45	< 45	< 45	< 44
Ce-144	< 251	< 200	< 207	< 163	< 156
Ra-226	< 995	< 661	< 734	< 622	< 548
Th-228	< 80	< 55	< 65	< 44	< 41

INDIAN POINT ENERGY CENTER

TABLE B-14

RADIONUCLIDES IN RIVER WATER SAMPLES - 2016

pCi/L ± 2 Sigma

Plant Inlet Hudson River Intake

9*

DATE	01/26/16	02/23/16	03/29/16	04/26/16	05/30/16	06/29/16
RADIOCHEMICAL						
H-3 (a)			< 186			< 189
GAMMA						
K-40	< 36	< 26	< 14	< 15	< 38	< 12
Mn-54	< 1	< 1	< 1	< 2	< 1	< 1
Co-58	< 2	< 2	< 2	< 2	< 2	< 2
Fe-59	< 4	< 4	< 4	< 4	< 3	< 4
Co-60	< 2	< 2	< 1	< 2	< 1	< 1
Zn-65	< 3	< 3	< 3	< 3	< 3	< 3
Nb-95	< 2	< 2	< 2	< 2	< 2	< 2
Zr-95	< 3	< 3	< 3	< 3	< 3	< 3
Ru-103	< 2	< 2	< 2	< 2	< 2	< 2
Ru-106	< 13	< 14	< 13	< 15	< 12	< 13
I-131	< 11	< 6	< 10	< 9	< 14	< 9
Cs-134	< 1	< 1	< 1	< 2	< 1	< 1
Cs-137	< 2	< 2	< 1	< 2	< 1	< 1
Ba-140	< 18	< 13	< 16	< 17	< 20	< 15
La-140	< 5	< 5	< 6	< 6	< 6	< 5
Ce-141	< 4	< 3	< 4	< 4	< 4	< 4
Ce-144	< 10	< 10	< 10	< 12	< 11	< 11
Ra-226	< 38	< 38	< 30	< 35	< 31	< 40
Ac-228	< 6	< 6	< 5	< 6	< 6	< 6
Th-228	< 3	< 3	< 2	< 3	< 3	< 3

* Control Location

(a) Quarterly Composite

INDIAN POINT ENERGY CENTER
TABLE B-14
RADIONUCLIDES IN RIVER WATER SAMPLES - 2016

pCi/L ± 2 Sigma

Plant Inlet Hudson River Intake
9*

DATE	07/26/16	08/30/16	09/27/16	10/25/16	11/29/16	12/28/16
RADIOCHEMICAL						
H-3 (a)			< 181			< 199
GAMMA						
K-40	< 18	50 ± 22	54 ± 22	94 ± 37	56 ± 27	< 15
Mn-54	< 2	< 1	< 1	< 2	< 2	< 2
Co-58	< 2	< 2	< 2	< 2	< 2	< 2
Fe-59	< 4	< 4	< 4	< 6	< 4	< 5
Co-60	< 2	< 1	< 1	< 2	< 2	< 2
Zn-65	< 4	< 3	< 3	< 4	< 3	< 4
Nb-95	< 2	< 2	< 2	< 2	< 2	< 2
Zr-95	< 3	< 3	< 3	< 4	< 3	< 4
Ru-103	< 2	< 2	< 2	< 3	< 2	< 2
Ru-106	< 15	< 13	< 13	< 19	< 15	< 16
I-131	< 7	< 12	< 9	< 14	< 10	< 10
Cs-134	< 2	< 1	< 1	< 2	< 2	< 2
Cs-137	< 2	< 1	< 1	< 2	< 2	< 2
Ba-140	< 14	< 18	< 14	< 24	< 17	< 18
La-140	< 5	< 6	< 5	< 8	< 5	< 5
Ce-141	< 4	< 4	< 4	< 6	< 4	< 4
Ce-144	< 12	< 11	< 11	< 16	< 13	< 13
Ra-226	< 40	< 32	< 32	129 ± 60	< 41	< 38
Ac-228	< 5	< 4	< 6	< 9	< 6	< 7
Th-228	< 3	< 2	< 3	7 ± 3	< 3	< 3

* Control Location
(a) Quarterly Composite

INDIAN POINT ENERGY CENTER
TABLE B-14
RADIONUCLIDES IN RIVER WATER SAMPLES - 2016

pCi/L ± 2 Sigma

Discharge Canal
10

DATE	01/26/16	02/23/16	03/29/16	04/26/16	05/30/16	06/29/16
RADIOCHEMICAL						
H-3 (a)			572 ± 142			257 ± 128
GAMMA						
K-40	48 ± 26	< 39	< 11	< 14	< 29	74 ± 29
Mn-54	< 1	< 1	< 1	< 2	< 1	< 2
Co-58	< 1	< 2	< 1	< 2	< 2	< 2
Fe-59	< 2	< 4	< 3	< 4	< 3	< 5
Co-60	< 1	< 2	< 1	< 2	< 1	< 2
Zn-65	< 2	< 4	< 2	< 3	< 2	< 4
Nb-95	< 1	< 2	< 2	< 2	< 2	< 2
Zr-95	< 2	< 3	< 2	< 3	< 2	< 4
Ru-103	< 1	< 2	< 2	< 2	< 2	< 3
Ru-106	< 9	< 16	< 11	< 16	< 11	< 17
I-131	< 7	< 8	< 10	< 10	< 14	< 12
Cs-134	< 1	< 2	< 1	< 2	< 1	< 2
Cs-137	< 1	< 2	< 1	< 2	< 1	< 2
Ba-140	< 12	< 15	< 16	< 16	< 18	< 20
La-140	< 4	< 5	< 4	< 4	< 5	< 7
Ce-141	< 2	< 4	< 4	< 5	< 4	< 4
Ce-144	< 7	< 13	< 11	< 14	< 11	< 13
Ra-226	< 21	< 46	< 31	< 46	< 30	< 39
Ac-228	< 3	< 6	< 5	< 6	< 4	< 6
Th-228	< 2	< 3	4 ± 2	< 3	< 3	< 3

(a) Quarterly Composite

INDIAN POINT ENERGY CENTER
TABLE B-14
RADIONUCLIDES IN RIVER WATER SAMPLES - 2016

pCi/L ± 2 Sigma

Discharge Canal
10

DATE	07/26/16	08/30/16	09/27/16	10/25/16	11/29/16	12/28/16
RADIOCHEMICAL						
H-3 (a)			< 177			< 195
GAMMA						
K-40	< 19	54 ± 26	48 ± 31	137 ± 31	53 ± 30	< 41
Mn-54	< 2	< 1	< 2	< 2	< 1	< 2
Co-58	< 2	< 2	< 2	< 2	< 1	< 2
Fe-59	< 5	< 4	< 5	< 5	< 3	< 5
Co-60	< 2	< 2	< 2	< 2	< 1	< 2
Zn-65	< 5	< 3	< 4	< 4	< 2	< 4
Nb-95	< 2	< 2	< 2	< 2	< 1	< 2
Zr-95	< 4	< 3	< 3	< 4	< 2	< 4
Ru-103	< 3	< 2	< 3	< 3	< 1	< 3
Ru-106	< 20	< 13	< 17	< 19	< 10	< 19
I-131	< 9	< 13	< 11	< 15	< 7	< 12
Cs-134	< 2	< 1	< 2	< 2	< 1	< 2
Cs-137	< 2	< 2	< 2	< 2	< 1	< 2
Ba-140	< 18	< 20	< 20	< 23	< 12	< 20
La-140	< 6	< 6	< 6	< 5	< 4	< 6
Ce-141	< 5	< 4	< 5	< 7	< 3	< 5
Ce-144	< 15	< 12	< 15	< 20	< 8	< 16
Ra-226	< 48	< 42	< 52	< 63	< 26	< 52
Ac-228	< 7	< 6	< 8	< 8	< 5	< 9
Th-228	< 4	< 3	< 4	< 4	< 2	< 4

(a) Quarterly Composite

INDIAN POINT ENERGY CENTER

TABLE B-15

GAMMA EMITTERS IN BOTTOM SEDIMENT SAMPLES - 2016

pCi/kg dry ± 2 Sigma

	Discharge Canal 10		Off Verplanck 17	
DATE	06/10/16	09/20/16	06/10/16	09/20/16
GAMMA				
Be-7	< 324	< 555	< 922	< 860
K-40	13900 ± 1310	14600 ± 1240	19000 ± 3270	20400 ± 2410
Mn-54	< 57	< 59	< 117	< 115
Co-58	< 40	< 60	< 111	< 108
Fe-59	< 100	< 132	< 310	< 251
Co-60	< 31	< 53	< 149	< 118
Zn-65	< 103	< 142	< 218	< 218
Nb-95	< 43	< 82	< 129	< 138
Zr-95	< 91	< 121	< 242	< 233
Ru-103	< 41	< 60	< 116	< 118
Ru-106	< 291	< 508	< 1060	< 1000
I-131	< 78	< 121	< 257	< 241
Cs-134	< 34	< 59	< 87	< 88
Cs-137	67 ± 42	< 78	266 ± 128	352 ± 133
Ba-140	< 191	< 332	< 775	< 635
Ce-141	< 60	< 98	< 211	< 148
Ce-144	< 234	< 365	< 721	< 541
Ra-226	< 926	< 1420	< 3050	< 2080
Th-228	270 ± 104	346 ± 81	1100 ± 257	1030 ± 152

INDIAN POINT ENERGY CENTER
TABLE B-15
GAMMA EMITTERS IN BOTTOM SEDIMENT SAMPLES - 2016

pCi/kg dry ± 2 Sigma

	Lent's Cove 28		Cold Spring 84*	
DATE	06/10/16	09/20/16	06/09/16	09/21/16
GAMMA				
Be-7	< 740	< 974	< 1420	< 972
K-40	19700 ± 2110	15100 ± 3010	19400 ± 3470	19500 ± 1990
Mn-54	< 93	< 138	< 127	< 98
Co-58	< 71	< 123	< 160	< 104
Fe-59	< 188	< 284	< 414	< 227
Co-60	< 88	< 137	< 122	< 81
Zn-65	< 188	< 289	< 328	< 279
Nb-95	< 98	< 134	< 190	< 119
Zr-95	< 148	< 180	< 262	< 181
Ru-103	< 90	< 135	< 133	< 105
Ru-106	< 668	< 1080	< 1260	< 866
I-131	< 210	< 218	< 358	< 208
Cs-134	< 85	< 120	< 136	< 143
Cs-137	210 ± 102	< 129	< 174	< 136
Ba-140	< 493	< 648	< 755	< 552
Ce-141	< 142	< 192	< 203	< 195
Ce-144	< 490	< 738	< 634	< 726
Ra-226	2670 ± 1780	< 3140	< 2360	3150 ± 1900
Th-228	1040 ± 143	1060 ± 235	1410 ± 301	1370 ± 228

* Control Location

INDIAN POINT ENERGY CENTER

TABLE B-16

RADIONUCLIDES IN SHORELINE SOIL SAMPLES - 2016

pCi/kg dry ± 2 Sigma

	Off Verplanck 17		Lent's Cove 28	
DATE	06/02/16	09/08/16	06/02/16	09/08/16
RADIOCHEMICAL				
Sr-90	< 25	< 40	< 22	< 35
GAMMA				
Be-7	< 422	< 596	< 488	< 416
K-40	13400 ± 1100	14600 ± 1500	12200 ± 1240	8670 ± 1100
Mn-54	< 43	< 58	< 44	< 42
Co-58	< 40	< 69	< 45	< 51
Fe-59	< 118	< 165	< 99	< 125
Co-60	< 43	< 53	< 48	< 30
Zn-65	< 100	< 125	< 88	< 114
Nb-95	< 51	< 61	< 53	< 57
Zr-95	< 81	< 115	< 90	< 87
Ru-103	< 40	< 61	< 52	< 50
Ru-106	< 412	< 489	< 425	< 367
I-131	< 177	< 145	< 168	< 115
Cs-134	< 32	< 49	< 36	< 42
Cs-137	< 44	< 67	< 44	< 44
Ba-140	< 342	< 309	< 383	< 289
La-140	< 89	< 123	< 109	< 81
Ce-141	< 96	< 80	< 94	< 69
Ce-144	< 296	< 272	< 298	< 246
Ra-226	< 948	< 971	1920 ± 987	< 995
Ac-228	< 149	< 201	< 149	< 278
Th-228	547 ± 90	565 ± 93	475 ± 75	199 ± 63

INDIAN POINT ENERGY CENTER
TABLE B-16
RADIONUCLIDES IN SHORELINE SOIL SAMPLES - 2016

pCi/kg dry ± 2 Sigma

	Manitou Inlet 50*		White Beach 53	
DATE	06/02/16	09/08/16	06/02/16	09/08/16
RADIOCHEMICAL				
Sr-90	< 40	< 30	< 48	< 34
GAMMA				
Be-7	< 842	< 435	< 430	< 395
K-40	9700 ± 1340	12900 ± 1070	10000 ± 1200	8420 ± 800
Mn-54	< 88	< 39	< 35	< 40
Co-58	< 90	< 36	< 41	< 44
Fe-59	< 199	< 98	< 115	< 104
Co-60	< 77	< 55	< 45	< 35
Zn-65	< 203	< 98	< 108	< 103
Nb-95	< 139	< 53	< 52	< 51
Zr-95	< 162	< 85	< 84	< 75
Ru-103	< 104	< 47	< 52	< 46
Ru-106	< 679	< 344	< 365	< 380
I-131	< 408	< 114	< 166	< 119
Cs-134	< 86	< 33	< 37	< 55
Cs-137	< 97	< 52	< 42	< 48
Ba-140	< 777	< 260	< 356	< 288
La-140	< 273	< 89	< 106	< 68
Ce-141	< 215	< 85	< 81	< 89
Ce-144	< 661	< 287	< 224	< 300
Ra-226	5800 ± 1990	1980 ± 1170	< 994	< 1040
Ac-228	< 476	< 283	< 228	< 177
Th-228	772 ± 145	667 ± 69	98 ± 52	< 76

* Control Location

INDIAN POINT ENERGY CENTER
TABLE B-16
RADIONUCLIDES IN SHORELINE SOIL SAMPLES - 2016

pCi/kg dry ± 2 Sigma

	Cold Spring 84*	
DATE	06/02/16	09/08/16
RADIOCHEMICAL		
Sr-90	< 29	< 42
GAMMA		
Be-7	< 801	< 494
K-40	26400 ± 2040	34700 ± 2090
Mn-54	< 85	< 57
Co-58	< 87	< 63
Fe-59	< 220	< 183
Co-60	< 75	< 69
Zn-65	< 184	< 161
Nb-95	< 94	< 72
Zr-95	< 163	< 107
Ru-103	< 82	< 67
Ru-106	< 703	< 515
I-131	< 336	< 156
Cs-134	< 70	< 59
Cs-137	< 91	< 72
Ba-140	< 678	< 388
La-140	< 109	< 110
Ce-141	< 180	< 91
Ce-144	< 548	< 322
Ra-226	< 1720	2170 ± 1280
Ac-228	< 518	< 235
Th-228	819 ± 173	656 ± 97

* Control Location

INDIAN POINT ENERGY CENTER

TABLE B-17

GAMMA EMITTERS IN AQUATIC VEGETATION SAMPLES - 2016

pCi/kg wet ± 2 Sigma

	Lent's Cove 28	
DATE	6/10/2016 Myrophyllium	9/21/2016 Myrophyllium
Be-7	(a)	< 336
K-40		2240 ± 568
Mn-54		< 32
Co-58		< 32
Fe-59		< 64
Co-60		< 35
Zn-65		< 56
Nb-95		< 35
Zr-95		< 56
Ru-103		< 31
Ru-106		< 276
I-131		< 51
Cs-134		< 27
Cs-137		< 35
Ba-140		< 169
La-140		< 31
Ce-141		< 62
Ce-144		< 204
Ra-226		< 814
Ac-228		< 182
Th-228		91 ± 43

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

INDIAN POINT ENERGY CENTER
TABLE B-17
GAMMA EMITTERS IN AQUATIC VEGETATION SAMPLES - 2016

pCi/kg wet ± 2 Sigma

	Off Verplanck 17	
DATE	6/10/2016 Myrophyllium	9/21/2016 Myrophyllium
Be-7	< 158	< 173
K-40	3260 ± 332	2680 ± 372
Mn-54	< 16	< 16
Co-58	< 16	< 19
Fe-59	< 34	< 43
Co-60	< 17	< 17
Zn-65	< 38	< 32
Nb-95	< 21	< 20
Zr-95	< 28	< 31
Ru-103	< 18	< 19
Ru-106	< 140	< 154
I-131	< 40	< 36
Cs-134	< 15	< 17
Cs-137	< 17	< 18
Ba-140	< 97	< 91
La-140	< 33	< 28
Ce-141	< 30	< 37
Ce-144	< 112	< 125
Ra-226	< 397	< 375
Ac-228	< 82	< 65
Th-228	109 ± 21	96 ± 26

INDIAN POINT ENERGY CENTER
TABLE B-17
GAMMA EMITTERS IN AQUATIC VEGETATION SAMPLES - 2016

pCi/kg wet ± 2 Sigma

	Cold Spring 84*	
DATE	6/9/2016 Myrophyllium	9/22/2016 Myrophyllium
Be-7	< 193	< 173
K-40	2540 ± 337	1960 ± 359
Mn-54	< 18	< 18
Co-58	< 18	< 20
Fe-59	< 39	< 45
Co-60	< 18	< 20
Zn-65	< 43	< 34
Nb-95	< 23	< 23
Zr-95	< 35	< 33
Ru-103	< 18	< 21
Ru-106	< 156	< 181
I-131	< 59	< 33
Cs-134	< 16	< 18
Cs-137	< 20	< 23
Ba-140	< 113	< 96
La-140	< 28	< 29
Ce-141	< 35	< 33
Ce-144	< 123	< 131
Ra-226	< 497	< 442
Ac-228	< 62	< 106
Th-228	67 ± 26	84 ± 28

* Control Location

INDIAN POINT ENERGY CENTER

TABLE B-18

RADIONUCLIDES IN FISH / INVERTEBRATES - 2016

pCi/kg wet ± 2 Sigma

	Downstream 107					
DATE	05/02/16	05/02/16	05/02/16	05/02/16	05/02/16	06/13/16
RADIOCHEMICAL						
Ni-63	< 67	< 69	< 54	< 62	< 70	< 86
Sr-90	< 3	< 4	< 4	< 5	< 3	< 3
GAMMA						
Be-7	< 987	< 707	< 864	< 631	< 760	< 652
K-40	1730 ± 951	1880 ± 816	2560 ± 757	2990 ± 673	3040 ± 751	1800 ± 827
Mn-54	< 55	< 49	< 54	< 43	< 46	< 70
Co-58	< 79	< 84	< 82	< 66	< 72	< 77
Fe-59	< 211	< 172	< 247	< 245	< 255	< 145
Co-60	< 78	< 41	< 49	< 35	< 39	< 58
Zn-65	< 111	< 126	< 135	< 110	< 109	< 112
Nb-95	< 113	< 87	< 86	< 87	< 94	< 75
Zr-95	< 169	< 145	< 123	< 130	< 146	< 138
Ru-103	< 156	< 153	< 136	< 97	< 143	< 70
Ru-106	< 412	< 457	< 509	< 424	< 479	< 524
I-131	< 6560	< 12400	< 13300	< 12900	< 15800	< 366
Cs-134	< 59	< 41	< 50	< 46	< 44	< 55
Cs-137	< 55	< 57	< 48	< 45	< 42	< 63
Ba-140	< 4880	< 5940	< 5750	< 4140	< 5610	< 708
La-140	< 1010	< 1370	< 1440	< 1410	< 2140	< 271
Ce-141	< 221	< 249	< 243	< 207	< 262	< 111
Ce-144	< 345	< 287	< 321	< 290	< 295	< 297
Ra-226	< 1490	< 1090	< 1060	< 675	< 1010	< 1300
Th-228	< 125	< 94	< 84	< 70	< 76	< 90

INDIAN POINT ENERGY CENTER
TABLE B-18
RADIONUCLIDES IN FISH / INVERTEBRATES - 2016

pCi/kg wet ± 2 Sigma

	Downstream 107					
DATE	08/09/16	08/09/16	08/11/16	08/11/16	08/22/16	09/09/16
RADIOCHEMICAL						
Ni-63	< 100	< 87	< 39	< 70	< 38	< 87
Sr-90	< 4	< 4	< 3	< 3	< 2	< 2
GAMMA						
Be-7	< 482	< 720	< 720	< 679	< 792	< 703
K-40	3300 ± 813	3100 ± 955	2840 ± 879	2710 ± 779	3430 ± 718	2600 ± 885
Mn-54	< 50	< 64	< 68	< 60	< 63	< 72
Co-58	< 67	< 78	< 60	< 76	< 71	< 64
Fe-59	< 127	< 217	< 259	< 132	< 165	< 191
Co-60	< 34	< 48	< 64	< 38	< 62	< 77
Zn-65	< 74	< 139	< 162	< 105	< 118	< 177
Nb-95	< 70	< 110	< 103	< 75	< 88	< 80
Zr-95	< 112	< 144	< 170	< 94	< 142	< 119
Ru-103	< 99	< 113	< 119	< 113	< 104	< 93
Ru-106	< 402	< 486	< 498	< 428	< 580	< 631
I-131	< 728	< 2030	< 3820	< 3120	< 1390	< 402
Cs-134	< 50	< 53	< 50	< 46	< 73	< 74
Cs-137	< 57	< 53	< 52	< 46	< 59	< 81
Ba-140	< 822	< 1750	< 2730	< 1940	< 1540	< 642
La-140	< 210	< 273	< 1010	< 331	< 419	< 272
Ce-141	< 133	< 161	< 175	< 188	< 207	< 143
Ce-144	< 302	< 326	< 290	< 283	< 418	< 417
Ra-226	< 1050	< 1210	< 1070	< 1120	< 1450	< 1490
Th-228	< 91	< 97	< 90	< 83	< 109	< 136

INDIAN POINT ENERGY CENTER

TABLE B-18

RADIONUCLIDES IN FISH / INVERTEBRATES - 2016

pCi/kg wet ± 2 Sigma

	Roseton 23*					
DATE	05/09/16	05/17/16	05/17/16	05/23/16	05/23/16	08/15/16
RADIOCHEMICAL						
Ni-63	< 63	< 82	< 85	< 78	< 81	< 37
Sr-90	< 5	< 3	< 3	< 5	< 4	< 3
GAMMA						
Be-7	< 1100	< 710	< 550	< 809	< 760	< 435
K-40	2050 ± 1040	2640 ± 719	2230 ± 836	2440 ± 835	2300 ± 925	3330 ± 724
Mn-54	< 74	< 48	< 31	< 60	< 59	< 38
Co-58	< 63	< 77	< 83	< 92	< 79	< 56
Fe-59	< 256	< 170	< 198	< 160	< 240	< 142
Co-60	< 51	< 47	< 47	< 50	< 37	< 30
Zn-65	< 146	< 137	< 125	< 128	< 101	< 60
Nb-95	< 82	< 73	< 93	< 108	< 70	< 56
Zr-95	< 176	< 114	< 94	< 189	< 137	< 99
Ru-103	< 159	< 124	< 115	< 132	< 117	< 62
Ru-106	< 607	< 380	< 569	< 649	< 446	< 371
I-131	< 9420	< 4820	< 4590	< 3400	< 3300	< 1340
Cs-134	< 68	< 53	< 46	< 64	< 46	< 35
Cs-137	< 60	< 50	< 57	< 56	< 49	< 38
Ba-140	< 5330	< 2720	< 3290	< 2620	< 1950	< 1240
La-140	< 1800	< 706	< 947	< 867	< 395	< 255
Ce-141	< 211	< 207	< 183	< 174	< 196	< 124
Ce-144	< 261	< 314	< 315	< 346	< 359	< 260
Ra-226	< 1090	< 975	< 1150	< 1250	< 1290	< 894
Th-228	< 98	< 92	< 99	< 99	< 117	< 67

* Control Location

INDIAN POINT ENERGY CENTER
TABLE B-18
RADIONUCLIDES IN FISH / INVERTEBRATES - 2016

pCi/kg wet ± 2 Sigma

	Roseton 23*				
DATE	08/15/16	08/15/16	08/16/16	08/16/16	08/18/16
RADIOCHEMICAL					
Ni-63	< 39	< 49	< 98	< 85	< 43
Sr-90	< 3	< 3	< 4	< 4	< 3
GAMMA					
Be-7	< 755	< 887	< 832	< 677	< 488
K-40	4260 ± 1010	1950 ± 858	2630 ± 695	2900 ± 719	3160 ± 792
Mn-54	< 49	< 67	< 59	< 56	< 50
Co-58	< 76	< 80	< 74	< 62	< 56
Fe-59	< 249	< 219	< 183	< 188	< 108
Co-60	< 46	< 63	< 56	< 59	< 49
Zn-65	< 126	< 124	< 130	< 98	< 67
Nb-95	< 72	< 87	< 93	< 85	< 69
Zr-95	< 143	< 131	< 160	< 103	< 127
Ru-103	< 94	< 126	< 116	< 102	< 61
Ru-106	< 450	< 645	< 588	< 523	< 452
I-131	< 2170	< 2970	< 2700	< 1990	< 773
Cs-134	< 54	< 69	< 65	< 52	< 42
Cs-137	< 64	< 73	< 63	< 54	< 52
Ba-140	< 1940	< 3010	< 2350	< 1810	< 1120
La-140	< 592	< 992	< 571	< 492	< 327
Ce-141	< 162	< 241	< 221	< 166	< 118
Ce-144	< 307	< 446	< 413	< 293	< 290
Ra-226	< 807	< 1450	< 1300	< 1060	< 1200
Th-228	< 90	< 126	< 107	< 98	< 83

* Control Location

INDIAN POINT ENERGY CENTER
TABLE B-18
RADIONUCLIDES IN FISH / INVERTEBRATES - 2016

pCi/kg wet ± 2 Sigma

	Downstream 25					
DATE	05/02/16	05/02/16	05/02/16	05/04/16	05/19/16	06/13/16
RADIOCHEMICAL						
Ni-63	< 62	< 65	< 74	< 46	< 64	< 86
Sr-90	< 3	< 3	< 4	< 4	< 5	< 4
GAMMA						
Be-7	< 753	< 1080	< 1320	< 758	< 740	< 696
K-40	2860 ± 796	2700 ± 732	2270 ± 1050	4150 ± 1010	2940 ± 789	2220 ± 985
Mn-54	< 64	< 62	< 84	< 61	< 54	< 61
Co-58	< 102	< 88	< 125	< 95	< 80	< 66
Fe-59	< 229	< 253	< 227	< 168	< 187	< 162
Co-60	< 41	< 51	< 72	< 43	< 41	< 54
Zn-65	< 97	< 130	< 173	< 107	< 123	< 114
Nb-95	< 88	< 123	< 146	< 115	< 60	< 84
Zr-95	< 163	< 193	< 259	< 147	< 168	< 118
Ru-103	< 129	< 163	< 249	< 106	< 114	< 102
Ru-106	< 434	< 613	< 642	< 442	< 423	< 647
I-131	< 16200	< 15800	< 23800	< 10400	< 3480	< 562
Cs-134	< 52	< 66	< 88	< 54	< 42	< 63
Cs-137	< 47	< 65	< 75	< 50	< 33	< 72
Ba-140	< 6980	< 7350	< 10800	< 4900	< 1590	< 940
La-140	< 2520	< 1940	< 2650	< 1310	< 932	< 340
Ce-141	< 266	< 347	< 450	< 268	< 203	< 156
Ce-144	< 262	< 431	< 539	< 292	< 293	< 411
Ra-226	< 992	< 1330	< 1650	< 1230	< 1170	< 1490
Th-228	< 88	< 103	< 136	< 95	< 101	< 98

INDIAN POINT ENERGY CENTER
TABLE B-18
RADIONUCLIDES IN FISH / INVERTEBRATES - 2016

pCi/kg wet ± 2 Sigma

	Downstream 25					
DATE	08/08/16	08/08/16	08/11/16	08/11/16	08/11/16	08/24/16
RADIOCHEMICAL						
Ni-63	< 98	< 41	< 97	< 54	< 42	< 92
Sr-90	< 4	< 2	< 2	< 4	< 3	< 2
GAMMA						
Be-7	< 862	< 605	< 703	< 845	< 861	< 1170
K-40	2650 ± 907	2450 ± 853	1640 ± 740	1940 ± 720	2250 ± 875	4130 ± 1170
Mn-54	< 62	< 42	< 57	< 64	< 79	< 78
Co-58	< 77	< 71	< 71	< 87	< 106	< 88
Fe-59	< 237	< 153	< 221	< 202	< 244	< 238
Co-60	< 53	< 64	< 51	< 57	< 76	< 90
Zn-65	< 137	< 72	< 140	< 184	< 149	< 219
Nb-95	< 85	< 90	< 90	< 98	< 112	< 120
Zr-95	< 161	< 124	< 169	< 160	< 213	< 173
Ru-103	< 148	< 102	< 94	< 153	< 144	< 158
Ru-106	< 621	< 460	< 353	< 493	< 568	< 788
I-131	< 3700	< 2330	< 3210	< 4570	< 4690	< 1870
Cs-134	< 79	< 43	< 53	< 67	< 61	< 91
Cs-137	< 56	< 50	< 58	< 76	< 75	< 94
Ba-140	< 3020	< 1960	< 2440	< 2660	< 3270	< 1680
La-140	< 882	< 480	< 664	< 678	< 743	< 553
Ce-141	< 235	< 171	< 172	< 245	< 208	< 239
Ce-144	< 411	< 292	< 276	< 433	< 359	< 517
Ra-226	< 1410	< 1020	< 1120	< 1390	< 1260	< 1990
Th-228	< 118	< 89	< 92	< 106	< 102	< 139

INDIAN POINT ENERGY CENTER

TABLE B-19

LAND USE CENSUS - RESIDENCE AND MILCH ANIMAL RESULTS

2016

The 2016 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).

INDIAN POINT ENERGY CENTER
TABLE B-20
LAND USE CENSUS
2016

UNRESTRICTED AREA BOUNDARY AND NEAREST RESIDENCES

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

APPENDIX C

HISTORICAL TRENDS

APPENDIX C

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 2016 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 2006-2016

Average Quarterly Dose (mR/Quarter)			
Year	Inner Ring	Outer Ring	Control Location
2006	13.9	14.3	17.5
2007	14.4	14.6	18.8
2008	14.5	14.2	17.3
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

Historical Average 2006-2015	13.9	14.1	15.3

FIGURE C-1

DIRECT RADIATION, ANNUAL SUMMARY
2006 to 2016

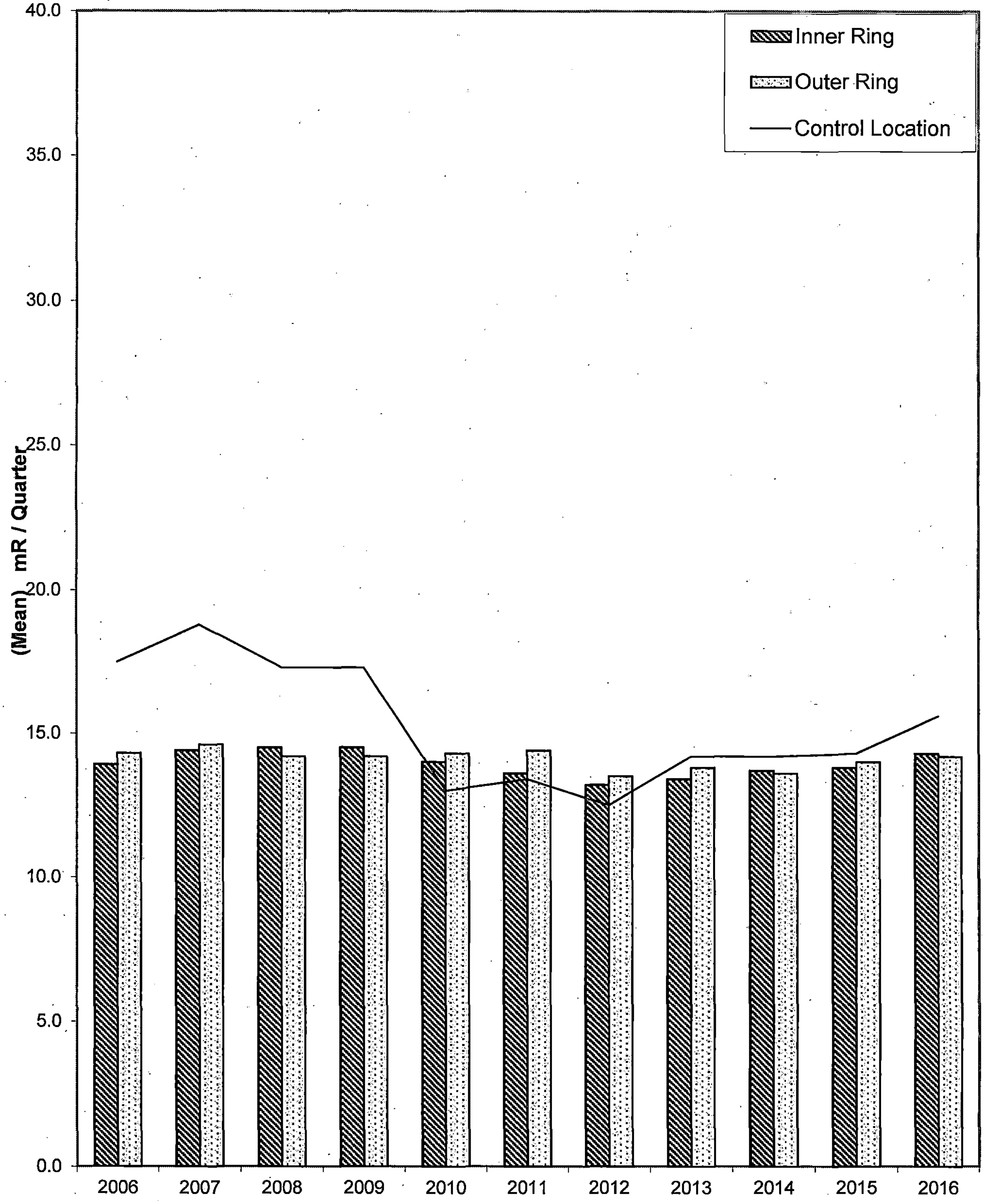


Table C-2

RADIONUCLIDES IN AIR 2006 to 2016 (pCi/m^3)

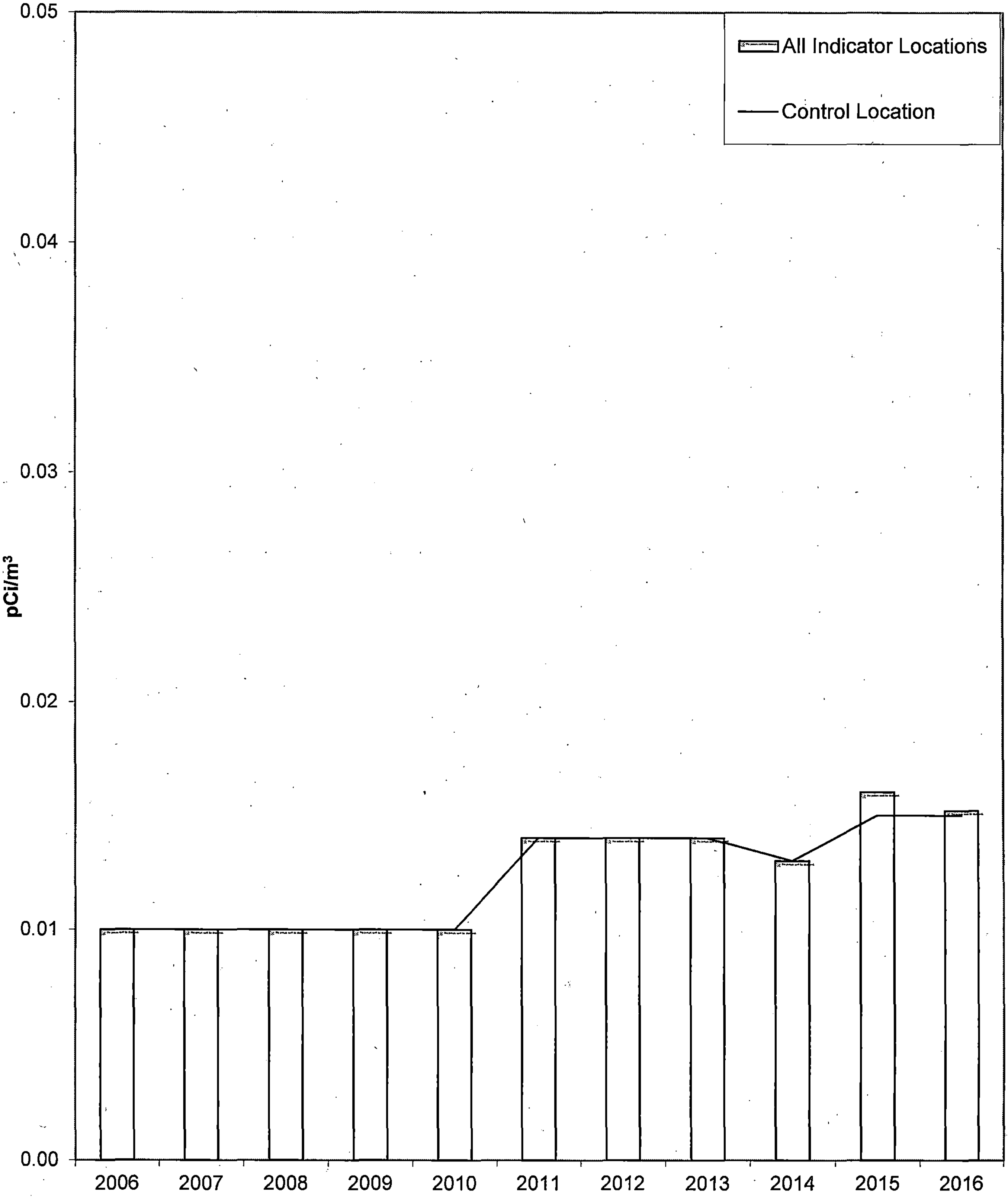
	Gross Beta		Cs-137	
Year	All Indicator Locations	Control Location	All Indicator Locations	Control Location
2006	0.01	0.01	< Lc	< Lc
2007	0.01	0.01	< Lc	< Lc
2008	0.01	0.01	< Lc	< Lc
2009	0.01	0.01	< Lc	< Lc
2010	0.01	0.01	< Lc	< Lc
2011	0.014	0.014	< L_c	< L_c
2012	0.014	0.014	< L_c	< L_c
2013	0.014	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
Historical Average 2006-2015	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
2006 to 2016



* Includes ODCM and non-ODCM indicator locations.

Gross Beta ODCM required LLD = 0.01 pCi/m^3

TABLE C-3

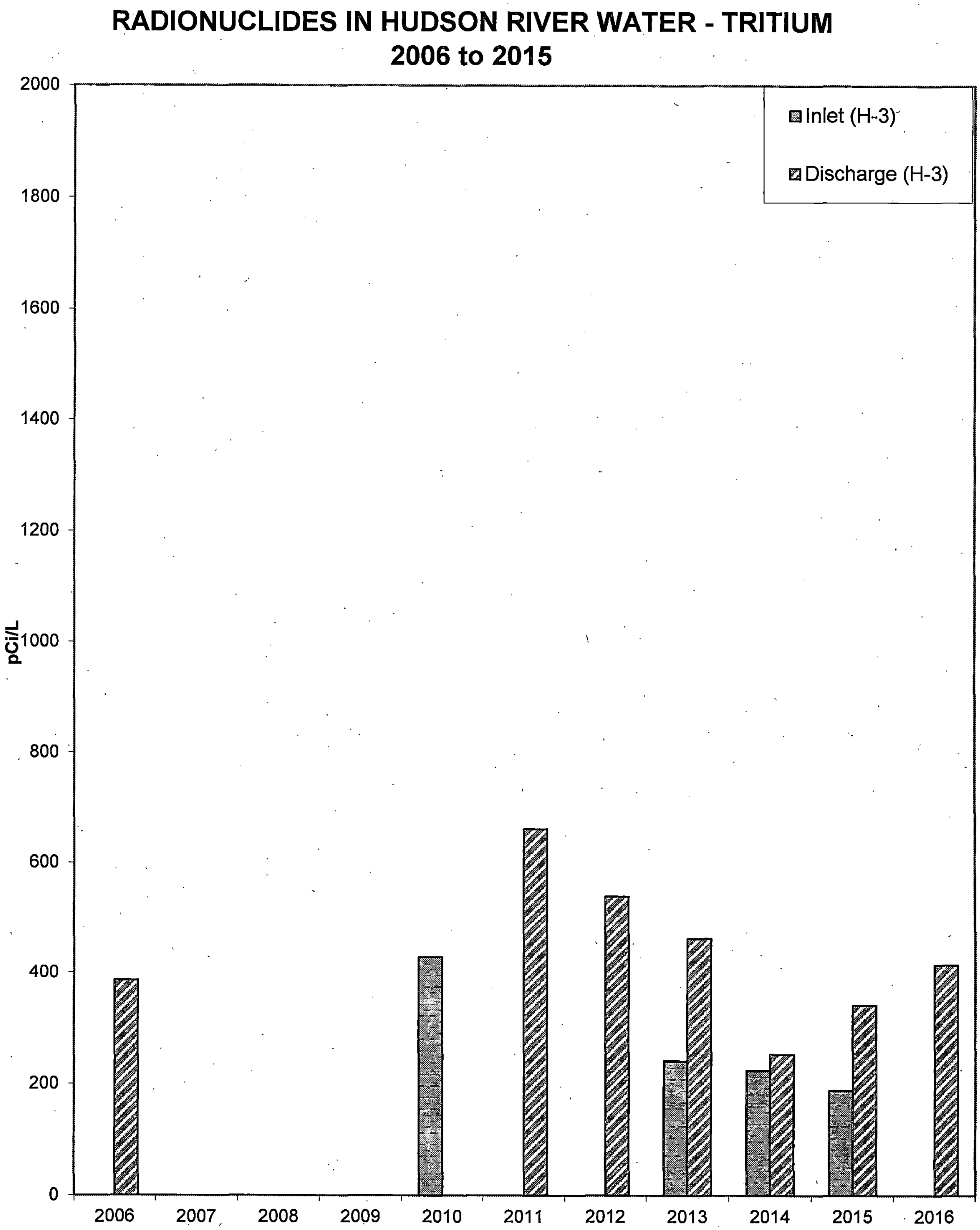
RADIONUCLIDES IN HUDSON RIVER WATER- TRITIUM
2006 to 2016
(pCi/L)

	Tritium (H-3)		Cs-137	
Year	Inlet	Discharge	Inlet	Discharge
2006	< Lc	386	< Lc	< Lc
2007	< Lc	< Lc	< Lc	< Lc
2008	< Lc	< Lc	< Lc	< Lc
2009	< Lc	< Lc	< Lc	< Lc
2010	428	< Lc	< Lc	< Lc
2011	< Lc	661	< L_c	< L_c
2012	< Lc	539	< L_c	< L_c
2013	241	462	< L_c	< L_c
2014	224	253	< L_c	< L_c
2015	188	341	< L_c	< L_c
2016	< L_c	415	< L_c	< L_c
Historical Average 2006-2015	270	441	< 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



Tritium ODCM required LLD = 3000 pCi/L

TABLE C-4

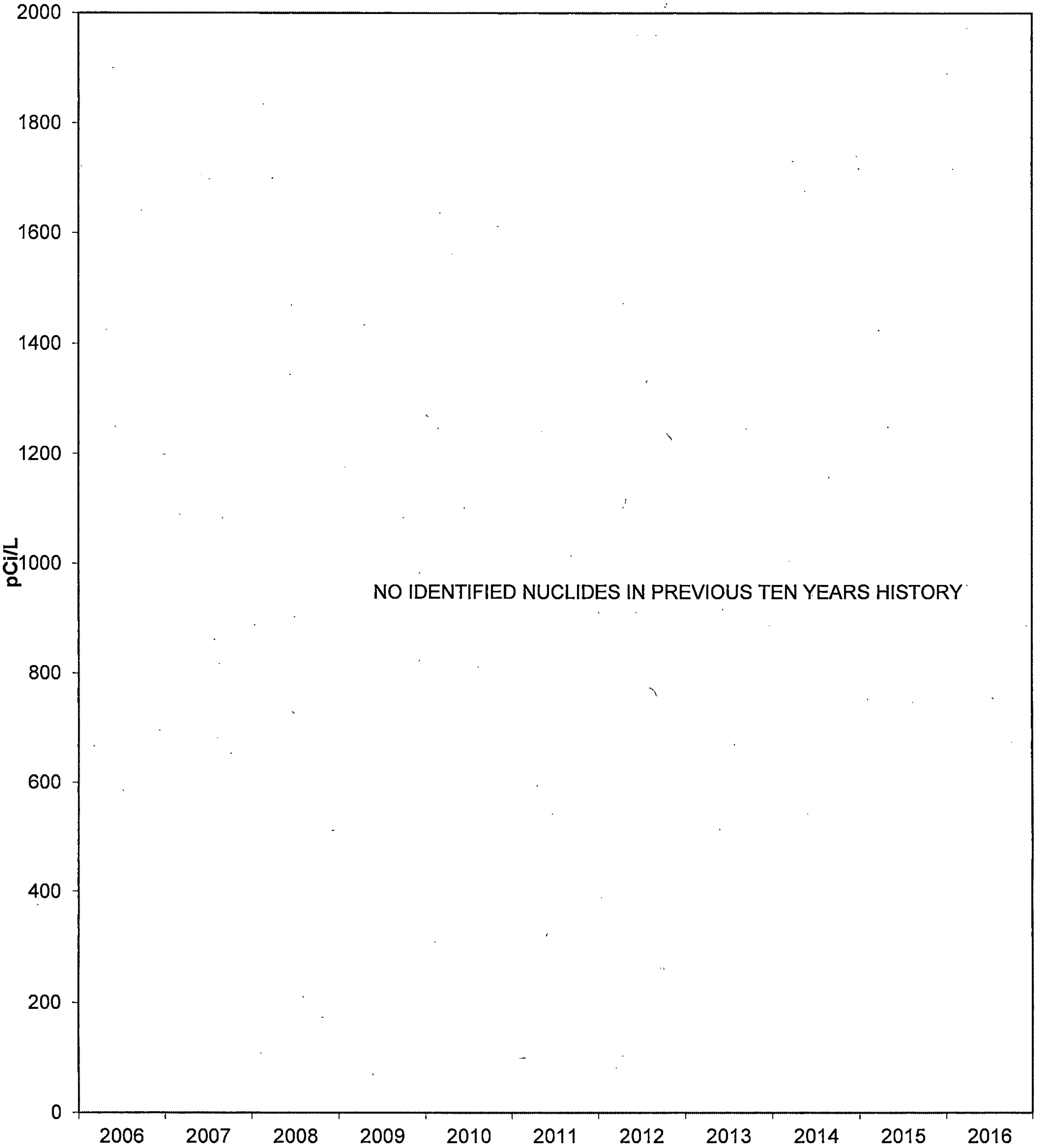
RADIONUCLIDES IN DRINKING WATER 2006 to 2016 (pCi/L)

Year	Tritium (H-3)	Cs-137
2006	< Lc	< Lc
2007	< Lc	< Lc
2008	< Lc	< Lc
2009	< Lc	< Lc
2010	< Lc	< Lc
2011	< Lc	< Lc
2012	< L_c	< L_c
2013	< L_c	< L_c
2014	< L_c	< L_c
2015	< L_c	< L_c
2016	< L_c	< L_c
Historical Average 2006-2015	< 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
2006 to 2016



Tritium ODCM required LLD = 2000 pCi/L

TABLE C-5

RADIONUCLIDES IN SHORELINE SOIL
2006 to 2016
(pCi/Kg, dry)

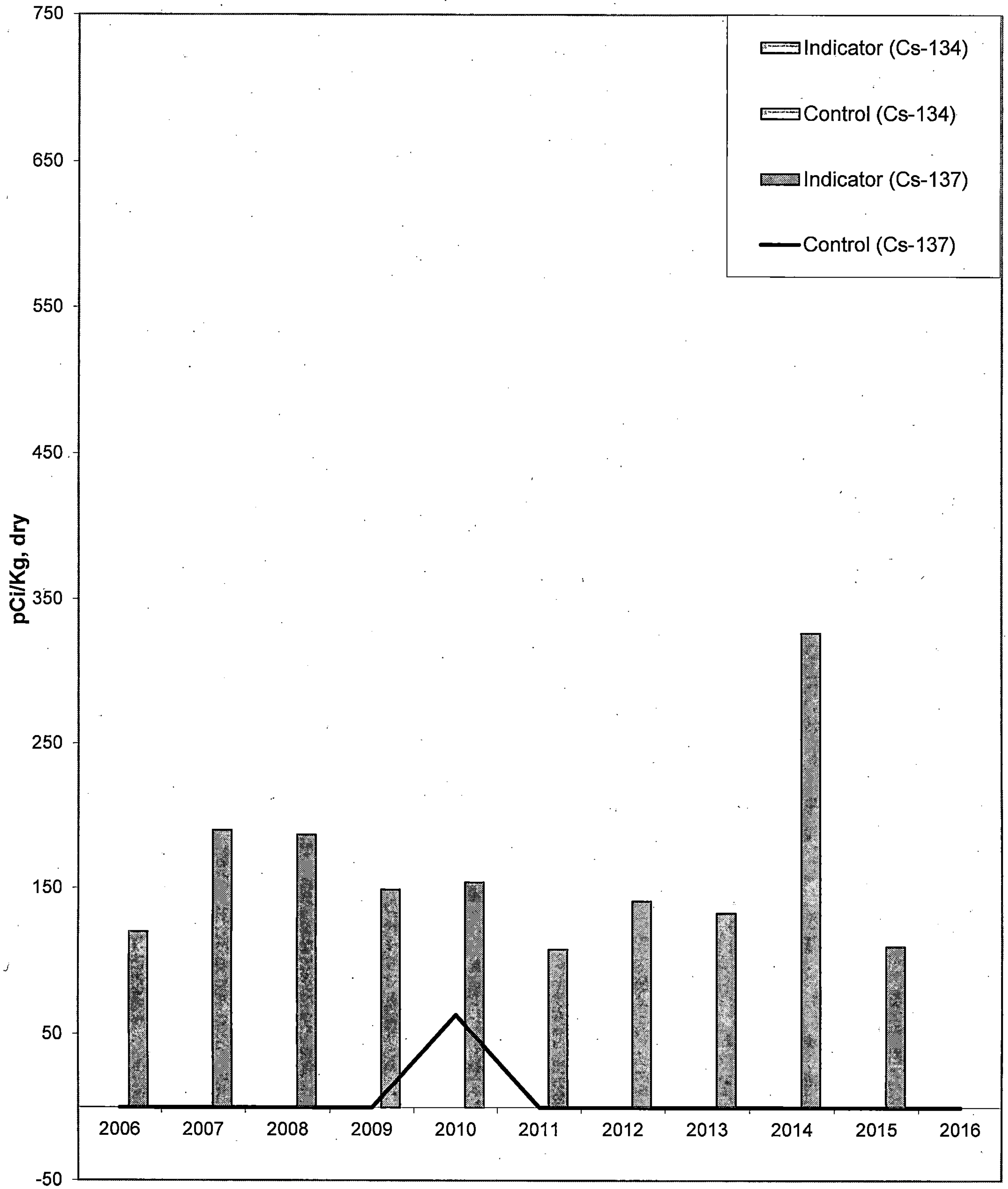
	Cs-134		Cs-137	
Year	Indicator	Control	Indicator	Control
2006	< Lc	< Lc	120	< Lc
2007	< Lc	< Lc	190	< Lc
2008	< Lc	< Lc	187	< Lc
2009	< Lc	< Lc	149	< Lc
2010	< Lc	< Lc	154	63
2011	< L_c	< L_c	108	< L_c
2012	< L_c	< L_c	141	< L_c
2013	< L_c	< L_c	133	< L_c
2014	< L_c	< L_c	327	< L_c
2015	< L_c	< L_c	110	< L_c
2016	< L_c	< L_c	< L_c	< L_c
Historical Average 2006-2015	< L_c	< L_c	162	63

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

<L_c indicates no positive values above sample critical level.

FIGURE C-5

RADIONUCLIDES IN SHORELINE SOIL
2006 to 2016



Cs-134 ODCM required LLD = 150 pCi/Kg, dry
Cs-137 ODCM required LLD = 175 pCi/Kg, dry

TABLE C-6

RADIONUCLIDES IN BROAD LEAF VEGETATION 2006 to 2016 (pCi/Kg, wet)

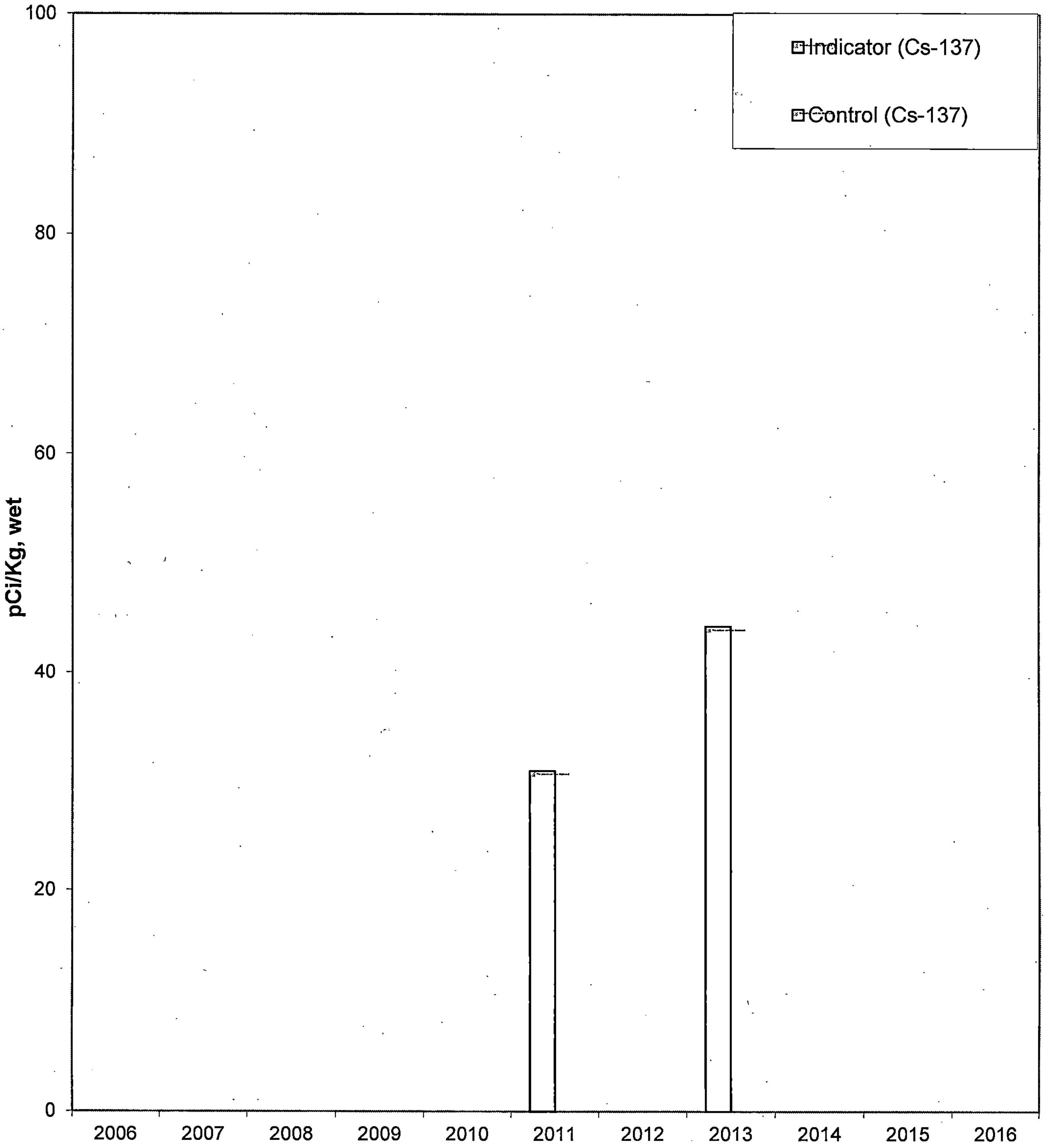
	Cs-137	
Year	**Indicator**	**Control**
2006	< Lc	< Lc
2007	< Lc	< Lc
2008	< Lc	< Lc
2009	< Lc	< Lc
2010	< Lc	< Lc
2011	31	< Lc
2012	< Lc	< L_c
2013	44	< L_c
2014	< L_c	< L_c
2015	< L_c	< L_c
2016	< L_c	< L_c
Historical Average 2006-2015	38	< Lc

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

<L_c indicates no positive values above sample critical level.

FIGURE C-6

BROAD LEAF VEGETATION
2006 to 2016



ODCM required LLD = 80 pCi/Kg, wet

TABLE C-7

FISH AND INVERTEBRATES
2006 to 2016
(pCi/Kg, dry)

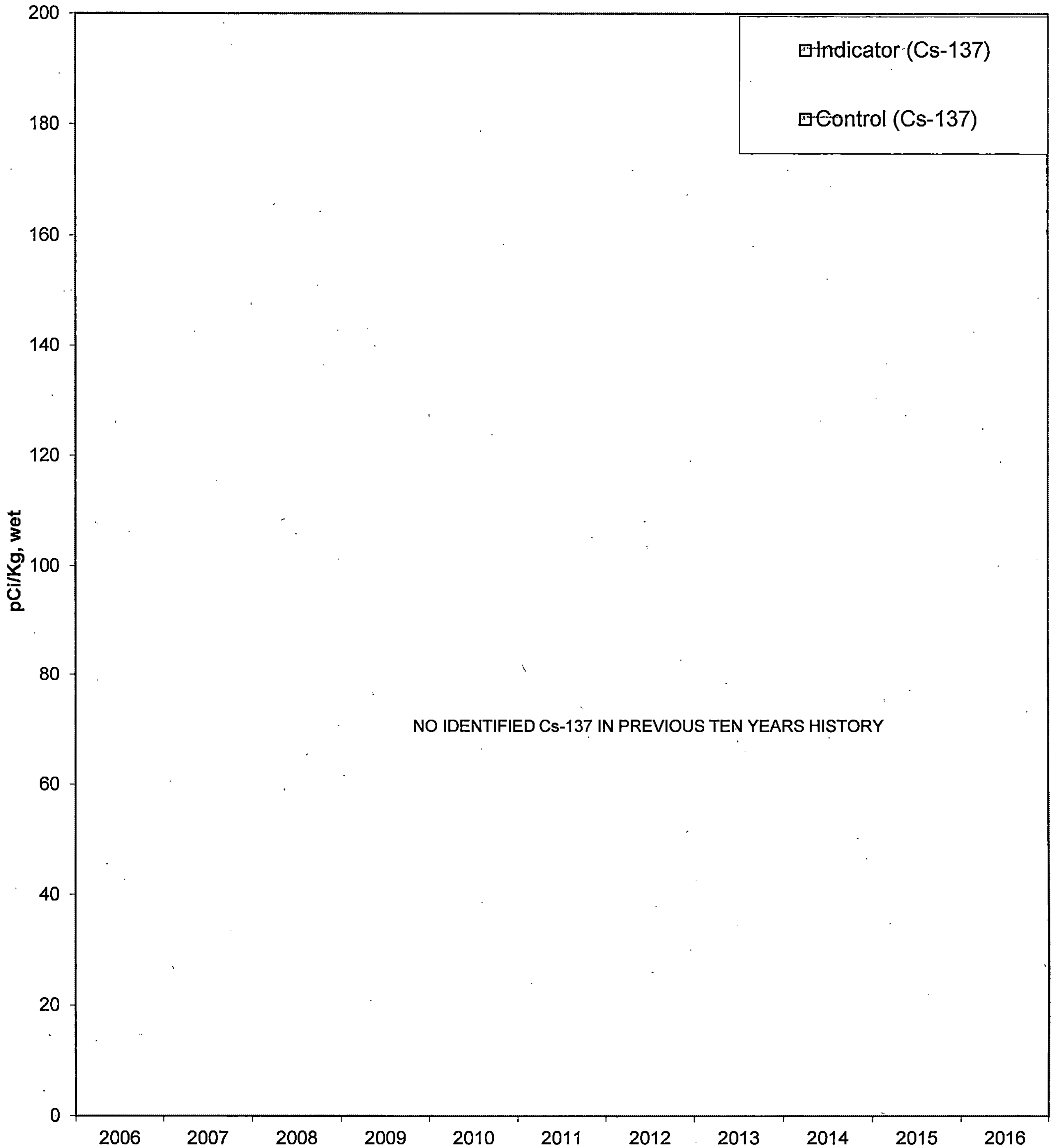
	Cs-137	
Year	Indicator	Control
2006	< Lc	< Lc
2007	< Lc	< Lc
2008	< Lc	< Lc
2009	< Lc	< Lc
2010	< Lc	< Lc
2011	< Lc	< Lc
2012	$< L_c$	$< L_c$
2013	$< L_c$	$< L_c$
2014	$< L_c$	$< L_c$
2015	$< L_c$	$< L_c$
2016	$< L_c$	$< L_c$
Historical Average 2006-2015	$< L_c$	$< L_c$

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

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

FIGURE C-7

FISH AND INVERTEBRATES - 2006 to 2016



Cs-137 ODCM required LLD = 150 pCi/Kg, wet

TABLE C-8

RIVER WATER - Discharge Area - Tritium
REMP vs. EFFLUENT
(pCi/liter)

Year	REMP*	EFFLUENT **
1Q 2102	617	2186
2Q 2012	< 178	394
3Q 2012	< 193	489
4Q 2012	460	860
1Q 2103	357	1813
2Q 2013	< 170	223
3Q 2013	< 186	428
4Q 2013	306	896
1Q 2104	<195	952
2Q 2014	253	82
3Q 2014	<189	26
4Q 2014	<157	218
1Q 2015	959	1940
2Q 2015	274	241
3Q 2015	<186	350
4Q 2015	341	536
1Q 2016	572	830
2Q 2016	257	762
3Q 2016	177	55
4Q 2016	195	253
Four Year Average, by Quarter, 2012 - 2015	446	727

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

TABLE C-8

RIVER WATER - Discharge Area - Tritium

** 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.

REMP vs. EFFLUENT
(pCi/liter)

TABLE C-9

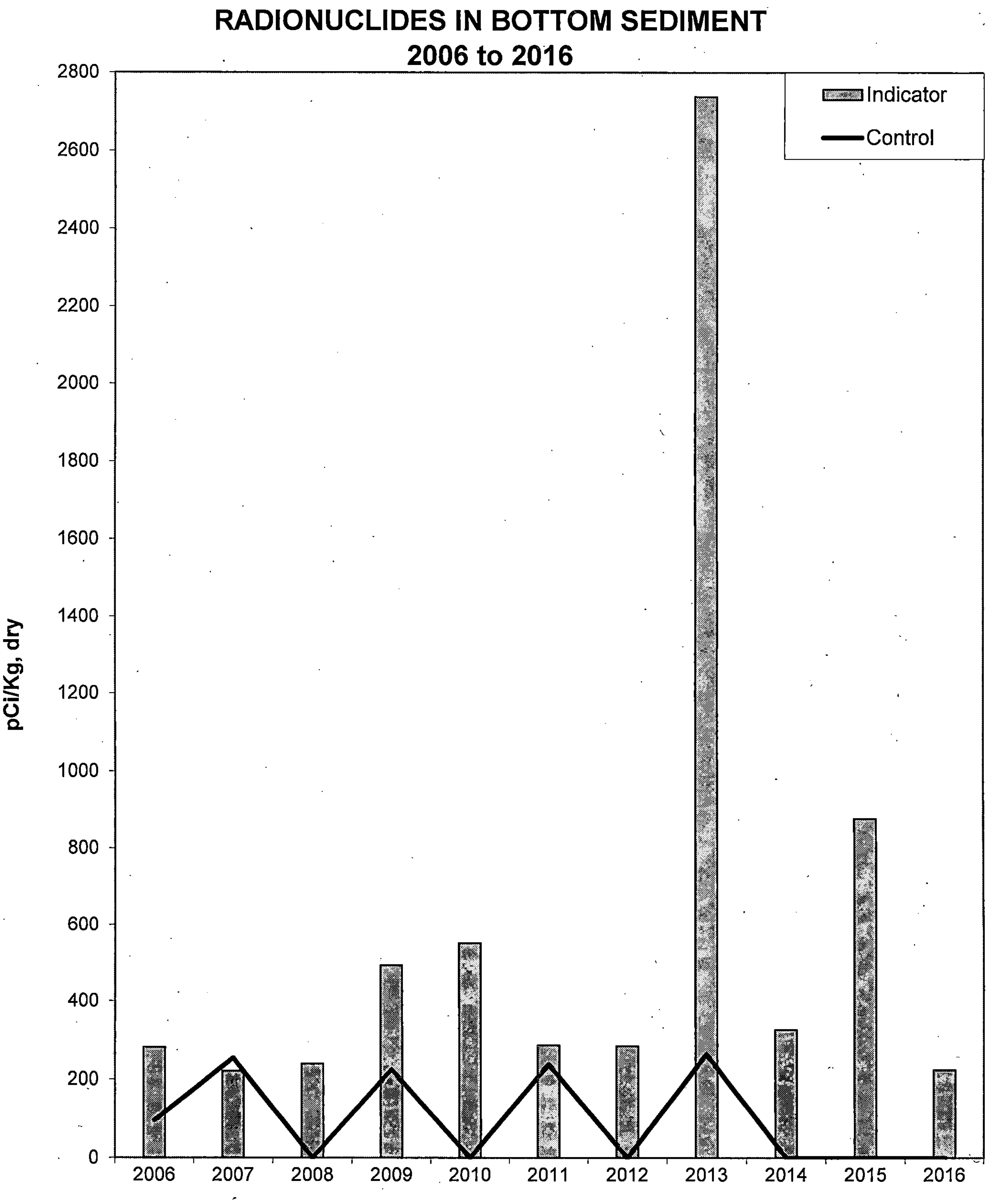
RADIONUCLIDES IN BOTTOM SEDIMENT
2006 to 2016
(pCi/Kg, dry)

Cs-137		
Year	Indicator	Control
2006	282	95
2007	221	254
2008	239	< L_c
2009	493	225
2010	552	< L_c
2011	287	238
2012	284	< L_c
2013	2738	264
2014	327	< L_c
2015	876	< L_c
2016	224	< Lc
Historical Average 2006-2015	630	215

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

<L_c indicates no positive values above sample critical level.

FIGURE C-9



Cs-137 ODCM required LLD = 175 pCi/Kg, dry

APPENDIX D

INTERLABORATORY COMPARISON PROGRAM

APPENDIX D

INTERLABORATORY COMPARISON PROGRAM

This section presents the results of the interlaboratory comparison program for the Teledyne Brown Engineering Environmental Services and Environmental Dosimetry Company. Since General Engineering Labs only analyzed 2 samples, their interlaboratory data is not presented. However, their results can be provided upon request.

D.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.

D.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.

D.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 Tables D-3.1, D-3.2, and D-3.3, a corresponding Ratio of Agreement interval is given.

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.

D.2.2 ERA and MAPEP Sample Result Evaluation

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

D.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
(PAGE 1 OF 3)

Month/Year	Identification Number	Matrix	Nuclide	Units	Reported Value (a)	Known Value (b)	Ratio (c) TBE/Analytics	Evaluation (d)
March 2016	E10646	Milk	Sr-89	pCi/L	97	86.7	1.12	A
			Sr-90	pCi/L	15	11.4	1.32	N(2)
	E10647	Milk	I-131	pCi/L	85.9	82.2	1.05	A
			Ce-141	pCi/L	106	98.4	1.08	A
			Cr-51	pCi/L	255	243	1.05	A
			Cs-134	pCi/L	134	130	1.03	A
			Cs-137	pCi/L	174	161	1.08	A
			Co-58	pCi/L	123	117	1.05	A
			Mn-54	pCi/L	141	117	1.21	W
			Fe-59	pCi/L	152	131	1.16	A
			Zn-65	pCi/L	193	179	1.08	A
			Co-60	pCi/L	259	244	1.06	A
	E10672	AP	Ce-141	pCi	69	81.1	0.85	A
			Cr-51	pCi	242	201	1.20	W
			Cs-134	pCi	98.1	107.0	0.92	A
			Cs-137	pCi	136	133	1.02	A
			Co-58	pCi	91.9	97	0.95	A
			Mn-54	pCi	98.6	96.2	1.02	A
			Fe-59	pCi	98.8	108	0.91	A
			Zn-65	pCi	131	147	0.89	A
			Co-60	pCi	209	201	1.04	A
	E10648	Charcoal	I-131	pCi	85.3	88.3	0.97	A
	E10673	Water	Fe-55	pCi/L	1800	1666	1.08	A
June 2016	E11537	Milk	Sr-89	pCi/L	94.4	94.4	1.00	A
			Sr-90	pCi/L	13.4	15.4	0.87	A
	E11538	Milk	I-131	pCi/L	96.8	94.5	1.02	A
			Ce-141	pCi/L	129	139	0.93	A
			Cr-51	pCi/L	240	276	0.87	A
			Cs-134	pCi/L	157	174	0.90	A
			Cs-137	pCi/L	117	120	0.98	A
			Co-58	pCi/L	131	142	0.92	A
			Mn-54	pCi/L	128	125	1.02	A
			Fe-59	pCi/L	132	122	1.08	A
			Zn-65	pCi/L	235	235	1.00	A
			Co-60	pCi/L	169	173	0.98	A

(a) Teledyne Brown Engineering reported result.

(b) 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.

(c) Ratio of Teledyne Brown Engineering to Analytics results.

(d) 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.

(2) NCR 16-26 was initiated

TABLE D-3.1

ANALYTICS ENVIRONMENTAL RADIOACTIVITY CROSS CHECK PROGRAM
TELEDYNE BROWN ENGINEERING ENVIRONMENTAL SERVICES

Month/Year	Identification Number	Matrix	Nuclide	Units	Reported Value (a)	Known Value (b)	Ratio (c) TBE/Analytics	Evaluation (d)
June 2016	E11539	Charcoal	I-131	pCi	86.1	89.4	0.96	A
	E11540	AP	Ce-141	pCi	105	99.8	1.05	A
			Cr-51	pCi	216	198.0	1.09	A
			Cs-134	pCi	113	125	0.90	A
			Cs-137	pCi	94.5	86.6	1.09	A
			Co-58	pCi	101	102	0.99	A
			Mn-54	pCi	88.8	90.2	0.98	A
			Fe-59	pCi	82	87.5	0.94	A
			Zn-65	pCi	174	169	1.03	A
			Co-60	pCi	143	124	1.15	A
	E11541	Water	Fe-55	pCi/L	164	186	0.88	A
September 2016	E11609	Milk	Sr-89	pCi/L	90	90.9	0.99	A
			Sr-90	pCi/L	13.3	13.7	0.97	A
	E11610	Milk	I-131	pCi/L	80.4	71.9	1.12	A
			Ce-141	pCi/L	81.3	93	0.87	A
			Cr-51	pCi/L	198	236	0.84	A
			Cs-134	pCi/L	122	136	0.90	A
			Cs-137	pCi/L	119	119	1.00	A
			Co-58	pCi/L	92.2	97.4	0.95	A
			Mn-54	pCi/L	156	152	1.03	A
			Fe-59	pCi/L	97.5	90.6	1.08	A
			Zn-65	pCi/L	189	179	1.06	A
			Co-60	pCi/L	131	135	0.97	A
	E11611	Charcoal	I-131	pCi	52.4	59.9	0.87	A
	E11612	AP	Ce-141	pCi	67.5	63.6	1.06	A
			Cr-51	pCi	192	161.0	1.19	A
			Cs-134	pCi	91.4	92.6	0.99	A
			Cs-137	pCi	93.9	80.8	1.16	A
			Co-58	pCi	66	66.4	0.99	A
			Mn-54	pCi	104	104	1.00	A
			Fe-59	pCi	60.5	61.8	0.98	A
			Zn-65	pCi	140	122	1.15	A
			Co-60	pCi	119	91.9	1.29	W

(a) Teledyne Brown Engineering reported result.

(b) 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.

(c) Ratio of Teledyne Brown Engineering to Analytics results.

(d) 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
(PAGE 3 OF 3)

Month/Year	Identification Number	Matrix	Nuclide	Units	Reported Value (a)	Known Value (b)	Ratio (c) TBE/Analytics	Evaluation (d)
September 2016	E11613	Water	Fe-55	pCi/L	1990	1670	1.19	A
	E11614	Soil	Ce-141	pCi/g	0.153	0.175	0.87	A
			Cr-51	pCi/g	0.482	0.441	1.09	A
			Cs-134	pCi/g	0.270	0.254	1.06	A
			Cs-137	pCi/g	0.313	0.299	1.05	A
			Co-58	pCi/g	0.177	0.182	0.97	A
			Mn-54	pCi/g	0.340	0.285	1.19	A
			Fe-59	pCi/g	0.206	0.17	1.21	W
			Zn-65	pCi/g	0.388	0.335	1.16	A
			Co-60	pCi/g	0.284	0.252	1.13	A
December 2016	E11699	Milk	Sr-89	pCi/L	95	74.2	1.28	W
			Sr-90	pCi/L	14.7	10	1.47	N(3)
	E11700	Milk	I-131	pCi/L	97.5	97.4	1.00	A
			Ce-141	pCi/L	136	143	0.95	A
			Cr-51	pCi/L	247	280	0.88	A
			Cs-134	pCi/L	164	178	0.92	A
			Cs-137	pCi/L	120	126	0.95	A
			Co-58	pCi/L	139	146	0.95	A
			Mn-54	pCi/L	126	129	0.98	A
			Fe-59	pCi/L	114	125	0.91	A
			Zn-65	pCi/L	237	244	0.97	A
			Co-60	pCi/L	168	178	0.94	A
	E11701	Charcoal	I-131	pCi	95.6	98	0.98	A
	E11702	AP	Ce-141	pCi	91.7	97.7	0.94	A
			Cr-51	pCi	210	192.0	1.09	A
			Cs-134	pCi	122	122	1.00	A
			Cs-137	pCi	93.9	86.4	1.09	A
			Co-58	pCi	92	100	0.92	A
			Mn-54	pCi	93.7	88.5	1.06	A
			Fe-59	pCi	84.9	84.5	1.00	A
			Zn-65	pCi	176	167	1.05	A
			Co-60	pCi	151	122	1.24	W
	E11702	AP	Sr-89	pCi	79.1	92	0.86	A
			Sr-90	pCi	10	12.5	0.80	A
	E11703	Water	Fe-55	pCi/L	2180	1800	1.21	W

(a) Teledyne Brown Engineering reported result.

(b) 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.

(c) Ratio of Teledyne Brown Engineering to Analytics results.

(d) 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.

(3) NCR 16-35 was initiated

TABLE D-3.2

DOE's MIXED ANALYTE PERFORMANCE EVALUATION PROGRAM (MAPEP) TELEDYNE BROWN ENGINEERING ENVIRONMENTAL SERVICES

Month/Year	Identification Number	Media	Nuclide	Units	Reported Value (a)	Known Value (b)	Acceptance Range	Evaluation (c)
March 2016	16-MaW34	Water	Am-241	Bq/L	0.008		(1)	A
			Ni-63	Bq/L	12.4	12.3	8.6-16.0	A
			Pu-238	Bq/L	1.4900	1.2440	0.871-1.617	A
			Pu-239/240	Bq/L	0.729	0.641	0.449-0.833	A
	16-MaS34	Soil	Ni-63	Bq/kg	1140	1250.0	875-1625	A
			Sr-90	Bq/kg	8.15		(1)	A
	16-RdF34	AP	U-234/233	Bq/sample	0.1620	0.1650	0.116-0.215	A
			U-238	Bq/sample	0.163	0.172	0.120-0.224	A
	16-GrF34	AP	Gr-A	Bq/sample	0.608	1.20	0.36-2.04	A
			Gr-B	Bq/sample	0.8060	0.79	0.40-1.19	A
	16-RdV34	Vegetation	Cs-134	Bq/sample	10.10	10.62	7.43-13.81	A
			Cs-137	Bq/sample	6.0	5.62	3.93-7.31	A
			Co-57	Bq/sample	13.3000	11.8	8.3-15.3	A
			Co-60	Bq/sample	0.013		(1)	A
			Mn-54	Bq/sample	0.0150		(1)	A
			Sr-90	Bq/sample	0.301		(1)	N(4)
			Zn-65	Bq/sample	10.500	9.6	6.7-12.5	A
September 2016	16-MaW35	Water	Am-241	Bq/L	0.626	0.814	.570-1058	W
			Ni-63	Bq/L	12.4	17.2	12.0-22.4	A
			Pu-238	Bq/L	1.23	1.13	0.79-1.47	W
			Pu-239/240	Bq/L	0.0318	0.013	(1)	A
	16-MaS35	Soil	Ni-63	Bq/kg	724	990	693-1287	A
			Sr-90	Bq/kg	747	894	626-1162	A
	16-RdF35	AP	U-234/233	Bq/sample	0.160	0.15	0.105-0.195	A
			U-238	Bq/sample	0.157	0.156	0.109-0.203	A
	16-RdV35	Vegetation	Cs-134	Bq/sample	-0.103		(1)	A
			Cs-137	Bq/sample	5.64	5.54	3.88-7.20	A
			Co-57	Bq/sample	7.38	6.81	4.77-8.85	A
			Co-60	Bq/sample	4.81	4.86	3.40-6.32	A
			Mn-54	Bq/sample	7.4	7.27	5.09-9.45	A
			Sr-90	Bq/sample	0.774	0.80	0.56-1.04	A
			Zn-65	Bq/sample	5.46	5.4	3.78-7.02	A

(1) False positive test.
(a) Teledyne Brown Engineering reported result.
(b) 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.
(c) DOE/MAPEP evaluation: A=acceptable, W=acceptable with warning, N=not acceptable.
(4)NCR 16-14 was initiated

TABLE D-3.3

ERA ENVIRONMENTAL RADIOACTIVITY CROSS CHECK PROGRAM
TELEDYNE BROWN ENGINEERING ENVIRONMENTAL SERVICES

Month/Year	Identification Number	Media	Nuclide	Units	Reported Value (a)	Known Value (b)	Acceptance Limits	Evaluation (c)
May 2016	RAD-105	Water	Sr-89	pCi/L	48.9	48.2	37.8 - 55.6	A
			Sr-90	pCi/L	25.0	28.5	20.7 - 33.1	A
			Ba-133	pCi/L	53.1	58.8	48.7 - 64.9	A
			Cs-134	pCi/L	40.9	43.3	34.6 - 47.6	A
			Cs-137	pCi/L	84.8	78.4	70.6 - 88.9	A
			Co-60	pCi/L	108	102	91.8 - 114	A
			Zn-65	pCi/L	226	214	193 - 251	A
			Gr-A	pCi/L	38.9	62.7	32.9 - 77.8	A
			Gr-B	pCi/L	41.9	39.2	26.0 - 46.7	A
			I-131	pCi/L	24.1	26.6	22.1 - 31.3	A
			U-Nat	pCi/L	4.68	4.64	3.39 - 5.68	A
			H-3	pCi/L	7720	7840	6790 - 8620	A
November 2016	RAD-107	Water	Sr-89	pCi/L	43.0	43.3	33.4-50.5	A
			Sr-90	pCi/L	30.0	33.6	24.6-38.8	A
			Ba-133	pCi/L	47.8	54.9	45.4-60.7	A
			Cs-134	pCi/L	72.9	81.8	67.0-90.0	A
			Cs-137	pCi/L	189	210	189-233	A
			Co-60	pCi/L	58.4	64.5	58.0-73.4	A
			Zn-65	pCi/L	243	245	220-287	A
			Gr-A	pCi/L	37.2	68.4	35.9-84.5	A
			Gr-B	pCi/L	35.1	33.9	22.1-41.6	A
			I-131	pCi/L	23.5	26.3	21.9-31.0	A
			U-Nat	pCi/L	49.2	51.2	41.6-56.9	A
			H-3	pCi/L	918	9820	8540-10800	N(5)
	MRAD-25	AP	Gr-A	pCi/Filter	56.8	71.2	23.9-111	A

(a) Teledyne Brown Engineering reported result.

(b) 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.

(c) ERA evaluation: A=acceptable. Reported result falls within the Warning Limits. NA=not acceptable. Reported result falls outside of the Control Limits. CE=check for Error. Reported result falls within the Control Limits and outside of the Warning Limit.

(5) NCR 16-34 was initiated

D.4 Environmental TLD Quality Assurance

Environmental dosimetry services for the reporting period of January – December, 2016 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 2016 (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 2016 [(1), (2)]

Process Date	Mean Bias %	Standard Deviation %	Tolerance Limit +/-15%
4/16/2016	55	4.5	Pass
4/28/2016	91	2.7	Pass
5/07/2016	48	0.3	Pass
7/22/2016	28	1.5	Pass
7/24/2016	106	2.9	Pass
8/06/2016	-77	-3.3	Pass
10/30/2016	28	3.7	Pass
11/04/2016	63	2.5	Pass
11/22/2016	85	-2.9	Pass
1/27/2016	61	3.1	Pass
1/31/2016	112	2.2	Pass
2/05/2016	36	3.2	Pass

(1)This table summarizes results of tests conducted by EDC for TLDs issued in 2016.
(2)Environmental dosimeter results are free in air.

TABLE D-4.3
SUMMARY OF INDEPENDENT DOSIMETER TESTING
JANUARY – DECEMBER 2016 [(1), (2)]

Issuance Period	Client	Mean Bias %	Standard Deviation %	Pass / Fail
1st Qtr. 2016	Millstone	-6.5	2.9	Pass
2nd Qtr.2016	Millstone	-2.2	3.7	Pass
2nd Qtr.2016	Seabrook	1.4	0.9	Pass
3rd Qtr. 2016	Millstone	-3.4	1.1	Pass
4th Qtr.2016	Millstone	-1.5	2.3	Pass
4th Qtr.2016	Seabrook	0.8	1.8	Pass

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