UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
Entergy Nuclear Operations, Inc. (Indian Point Nuclear Generating Units 2 and 3)	)	Docket Nos. 50-247-LR and 50-286-LR

PREFILED DIRECT TESTIMONY OF ARNOLD GUNDERSEN REGARDING CONSOLIDATED CONTENTION RK-EC-3/CW-EC-1 (SPENT FUEL POOL LEAKS)

On behalf of Riverkeeper, Inc. ("Riverkeeper") and Hudson River Sloop Clearwater, Inc. ("Clearwater"), Arnold Gundersen submits the following testimony regarding Riverkeeper and Clearwater's Consolidated Contention RK-EC-3/CW-EC-1:

INTRODUCTION

Q. Please state your name and address.

A. My name is Arnold Gundersen and my business addresses are 376 Appletree Point Road, Burlington, VT 05408 and 96 South Union Street, Burlington, VT 05401.

Q. Please state your occupation.

A. I am an independent nuclear engineering and safety expert at Fairewinds Associates, Inc. My title is Chief Engineer.

Q. Please describe your educational and professional background and qualifications.

A. I have a Bachelor and Master Degree in Nuclear Engineering from Rensselaer Polytechnic Institute (RPI) *cum laude*. I was awarded an Atomic Energy Commission Fellowship to pursue my Master Degree in Nuclear Engineering.

After beginning my career as a reactor operator and instructor in 1971, I progressed to the position of Senior Vice President for a nuclear licensee before moving into independent consulting work. I have testified as an expert witness before the Nuclear Regulatory Commission (NRC) Atomic Safety and Licensing Board (ASLB) and Advisory Committee on

Reactor Safeguards (ACRS), the State of Vermont Public Service Board, the State of Vermont Environmental Court, the Florida Public Service Commission, and in Federal Court.

I am an author of the first edition of the Department of Energy (DOE) Decommissioning Handbook. I have more than 39 years of professional nuclear experience *including and not limited to*: Nuclear Power Operations, Nuclear Safety Assessments, Nuclear Power Management, Nuclear Quality Assurance, Radiological Assessment, Archival Storage and Document Control, NRC Regulations and Enforcement, Licensing, Engineering Management, Contract Administration, Reliability Engineering, In-service Inspection, Thermohydraulics, Criticality Analysis, Radioactive Waste Processes, Decommissioning, Waste Disposal, Cooling Tower Operation, Cooling Tower Plumes, Consumptive Water Use, Source Term Reconstruction, Dose Assessment, Technical Patents, Structural Engineering Assessments, Nuclear Fuel Rack Design and Manufacturing, Nuclear Equipment Design and Manufacturing, Public Relations, Prudency Defense, Employee Awareness Programs, and Whistleblower Protection.

My full curriculum vitae is attached to this testimony as Riverkeeper Exhibit RIV000062.

Q. Please describe your experience with respect to radiological leakage and discharge issues at nuclear power plants.

A. When I began my career, I worked as a radiation-shielding engineer on Newbold Island, which entailed measuring radiation. Early in my career, when Northeast Utilities employed me, I began focusing on radiological release problems at Northeast Utilities' Millstone 1 Nuclear Power Plant. I was the project engineer in the first Monte Carlo calculation of sky shine.[1] I was the project engineer in developing an ammonia sniffer designed to detect Nitrogen 16 (N16) carryover into turbine buildings. I performed numerous gamma and neutron surveys of the Millstone and Connecticut Yankee sites. As the lead engineer for New York State Electric & Gas's proposed nuclear power plant, I was responsible for procuring the Nuclear Steam Supply System, which includes the nuclear reactor and nuclear fuel.

[1] Monte Carlo refers to a certain methodology of performing scientific calculations; Sky shine is the term used for radiation that originates near the surface of the earth with an upward velocity and then is scattered back by the molecules in the atmosphere.

As a senior manager at Nuclear Energy Services in Danbury, Connecticut, I was a member of the radiation safety committee of this NRC licensee responsible for assuring that all conditions of the NRC license were upheld. Personnel reporting to me conducted contamination assessments of the West Valley New York nuclear reprocessing facility and were assigned to the Shippingport nuclear power plant decommissioning project. I have been employed as a nuclear engineering consultant and engineering expert witness since 1990.

I have provided expertise and testimony in relation to accidental radiological leak issues occurring at nuclear power plants across the U.S., including the following:

- In 2007, I testified before the NRC Atomic Safety and Licensing Board regarding the failure of Entergy Nuclear Operations, Inc.'s Aging Management Program to address the leaking buried and underground pipes at its Pilgrim Nuclear Power Plant outside of Boston, MA.
- I served as a consultant to the Vermont Legislature's Joint Fiscal Office concerning leaking underground pipes at Entergy's Vermont Yankee Nuclear Power Station. I identified the existence of leaking pipes, which Entergy executives had misled investigators about.[2] I also advised the Joint Fiscal Office and Governor elect Shumlin, and provided recommendations to the state legislature, regarding the use of extraction wells at Vermont Yankee to address tritium contamination.
- I briefed the NRC's Regulatory Information Conference in 2009 concerning the identification and remediation of strontium and tritium leaks discovered at Vermont Yankee.
- I briefed investigators of the U.S. Government Accountability Office (GAO) concerning underground contamination from leaky pipes at nuclear reactors. GAO's investigation resulted in a report published in June 2011, entitled *Nuclear Regulatory Commission: Oversight of Underground Piping Systems Commensurate with Risk, but Proactive*

[2] *See* Vermont Yankee, Office of the Attorney General's Criminal Investigation Report (July 6, 2011), *available at*, http://www.atg.state.vt.us/assets/files/Office%20of%20the%20Attorney%20Generals%20Criminal%20Investigation%20Report%20on%20Vermont%20Yankee.pdf, at 8 ("The AGO investigation, as did that of MLB [Morgan Lewis & Bockius], readily leads to the conclusion that ENVY and various of its personnel repeatedly misled State officials with direct misstatements and repeatedly failed to clarify misperceptions as to the existence of underground piping carrying radionuclides. These actions and inactions were at best negligent.").

Measures Could Help Address Future Leaks, for which I was an expert.[3]

My expertise and testimony provided in the New York State proceeding regarding Entergy's Application for Clean Water Act § 401 Water Quality Certification specifically discussed the ongoing radiological leakage issues that are unique to Indian Point and are impacting the Hudson River.

Q. What is the purpose of your testimony?

A. The purpose of my testimony is to provide support for, and my views on Riverkeeper and Clearwater's Consolidated Contention RK-EC-3/CW-EC-1. Riverkeeper and Clearwater assert that Entergy and the NRC Staff have failed to adequately analyze the environmental impacts of spent fuel pool leaks and groundwater contamination at the Indian Point nuclear power plant. Therefore, the purpose of my testimony is to appraise the adequacy of the evaluation by Entergy and the NRC Staff of spent fuel pool leaks and groundwater contamination in the Indian Point License Renewal Proceeding. This contention was initially admitted by the ASLB on July 31, 2008 as applied to the assessment of Entergy in its Environmental Report,[4] and later accepted by the ASLB as applied to the assessment of NRC Staff in the Supplemental Environmental Impact Statement related to the Indian Point license renewal proceeding.[5]

Q. What did you review in preparing your testimony?

A. I reviewed the pleadings related to Riverkeeper and Clearwater's Consolidated Contention RK-EC-3/CW-EC-1 and those portions of Entergy's Environmental Report and NRC Staff's draft and final supplemental environmental impact statements ("DSEIS" and "FSEIS"

[3] *See* Exhibit RIV000089.

[4] *See* In the Matter of Entergy Nuclear Operations, Inc. (Indian Point Nuclear Generating Units 2 and 3), Docket Nos. 50-247-LR and 50-286-LR, ASLBP No. 07-858-03-LR-BD01, Memorandum and Order (Ruling on Petitions to Intervene and Requests for Hearing) (July 31, 2008), at 161-62.

[5] In the Matter of Entergy Nuclear Operations, Inc. (Indian Point Nuclear Generating Units 2 and 3), Docket Nos. 50-0247-LR and 50-286-LR, ASLBP No. 07-858-03-LR-BD01, Order (Applying Consolidated Contention Riverkeeper EC-3/Clearwater EC-1 to the NRC Staff's Draft Supplemental Environmental Impact Statement) (May 28, 2009), ADAMS Accession No. ML091480466; In the Matter of Entergy Nuclear Operations, Inc. (Indian Point Nuclear Generating Units 2 and 3), Docket Nos. 50-0247-LR and 50-286-LR, ASLBP No. 07-858-03-LR-BD01, Order (Ruling on Pending Motions for Leave to File New and Amended Contentions) (July 6, 2011), at 35-36, ADAMS Accession No. ML111870344.

respectively) related to the Indian Point license renewal proceeding that discussed and evaluated spent fuel pool leaks and groundwater contamination. In addition, I also reviewed hundreds of documents provided by Entergy to Riverkeeper in discovery, which were designated by Entergy as relevant to radiological leakage issues at Indian Point. These documents included, but were not limited to: quarterly groundwater monitoring reports generated by Entergy's consultant, GZA GeoEnvironmental, Inc., groundwater monitoring data, engineering reports, documents concerning the investigation of leakage issues at Indian Point, procedure documents, Aging Management Program materials, condition reports, corrective action reports, e-mails, presentations, plans, manuals, notes, checklists, status reports, and other reports. I also reviewed documents generated by NRC, which were available through NRC's public document database (Agencywide Documents Access and Management System, ADAMS), related to radiological discharge and leakage issues at Indian Point, including inspection reports, other reports, e-mails, and correspondence. Additionally, I reviewed documents generated by other government agencies (including the aforementioned GAO report concerning radiological leak issues) and scientific organizations. I have reviewed all such documents to inform me of the relevant facts and formulate my conclusions.

A list of the particular documents that I reference and rely upon in this written testimony is included at the end of this testimony. Those references have been provided as RIV000064 through RIV000100, (or have been previously been provided as exhibits by another party in the proceeding), in support of my testimony. To the best of my knowledge, I have referred to true and accurate copies of each document that I used and/or relied upon in preparing my testimony. If a document was extremely long and only a small portion is relevant to my testimony, an excerpt of that document is provided and the fact that it is only an excerpt is noted on the cover of the Exhibit.

Q. What particular issues does your testimony address?

A. My testimony addresses numerous deficiencies found in the assessments conducted by Entergy and NRC Staff of spent fuel pool leaks and groundwater contamination at Indian Point, including:

- The failure to recognize and assess ongoing and likely future leaks from the Indian Point

Unit 2 spent fuel pool;

- The failure to properly consider the toxic contamination that has resulted from the Indian Point Unit 1 spent fuel pools;
- The failure to address co-mingling of the radioactive plumes from both Unit 1's and Unit 2's spent fuel pools;
- The failure to account for and assess the impacts of current and likely future leaks from other plant components;
- The failure to properly categorize and assess the level of groundwater contamination at Indian Point;
- The failure to assess current and future impacts of the groundwater contamination on the Hudson River; and
- The failure to consider the numerous measures available to mitigate the adverse environmental consequences of radiological leaks and groundwater contamination at Indian Point.

ONGOING AND FUTURE LEAKS FROM THE INDIAN POINT UNIT 2 SPENT FUEL POOL

Q. Please assess the position taken in Entergy's Environmental Report and NRC Staff's FSEIS that leaks from the Unit 2 spent fuel pool are under "control" and that there is "no active leakage" from the pool.

A. The Unit 2 spent fuel pool has continued to experience leakage since Entergy's discovery of cracks in the pool wall in 2005,[6] and is apparently still actively leaking. In particular, a new leak of the Unit 2 SFP was identified recently in 2010:

> Beginning in the third quarter of 2010, we noticed increased tritium levels in a monitoring location adjacent to the IP2 SFP . . . . [T]he increased flow appears to be attributable to . . . a leak path

[6] GZA, GeoEnvironmental, Inc., Hydrogeologic Site Investigation Report, Indian Point Energy Center, January 7, 2008, IPEC00195418, at viii, 2-5 (Exhibit RIV000066); Entergy, Groundwater Investigation Executive Summary, Indian Point Energy Center, Buchanan, NY (January 2008) (Exhibit RIV000068).

> from light boxes near the top of the SFP, allowing water to get behind the stainless steel liner plates on the face of the SFP.[7]

Since its discovery, only a temporary repair to this leak path has been applied and "additional evaluations continue, so as to fully understand this issue."[8]

In addition, there is no evidence that all other potential leaks in the Unit 2 spent fuel pool have been identified and completely repaired or that the pool is now leak proof. In fact, it is impossible to adequately inspect the spent fuel pool for leaks: Entergy has never inspected a significant portion of the stainless steel spent fuel pool liner due to the complete inaccessibility of portions of the pool. As explained in the NRC's 2009 Safety Evaluation Report ("SER") relating to the proposed relicensing of Indian Point, "[t]he licensee stated that it completed, in 2007, a *one-time inspection* of the *accessible 40 percent* of the SFP liner above the fuel racks."[9]

Entergy cannot adequately access this liner for inspection due to the high density of fuel in the pool and the minimal amount of space between the fuel racks and the bottom and lower sides of the liner. For example, an Entergy e-mail correspondence explains the significant challenges to inspecting the Unit 2 spent duel pool for leaks (and the resulting lack of ability to repair any leaks) because without moving fuel, key areas are totally inaccessible to inspection.[10] In particular, in this document, Entergy explains that

> the examination of the spent pool floor will be challenging. . . . but to obtain meaningful results is an entirely different story. . . .[A] challenge would be the 30 years of debris accumulated on the bottom of the fuel pool. . . . The alternative to not cleaning would be the equivalent of trying to located [sic] cracks in a sidewalk, with 2" of snow covering the sidewalk. . . . [T]he examination of

[7] In the Matter of Entergy Nuclear Indian Point 2, LLC, and Entergy Nuclear Indian Point 3, LLC, and Entergy Nuclear Operations Inc's Joint Application for CWA § 401 Water Quality Certification, Prefiled Testimony of Matthew J. Barvenik, Issue for Adjudication No. 3 – Radiological Materials (July 22, 2011), at 11 ("Barvenik Direct Testimony") (Exhibit RIV000071).

[8] *Id.*

[9] U.S. Nuclear Regulatory Commission, Safety Evaluation Report Related to the License Renewal of Indian Point Nuclear Generating Unit Nos. 2 and 3, (NUREG-1930) Docket Nos. 50-247 and 50-286 (November 2009), NRC ADAMS Accession No. ML093170671, at 3-134 (hereinafter "IP SER")

[10] E-mail from Michael Rutkoske to Steven Verrochi (Entergy), Re: SFP Exams - What's Next? (Nov. 19, 2005), IPEC00065830 (Exhibit RIV000072).

> the spent fuel pool wall behind the fuel racks is especially challenging. . . . While it is important to identify any area of potential leakage, it is also important to consider the ability to repair areas of potential leaks. . . . there are hundreds of indications that would be considered unacceptable and potential leak paths by any welding standard, in the areas we have examined so far. I would not expect the quality of the floor plates or exposed wall sections to be any different.[11]

Another Entergy document states that Entergy's remote operated vehicle encountered "numerous interferences [and] substantial debris on the floor" (with no debris removal plan), when attempting to inspect the area beneath the spent fuel racks.[12] Another Entergy report also notes how "only a portion of the pool has been able to be inspected due to interference limitations. . . .".[13] Entergy's Groundwater Investigation Executive Summary explains that "active leaks cannot be completely ruled out."[14] An Entergy e-mail correspondence further confirms that numerous areas of the Unit 2 spent fuel pool cannot be observed or inspected, and acknowledges the existence of additional leaks that have not yet been identified: "we believe there could be other leaks in the unit 2 fuel pool that we cannot observe. . .".[15]

In addition, GZA explained in its quarterly monitoring report for the second quarter of 2010, the most recent quarterly report that Entergy provided to Riverkeeper as of the date of this testimony, that "analyses cannot definitively and completely rule out the possibility of a remaining small leak which could then also be supplying Tritium to the groundwater . . ."[16]

[11] *Id.*

[12] Entergy, U2 SFP Leak Monitoring Wells and Underground Piping (3/31/06), IPEC00063518 (Exhibit RIV000073).

[13] Entergy, Problem Development Sheet – Groundwater, IPEC00207416 (Exhibit RIV000074).

[14] Entergy, Groundwater Investigation Executive Summary, Indian Point Energy Center, Buchanan, NY (January 2008), at 2 (Exhibit RIV000068).

[15] E-mail from Ronald Sachatello to Donald Mayer (Entergy), Joseph Adler (TLG), Gary Hinrichs (Entergy), Re: IS THE POOL LEAK OFF COLLECTION BOX EFFECTIVE?, IPEC00063351 (Exhibit RIV000075).

[16] GZA, GeoEnvironmental, Inc. Final IPEC Quarterly Long-Term Groundwater Monitoring Report, Quarter Two 2010 (Report No. 10) (February 15, 2011), IPEC00227561, at p.1-3, footnote 6 (Exhibit RIV000076).

In conclusion, there is no basis for the positions taken in Entergy's Environmental Report or NRC Staff's FSEIS that the leaks from the Unit 2 spent fuel pool are currently under control and accounted for.

Q. In your opinion, are leaks from the Indian Point Unit 2 spent fuel pool likely to occur in the future?

A. Yes. The fact that new leaks were identified as recently as 2010, more than three years after all leaks were reportedly repaired and an alleged thorough examination of the Unit 2 SFP was conducted, speaks to the lack of rigor that Entergy has applied to the inspections of the Indian Point Unit 2 SFP.

Entergy was unable to identify the source of this new leak by either its inspection of the Indian Point site or its ongoing specific aging management and monitoring techniques currently applied to the Unit 2 SFP. The area where the 2010 leak occurred, unlike other portions of the SFP, was easily accessible during the 2007 inspection and it is likely that this newly identified leak existed undetected for many years. Additionally, the Unit 2 SFP leak-collection box installed in 2007 failed in 2010 to meet its intended design function to collect any radioactive leaks and prevent such contamination from entering the groundwater.

The ongoing leaks call into question the thoroughness of the initial inspection in 2005 by Entergy's team and alert us to Entergy's ongoing failure to adequately address the serious aging management issues confronting the Unit 2 spent fuel pool. Leaks from the Unit 2 spent fuel pool have not been eliminated because the sources have not yet been adequately identified or remediated. These circumstances make future undetected leaks from the already degraded Unit 2 SFP very likely.

The 2010 leak confirms and indicates that Entergy has no preventative measures in place to be able to detect and avert future leaks from the Unit 2 pool during the proposed relicensing term. Instead, Entergy relies upon a one-time inspection of a fraction of the pool liner as well as groundwater monitoring, which will admittedly only be able to detect leaks after they occur, for its assurance that the Unit 2 pool will remain sound during the proposed 20-year license renewal

period. Notably, the Unit 2 spent fuel pool "does not have a tell tail [sic] drain collection system which poses a vulnerability for additional activity leakage."[17] In contrast, Unit 3 and other nuclear power plants have a collection system underneath the stainless steel cladding of the fuel pool that works to detect leaks.

As early as 2009, the NRC approved (with a very narrow implication) Entergy's plan to simply monitor radionuclide levels in the groundwater as the method to detect any degraded condition of the pools:

> Entergy made no commitment for augmented inspection during the extended period of operation. . . . Due to the lack of a leak-chase channel system at IP2 to monitor, detect and quantify potential leakage through the SFP liner, the staff is concerned that there has been insufficient time following the corrective actions to be certain that the leakage problems have been permanently corrected . . . . The licensee stated that it completed, in 2007, a one-time inspection of the accessible 40 percent of the SFP liner. . . . To provide additional indication of potential spent fuel pool leakage, the applicant has committed to test the groundwater outside the IP2 spent fuel pool for the presence of tritium . . . every 3 months. . . . Tritium in the groundwater would indicate leakage from the spent fuel pool, which may lead to degradation . . . . Based on . . . applicant's additional commitment to monitor the groundwater . . . there is reasonable assurance that any degradation of the IP2 spent fuel pool would be identified.[18]

Entergy's approach will only discover leaks *after* they occur. Entergy's lax process of relying solely upon a groundwater-monitoring plan has previously taken months to detect leaks, while such leaks continually contaminated the groundwater and ultimately discharged into the Hudson River. This was precisely the case in relation to the newly discovered 2010 Unit 2 spent fuel pool leak path.

In addition, future leaks from the Unit 2 pool are increasingly likely since the pool is 35-years old and facing the typical bathtub curve issues that aging plants face with concrete and systems degradation. A "bathtub curve" is defined as "the phenomenon that the fraction of products

[17] Entergy, Problem Development Sheet – Groundwater, IPEC00207416 ((Exhibit RIV000074).

[18] IP SER at 3-134, 1-139.

failing in a given timespan is usually high early in the lifecycle, low in the middle, and rising strongly towards the end. When plotted as a curve, this looks like the profile of a bathtub."[19] The bathtub curve phenomenon shows that Entergy's Indian Point spent fuel pools will face more aging and leakage issues as the plant continues to operate, not less. In fact, an Entergy document listing areas and components at the Indian Point site that are susceptible to inadvertent leaks indicates that the potential for leakage relating to the Unit 2 spent fuel pool is "High."[20]

Given Entergy's own assessment, it is highly likely that the Unit 2 pool will continue to experience radiological leaks.

In conclusion, given the already degraded condition of the Unit 2 SFP, currently ongoing leaks, and Entergy's remarkably insufficient preventative measures, it is my opinion that leaks from the Unit 2 SFP are likely to continue.

Q. What do you mean that the NRC's approval of a groundwater monitoring system has a narrow implication?

A. NRC accepted Entergy's groundwater monitoring program with only one purpose in mind: according to NRC, this monitoring system is adequate for detecting conditions that have *safety implications* and which could result in a catastrophic meltdown in the event of an accident. In other words, the NRC has only evaluated this program in terms of whether or not the program will assure that the safety function of the spent fuel pools will be maintained and not result in a "loss of intended function" of the SFP.[21] The NRC did *not* approve the groundwater monitoring commitment as a system that stops components from leaking, and the NRC is not concerned about whether leaks enter the environment. To the contrary, from the NRC's perspective Entergy's monitoring program will work *despite* component leak.

[19] WordIQ.com, Bathtub curve – Definition, http://www.wordiq.com/definition/Bathtub_curve (last visited Dec.21, 2011).

[20] Entergy Chart of Leak Locations, IPEC00059360 (Exhibit RIV000077).

[21] IP SER at 3-139.

Q. Please describe any limitations of Entergy's network of monitoring wells.

A. The network of wells will not detect all leaks. GZA has acknowledged that certain minimum leaks remain undetectable by the groundwater monitoring system at Indian Point.[22] Therefore, Entergy's ability to detect smaller, longer lasting leaks apparently is highly questionable.

In addition, while the monitoring wells may indicate that a leak is occurring, a monitoring well has a limited ability to identify the exact location of the leak associated with the elevated findings. As such, monitoring wells are not necessarily conducive to being able to rapidly respond to and repair leak issues. The 2010 Unit 2 spent fuel pool leak path is evidence of this: elevated tritium levels were detected in the third quarter of 2010, and, as of July 2011, no permanent repair has been applied.[23]

FUTURE IMPACTS RESULTING FROM THE UNIT 1 SPENT FUEL POOL LEAKS

Q. Please assess the findings in Entergy's Environmental Report and the NRC Staff's FSEIS related to the mitigation actions pertaining to the Unit 1 spent fuel pool.

A. While the Unit 1 spent fuel pools have been drained, a considerable amount of radiation remains in the concrete and surrounding soil, and groundwater. This contamination will remain in the groundwater and actively leach into the Hudson River for decades.

In addition, a substantial amount of contamination from the Unit 1 pools remains stored in structures associated with the Unit 1 pools, including the north curtain drain and the sphere foundation drain sump.[24] So, even though the pools have been drained, residual contamination from these structures will continue to periodically release to the groundwater, until the entire Indian Point site is decommissioned.

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[22] GZA, GeoEnvironmental, Inc. Final IPEC Quarterly Long-Term Groundwater Monitoring Report, Quarter Two 2010 (Report No. 10) (February 15, 2011), IPEC00227561, at pg.1-3, footnote 6 (Exhibit RIV000076).

[23] Barvenik Direct Testimony at 11 (Exhibit RIV000071).

[24] *See* In the Matter of Entergy Nuclear Indian Point 2, LLC, and Entergy Nuclear Indian Point 3, LLC, and Entergy Nuclear Operations Inc's Joint Application for CWA § 401 Water Quality Certification, Combined Prefiled Rebuttal Testimony of Thomas C. Esselman, Ph.D., Matthew J. Barvenik, and Owen Hoffman, Ph.D., Radiological – Issue for Adjudication No. 3 (October 4, 2011), at 23 ("Barvenik Rebuttal Testimony") (Exhibit RIV000099).

ONGOING AND FUTURE LEAKS FROM OTHER SYSTEMS, STRUCTURES AND COMPONENTS AT INDIAN POINT

Q. Please describe any other sources of accidental radiological leakage at the Indian Point site in addition to the spent fuel pool leaks.

A. Aging components and underground piping at Indian Point have experienced leakage issues. For example, in 2009 due to unmonitored, undetected corrosion, a pipe buried eight feet underground at Indian Point leaked, and was discovered only when a plant worker observed water on the floor. This particular leak resulted in more than 100,000 gallons of tritiated water being released to the groundwater.[25]

During the first quarter of 2009, leakage of water from a distillation tank valve located within the Indian Point Unit 1 chemical systems building resulted in increased tritium levels in nearby monitoring wells.[26]

Just recently, "[o]n June 27, 2011 while reviewing the second quarter 2011 groundwater monitoring well sample results, Entergy personnel identified an increase in tritium concentrations in Unit 1 monitoring wells MW-56 and MW-57 (76,000 pCi/L and 20,000 pCi/L, respectively)."[27] Though "Entergy personnel conducted an investigation of this unexpected condition" NRC reported recently in November 2011 that "the source of the contamination has not been identified."[28] At the time this report is written, it is unclear whether the source of the leak is from Unit 1, Unit 2 or Unit 3.

[25] IPEC Site Management Manual, IP-SMM, CY-110, Rev. 1, 8.6 RGWMP Quarterly Integrated Review Checklist (Quarter 1, 2009), IPEC00225217 (Exhibit RIV000078); Annie Correal, *Indian Pt. Broken Pipe Spurs Safety Worries*, THE NEW YORK TIMES (March 1, 2009) (Exhibit RIV000079).

[26] Barvenik Direct Testimony at 10 (Exhibit RIV000071).

[27] Indian Point Nuclear Generating Unit 3 – NRC Integrated Inspection Report 05000286/2011004 (November 7, 2011), at 15-16 (Exhibit RIV000085).

[28] *Id.*

Accidental spills have also been documented. For example, two Energy Groundwater Monitoring Checklists reveal that in November 2009, a "RWST[[29]] processing skid" spilled "RWST water to the MOB yard area adjacent to the Unit 2 PAB"[30], which resulted in the detection of "greatly elevated" levels of tritium in the groundwater.[31]

The persistent presence of elevated levels of radioactivity in the storm drains at Indian Point is further evidence of radiological leaks and discharges from plant components, such as pipes and other undetermined/unspecified onsite sources. Entergy's report entitled *Troubleshooting Plan for H-3[32] investigation: Storm Drains System A, March/April 2009 (EN-MA-125)* explains that tritium was found in Storm Drain System A in March of 2009.[33] Concentrations of tritium in Storm Drain System A were at 90,000 pCi/L, which is at least three times higher than the EPA Maximum Contaminant Level for tritium, that is, 20,000 pCi/L. In following the leak path delineated in the report, one will note that Storm Drain System A ". . . empties into A-6 drain, which does NOT retain water long, passing quickly to the E system where it drains down the old roadway to the old command post area and into the discharge canal" which exits into the Hudson River.[34] The plant staff speculated that these high levels of contamination might be due to failures in "underground piping or an unknown source," but determined that "[t]he most likely cause of the elevated H-3 [tritium] in the effected storm drains was determined to be an accumulation of liquid H-3 condensation from the various airborne vents (washout)…".[35] Thus, this report reveals that "washout" is also a problem at Indian Point.

[29] RWST stands for "Reactor Waste Storage Tank."

[30] PAB stands for "Primary Auxiliary Building."

[31] IPEC Site Management Manual, IP-SMM, CY-110, Rev. 3, 8.6 RGWMP Quarterly Integrated Review Checklist (Quarter 1, 2010), IPEC00225219 (Exhibit RIV000080); IPEC Site Management Manual, IP-SMM, CY-110, Rev. 1, 8.6 RGWMP Quarterly Integrated Review Checklist (Quarter 2, 2010), IPEC00225223 (Exhibit RIV000081).

[32] H-3 stands for tritium.

[33] Entergy, Nuclear Management Manual, EN-MA-125, Rev. 4, Attachment 9.1, Initial Investigation, *Troubleshooting Plan for H-3 Investigation, Storm Drain System A*, March/April 2009, IPEC00194517 (Exhibit RIV000082).

[34] *Id.*

[35] *Id.*

Entergy's "Groundwater Monitoring Program Quarterly Integrated Review Checklist" for the fourth quarter of 2010 as well as the same report for the first quarter of 2011, both state that elevated levels of tritium were again detected in storm drains onsite; this is indicative of ongoing rainout, and/or leaks elsewhere onsite that have yet to be identified and addressed.[36]

Q. Please explain what "washout" is.

A. "Washout," also known as "rainout," is a nuclear industry term for airborne tritium releases that are regularly released from nuclear power plants. Such airborne tritium releases are caused by hot radioactive water or radioactive steam leaking from components in the nuclear facility.

Q. How is washout problematic at Indian Point?

A. Aged plants like Indian Point are more susceptible to leakage, as their components have deteriorated and are approaching the end of their design life. These leaks contaminate the air inside the plant with radioactivity. The contaminated air is then released through vents in the roof or out the exhaust stack of the plant. Entergy's Indian Point plants contain numerous airborne vents. Once this humid, radioactive air is released from the building, it condenses and rains down or *washes out* of the air.

Radioactive rain falls on the landscape surrounding Indian Point and also directly into the Hudson River. Leakage that Entergy views as normal on the Indian Point site is creating clouds of tritiated water that migrate offsite and deposit tritium in the Hudson River and adjacent offsite lands. Where the rainout/washout migrates and deposits its radioactive isotopes depends upon weather patterns along the Hudson River and adjacent to the Indian Point site.

Q. Please describe the impact of other component leaks discussed above has on the plumes of contamination caused by the spent fuel pool leaks at Indian Point.

A. Newly identified leaks will add to and commingle with the existing radionuclides in the groundwater. This is evidenced by the fact that the newly discovered leaks discussed above led

[36] IPEC Site Management Manual, IP-SMM, CY-110, Rev. 3, 8.6 RGWMP Quarterly Integrated Review Checklist (Quarter 4, 2010), IPEC00233519 (Exhibit RIV000083); IPEC Site Management Manual, IP-SMM, CY-110, Rev. 4, 10.7 RGWMP Quarterly Integrated Review Checklist (Quarter 1, 2011), IPEC00233515 (Exhibit RIV000084).

to spikes in the levels of tritium found in Entergy's monitoring well samples.[37]

Q. In your opinion, are leaks from other plant components likely to occur in the future?

A. Yes, leaks from pipes and other structures will most definitely occur in the future. One chart provided by Entergy lists numerous varied locations at the Indian Point site that may currently be leaking tritium and other radioactive isotopes or have a high potential for leakage of tritium and other radioactivity in the future.[38] According to Entergy, there are at least nineteen (19) sources at the Indian Point site that have a "High" potential for leakage of tritium and other radioactive isotopes.[39] Many of the sources of radiological leaks identified by Entergy have already introduced radioactive contamination into the soil and site groundwater at Indian Point. Entergy's (undated) chart evidences a site overrun by significant aging management issues, and once again, Indian Point's aging, degrading components face a bathtub curve, whereby leakage issues will most likely increase over time, and not lessen or cease.

Furthermore, Entergy does not have adequate aging management methods in place in order to be able to detect and prevent future leaks.

Q. Please elaborate upon your position that Entergy does not have adequate aging management methods and programs for detecting and preventing future leaks.

A. I have reviewed various documents related to Entergy's program for managing problematic leaking components, including Entergy's fleet-wide Aging Management Program (AMP) for leaking buried components and structures,[40] a supplement to the Indian Point Safety Evaluation Report which discusses aging management of buried components,[41] as well as an Entergy document concerning inspection methods employed for potential sources of tritium at

[37] Barvenik Direct Testimony at 10-11 (Exhibit RIV000071).

[38] Entergy Chart of Leak Locations, IPEC00059360 (Exhibit RIV000077).

[39] *Id.*

[40] Entergy Nuclear Management Manual, EN-DC-343, Buried Piping and Tanks Inspection and Monitoring Program (Exhibit NYS000172); CEP-BPT-0100, Buried Piping and Tanks Inspection and Monitoring (Exhibit NYS000173).

[41] U.S. Nuclear Regulatory Commission, Safety Evaluation Report Related to the License Renewal of Indian Point Nuclear Generating Unit Nos. 2 and 3, (NUREG-1930, Supplement 1) (August 2011), at 3-1 to 3-5, ADAMS Accession No. ML11242A215.

Indian Point.[42] My review of these documents leads me to conclude that Entergy's programs and methods are inadequate to prevent radiological leaks in the future.

Entergy's AMP for buried structures is not designed to identify or stop all potential radiological leaks. In fact, this program is not intended to prevent any radiological leaks, since it is only concerned with maintaining safety functions of the relevant plant components.

A considerable number of components at Indian Point are inaccessible to examination because they are buried, or otherwise obstructed. However, Entergy's AMP does not require inspections of 100% of such components. Many of Indian Point's underground pipes and structures have been buried since the plant began operating and have never been inspected during the plants nearly 40 years of operation. Rather, Entergy's AMP largely provides only for opportunistic inspections, which only uncover a few piping components periodically. Entergy itself readily acknowledges its inability to identify and stop leaks, as an spokesperson stated in response to the February 2009 accidental underground pipe leak: "[i]t's eight feet underground, so there's no way of knowing when you have to replace it."[43]

These problems are confirmed by GAO's recent investigation report regarding tritium leak issues. In particular, GAO concludes that because "underground piping systems tend to corrode" and are "largely inaccessible and difficult to inspect, . . . pipes will continue to age and further corro[de]" and that the "severity of leaks could increase without mitigating actions."[44] GAO further states that "[t]he occurrence of leaks at nuclear power plants from underground piping systems is expected to continue."[45]

Another major concern with Entergy's methods for preventing future radiological leaks is that a

[42] Potential Sources of Tritium at IPEC & Inspection Method, IPEC00065506 (Exhibit RIV000087).

[43] Annie Correal, *Indian Pt. Broken Pipe Spurs Safety Worries*, THE NEW YORK TIMES (March 1, 2009) (Exhibit RIV000079).

[44] GAO Report to Congressional Requesters, Nuclear Regulatory Commission, *Oversight of Underground Piping Systems Commensurate with Risk, but Proactive Measures Could Help Address Future Leaks*, GAO-11-563 (June 2011) (Exhibit RIV000089).

[45] *Id.*

vast majority of Indian Point's inspection methods rely only upon physical inspections. Industry experience with physical inspections indicates that they are completely inadequate to detect a leak before it occurs, since this type of inspection does not analyze the piping internally, nor does it completely examine the outside of the pipes. These external inspections are called "opportunistic" and are limited to situations where the pipe is uncovered for other reasons. One Entergy document identifies physical inspection methods for dozens of locations that may currently, or in the future, leak tritium and/or other radioactive isotopes.[46]

An additional problem is that Entergy's approach to identifying and repairing degraded and/or leaking components is completely reactive, and not proactive or preventative in nature. For example, several Entergy documents I reviewed demonstrate Entergy's reactive approach in addressing the initial discovery of the spent fuel pool leaks in 2005.[47] One document, entitled *Top Ten Lessons Learned* indicates that Entergy could have attained earlier indications of a problem if staff had performed evaluations earlier, and that Entergy did not effectively review information concerning elevated levels of contamination in sampling results.[48] Various other documents indicate that outside pressure (including from non-profit organizations like Union of Concerned Scientists, the public, the NRC, the media, and public officials such as the former President Bill Clinton and then-Senator Hilary Clinton) was the primary reason Entergy developed a tritium mitigation program at Indian Point.[49] Entergy continues to employ a reactive approach to the management of radiological leaks at the Indian Point site, as evidenced by numerous instances whereby Entergy only identifies new leaks when they literally spring, or when they have already manifested in well samples, as opposed to proactively engaging in necessary inspections of problematic or potentially problematic components and structures.

Yet another issue with Entergy's approach to managing radiological leaks at Indian Point is that Entergy is failing to sufficiently fund its maintenance programs. An independent report commissioned by the Vermont Legislature acknowledges this, explaining that "[l]imited resource

[46] Potential Sources of Tritium at IPEC & Inspection Method, IPEC00065506 (Exhibit RIV000087).

[47] Entergy correspondence, e-mails regarding approach to groundwater contamination, IPEC00067228, IPEC00065510, IPEC00130549, IPEC00062936 (Exhibit RIV000086).

[48] *Id.*

[49] *Id.*

allocation for non-safety systems" can be characterized as "systemic within Entergy."[50] This report further explains that at Indian Point, "[t]he physical condition of the plant in non-safety areas is visibly deficient" and that "the care and maintenance of some . . . plant systems and structures do not meet the standards of high-performing plants."[51] This failure to adequately fund maintenance contributes significantly to the likelihood of radiological leaks at Indian Point.

Based upon Entergy's failure to adequately manage the aging of increasingly degraded plant components, as well as the fact that only a limited number of components will be inspected using inferior inspection methods, it is highly likely that many tanks, pipes, and other components on the Indian Point site will leak in the future prior to detection by Entergy.

THE SIGNIFICANCE OF CONTAMINATION LEVELS IN THE GROUNDWATER

Q. Please assess Entergy's characterization of the groundwater contamination as "low" in the Environmental Report.

A. By characterizing the groundwater contamination as low in its Environmental Report, Entergy is simply attempting to minimize the significance of the severity of the radioactive contamination at Indian Point. Due to the size of the plumes, the varied range of radionuclides present in the groundwater, the dangerous toxicity of various radionuclides in the plumes (including Strontium-90 and Cesium-137), and the persistence of the plumes, I believe that the contamination at Indian Point makes it one of the most contaminated operating nuclear power plant sites in the United States. At the time of my review, I have been unable to find any other operating U.S. nuclear power plant that is leaking such extensive amounts of tritium *and* strontium contamination into any major body of water like the Hudson River.

Because Entergy and NRC focus only on the dose to humans through the consumption of fish from the Hudson River, they do not speak at all to the level of contamination actually in the

[50] Supplemental Report of the Public Oversight Panel Regarding the Comprehensive Reliability Assessment of the Vermont Yankee Nuclear Power Plant, July 20, 2010, at 10 (Exhibit RIV000088)

[51] *Id.* at 9-10.

groundwater, or address EPA Maximum Contaminant Levels ("MCLs").[52] These EPA limits are a highly conservative benchmark that are regularly used for comparison purposes to assess the degree of radioactive contamination.[53]

At Indian Point, a review of the exceedances over EPA MCLs quickly reveals that the level of contamination is definitely not "low." Since the groundwater contamination at Indian Point was discovered, radionuclides have regularly been detected at high levels, well in excess of EPA MCLs. The most recent monitoring well sampling data provided by Entergy and in Riverkeeper's possession as of the date of this testimony, from the second quarter of 2011, shows that Entergy continues to detect excessive levels of contamination in numerous sample locations, as follows: Cesium-137 was detected in monitoring well ("MW")-42 at 21,500 pCi/l, more than 100 times the EPA MCL set at 200 pCi/l; Tritium was detected in MW-30, MW-56, and MW-57 at 113,000 pCi/l, 76,4000 pCi/l, and 20,300 pCi/l, respectively, all in excess of the EPA MCL for tritium set at 20,000 pCi/l; Nickel-63 was detected in MW-42 at 190 pCi/l, almost four times the EPA MCL set at 50 pCi/l; and Strontium-90 was detected in eight monitoring wells and an additional sampling location in excess of the EPA MCL for Strontium-90 set at 8 pCi/l: MW-37 (8.72 pCi/l), MW-49 (12.6 pCi/l, 15.7 pCi/l and 16.2 pCi/l), MW-50 (9.53 pCi/l and 26.3 pCi/l), MW-53 (35.5 pCi/l), MW-54 (12 pCi/l and 19 pCi/l), MW-57 (31.1 pCi/l), MW-66 (10.6 pCi/l), MW-67 (12.5 pCi/l), and at sample location U1-CSS (16.1 pCi/l).[54]

Levels of radionuclides in the groundwater are likely not decreasing. Decades worth of contamination that is now underneath the site will bleed out slowly, and not rapidly, to the Hudson River. As a result, the few years of monitoring that have been completed are not likely to be enough to establish a definitive downward trend. GZA flatly recognizes that years of monitoring are necessary in order to confirm the status of the plumes.[55] Also, over time, the

[52] U.S. EPA, Radionuclides in Drinking Water: A Small Entity Compliance Guide (February 2002) at 13 (Exhibit RIV000065).

[53] *See, e.g.*, Indian Point Nuclear Generating Unit 2 – NRC Special Inspection Report No. 05000247/2005011, March 16, 2006, at 3, A1-3, A1-7 (Exhibit RIV000069).

[54] Entergy Groundwater Well Data, Quarter 2, 2011, IPEC00225100 (Exhibit RIV000090).

[55] GZA, GeoEnvironmental, Inc. Final IPEC Quarterly Long-Term Groundwater Monitoring Report, Quarter Two 2010 (Report No. 10) (February 15, 2011), at p.1-3, IPEC00227561 (Exhibit RIV000076).

contamination spreads wider and deeper, causing individual monitoring well concentrations to decrease, which may cast an inaccurate picture of the rate of any overall decline of these radiologically contaminated plumes.

To the contrary, levels of radionuclides in the groundwater will likely remain high in the future. Even if there are no additional leaks, additional peaks will occur. As GZA explains, "[p]eaks of tritium have been observed in multiple sampling points. . . This long term variability appears to be with the episodic releases of Tritium historically stored in the subsurface. . . . This additional unsaturated zone source will likely be manifested in the future as additional non-specific peaks in radionuclide levels due to episodic releases to the groundwater . . .".[56] Furthermore, ongoing and future leaks will continue to add to the existing plumes of contamination. For example, as noted in the 2010 Quarter 2 GZA Monitoring Report, "70% of the sampling intervals exhibited an increase in Tritium levels" due to the RWST "skid surface spill," discussed above.[57] This incident "resulted in an increase in the Unit 2 plume total Tritium activity."[58]

All indications are that Entergy is going to simply allow such persistent contamination to sit in the groundwater for decades to come without any removal or remediation. New leaks, including the 2010 Unit SFP leak, and other likely future leaks from aging components at Indian Point, guarantee that the present groundwater contamination will not be abated -- and, to the contrary, will grow. It is, therefore, foreseeable that levels in the groundwater will remain high, and continue to exceed EPA MCLs.

[56] *Id.* at p.1-2.

[57] *Id.*; IPEC Site Management Manual, IP-SMM, CY-110, Rev. 3, 8.6 RGWMP Quarterly Integrated Review Checklist (Quarter 1, 2010), IPEC00225219 (Exhibit RIV000080); IPEC Site Management Manual, IP-SMM, CY-110, Rev. 1, 8.6 RGWMP Quarterly Integrated Review Checklist (Quarter 2, 2010), IPEC00225223 (Exhibit RIV000081).

[58] GZA, GeoEnvironmental, Inc. Final IPEC Quarterly Long-Term Groundwater Monitoring Report, Quarter Two 2010 (Report No. 10) (February 15, 2011), at p.1-2, IPEC00227561 (Exhibit RIV000076).

CURRENT AND FUTURE IMPACTS OF GROUNDWATER CONTAMINATION ON THE HUDSON RIVER

Q. Please explain whether radiological leaks and discharges from Indian Point have contaminated the Hudson River.

A. Entergy documents explicitly acknowledge that the underground radioactive plumes of contamination migrate and eventually discharge to the Hudson River.[59] As one Entergy document I reviewed explains, the tritium plume from the Unit 2 spent fuel pool "tracks with downgradient groundwater flow through the Unit 2 transformer yard, under the Discharge Canal and discharges to the river between IP2 and IP1 intake structures."[60]

Entergy currently implements Monitored Natural Attenuation to allegedly "manage the contamination"[61] at Indian Point. My nearly 40-year experience as a nuclear engineer indicates that the process to completely eliminate any radioactive contamination by simply hoping it will eventually "flush" out into a nearby body of water will take many decades if not an entire century after the shutdown and dismantlement of Indian Point before the site is free of radioactive contamination. Thus, because the contamination at Indian Point will persist, likely grow, and migrate slowly, Indian Point will continue to discharge radiologically contaminated water into the Hudson River for decades.

Q. Please describe the nature of the radionuclides that are currently being released, and will continue to be released, into the Hudson River.

A. Entergy has acknowledged that the plumes of contamination at the site contain not only tritium but also deleterious substances including Nickel-63, Cesium-137, and Strontium-90.

[59] GZA, GeoEnvironmental, Inc., Hydrogeologic Site Investigation Report, Indian Point Energy Center, January 7, 2008, IPEC00195418, at viii, ix (Exhibit RIV000066); Entergy, Groundwater Investigation Executive Summary, Indian Point Energy Center, Buchanan, NY (January 2008) (Exhibit RIV000068).

[60] GZA, GeoEnvironmental, Inc., Hydrogeologic Site Investigation Report, Indian Point Energy Center, January 7, 2008, IPEC00195418, at 90 (Exhibit RIV000066).

[61] *Id.* at 127; GZA, GeoEnvironmental, Inc. Final IPEC Quarterly Long-Term Groundwater Monitoring Report, Quarter Two 2010 (Report No. 10) (February 15, 2011), at p.1-3, IPEC00227561 (Exhibit RIV000076).

With a 30-year half-life, meaning it contaminates the environment for 300 years,[62] the toxicity of strontium is much greater than that of almost every radioactive isotope released by a nuclear reactor. Strontium-90 is called a bone seeker because if it is ingested, it mimics calcium and is absorbed by bone where it can create leukemia and other forms of cancer. Cesium-137 mimics potassium and is absorbed by muscle where it too can cause cancers and deformities. Tritium is basically radioactive water. Wherever there is water in an organic substance, radioactive tritium, also known as tritiated water, can replace water at a cellular level. Tritium can be ingested, inhaled, or absorbed through the skin.

Q. In your opinion, could the discharges of these radionuclides to the Hudson River impact the aquatic ecosystem during the proposed period of extended operation?

A. Yes. Strontium-90 contaminates the environment for decades and is a bone seeker that bioaccumulates instead of dissipating; it is, therefore, possible that Strontium-90 and/or other radionuclides could impact Hudson River fish in the future.

Entergy's own Indian Point monitoring wells have clearly determined that Strontium-90, tritium, and other toxic radionuclides contaminate the Indian Point site and flush directly into the Hudson River. These radionuclides have the potential to impact fish in the river during Entergy's proposed period of extended operation. For example, in January 2007, Entergy shared data with the NRC from the 1970s and 1980s (generated before NRC discontinued the requirement that nuclear licensees test for Strontium-90 in the offsite environment) that showed that both fish and shellfish showed detectable levels of not only Strontium-90, but also of Strontium-89, a shorter lived isotope that is not found in residual background radiation resulting from nuclear weapons testing.[63] This supports the need for further and ongoing assessment of the effect that Strontium-90 and other radionuclides may have on Hudson River biota and nearby significant habitat of Haverstraw Bay.[64]

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[62] "Half-life" is defined as "[t]he time required for half the nuclei of a specific radionuclide or radioactive substance to undergo radioactive decay." *See* The American Heritage® Medical Dictionary, Houghton Mifflin Company (2007). A radionuclide will essentially fully decay after approximately 10 half-lives.

[63] E-mail From Dara Gray (Entergy) to J. Noggle (NRC) (Jan. 24, 2007), Re: Historical Sr Data (Exhibit RIV000100).

[64] NYS Department of State, Division of Coastal Resources, Coastal Fish & Wildlife Habitat Rating Form, Haverstraw Bay (Exhibit RIV000092).

Additionally, while a 2009 NYSDEC report suggests that the Strontium-90 concentrations in fish near Indian Point are no different than Strontium-90 concentrations in fish upstream from the plant, this does not support a conclusion that that there is no effect on fish, or that there will not be an effect on fish in the future due to the radiological leaks. NYSDEC's report also fails to note that other possible upstream sources of Strontium-90, especially the Knolls Atomic Power Lab (KAPL), may have affected the NYSDEC's assessment of other non-fallout related sources of Strontium-90. In addition, the NYSDEC 2009 study appears to have been a one-time investigation.

Q. In your opinion, could the discharges of radionuclides to the Hudson River have any other impacts during the period of extended operation?

A. Yes. Because Entergy and NRC focus only on the impact of radiological releases to the Hudson River in terms of NRC dose calculations of radiation exposure by consumption of contaminated fish, they fail to acknowledge other potential impacts that radioactive releases to the Hudson River may have upon the health of residents in proximity to the Hudson River. The Biological Effects of Ionizing[65] Radiation (BEIR) VII Report, issued by the National Academy of Science, reaffirmed the conclusion of the prior report that every exposure to radiation, regardless of how small, produces a corresponding increase in the likelihood of cancer.[66] Based upon the BEIR VII report by the National Academy of Science, the radioactive releases "flushed" into the Hudson River via ground and surface water from the Indian Point site could increase the incidence of cancer to those exposed through recreational activities, such as swimming.

[65] Ionizing radiation are alpha, beta, gamma, and neutrons that cause cellular damage by ionization, that is the process that breaks atomic bonds and creates negative and positive ions.

[66] National Research Council, Health Risks from Exposure to Low Levels of Ionizing Radiation: BEIR VII – Phase 2 (2006) (Exhibit RIV000093).

AVAILABLE AND FEASIBLE MITIGATION MEASURES TO MINIMIZE OR REDUCE THE ADVERSE IMPACTS OF THE RADIOLOGICAL LEAKS AND GROUNDWATER CONTAMINATION AT INDIAN POINT

Q. Please evaluate the effectiveness of Entergy's Monitored Natural Attenuation as a strategy for handling the contamination at Indian Point.

A. Monitored Natural Attenuation is not a remedial approach, because it does nothing to mitigate the progress of the radioactive plumes to the groundwater adjacent to the Indian Point site or into the Hudson River. In light of Entergy's approach, radioactive contamination (from past leaks, current leaks, and likely future leaks) will persist in the groundwater, likely at high levels, and be released to the Hudson River for decades into the foreseeable future. As I stated previously in this testimony, all radioactive releases, no matter how low the concentration have potentially deleterious health effects.[67] Therefore, Monitored Natural Attenuation is not a valid remediation approach to the extensive tritium and strontium leakage at Indian Point.

Q. Please explain whether there is preferable approach to handling radiological leaks at Indian Point?

A. Remediation of the radiological contamination via extraction wells is a far superior approach for handling the contamination and leak issues at Indian Point. Such mitigation processes would clean the site much faster and more thoroughly than allowing the groundwater to flush radiological contamination directly into the Hudson River.

Q. What are extraction wells and why do they matter?

A. Extraction wells mitigate the volume and spread of radiation and draw contaminants out of the ground in order to prevent their movement to nearby bodies of water, the existing water table, or to prevent aquifer contamination. At Indian Point, for example, which has tritium and other radioactive isotopes like Strontium (Sr90), an extraction well would reduce the level of contamination in the groundwater and prevent radioactive contamination from spreading across the site and into the Hudson River. Removing a radioactive isotope like Sr90 would prevent its ongoing contamination for 300 years. Sr90 has a half-life of 30 years which means that it will be

[67] *See id.*

in the environment for 300 years.

Q. In your opinion, is extraction feasible to address the groundwater contamination at Indian Point?

A. Yes. Entergy documentation indicates that in May 2006, Entergy's consultant, GZA, recommended that a remedial extraction well be installed in the Unit 2 spent fuel pool building:

> The remedial option letter is . . . basically complete . . . I showed the team the results of the model and the locations of the proposed pumping wells and rates. Basically, we are recommending a pumping well in the IP2-FSB to address the source of the Tritium. A second pumping well would be located in the Superheater building, west of the CS Sump. This well should capture the majority of the Sr contamination on the Unit 1 side. [68]

Further Entergy documentation indicates that pilot pumping tests were performed, which indicated that remediation of the contamination at Indian Point is feasible. An Entergy document entitled *Groundwater Investigation '06 Quarter 4 Activities and Results* details pilot tests conducted on behalf of Entergy to determine if an extraction well would help to remove tritiated and other radioactively contaminated water from the ground on the Indian Point site. This document explains the success of the pilot testing as follows:

> Remediation Pilot Test: The groundwater investigation team conducted a pump test to determine if a recovery well, could be used to hydraulically prevent the migration of tritiated groundwater around the Unit 2 Fuel Building. The test is also designed to test the feasibility of pumping groundwater from the area near IP2. **The test did indicate that water could be drawn from around Unit 2 without drawing Sr-90 contaminated water from Unit 1.** The RW-I well pumping did influence water in the Unit 2 Transformer Yard (MW[69]-34) as expected. Sampling from the monitoring wells has resumed. [*Emphasis Added*][70]

And, an Indian Point Energy Center Status Report from December of 2006 also memorializes the success of the pilot pumping from RW-1:

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[68] Entergy E-mail from David Winslow (GZA) to Donald Mayer (Entergy), G. Hinrichs (Entergy), Re: Remedial Report (May 19, 2006), IPEC00064221 (Exhibit RIV000094)

[69] "MW" stands for monitoring well.

[70] Groundwater Investigation '06 Quarter 4 Activities and Results, IPEC00063899 (Exhibit RIV000095).

> Tritium concentrations were reduced during the recent recovery well pump test. The tritium concentration in RW-1 at the beginning of the test was about 100,000 pCi/L and dropped to 19,000 pCi/L at the end of the test. Levels remained lower (30,000 pCi/L) three weeks later. A similar drop was observed in MW-30 . . . The tritium concentration was reduced by about half. This is a limited data set but does provide some evidence that groundwater tritium levels can be reduced in this fashion.[71]

Another Entergy document also explained that the pilot test decreased tritium levels significantly, and stated that a "permanent system installation [was] planned for completion in May 2007."[72]

The record suggests that there is no reason why extraction is not possible at Indian Point. Furthermore, the documents I have reviewed demonstrate that extraction of tritium and other radioactive isotopes would successfully mitigate the contamination. Moreover, Entergy already knows that the installation and application of extraction wells is a successful remediation technique: the extraction process currently applied by Entergy at some of its other operating nuclear power plant sites physically extracts radioactive water from underground leaks and deposits it into above-ground tanks. This radioactive water is then treated and processed. Thus, Entergy is fully aware of the positive effectiveness of extraction wells upon remediating radioactive isotopic contamination.

In fact, a representative of GZA recently testified for Entergy about issues relating to radiological leaks at Indian Point and confirmed that extraction is feasible and could reduce the contamination on-site and prevent contamination from reaching the Hudson River:

> Based on my knowledge of the Indian Point site hydrogeology, and my experience with groundwater contamination, I have performed an analysis of possible measures that could be taken to prevent these radionuclides from reaching the Hudson River. Based on that analysis, I have concluded that *Entergy could install a sufficient number of groundwater extraction* wells so as to contain

[71] Entergy E-mail from Kathleen McMullin (Entergy) to various, Re: IPEC Status Report for Dec. 21 (Exhibit RIV000096).

[72] Entergy Document, "Unit 1 Status for ENC Presentation notes," "Groundwater Status," IPEC00062939 (Exhibit RIV000097).

> these radionuclides on-site by establishing a groundwater gradient reversal . . . [T]he extraction wells would result in groundwater flowing from the Hudson River toward the wells located on-site. Entergy would then *extract the groundwater containing radionuclides from the subsurface, and process that groundwater* in an appropriate manner.[73]

As a result, there really is no dispute that extraction is a viable and preferable alternative to MNA.

Q. What is the current status of remediating radioactive underground water through extraction at Indian Point?

A. Although numerous reports, as early as 2006, recommended remediation through extraction of radioactive water, and despite GZA's very recent acknowledgement that extraction is feasible, Entergy has not implemented any of these recommendations, and instead continues to solely rely upon Monitored Natural Attenuation.

In the past, Entergy has attempted to rationalize its choice to only rely upon MNA, namely because it would alter groundwater flow and possibly cause plume commingling.[74] Since ample documentation demonstrates that pilot pumping did not alter Sr-90 contamination flow, and that the extraction had the clear advantage of being successful, Entergy's position on this issue is not justified. But, even if the extraction altered the groundwater flow and the contamination plumes, the benefit of extraction clearly outweighs any negative aspect of an allegedly altered groundwater flow. Moreover, Entergy's earlier position is no longer justified in light of GZA's recent admission that extraction may be successfully executed.

[73] Barvenik Rebuttal Testimony at 41-42 (Exhibit RIV000099).

[74] Letter from Kathryn Sutton (Counsel for Entergy) to Deborah Brancato (Riverkeeper), Re: Entergy Nuclear Operations, Inc. (Indian Point Nuclear Generating Units 2 and 3), Docket Nos. 50-247-LR and 50-286-LR (June 24, 2011) (Exhibit RIV000098); Indian Point Nuclear Generating Units 1 & 2 – NRC Inspection Report Nos. 05000003/2007010 and 05000247/2007010, EA-08-088, May 13, 2008 at 13 (Exhibit RIV000067).

Q. Please describe whether there are any other feasible measures to mitigate or minimize the adverse impacts of the radiological leaks and groundwater contamination at Indian Point.

A. There are a range of feasible measures that would mitigate the adverse impacts of the leaks and contamination at Indian Point. These include:

1. If Entergy chose to reduce the amount of spent fuel stored in the Unit 2 spent fuel pool by using dry cask storage instead, it would be possible to remove some racks and shuffle the remaining fuel to completely inspect the Unit 2 spent fuel pool liner for leaks and other imperfections.
2. At Entergy's Palisades nuclear plant, published reports indicate that Entergy has chosen to move pipes containing radioactive material above ground for ease of inspection. Exelon is also employing a similar approach on Oyster Creek. This approach could also be used on Indian point 2 and 3 and would reduce the likelihood of leaks and greatly enhance Entergy's ability to inspect for leaks.
3. Thorough physical inspections of extensive segments of underground pipe could be employed as a pre-condition to license renewal.
4. An increase in inspection frequency of all underground pipe beyond that which Entergy has suggested in its AMP should be required as a condition of license renewal.
5. And, in a public commitment to more openness and transparency, Entergy should be required to fully disclose Indian Point's radiological monitoring results and publish them on a monthly basis in an accessible online database in order to keep the public fully informed of the ongoing radiological contamination of the groundwater at and adjacent to Indian Point and the radiological contamination of the Hudson River.

<u>CONCLUSIONS</u>

Q. Please summarize your conclusions regarding radiological leaks and groundwater contamination at Indian Point.

- The Unit 2 spent fuel pool is currently leaking and will most likely continue to leak in the future;
- The leaks that occurred from the Unit 1 spent fuel pools has resulted in contamination

that will continue to impact the environment for the foreseeable future;

- Other plant systems, structures, and components, including buried pipes and structures, have recently caused leakage issues, and will most likely leak in the future; such leaks will add to and commingle with the existing plumes of contamination;
- The current level of groundwater contamination at Indian Point is high, and will continue to reach high levels during the proposed period of extended operation;
- The groundwater contamination may cause impacts to the Hudson River during the proposed extended licensing terms, including impacts to aquatic ecology, impacts to recreational activities in the river, and impacts to drinking water sources; and
- There exists a wide range of reasonable, feasible, cost-beneficial measures that could mitigate, minimize, and lessen the adverse environmental consequences of radiological leaks and groundwater contamination from Indian Point to the surrounding groundwater and Hudson River.

Q. Does this conclude your direct testimony?

A. Yes.

REFERENCES

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2. NUREG-1437, Revision 1, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (July 2009), Draft Report for Comment (Exhibit RIV000064)

3. Generic Environmental Impact Statement for License Renewal of Nuclear Plants, NUREG-1437, Supplement 38, Regarding Indian Point Nuclear Generating Unit Nos. 2 and 3, Draft Report, December 2008, ADAMS Accession Nos. ML083540594, ML083540614 (Exhibits NYS00132A-NYS00132D)

4. Generic Environmental Impact Statement for License Renewal of Nuclear Plants, NUREG-1437, Supplement 38, Regarding Indian Point Nuclear Generating Unit Nos. 2 and 3, December 2010 *available at* http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1437/supplement38/

5. U.S. EPA, Radionuclides in Drinking Water: A Small Entity Compliance Guide (February 2002) (Exhibit RIV000065)

6. GZA, GeoEnvironmental, Inc., Hydrogeologic Site Investigation Report, Indian Point Energy Center, January 7, 2008, IPEC00195418 (Exhibit RIV000066)

7. Indian Point Nuclear Generating Units 1 & 2 – NRC Inspection Report Nos. 05000003/2007010 and 05000247/2007010, EA-08-088, May 13, 2008 (Exhibit RIV000067)

8. Entergy, Groundwater Investigation Executive Summary, Indian Point Energy Center, Buchanan, NY (January 2008) (Exhibit RIV000068)

9. Indian Point Nuclear Generating Unit 2 – NRC Special Inspection Report No. 05000247/2005011, March 16, 2006 (Exhibit RIV000069)

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11. In the Matter of Entergy Nuclear Indian Point 2, LLC, and Entergy Nuclear Indian Point 3, LLC, and Entergy Nuclear Operations Inc's Joint Application for CWA § 401 Water Quality Certification, Prefiled Testimony of Matthew J. Barvenik, Issue for Adjudication No. 3 – Radiological Materials (July 22, 2011) (Exhibit RIV000071)

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13. E-mail from Michael Rutkoske to Steven Verrochi (Entergy), Re: SFP Exams - What's Next? (Nov. 19, 2005), IPEC00065830 (Exhibit RIV000072)

14. Entergy, U2 SFP Leak Monitoring Wells and Underground Piping (3/31/06), IPEC00063518 (Exhibit RIV000073)

15. Entergy, Problem Development Sheet – Groundwater, IPEC00207416 (Exhibit RIV000074)

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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
Entergy Nuclear Operations, Inc.	)	Docket Nos.
(Indian Point Nuclear Generating	)	50-247-LR
Units 2 and 3)	)	and 50-286-LR

DECLARATION OF ARNOLD GUNDERSEN

I, Arnold Gundersen, do hereby declare under penalty of perjury that my statements in the foregoing testimony and my statement of professional qualifications are true and correct to the best of my knowledge and belief.

Executed in Accord with 10 C.F.R. § 2.304(d)

Arnold Gundersen
376 Appletree Point Road
Burlington, VT 05408

December 21, 2011