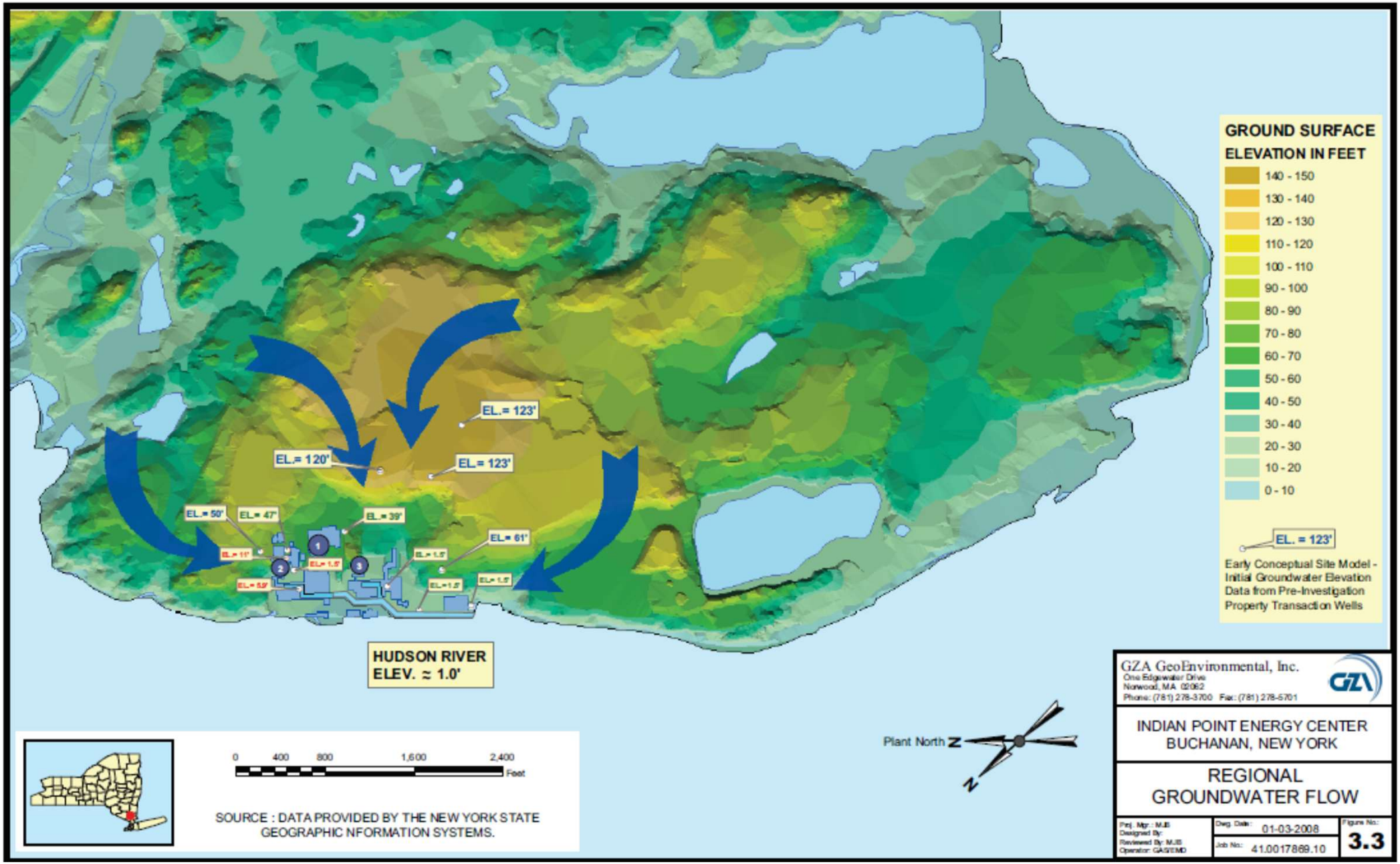
Followup to Senator Peter Harckham and Assemblywoman Dana Levenberg from the February 2, 2023, DOB meeting

① Underground plumes from Unit 1 and 2 spent fuel pool leaks

② Release of water from the Unit 1 spent fuel pool to the river in 2008

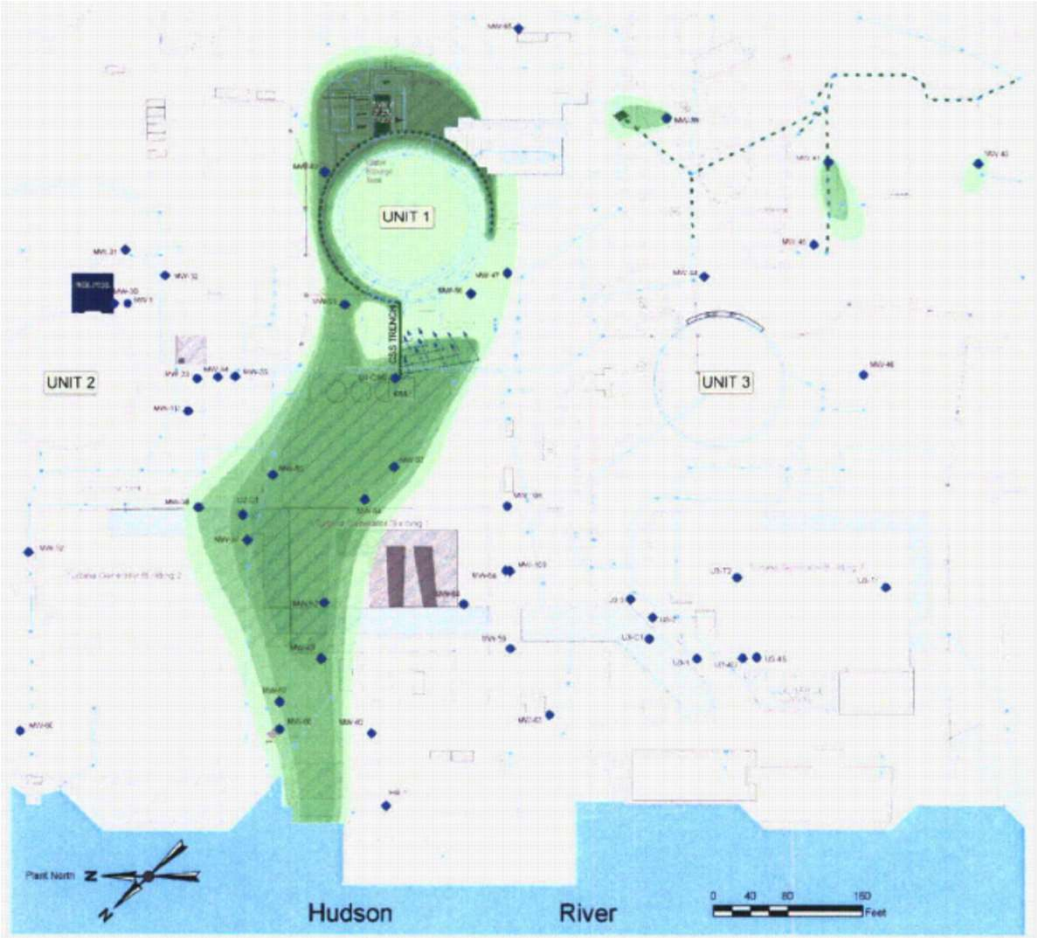
③ Impacts of bioaccumulation

Dave Lochbaum
March 3, 2023

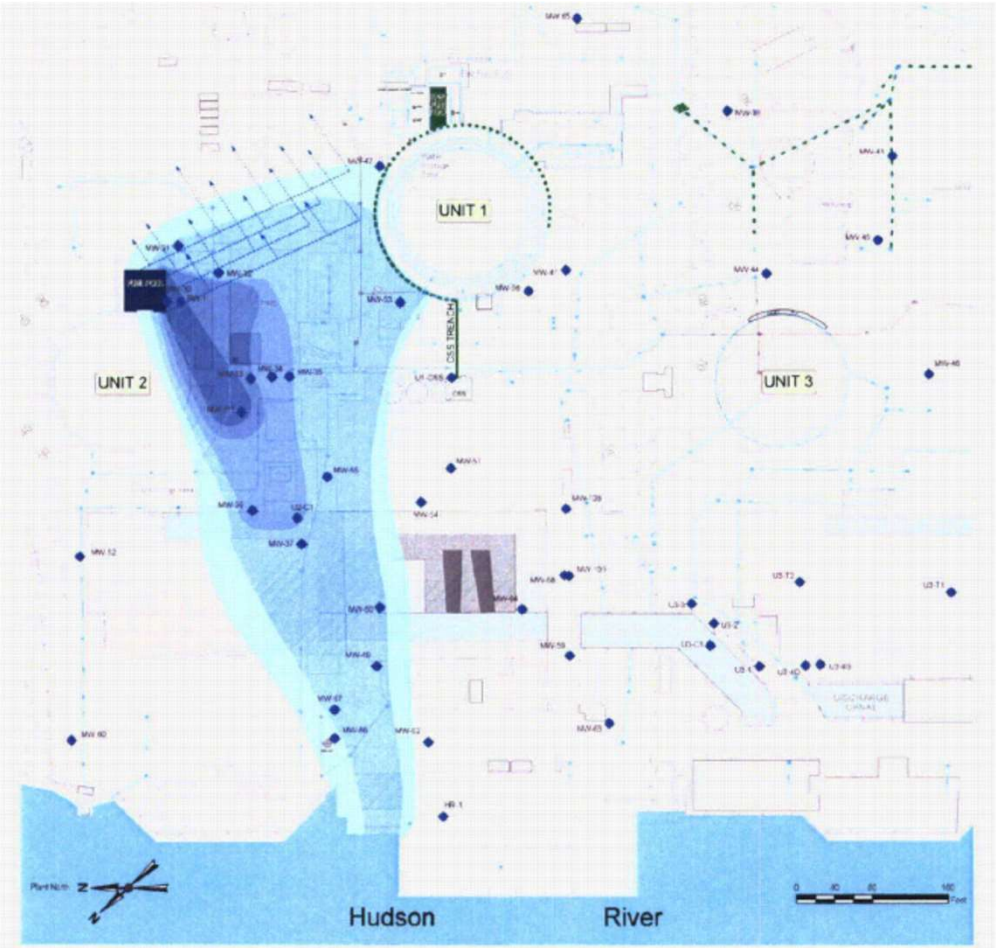


The site's topography showed that groundwater would carry water leaked from Indian Point to the river.

Source: ML12338A619



UNIT 1 BOUNDING ACTIVITY ISOPLETHS



UNIT 2 BOUNDING ACTIVITY ISOPLETHS

Based on geology and monitoring wells (blue dots), the plumes from the leaking Unit 1 (left) and Unit 2 (right) spent fuel pools was plotted. Both plumes reach the river.

https://adamswebsearch2.nrc.gov/webSearch2/main.jsp?AccessionNumber=ML080320540

Entergy's annual radioactive effluent report submitted in 2009 for releases in 2008 discussed the draining of the Unit 1 spent fuel pool water and its discharge to the Hudson River in September 2008:

As a result of aggressive processing before, during, and after the defueling operation, the effluent release from draining the pools (Sep, 2008) resulted in curies and mrem consistent with or slightly lower than routine monthly effluent. Strontium-90 releases, in particular, were essentially nonexistent, because the pool water had been cleaned up for months prior draining.

Based on the above analysis, it is estimated that approximately 0.2 Curies of Tritium migrated directly to the river via the GW flow path in 2008, resulting in an approximate total body dose of less than 0.1 mrem (2.2E-7 mrem). It is evident that tritium alone, whether from ground water or routine effluents, does not significantly add to offsite dose.

Strontium-90, Cesium-137, and Co-60 collectively contributed approximately 0.00016 curies to site effluent from the groundwater pathway. Combined groundwater releases from IPEC in 2008 (all radionuclides) resulted in a calculated annual dose of less than 0.1 mrem to the whole body and critical organ:

0.000286 mrem to the total body, (<0.01% limit)

Source: ML091260208

INDIAN POINT 1 and 2 RADIOACTIVE EFFLUENT REPORT (Jan - Dec 2008)

LIQUID EFFLUENTS - SUMMATION OF ALL RELEASES

A. Fission & Activation Products	Units	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Year 2008	Est. Total % Error
1. Total Release (not including Tritium, Gr Alpha, & Gases)	Ci	1.57E-02	2.01E-02	1.24E-02	6.37E-03	5.46E-02	+ 25
2. Average Diluted Conc	uCi/ml	2.71E-11	2.95E-11	1.44E-11	8.85E-12	1.92E-11	

B. Tritium							
1. Total Release	Ci	6.42E+01	5.52E+01	6.16E+01	2.92E+01	2.10E+02	± 25
2. Average Diluted Conc	uCi/ml	1.11E-07	8.10E-08	7.14E-08	4.05E-08	7.39E-08	

C. Dissolved & Entrained Gases							
1. Total Release	Ci	1.63E-03	1.13E-05	3.58E-02	-	3.75E-02	± 25
2. AverageDiluted Conc	uCi/ml	2.81E-12	1.65E-14	4.15E-11	-	1.32E-11	

D. Gross Alpha							
1. Total Release	Ci	-	-	-	-	-	± 25

E. Volume of Waste Released							
1. Processed Waste (LW & NCD)	liters	3.90E+06	2.10E+06	3.94E+06	2.16E+06	1.21E+07	+ 10
2. Unprocessed (SGBD, SFDS, UHD)	liters	4.13E+07	5.62E+07	4.61E+07	4.79E+07	1.91E+08	± 10

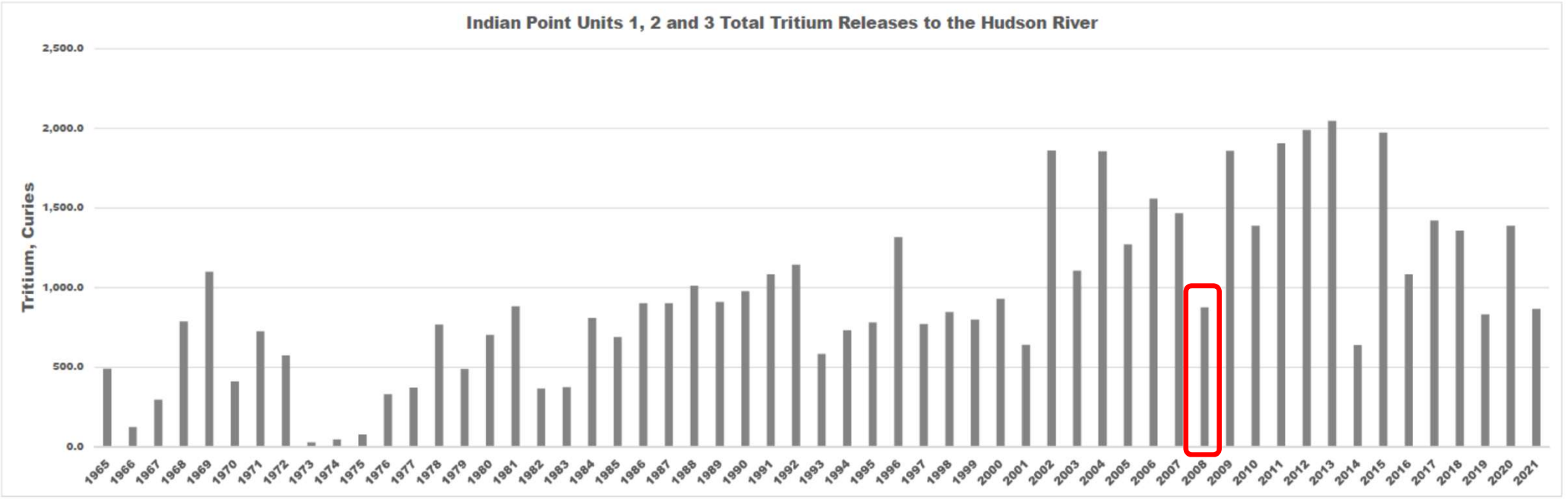
F. Volume of Dilution Water	liters	5.79E+11	6.81E+11	8.63E+11	7.19E+11	2.84E+12	+ 10

- Indicates < MDA

Source: ML091260208

The amount of tritium released in the 3rd quarter of 2008, including the Unit 1 spent fuel pool draindown, of 61.6 curies was less than the 1st quarter release (64.2 curies) and slightly above the 2nd quarter release (55.2 curies).

210 curies of tritium released into 2,840,000,000,000 gallons of dilution flow is an average tritium concentration of 73.9 picocuries per liter, below the 20,000 picocurie per liter EPA limit for drinking water.

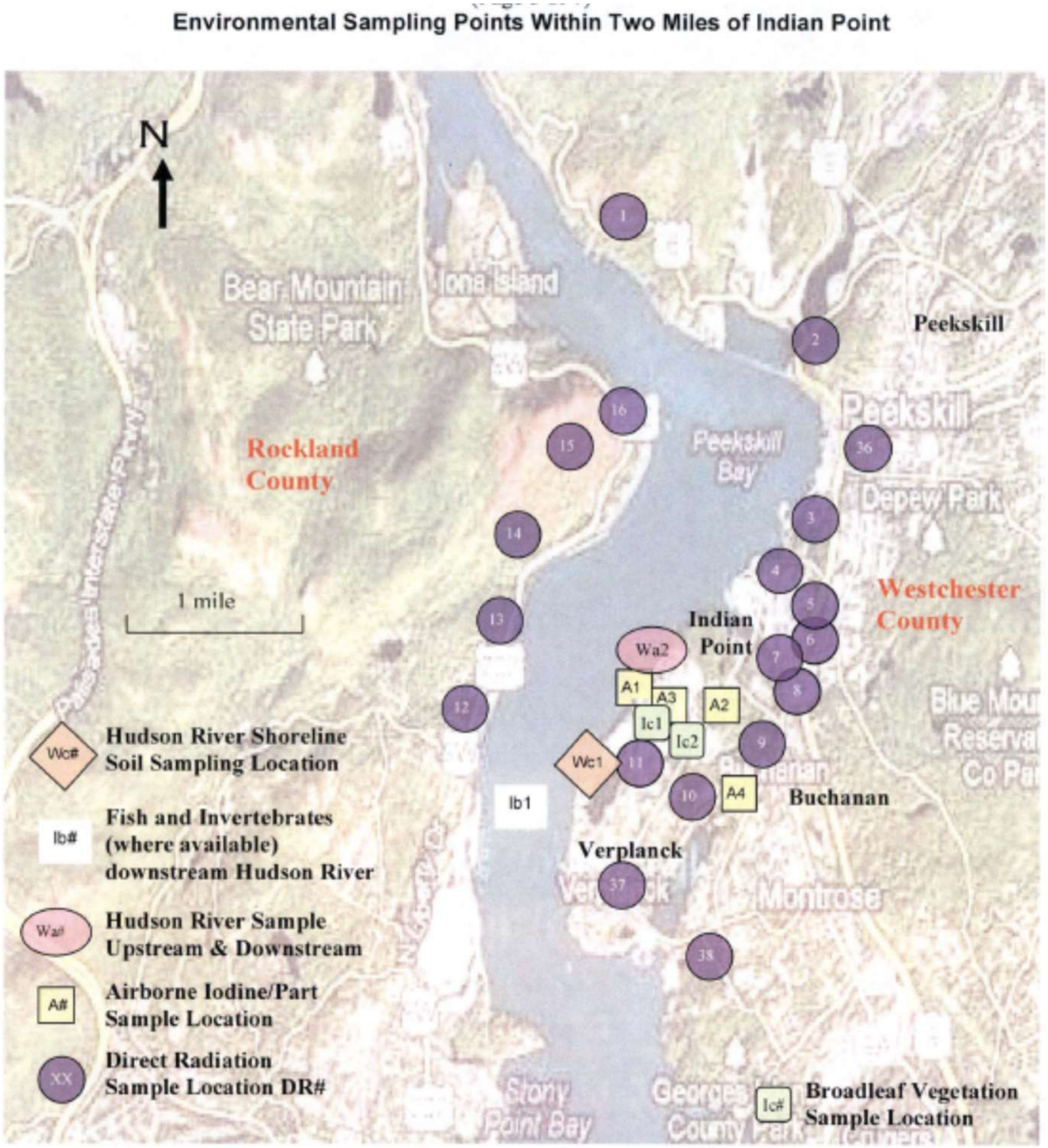


The annual releases of tritium from Indian Point to the Hudson River was lower in 2008 than in the five years prior to and subsequent to it. The annual radiation effluent reports to NRC were reviewed to understand why the 2008 tritium releases were lower.

Units 1 and 2 had 37 batch releases (i.e., discharge of a tank to the river after filtering and sampling) in 2007, 54 batch releases in 2008, and 31 batch releases in 2009.

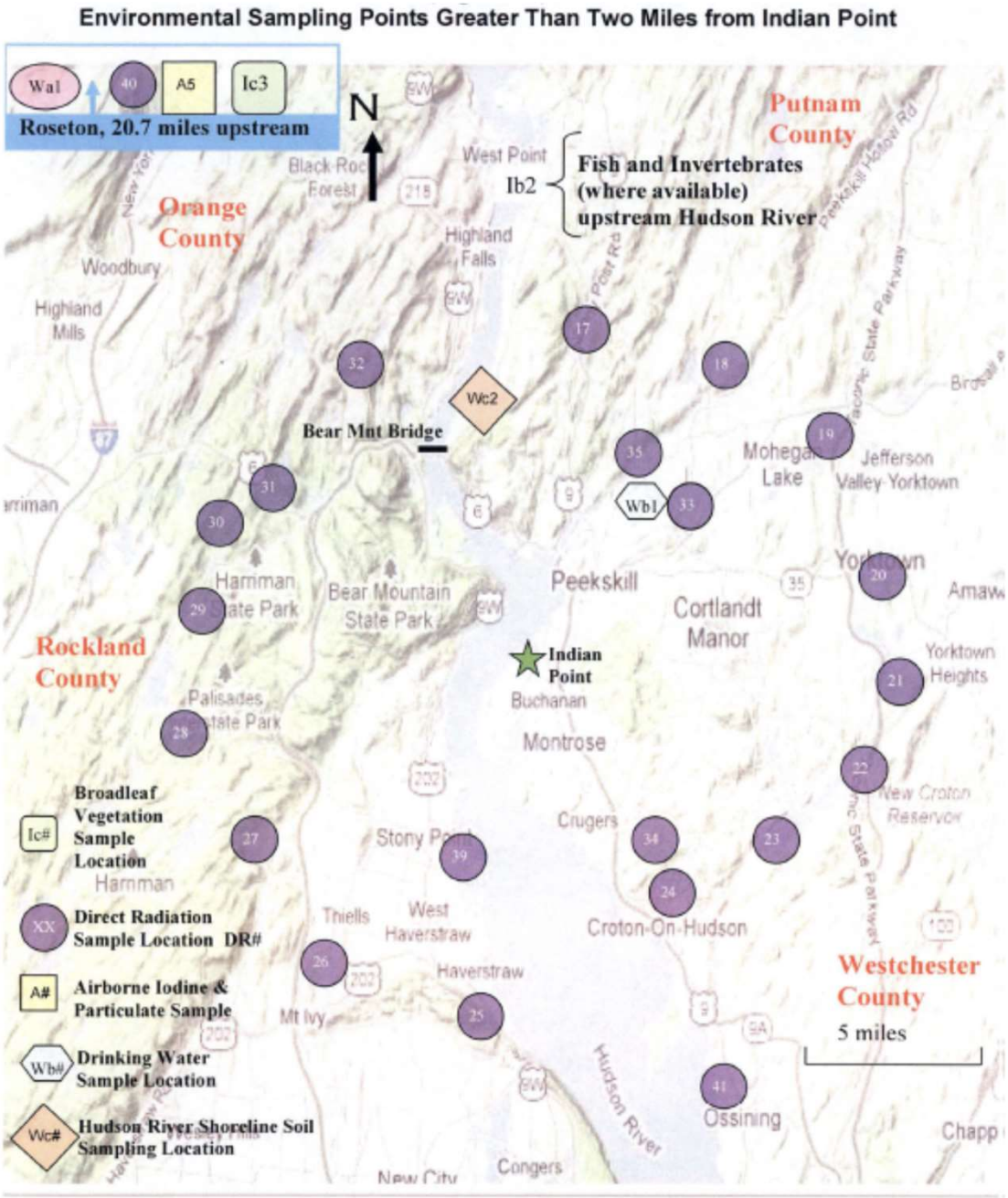
Unit 3 had 127 batch releases in 2007, 40 batch releases in 2008, and 101 batch releases in 2009.

The reports did not explain why the Unit 1 and 2 batch releases in 2008 nearly doubled the number of releases in 2007 and 2009; nor did the reports explain why the Unit 3 batch releases in 2008 were less than half the number of releases in 2007 and 2009.



Per federal regulations, samples of water, soil, fish, and vegetation within two miles are collected, evaluated, and reported to the NRC annually.

Entergy Nuclear Northeast, "Indian Point Energy Center Units 1, 2, and 3 Offsite Dose Calculation Manual (ODCM) Rev. 5," October 30, 2020 (ML21168A060).



Per federal regulations, samples of water, soil, fish, and vegetation greater than two miles away are collected, evaluated, and reported to the NRC annually.

Annual reports to the NRC (sources of maps like this one) contain tables with details on the sample locations. For example, drinking water sample location WB1 is the Camp Field Reservoir 3.4 miles northeast of the site.

Entergy Nuclear Northeast, "Indian Point Energy Center Units 1, 2, and 3 Offsite Dose Calculation Manual (ODCM) Rev. 5," October 30, 2020 (ML21168A060).

Summary of Sampling Deviations - 2021

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

TOTAL NUMBER OF SAMPLES COLLECTED = 1172

* Samples not collected or unable to be analyzed.

** Several sample types require more than one analysis

Lots of samples are collected from lots of locations.

1,319 samples were collected during 2021.

Holtec Decommissioning International, "Indian Point Energy Center 2021 Annual Radiological Environmental Operating Report," May 3, 2022 (ML22123A206).

RADIONUCLIDES IN DRINKING WATER SAMPLES - 2021

pCi/L ± 2 Sigma

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

The samples are analyzed to identify their isotopic contents.

This table provides the results from drinking water samples from WB1 at the Camp Field Reservoir.

Holtec Decommissioning International, "Indian Point Energy Center 2021 Annual Radiological Environmental Operating Report," May 3, 2022 (ML22123A206).

GAMMA EMITTERS IN BROAD LEAF VEGETATION SAMPLES - 2021

pCi/kg wet ± 2 Sigma

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

The samples are analyzed to identify their isotopic contents.

Holtec Decommissioning International, "Indian Point Energy Center 2021 Annual Radiological Environmental Operating Report," May 3, 2022 (ML22123A206).

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

(AiT)
mrem/hr per uCi/ml

ISOTOPE	BONE	LIVER	TOT BODY	THYROID	KIDNEY	LUNG	GI-LLI
H-3	0.00E+00	1.81E-01	1.81E-01	1.81E-01	1.81E-01	1.81E-01	1.81E-01
BE-7	4.77E-01	8.08E-01	5.33E-01	0.00E+00	7.96E-01	0.00E+00	4.52E+01
NA-24	4.57E+02	4.57E+02	4.57E+02	4.57E+02	4.57E+02	4.57E+02	4.57E+02
P-32	6.98E+07	3.27E+06	2.69E+06	0.00E+00	0.00E+00	0.00E+00	1.93E+06
CR-51	0.00E+00	0.00E+00	4.86E+00	2.70E+00	7.37E-01	4.92E+00	2.58E+02
MN-54	0.00E+00	4.20E+03	1.12E+03	0.00E+00	1.18E+03	0.00E+00	3.53E+03
MN-56	0.00E+00	1.31E+02	2.96E+01	0.00E+00	1.59E+02	0.00E+00	1.90E+04
FE-55	4.55E+04	2.42E+04	7.48E+03	0.00E+00	0.00E+00	1.37E+04	4.47E+03
FE-59	6.53E+04	1.06E+05	5.27E+04	0.00E+00	0.00E+00	3.07E+04	1.10E+05
CO-58	0.00E+00	4.20E+02	1.29E+03	0.00E+00	0.00E+00	0.00E+00	2.45E+03
CO-60	0.00E+00	1.23E+03	3.64E+03	0.00E+00	0.00E+00	0.00E+00	6.84E+03
NI-63	6.85E+04	3.67E+03	2.33E+03	0.00E+00	0.00E+00	0.00E+00	2.47E+02
NI-65	2.83E+02	2.66E+01	1.55E+01	0.00E+00	0.00E+00	0.00E+00	3.26E+03
CU-64	0.00E+00	9.05E+01	5.47E+01	0.00E+00	2.19E+02	0.00E+00	4.25E+03
ZN-65	1.55E+05	4.12E+05	2.56E+05	0.00E+00	2.59E+05	0.00E+00	7.23E+04
ZN-69	4.94E+02	7.14E+02	6.60E+01	0.00E+00	4.33E+02	0.00E+00	4.50E+04
BR-83	0.00E+00	0.00E+00	5.67E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BR-84	0.00E+00	0.00E+00	6.56E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BR-85	0.00E+00	0.00E+00	3.02E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RB-86	0.00E+00	1.06E+05	6.50E+04	0.00E+00	0.00E+00	0.00E+00	6.80E+03
RB-88	0.00E+00	3.00E+02	2.08E+02	0.00E+00	0.00E+00	0.00E+00	1.47E+01
RB-89	0.00E+00	1.85E+02	1.64E+02	0.00E+00	0.00E+00	0.00E+00	1.61E+00
SR-89	3.63E+04	0.00E+00	1.04E+03	0.00E+00	0.00E+00	0.00E+00	1.41E+03
SR-90	4.68E+05	0.00E+00	1.19E+05	0.00E+00	0.00E+00	0.00E+00	6.30E+03
SR-91	6.60E+02	0.00E+00	2.49E+01	0.00E+00	0.00E+00	0.00E+00	1.46E+03
SR-92	2.48E+02	0.00E+00	9.96E+00	0.00E+00	0.00E+00	0.00E+00	4.70E+03

How various isotopes interact within a child's body are considered when calculating the radiation dose.

NOTE: The concentration (µCi/ml) of an isotope measured in a sample are multiplied by the value in this table to determine the radiation dose rate.

Entergy Nuclear Northeast, "Indian Point Energy Center Units 1, 2, and 3 Offsite Dose Calculation Manual (ODCM) Rev. 5," October 30, 2020 (ML21168A060).

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

(AiT)
mrem/hr per uCi/ml

ISOTOPE	BONE	LIVER	TOT BODY	THYROID	KIDNEY	LUNG	GI-LLI
H-3	0.00E+00	2.17E-01	2.17E-01	2.17E-01	2.17E-01	2.17E-01	2.17E-01
BE-7	3.58E-01	8.02E-01	4.01E-01	0.00E+00	8.50E-01	0.00E+00	9.76E+01
NA-24	4.20E+02	4.20E+02	4.20E+02	4.20E+02	4.20E+02	4.20E+02	4.20E+02
P-32	5.40E+07	3.35E+06	2.09E+06	0.00E+00	0.00E+00	0.00E+00	4.54E+06
CR-51	0.00E+00	0.00E+00	4.44E+00	2.47E+00	9.73E-01	6.34E+00	7.46E+02
MN-54	0.00E+00	5.33E+03	1.06E+03	0.00E+00	1.59E+03	0.00E+00	1.09E+04
MN-56	0.00E+00	1.43E+02	2.54E+01	0.00E+00	1.81E+02	0.00E+00	9.40E+03
FE-55	3.35E+04	2.37E+04	5.54E+03	0.00E+00	0.00E+00	1.51E+04	1.03E+04
FE-59	5.20E+04	1.21E+05	4.69E+04	0.00E+00	0.00E+00	3.83E+04	2.87E+05
CO-58	0.00E+00	5.10E+02	1.18E+03	0.00E+00	0.00E+00	0.00E+00	7.04E+03
CO-60	0.00E+00	1.48E+03	3.32E+03	0.00E+00	0.00E+00	0.00E+00	1.92E+04
NI-63	5.15E+04	3.64E+03	1.75E+03	0.00E+00	0.00E+00	0.00E+00	5.79E+02
NI-65	2.18E+02	2.79E+01	1.27E+01	0.00E+00	0.00E+00	0.00E+00	1.51E+03
CU-64	0.00E+00	9.53E+01	4.48E+01	0.00E+00	2.41E+02	0.00E+00	7.39E+03
ZN-65	1.46E+05	5.07E+05	2.36E+05	0.00E+00	3.24E+05	0.00E+00	2.15E+05
ZN-69	3.73E+02	7.10E+02	4.97E+01	0.00E+00	4.64E+02	0.00E+00	1.31E+03
BR-83	0.00E+00	0.00E+00	4.41E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BR-84	0.00E+00	0.00E+00	5.55E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BR-85	0.00E+00	0.00E+00	2.34E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RB-86	0.00E+00	1.09E+05	5.12E+04	0.00E+00	0.00E+00	0.00E+00	1.61E+04
RB-88	0.00E+00	3.12E+02	1.66E+02	0.00E+00	0.00E+00	0.00E+00	2.67E-05
RB-89	0.00E+00	2.01E+02	1.42E+02	0.00E+00	0.00E+00	0.00E+00	3.09E-07
SR-89	2.79E+04	0.00E+00	8.00E+02	0.00E+00	0.00E+00	0.00E+00	3.33E+03
SR-90	5.27E+05	0.00E+00	1.30E+05	0.00E+00	0.00E+00	0.00E+00	1.48E+04
SR-91	5.12E+02	0.00E+00	2.04E+01	0.00E+00	0.00E+00	0.00E+00	2.32E+03
SR-92	1.94E+02	0.00E+00	8.25E+00	0.00E+00	0.00E+00	0.00E+00	4.93E+03

How various isotopes interact within a teen's body are considered when calculating the radiation dose.

NOTE: The concentration (µCi/ml) of an isotope measured in a sample are multiplied by the value in this table to determine the radiation dose rate.

Entergy Nuclear Northeast, "Indian Point Energy Center Units 1, 2, and 3 Offsite Dose Calculation Manual (ODCM) Rev. 5," October 30, 2020 (ML21168A060).

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

(AiT)
mrem/hr per uCi/ml

ISOTOPE	BONE	LIVER	TOT BODY	THYROID	KIDNEY	LUNG	GI-LLI
H-3	0.00E+00	2.82E-01	2.82E-01	2.82E-01	2.82E-01	2.82E-01	2.82E-01
BE-7	3.29E-01	7.45E-01	3.69E-01	0.00E+00	7.83E-01	0.00E+00	1.28E+02
NA-24	4.08E+02	4.08E+02	4.08E+02	4.08E+02	4.08E+02	4.08E+02	4.08E+02
P-32	4.96E+07	3.08E+06	1.92E+06	0.00E+00	0.00E+00	0.00E+00	5.57E+06
CR-51	0.00E+00	0.00E+00	4.31E+00	2.58E+00	9.50E-01	5.72E+00	1.08E+03
MN-54	0.00E+00	5.43E+03	1.04E+03	0.00E+00	1.61E+03	0.00E+00	1.66E+04
MN-56	0.00E+00	1.37E+02	2.42E+01	0.00E+00	1.73E+02	0.00E+00	4.36E+03
FE-55	3.21E+04	2.21E+04	5.16E+03	0.00E+00	0.00E+00	1.24E+04	1.27E+04
FE-59	5.06E+04	1.19E+05	4.56E+04	0.00E+00	0.00E+00	3.32E+04	3.96E+05
CO-58	0.00E+00	5.15E+02	1.15E+03	0.00E+00	0.00E+00	0.00E+00	1.04E+04
CO-60	0.00E+00	1.48E+03	3.26E+03	0.00E+00	0.00E+00	0.00E+00	2.78E+04
NI-63	4.97E+04	3.45E+03	1.67E+03	0.00E+00	0.00E+00	0.00E+00	7.19E+02
NI-65	2.02E+02	2.62E+01	1.20E+01	0.00E+00	0.00E+00	0.00E+00	6.65E+02
CU-64	0.00E+00	9.08E+01	4.26E+01	0.00E+00	2.29E+02	0.00E+00	7.74E+03
ZN-65	1.61E+05	5.13E+05	2.32E+05	0.00E+00	3.43E+05	0.00E+00	3.23E+05
ZN-69	3.43E+02	6.57E+02	4.57E+01	0.00E+00	4.27E+02	0.00E+00	9.87E+01
BR-83	0.00E+00	0.00E+00	4.05E+01	0.00E+00	0.00E+00	0.00E+00	5.84E+01
BR-84	0.00E+00	0.00E+00	5.25E+01	0.00E+00	0.00E+00	0.00E+00	4.13E-04
BR-85	0.00E+00	0.00E+00	2.16E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RB-86	0.00E+00	1.01E+05	4.72E+04	0.00E+00	0.00E+00	0.00E+00	2.00E+04
RB-88	0.00E+00	2.91E+02	1.54E+02	0.00E+00	0.00E+00	0.00E+00	4.02E-09
RB-89	0.00E+00	1.93E+02	1.35E+02	0.00E+00	0.00E+00	0.00E+00	1.12E-11
SR-89	2.57E+04	0.00E+00	7.37E+02	0.00E+00	0.00E+00	0.00E+00	4.12E+03
SR-90	6.32E+05	0.00E+00	1.55E+05	0.00E+00	0.00E+00	0.00E+00	1.82E+04
SR-91	4.72E+02	0.00E+00	1.91E+01	0.00E+00	0.00E+00	0.00E+00	2.25E+03
SR-92	1.79E+02	0.00E+00	7.75E+00	0.00E+00	0.00E+00	0.00E+00	3.55E+03

How various isotopes interact within a adult's body are considered when calculating the radiation dose.

NOTE: The concentration (µCi/ml) of an isotope measured in a sample are multiplied by the value in this table to determine the radiation dose rate.

Entergy Nuclear Northeast, "Indian Point Energy Center Units 1, 2, and 3 Offsite Dose Calculation Manual (ODCM) Rev. 5," October 30, 2020 (ML21168A060).

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

ISOTOPE	Freshwater Fish BFi	Saltwater Invertebrates BIi	ISOTOPE	Freshwater Fish BFi	Saltwater Invertebrates BIi
H-3	9.000E-01	9.300E-01	TE-125M	4.000E+02	1.000E+02
BE-7	2.000E+00	2.000E+02	TE-127M	4.000E+02	1.000E+02
NA-24	1.000E+02	1.900E-01	TE-127	4.000E+02	1.000E+02
P-32	1.000E+05	3.000E+04	TE-129M	4.000E+02	1.000E+02
CR-51	2.000E+02	2.000E+03	TE-129	4.000E+02	1.000E+02
MN-54	4.000E+02	4.000E+02	TE-131M	4.000E+02	1.000E+02
MN-56	4.000E+02	4.000E+02	TE-131	4.000E+02	1.000E+02
FE-55	1.000E+02	2.000E+04	TE-132	4.000E+02	1.000E+02
FE-59	1.000E+02	2.000E+04	I-130	1.500E+01	5.000E+01
CO-58	5.000E+01	1.000E+03	I-131	1.500E+01	5.000E+01
CO-60	5.000E+01	1.000E+03	I-132	1.500E+01	5.000E+01
NI-63	1.000E+02	2.500E+02	I-133	1.500E+01	5.000E+01
NI-65	1.000E+02	2.500E+02	I-134	1.500E+01	5.000E+01
CU-64	5.000E+01	1.700E+03	I-135	1.500E+01	5.000E+01
ZN-65	2.000E+03	5.000E+04	CS-134	2.240E+02	2.240E+02
ZN-69	2.000E+03	5.000E+04	CS-136	2.240E+02	2.240E+02
BR-83	4.200E+02	3.100E+00	CS-137	2.240E+02	2.240E+02
BR-84	4.200E+02	3.100E+00	CS-138	2.240E+02	2.240E+02
BR-85	4.200E+02	3.100E+00	BA-139	4.000E+00	1.000E+02
RB-86	2.000E+03	1.700E+01	BA-140	4.000E+00	1.000E+02
RB-88	2.000E+03	1.700E+01	BA-141	4.000E+00	1.000E+02
RB-89	2.000E+03	1.700E+01	BA-142	4.000E+00	1.000E+02
SR-89	3.000E+01	2.000E+01	LA-140	2.500E+01	1.000E+03
SR-90	3.000E+01	2.000E+01	LA-142	2.500E+01	1.000E+03
SR-91	3.000E+01	2.000E+01	CE-141	1.000E+00	6.000E+02
SR-92	3.000E+01	2.000E+01	CE-143	1.000E+00	6.000E+02

How various isotopes can bio-accumulate in fish and invertebrates and be consumed by individuals are considered when calculating the radiation dose.

Entergy Nuclear Northeast, "Indian Point Energy Center Units 1, 2, and 3 Offsite Dose Calculation Manual (ODCM) Rev. 5," October 30, 2020 (ML21168A060).

Calculating Radiation Dose to the Public

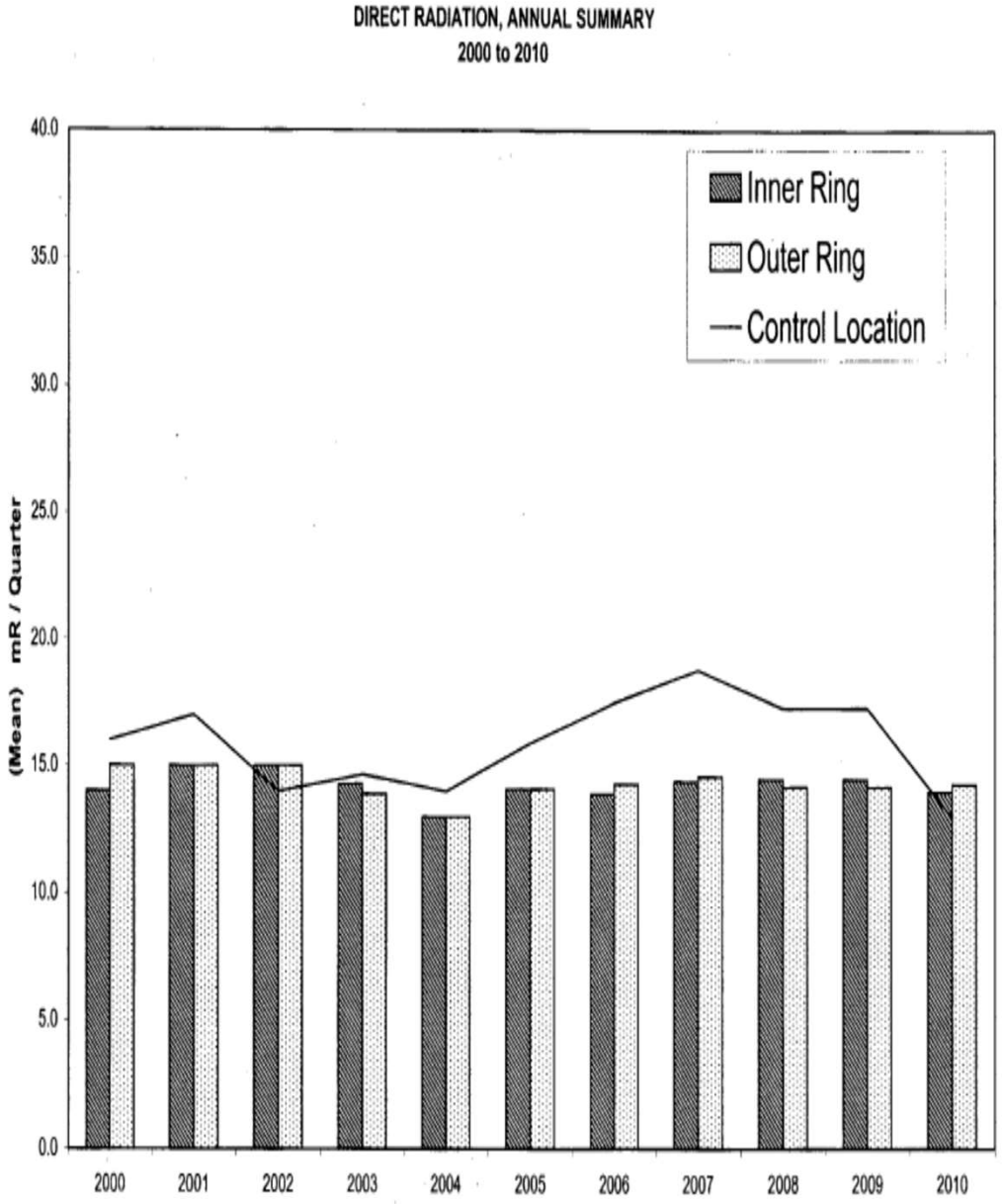
The sampling of vegetation, drinking water, fish, etc. identifies how much of Isotope A, Isotope B, Isotope C, etc. are present in terms of picocuries per liter for liquids and picocuries per gram for solids.

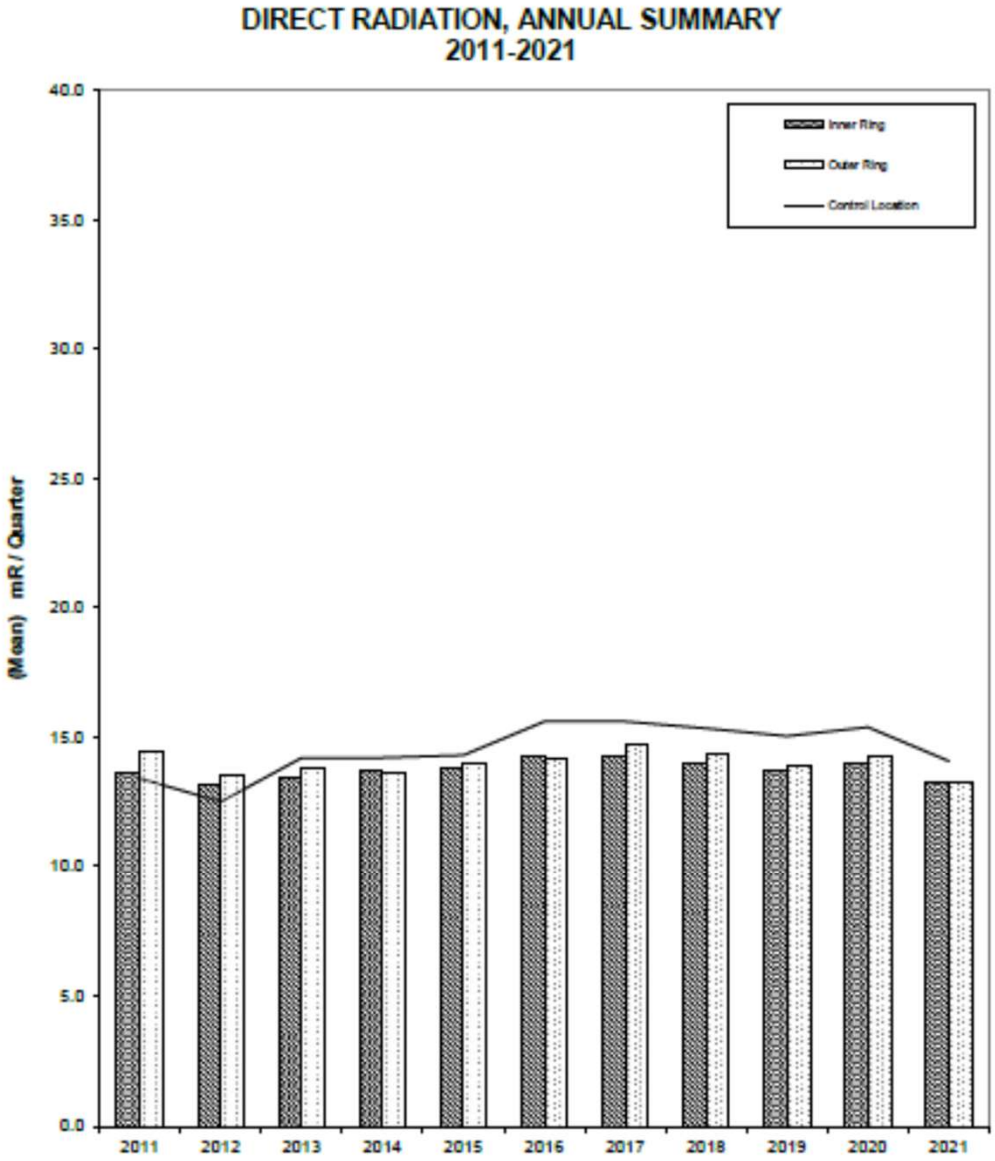
Research results into how Isotope A, Isotope B, Isotope C, etc. affect the body are taken into account.

In addition, breathing rate and consumption rates for children, teenagers, and adults determine how much of the various isotopes be ingested.

With inputs on what isotopes exist in what materials inhaled and consumed by children, teenagers, and adults, calculations determine the maximum radiation exposure each population received.

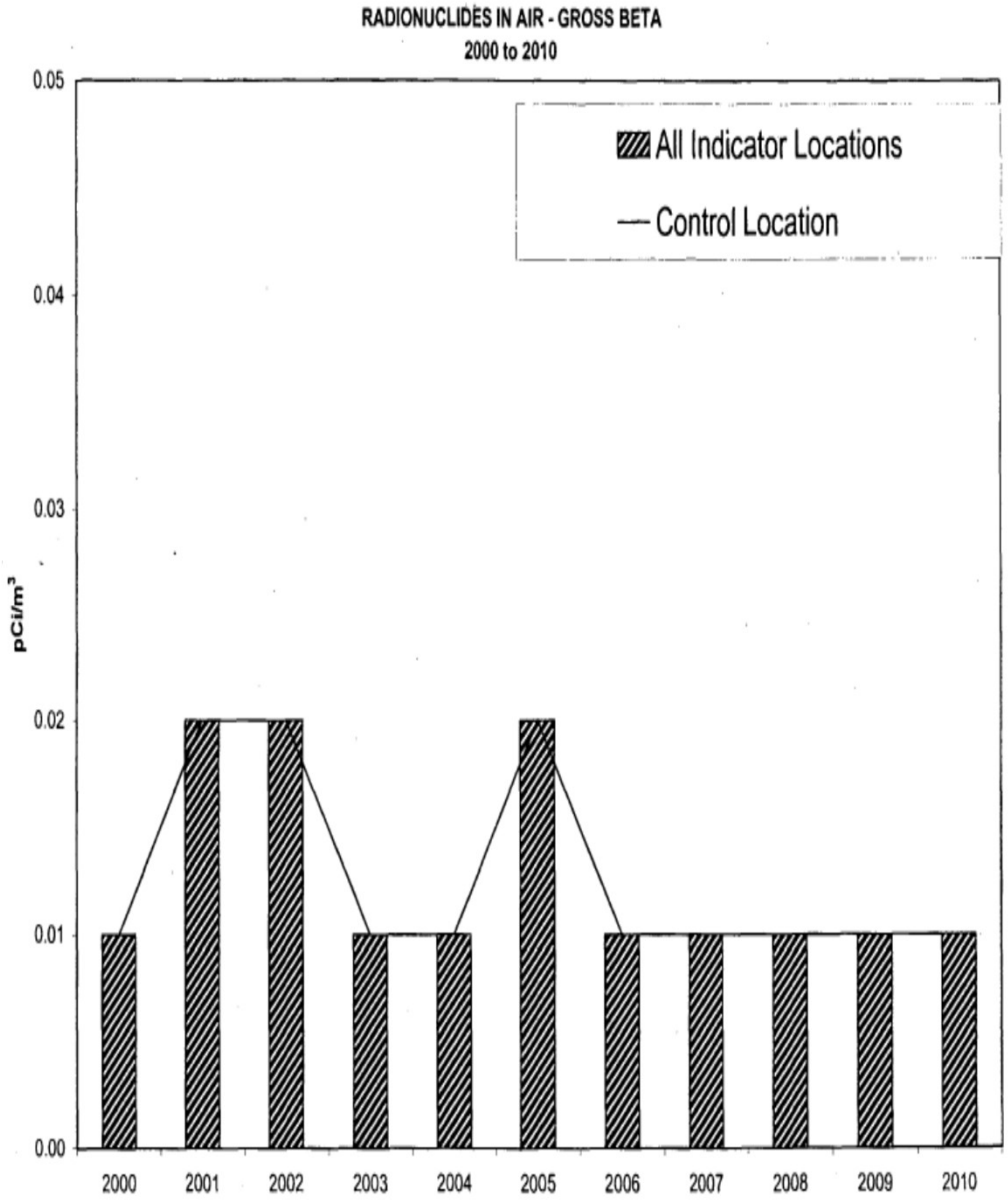
The federal limits on radiation effluents focus on public radiation exposures rather than individual isotope limits because the pathways for isotopes to reach human bodies differ from site to site depending on geology, hydrology, meteorology, and many other factors.

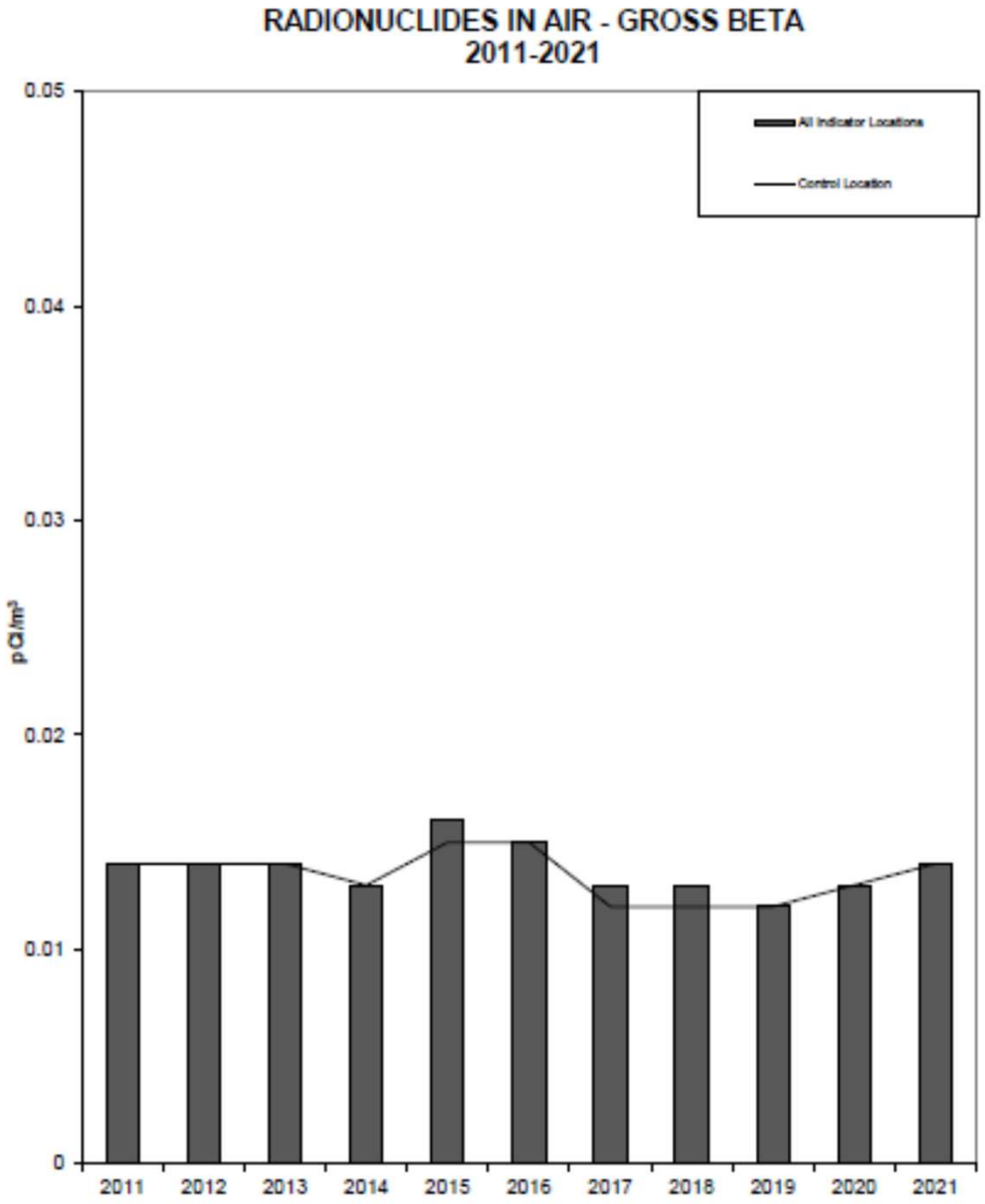




Data from thermal luminescent dosimeters (i.e., radiation dose monitors) show no increasing or decreasing trend over two decades.

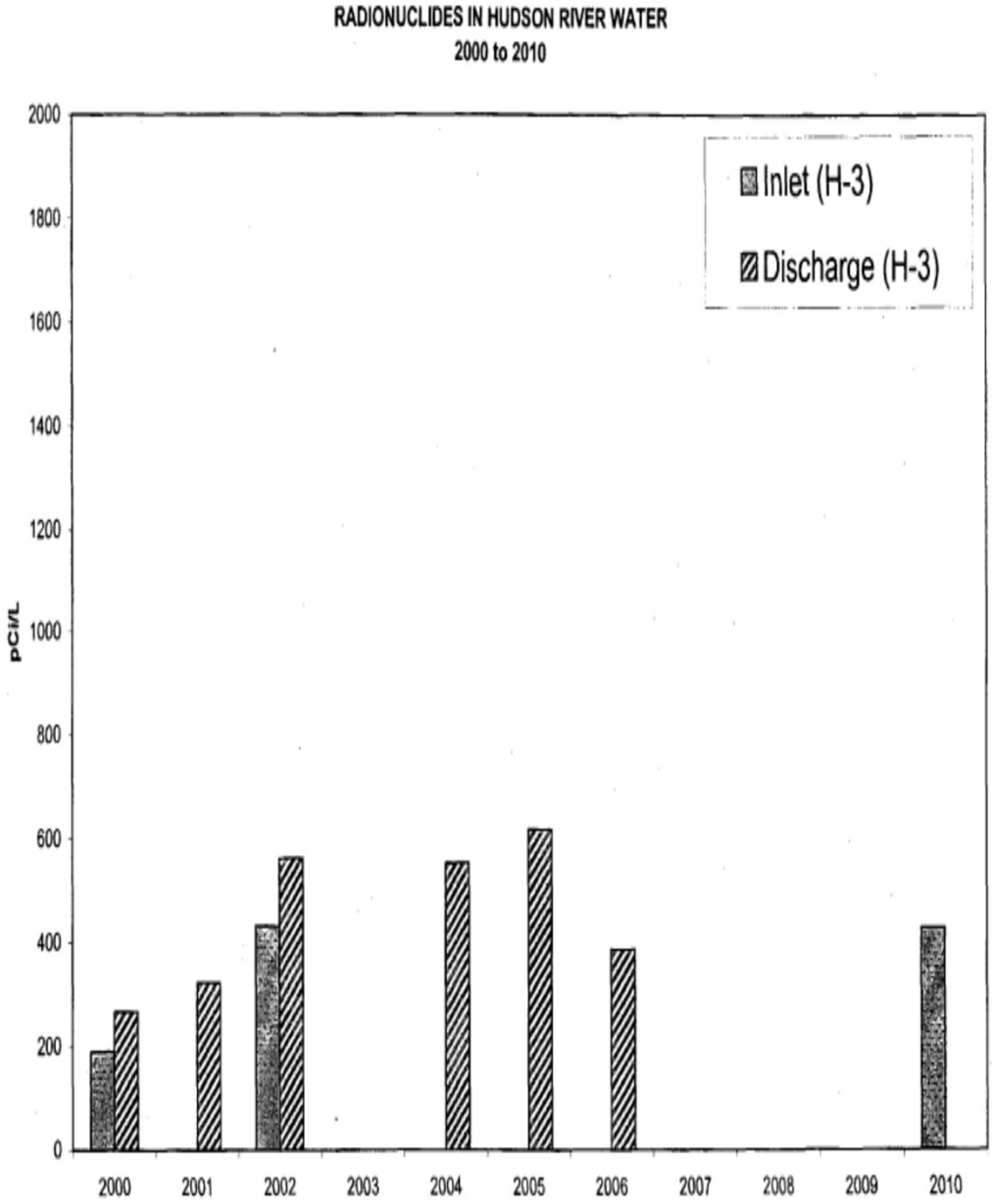
Sources: ML11143A052 and ML22123A206

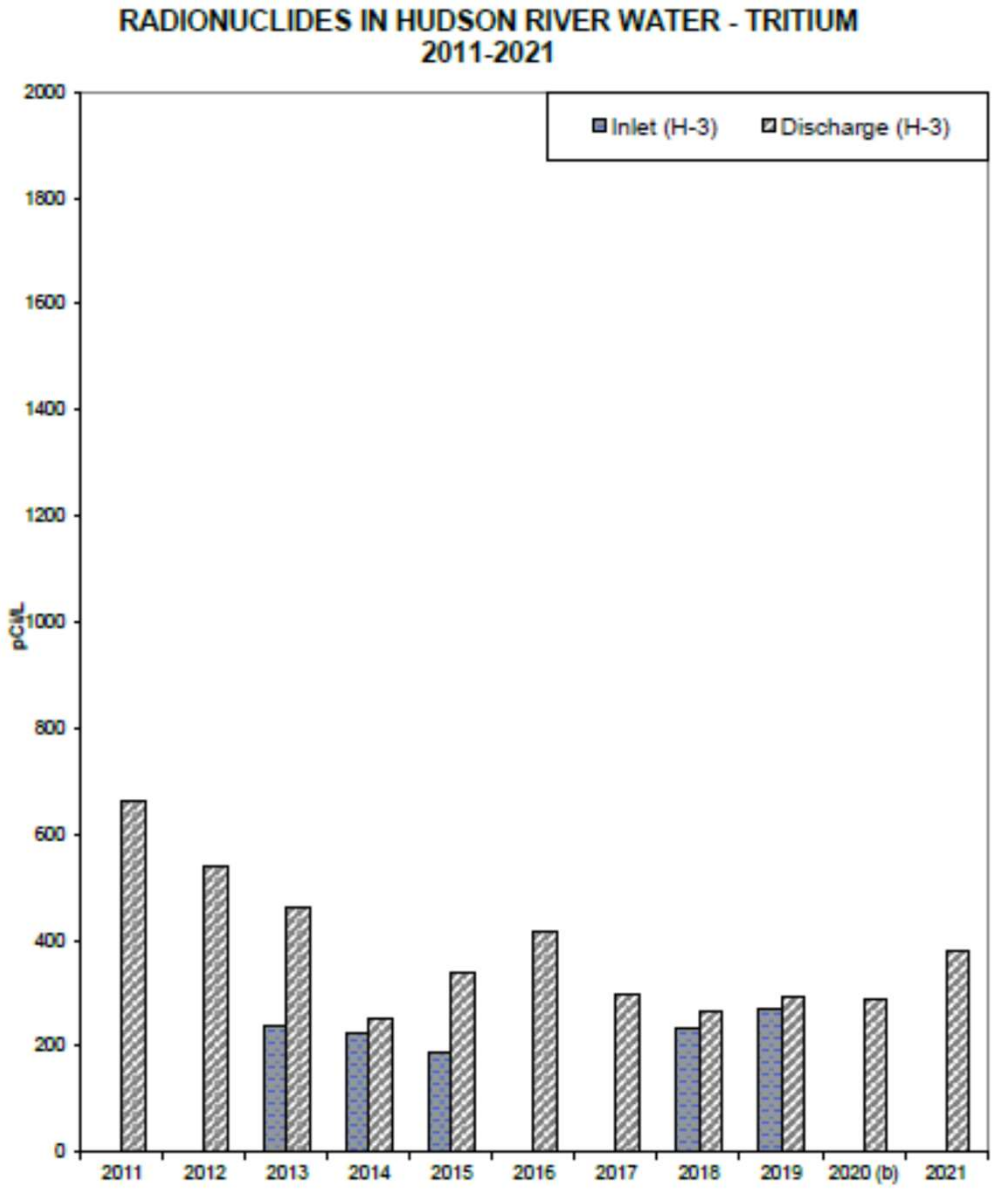




Beta emissions from air sampling (such as from tritium gas) show low levels with no discernible trend.

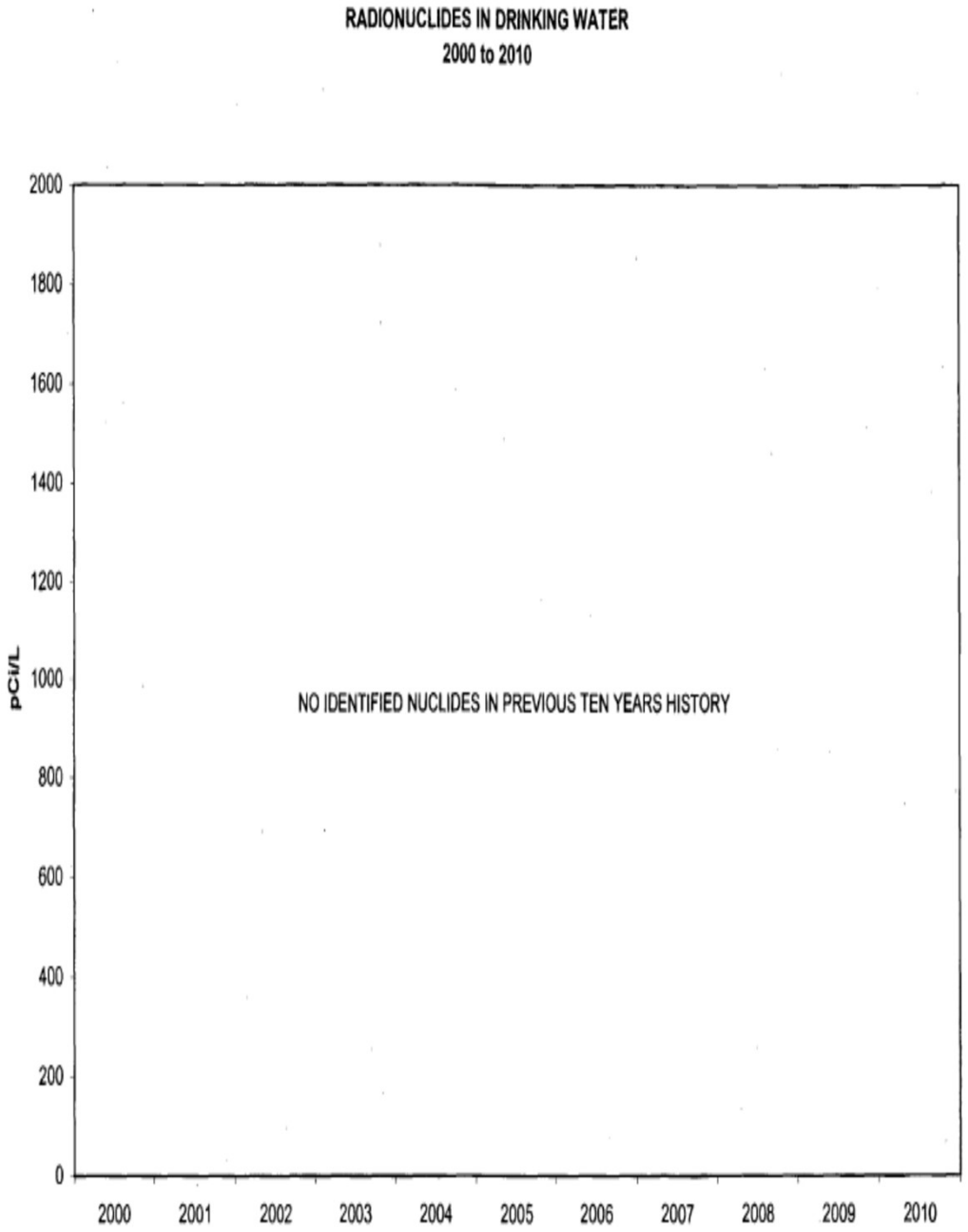
Sources: ML11143A052 and ML22123A206

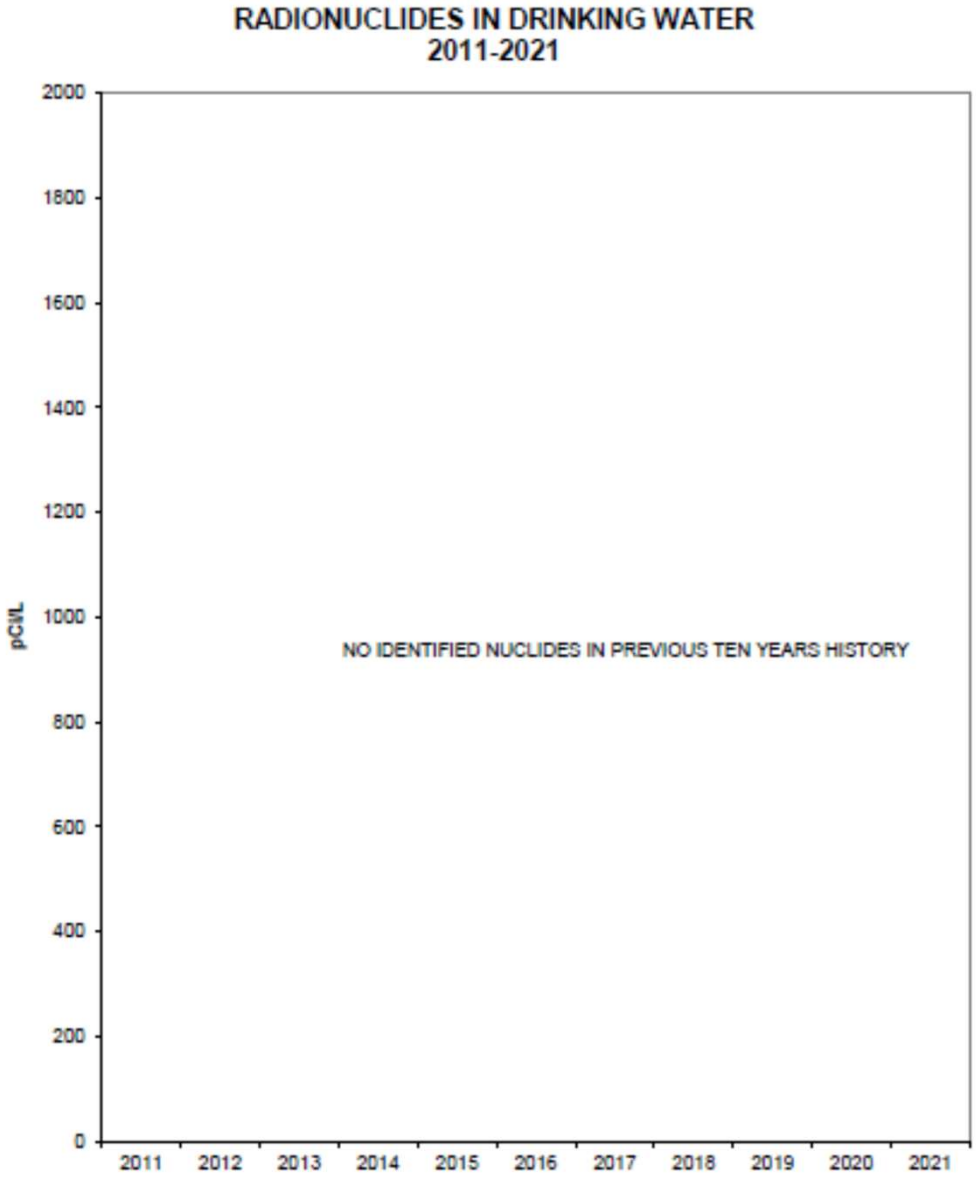




The tritium concentrations measures in the intake to and discharge from Indian Point was far below the 20,000 picocurie per liter EPA drinking water standard.

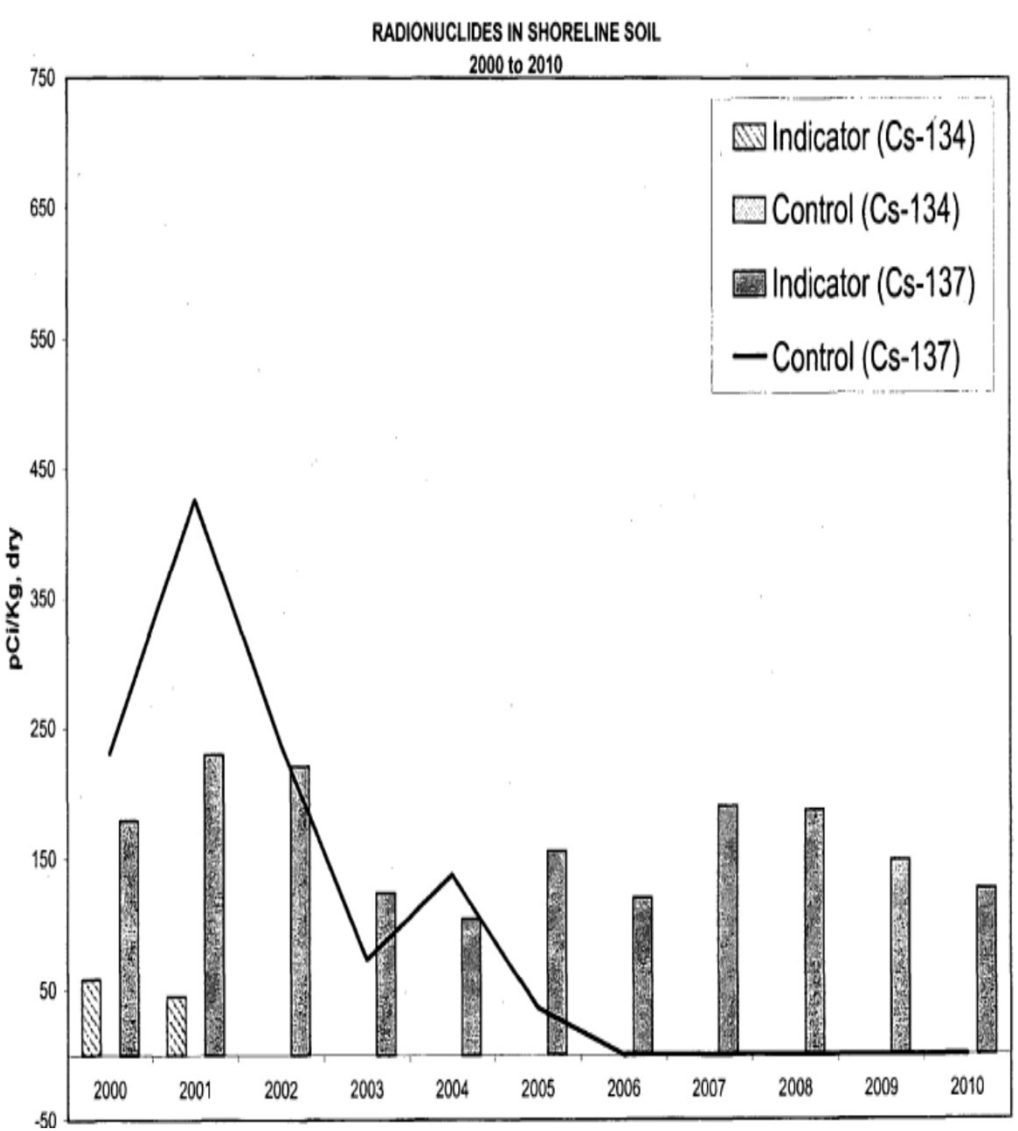
Sources: ML11143A052 and ML22123A206

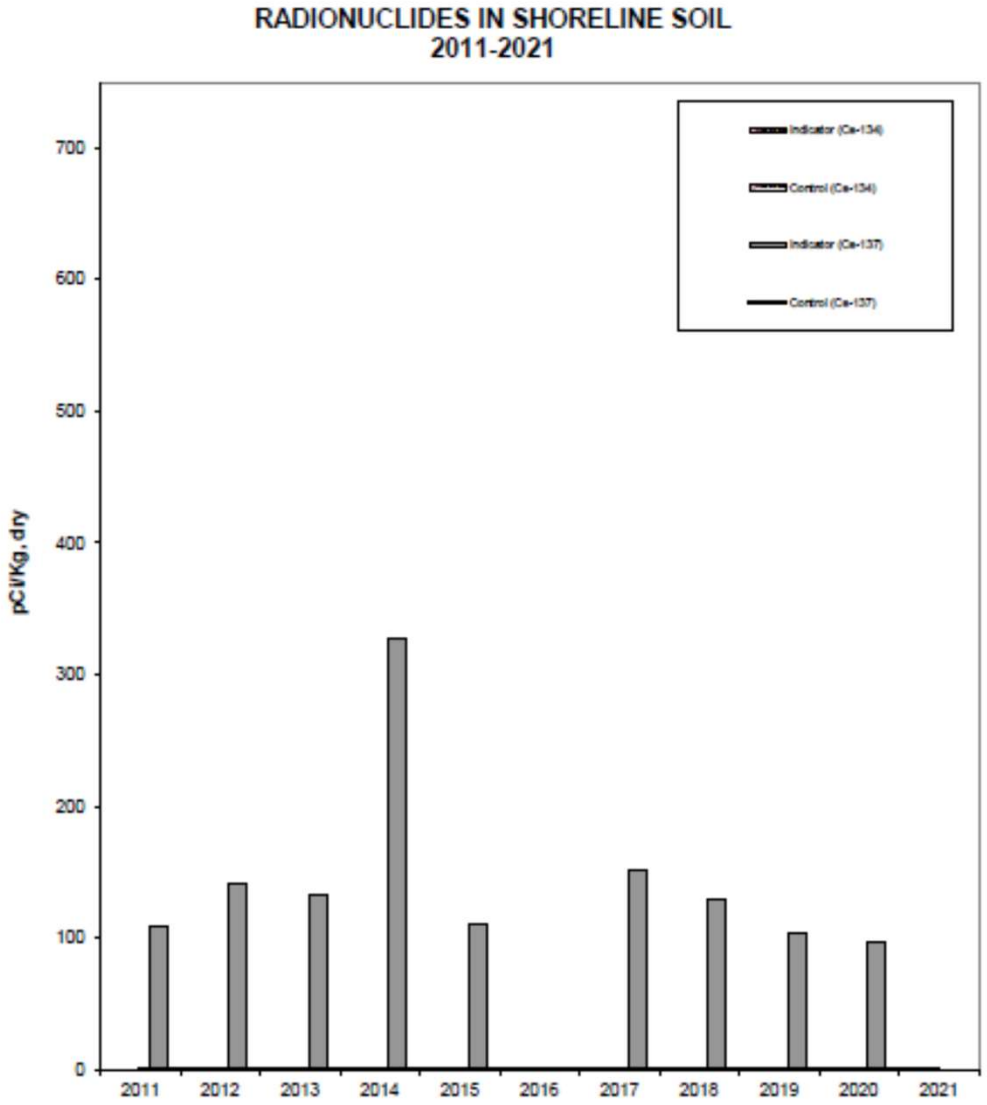




Radionuclides have not been detected in drinking water.

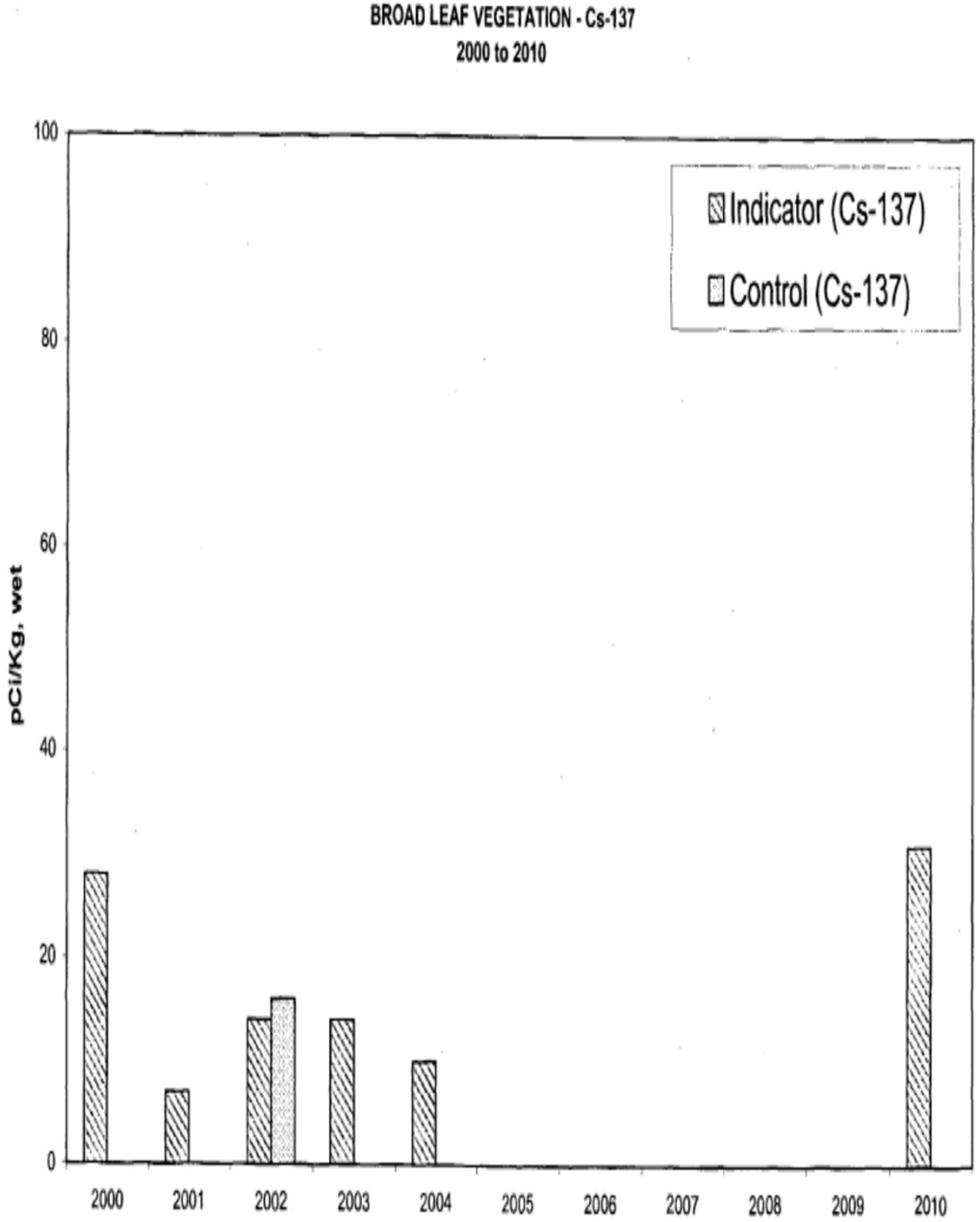
Sources: ML11143A052 and ML22123A206

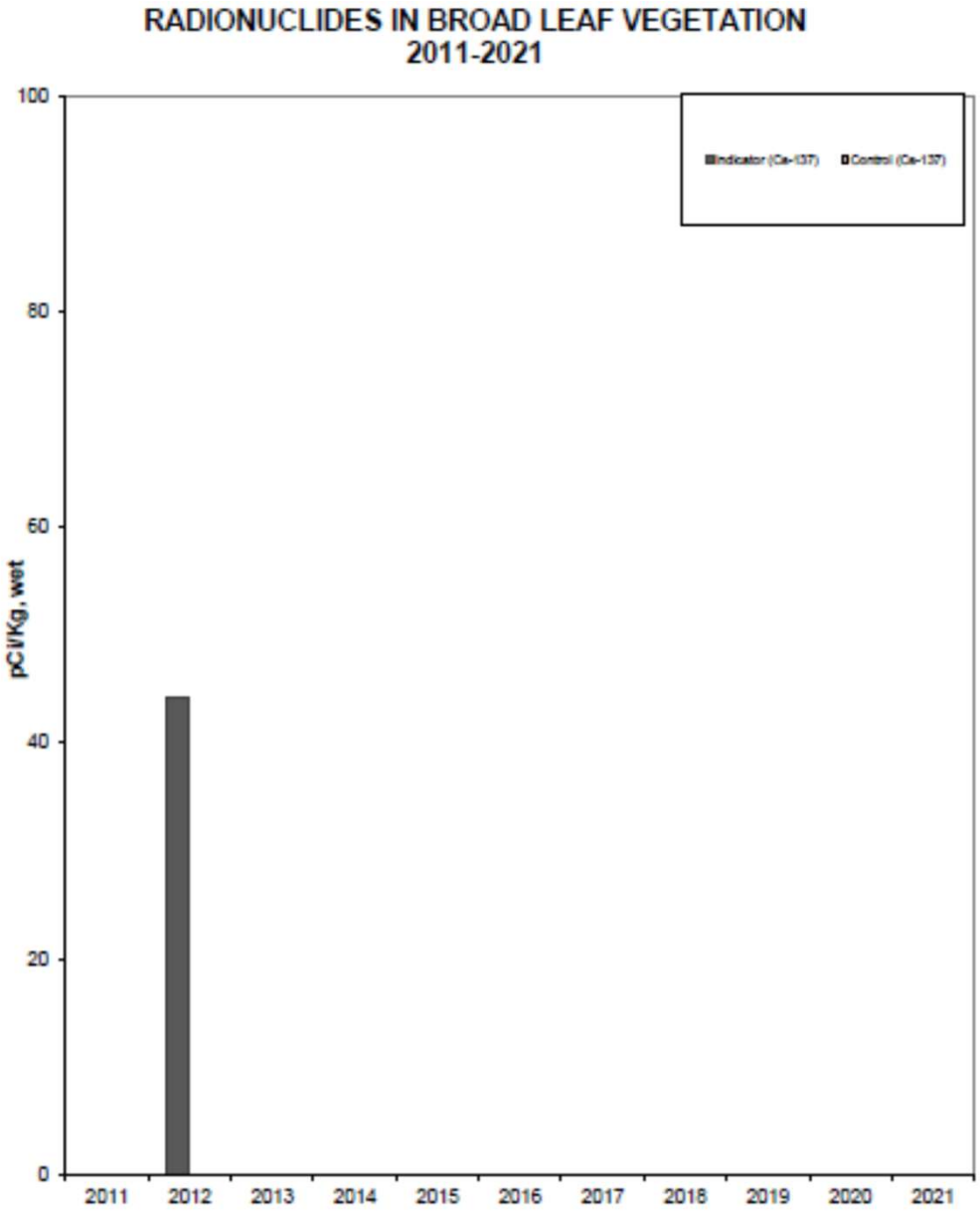




Radionuclide concentrations in Hudson River shoreline soil samples have been low with no indication of an increasing trend.

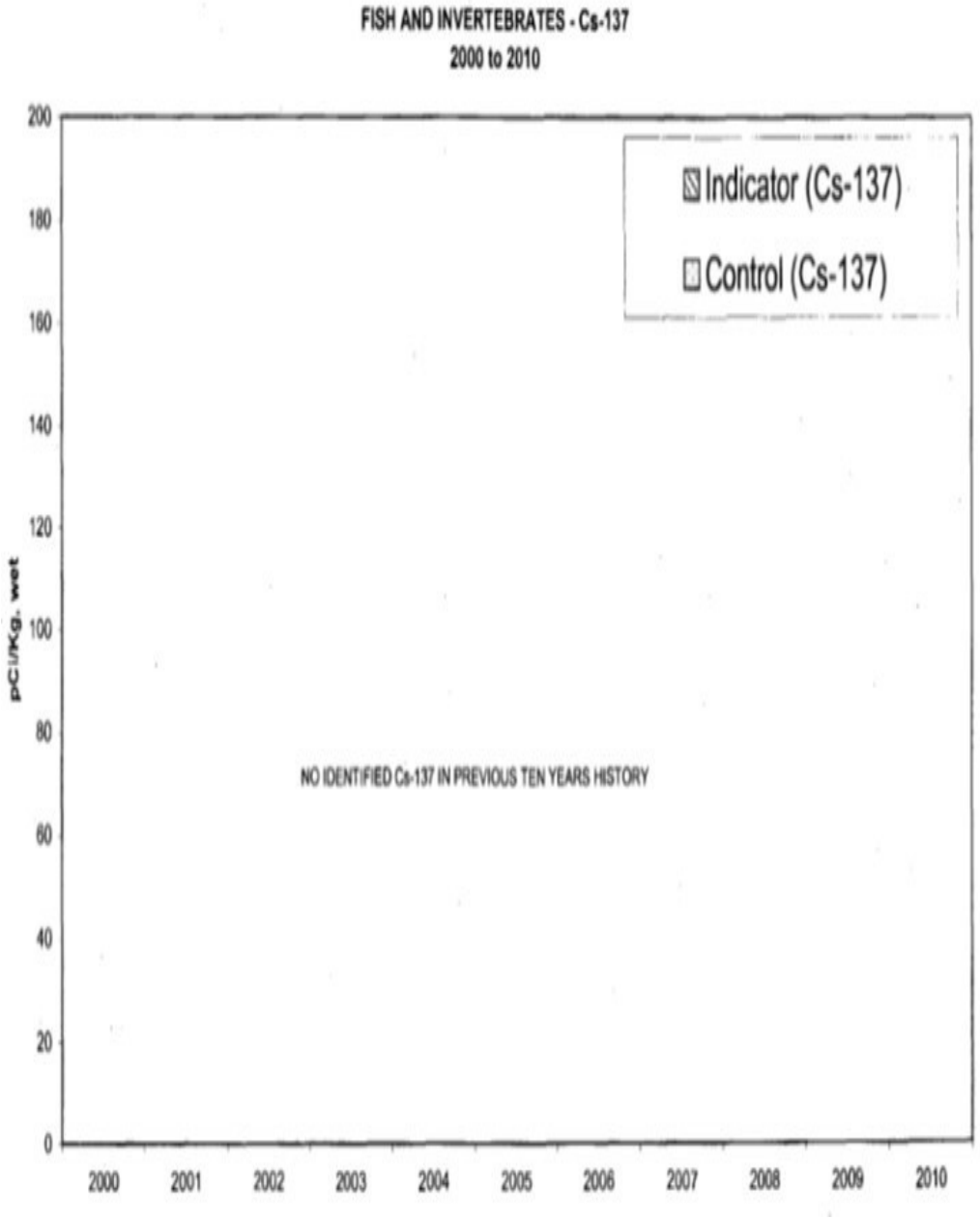
Sources: ML11143A052 and ML22123A206

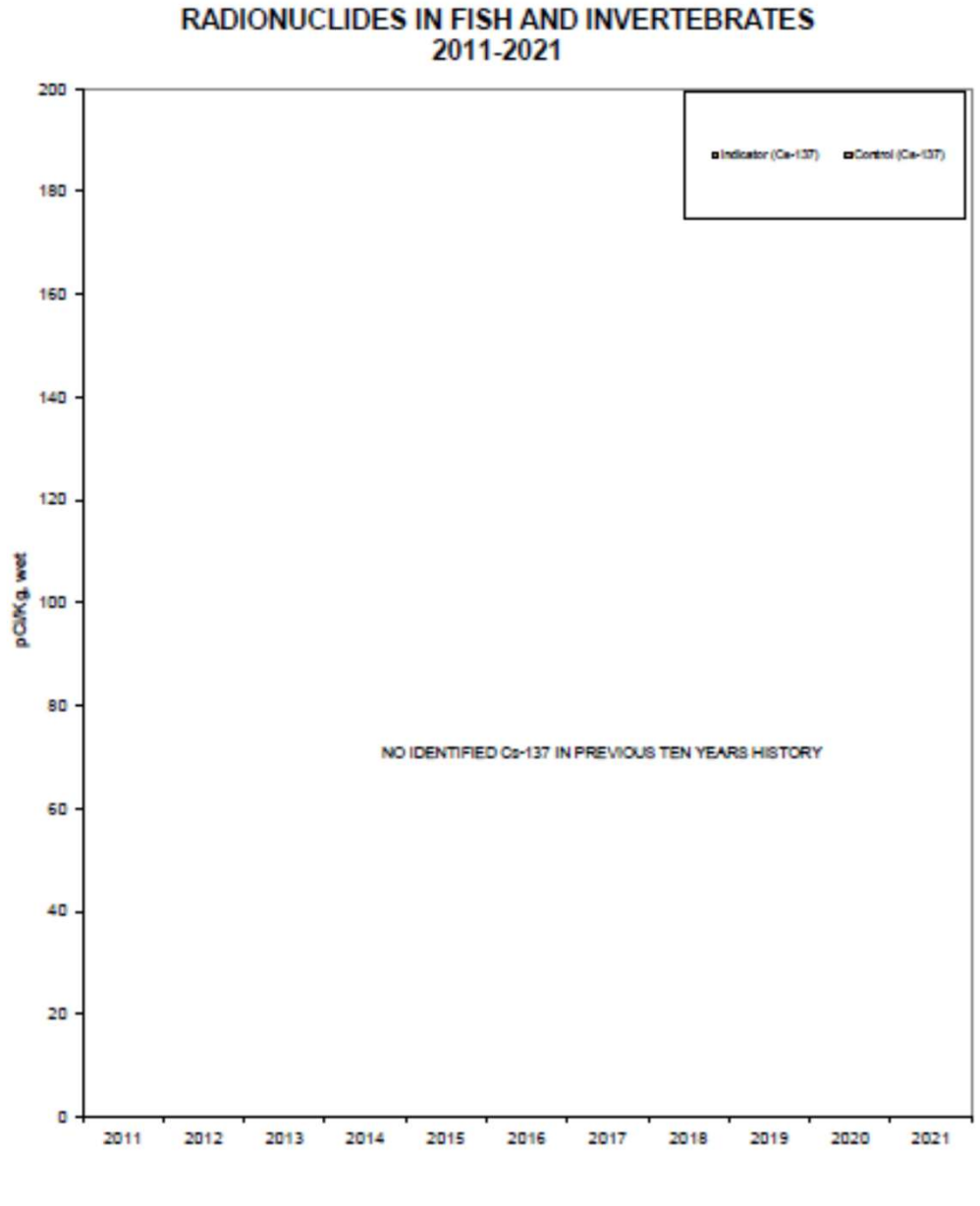




Radionuclide concentrations in vegetation samples have no indication of an increasing trend.

Sources: ML11143A052 and ML22123A206





Radionuclides have not been detected in fish and invertebrate samples.

Sources: ML11143A052 and ML22123A206

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

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

The offsite sampling process includes having samples tested by two different labs. The second column from the right is the ratio of one lab's results to the second lab's results.

1.00 reflects both labs having the same result.

Holtec Decommissioning International, "Indian Point Energy Center 2021 Annual Radiological Environmental Operating Report," May 3, 2022 (ML22123A206).

SUMMARY

Due to topography, water leaked from the Unit 1 and 2 spent fuel pools flows to the Hudson River and away from drinking water locations.

The discharge of filtered water from the Unit 1 spent fuel pool resulted in detectable releases of radioactivity to the Hudson River with low radiation dose implications.

The offsite sampling of water, soil, air, aquatic wildlife, and vegetation serves two important roles:

1) **Checking whether routine releases of radioactivity to the river and air are bio-accumulating/concentrating. The historical data shows no evidence of bio-accumulation.**

2) **Backing up the monitoring of releases to the water and air (i.e., if a radiation detector was mis-calibrated or a "midnight dump" or "midnight vent" happened, the offsite sampling would likely catch a significant release of radioactivity. The historical data shows no such anomalies.**

Annual radiation reports for Indian Point back to 2005 are available online at
https://www.nrc.gov/reactors/operating/ops-experience/tritium/plant-specific-reports/ip2-3.html