UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	Docket Nos. 50-247-LR and 50-286-LR
	)	
ENTERGY NUCLEAR OPERATIONS, INC.	)	
	)	
(Indian Point Nuclear Generating Units 2 and 3)	)	
	)	March 29, 2012

TESTIMONY OF ENTERGY WITNESSES DONALD M. MAYER, ALAN B. COX, THOMAS C. ESSELMAN, MATTHEW J. BARVENIK, CARL J. PAPERIELLO, AND F. OWEN HOFFMAN REGARDING CONSOLIDATED CONTENTION RK-EC-3/CW-EC-1 (SPENT FUEL POOL LEAKS)

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I. WITNESS BACKGROUND

A. Donald M. Mayer ("DMM")

Q1. Please state your full name.

A1. (DMM) My name is Donald M. Mayer.

Q2. By whom are you employed and what is your position?

A2. (DMM) I currently am employed by Entergy Nuclear Operations Inc. ("Entergy") as the Director of Indian Point Nuclear Generating Station Unit 1 ("IP1").

Q3. Please describe your educational and professional qualifications, including relevant professional activities.

A3. (DMM) My qualifications are summarized in the attached *curriculum vitae* (ENT000302). In brief, I hold a Master of Radiological Sciences degree from the University of Lowell Mass and a Master of Business Administration ("MBA") from Mt. St. Mary College in Newburg, New York. I have 29 years of professional experience in Radiation Protection and Project Management. I have been a certified health physicist since 1988. I am currently the Director of IP1, where I have overall project direction of and manage the retired IP1 plant, as

well as senior management oversight for a variety of strategic projects for Entergy at Indian Point.

Q4. Please describe the basis for your familiarity with Indian Point, and the IP2 and IP3 license renewal project.

A4. (DMM) As the Director of IP1 and Special Projects, I am responsible for all programs related to IP1 safe storage and was responsible for Entergy initiatives to improve the robustness of those programs, including ultimately removing the spent fuel from the storage pools in 2008. I am also the senior manager responsible for oversight of the site implementation of our emergency plan and provide project direction and oversight for various site projects in the areas of security, emergency planning, and overall site facility improvements.

During the 2005 to 2009 timeframe, I was responsible for management of the overall site investigation of groundwater contamination as it relates to the IP1, as well as Indian Point Nuclear Generating Units 2 and 3 ("IP2" and "IP3," respectively). This included responsibility for the hydrogeological, remedial, and radiological aspects of the effort. This investigation culminated in the development of a comprehensive groundwater monitoring program and final investigation report. The investigation report was submitted to U.S. Nuclear Regulatory Commission ("NRC") in January 2008.

Based on this experience, I am familiar with the history and status of IP1 and IP2 spent fuel pool ("SFP") leaks. I am also familiar with issues related to SFP remediation activities, groundwater monitoring (including the results of ongoing Indian Point groundwater monitoring), dose assessments, and associated NRC Staff inspection activities. I am also familiar with other independent assessments of SFP leaks at IP1 and IP2, including assessments by the New York State Department of Environmental Conservation ("NYSDEC").

B. <u>Alan B. Cox ("ABC")</u>

Q5. Please state your full name.

A5. (ABC) My name is Alan B. Cox.

Q6. By whom are you employed and what is your position?

A6. (ABC) I am employed by Entergy as Technical Manager, License Renewal. My office is located at Entergy's Arkansas Nuclear One ("ANO") facility in Russellville, Arkansas.

Q7. Please describe your educational and professional qualifications, including relevant professional activities.

A7. (ABC) My qualifications are summarized in the attached *curriculum vitae* (ENT000031). Briefly, I hold a Bachelor of Science degree in Nuclear Engineering from the University of Oklahoma and an MBA from the University of Arkansas at Little Rock. I have more than 34 years of experience in the nuclear power industry, having served in various positions related to engineering and operations of nuclear power plants. I was licensed by the NRC as a reactor operator in 1981 and as a senior reactor operator in 1984 for ANO Unit 1. In addition, I was licensed as a registered professional engineer in the State of Arkansas from 1985 to 2002.

Since 2001, I have worked full-time on license renewal supporting the development of integrated plant assessments and license renewal applications ("LRAs") for Entergy license renewal projects, as well as projects for other utilities. I am a member of the Nuclear Energy Institute ("NEI") License Renewal Task Force and have been a past representative on the NEI License Renewal Mechanical Working Group and the NEI License Renewal Electrical Working Group. As a member of the Entergy license renewal team, I have participated in the development of nine LRAs and in industry peer reviews of twelve additional LRAs. I am

providing testimony on behalf of Entergy in connection with the adjudication of other contentions in this proceeding, including NYS-5 (Buried Piping and Tanks).

Q8. Please describe the basis for your familiarity with Indian Point, and the IP2 and IP3 license renewal project.

A8. (ABC) As Technical Manager, I was directly involved in preparing the Indian Point LRA, and developing and reviewing aging management program ("AMP") descriptions for IP2 and IP3, including the Structures Monitoring Program and the Water Chemistry Control – Primary and Secondary Program. I also have been directly involved in developing or reviewing Entergy responses to NRC Staff Requests for Additional Information ("RAIs") concerning the LRA and any necessary application amendments or revisions. Accordingly, I have personal knowledge of the development and implementation of the aforementioned programs, including the description of those programs in the LRA and other related documentation discussed below.

C. <u>Thomas C. Esselman ("TCE")</u>

Q9. Please state your full name.

A9. (TCE) My name is Thomas C. Esselman.

Q10. By whom are you employed and what is your position?

A10. (TCE) I am a Principal of Lucius Pitkin, Inc., a company that provides a wide-range of engineering services to the industries of nuclear power, energy generation and distribution, aerospace, petrochemical, and infrastructure, among others. We have provided support and engineering services to nuclear plants for over forty years.

Q11. Please describe your educational and professional qualifications, including relevant professional activities.

A11. (TCE) My qualifications are summarized in the attached *curriculum vitae* (ENT000303). Briefly, I hold a Bachelor of Science degree in Mechanical Engineering, and a

Master of Science degree and a Ph.D. in Engineering Mechanics, all from Case Western Reserve University. I have more than 35 years of experience in engineering, including the areas of component and structure performance, aging, stress analysis, dynamics, seismic design and analysis, mechanical design, thermo-hydraulics, materials, materials degradation, and failure analysis. I have extensive experience with nuclear power facilities. My responsibilities have included performance and management of a large variety of engineering, engineering development, and engineering evaluation projects. I consult frequently on power generation and delivery, generating plant design and operation, material degradation, plant and system aging issues, and materials evaluations.

Q12. Please describe the basis for your familiarity with Indian Point, and the IP2 and IP3 license renewal project.

A12. (TCE) I first became involved with IP2 in 1974, which was about the time that its construction was nearing completion. At that time, I was working for Westinghouse Electric Corporation and was assigned a project involving the qualification of some of the reactor coolant loop components at Indian Point. Throughout my career at Westinghouse and in my consulting career, I have worked periodically with the Indian Point plants. For example, in 2010, Lucius Pitkin assisted in the development of the inspection prioritization scheme for Entergy's radiological buried piping programs, and Lucius Pitkin engineers have provided concrete integrity, leak detection, and fitness-for-service studies of the IP1 and IP2 SFPs.

In January 2012, I testified as an expert on behalf of Entergy in the IP2 and IP3 New York State Department of Environmental Conservation ("NYSDEC") Clean Water Act Section 401 Water Quality Certification hearing concerning the environmental impacts associated with

radiological leaks. I have been retained by Entergy as an expert in the hearing on RK-EC-3/CW-EC-1.

D. <u>Matthew J. Barvenik ("MJB")</u>

Q13. Please state your full name.

A13. (MJB) My name is Matthew J. Barvenik.

Q14. By whom are you employed and what is your position?

A14. (MJB) I am a Senior Principal with GZA GeoEnvironmental, Inc. ("GZA"), a company that provides a wide-range of geotechnical engineering, environmental consulting, and remediation services. I also hold GZA's highest technical position: Senior Technical Consultant.

Q15. Please describe your educational and professional qualifications, including relevant professional activities.

A15. (MJB) My qualifications are summarized in the attached *curriculum vitae* (ENT000304). In brief, I hold a Bachelor of Science degree in Civil Engineering from Northeastern University and a Master of Science degree in Geotechnical Engineering from the Massachusetts Institute of Technology. I am also a registered Licensed Site Professional in Massachusetts. I have over 35 years of professional experience in hydrogeology, civil, geotechnical, and instrumentation engineering, the largest portion of which was focused on the investigation and remediation of contaminated soil and groundwater. My work has encompassed hundreds of sites, and has focused on groundwater flow and contaminant fate and transport. My early projects included the nation's first cooperatively funded U.S. Environmental Protection Agency ("EPA") Superfund hydrodynamic isolation/cutoff wall remediation. My more recent projects include radionuclide fate and transport for a weapons manufacturer, and groundwater protection initiative and NRC combined construction and operating license application work for private clients. I am a member of the American Nuclear Society ("ANS"), where I served on the

Working Group responsible for writing the recently completed ANS standard for Evaluation of Subsurface Radionuclide Transport at Commercial Nuclear Power Plants. I am also a member of two newly formed ANS Working Groups responsible for drafting future standards on the evaluation of groundwater supplies and remediation methods for nuclear power sites.

Q16. Please describe the basis for your familiarity with Indian Point, and the IP2 and IP3 license renewal project.

A16. (MJB) I was engaged by Entergy immediately upon identification of the IP2 SFP shrinkage cracks in September 2005, discussed later in this testimony. I have served as the lead technical investigator for the Indian Point hydrogeologic site characterization program, including development of the January 11, 2008 Site Investigation Report, the Conceptual Site Model, the Long-Term Groundwater Monitoring Program, and the radionuclide mass flux portion of dose computations. Based on my direct involvement with issues related to the Indian Point hydrogeologic site investigation and the ongoing groundwater monitoring program, I am very familiar with the Indian Point hydrogeologic setting and groundwater flow patterns, identified contaminant sources and transport, historical and ongoing groundwater monitoring efforts, and current remediation plans. In fact, I believe I have as good an understanding of the Indian Point site as it relates to these issues, as I have of any of the sites I have worked on in my 35-year professional career. Additionally, based on this experience, I am familiar with the history and status of Indian Point SFP leaks, corresponding dose assessments, and associated NRC Staff inspection activities, as well as other independent assessments of the SFP leaks, including assessments by the NYSDEC and the United States Geological Survey ("USGS").

In January 2012, I testified as an expert on behalf of Entergy in the IP2 and IP3 NYSDEC Clean Water Act Section 401 Water Quality Certification hearing concerning radiological issues

associated with site groundwater contamination. I have also been retained by Entergy as an expert in the hearing on RK-EC-3/CW-EC-1.

E. <u>Carl J. Paperiello ("CJP")</u>

Q17. Please state your full name.

A17. (CJP) My name is Carl J. Paperiello.

Q18. By whom are you employed and what is your position?

A18. (CJP) I am a Senior Nuclear Consultant with Talisman International, LLC. Since 2006, I have provided consulting services in the areas of health physics, fuel cycle and materials licensing, waste management, and decommissioning.

Q19. Please describe your educational and professional qualifications, including relevant professional activities.

A19. (CJP) My qualifications are summarized in the attached *curriculum vitae* (ENT000305). In brief, I hold a Bachelor of Science degree in Physics from the LaSalle College and a Ph.D. in Nuclear Physics from the University of Notre Dame. I have been certified in Comprehensive Health Physics since 1975, and since 2002 I have been a Councilor for the National Council for Radiological Protection and Measurement ("NCRP"), the organization chartered by the U.S. Congress to make recommendations on radiation protection and measurements. In 2011, I was elected a Fellow of the Health Physics Society.

I have more than 40 years of professional experience in areas of health physics, nuclear physics, environmental radiochemical analysis, and nuclear spectroscopy. I was a member of the NRC Staff from 1975 to 2006. While at the NRC, I served in a number of leadership positions, including as the Director of the Office of Nuclear Regulatory Research, the Director of the Office of Nuclear Materials Safety and Safeguards, and the Deputy Executive Director for

Materials, Research, and State Programs. I also have extensive NRC regional inspection and enforcement experience, having served as the Deputy Regional Administrator for Region III.

I started employment with the NRC in 1975 as a Radiation Specialist in the NRC Region I office. After being promoted to a section chief in Region III in 1978, I was promoted to successively higher positions. Several of these included management of radiation specialists, health physics, and environmental inspectors. As Director of the Office of Nuclear Materials Safety and Safeguards, I was responsible for the maintenance and interpretation of 10 C.F.R. Part 20, NRC's radiation safety regulations.

Prior to my service at NRC, I worked for the New York State Department of Health from 1970 until 1975 in the Radiological Sciences Laboratory performing radiological environmental analyses on air, water, vegetation, fish and game samples from around New York. Environmental analyses included alpha and beta counting, gamma spectroscopy, alpha spectroscopy, and monitoring for strontium-89, strontium-90, radium-226, uranium, and tritium. Additionally, I participated in the development of analytical procedures for iron-55, nickel-63, and iodine-129 and built counting systems for airborne radionuclides including xenon-133, krypton-85 and carbon-14.

Based on this experience, I am very familiar with the NRC's requirements and guidance on the dose limits, radiological effluent releases, and environmental radiological monitoring, as well as the analyses needed to determine compliance with applicable regulations. I am also familiar with international radiation standards and recommendations since I served as the U.S. representative to the International Atomic Energy Agency's Radiation Safety Standards Committee from about 2000 to 2003.

Q20. Please describe the basis for your familiarity with Indian Point, and the IP2 and IP3 license renewal project.

A20. (CJP) I first became involved with Indian Point in the 1970s as a member of the NRC Staff responsible for standard, ongoing radioactive effluent monitoring inspections. More recently, I have been retained by Entergy as an expert in connection with the hearing on RK-EC-3/CW-EC-1. In preparing my testimony, I reviewed the NRC's environmental protection regulations in 10 C.F.R. Part 51; NRC's radiation protection regulations in 10 C.F.R. Part 20 and the light water reactor effluent regulations in 10 C.F.R. Part 50; the NRC Staff's Final Supplemental Environmental Impact Statement ("FSEIS"); Entergy's "Indian Point Energy Center, Units 1, 2, and 3, Offsite Dose Calculation Manual, Rev. 3" (Jan. 24, 2011) ("IPEC ODCM") (ENT000307); and Entergy's Annual Radiological Environmental Operating Reports (ENT000308 through ENT000313) and Annual Radioactive Effluent Release Reports (ENT000314 through ENT000319) from 2005 through 2010. Further, I reviewed material related to a hypothetical future drinking water pathway associated with a desalination plant that might be built by United Water New York, Inc. on the Hudson River in Haverstraw, New York.

F. <u>F. Owen Hoffman ("FOH")</u>

Q21. Please state your full name.

A21. (FOH) My name is F. Owen Hoffman.

Q22. By whom are you employed and what is your position?

A22. (FOH) I am president and director of SENES Oak Ridge, Inc. Center for Risk Analysis, an organization that specializes in human health and ecological risk estimation, risk assessment, and risk communication, with respect to environmental radiation and chemicals.

Q23. Please describe your educational and professional qualifications, including relevant professional activities.

A23. (FOH) My qualifications are summarized in the attached *curriculum vitae* (ENT000306). Briefly, I hold a Bachelor of Science degree in Biological Conservation from the San Jose State College, a Master of Science degree in Fisheries Limnology from Oregon State University, and a Ph.D. in Ecology, with a specialty in Radiation Ecology, from the University of Tennessee. I have more than 40 years of experience in issues related to the evaluation of human and ecological risk from the release and transport of radionuclides and chemicals in terrestrial and aquatic systems. I am a Distinguished Emeritus Member of the National Council for Radiological Protection and Measurements ("NCRP") and a former corresponding member of the International Commission on Radiological Protection ("ICRP"), a renowned independent, international advisory organization that provides recommendations and guidance on radiation protection standards. In addition, I am currently a consultant to the United Nations Scientific Committee on the Effects of Atomic Radiation ("UNSCEAR").

Q24. Please describe the basis for your familiarity with Indian Point, and the IP2 and IP3 license renewal project.

A24. (FOH) I testified as an expert on behalf of Entergy in the IP2 and IP3 NYSDEC Clean Water Act Section 401 Water Quality Certification hearing concerning radiological issues. I also have been retained by Entergy as an expert in connection with the hearing on RK-EC-3/CW-EC-1. In preparing my testimony, I reviewed the NRC's environmental protection regulations in 10 C.F.R. Part 51, NRC's radiation protection regulations in 10 C.F.R. Part 20, NRC's light water reactor effluent regulations in 10 C.F.R. Part 50, the NRC Staff's FSEIS, Entergy's IPEC ODCM, and Entergy's Annual Radiological Environmental Operating Reports

and Annual Radioactive Effluent Release Reports from 2005 through 2010. Further, I reviewed material related to a hypothetical future drinking water pathway associated with a desalination plant that might be built by United Water New York, Inc. on the Hudson River in Haverstraw, New York. I also performed an independent assessment of the radiological impacts to the Hudson River ecosystem from Indian Point SFP leaks to site groundwater.

II. OVERVIEW OF CONSOLIDATED CONTENTION RK-EC-3/CW-EC-1

Q25. Are you familiar with RK-EC-3/CW-EC-1, as originally proposed by Riverkeeper and Clearwater?

A25. (DMM, ABC, TCE, MJB, CJP, FOH) Yes. We have reviewed the applicable portions of "Riverkeeper, Inc.'s Request for Hearing and Petition to Intervene," dated November 30, 2007 ("Riverkeeper Petition"), *available at* ADAMS Accession No. ML073410093; "Hudson River Sloop Clearwater Inc's Petition to Intervene and Request for Hearing," dated December 10, 2007 ("Clearwater Petition"), *available at* ADAMS Accession No. ML073520042; "Hudson River Sloop Clearwater Inc's Reply to Entergy and the Nuclear Regulatory Commission (NRC) Responses to Clearwater Petition to Intervene and Request for Hearing," dated February 8, 2008 ("Clearwater Reply"); "Riverkeeper, Inc's Reply to Entergy's and NRC Staff's Responses to Hearing Request and Petition to Intervene," dated February 15, 2008 ("Riverkeeper Reply"), *available at* ADAMS Accession No. ML080560247; "Consolidated Contention of Petitioners Riverkeeper, Inc. (EC-3) and Hudson River Sloop Clearwater, Inc. (EC-1) Spent Fuel Pool Leaks," dated August 21, 2008 ("Consolidated Contention" or "RK-EC-3/CW-EC-1"), *available at* ADAMS Accession No. ML082420284; "Hudson River Sloop Clearwater Inc.'s Motion for Leave to File a New Contention Regarding Environmental Impacts and Public Health Impacts of Indian Point on the Hudson Water as a Source of Drinking Water Supply," dated March 19, 2009 ("Desalination Contention"), *available*

at ADAMS Accession No. ML090861002; Clearwater's "Reply to NRC Staff's Opposition to Petition to Add a New Contention Preliminary Statement," dated April 20, 2009, *available at* ADAMS Accession No. ML091180476; "Riverkeeper, Inc.'s Challenge to NRC Staff's Assessment of Impacts of Spent Fuel Pool Leaks in the Draft Supplemental Environmental Impact Statement," dated February 27, 2009, *available at* ADAMS Accession No. ML090820633; and "Riverkeeper, Inc. and Clearwater, Inc. Challenge to NRC Staff's Assessment of Impacts of Spent Fuel Pool Leaks in the Final Supplemental Environmental Impact Statement," dated February 3, 2011, *available at* ADAMS Accession No. ML110410362.

In brief, RK-EC-3/CW-EC-1 alleges that Entergy's Environmental Report ("ER") fails to satisfy the National Environmental Policy Act ("NEPA") and 10 C.F.R. Part 51 because it does not adequately assess the significance of new information concerning the environmental impacts of radionuclide leaks from IP1 and IP2 SFPs into the groundwater and Hudson River ecosystem. Consolidated Contention at 1, 2. More specifically, Riverkeeper and Clearwater (jointly, "Intervenors") asserted: (1) Entergy's claim that only "low concentrations" of certain radionuclides have been detected in onsite groundwater samples is incorrect given that onsite groundwater samples indicated radionuclide concentrations greater than the U.S. Environmental Protection Agency's ("EPA's") maximum contaminant levels ("MCLs") for drinking water; (2) Entergy failed to include an assessment of current and future impacts of groundwater contamination on the Hudson River ecosystem despite recent samples of Hudson River fish and shellfish showing elevated levels of strontium-90; and (3) Entergy's claim that the IP2 SFP is no longer leaking is unsupported, and determining the status and duration of such leaks is necessary to assess current and future groundwater impacts. Consolidated Contention at 2-4.

In addition to these arguments, Clearwater, in a separate contention precipitated by an application for a proposed desalination plant in the Hudson River approximately 3.5 miles downstream from Indian Point, alleged that Entergy did not assess the impacts of license renewal on the Hudson River drinking water quality and degradation, assuming this desalination plant becomes operational and provides drinking water. Desalination Contention at 1; *see also* United Water Haverstraw Water Supply Project 6 NYCCRR Part 601 Water Supply Permit Application App. A (Dec. 2011) ("United Water Supply Permit Application") (ENT00320A-D) (listing Indian Point as 3.55 miles from proposed desalination plant intake (FRS ID 110008054327)).

Q26. Are you familiar with RK-EC-3/CW-EC-1 as admitted by the Board?

A26. (DMM, ABC, TCE, MJB, CJP, FOH) Yes. The Board admitted RK-EC-3/CW-EC-1 as it relates to the significance of the environmental impacts resulting from the SFP leaks. *See Entergy Nuclear Operations, Inc.* (Indian Point Nuclear Generating Units 2 & 3), LBP-08-13, 68 NRC 43, 190 (2008). In this regard, the Board found that there was a genuine dispute regarding the significance of new information concerning the SFP leaks, including the data and conclusions presented in the Indian Point "Hydrogeologic Site Investigation Report" (Jan. 7, 2008) ("Site Investigation Report") (ENT00331A-P), whether the maximum groundwater impact (and, in turn, the maximum dose) has been determined for the site, and whether release concentrations to the Hudson River are low and have an impact on the Hudson River ecosystem. *See Indian Point*, LBP-08-13, 68 NRC at 190-191, 193-194.

As later clarified by the Board, this contention includes consideration of use of the Hudson River as a potential drinking water source. Licensing Board Order (Denying Clearwater's Petition to File a New Contention) at 5 (May 28, 2009) (unpublished). The Intervenors have since requested that the Board recognize that the Consolidated Contention, as

admitted, applies to the NRC Staff's DSEIS and FSEIS, and the Board agreed to such requests. Licensing Board Order (Ruling on Pending Motions for Leave to File New and Amended Contentions) at 36 (July 6, 2011) (unpublished); Licensing Board Order (Applying Consolidated Contention Riverkeeper EC-3/Clearwater EC-1 to the NRC Staff's Draft Supplemental Environmental Impact Statement) at 1-2 (May 28, 2009) (unpublished).

Q27. Have you reviewed the Intervenors' initial written statement of position, prefiled direct testimony, and supporting exhibits concerning RK-EC-3/CW-EC-1, as filed on December 22, 2011?

A27. (DMM, ABC, TCE, MJB, CJP, FOH) Yes. We have each individually reviewed the Intervenors' prefiled testimony of Mr. Gundersen and Dr. Stewart (RIV000060 and RIV000061, respectively) and other supporting exhibits. Our following testimony fully addresses the Intervenors' specific concerns and arguments.

Q28. Have you reviewed other materials in preparation for your testimony?

A28. (DMM, ABC, TCE, MJB, CJP, FOH) Yes, as they pertain to our respective areas of testimony. We note at the outset that we cannot offer legal opinions on the language of the NRC regulations, orders, or related guidance discussed in our testimony. However, reading statements therein as technical statements, and using our expertise, we can interpret what those statements mean for purposes of our testimony.

Q29. What is the source of those materials?

A29. (DMM, ABC, TCE, MJB, CJP, FOH) Many are documents prepared by government agencies, scientific consensus bodies, or documents prepared by or for Entergy or the utility industry pertaining to radiological groundwater monitoring, and human health environmental impact assessment. These documents include, for example, NRC and EPA

regulations and guidance documents, the Indian Point license renewal application, NRC Staff's Generic Environmental Impact Statement ("GEIS") and Indian Point FSEIS, the GZA Site Investigation Report (ENT000331A-P) and Quarterly Monitoring Reports, (*e.g.*, ENT00334A-E and ENT00335A-E), Indian Point Annual Radiological Environmental Operating Reports and Radioactive Effluent Release Reports, the report by Lawrence C. Skinner and Timothy J. Sinnot, "Measurement of Strontium (90Sr) and Other Radionuclides in Edible Tissues and Bone/Carapace of Fish and Blue Crabs from the Lower Hudson River," (Nov. 2009) ("NYSDEC Strontium Study") (ENT000321), and the United Water, Inc. Haverstraw Water Supply Project Draft Environmental Impact Statement ("United Water DEIS") (RIV000101).

Q30. I show you what has been marked as Exhibit ENT000001. Do you recognize this document?

A30. (DMM, ABC, TCE, MJB, CJP, FOH) Yes. It is a list of Entergy's exhibits, and includes those documents which we referred to, used, or relied upon in preparing respective portions of our testimony, ENT00015A-B, ENT000269, ENT000302 to ENT000368, and ENT000370 to ENT000371.

Q31. I show you Exhibits ENT00015A-B, ENT000269, ENT000302 to ENT000368, and ENT000370 to ENT000371. Do you recognize these documents?

A31. (DMM, ABC, TCE, MJB, CJP, FOH) Yes. These are true and accurate copies of the documents that we have referred to, used and or relied upon in preparing this testimony. Where we have attached only a document excerpt as an exhibit, that is noted in Entergy's exhibit list.

Q32. How do these documents relate to the work that you do as an expert in forming opinions such as those contained in this testimony?

A32. (DMM, ABC, TCE, MJB, CJP, FOH) These documents represent the type of information that persons within our respective fields of expertise reasonably rely upon in forming opinions of the type offered in this testimony.

III. SUMMARY OF DIRECT TESTIMONY AND CONCLUSIONS

Q33. What is the purpose of your testimony?

A33. (DMM, ABC, TCE, MJB, CJP, FOH) The purpose of our testimony is to explain why RK-EC-3/CW-EC-1 lacks merit, and why the NRC Staff FSEIS appropriately concludes that new information regarding IP1 and IP2 SFP leaks into the groundwater and Hudson River ecosystem is not environmentally significant. Specifically, we demonstrate that environmental impacts from such leaks on human health, groundwater quality, and ecological resources are all SMALL, as defined by 10 C.F.R. Part 51, App. B, Table B-1.

Q34. Please summarize the basis for your disagreement with the claims made by the Intervenors and their proffered witnesses in RK-EC-3/CW-EC-1.

A34. (DMM, ABC, TCE, MJB, CJP, FOH) Entergy has extensively studied the hydrogeology and the groundwater flow mechanisms at Indian Point, and has installed a broad network of groundwater monitoring wells in order to monitor the movement of radionuclides in groundwater that are principally the result of past releases of water from IP1 and IP2 SFPs, and also to help detect future releases of radionuclides into groundwater, should they occur. Site Investigation Report at 4; *id.* at 89 (ENT0331B). As Entergy concluded, some of the groundwater beneath the site contains detectable levels of radionuclides, principally tritium (mostly resulting from the IP2 SFP), and strontium (resulting from the now-empty and drained IP1 SFPs). Some of this groundwater migrates to the Hudson River, resulting in low levels of

tritium and strontium reaching the river, in amounts orders of magnitude below the allowable federal regulatory limits for radiological effluent releases. Site Investigation Report at 130 (ENT0331B).

For these and the following reasons, the human health, groundwater quality, and aquatic ecology impacts from SFP leaks have been and will continue to be SMALL, as defined in NRC regulations—*i.e.*, impacts that are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource. For the purposes of assessing radiological impacts, the Commission has concluded that those impacts that do not exceed permissible levels in the Commission's regulations are considered SMALL. NUREG-1437, Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Final Report at 1-4 (May 1996) ("GEIS") (NYS00131A).

Q35. Please summarize your basis for concluding that human health impacts are SMALL.

A35. (DMM, ABC, MJB, CJP, FOH) Entergy accounts for radiological releases associated with the groundwater and storm water pathways in its annual release and dose calculations. *See* IPEC ODCM Pt. II, at 9, 2.1.16 (ENT000307). As demonstrated in Entergy's Annual Radioactive Effluent Release Reports, Indian Point does not exceed any permissible levels specified in 10 C.F.R. Part 20 and Part 50, Appendix I of the Commission's regulations, or in EPA's 40 C.F.R. 190. In fact, Indian Point doses due to releases comply with these requirements by a wide margin, and these releases are orders of magnitude lower than federal regulatory limits for radioactive effluents, limits designed to protect human health. *See, e.g.*, Entergy's 2010 Annual Radioactive Effluent Release Report, Rev. 1 at 41 ("2010 Annual

Radioactive Effluent Release Report") (June 10, 2010) (ENT000319). Therefore, human health impacts due to radiation exposures to the public from Indian Point are SMALL.

Q36. Please summarize your basis for concluding that groundwater impacts are SMALL.

A36. (DMM, ABC, MJB, CJP, FOH) There are no current or reasonably anticipated uses of onsite groundwater for potable purposes. *See* Site Investigation Report at 4; *id.* at 89 (ENT00331A-B). Thus, EPA drinking water limits do not apply. *See* SECY-11-0019, Senior Management Review of Overall Regulatory Approach to Groundwater Protection Encl. 2, at 2 (Feb. 9, 2011) (Regulatory Framework) (ENT000332). Groundwater does not travel offsite from the power block area, other than to the Hudson River, and the migration of low-level radionuclides to the Hudson River has had no discernible effect on the level of radionuclides contained in Hudson River water. Site Investigation Report at 127, 130 (ENT00331B). Entergy's extensive network of groundwater monitoring wells is sufficient to allow Entergy to detect potential future releases into groundwater comparable in magnitude to those previously identified and respond appropriately to such releases. *See* responses to Questions 74 and 101, below. For these reasons, the impacts on groundwater quality are SMALL.

Q37. Please summarize your basis for concluding that aquatic ecology impacts are SMALL.

A37. (DMM, ABC, MJB, CJP, FOH) Because the migration of low-level radionuclides to the Hudson River has had no discernible effect on the level of radionuclides contained in Hudson River water, there are no adverse impacts to the Hudson River ecosystem. FSEIS at 2-105 (NYS00133A). Calculations show that dose rates from releases of Indian Point groundwater to the Hudson River are orders of magnitude below guidelines used to assess the potential for

ecologically significant impacts. *See* Dr. F. Hoffman, Entergy Aquatic Biota Calculations (Feb. 10, 2012) (ENT000323); NYSDEC Strontium Study at 8 (ENT000321). Accordingly, impacts to the Hudson River aquatic ecosystem are SMALL.

Q38. Please summarize your basis for concluding that environmental impacts will likely remain SMALL.

A38. (DMM, ABC, TCE, MJB, CJP, FOH) Although the environmental impacts from SFP leaks have and will continue to be SMALL, Entergy has been proactive in identifying and addressing SFP leaks. The IP1 SFPs have been emptied and are no longer a source of new releases. E-mail notification from Donald Mayer, Director, IPEC Unit 1, Entergy, to John White, Branch Chief, Radiation Protection, NRC Region 1, "Subject: Indian Point 1" (Nov. 5, 2008) (ENT000324). Even so, Entergy continues to operate and maintain the IP1 foundation collection drains and treatment system to capture a majority of the residual contamination partitioning off of the subsurface materials into the groundwater. *See* response to Question 67, below.

All previously identified releases from the IP2 SFP have been stopped. *See* responses to Questions 70-75, 100, below. Monitoring data indicate that overall tritium activity in the IP2 SFP plume has generally undergone long-term, overall reductions since the termination of these releases. *See* response to Question 100, below; GZA Graph, Changes in Computed Tritium Plume Total Activity Over Time - Exponential Decay Curve Trending of Quarterly Data through Q3 2011" (ENT000332); GZA Graph, Changes in Computed Strontium Plume Total Activity Over Time - Exponential Decay Curve Trending of Quarterly Data through Q3 2011 (ENT000333). Reasonably accessible portions of the IP2 SFP have been inspected. Lucius

Pitkin, Inc., "Discussion on Aging of the Indian Point 2 Spent Fuel Pit," Report No: A11357-R-001 at 21-22 (Feb. 2012) ("Lucius Pitkin Report") (ENT000326).

Notwithstanding the Intervenors' generalizations about aging and the "bathtub" curve, prior IP2 SFP leaks were not the result of age-related degradation mechanisms, and SFP inspections and analyses have not identified aging mechanisms that would cause a SFP leak or that would increase the size of any undetected existing leak. Prefiled Direct Testimony of Arnold Gunderson at 10-11 (RIV000060). To the extent that any small, undetected leak may exist, it must be smaller than those identified and repaired by Entergy given the subsequent attenuation of the tritium plume. *See* response to Questions 99-102, below. The network of monitoring wells is sufficient to allow Entergy to identify future SFP releases, if any, of radionuclides into groundwater comparable in magnitude to those previously identified, and to take action to investigate and respond appropriately. *See* response to Question 101, below.

IV. BACKGROUND ON RELEVANT REGULATIONS

A. 10 C.F.R. Part 54 Requirements for License Renewal

Q39. Please identify and briefly describe the NRC's 10 C.F.R. Part 54 requirements applicable to license renewal applications.

A39. (ABC) The safety issues that must be considered in a license renewal proceeding are set forth in 10 C.F.R. Part 54. Part 54 defines the extent of the license renewal safety review to include the management of the effects of aging on certain systems, structures, and components ("SSCs") and the review of certain time-limited aging analyses. NRC's license renewal regulations are based on the distinction between aging management issues, on the one hand, and the ongoing regulatory process on the other. The license renewal framework assumes that, with the exception of aging management issues, the NRC's ongoing regulatory process is adequate to ensure that the current licensing basis of operating plants provides and maintains an acceptable

level of safety. For some passive structures and components within the scope of the license renewal rule, no additional action may be required where an applicant can demonstrate that existing programs provide adequate aging management throughout the period of extended operation. *See* Final Rule, Nuclear Power Plant License Renewal; Revisions, 60 Fed. Reg. 22,461, 22,464-65 (May 8, 1995) (NYS000016). However, if additional aging management activities are warranted for a structure or component within the scope of the rule, then applicants may, for example, identify an aging management program ("AMP") to manage the effects of aging during the period of extended operation.

Q40. What systems are within the scope of the license renewal safety review?

A40. (ABC) Section 54.4 defines the plant SSCs that are within the scope of the license renewal rule based on their intended functions.

Q41. Are any IP1 SSCs, including the SFPs, within the scope of the license renewal safety review?

A41. (ABC) Entergy's LRA is for renewal of the operating licenses for IP2 and IP3. The IP1 systems that are needed to support IP2 and IP3 are within the scope of license renewal. *See* LRA at 2.1-2 (ENT00015A). The IP1 SFPs, which are not needed to support IP2 and IP3, are not within the scope of license renewal. *See* LRA at 2.2-25, Tbl. 2.2-4 (ENT00015A) (listing the IP1 fuel handling and chemical system building, which contains the IP1 SFPs, as not within the scope of license renewal).

Q42. Are IP2 and IP3 SFPs within the scope of license renewal?

A42. (ABC) Yes. In accordance with 10 C.F.R. Part 54, the IP2 and IP3 SFPs are within the scope of license renewal for IP2 and IP3. *See* LRA at 2.3-76 to -77 (ENT00015A).

Q43. Please identify any programs that are used to manage aging of the IP2 and IP3 SFPs.

A43. (ABC) Entergy will rely on the Structures Monitoring Program for aging management of IP2 and IP3 SFP concrete. FSER at 3-134 (NYS00326C). In addition, Entergy will rely on the Water Chemistry Control – Primary and Secondary Program and the monitoring of the pool level pursuant to Technical Specifications for managing the effects of aging on the IP2 and IP3 SFP stainless steel liner. See FSER at 3-134 (NYS00326C). As discussed in further detail later in Question 71 of this testimony, Entergy also performed inspections of the accessible areas of the IP2 SFP as part of prior leak investigations. The results of these inspections provide further assurance of the continued ability of the IP2 SFP to fulfill its license renewal intended function throughout the period of extended operation.

B. <u>Environmental Protection Regulations</u>

Q44. Please identify the NRC regulations implementing NEPA and briefly describe how those regulations apply to license renewal applications.

A44. (CJP) The NRC's NEPA regulations are found in 10 C.F.R. Part 51. Part 51 requires an applicant to prepare an environmental report ("ER") and the NRC Staff to prepare an environmental impact statement ("EIS") for certain Commission actions, including for major licensing actions. In 1996, the Commission amended Part 51 to address the scope of its environmental review for license renewal applications ("LRA"). *See* Final Rule, Environmental Review for Renewal of Nuclear Power Plant Operating Licenses, 61 Fed. Reg. 28,467 (June 5, 1996) (NYS000127), *amended by* 61 Fed. Reg. 66,537 (Dec. 18, 1996) (NYS000128).

To make Part 51 more efficient and focused, the NRC divided the environmental requirements for license renewal into generic and plant-specific components. The NRC Staff prepared a Generic Environmental Impact Statement for License Renewal of Nuclear Plants

("GEIS") to evaluate and document those environmental impacts that are well understood based on experience gained from the operation of the existing fleet of U.S. nuclear power plants. *See* NUREG-1437, Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Final Report, Vols. 1 & 2 (May 1996) ("GEIS") (NYS00131A-I).

Generic issues are identified in the GEIS as "Category 1" issues. Category 1 issues are those for which the Commission found that it could draw generic conclusions that would apply to all nuclear power plants, or, a specific group of those plants. GEIS at xxxv (NYS00131A). The Commission concluded that such issues involve environmental impacts that are similar for all plants, and thus need not be assessed on a site-specific basis. GEIS at xxxv (NYS00131A). The NRC codified its generic findings in Table B-1, Appendix B to Subpart A of 10 C.F.R. Part 51.

Pursuant to 10 C.F.R. § 51.53(c)(3)(i), a license renewal applicant may, in its ER, refer to and, in the absence of new and significant information, adopt the generic environmental impact findings found in Appendix B, Table B-1, for Category 1 issues. An applicant, however, must address certain environmental issues for which the Commission was not able to make generic environmental findings. *See* 10 C.F.R. § 51.53(c)(3)(ii). Specifically, an ER must contain analyses of the environmental impacts of the proposed action for those issues listed at 10 C.F.R. § 51.53(c)(3)(ii) and identified as "Category 2," or "plant specific," issues in Table B-1. In its ER, an applicant also must include a site-specific analysis of "any new and significant information regarding the environmental impacts of license renewal of which the applicant is aware." 10 C.F.R. § 51.53(c)(3)(iv). The NRC Staff must then prepare a site-specific supplement to the GEIS for each license renewal application that evaluates applicable site-

specific Category 2 issues and any "new and significant information." 10 C.F.R. §§ 51.71(d), 51.95(c)(3).

NRC Staff regulatory guidance defines "new and significant information" as follows: (1) information that identifies a significant environmental issue that was not considered in the GEIS and, consequently, not codified in Table B-1; or (2) information that was not considered in the analyses summarized in the GEIS and that leads to an impact finding different from that codified in 10 C.F.R. Part 51. Regulatory Guide 4.2, Supp. 1, Preparation of Supplemental Environmental Reports for Application to Renew Nuclear Power Plant Operating Licenses 4.2-S-4 (Sept. 2000) ("RG 4.2S1") (ENT000338).

Q45. Does NRC provide any further guidance defining significance?

A45. (CJP) Yes. Environmental issues that are reviewed in NRC environmental impact statements are assigned significance levels based on the following definitions:

> SMALL: Environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource. For the purposes of assessing radiological impacts, the Commission has concluded that *those impacts that do not exceed permissible levels in the Commission's regulations are considered small*.
>
> MODERATE: Environmental effects are sufficient to alter noticeably, but not to destabilize, any important attributes of the resource.
>
> LARGE: Environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource.

10 C.F.R. pt. 51, app. B, tbl. B-1 (emphasis added).

Q46. Please identify any issues addressed in the GEIS and Table B-1 that are relevant to RK-EC-3/CW-EC-1.

A46. (CJP) RK-EC-3/CW-EC-1 identifies three main environmental issues related to the Indian Point SFP leaks: (1) potential human health impacts; (2) groundwater quality impacts; and (3) aquatic ecology impacts. *See* Consolidated Contention at 2-4.

First, with regard to the potential for human health impacts due to radiation exposures to the public, the GEIS finds that radiation exposure from power reactor operation is a "Category 1 issue" with SMALL significance, in part, because aging effects would not significantly change radioactive effluents. GEIS at 4-95 (NYS00131B). This finding also rests on the NRC's finding of how well nuclear power plants have met applicable NRC radiological dose regulations. *See* GEIS at 4-95 (NYS00131B). Table B-1 codifies this finding and indicates that the issue of radiation exposure during the license renewal term has a SMALL significance level based on the expectation that "[r]adiation doses to the public will continue at current levels associated with normal operations." 10 C.F.R. pt. 51, subpt. A, app. B, tbl. B-1.

Second, Section 4.8.2 of the GEIS addresses the issue of impairment of groundwater quality, including potential impacts due to tritium contamination. *See* GEIS at 4-118 (NYS00131B). In this section, the GEIS indicates that groundwater quality impacts are considered to be of SMALL significance when a plant does not contribute to changes in groundwater quality that would preclude current and future uses of groundwater. The GEIS further considers low-level groundwater contamination at the Prairie Island nuclear power plant site and concludes that "the contribution of plant operations (during the license renewal period) to the cumulative impacts of major activities on groundwater quality would be relatively small."

GEIS at 4-119 (NYS00131B). Table B-1, however, does not list groundwater quality impacts due to radiological contamination as a Category 1 or Category 2 issue.

Third, the GEIS and Table B-1 list several issues related to ecological impacts. *See, e.g.*, 10 C.F.R. pt. 51, app. B, tbl. B-1 (listing various aquatic ecology-related Category 1 and 2 issues). However, none of these issues relates to the potential impacts of radionuclides from SFP leaks on aquatic organisms during the license renewal term.

C. Liquid Effluent Radiological Dose Limits and Environmental Monitoring Requirements

Q47. Please provide an overview of the regulations that establish dose limits for members of the public for nuclear power plants.

A47. (CJP, FOH) As an initial matter, the radiation protection standards for Indian Point will not change if license renewal is approved by the NRC. NRC regulations in 10 C.F.R. Part 20, "Standards for Protection Against Radiation" are applicable to all nuclear power plants, including Indian Point, and establish several relevant dose limitations. The regulations found in Part 20 establish standards for protection against ionizing radiation resulting from activities of NRC licensees and are intended to control, among other things, the possession and use of licensed materials such that the total dose to an individual member of the public does not exceed radiation protection standards. Pursuant to 10 C.F.R. § 20.1301(a), licensees must conduct operations so that the total effective dose equivalent above background at the boundary of unrestricted areas (*i.e.*, areas for which access is not limited or controlled by a licensee) does not exceed 100 millirem ("mrem") in a year to individual members of the public.

Furthermore, 10 C.F.R. § 20.1301(e) incorporates by reference the U.S. Environmental Protection Agency ("EPA") environmental radiation protection standard found at 40 C.F.R. § 190.10. Section 190.10 imposes the following dose limits on any member of the public

resulting from planned discharges of radioactive materials to the general environment from uranium fuel cycle operations (which includes nuclear power plant operations): 25 mrem/yr to the whole body; 75 mrem/yr to the thyroid; and 25 mrem/yr to any other organ.

To demonstrate compliance with dose limits for members of the public, 10 C.F.R. § 20.1302 requires that licensees conduct surveys of radiation levels in both unrestricted and controlled areas, and of radioactive materials in effluents released to unrestricted and controlled areas.

In addition to the Part 20 and EPA limits, 10 C.F.R. Part 50 places additional restrictions on public dose from the operations of nuclear power plants such as IP2 and IP3. Specifically, 10 C.F.R. § 50.36a imposes conditions on operating licensees in the form of Technical Specifications (*i.e.*, enforceable license conditions) on effluents from nuclear power reactors. These specifications are intended to keep radiological releases to unrestricted areas during normal operations, including expected occurrences (*e.g.*, leaks), "as low as reasonably achievable" ("ALARA"). Appendix I to 10 C.F.R. Part 50, "Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion 'As Low as is Reasonably Achievable' for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents," provides numerical guidance on design objectives and limiting conditions for effluents from light-water reactor to meet the ALARA requirement. Appendix I also establishes requirements for demonstrating compliance with the design objectives, actions to be taken if the effluent releases in any calendar quarter exceed one-half of any of the annual design objectives and requirements to conduct surveillance and monitoring programs to demonstrate compliance.

The numerical design objectives of Appendix I to Part 50 are a fraction of the Part 20 limits (including the EPA 40 C.F.R. § 190.10 limits). Thus, in practice, because the Part 50,

Appendix I design objectives are far more restrictive than Part 20 allowable dose limits or effluent concentration levels, the Part 50, Appendix I ALARA objectives are controlling for power reactor licensees.

To implement 10 C.F.R. Part 50, Appendix I, the NRC Staff developed Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," Rev. 1 (Oct. 1977) ("Regulatory Guide 1.109") (ENT000339). Regulatory Guide 1.109 describes basic features for calculation models and suggests parameters for the estimation of radiation doses to members of the general public from effluent releases.

The following are the liquid effluent design objectives of Appendix I, 10 C.F.R. Part 50, as summarized in Table 1 of Regulatory Guide 1.109, for the hypothetical maximally exposed individual at the site boundary (integrated total dose on an annual basis):

- Annual dose to the total body from all pathways – 3 mrem per reactor – location of highest dose offsite evaluated at a location that is anticipated to be occupied during the plant lifetime or evaluated with respect to such potential land and water usage and food pathways as could actually exist during the term of plant operation.
- Annual dose to any organ from all pathways – 10 mrem per reactor – location same as above.

The relevant 10 C.F.R. Part 50, Appendix I and 40 C.F.R. § 190.10 limits are summarized in GEIS Tables E.4 and E.5, respectively and are reproduced below. *See* GEIS at E-10 (NYS00131H).

Table E.4 Ten CFR Part 50, Appendix I, design objectives and annual limits on radiation doses to the general public from nuclear power plants[a]

Tissue	Gaseous	Liquid
Total body	5 mrem	3 mrem
Any organ (all pathways)	—	10 mrem
Ground-level air dose	10 mrad gamma and 30 mrad beta	—
		—
Any organ[b] (all pathways)	15 mrem	—
Skin	15 mrem	

[a]Calculated doses.
[b]Particulates, radioiodines.
Note: To convert millirem to millisievert, multiply by 0.01.

Table E.5 Forty CFR 190, Subpart B, annual limits on doses to the general public from nuclear power operations[a]

Tissue	Limit	Source
Total body	25 mrem	All effluents and direct radiation from nuclear power operations
Thyroid	75 mrem	"
Any other organ	25 mrem	"

[a]Calculated doses.
Note: To convert millirem to millisievert, multiply by 0.01.

Q48. Do NRC regulations require that licensees verify and report compliance with these limits?

A48. (CJP, FOH) Yes. 10 C.F.R. § 50.36a requires licensees to have Technical Specifications to ensure compliance with Sections 20.1301 and 50.34a, and to use operating procedures and radioactive waste systems to maintain radioactive effluents ALARA. Section 50.36a also requires that licensees submit to the Commission an Annual Radiological Effluent Release Report that specifies the quantity of each of the principal radionuclides released to the

unrestricted areas in all liquid and airborne effluents during the previous 12 months. Further, in accordance with 10 C.F.R. Part 50, Appendix I, Section IV.B, NRC regulations require that nuclear power plant operators monitor the environment in the vicinity of the nuclear power plant to assess the cumulative impact of the radioactive material that has been released and, on an annual basis, to submit the results of this environmental monitoring program to the NRC in an Annual Radiological Environmental Operating Report. Detailed environmental monitoring program description and reporting requirements are found in Technical Specifications and the Offsite Dose Calculation Manual, which are reviewed and approved by the NRC.

Q49. Do NRC regulations require that a licensee account for inadvertent or unanticipated releases?

A49. (CJP, FOH) Yes. The NRC limits and ALARA design objectives described above do not differentiate between normal effluent discharges and unplanned releases such as leaks containing radioactive materials. *See* 10 C.F.R. § 50.36a; Appendix I, 10 C.F.R. Part 50. Regardless of the source, each nuclear power plant is required to account for the radioactivity released to the environment, including planned and unplanned releases. *See* SECY-11-0019, Senior Management Review of Overall Regulatory Approach to Groundwater Protection Encl. 2, at 2 (Feb. 9, 2011) (Regulatory Framework) (ENT000322) ("SECY-11-0019"). Each licensee is responsible for accounting for the release, evaluating the release relative to NRC regulatory requirements, and reporting the quantity of radioactivity released and the estimated highest radiation dose to any member of the public. *See* SECY-11-0019, Encl. 2, at 2 (ENT000322). Along with all other releases, unplanned or abnormal releases are specifically identified in the required Annual Radiological Effluent Release Report provided to the NRC. *See, e.g.*, 2010 Annual Radioactive Effluent Release Report at 5 (ENT000319).

Q50. Are you familiar with Entergy's Indian Point Offsite Dose Calculation Manual ("ODCM")?

A50. (CJP, FOH) Yes. We have reviewed the Indian Point Energy Center, Units 1, 2, and 3, Offsite Dose Calculation Manual, Rev. 3 (Jan. 24, 2011) ("IPEC ODCM"). It is marked as Exhibit ENT000307. The Indian Point ODCM establishes radiological effluent controls and monitoring requirements with which Entergy must comply pursuant to license conditions. *See* IPEC ODCM at viii (ENT000307). The ODCM includes direction on the number and distribution of offsite sampling locations, the types of samples for collection, and the types of analyses to be performed for measurement of radioactivity. The ODCM also details the methods to calculate radiation dose rates and doses to the hypothetical maximally exposed individual in the vicinity of Indian Point due to effluent releases.

Q51. Does Entergy account for radionuclides released to the Hudson River from groundwater?

A51. (CJP, FOH) Yes. Consistent with Regulatory Guide 1.109 and the design objectives of 10 C.F.R. Part 50, Appendix I, the ODCM specifies the methods for performing the required quantification and dose assessment of radioactive groundwater leaving Indian Point. Calculations are performed annually to account for actual source terms, release rates, and dilution flows throughout the year. *See* IPEC ODCM Pt. II, at 9 (ENT000307).

Q52. Does Entergy's ODCM establish procedures to ensure compliance with dose limits in 10 C.F.R. Part 50, Appendix I to Indian Point radionuclide releases?

A52. (CJP, FOH) Yes. In accordance with Regulatory Guide 1.109 and Appendix I of Part 50, for a calendar year, the ODCM limits the dose to a member of the public from all liquid effluents (including releases from groundwater) to 3 mrem to the total body and 10 mrem to any

organ. *See* IPEC ODCM Pt. II, at 12 (ENT000307). If the quantity of radioactive material actually released in effluents to unrestricted areas during any quarter is such that the resulting radiation exposure would exceed one-half the design objective annual exposure, then Entergy must investigate the cause, initiate a program of corrective action, and report these actions to the NRC within 30 days from the end of the quarter during which the release occurred. 10 C.F.R. pt. 50, app. I § IV.A.

The ODCM also directs the submission to the NRC of an Annual Radioactive Effluent Release Report, which reports the amount of radioactive material released to the environment during the past year, including releases from the groundwater pathway. *See* IPEC ODCM Pt. II, App. J (Groundwater Flow and Offsite Dose Calculation Details); *id.* at 9, § 2.1.16 (ENT000307). The report must include a summary of the quantities of radioactive liquid and airborne effluents released, and must be consistent with the objectives outlined in Part 50, Appendix I, Section IV.B.1.

Q53. Please describe any other activities and programs Entergy has in place at Indian Point to determine compliance with NRC dose limits.

A53. (CJP, FOH) The ODCM specifies the radiological environmental monitoring activities that Entergy must perform as part of its NRC-required Radiological Environmental Monitoring Program ("REMP"). *See* IPEC ODCM Pt. I, D 3.5.1 (Radiological Environmental Monitoring) (ENT000307). The REMP, which is subject to NRC inspection and enforcement, directs the number and distribution of environmental sampling locations, the types of samples for collection, and the types of analyses to be performed for measurement of radioactivity. *See* IPEC ODCM Pt. I, D 3.5.1 (Radiological Environmental Monitoring), Tbl. D 3.5.1-1 (ENT000307). The REMP supplements the radiological effluent controls program by

monitoring for any measurable concentrations of radioactive material in the environment that are higher than expected.

The REMP is designed to achieve two objectives: (1) enable the identification and quantification of changes in the radioactivity of the area; and (2) measure radionuclide concentrations in the environment attributable to operations at Indian Point regardless of the sources. FSEIS at 2-104 (NYS00133A). To identify changes in activity, analyses are conducted for specific environmental media (*e.g.*, water, soil, and food products) on a regular basis. *See* IPEC ODCM Pt. II, App. G at 116 (Environmental Sampling Points) (ENT000307). The radioactivity profile of the environment is established and monitored through routine evaluation of the results obtained.

Q54. Does the REMP require both onsite and offsite monitoring?

A54. (CJP, FOH) Yes. Both onsite and offsite sampling locations for the collection of environmental media are designated in the REMP. *See* IPEC ODCM Pt. II, App. G at 115-122 (Environmental Sampling Points) (ENT000307). Offsite locations include, for example, the Camp Field and Croton Reservoirs, two local water supplies. IPEC ODCM at 117 (Appendix G, Environmental Sampling Points) (ENT000307).

The offsite locations are subdivided into indicator and control locations. Indicator locations are established on or near the site, where the presence of environmental radioactivity of plant origin is most likely to be detected. Control locations are established farther away (and upwind/upstream) from the site, where the level of radioactivity is expected to not be affected by plant discharges. The use of indicator and control locations enables the identification of potential sources of detected radioactivity. *See* 2010 Annual Radiological Environmental

Operating Report at 2-1 to 2-2 (2011) (attachment to Letter NL-11-038, from P. Conroy, Entergy, to NRC (May 15, 2011)) (ENT000319).

Q55. Does this sampling allow for measurement of radionuclides attributable to Indian Point in potential exposure pathways?

A55. (CJP, FOH) Yes. Another REMP objective is verification of expected radionuclide concentrations resulting from effluent releases attributable to Indian Point. Due to the exceedingly small environmental radionuclide concentrations from Indian Point radiological plant releases, verification of projected concentrations through the REMP is difficult. Generally speaking, historical sampling indicates that residual radioactivity from atmospheric weapons testing and naturally occurring radionuclides are the predominant sources of radioactivity in the samples near Indian Point. *See* 2010 Annual Radiological Environmental Operating Report at 2-1 to 2-2 (ENT000319).

In accordance with the REMP, Entergy obtains measurements of radioactive material in exposure pathways that may lead to potential exposures of individuals as a result of Indian Point plant operation. For example, the waterborne pathway consists of the Hudson River water, fish and invertebrates, aquatic vegetation, bottom sediment, and shoreline sediment. IPEC ODCM Pt. II, App. G at 118 (ENT000307). The radionuclides detected in this pathway can be grouped into three categories: (1) naturally occurring radionuclides; (2) radionuclides resulting from weapons testing and other non-plant related, anthropogenic (*i.e.*, human-caused) sources; and (3) radionuclides resulting from plant operations. As a result of the SFP leaks, Entergy added to the REMP groundwater sampling at an offsite monitoring well southwest of the site boundary, as well as for analysis strontium-90 and nickel-63 in fish and invertebrates. *See* IPEC ODCM Pt. I, at D 3.5.1-7, D 3.5.1-9; *id.* Pt. II, App. J, at 9, § 2.1.16 (ENT000307).

Q56. Are the results from this sampling reliable?

A56. (CJP, FOH) Yes. After obtaining a sample from these locations, the ODCM requires that Entergy participate in an Interlaboratory Comparison Program. *See* IPEC ODCM Pt. II, App. H at 122 (ENT000307). The Interlaboratory Comparison Program involves providing Entergy's analysis laboratory with samples that contain certified levels of radioactivity unknown to the laboratory. The Interlaboratory Comparison Program ensures that independent checks on the precision and accuracy of the measurement of radioactive material in the environmental samples are performed in line with the quality assurance program for environmental monitoring. *See* IPEC ODCM at B D 3.5.3-1 (ENT000307).

Q57. Would the ODCM need to be revised if changes in local land use or activities resulted in a new exposure pathway?

A57. (CJP, FOH) Yes. Entergy performs a Land Use Census annually, per the ODCM, to determine if land use (*e.g.*, new farms or gardens) or other activities in the area have changed. *See* IPEC ODCM at D 3.5.2-1 to D 3.5.2-3, B D 3.5.2-1 (ENT000307).

V. DESCRIPTION OF THE PLANT AND SITE

Q58. Please describe the operational history of IP1, IP2, and IP3.

A58. (DMM, MJB) IP2 has operated since August 1974, and IP3 since August 1976. *See* FSEIS at 1-1 (NYS00133A). Entergy bought IP3 from the New York Power Authority in 2000 and IP2 from Consolidated Edison in 2001. *See* ER at 1-1 (ENT00015B).

IP1 is also located on the site, between IP2 and IP3. IP1 began commercial operations in August 1962, and operated until October 1974. FSEIS at 2-138 (NYS00133B). By January 1976, all spent fuel was moved from the IP1 reactor vessel into the IP1 SFPs. In January 1996, the NRC issued an order approving the current safe storage condition ("SAFSTOR") for IP1 until decontamination and decommissioning is performed in conjunction with the

decommissioning of IP2. When Entergy purchased IP2 from Consolidated Edison in 2001, it also purchased IP1.

Q59. Please describe the Indian Point site and the area surrounding the site location.

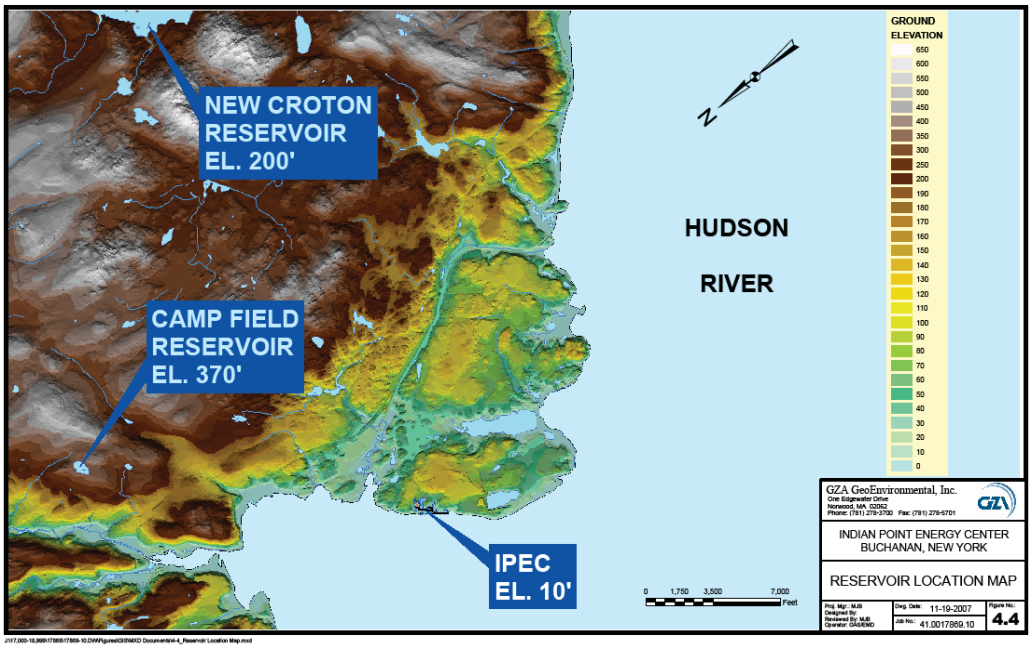
A59. (DMM, MJB) Indian Point is located on the eastern bank of the Hudson River, in the Village of Buchanan, in upper Westchester County, New York. FSEIS at 1-6 (NYS00133A). The Indian Point Site is approximately 239 acres, bounded on the north, south, and east by privately-owned land, and on the west by the Hudson River. FSEIS at 2-1, 2-24, 2-85 (NYS00133A) (The Hudson River in the vicinity of Indian Point, approximately at river mile 43, is approximately 4,500 feet wide and, on average, 40 feet deep. ER at 2-4 (ENT00015B). As discussed in more detail later in this testimony, in the vicinity of Indian Point, the Hudson River is not used for drinking water purposes. FSEIS at 2-111 to 2-112 (NYS00133A); ER at 5-5 (ENT00015B).

Q60. Does Indian Point use groundwater for plant operations?

A60. (DMM, MJB) No. Indian Point does not utilize groundwater, either for plant operations or for potable water. FSEIS at 8-32 (NYS00133C). Wells located at the site are used for groundwater monitoring purposes only and are not equipped to withdraw water for plant operations or as a potable water source. *See* FSEIS at 4-56 (NYS00133B). Surface water from the Hudson River and city water supply plant operational needs. FSEIS at 2-116 (NYS00133B). Potable water for the plant is supplied to the site by the Village of Buchanan water supply system, which obtains its water from the City of Peekskill Public Water System and the Montrose Improvement District. FSEIS at 2-116 (NYS00133B).

Q61. Are there any potable water wells located near Indian Point?

A61. (DMM, MJB) No. As explained in the FSEIS, there are no active potable water wells or other production wells in the vicinity of Indian Point. FSEIS at 2-111 (NYS00133A); *see also* NYSDEC 2007 Community Fact Sheet at 1 (Sept. 2007) (ENT000325). Drinking water in the area (Village of Buchanan and City of Peekskill) is supplied from surface water reservoirs located in Westchester County and the Catskills region. Site Investigation Report at 14 (ENT00331A). As shown on the figure below, the nearest of these reservoirs is the Camp Field Reservoir, which is located 3.3 miles north-northeast of Indian Point, in a cross-gradient direction (*i.e.*, perpendicular to the direction that groundwater flows), several watersheds away and at an elevation of over 300 feet above the Indian Point power block. Site Investigation Report at 14 (ENT00331A).



Q62. Please briefly describe the radiological waste management and effluent discharge systems at Indian Point.

A62. (DMM, MJB) IP2 and IP3 radioactive waste systems are licensed and designed to collect, treat, monitor, and dispose of radioactive and potentially radioactive wastes that are byproducts of plant operations. FSEIS at 2-14 (NYS00133A). Radioactive wastes resulting from plant operations are classified as liquid, gaseous, or solid. FSEIS at 2-14 (NYS00133A). Liquid radioactive wastes are generated from liquids received directly from portions of the reactor coolant system or that were contaminated by contact with liquids from the reactor coolant system. FSEIS at 2-14 (NYS00133A).

The liquid waste processing system collects, holds, treats, processes, monitors, and allows for reuse or disposal of liquid radioactive wastes, and has provisions for manual sampling. FSEIS at 2-15 (NYS00133A). Liquid waste meeting NRC release standards is discharged to the Hudson River through the shared IP2 and IP3 Discharge Canal that is sampled hourly in accordance with applicable NRC regulations. *See* ER at 3-43 (Figure 3-7) (ENT00015B); IPEC ODCM Pt. I, at D 3.5.1-6, -8 (ENT000307). Administrative limits are established on liquid effluents to ensure that actual effluent activities are well below NRC limits. *See* IPEC ODCM Pt. I, at D 3.1.1-1 to D 3.1.4-1 (Radioactive Liquid Effluents) (ENT000307).

Q63. Please describe the design of the IP1 SFPs and related systems.

A63. (DMM, TCE, MJB) The IP1 SFPs are located within the IP1 Fuel Handling Building. The SFP system for IP1 consists of six interconnecting pools and a water storage pool. *See* Site Investigation Report at 102 (ENT00331B). These IP1 SFPs were constructed of reinforced concrete. Stainless steel liners were not included in the design of these early fuel pools. Instead, the IP1 SFP contained an epoxy coating.

The IP1 Fuel Handling Building and Containment Building complex contains three subsurface footing drains. These collection systems include:

- the South Curtain Drain;
- the North Curtain Drain, which, after treatment, is released to the Discharge Canal through the utility tunnel; and
- the Chemical Systems Building Drain, which discharges to the Sphere Foundation Drain Sump. *See* Site Investigation Report at 103-05, Figure 1.3 (ENT00331B, ENT00331D).

The North Curtain Drain, as is typical of the other IP1 drains, consists of a perforated pipe embedded in crushed stone placed along the outside of the IP1 foundation walls/footings. Groundwater above the drain elevation flows into the perforated pipe and is conveyed away for treatment, then discharge. Removal of this water depresses the groundwater elevation in the vicinity of the drain, thus causing additional groundwater to flow towards the "low point." As such, and as discussed later in this testimony, the drain captures groundwater containing historical leakage from the IP1 SFPs.

Q64. Please describe the design of the IP2 SFP.

A64. (DMM, TCE, MJB) The IP2 SFP consists of both the fuel pool itself and an integral Transfer Canal. *See* Lucius Pitkin Report at 12 (Figure 2-3) (ENT000326). The IP2 SFP is situated directly on bedrock that was excavated to an elevation of 51.6 feet for construction of this structure. As such, the IP2 SFP is located approximately 10 to 40 feet above groundwater. Site Investigation Report at 92 (ENT00331B).

During construction, a grid of steel "T-beams" was embedded in the interior surface of the 4- to 6-feet-thick concrete pool walls and the 3-feet thick floor slab. The IP2 SFP includes a 1/4-inch-thick stainless steel liner. Lucius Pitkin Report at 6 (ENT000326). The T-beams

provide linear weld points for the generally 6- by 20-feet stainless steel liner plates which are affectively "wall-papered" onto the T-beams embedded in the finished concrete walls and floor. Lucius Pitkin Report at 6 (ENT000326).

Given this construction method, an interstitial space exists between the back of the 1/4-inch-thick stainless steel pool liner and the concrete walls. Lucius Pitkin Report at 6, A2 (ENT000326). This interstitial space is likely irregularly shaped and, while the exact width is unknown, is estimated to be as much as 1/8 to 1/4-inch. Site Investigation Report at 92 (ENT00331B). Based on this estimate, the total volume of the space behind the liner is estimated to be as much as 1400 gallons. Lucius Pitkin Report App. A (ENT000326). The degree of interconnection between the spaces behind the liner plates is also expected to be highly variable. Therefore, the travel path for SFP water that may penetrate through a leak in the liner is likely to be highly circuitous. Site Investigation Report at 92 (ENT00331B).

Q65. Please describe the design of the IP3 SFP.

A65. (DMM, TCE, MJB) The more recently-constructed IP3 SFP includes a stainless steel liner (consistent with the IP2 design). Site Investigation Report at 92 (ENT00331B). The IP3 SFP also contains a leak detection tell-tale drain system. The purpose of the tell-tale drain system is to capture water that might leak through the stainless steel liner and channel it to a collection pipe as an indication of a liner leak. *See* Site Investigation Report at 89 (ENT00331B). The IP3 SFP tell-tale system is regularly monitored for leakage accumulation, and is also routinely inspected to verify it is in good working condition. Radioactive Sampling Schedule 3-CY-2325, Rev. 10, at 8 (June 16, 2011) ("3-CY-2325") (ENT000327).

VI. BACKGROUND INFORMATION ON INDIAN POINT SFP LEAKS

Q66. Although this hearing concerns the IP2 and IP3 license renewal application, please provide an overview of past IP1 SFP leaks.

A66. (DMM, TCE, MJB) IP1 ceased commercial operation on October 31, 1974. In 1992, the previous owner of IP1 identified an SFP leak with a net leak rate of approximately 25 gallons per day. NRC Inspection Report Nos. 05000003/200710, 05000247/2007010, at 11 (May 13, 2008) ("May 13, 2008 NRC Inspection Report") (RIV000067). The former owner attributed the cause of this leak to degradation of the epoxy coating that was applied over the fuel pool concrete. May 13, 2008 NRC Inspection Report at 11 (RIV000067).

As noted previously, the IP1 SFP did not have a stainless steel liner as do the IP2 and IP3 SFPs. The corrective actions by the former owner focused on identifying potential leakage paths within the IP1 plant structures, including groundwater collected in the external IP1 building foundation drain system. During this period, the IP1 SFP leakage collected by the North Curtain Drain was contained via internal systems and tested prior to discharge through monitored pathways. *See* May 13, 2008 NRC Inspection Report at 13 (RIV000067). The investigations performed concluded the releases through this monitored pathway were well within the ALARA 10 C.F.R. Part 50 dose guidelines. *See* May 13, 2008 NRC Inspection Report at 11-12 (RIV000067).

After the purchase of Indian Point in 2001, Entergy gained operating experience on the existing system and concluded that the identified IP1 SFP leakage could be addressed with a more effective and efficient drainage system. While the North Curtain Drain flow was already being collected and discharged through monitored pathways that complied with regulatory limits, Entergy nonetheless decided to do more to address this release. Entergy developed a plan to design, construct, and install a separate treatment system on the North Curtain Drain. This stand-

alone treatment system became fully operational by February 2004. This system was proactively implemented by Entergy, even though the release it addressed was below regulatory limits.

Entergy believed that the leak collection system was adequately capturing the leakage from the IP1 SFPs until 2006, when it was discovered that some of the leakage had bypassed the foundation drain systems and entered groundwater. Site Investigation Report at 105 (ENT00331B). By this time, Entergy already had begun the project to empty and drain the IP1 SFPs as a proactive measure to stop any active leakage.

The IP1 SFPs leakage continued until late 2008, when all the spent fuel was removed from the IP1 SFPs and the pool water was subsequently drained. *See* Email from Donald Mayer, Director, IPEC Unit 1, Entergy, to John White, Branch Chief, Radiation Protection, NRC Region 1, "Subject: Indian Point 1" (Nov. 5, 2008) ("Mayer Nov. 5, 2008 Email") (ENT000324). As such, the IP1 SFPs are no longer an active source of radionuclides to the subsurface.

The defueling process required raising the pool levels, which caused an increase in the release rate from IP1 SFPs. As expected, this increased leakage resulted in an increase in the measured levels of strontium in the groundwater plume beneath the site. *See* GZA, Final IPEC Quarterly Long-Term Groundwater Monitoring Report, Quarter One 2009 (Report No. 5) at 1-1 (June 22, 2010) ("GZA Q1 2009 Quarterly Monitoring Report") (ENT00335A). Since completion of the defueling and the removal of all of the water from the pools, strontium levels have been decreasing as the groundwater water flushes the residual strontium through the subsurface to the river. Overall total plume strontium levels have now decreased to approximately 70 percent below levels measure during defueling. A figure depicting this decrease is provided in response to Question 100.

Q67. Do the IP1 foundation drains still play a role in containing the historical leakage for the IP1 SFPs?

A67. (DMM, MJB) Yes. The IP1 foundation drains did, and currently still do, contain the majority of this historical leakage and subsequent residual contaminant migration. More specifically, even now that the IP1 SFPs have been emptied and are no longer a source of releases, the IP1 collection drains are still capturing residual contamination partitioning off of the subsurface materials into the groundwater. As such, these drains function as a valuable ongoing source control element of Monitored Natural Attenuation at Indian Point, and routine sampling and analysis of their discharge is incorporated into the Long-Term Monitoring Program.

Q68. Please provide an overview of the IP2 SFP leak discovered in 1992.

A68. (DMM, TCE, MJB) In May 1992, the former owner observed boric acid depositions on the exterior portion of the eastern IP2 SFP / Fuel Storage Building wall. Lucius Pitkin Report at 7 (ENT000326). With the help of divers, the former owner indentified a small hole in the SFP liner, approximately five feet below the pool surface in the northeast corner of the SFP. Lucius Pitkin Report at 7 (Feb. 2012) (ENT000326). Maintenance records on the IP2 SFP indicated that work was performed on the liner by the former owner in October 1990, and that the root cause of the SFP liner puncture was maintenance error. Lucius Pitkin Report at 7 (ENT000326). The SFP liner was estimated to be leaking at a rate of approximately 50 gallons per day. *See* May 13, 2008 Inspection Report Attach. 1 (IP2 SFP Timeline No. 2) (RIV000067). This leak rate and the time scale of the release event would be expected to fill the interconnected portions of the accessible interstitial space behind the liner, and once the space behind the liner was sufficiently filled, water began to leak out of the cracks in the east concrete wall. *See* Site Investigation Report at 93 (ENT00331B). Following the identification of the leak location, an

underwater epoxy patch was installed to seal the leak. A steel box was then welded over the liner perforation to permanently seal the leak in June 1992. Lucius Pitkin Report at 7 (ENT000326). Other liner work areas were also examined for similar perforations, but none were found. *See* May 13, 2008 Inspection Report Attach. 1 (IP2 SFP Timeline No. 2) (RIV000067).

Q69. Please provide an overview of the leaks associated with the IP2 SFP shrinkage cracks.

A69. (DMM, TCE, MJB) In August 2005, Entergy began excavating adjacent to the south wall of the SFP, in preparation for installation of a crane to support construction of an independent spent fuel storage installation ("ISFSI"). While removing material along the south exterior wall of the SFP, Entergy discovered hairline concrete shrinkage cracks. Although this type of cracking is not unusual for thick concrete walls such as these, some of the cracks exhibited moisture. Lucius Pitkin Report at 8 (ENT000326). Chemical analysis of the collected moisture demonstrated it was SFP water. Lucius Pitkin Report at 8 (Feb. 2012) (ENT000326). Entergy installed a temporary collection device over these cracks to collect any leaking liquid. *See* May 13, 2008 Inspection Report Attach. 1 (RIV000067); Site Investigation Report at 3 (ENT00331A). Prior to backfilling the excavation to complete the necessary ISFSI infrastructure, a permanent collection device was installed in January 2006, from which all collected water is piped to an adjacent building where it is sampled and its volume measured prior to processing. *See* May 13, 2008 Inspection Report Attach. 1 (IP2 SFP Timeline No. 13) (RIV000067). The discovery of this leakage prompted Entergy to contract with GZA to conduct an onsite investigation, develop the Conceptual Site Model, and install the network of monitoring wells discussed below.

During the course of investigating potential leakage sources from 2005 through 2007, the IP2 SFP was inspected and evaluated. In September 2007, in the course of its investigation of the source of the IP2 SFP release, Entergy drained the IP2 SFP canal used to transfer spent fuel from the reactor to the spent fuel pool to inspect its liner. At that time, Entergy identified a pinhole leak in a single weld imperfection, which, in December 2007, was repaired. *See* Site Investigation Report at 92 (ENT00331B); Lucius Pitkin Report at 9 (ENT000326). This issue is discussed further below. As of December 2007, Entergy had repaired all then-identified imperfections in the IP2 SFP. *See* Lucius Pitkin Report at 25 (ENT000326).

The IP2 Transfer Canal leak likely released tritiated pool water into the interstitial space behind the area of the liner plates when the Transfer Canal was filled above the depth of the imperfection. Although the Transfer Canal leak was repaired in December 2007, it is likely that the practice of maintaining water in the Transfer Canal during normal plant operations resulted in a generally continuous release of pool water into the interstitial space behind the liner over time, and then potentially through the concrete pool walls and into the groundwater. *See* Site Investigation Report at 94 (ENT00331B).

Q70. Please provide an overview of the status of any ongoing investigations into any other IP2 SFP leak.

A70. (DMM, TCE, MJB) As will discuss in more detail, from both qualitative and quantitative perspectives, the overall monitoring data indicate that tritium activity in the IP2 SFP plume has been generally decreasing and that the plume is undergoing long-term, overall reductions in activity since the repairs. GZA Graph, Estimated Tritium Plume Activity Over Time (ENT000332). Although there has been long-term, overall reductions in activity, an episode of uncharacteristic increased flow into the Leak Collection Device was noted at the

beginning of the third quarter of 2010. The increased flow subsequently was found to generally coincide with increased tritium levels in monitoring locations adjacent to the IP2 SFP. The elevated flow rate, which over the period from June through October averaged 1.5 liters per day ("L/d") (*i.e.*, 0.40 gallons per day), generally subsided to historical baseline levels which are less than 0.02 L/d (0.005 gallons per day). A second occurrence of increased flow rate into the Leak Collection Device occurred in March 2011, again averaging approximately 1.5 L/d (0.40 gallons per day) from March through September and then subsided to approximately 0.5 L/d (0.13 gallons per day), which is still elevated when compared to long-term historic baseline values.

As an initial finding of this ongoing investigation, the increased flow to the collection device appears attributable, at least in part, to temporarily raising the SFP water to levels which correspond to the elevation at which several underwater lighting electrical junction boxes ("light boxes") are mounted. Lucius Pitkin Report at 8 (ENT000326). These higher than normal water levels resulted in a leak path through the light boxes near the top of the SFP, thus allowing water into the space between the internal stainless steel liner and the concrete SFP walls. Lucius Pitkin Report at 21 (ENT000326). This leak path has had a temporary repair applied through sealing of the light boxes. Lucius Pitkin Report at 21 (ENT000326). Entergy plans to remove the light boxes and permanently seal the associated liner penetrations. Lucius Pitkin Report at 21 (ENT000326).

Given the ongoing flow into the Leak Collection Device at greater than historical lower baseline levels, and the continuing detection of tritium in some of the monitoring points proximate to the pool, investigations are still continuing. The most recent data for the monitoring point of most interest (in a down gradient foundation drain monitoring location) has shown a return to levels approaching historic lows. Notwithstanding the negligible dose (which

is discussed in more detail later), additional evaluations continue so as to more fully understand the continuing flow into the Leak Collection Device.

Q71. Can you further describe the evaluations performed concerning the integrity of the IP2 SFP liner?

A71. (DMM, TCE) Since the discovery of moisture on the IP2 SFP south exterior wall hairline cracks, Entergy has employed several inspection techniques, including the use of visual inspections, robotic cameras, and vacuum box testing using divers on areas of the IP2 SFP liner that presented a possibility for leakage based on general visual and robotic camera inspections. Lucius Pitkin Report at 8-9 (ENT000326).

In 2005, a remote visual inspection of the accessible areas of the IP2 SFP was performed to locate any potential source of leakage. Lucius Pitkin Report at 8 (ENT000326). This inspection covered the cask loading area (region close to observed leakage on the south wall), together with the IP2 SFP walls from approximately 2 feet above the fuel racks to the water surface. The tops of the fuel racks are approximately 15 feet above the floor of the pool. This inspection identified three areas with "brown" staining as possible leak locations. Following this remote inspection, a diver entered the pool and performed vacuum box tests on these locations. No detectable leakage was identified. Following the inspection, the diver applied a coat of epoxy material over identified weld anomalies even though leakage was not detected. Lucius Pitkin Report at 8-9 (ENT000326).

A diver also examined the SFP walls to a depth of approximately 20 feet from the surface, a limit specified to ensure the diver's safety. Any identified indications were reviewed by Entergy's metallurgist and seven indications were identified as having the greatest potential

for through-wall leakage. The locations were vacuum box tested and again no signs of leakage were identified. Lucius Pitkin Report at 9 (ENT000326).

In 2006, the walls of the SFP down to approximately the top of the fuel racks were also visually inspected remotely by ROV Technologies, Inc. using an underwater camera. This inspection did not reveal any indications that the inspection team concluded would likely result in a through-wall leak. Lucius Pitkin Report at 9 (ENT000326).

In 2007, a nondestructive examination of the SFP Transfer Canal region was performed. This inspection used a combination of vacuum box testing, ultrasonic testing, penetrant testing, and visual inspections to identify any indications of flaws or leakage. Lucius Pitkin Report at 9 (ENT000326). As discussed above, this inspection identified a small through-wall indication at a plug weld in the liner, which was subsequently repaired in 2007. Lucius Pitkin Report at 9, 21 (ENT000326). The identified through-wall indication was removed for laboratory failure analysis which determined that the leakage at the plug weld was the result of interconnected bubble porosity that extended through the thickness of the plug weld metal. Lucius Pitkin Report at 9-10 (ENT000326). The canal side end of the porosity channel was likely opened during construction by grinding flush of the plug weld. Lucius Pitkin Report at 10 (ENT000326). Thus, the apparent root cause of this leak was a welding defect that occurred during the initial installation of the pool liner. Lucius Pitkin Report at 10 (ENT000326). The examined location contained no discernible indications of corrosion, supporting the hypothesis that the leak existed from original fabrication. Lucius Pitkin Report at 10 (ENT000326). No progressive degradation mechanisms of significance were detected based on both in situ inspections and laboratory examination of the removed weld sample. Lucius Pitkin Report at 10 (ENT000326).

Q72. What percentage of the IP2 SFP liner has been inspected?

A72. (DMM, TCE) Overall, greater than 65 percent of the IP2 SFP liner, including the Transfer Canal, has been inspected. Lucius Pitkin Report at 21-22 (ENT000326).

Q73. Please discuss why Entergy did not inspect the entire IP2 SFP liner.

A73. (DMM, TCE) Inspection of 100 percent of the IP2 SFP liner is extremely impractical and would result in unnecessary radiation dose. Spent nuclear fuel is stored vertically in racks at the bottom of the SFPs. The only way to visually inspect the entire liner would be to remove essentially all or most of the fuel and the racks from the SFP, since the proximity of the fuel and racks to the wall and floor surfaces would preclude a reliable inspection. Removal of the amount of fuel necessary to execute such inspections would cause unnecessary radiation dose to workers, which would be inconsistent with regulatory ALARA guidance, particularly in light of the extraordinarily low offsite dose and insignificant environmental impacts from the prior leaks. Although theoretically there is potential for a pinhole leak in the unexamined portion of the IP2 SFP, evaluations performed to date identified no mechanism for such a leak to get worse or for a new leak to develop. *See* Lucius Pitkin Report at 21-22 (ENT000326).

Q74. Is inspection of the entire IP2 SFP liner necessary to determine if there is an ongoing leak, or to detect a potential future leak?

A74. (DMM, MJB) No. The groundwater monitoring program is sufficiently robust to detect a SFP leak of less than approximately 10 to 30 gallons per day. GZA Q2 2010 Quarterly Monitoring Report at 1-3 n.6 (ENT00334A). Although a hypothetical leak that is less than this amount might, in theory, go undetected, it would be essentially impossible to detect in offsite surface water because the release to the Hudson River would be a small percentage of the normal

authorized releases through the Discharge Canal. As discussed further in Section XIII of this testimony, releases of this small magnitude have already been evaluated and shown to have no impact on public health or the environment.

Q75. Can you further describe the evaluations performed concerning the integrity of the IP2 SFP concrete?

A75. (TCE) The IP2 SFP reinforced concrete structure has also been subjected to extensive evaluations. *See* Lucius Pitkin Report at 19-20 (ENT000326). Following the identification of SFP leakage in 1992, evaluations found that the strength of the concrete had not degraded and that no corrosion of the steel reinforcement had occurred. Lucius Pitkin Report at 19 (ENT000326). More recently, in 2005, rebar in the South Wall was intentionally exposed and inspected and little or no corrosion was observed. Lucius Pitkin Report at 19, 23-24 (ENT000326). Evaluations at that time also found that the IP2 SFP will maintain sufficient strength throughout the period of extended operation. Lucius Pitkin Report at 20 (ENT000326).

Q76. Please provide an overview of the history of any IP3 SFP leaks.

A76. (DMM, MJB) Entergy has identified no leaks from the IP3 SFP. The absence of IP3 SFP leaks to groundwater is attributed to the design upgrades incorporated in the more recently constructed IP3 SFP, including the stainless steel liner (consistent with IP2 but not included in the IP1 design) and the leak detection tell-tale drain system (not included in the IP2 design). Site Investigation Report at 100 (ENT00331B). The IP3 SFP tell-tale system is regularly monitored for leakage accumulation. 3-CY-2325 at 8 (ENT000327). It also is routinely inspected to verify that it is in good working condition. The monthly monitoring results of the tell-tale leak system have never shown leakage accumulation in the system. Nevertheless, following the discovery of IP2 SFP leakage, additional monitoring wells were put

in place to monitor the groundwater near the IP3 SFP. *See* Site Investigation Report at 7 (ENT00331A).

VII. DETAILS OF THE SITE HYDROGEOLOGIC STUDY AT INDIAN POINT

Q77. Please provide an overview of the purpose and objectives of the Indian Point hydrogeologic investigation.

A77. (MJB) As previously stated, following the discovery of the IP2 SFP hairline cracks in September 2005, Entergy contracted with GZA to conduct a comprehensive groundwater investigation of all three Indian Point reactor units and surrounding areas. *See* Site Investigation Report at 1 (ENT00331A). The overall purpose of the investigation was to identify the nature and extent of radiological groundwater contamination and, by using state-of-the-practice science and technology, assess the hydrogeologic implications and extent of radiological groundwater contamination. *See* Site Investigation Report at 1 (ENT00331A). The groundwater monitoring network established as part of this study is extensive and comprised of shallow to deep, overburden and bedrock, single and multi-level monitoring instrumentation installations, site storm drains, sumps, and building footing drains. *See* Site Investigation Report § 1.2, at 4-5 (ENT00331A).

Q78. How and when was this hydrogeologic study implemented?

A78. (MJB) GZA executed its investigation by utilizing a three-phased approach, between September 2005 and September 2007.

Q79. When did Phase I begin and what did it involve?

A79. (MJB) Phase I investigations began in September 2005 and focused on identifying groundwater flow paths from the IP2 SFP, and evaluating how radionuclides move through the environment beneath the site. *See* Site Investigation Report § 2.1 at 6 (ENT00331A). During this phase, groundwater sampling focused on tritium because it was the

primary radionuclide associated with the IP2 shrinkage crack leak. In addition, tritium does not partition to geologic media (*i.e.*, unlike other radionuclides such as strontium, tritium does not move out of the groundwater and preferentially adsorb to the surface of solid materials such as soil, bedrock, and concrete) and thus moves faster in the subsurface than other radionuclides. *See* Site Investigation Report at 11 (ENT00331A). Therefore, tritium would show the maximum extent of the plume.

A major aspect of Phase I was development of the initial Conceptual Site Model to characterize the groundwater flow and radionuclide transport at Indian Point. Among other things, activities during Phase I included borehole drilling and testing to locate potential fractures in the bedrock that could conduct groundwater flow. The new boreholes were primarily focused on the IP2 area. Extensive sampling and analysis of groundwater from a large number of newly installed and existing monitoring wells was also conducted across the entire site. *See* Investigation Report § 2.1, at 6-7, 17 (ENT00331A).

Q80. When did Phase II of the investigation begin and what was its purpose?

A80. (MJB) Phase II of the investigation commenced in January 2006. *See* Site Investigation Report § 2.2 at 7 (ENT00331A). The focus of Phase II work was to confirm the initial Phase I findings, better estimate the concentration of radionuclides in groundwater at Indian Point, and augment the network of wells across the site to allow identification of potential releases into groundwater on a long-term basis from all three units. *See* Site Investigation Report § 2.1 at 6 (ENT00331A). In support of these objectives, GZA drilled 23 additional boreholes to locate further fractures in the bedrock that could potentially conduct groundwater flow. *See* Site Investigation Report § 2.1 at 6 (ENT00331A). As with the prior phase, Phase II involved groundwater testing; while initially focused on tritium in 2006, the testing was expanded to

encompass strontium and other radionuclides typically associated with nuclear power generation. *See* Site Investigation Report § 2.2, at 7-8 (ENT00331A).

Q81. When did Phase III begin and what was its purpose?

A81. (MJB) In June 2006, the Phase III investigations began. Site Investigation Report § 2.3 at 8 (ENT00331A). Phase III of the investigation focused on further defining the extent of strontium detected during Phase II and augmenting the characterization of bedrock aquifer properties to allow evaluation of potential remedial options. Site Investigation Report § 2.3 at 8 (ENT00331A). Phase III involved the installation of 14 additional wells to further define the horizontal and vertical extent of contamination. Site Investigation Report § 2.3 at 8 (ENT00331A). During Phase III, GZA conducted various pumping and tracer tests to better assess the hydraulic properties of the bedrock and to augment our understanding of contaminant migration and transport mechanisms. *See* Site Investigation Report, § 2.3, at 8 (ENT00331A).

Q82. What are the key components of the Conceptual Site Model?

A82. (MJB, DMM) In 2005, GZA developed the initial Conceptual Site Model for Indian Point in order to guide investigations, assess the reasonableness of the findings, and define the parameters controlling contaminant transport. Site Investigation Report § 3.0 at 9 (ENT00331A). This model was then iteratively enhanced and refined continually throughout the investigation process as new data became available. *See* Site Investigation Report at 5 (ENT00331A). The Conceptual Site Model comprises five primary components: (1) the overall hydrogeologic setting, (2) groundwater flow patterns, (3) identified contaminant sources, (4) contaminants of potential concern, and (5) identified receptors. Site Investigation Report § 3.0, at 9 (ENT00331A). The Conceptual Site Model also accounts for Indian Point construction

practices that may influence contaminant migration (*e.g.*, extent of blasting, installation of foundation backfill and foundation drains).

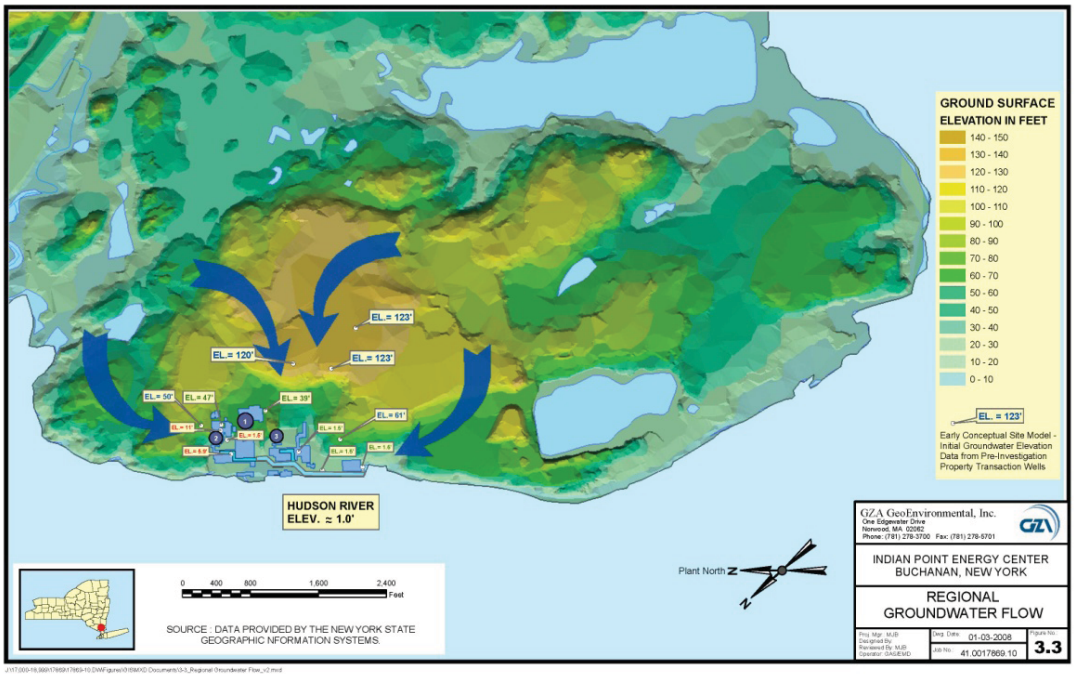
Q83. Please describe the hydrogeologic setting component of the Conceptual Site Model.

A83. (MJB) The Indian Point watershed area is relatively limited—the distance from the Hudson River to the upgradient no-flow boundary (*i.e.*, the location where groundwater on one side flows in the opposite direction from that on the other side, much like a marble on a hill rolls downhill in opposite directions on either side of the high point) located at the top of the watershed is only approximately 2,200 feet. *See* Site Investigation Report §§ 3.0-3.1, at 9-10; Fig. 3.1 (ENT00331A; ENT00331D). Based on the limited watershed area, the volume of precipitation available for aquifer recharge is limited. Recharge is further limited by the density of site structures and amount of paving, which induces direct run-off to surface water. Based on the 2004 U.S. Geological Survey ("USGS") infiltration study for Westchester County and nearby areas, as well as site-specific evaluations, approximately 25 percent of the precipitation falling on pervious surfaces over the Indian Point site watershed area results in infiltration recharge to the groundwater (typically approximately 10 inches of infiltration per year). *See generally* USGS, Water Use, Ground-Water Recharge and Availability, and Quality of Water in the Greenwich Area, Fairfield County, Connecticut and Westchester County, New York, 2000-2002 (2004) (ENT000328); *see also* Site Investigation Report at 10, 47-48 (ENT00331A).

Q84. Please describe the groundwater flow pattern component of the Conceptual Site Model.

A84. (MJB) Based upon the regional topography, site topography, anthropogenic influences, and the geostructural setting, even at the initial stages of the investigations, GZA

expected, and later confirmed, that groundwater would flow into the lower elevations at which Indian Point was constructed from the higher elevations to the north, east, and south, and then discharge to the Hudson River, with portions of the flow being intercepted by the Discharge Canal. Site Investigation Report at 10-11; Fig. 3.3 (ENT00331A; ENT00331D). This is illustrated in the following ground surface elevation map from the Site Investigation Report, with arrows delineating the inward flow of groundwater towards the site:



Q85. Please describe the contaminant sources identified as part of the Conceptual Site Model.

A85. (MJB) To identify potential groundwater contaminant sources, GZA, in conjunction with Entergy personnel, conducted a review of construction drawings, aerial photographs, prior reports, and documented releases, and interviewed Entergy personnel relevant to current operations and site history. Site Investigation Report at 11 (ENT00331A). That review, in conjunction with the observed distribution of contaminants and groundwater flow

directions, identified IP2 SFP and IP1 SFPs as the primary potential sources of the radiological groundwater contamination. Site Investigation Report at 11 (ENT00331A).

No releases were identified from IP3. As noted previously in response to Question 76, the absence of IP3 sources is attributed to the design upgrades incorporated in the more recently constructed IP3 SFP. Site Investigation Report at 11 (ENT00331A). However, some residual contamination does exist in the IP3 area. This contamination is primarily associated with IP1 legacy piping (*i.e.*, piping used by prior plant owners that is now sealed and not used by Entergy) that conveyed water from the IP1 Sphere Foundation Drain Sump to the storm water system in the IP3 area. Site Investigation Report at 70, 135 (ENT00331B). The locations of the IP1 and IP2 structures of interest, as well as the IP1 legacy piping in the IP3 area, are shown on Figure 3.4 of the Site Investigation Report and discussed in further detail in Section 8 of that Report.

Q86. Please describe the contaminants of potential concern that are part of the Conceptual Site Model.

A86. (MJB) The initial site investigation identified tritium and strontium as the principal radiological constituents characteristic of the groundwater contamination at Indian Point. Site Investigation Report at 11 (ENT00331A). Both radionuclides served as the most representative contaminant tracer tools from the perspective of source term, frequency of observed occurrence, as well as contaminant transport across the Indian Point site. Other radionuclides (primarily Cs-137, Ni-63, and Co-60) were more sporadically identified and isolated to specific locations within the site. Site Investigation Report at 11 (ENT00331A). These radionuclides are encompassed by the IP2 (tritium) and IP1 (strontium) plumes. All detected radionuclides have been accounted for by Entergy in their dose assessment analyses (discussed previously in response to Question 51).

Q87. Do tritium and strontium fully characterize the groundwater plume?

A87. (MJB) Yes. Both tritium and strontium allow for a full characterization of the radiological groundwater plume and extent of groundwater contamination due to their divergent nature in the subsurface. Tritium, which is conserved in groundwater, moves at the same speed as water, and thus serves as a predictable indicator of recent releases. Site Investigation Report at 11 (ENT00331A). Conversely, strontium, while capable of migration, has strong partitioning characteristics relative to tritium (*i.e.*, strontium adsorbs to solid materials such as subsurface soil and bedrock), has a longer half-life, and thus is generally an indicator of older, historic releases. Site Investigation Report at 11 (ENT00331A).

Q88. Please describe the receptors identified as part of the Conceptual Site Model.

A88. (MJB) Following NRC regulations and guidance for calculating the radiation dose to the public, the Site Investigation Report summarized the procedures for identifying receptors potentially exposed to radioactive releases, either directly or indirectly. *See* Site Investigation Report at 12-14 (ENT00331A). As discussed in more detail later, in Question 89, drinking water is not a viable pathway for Indian Point releases. Based on the methodology set forth in Regulatory Guide 1.109, the only potentially significant dose pathway for liquid releases is consumption of aquatic foods; *i.e.*, Hudson River fish and invertebrates. *See* IPEC-CHM-12-005, IPEC ODCM Liquid Effluent Pathway Bases (Feb. 12, 2012) ("CHM-12-005") (ENT000329); Consolidated Edison, An Evaluation to Demonstrate the Compliance of the Indian Point Reactors with the Design Objectives of 10 CFR Part 50, App. I, Vol. 1 – Main Report at 39-40, 74 (Feb. 1977) (ENT000330). The specific methodology used to calculate doses by a receptor from liquid radioactive effluents is based on NRC guidance and is contained in the Indian Point ODCM. *See* IPEC ODCM Pt. II, at 13 (ENT000307). The volume of

groundwater traversing the site and discharging into the Hudson River, as estimated by GZA using the data as presented in its groundwater reports, is used in conjunction with measured concentrations of radionuclides in groundwater to calculate the total amount of radionuclides released to the Hudson River, and subsequently, their dose impact to receptors.

Q89. Please explain why the drinking water pathway was not considered an exposure pathway associated with the releases into groundwater.

A89. (MJB) As discussed previously in Question 61, groundwater at Indian Point is not used for drinking water. Early in the investigative process, New York State Department of Health ("NYSDOH") assessed whether any drinking water supply wells were present in the vicinity of the site. As explained in the FSEIS, there are no active potable water wells or other production wells in the vicinity of Indian Point. FSEIS at 2-111 (NYS00133A); *see also* NYSDEC 2007 Community Fact Sheet at 1 (ENT000325).

GZA also had Environmental Data Resources, Inc. ("EDR"), an environmental information firm, conduct a search for public water supply wells within 1 mile of the site. EDR determined, based on records maintained by the EPA, that there were no water supply wells located within 1 mile of the site. Site Investigation Report at 14 n.13 (ENT00331A). Drinking water in the area (Town of Buchanan and City of Peekskill) is supplied by the communities and is sourced from surface water reservoirs located in Westchester County and the Catskills region of New York. Site Investigation Report at 14 (ENT00331A). The nearest of these reservoirs, the Camp Field Reservoir, is located 3.3 miles north-northeast of Indian Point and its surface water elevation is over 300 feet above Indian Point, in a cross-gradient direction, several watersheds away. Site Investigation Report at 14 (ENT00331A). In addition, groundwater flow directions on the site are to the west, towards the Hudson River. Site Investigation Report at 14

(ENT00331A). Therefore, it is not possible for the contaminated groundwater at Indian Point to ever impact these drinking water sources.

Q90. Is it likely for contaminated groundwater at Indian Point to impact existing drinking water sources?

A90. (MJB, DMM, CJP, FOH) No. As discussed above, onsite groundwater at Indian Point is not used for any purpose other than monitoring. Nor is it reasonable to expect that groundwater onsite will be used for drinking water in the future, particularly since Indian Point is a bedrock site of low hydraulic conductivity situated immediately proximate to a body of brackish surface water. We later address a hypothetical future surface water drinking pathway associated with a desalination plant that might be built by United Water New York, Inc. on the Hudson River in Haverstraw, New York.

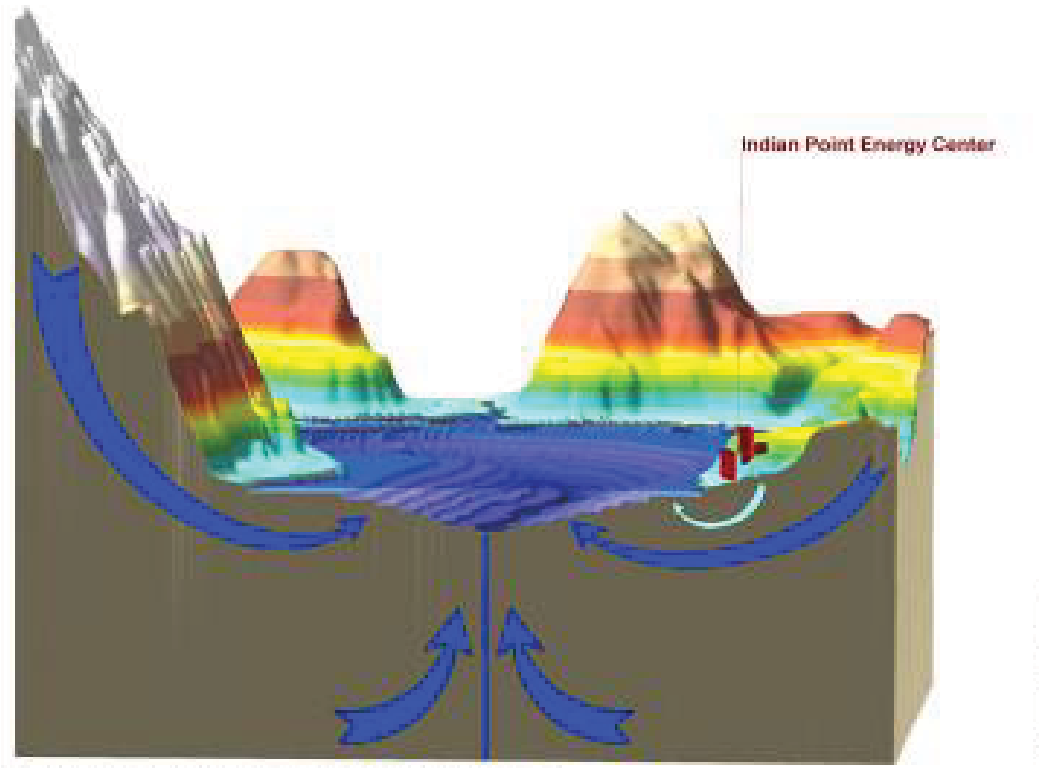
Q91. Please describe how releases through the groundwater flow path are accounted for in Indian Point dose calculations.

A91. (MJB, CJP, FOH) In accordance with NRC regulations, inadvertent releases into groundwater are accounted for in accordance with Entergy's Indian Point ODCM. *See* IPEC ODCM Pt. II at 9, § 2.1.16; *id.* App. J (Groundwater Flow and Offsite Dose Calculation Details) (ENT000307). Specifically, details about the groundwater flow and offsite dose calculation models are described in Appendix J to the ODCM. *See* Indian Point Energy Center, Units 1, 2, and 3, Offsite Dose Calculation Manual, Rev. 3, App. J. The precipitation mass balance method in the ODCM used to calculate radionuclide release into the Hudson River through the groundwater pathway considers five site-specific parameters: (1) overall direction of groundwater flow; (2) facility-specific groundwater flow paths; (3) rate of groundwater flow; (4)

groundwater radionuclide activities; and (5) radionuclide release rate to the river. IPEC ODCM, Part II, App. J at 130-131 (ENT000307).

Q92. Was consideration given to whether contaminated groundwater might flow from the Indian Point site, underneath the Hudson River, and then impact groundwater on the west side of the Hudson River?

A92. (MJB) Yes. This issue was specifically considered in the initial site investigations. As explained in the Site Investigation Report, the Hudson River is the regional sink in the area. Site Investigation Report at 48 (ENT00331A). As such, groundwater from the upland areas on both sides of the Hudson River flows towards and discharges into the Hudson River. Site Investigation Report at 11 (ENT00331A). In other words, groundwater from Indian Point does *not* flow under the Hudson River to the other side (*e.g.*, to Rockland County) under ambient conditions. Site Investigation Report at 11 (ENT00331A). This is shown in the following figure from the Site Investigation Report (Site Investigation Report Fig. 6.1 (ENT00331E)):



Furthermore, because of the hydraulic properties of the bedrock, as well as the large size of the Hudson River in this area, there is no reason to believe that any potential future changes to ambient conditions (*e.g.*, offsite pumping) would induce such flows. Site Investigation Report at 48; *see also* Fig. 6.1 (ENT00331E).

VIII. LONG-TERM GROUNDWATER MONITORING PROGRAM

Q93. Since completion of the Site Investigation Report, has Entergy continued to monitor groundwater at Indian Point?

A93. (MJB) Yes. Entergy has established a Long-Term Groundwater Monitoring Program to monitor the existing plumes and to monitor for potential future releases to the subsurface. GZA, GeoEnvironmental, Inc. Final IPEC Quarterly Long-Term Groundwater Monitoring Report, Quarter Two 2010 at 3-3 ("GZA Q2 2010 Quarterly Monitoring Report") (ENT00334A). The program has four objectives:

- Monitor groundwater flow rate and radionuclide concentrations to characterize current and potential future releases of radionuclides from groundwater into the Hudson River to provide data for dose computations;
- Monitor groundwater close to Indian Point SSCs to detect potential future releases of radionuclides from these SSCs into groundwater at Indian Point;
- Monitor groundwater along the Indian Point site property boundary to confirm that groundwater containing radionuclides is not migrating from the site to locations other than the river; and
- Monitor groundwater plumes identified onsite to asses total activity over time. GZA Q2 2010 Quarterly Monitoring Report at 3-1 (ENT00334A).

In addition to monitoring groundwater plumes, the Long-Term Groundwater Monitoring Program is designed to detect potential leaks from SSCs that may result in releases of radionuclides into the groundwater at Indian Point. GZA Q2 2010 Quarterly Monitoring Report at 3-3 (ENT00334A). To monitor SSCs, a broad network of on-site monitoring installations are used, as well as foundation drains and numerous storm drains and sumps throughout the site, as

described above in response to Questions 79-81. For these monitoring locations, Entergy has established investigation levels that define quantitative radionuclide concentrations above which further action would be undertaken. GZA Q2 2010 Quarterly Monitoring Report at 3-4 (ENT00334A).

Those investigation levels are such that appropriate actions would be taken well before any NRC effluent limits would be approached. The Long-Term Groundwater Monitoring Program positions Entergy to timely investigate these occurrences should they have an impact on groundwater beneath the site.

Q94. Please describe briefly what has been done to develop and execute the Long-Term Groundwater Monitoring Program.

A94. (MJB) Under the Long-Term Groundwater Monitoring Program, GZA conducts quarterly groundwater monitoring and sampling activities. *See, e.g.*, Quarterly Monitoring Reports, (*e.g.*, GZA Q2 2010 Quarterly Monitoring Report (ENT00334A-E)). The overall foundation for the development and execution of this Long-Term Groundwater Monitoring Program is the Conceptual Site Model, as described in the Site Investigation Report. Generally, the scope of Long-Term Groundwater Monitoring Program work involves the following areas:

First, GZA installed dedicated sampling equipment in the monitoring installations designated for sampling as part of this program. *See* GZA Q2 2010 Quarterly Monitoring Report at 2-2 (ENT00334A). The use of dedicated sampling equipment limits the possibility of cross-contamination between monitoring installations or individual multi-level samples within a single installation. *See* GZA Q2 2010 Quarterly Monitoring Report at 2-2 (ENT00334A).

Second, GZA maintains transducers and data loggers, as part of the monitoring instrumentation located across the site, which record groundwater elevation and temperature

measurements at regular time intervals. These data are then downloaded on a quarterly basis. *See* GZA Q2 2010 Quarterly Monitoring Report at 2-1 (ENT00334A).

Third, GZA collects water levels and groundwater samples for radionuclide analysis during scheduled sampling intervals within select monitoring installations. *See* GZA Q2 2010 Quarterly Monitoring Report at 2-1 (ENT00334A). If unexpected quarterly results are encountered, then mid-quarter and confirmatory samples may also be collected. *See, e.g.*, GZA Q2 2010 Quarterly Monitoring Report at 2-3, 3-5 (ENT00334A). Sampling frequency is also increased close to the time of scheduled operations that may carry increased risk of a spill. *See, e.g.*, GZA Q2 2010 Quarterly Monitoring Report at 3-5 n.30 (ENT00334A). When requested, split groundwater samples from select locations are provided to NRC Staff and NYSDEC.

Fourth, GZA collects water samples from drain lines in several manholes onsite to characterize discharge from foundation drains around and below IP2 and IP3 structures. These drains are part of the early leak detection monitoring network. *See, e.g.*, GZA Q2 2010 Quarterly Monitoring Report at 2-2 (ENT00334A).

Fifth, the groundwater samples are provided to Entergy for laboratory analysis of radionuclide constituents.

Sixth, GZA, in collaboration with Entergy, evaluates the laboratory data relative to the four objectives previously discussed: dose computations, SSC leak detection, off-site migration, and plume attenuation. *See, e.g.*, GZA Q2 2010 Quarterly Monitoring Report, Fig. 4 (ENT00334A). *See also* IP-SMM-CY-110, Rev. 5, Radiological Ground Water Monitoring Program (Mar. 9, 2011) (ENT000336).

Q95. Please describe the current groundwater monitoring network in place at Indian Point.

A95. (MJB) Presently, the monitoring network installed by GZA contains over 150 depth-specific sampling locations at 65 monitoring installations, which allows Entergy to sample groundwater at various depths from the groundwater surface to over 300 feet below the top of bedrock. A depiction of the current array of groundwater monitoring installations is contained in Figure 4 of the 2nd Quarter 2010 GZA Report (ENT00334A). In the fall of 2011, a new multi-level monitoring well was installed at IP3. This well will be included in the monitoring program starting in the first quarter of 2012. *See* 2010 Q2 Quarterly Monitoring Report at 3-4 (ENT00334A). Over 40 percent of these monitoring installations were specifically installed as sentinel wells, which were located as close as possible to certain targeted SSCs. Due to their proximity and specific-SSC-targeted nature, these wells are then able to narrow the location of a potential spill or leak, and thus focus subsequent investigations into the specific plant systems in that impacted area.

In addition to these installations, included in the overall groundwater monitoring program are approximately 75 storm drains and 25 sumps throughout the Indian Point site, from which samples are also periodically taken and analyzed by the Indian Point Chemistry Department. *See generally* 2-CY-2625, Rev. 16, General Plant Systems Specifications and Frequencies at 8 (Mar. 17, 2012) (ENT000337); 3-CY-2325 at 10 (ENT000328). This broad network of monitoring locations allows Entergy to characterize the extent and concentration of radionuclides present in the groundwater from past releases, and to detect potential future releases of radionuclides to the groundwater at the site.

IX. RESULTS OF HYDROGEOLOGIC INVESTIGATIONS AND LONG-TERM GROUNDWATER MONITORING PROGRAM

Q96. As a result of your site hydrogeology work, have you determined how water moves beneath the site?

A96. (MJB) Yes. As described previously in response to Question 84, the Conceptual Site Model demonstrates that groundwater flows into the Indian Point power block area from the north, east and south, and then flows into the Hudson River to the west. Thus, groundwater, and any radionuclides contained in the groundwater, do not flow off the site from the power block area, except into the Hudson River.

Q97. As a result of your site hydrogeology work, have you identified the presence of IP2 SFP-related radionuclides in the groundwater beneath the site?

A97. (MJB) Yes. As a result of our groundwater monitoring program, we have identified two distinct "plumes" of groundwater containing radionuclides, one containing principally tritium, and one containing principally strontium. Site Investigation Report at 89 (ENT00331B). As a result of site hydrogeology work, and further investigation by Entergy, we have concluded that the "tritium plume" is primarily a result of releases of water from the IP2 SFP, described previously in response to Question 86. The bounding IP2 plume is illustrated in Figure 8.1 of the Site Investigation Report (ENT00331G). This figure helps illustrate the tritium contamination, which tracks with down-gradient groundwater flow through the IP2 Transformer Yard, under and into the Discharge Canal, before the groundwater reaches and enters the Hudson River between the IP2 and IP1 intake structures.

When visualizing this plume depiction, it is important to recognize that it represents maximum activities through August 2007, during the period before Entergy repaired identified leaks. In addition, the plume shown in Figure 8.1 is a bounding, worst case depiction of

groundwater tritium activities. The isopleths presented contour the highest, upper bound concentrations for samples taken at *any time* from the beginning of the investigation through August 2007, and *any depth* at a particular location. Further, the groundwater containing radionuclides is actually confined to very thin fractures in a massive, solid marble bedrock formation.

As such, the volume of the groundwater is substantially less than 1 percent of the crystalline bedrock encompassed by the plume outline. Therefore, this "plume" is an overstatement of the tritium levels existing at any time over the depth of the plume. Further, the concentration of tritium in the groundwater beneath the site, and therefore the overall tritium plume, has been generally decreasing since this time. *See* Site Investigation Report at 101 n.86 (ENT00331B). A depiction of the change in the tritium plume activity over the span of Entergy's groundwater monitoring program is contained in Figure G-17 of the Q2 2010 Quarterly Report (ENT00334E), which shows a decrease in total tritium of 89 percent since the shrinkage crack leaks were contained in late 2005.

Q98. As a result of your site hydrogeology work, have you identified the presence of IP1 SFP-related radionuclides in the groundwater beneath the site?

A98. (MJB) Yes. Based on our site hydrogeology work and further investigation by Entergy, we have concluded that the "strontium plume" is primarily a result of a past release of water from IP1 SFPs, described previously in response to Question 34. While the plume from the IP1 SFPs consists primarily of strontium, groundwater testing has also identified tritium and sporadic observations of cesium-137, nickel-63, and cobalt-60 within that plume. *See* Site Investigation Report at 89 n.61 (ENT00331B). As noted previously, the IP1 SFPs no longer

contain spent fuel and have since been drained and, therefore, are no longer a source of radionuclide releases to the environment.

Q99. Is the extent and level of groundwater contamination from the release of water from the SFPs decreasing?

A99. (MJB) Yes. It is our conclusion that the tritium and strontium plumes had already reached their maximum extents and total activities prior to termination of the historic releases from the IP1 and IP2 SFPs. The total activities of these two plumes have subsequently been decreasing since source termination, with periodic, localized fluctuations in activity and overall reductions in the rate of decrease with time, as would be expected. As discussed below, our continued quarterly monitoring program has confirmed these results.

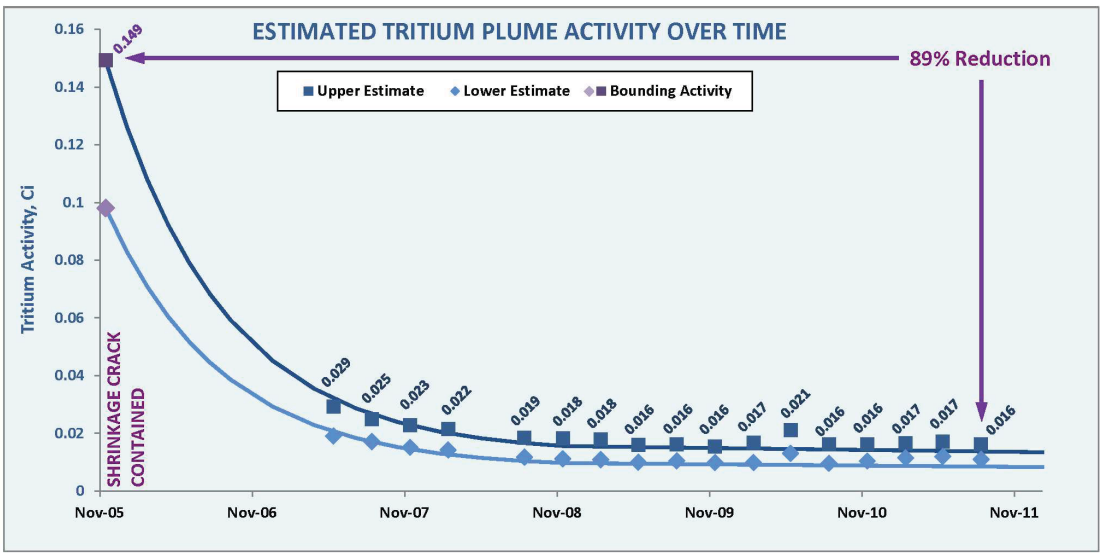
Q100. Can you explain these periodic, localized fluctuations in activity at individual monitoring locations?

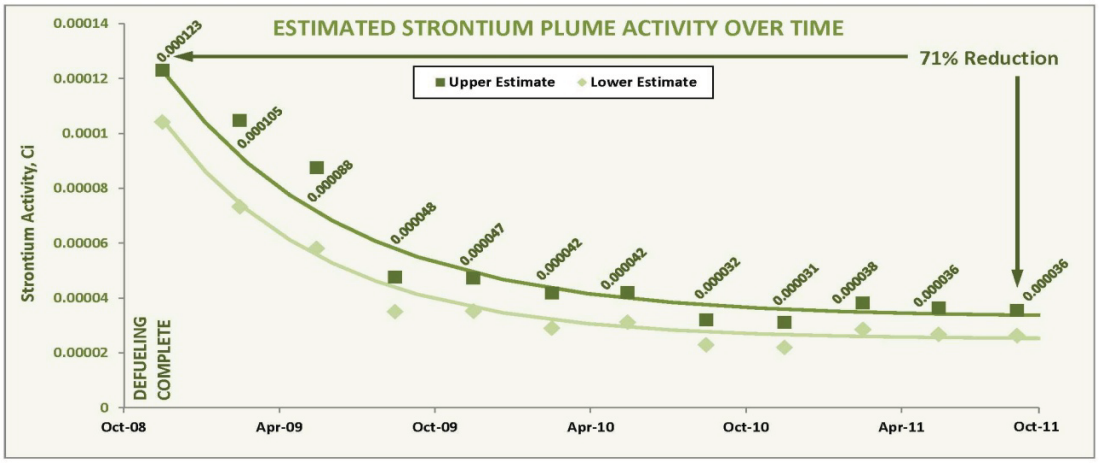
A100. (MJB) Yes. Separate from transients associated with a few isolated spills detected by the monitoring program, the variability in these long-term decreasing plume trends must also be viewed in light of contaminant fluctuations over time due to subsurface mechanisms in the unsaturated and saturated zones under and around the IP1 and IP2 SFPs that can retain substantial volumes of pool water for substantial amounts of time. *See* Site Investigation Report at 97-101 (ENT00331B). The existence of such "retention mechanisms" is supported by the results of the tracer test and the evaluation of contaminant concentration variability trends over short timeframes associated with precipitation. *See* GZA Q1 2009 Quarterly Monitoring Report at 3-19 to 3-21 (ENT000335A); Site Investigation Report at 97-101 (ENT00331B).

These indirect storage sources are related to natural hydrogeologic and anthropogenic mechanisms in the unsaturated and saturated zones such as dead-end bedrock fractures and

subsurface foundation construction details. *See* Site Investigation Report at 98-101 (ENT00331B). Thus, sporadic fluctuations in contaminant concentrations are expected as a result of these retention mechanisms. These retention mechanisms apply to both the IP2 tritium plume and the IP1 strontium plume; however, it is expected that the response of strontium activities will be somewhat more protracted as compared to tritium response due to strontium partitioning to the geologic and anthropogenic media. *See* 2009 Q1 Quarterly Monitoring Report at 3-15 (ENT00335A).

While individual monitoring wells may temporarily show increasing activity trends at specific times, both overall plumes exhibit long-term decreasing trends after source termination. *See* Q2 2010 Quarterly Report at 3-13 (ENT00334A). This behavior is best understood by examining the total radionuclide content of each plume over time, rather than focusing on individual well behavior. *See* GZA Q1 2009 Quarterly Monitoring Report at 3-21 to 3-22 (ENT00335A). As shown below, this analysis demonstrates that the total amount of tritium and strontium in the IP2 and IP1 plumes, respectively, have decreased substantially since the identified leaks were terminated.





Source: GZA, Changes in Computed Tritium Plume Total Activity Over Time - Exponential Decay Curve Trending of Quarterly Data through Q3 2011 (ENT000332); 1GZA, Changes in Computed Strontium Plume Total Activity Over Time - Exponential Decay Curve Trending of Quarterly Data through Q3 2011 (ENT000333).

Q101. Do you believe that Entergy's monitoring system provides reasonable assurance that future releases of radionuclides into groundwater will be detected?

A101. (MJB, CJP, FOH) Yes. A primary purpose of the groundwater monitoring program is to do exactly that. It is our conclusion that the groundwater monitoring program, including the system of groundwater monitoring installations dispersed throughout the site, will readily detect future releases of radionuclides to the groundwater of a magnitude comparable to the SFP leaks described above. Entergy will therefore be able to take timely and appropriate corrective actions upon the detection of any such future releases.

Q102. Has the monitoring program allowed you to identify any potential additional SFP releases into groundwater?

A102. (MJB) Yes. In addition to the broad array of groundwater monitoring installations discussed above, the Leak Collection Device installed on the IP2 SFP wall also provides valuable monitoring data. Since the installation of the Leak Collection Device, the leak rate has historically been variable, characterized by a baseline of typically prolonged rates of less than 0.20 liters per day (L/d), but with intermittent relatively shorter periods of leak rates greater

than 0.20 L/d. *See* GZA 2009 Q1 Quarterly Monitoring Report at 3-25 (ENT00335A). However, beginning in the third quarter of 2010, an uncharacteristic increase in the rate of water flowing into the Leak Collection Device was observed (*i.e.*, rates generally greater than 1.5 L/d, all of which is contained, processed, and discharged through a monitored pathway), which subsequently was found to somewhat coincide with increased tritium levels in monitoring locations adjacent to the IP2 SFP.

As discussed previously in response to Question 70, investigations are still ongoing, but the increased flow to the Leak Collection Device appears attributable, at least in part, to a leak path through light boxes near the top of the SFP. Given the ongoing flow into the Leak Collection Device and the detection of elevated tritium in some of the monitoring points proximate to the pool, investigations are ongoing.

It is important to emphasize that there is no indication that this leakage has resulted in any material increase in the tritium plume. In fact, all the leakage collected in the Leak Collection Device is contained, processed, and discharged through a monitored pathway, and the increases in tritium noted in the IP2 Vapor Containment Curtain Drain monitoring point are also being captured by this drain and transported to the Discharge Canal as a monitored release, with negligible impact to human health or the environment. *See* Site Investigation Report at 3 (ENT00331A). Further, while the increased concentrations of tritium in the drain have, in part, resulted in a calculated increase in the offsite 2011 dose, as compared to 2010, Entergy's regularly performed analysis demonstrates that the dose remains negligible. Notwithstanding the negligible dose, additional evaluations continue, so as to more fully understand increases in flow to the Leak Collection Device.

Based, in part, on the above, it is my professional opinion that Entergy's ability to identify, characterize, and respond appropriately to sporadic releases demonstrates the efficacy of the Long-Term Groundwater Monitoring Program.

Q103. Has Entergy selected a remediation action for Indian Point groundwater contamination?

A103. (MJB) Yes. Based, in part, on GZA's recommendation, Entergy selected Monitored Natural Attenuation as the remedial strategy for Indian Point. *See* Site Investigation Report at x (ENT00331A).

Q104. What is Monitored Natural Attenuation?

A104. (MJB) Monitored Natural Attenuation is a recognized and proven remedial approach that allows natural processes to reduce contaminant concentrations.

Q105. Is Monitored Natural Attenuation a valid remedial approach?

A105. (MJB) Yes. EPA has long recognized Monitored Natural Attenuation as an appropriate remedial approach whereby residual contamination results in no significant risk to the public or the environment. Specifically, EPA's guidance on the use of Monitored Natural Attenuation states that Monitored Natural Attenuation involves the reliance on natural attenuation processes (*e.g.*, dispersion, dilution, sorption, radioactive decay) "that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater." EPA, Monitored Natural Attenuation, OSWER Directive 9200.4-17P at 3 (Apr. 1999) ("OSWER Directive 9200.4-17P") (ENT000340). This EPA guidance also states that EPA does not consider Monitored Natural Attenuation to be a "presumptive" or "default" remedy, or a "no action" or "walk-away" approach, but rather "an alternative means of achieving remediation objectives that may be

appropriate for . . . [specific, well-documented] site circumstances." OSWER Directive 9200.4-17P at 1-2 (ENT000340).

Q106. Do you continue to believe that Monitored Natural Attenuations is the correct remediation action for Indian Point's groundwater contamination?

A106. (MJB) Yes. Because of the favorable site conditions and extensive investigations conducted, Monitored Natural Attenuation, along with other ongoing active measures, is the appropriate remediation action for Indian Point. Specifically:

- Interdiction measures to date have eliminated or controlled the identified active sources of groundwater contamination.
- Groundwater flow at Indian Point precludes offsite migration of contaminated groundwater to the north, south or east.
- Consistent with the Conceptual Site Model, and as discussed later in Question 119, no Indian Point contaminants have been detected above regional background levels in any of the offsite monitoring locations or drinking water supply systems in the area.
- The only on-site exposure route for the documented contamination is through direct exposure. Because the majority of the site is capped by impermeable surfaces, there is no uncontrolled direct contact with contaminants. *See* Site Investigation Report at 135-136 (ENT00331B)
- Our studies indicate that under existing conditions, the spatial extent of the groundwater plume should continue to decrease with time. *See* Site Investigation Report at 136 (ENT00331B). Overall, since the original recommendation for Monitored Natural Attenuation was made, there has been a substantial decrease in the plume. *See* Site Investigation Report at 134-135 (ENT00331B).

- Groundwater is not used as a source of drinking water on the site or in the immediate vicinity of the site, and there is no reason to believe that this practice will change in the foreseeable future. *See* Site Investigation Report at 136 (ENT00331B).

At the locations where contaminated groundwater discharges into the Hudson River, the concentrations have been, and will continue to be, reduced by sorption, hydrodynamic dispersion, dilution, and radioactive decay. *See* Site Investigation Report at 136 (ENT00331B). As discussed later by Dr. Paperiello and Dr. Hoffman in Section XIII of this testimony, the potential dose to the public and aquatic organisms resulting from the unplanned releases is extremely small, providing further support for the selection of Monitored Natural Attenuation as the appropriate remedial action for the Indian Point site.

Q107. Is Entergy relying on Monitored Natural Attenuation as the exclusive remediation action for Indian Point's groundwater contamination?

A107. (DMM, MJB) No. While Monitored Natural Attenuation is the primary remedial action, groundwater extraction through a number of foundation drains also has been, and continues to be, implemented at the site. *See* Site Investigation Report at 73-74 (ENT00331B). In this regard, Indian Point uses several separate foundation drain systems including:

- The IP2 Vapor Containment Building Foundation Drain;
- The IP1 North Curtain Drain, South Curtain Drain, and Chemical Systems Building Drain; and
- The IP3 Vapor Containment Building North Foundation Drain, and South Foundation Drain.

These drains capture radionuclides in groundwater and remove them from the subsurface for subsequent discharge through monitored pathways. The IP1 drains are particularly effective at

further reducing already-low groundwater dose. More specifically, these IP1 drains capture strontium-containing groundwater in the immediate vicinity of the IP1 SFPs and, after treatment of the North Curtain Drain water, release it through monitored pathways. *See* IPEC ODCM Pt. I, at 3.1.1-2 and Pt. II at 109 (ENT000307). These drains capture the majority of the residual strontium which would otherwise migrate to the river through the groundwater pathway.

X. INDEPENDENT ASSESSMENTS OF SFP LEAKS AT INDIAN POINT

Q108. Were any independent regulatory authorities involved with Entergy's assessments of the impacts of the SFP leaks?

A108. (DMM, MJB) Yes. Throughout the two-year hydrogeologic site investigation study Entergy provided full and open access to independent regulatory authorities, including holding regular meetings attended by the NRC Staff, USGS, and NYSDEC. Also, early in the investigation process, at the request of NYSDEC, the New York State Department of Health ("NYSDOH") evaluated whether drinking water supply wells were present in the vicinity of Indian Point.

Q109. Please provide a brief background of NRC Staff inspection activities at Indian Point since the September 2005 discovery of hairline cracks in the IP2 SFP wall.

A109. (DMM, MJB, CJP) After Entergy informed the NRC of the hairline cracks identified in the IP2 SFP wall in 2005, which led to the discovery of low levels of tritium contamination in the groundwater, NRC Staff initiated a special inspection on September 20, 2005. See May 13, 2008 NRC Inspection Report at iv (ENT00331A). Although Entergy did not exceed any specific thresholds in the NRC Reactor Oversight Process Action Matrix mandating additional regulatory oversight, the Staff nonetheless increased its oversight of the IP2 SFP. *See* Memorandum from James Dyer, NRC Region I Administrator, to Luis Reyes, NRC Executive Director of Operations, "Request for Deviation from the Reactor Oversight Process Action

Matrix to Provide Increased NRC Oversight of Specific Issues at Indian Point Energy Center" at 1 (Oct. 28, 2005) (ENT000346). The purpose of the inspection was to examine Entergy's performance and determine if the contaminated groundwater affected, or could affect, public health and safety.

Q110. Did the NRC Staff issue a report during this special inspection?

A110. (DMM, MJB, CJP) Yes. NRC Staff issued a Special Inspection Report in March 2006, which assessed Entergy's performance and plans for more extensive site characterization. *See* NRC Special Inspection Report No. 05000247/2005011 (Mar. 16, 2006) ("2006 NRC Special Inspection Report") (RIV000069). The NRC Staff found that the groundwater contamination did not and was not likely to adversely affect public health and safety. 2006 NRC Special Inspection Report at iv (RIV000069). In that report, and subsequent public meetings, the NRC Staff indicated that a final conclusion would be reached after Entergy completed its groundwater characterization initiative. 2006 NRC Special Inspection Report at 1 (Mar. 16, 2006) (RIV000069). While groundwater characterization was ongoing, NRC Staff continued frequent inspections and implemented an independent monitoring regime for Entergy's onsite groundwater monitoring activities. *See, e.g.*, Indian Point Nuclear Generating Unit 3 – NRC Integrated Inspection Report 05000286/2007003 at 20-22 (Aug. 8, 2007) ("2007 NRC Inspection Report") (ENT000347).

Q111. After the 2006 Inspection Report, did NRC Staff continue its independent inspections?

A111. (DMM, MJB, CJP) Yes. Subsequent to 2006, the NRC Staff continued to closely monitor Entergy's groundwater characterization efforts, performed independent inspections and testing, and independently evaluated radiological and hydrological conditions affecting

groundwater onsite. *See, e.g.*, 2007 NRC Inspection Report at 20-22 (ENT000346). Additionally, the NRC Staff continued to independently verify groundwater sample results by conducting split monitoring well sampling with Entergy and NYSDEC. *See* May 13, 2008 NRC Inspection Report at 4-5 (RIV000067).

Q112. Did NRC Staff review Entergy's Site Investigation Report?

A112. (DMM, MJB, CJP) Yes. After receiving Entergy's results from the hydrogeologic site characterization investigation contained in the Site Investigation Report in January 2008, including Entergy's plan for remediation (*i.e.*, Monitored Natural Attenuation) and long-term monitoring of onsite groundwater systems, the NRC Staff conducted its own, detailed inspection. May 13, 2008 NRC Inspection Report (RIV000067). The results of the NRC Staff's May 13, 2008 inspection confirmed Entergy's conclusions. Specifically, in the May 13, 2008 Inspection Report documenting the inspection results, the NRC Staff made several important findings, including:

- Entergy had properly identified the source of groundwater releases as the IP1 and IP2 SFPs (May 13, 2008 Inspection Report at vi, 3 (RIV000067);
- No releases were observed or detected from IP3 (May 13, 2008 Inspection Report at viii, 10 (RIV000067);
- Entergy's hydrogeologic site characterization studies provide sufficiently detailed field observations, monitoring, and test data that supported the development and confirmation of a reasonable Conceptual Site Model (May 13, 2008 Inspection Report at vii, 4 (RIV000067);

- The Conceptual Site Model provides a reasonable basis to support the finding that liquid effluent releases from the SFPs migrate west towards the Hudson River and do not otherwise migrate offsite (May 13, 2008 Inspection Report at vii, 5 (RIV000067);
- There are no drinking water sources that can be impacted by the contaminated groundwater conditions (May 13, 2008 Inspection Report at vii, 6 (RIV000067);
- The annual calculated exposure to the hypothetical maximally exposed individual relative to the liquid effluent aquatic food exposure pathway is currently, and is expected to remain, less than 0.1 percent of the ALARA guidelines in Appendix I of 10 C.F.R. Part 50, which are considered to be negligible with respect to public health, safety, and the environment (May 13, 2008 Inspection Report at vii, 7 (RIV000067) (this topic is discussed in further detail below, in Section XI);
- There is no evidence of any significant leak or loss of radioactive water inventory from the site that was discernible in the offsite environment (May 13, 2008 Inspection Report at vii, 8 (RIV000067); and
- Entergy's remediation approach (*i.e.*, Monitored Natural Attenuation) and plans for long-term monitoring of residual groundwater contamination were reasonable (May 13, 2008 Inspection Report at vii, 8 (RIV000067).)

In reaching these conclusions, the NRC Staff relied, in part, on an independent analysis of groundwater transport through fractured bedrock (utilizing geophysical well logging data) conducted by the USGS. As the NRC Staff pointed out in its inspection report, the USGS assessment corroborated the groundwater transport characteristics that were developed by GZA. May 13, 2008 Inspection Report at vii (RIV000067); *see also* USGS, Flow-Log Analysis for Hydraulic Characterization of Selected Test Wells at the Indian Point Energy Center, Buchanan,

New York (2008) (ENT000341). The NRC Staff also worked closely with NYSDEC by sharing data and assessment information, coordinating independent split sampling of various sample media, and providing a combined oversight of licensee performance. *See* May 13, 2008 Inspection Report at 1 (RIV000067). The findings in the May 13, 2008 Inspection Report are summarized and incorporated by reference in the FSEIS. *See* FSEIS at 2-111 (NYS00133A).

Q113. In order to resume normal Reactor Oversight Process inspection activity, what did the NRC Staff conclude?

A113. (DMM, CJP) In a December 16, 2008 memorandum, the NRC Staff established various objectives for Entergy to satisfy before Indian Point could return to the normal NRC oversight process. *See* Memorandum from Samuel J. Collins, NRC Region I Administrator, to R. William Borchardt, NRC Executive Director of Operations, "Request for Renewal of Deviation to the Action Matrix to Provide Heightened NRC Oversight of Onsite Ground Water Monitoring at [IPEC]" (Dec. 16, 2008) (ENT000342). Specifically, before resuming normal inspection activities under the NRC's Reactor Oversight Process, the Staff evaluated whether Entergy: (1) had sufficient data to establish a new groundwater contaminant baseline, since the IP1 source term has been terminated; (2) determined whether active IP2 SFP leakage continues and, if necessary, whether appropriate monitoring and control measures were implemented; and (3) established and implemented effluent control and environmental monitoring procedures that provide reasonable assurance that the existing groundwater conditions will continue to be effectively monitored and assessed, that the procedures will detect new or changed conditions in a timely manner, and that the procedures are sufficient to monitor natural attenuation of IP1 and IP2 plumes. Letter from Darrel J. Roberts, NRC, to Joseph Pollock, Entergy, "[IP1, IP2 & IP 3]

NRC Inspection Report Nos. 05000003/2009008; 05000247/2009008; and 05000286/2009008," encl. at 5 (Oct. 19, 2009) ("Oct. 19, 2009 Inspection Report") (ENT000343).

As to Objective 1, the NRC Staff determined that given the fact that the original source of contamination from the IP1 SFP was terminated, any residual groundwater contamination will naturally attenuate over time. *See* Oct. 19, 2009 Inspection Report at 6 (ENT000343). The NRC Staff also confirmed Entergy's finding that the current groundwater contamination has not and will not affect public health and safety, determining that the public radiological dose consequences will likely remain a mere fraction of the NRC regulatory limit. *See* Oct. 19, 2009 Inspection Report at 6 (ENT000343).

The NRC Staff confirmed Entergy's findings on Objective 2, concluding that even if persistent small leaks resulted from the IP2 SFP, the current groundwater conditions will not impact the public health and safety because the public radiological dose consequence will likely remain a mere fraction of the NRC regulatory limit. *See* Oct. 19, 2009 Inspection Report at 7 (ENT000343). The NRC Staff also confirmed, specific to Objectives 2 and 3, that Entergy's Long-Term Groundwater Monitoring Program is of sufficient scope and has the implementation requirements necessary to monitor the migration and attenuation of existing groundwater conditions affecting Indian Point. Oct. 19, 2009 Inspection Report at 8 (ENT000343). In recognition of Entergy meeting the commitments and criteria in the Deviation Memorandum, the NRC Staff returned Indian Point to the normal baseline Reactor Oversight Process in 2010. *See* Letter from D. C. Lew, NRC, to J. E. Pollock, Entergy, "Annual Assessment Letter – Indian Point Nuclear Generating Units 2 and 3 (Reports 05000247/2010001 & 05000286/20100001)," at 2 (Mar. 3, 2010) (ENT000344).

Q114. Did NYSDEC conduct its own independent investigations?

A114. (DMM, MJB) Yes. NYSDEC (with support from the NYS Department Of Health) actively monitored Entergy's hydrological investigation, independently analyzed split samples from onsite and offsite monitoring wells, and made recommendations on the work being performed. *See* FSEIS at 2-112 (NYS00133A); May 13, 2008 Inspection Report at 5 (RIV000067). Importantly, NYSDEC performed its own independent assessment of public health and environmental impacts. *See* FSEIS at 2-112 (NYS00133A); NYSDEC 2007 Community Fact Sheet (ENT000325); NYSDEC Strontium Study (ENT000321).

Q115. What did NYSDEC conclude during its 2007 independent assessment?

A115. (DMM, MJB, CJP, FOH) In brief, NYSDEC's reported conclusions were consistent with the findings in the hydrogeologic Site Investigation Report and confirmed by the NRC Staff. As to any strontium contamination, NYSDEC concluded that removal of the spent fuel and water from the IP1 SFPs will (and did) halt the active source of contamination. *See* NYSDEC Community Fact Sheet (May 2008) ("NYSDEC 2008 Community Fact Sheet") (ENT000345). While public exposure can occur through consumption of fish from the Hudson River, NYSDEC determined strontium levels in fish near the site are no higher than those collected from other statewide locations. NYSDEC 2007 Community Fact Sheet at 1 (ENT000325). In doing so, NYSDEC corroborated Entergy's finding that calculated doses to the public through fish consumption (0.00027 mrem whole body and 0.00099 mrem organ dose) are less than 1 percent of the allowable NRC 10 C.F.R. 50, Appendix I annual dose objectives (0.0089 percent whole body and 0.0099 percent organ dose). NYSDEC 2008 Community Fact Sheet (ENT000345); *see also* 2007 Annual Radioactive Effluent Release Report at 35 (ENT00316A). Thus, NYSDEC's findings support the determination that there is no discernable

effect on fish from the radionuclide releases into groundwater, and no public health concern due to radiation associated with eating fish from the Hudson River. *See* NYSDEC 2007 Community Fact Sheet at 1 (ENT000325).

In addition, NYSDEC concluded that any radionuclides reaching the Hudson River as a result of the radionuclide releases into groundwater did not violate state and federal drinking water limits. NYSDEC 2008 Community Fact Sheet at 1 (ENT000345). Moreover, it accepted Monitored Natural Attenuation as the appropriate remedial approach for addressing the tritium and strontium plumes: "With the removal of the active contamination source, Entergy's planned use of monitored natural attenuation is an acceptable approach to managing the remaining Sr-90 and H-3 plumes." *See* NYSDEC 2008 Community Fact Sheet (ENT000345).

Q116. What did NYSDEC conclude in its strontium study, issued in 2009?

A116. (DMM, MJB, CJP, FOH) In 2007, NYSDEC conducted an enhanced, independent radiological surveillance of several aquatic species in the lower Hudson River. It published the results of this assessment in 2009. *See* NYSDEC Strontium Study (ENT000321). Specifically, NYSDEC concluded that there were no significant differences in the concentrations of strontium in fish and shellfish samples near Indian Point and those sampled upriver at control locations (which included an additional reference location in the river, 50 miles north of Indian Point so as to be outside the migratory range of the subject fish). *See* NYSDEC Strontium Study at 8 (ENT000321). In addition, NYSDEC concluded that the levels of all radionuclides (including strontium) in fish and shellfish at all of the sampling locations were two to five orders of magnitude lower than established criteria for protection of freshwater ecosystems. NYSDEC Strontium Study at 8 (ENT000321).

Q117. Are you aware of any independent monitoring conducted by Riverkeeper?

A117. (DMM, MJB, CJP, FOH) Yes. Through the discovery process, we learned that Riverkeeper requested that Dr. Christopher Gobler, an Associate Professor in the School of Marine and Atmospheric Sciences at Stony Brook University, perform a study of Hudson River biota and sediment to assess the long-term environmental impacts attributable to Indian Point radiological releases. *See* E-mail from Christopher J. Gobler, Stony Brook University, to Scott Cullen, "radioisotope proposal" (Aug. 17, 2007) (Bates No. RK0001060) (ENT000366); Study of Hudson River Finfish, Shellfish and Sediment to Assess the Long-term Environmental Impacts of Liquid Radiological Releases from Indian Point on the Hudson River Biota (Bates No. RK0001105) (ENT000367). An e-mail from Dr. Gobler to Riverkeeper reported the sampling results as follows:

> 1. Regarding the shellfish, levels of Cs-137, Sr-90, Cs-134, Co-60, or Sr-89 clam shells and meats were all below the methodological limit of detection.
>
> 2. Regarding sediment, there we quantified Cs-137, K-40, Ra-226, and Th-232 in the sediments collected in close vicinity to Indian Point. However, those levels were not elevated relative to sediment samples north or south of the IP facility.

E-mail from Christopher J. Gobler, Stony Brook University, to Phillip Musegaas, Riverkeeper, "RE: IP Sampling" (July 10, 2008) (Bates No. RK0001069) (ENT000368) ("Gobler July 10, 2008 e-mail"). Dr. Gobler further stated that the results were not what he was expecting, but that "the data is solid." Gobler July 10, 2008 e-mail (ENT000368). It is our understanding that no final report of this sampling was made available to Entergy. Nor is this sampling discussed in the Intervenors' prefiled direct testimony. Nonetheless, these results are consistent with the findings made in the Site Investigation Report and by the NRC Staff and NYSDEC.

XI. COMPLIANCE WITH APPLICABLE DOSE LIMITS

Q118. Please describe Indian Point's compliance with applicable dose limits.

A118. (CJP, FOH) As required by 10 C.F.R. § 50.36a(a)(2), Entergy submits an Annual Radioactive Effluent Release Report for Indian Point to the NRC detailing the amount of radioactive material released to the environment during each year and the resulting dose calculated in accordance with the ODCM. As explained previously in response to Question 45, we reviewed Indian Point's ODCM, and the ODCM is consistent with NRC regulatory requirements and guidance. We also reviewed Entergy's six most recent Annual Effluent Release Reports, for years 2005 to 2010. These reports show that, for Indian Point, the total annual whole body dose to the highest hypothetical maximally exposed member of the public is well below regulatory limits. *See* 2005 Annual Radioactive Effluent Release Report at 35 (ENT000314); 2006 Annual Radioactive Effluent Release Report at 36 (ENT000315); 2007 Annual Radioactive Effluent Release Report at 35 (ENT00316A); 2008 Annual Radioactive Effluent Release Report at 41 (ENT000317); 2009 Annual Radioactive Effluent Release Report at 35 (ENT000318); 2010 Annual Radioactive Effluent Release Report at 35 (ENT000319).

The Annual Effluent Release Reports also summarize annual groundwater and storm water activity. The Indian Point groundwater and storm water effluent dose ranged from 1.73×10^{-4} to 2.12×10^{-3} mrem in a year to the total body and from 9.72×10^{-3} to 7.06×10^{-4} mrem in a year to the maximum exposed organ (bone), which can be compared to Appendix I design objectives of 3 mrem to the total body and 10 mrem to any organ, respectively. *See* 2005 Annual Radioactive Effluent Release Report at 35 (ENT000314); 2006 Annual Radioactive Effluent Release Report at 36 (ENT000315); 2007 Annual Radioactive Effluent Release Report at 35 (ENT00316A); 2008 Annual Radioactive Effluent Release Report at 35 (ENT000317);

2009 Annual Radioactive Effluent Release Report at 35 (ENT000318); 2010 Annual Radioactive Effluent Release Report at 35 (ENT000319).

Entergy meets all NRC 10 C.F.R. Part 20 and Part 50, Appendix I requirements at Indian Point by a very wide margin, as well as EPA 40 C.F.R. Part 190 requirements. In fact, the combined groundwater and storm water dose is less than 0.1 percent of the ALARA guidelines in Appendix I of 10 C.F.R. Part 50. *See* 2005 Annual Radioactive Effluent Release Report at 92 (ENT000314); 2006 Annual Radioactive Effluent Release Report at 45 (ENT000315); 2007 Annual Radioactive Effluent Release Report at 44 (ENT00316A); 2008 Annual Radioactive Effluent Release Report at 41 (ENT000317); 2009 Annual Radioactive Effluent Release Report at 41 (ENT000318); 2010 Annual Radioactive Effluent Release Report at 41 (ENT000318).

XII. SUMMARY OF NEPA EVALUATIONS OF THE ENVIRONMENTAL SIGNIFICANCE OF SFP LEAKS

A. Evaluation of the SFP Leaks in the ER

Q119. Please describe how Entergy analyzed SFP leaks and associated groundwater impacts at Indian Point in the ER.

A119. (DMM, MJB, CJP, FOH) As required by 10 C.F.R. Part 51, Entergy prepared an ER for purposes of license renewal that analyzed the potential environmental impacts associated with license renewal for all relevant Category 2 issues. 10 C.F.R. § 51.53(c)(3)(ii). Entergy also performed an analysis to identify any new and significant information concerning the environmental impacts of license renewal. Specifically, Section 5.0 of the ER contains Entergy's response to the NRC requirement that a license renewal applicant assess any potentially "new and significant" information regarding environmental impacts of a plant's operation during the extended license term. 10 C.F.R. § 51.53(c)(3)(iv). To do so, Entergy identified new information that (1) identifies a significant environmental issue not covered in the NRC's GEIS

and codified in Part 51; and (2) was not covered in the GEIS analyses that lead to an impact finding different from that codified in Part 51.

Section 5.1 of the ER, entitled "New and Significant Information: Groundwater Contamination," provides Entergy's assessment of whether groundwater radionuclide contamination identified at Indian Point is potentially "new and significant" as it relates to license renewal. As a result of the then-ongoing hydrogeologic characterization of the site, the ER explains that tritium, strontium-90, cesium-137, and nickel-63 "have been detected in low concentrations in some onsite groundwater monitoring well samples." ER at 5-4 (ENT00015B). Furthermore, the ER identifies that the IP1 SFP was "a confirmed source of at least some of the tritium, as well as strontium, cesium and nickel in groundwater." ER at 5-5 (ENT00015B). With regard to IP2, based on preliminary site monitoring data available at that time, the ER states that contamination related to the IP2 SFP was "the result of historical pool leakage in the 1990s which has since been repaired." ER at 5-6 (ENT00015B).

An important factor in Entergy's assessment of the significance of the identified groundwater contamination, as ER Sections 5.1 and 2.3 explains, is that no one, including Indian Point, uses this groundwater for any of its potable water needs. Therefore, EPA drinking water standards do not apply. *See, e.g.*, 40 C.F.R. §§ 141.1. 141.2 (indicating that federal drinking regulations apply to public water systems). There also is no known drinking water pathway associated with groundwater or the Hudson River in the area surrounding the site. For these reasons, the ER states that "EPA drinking water limits are not applicable" to site area groundwater. ER at 5-6 (ENT00015B). As explained in Sections 5.1 and 2.3 of the ER, samples taken in support of the REMP further indicate that there are no detectable plant-related radionuclides in offsite groundwater above safe drinking water standards. ER at 5-5

(ENT00015B). These samples included the offsite REMP sampling locations defined in the IPEC ODCM—the local drinking water reservoirs and other groundwater monitoring wells near the plant. Entergy's continued sampling confirms these results, as is discussed in greater detail below.

Q120. Based on this analysis, what did Entergy conclude in the ER regarding groundwater contamination?

A120. (DMM, MJB, CJP, FOH) Based on the information in Section 5 of the ER, Entergy concludes in the ER that no NRC dose limits have been exceeded at Indian Point. ER at 5-6 (ENT00015B). Specifically, Entergy explains that it fully complied with 10 C.F.R. Part 50, Appendix I, and that the total body dose to the hypothetical maximally exposed individual as a result of the identified groundwater contamination represents less than 0.1 percent of applicable NRC limits. *See* ER at 5-5 (ENT00015B).

In addition, the ER states that the SFP leaks to groundwater are "not anticipated to change environmental considerations, such as water usage, land usage, terrestrial or aquatic ecological conditions, or air quality, and is not expected to affect socioeconomic conditions, as a result of license renewal activities." ER at 5-6 (ENT00015B). Therefore, Entergy has determined that, while the identification of site groundwater contamination is potentially "new," the impacts of those radionuclides would be SMALL and thus, not "significant." *See* ER at 5-6 (ENT00015B).

Entergy also emphasizes the fundamental point that characterization of the impacts as SMALL—and therefore not significant—complies fully with 10 C.F.R. Part 51, Subpart A, Appendix B, which states that "[f]or the purposes of assessing radiological impacts, the

Commission has concluded that those impacts that do not exceed permissible levels in the Commission's regulations are considered small."

Q121. After submitting the ER in 2007, did Entergy provide NRC with any addition information concerning SFP leaks and associated groundwater impacts?

A121. (DMM, MJB, CJP, FOH) Yes. Following the submission of the ER in April 2007, Entergy continued to provide the NRC with updates regarding the status of the IP1 and IP2 SFPs and with relevant assessments of potential environmental impact resulting from groundwater contamination. *See, e.g.*, Letter NL-08-023, from F. Dacimo, Entergy, to NRC, "Supplemental Response to Request for Additional Information Regarding Environmental Review for License Renewal Application (Jan. 30, 2008) ("NL-08-023") (ENT000370); Letter NL-08-009, from J. Pollock, Entergy, to NRC, "Results of Ground Water Contamination Investigation" (Jan. 11, 2008) ("NL-08-009") (ENT000371). Specifically, after the submission of the ER, Entergy completed the two-year site hydrogeologic investigation of the entire site and provided NRC with the comprehensive Site Investigation Report, which summarized the findings and conclusions from the investigation. *See* NL-08-009 at 1-4 (ENT000371).

Also, after the submission of the ER, Entergy identified the leak in the weld imperfection in the IP2 SFP Transfer Canal, and determined that, while additional IP2 leaks could not be completely ruled out, if any existed, data indicated that any such leaks would be very small and of little impact to groundwater. *See* NL-08-023, Att. 1, at 2 (ENT000370). Entergy also confirmed that the IP1 SFPs were the source of the strontium contamination detected in groundwater beneath the site and provided plans to permanently eliminate the IP1 SFPs as a source of contamination to groundwater by relocating IP1 spent fuel to dry cask storage. NL-08-

023, Att. I at 2 (ENT000370). As previously noted, in late 2008, all the fuel rods were removed from the IP1 SFPs and the pool water drained. *See* Mayer Nov. 5, 2008 Email (ENT000324).

Q122. What did this supplemental information demonstrate?

A122. (DMM, MJB, CJP, FOH) Consistent with Section 5.1 of the ER, this supplemental information confirms that there is no current or reasonably anticipated use of groundwater at Indian Point, and that the calculated doses to members of the public from the groundwater pathway remained less than 1 percent of federal limits. NL-08-023, Att. 1, at 2 (ENT000370). While the ER did not, and could not have addressed the later-identified leak in the IP2 SFP Transfer Canal, the Site Investigation Report (which did address the leak from the IP2 SFP Transfer Canal) submitted to the NRC in January 2008, demonstrates that the conclusions in the ER remained the same—estimated doses due to the groundwater contamination are and are expected to remain well below NRC dose limits for the period of the renewed operating license. *See* NL-08-023, Att. 1 at 3 (ENT000370). Accordingly, in light of this subsequently developed information, Entergy adequately and appropriately characterizes the environmental impacts of the water leaks from IP1 and IP2 SFPs on the groundwater and the Hudson River ecosystem as new, but not significant information. *See* NL-08-023, Att. I at 3 (ENT000370).

B. <u>Evaluation of the SFP Leaks in the FSEIS</u>

Q123. Did the NRC Staff address SFP leaks in its FSEIS?

A123. (DMM, MJB, CJP, FOH) Yes. The NRC Staff considers Indian Point SFP leaks in a number of sections in the FSEIS, including Sections 2.1.4.1 (Liquid Waste Processing Systems and Effluent Controls), 2.2.3 (Water Quality), 2.2.7 (Plant Interaction with the Environment – Radiological Impacts), 4.3 (Radiological Impacts of Normal Operations), 4.5 (Ground Water Use and Quality), 4.7 (Evaluation of New and Potentially Significant Information

on Impacts of Operations During the Renewal Term), 4.8.3 (Cumulative Radiological Impacts), and 4.8.5 (Cumulative Impacts on Ground Water Use and Quality).

Q124. Please describe how the NRC Staff analyzed the environmental impacts of radionuclide releases from SFPs in the FSEIS.

A124. (DMM, MJB, CJP, FOH) The NRC Staff's FSEIS evaluation of the SFP leakage concludes that these liquid releases, while new information, are well below the NRC's radiation safety standards contained in 10 C.F.R. Part 20 and Appendix I to 10 C.F.R. Part 50. FSEIS at 2-111 (NYS00133A). The NRC Staff independent evaluation considers information in Entergy's ER and Site Investigation Report, as well as the NRC Staff and NYSDEC inspection results, and public comments. FSEIS at 2-110 to 2-111 (NYS00133A).

Q125. How did the NRC Staff consider the Site Investigation Report in the FSEIS?

A125. (DMM, MJB, CJP, FOH) The FSEIS explains that the Site Investigation Report identified sources of leakage, determined the radiological impacts resulting from the leakage, and concluded that the only noteworthy dose pathway resulting from contaminated groundwater migration was through the consumption of fish and invertebrates from the Hudson River, which resulted in a calculated dose to a hypothetical maximally exposed individual of less than 0.1% of the federal limits. *See* FSEIS at 2-111 (NYS00133A).

Q126. Please describe how the FSEIS addressed the NRC Staff's and NYSDEC inspection results.

A126. (DMM, MJB, CJP, FOH) The FSEIS discusses the extensive NRC Staff independent inspection of Entergy's actions to respond to the discovery of the SFP leaks and the subsequent expansion of Entergy's groundwater monitoring program. *See* FSEIS at 2-111 (NYS00133A). The FSEIS adopts the findings and contents of the NRC Staff's May 13, 2008,

Inspection Report, including the following findings: there is no drinking water pathway; the only potential exposure pathway to humans is through consumption of Hudson River aquatic foods; and the annual maximum dose to a hypothetical maximally exposed individual is less than 0.1% of NRC's ALARA guidelines. FSEIS at 2-111 (NYS00133A). Further, the FSEIS discusses the independent groundwater investigations performed by NYSDEC, which also confirmed that there are no known impacts to any drinking water source, and that the principle pathway for public exposure to humans is through the fish consumption pathway. *See* FSEIS at 2-111 (NYS00133A).

Q127. Did the FSEIS address IP1 SFP leaks?

A127. (DMM, MJB, CJP, FOH) Yes. The FSEIS notes that the NRC Staff continued to monitor Entergy's SFP-related actions, including the removal of all spent fuel from and the draining of the IP1 SFP, as well as the incorporation of the groundwater monitoring program into the ODCM and associated procedures. *See* FSEIS at 2-111 (NYS00133A).

Q128. What did the FSEIS conclude with respect to the significance of SFP leaks to human health?

A128. (DMM, MJB, CJP, FOH) Based on Entergy's, NRC's and NYSDEC's analyses, the FSEIS concludes that groundwater contamination and the new effluent release pathway from SFP leakage is not environmentally significant and impacts on human health are SMALL. *See* FSEIS at 4-41 to 4-42 (NYS00133B).

Q129. What did the FSEIS conclude with respect to the significance of SFP leaks on groundwater quality?

A129. (DMM, MJB, CJP, FOH) The FSEIS points out that the topography of the Indian Point site and the foundation drains around the structures result in a flow regime that transports

groundwater towards the Hudson River, and as a result, the contaminated groundwater would be transported to the Hudson River and not offsite in a direction that it might be captured by an offsite groundwater user. *See* FSEIS at 4-56, 4-69 (NYS00133B). Thus, the Staff finds that any effects from the plant, previous development, or future development on site would remain limited to effects of groundwater migrating from Indian Point to the Hudson River. *See* FSEIS at 4-56, 4-69 (NYS00133B). Accordingly, the FSEIS concludes that impacts on groundwater use and quality are SMALL. *See* FSEIS at 4-56, 4-69 (NYS00133B).

Q130. What did the FSEIS conclude with respect to the significance of SFP leaks on the Hudson River ecosystem?

A130. (DMM, MJB, CJP, FOH) The FSEIS discusses the results from environmental monitoring of Hudson River water, fish and invertebrates, aquatic vegetation, bottom sediment, and shoreline soil (*i.e.*, Entergy's REMP results). *See* FSEIS at 2-105 to 2-112 (NYS00133A). The FSEIS finds that while these monitoring results indicated that some very low levels of radioactivity were detected, no adverse radiological impact to the surrounding environment was attributed to IP2 and IP3 operations. *See* FSEIS at 2-105 to 2-108 (NYS00133A). For example, sampling from 2006 detected strontium-90 in four fish and invertebrate samples—three in the control samples and one in an indicator sample. Since the levels detected in the indicator and control location samples were comparable, the Staff concluded that atmospheric weapon testing is the likely cause. *See* FSEIS at 2-106 to 2-107 (NYS00133A). The Staff also discusses the findings from the NRC May 13, 2008 Inspection Report and NYSDEC's investigation, which both confirmed that no radioactivity distinguishable from background was detected in fish and invertebrates taken from near Indian Point and designated control locations. FSEIS at 2-111 (NYS00133A).

The FSEIS also reviews more recent environmental monitoring data from 2009, but notes that strontium-90 results in fish and invertebrates samples were not available. *See* FSEIS at 2-107 (NYS00133A). Entergy addresses this issue further in the 2010 Annual Radiological Environmental Operating Report, which explains that there were no certifiable results due to the extremely low detection level requested. An improved technique was adopted in 2010, and this method, with increased sensitivity and reliability, identified no strontium in the 2010 fish and invertebrates samples. *See* 2010 Annual Radiological Environmental Operating Report at 4-3 (May 16, 2011) (ENT000313). This information, however, became available after the publication of the FSEIS.

Q131. Did the FSEIS respond to any public comments about SFP leaks?

A131. (DMM, MJB, CJP, FOH) Yes. The FSEIS addresses public comments made during the DSEIS comment period asserting that the NRC Staff did not adequately discuss the long-term impacts from releases of radionuclides from SFP leaks into the groundwater and drinking water, including the potential Rockland County (Haverstraw) desalination plant's use of Hudson River water, and the impacts from eating fish from the Hudson River. *See* FSEIS App. A at A-94 to A-96 (NYS00133D). In response to public comments, the NRC Staff explains that applicable NRC and EPA radiation protection limits protect members of the public from cumulative radiation impacts, the State of New York would regulate any potential future desalination facility, and if plans for the facility advance, the facility would be required to have the means to monitor the source water and, if necessary, have a treatment system to meet applicable drinking water standards for radioactive and nonradioactive contaminants. FSEIS at A-95 (NYS00133D). The FSEIS also notes that ER Chapters 2 and 4 address impacts to human health from routine and abnormal radiological releases, and that site monitoring data show that

the calculated doses to a hypothetical maximally exposed member of the public from the radiological releases were within NRC's radiation dose standards. *See* FSEIS at A-60 (NYS00133D).

Q132. What did the FSEIS ultimately conclude about the environmental significance of Indian Point SFP leaks?

A132. (DMM, MJB, CJP, FOH) Based on the NRC Staff's review of the groundwater data and associated analyses, the FSEIS concludes that "the abnormal liquid releases discussed by Entergy in its ER, while constituting new information, are within the NRC's radiation safety standards contained in 10 CFR Part 20 and are not considered to have a significant impact on plant workers, the public, or the environment (i.e., while the information related to [SFP] leakage is new, it is not significant)." FSEIS at 4-61 (NYS00133B).

XIII. ENVIRONMENTAL IMPACTS DURING THE LICENSE RENEWAL TERM

A. Human Health

Q133. Please provide a summary of how the NRC Staff generally addresses human health impacts due to radiation exposures to the public in license renewal reviews.

A133. (CJP, FOH) As explained previously in response to Question 33, NRC regulations in Table B-1, Appendix B to Subpart A of 10 C.F.R. Part 51 list human health impacts from radiation exposures as a generic, Category 1 issue with SMALL significance. In defining the term SMALL, Table B-1 establishes that "[f]or the purposes of assessing radiological impacts, the Commission has concluded that those impacts that do not exceed permissible levels in the Commission's regulations are considered small as the term is used in this table."

In promulgating Part 51, the Commission explained that the Atomic Energy Act requires that the NRC "promulgate, inspect and enforce standards that provide an adequate level of

protection of the public health and safety and the environment" and that "[t]he implementation of these regulatory programs provides a margin of safety." Final Rule, Environmental Review for Renewal of Nuclear Power Plant Operating Licenses, 61 Fed. Reg. at 28,476 (NYS000127). Moreover, with regard to whether additional mitigative measures should be required, the Commission pointed out that 10 C.F.R. Parts 20 and 50 already include provisions requiring that "radiological impacts associated with plant operation be reduced to levels as low as reasonably achievable (ALARA)." Final Rule, Environmental Review for Renewal of Nuclear Power Plant Operating Licenses, 61 Fed. Reg. 28,467, 28,476 (June 5, 1996) (NYS000127).

Q134. What, if any, conclusions can you draw about the human health impacts due to radiation exposures to the public due to the IP2 and IP3 license renewal?

A134. (CJP, FOH) NRC and EPA regulations protect the public from unsafe levels of radiation exposure. Indian Point not only meets all NRC and EPA dose standards limiting radiation exposures, but Indian Point has been well below these standards as demonstrated in Section XI of this testimony, with annual doses from radioactive effluents far below 1 mrem including groundwater effluents into the Hudson River. *See* 2005 Annual Radioactive Effluent Release Report at 35 (ENT000314); 2006 Annual Radioactive Effluent Release Report at 36 (ENT000315); 2007 Annual Radioactive Effluent Release Report at 35 (ENT00316A); 2008 Annual Radioactive Effluent Release Report at 41 (ENT000317); 2009 Annual Radioactive Effluent Release Report at 35 (ENT000318); 2010 Annual Radioactive Effluent Release Report at 35 (ENT000319). Therefore, during license renewal, human health impacts from Indian Point radiation exposures will be SMALL.

Q135. How does consideration of the pathway of radionuclides from SFP leaks affect this conclusion about human health impacts due to radiation exposures?

A135. (CJP, FOH) The NRC's generic conclusion that the human health impacts due to radiation exposures to the public during the license renewal term are SMALL is not impacted by the groundwater pathway. Entergy accounts for releases associated with this pathway in its annual release and dose calculations. *See* IPEC ODCM D at 5.6 ("Radiological Ground Water Monitoring Program") (ENT000307); 2010 Annual Radioactive Effluent Release Report at 40 (ENT000319). The dose to the hypothetical maximally exposed member of the public due to releases into the Hudson River from groundwater and storm water on an annual basis is orders of magnitude below the allowable federal regulatory limits for radioactive effluents, and orders of magnitude below allowable federal regulatory levels for Entergy's annual Discharge Canal releases to the river pursuant to its NRC licenses. *See* Table 2A in each of Entergy's Annual Radioactive Effluent Release Reports ("Effluent Release Reports") from 2006 to 2010 (ENT000314 through ENT000319).

Moreover, the dose from groundwater and storm water is so small as to be inconsequential to human health or the environment. To provide an example, in 2010, the total annual radiation dose to a hypothetical maximally exposed individual from groundwater and storm water releases was 0.0002 mrem. *See* 2010 Annual Radioactive Effluent Release Report at 35 (2011) (ENT000319). The average annual radiation exposure for the typical individual in the United States is 620 mrem. National Council on Radiation Protection and Measurements [("NCRP")], Report No. 160, Ionizing Radiation Exposure of the Population of the United States (2009) (ENT00269A) (stating that the total effective dose per individual in the U.S. is 6.2 mSv or 620 mrem). Indeed, the typical radiation exposure from eating a banana, which contains small amounts of radioactive potassium, is 0.01 mrem, which is far greater than the total annual radiation dose to a hypothetical maximally exposed individual from groundwater and storm

water releases. The low dose consequences demonstrate conclusively that there is no material negative effect on human health from SFP leaks.

B. Groundwater Quality

Q136. Please provide a summary of how the NRC assesses groundwater quality impacts due to radiological contamination.

A136. (MJB, CJP) The NRC's main focus in investigating groundwater contamination is to determine if groundwater contamination affects, or could affect, public health and safety. *See generally* Request for Deviation from the Reactor Oversight Process Action Matrix to Provide Increased NRC Oversight of Specific Issues at Indian Point Energy Center (Oct. 28, 2005) (ENT000346). NRC regulations do not preclude releases to site groundwater, but instead require that licensees account for such releases, evaluate them relative to NRC regulatory requirements, and report the quantity of radioactivity released and the dose to the hypothetical maximally exposed member of the public. *See* SECY-11-0019, Encl. 2, at 2-3 (ENT000322). This process is consistent with NRC regulatory reporting guidance which recognizes that nuclear power plant operations may have abnormal operational occurrences that take place and result in unplanned releases. *See* SECY-11-0019, Encl. 2, at 2-3 (ENT000322). Apart from these regulatory requirements, groundwater quality impacts are considered to be of small significance in license renewal proceedings when the plant does not contribute to changes in groundwater quality that would preclude current and reasonably anticipated future uses of groundwater. GEIS at 4-119 (NYS00131B).

Q137. What, if any, conclusions can you draw about the groundwater impacts due to radiological contamination due to the IP2 and IP3 license renewal?

A137. (MJB, CJP, FOH) As explained above in Sections VI and IX, there has been a long-term decrease, a trend which is expected to continue, in radionuclide activity in the overall

site groundwater, and consequently, reaching the Hudson River. Based on sampling and testing of Hudson River water in the vicinity of Indian Point and at control locations away from Indian Point, the migration of low levels of radionuclides to the Hudson River has had no discernible effect on the level of radionuclides contained in Hudson River water. Entergy's network of groundwater monitoring wells is sufficient to allow Entergy to detect comparable potential future releases into groundwater at the site and to respond appropriately to such releases. Thus, because contaminated water travels into the Hudson River and there are no current or reasonably anticipated users for onsite groundwater, the impacts on groundwater quality during license renewal are SMALL.

Q138. Can you explain in further detail why future small SFP leaks, if any, would not contribute to changes in groundwater quality that would preclude current and reasonably anticipated future uses of groundwater?

A138. (MJB) As an initial matter, as I discussed previously in Question 60, Indian Point does not utilize groundwater for plant operations or potable water. Further, there are no planned or reasonably anticipated future uses for onsite groundwater. In fact, it would not be practicable to develop a potable water source on the Indian Point site for two reasons relating to the site hydrogeology. First, the groundwater zone is characterized by very tight bedrock, where the water is constrained to flow through very thin fractures—mostly less than the thickness of a sheet of paper. *See* Site Investigation Report at 62 and table 4.4 (ENT00331A, ENT00331C). It simply would not be economical to attempt to extract this small amount of groundwater for potable use. Second, given the proximity to the Hudson River, attempts to extract sufficient water would likely pull in river water, which is brackish (*i.e.*, salty). *See generally* Site Investigation Report at 71 & Fig. 6.16 (ENT00331B, ENT00331F). This water would be

unsuitable for potable purposes. While the water could be treated, treatment would be expensive and not economically justifiable given the very small amounts of water that could be extracted. Thus, not only are there no current plans to use onsite groundwater, but also the site hydrogeology would, as a practical matter, essentially preclude such future uses for potable water.

C. Ecological Resources

Q139. Does the NRC have radiation protection requirements that address radiological impacts on the aquatic ecosystem?

A139. (FOH, CJP) No. The NRC has not issued radiation dose limits to protect aquatic biota. NRC radiation protection dose limits apply specifically to members of the public or other persons in unrestricted areas. Further, the potential impacts of radionuclides on aquatic organisms resulting from normal operations of a nuclear power plant during the license renewal term were not evaluated separately in the 1996 GEIS.

NRC practice is consistent with the longstanding view of the International Council on Radiation Protection ("ICRP") that "if man is adequately protected, then other living things are also likely to be sufficiently protected." ICRP, Annals Publication 26, Recommendations of the International Commission on Radiological Protection at 3, ¶ 14 (1977) (ENT000348). This position was restated in 1990 by the ICRP as "the Commission believes that the standard of environmental control needed to protect man to the degree currently thought desirable will ensure that other species are not put at risk." ICRP, Annals Publication 60, Recommendations of the International Commission on Radiological Protection at 3, ¶ 16 (1990) (ENT000349). The National Council on Radiation Protection and Measurements ("NCRP") has concluded that the ICRP statement in ICRP Publication 26 was valid for scenarios where human exposure is controlled to a level of 1 mSv/year (*i.e.*, 100 mrem/yr). NCRP, Report No. 109, Effects of

Ionizing Radiation on Aquatic Organisms at 62 (1991) (ENT000350). NCRP Report No. 109 also observed that NRC's ALARA principle minimizes impacts on natural populations of aquatic organisms.

In 2007, however, ICRP Publication 103 discussed the development of a system of radiation protection standards for animals and plants. *See* ICRP, Annals Publication 103, Recommendations of the International Commission on Radiological Protection at 133-135 (2007) (ENT000351). In 2008, the NRC Staff presented options to the Commission concerning ICRP Publication 103 and recommended that the Commission *not* adopt dose limits for reference animals and plants. *See* SECY-08-0197, Options to Revise Radiation Protection Regulations and Guidance with Respect to the 2007 Recommendations of the International Commission on Radiological Protection (Dec. 18, 2008) (ENT000352). In response, the Commission issued a Staff Requirements Memorandum ("SRM") agreeing with the NRC Staff finding that there is no evidence that the current set of radiation protection controls is not protective of the environment, and that the NRC should *not* develop separate radiation protection regulations for plant and animal species. *See* SRM, SECY-08-0197, Options to Revise Radiation Protection Regulations and Guidance with Respect to the 2007 Recommendations of the International Commission on Radiological Protection (Apr. 2, 2009) (ENT000352).

In 2011, when examining the issue of industry releases to groundwater, an NRC Senior Management Review Group discussed the findings in SECY-08-0197 and found that licensee actions taken in response to leaks and spills are protective of the environment, and confirmed that no new policy actions were needed with respect to protection for plant and animal species in the environment. *See* SECY-11-0019, Encl. 2, at 3 (ENT000322). Thus, there are no separate NRC dose regulations for plants and animals.

Q140. Although there are no applicable NRC regulations, are there any other generally accepted guidelines for assessing the effects on aquatic biota from releases of radionuclides from groundwater to the Hudson River?

A140. (FOH) Yes. The U.S. Department of Energy ("DOE") has established radiation dose rate guidelines that recommend limiting the dose to aquatic biota to less than 1.0 rad/d (0.01 Gy/d). *See* DOE, DOE-STD-1153-2002, A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota (July 2002) (excerpts included as ENT000353). These guidelines were developed on the basis of experimental data that indicated that there would not be any negative population-level effects at these doses.

Q141. Did you perform any dose rate calculations for aquatic biota in the area in the vicinity of Indian Point which can be compared to these guidelines?

A141. (FOH) Yes. As part of my preparation for the NYSDEC Section 401 Water Quality Certification matter, I used the DOE's RESRAD-BIOTA dose evaluation model (v.1.5/level 3) to calculate the dose rate to aquatic organisms in the vicinity of Indian Point. Furthermore, I compared the estimates of dose rate obtained with RESRAD-BIOTA with dose rates calculated with the use of biota dose coefficients for tritium and strontium-90 documented for external and internal exposures in UNSCEAR, Sources and Effects of Ionizing Radiation, Report to the General Assembly Vol. II, Annex E (2008) (Effects of Ionizing Radiation on Non-Human Biota) (ENT000354), and an assumed water-to-whole organism bioconcentration factor of 320 for strontium-90.

To perform these calculations, I used conservative upper-bound estimates of the rolling average concentration of both tritium and strontium in the groundwater migrating to the Hudson River. Dr. F. O. Hoffman, Entergy Aquatic Biota Calculations (Feb. 10, 2012) ("Hoffman,

Entergy Aquatic Biota Calculations") (ENT000323). Using the RESRAD-BIOTA dose model, I calculated a dose rate to aquatic organisms in the vicinity of Indian Point of 2.05 x 10^{-9} rad/d for tritium, and 3.71 x 10^{-4} rad/d for strontium-90. Using the UNSCEAR approach, I calculated a dose rate to aquatic organisms in the vicinity of Indian Point of 2.9 x 10^{-9} rad/d for tritium, and 4.7 x 10^{-4} rad/d for strontium-90. These dose rates are orders of magnitude below the DOE 1 rad/d guideline, and support my conclusion that effluent releases from the Indian Point SFPs have not and will not result in any negative effects on the ecosystem. Accordingly, Indian Point radionuclide releases from groundwater to the Hudson River have a SMALL impact on aquatic biota. *See* Hoffman, Entergy Aquatic Biota Calculations (ENT000323).

Q142. Are you aware of any other independent dose assessments of the impact of Indian Point radiological releases on aquatic biota in the vicinity of Indian Point?

A142. (FOH) Yes. In 2009, the NYSDEC published the results of enhanced, independent radiological surveillance of several aquatic species in the lower Hudson River conducted in 2007. *See* NYSDEC Strontium Study (ENT000321). The NYSDEC Strontium Study involved an independent assessment of fish and invertebrates sampling performed as part of Entergy's REMP.

Typically, radiological surveillance under the REMP involves samples of edible tissues of two or more important commercial or recreational fish or invertebrate species (*e.g.*, striped bass, white perch, American eel, catfish, sunfish, or blue crab) performed in the spring and fall of each year at two locations—in the vicinity of Indian Point (approximately river mile 42) and the vicinity of Roseton Generating Station (the traditional reference station at approximate river mile 65, about 21 miles from the Indian Point site). *See* IPEC ODCM App. G (ENT000307). The one-time design modifications for the 2007 effort included: the addition of carp to the target

species list; adding Strontium to the list of radionuclides analyzed; analysis of fish bone or crab carapace; and sampling fish at a third location in the Catskill Region between river miles 107 and 125 to help assure appropriate separation of fish populations that are resident to the river, and, consequently, assures isolation of resident fish populations from the potential influence of Indian Point. NYSDEC Strontium Study at 3 (ENT000321)).

Sampling was conducted by Normandeau Associates, Inc., under contract with Entergy. NYSDEC Strontium Study at 3 (ENT000321). Samples were split three ways between Entergy's contract laboratory, AREVA, Inc.; the NRC Staff for analysis at Oak Ridge Institute for Science and Education; and NYSDOH Wadsworth Center for Labs and Research. NYSDEC Strontium Study at 3 (ENT000321). NYSDEC found that there were no differences in the concentrations of strontium-90 or radium-224 from the three locations in the lower Hudson River. NYSDEC Strontium Study at 6 (ENT000321). In contrast, K-40 levels were somewhat greater in the vicinity of Roseton Generating Station. *See* NYSDEC Strontium Study at 5 (ENT000321). Furthermore, NYSDEC calculated dose rates from strontium-90, uranium-238, and thorium-232 and compared those rates to the DOE standard for protecting aquatic biota. NYSDEC concluded that the levels of radionuclides—including strontium-90—were two to five orders of magnitude lower than the criteria established for protection of freshwater ecosystems. NYSDEC Strontium Study at 8 (ENT000321).

In addition, in October 2011, the National Marine Fisheries Service ("NMFS"), the federal agency responsible for implementing the Endangered Species Act as it concerns marine and anadromous species, issued a Biological Opinion confirming that operation of IP2 and IP3 during the period of extended operation is not likely to jeopardize the continued existence of the endangered shortnose sturgeon. NMFS, Relicensing - Indian Point Nuclear Generating Station

F/NER/2009/00619, Endangered Species Act Section 7 Consultation, Biological Opinion at 61 (Oct. 14, 2011) ("NMFS 2011 Biological Opinion") (ENT000355). In that Biological Opinion, NMFS addressed potential radionuclide releases to the Hudson River, including groundwater releases from SFP leaks. *See* NMFS 2011 Biological Opinion at 49-50 (ENT000355). Based on the information in the NYSDEC Strontium Study, as well as in NRC Staff's FSEIS and Entergy's Annual Radiological Environmental Operating Reports, NMFS reached the following conclusions: "[W]hile shortnose sturgeon may be exposed to radionuclides originating from Indian Point, as well as other sources, any exposure is not likely to be at levels that would affect the health or fitness of any individual shortnose sturgeon. Thus, NMFS considers the effects to shortnose sturgeon from radionuclides to be insignificant and discountable." NMFS 2011 Biological Opinion at 51 (ENT000355).

XIV. RESPONSE TO ISSUES RAISED IN CONTENTION RK-EC-3/CW-EC-1

Q143. The Intervenors' claim that the groundwater impacts are significant because certain radionuclide levels found in onsite groundwater exceed EPA drinking water limits. How does this claim impact your conclusion that the groundwater quality impacts are small?

A143. (MJB, CJP, FOH) As initial matter, EPA Maximum Contaminant Levels ("MCLs") apply only to drinking water from defined drinking water providers and therefore, do not apply to Indian Point site groundwater. *See* May 13, 2008 NRC Inspection Report at 7 (RIV000067); SRM, SECY-97-046A: Final Rule on Radiological Criteria for License Termination at 74 (May 21, 1997) (ENT000356). Indian Point is not a drinking water provider, and no plant-related radionuclides attributable to the Indian Point leakage have affected drinking water in the vicinity of Indian Point, let alone in excess of EPA MCLs. *See* 2010 Annual Radiological Environmental Operating Report at 4-6, C-8 (2011) (attachment to Letter NL-11-

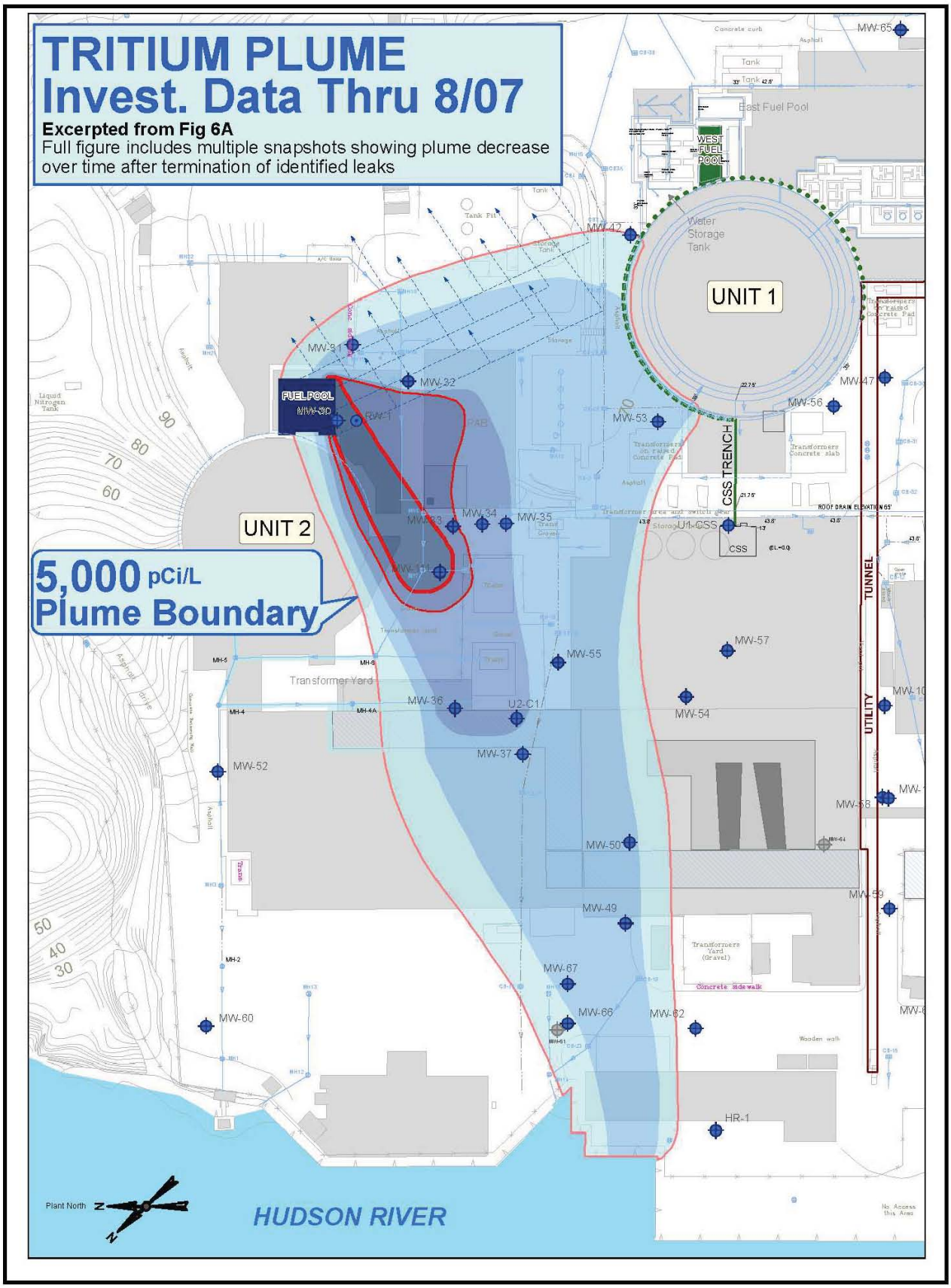
038, from P. Conroy, Entergy, to NRC (May 15, 2011)) (ENT000313). This has been confirmed by NYSDEC, NYSDOH, and the NRC Staff. *See* NYSDEC 2007 Community Fact Sheet at 1 (ENT000325) ("There are no known impacts to any drinking water sources [from Indian Point leaks]"); NYSDEC 2008 Community Fact Sheet (ENT000345) ("No drinking water sources are affected [by Indian Point leaks]"); May 13, 2008 NRC Inspection Report at vii (ENT00331A) ("Currently, there is no drinking water exposure pathway to humans that is affected by the contaminated groundwater conditions at Indian Point Energy Center. Potable water sources in the area of concern are not presently derived from groundwater sources or the Hudson River, a fact confirmed by the New York State Department of Health.").

EPA MCLs are, however, sometimes used as a comparison benchmark for screening purposes. If groundwater levels are below these levels, then there is generally no further need for additional evaluation. If groundwater levels are above those levels, then the next step is to evaluate whether or not there is a completed exposure pathway. In the case of Indian Point, groundwater travels into the Hudson River and that pathway, as we have previously discussed, has been thoroughly evaluated and found to have SMALL impacts.

Q144. On page 30 of his testimony, Mr. Gundersen states that: "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." Do you agree with these statements?

A144. (MJB) No. Contrary to Mr. Gundersen's characterization, the "current" state of radionuclides in groundwater is not "high." In the context of evaluating a leak, a "high" level of contamination for purposes of assessing environmental impacts is best understood as one that has a negative effect on human health or the environment or exceeds NRC's dose regulations. As confirmed by Entergy, the NRC Staff, NYSDEC, and even Riverkeeper, based on its aquatic sampling, the radiation dose and impact on the environment from Entergy's groundwater contamination has always been low and well below applicable regulatory limits.

In addition, the tritium plume boundary demarking the estimated boundary that separates tritium levels greater than 5,000 pCi/L from those below this value, a level of one-quarter the drinking water standard, is shown in Figure 6A of the Q2 2010 GZA quarterly report (ENT00334A). This figure shows attenuation of the tritium plume over time between August 2007 and the second quarter of 2010. As the two excerpted portions below demonstrate, the plume attenuation has been significant and, in fact, the 5,000 pCi/L boundary no longer extends to the river.


TRITIUM PLUME
Invest. Data Thru 8/07
Excerpted from Fig 6A
Full figure includes multiple snapshots showing plume decrease over time after termination of identified leaks
5,000 pCi/L
Plume Boundary
UNIT 1
UNIT 2
FUEL POOL
MW-30
FW-1
WEST FUEL POOL
East Fuel Pool
Water Storage Tank
CSS TRENCH
U1-CSS
CSS
TUNNEL
UTILITY
Transformer Yard
HUDSON RIVER
Plant North
MW-31
MW-32
MW-33
MW-34
MW-35
MW-36
MW-37
MW-42
MW-47
MW-49
MW-50
MW-52
MW-53
MW-54
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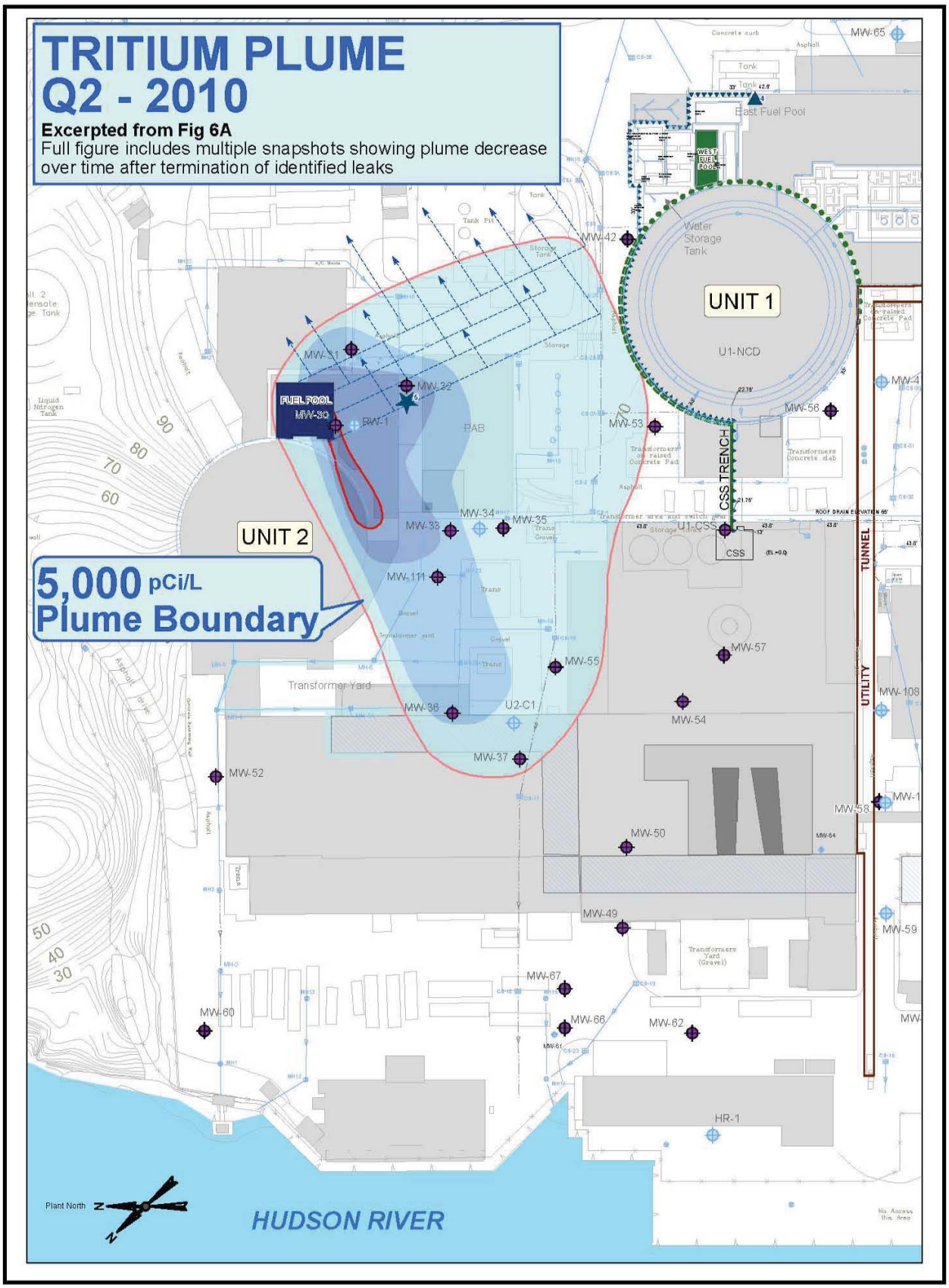
MW-59
MW-60
MW-62
MW-65
MW-66
MW-67
U2-C1
HR-1


TRITIUM PLUME
Q2 - 2010
Excerpted from Fig 6A
Full figure includes multiple snapshots showing plume decrease over time after termination of identified leaks
5,000 pCi/L
Plume Boundary
UNIT 1
UNIT 2
U1-NCD
Water Storage Tank
East Fuel Pool
WEST FUEL POOL
FUEL POOL
MW-30
MW-31
MW-32
MW-33
MW-34
MW-35
MW-36
MW-37
MW-42
MW-49
MW-50
MW-52
MW-53
MW-54
MW-55
MW-56
MW-57
MW-58
MW-59
MW-60
MW-62
MW-65
MW-66
MW-67
MW-108
MW-111
PAB
U2-C1
U1-CSS
CSS
CSS TRENCH
TUNNEL
UTILITY
Transformer Yard
HR-1
Plant North
HUDSON RIVER

Further, the actual levels of radionuclides detected in the groundwater monitoring wells beneath Indian Point have decreased dramatically since source termination (as shown in the two graphs in Answer 100).

Q145. Beginning on page 10, line 32 of his prefiled testimony, Mr. Gundersen states "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" and that the IP2 SFP "will face more aging and leakage issues as the plant continues to operate, not less." Do you agree with Mr. Gundersen's assessment of the likelihood of future leaks?

A145. (TCE) No. As an initial matter, Mr. Gunderson's assertions appear to be based on generalizations and not based on any Indian Point-specific data or engineering analysis. A "bathtub" curve is a commonly used, but often misunderstood term. It is a plot of probability of failure versus time in operation to illustrate, in simple terms, that the probability of an individual component failing is related to its time in service. Most components face an early life "run-in" period where there is a higher likelihood of failure. This is followed by what is commonly many years of low and relatively flat failure likelihood. Eventually, a "wear-out" period occurs when the likelihood of failure begins to increase due to age-related degradation mechanisms.

Mr. Gundersen, however, does not identify any age-related degradation mechanism that would impact the IP2 SFP. To the contrary, evaluations of the IP2 SFP confirm that no active time-dependent aging mechanism is affecting the SFP stainless steel liner or concrete. Lucius Pitkin Report at 18 (ENT000326). In other words, the SFP is operating on the flat part of the curve and there is no indication that it is approaching the knee of the curve—the start of the wear-out period. Lucius Pitkin Report at 18 (ENT000326).

Prior IP2 SFP leaks identified above were not the result of age-related degradation mechanisms. Lucius Pitkin Report at 21 (ENT000326). Absent a time-dependent active degradation mechanism, the only leakage paths through the pool would be weld defects that have been there since construction or maintenance-related damage Lucius Pitkin Report at 25 (ENT000326). These would not be expected to increase in magnitude over time since there is no active corrosion mechanism and the driving pressure and flow rate through them is very low.

Q146. Mr. Gundersen's testimony states at page 11, line 22, that "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" (emphasis added). Do you agree with Mr. Gundersen's characterization of the NRC's review of Entergy's response to Indian Point SFP leaks?

A146. (DMM, CJP) No. Mr. Gundersen's statement is incorrect. The NRC Staff thoroughly evaluated Entergy's SFP leakage investigations and groundwater monitoring program. Mr. Gundersen, however cites to the 2009 Safety Evaluation Report ("SER") for Indian Point license renewal to suggest NRC Staff was only concerned with a serious structural failure of the SFP. For purposes of license renewal, NRC Staff was interested in Entergy's engineering review of the SFP structure and determined that Entergy was appropriately managing the effects of aging.

Although the NRC Staff's license renewal SER appropriately focused on the structural integrity of the SFP to perform its license renewal intended function, Mr. Gundersen does not account for the fact that, as discussed previously, outside of the license renewal context, NRC Staff assessed Entergy's groundwater investigations, including the groundwater monitoring program, as part of the ongoing Reactor Oversight Process. The primary focus of NRC's

Reactor Oversight Process assessment was on the potential for offsite impacts to public health, safety, and the environment. Thus, contrary to Mr. Gundersen's suggestion, NRC Staff was concerned about and fully considered whether and the extent to which SFP leaks enter and may impact the environment.

Q147. Beginning on page 24, line 13 of his prefiled testimony, Mr. Gundersen states: "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." Does this statement impact your conclusions about Entergy's dose calculations and the potential for human health impacts?

A147. (CJP, FOH) No. Entergy reviewed the potential for other credible exposure pathways in the vicinity of Indian Point discharges to the Hudson River and appropriately concluded that exposure via consumption of fish was the only credible exposure pathway of concern. *See* CHM-12-005 (ENT000329); Consolidated Edison, An Evaluation to Demonstrate the Compliance of the Indian Point Reactors with the Design Objectives of 10 CFR Part 50, App. I, Vol. 1 – Main Report (ENT000330). If other hypothetical exposure pathways had been considered, such as swimming, boating, and inadvertent consumption of water while swimming, the resulting additional doses to a hypothetical maximally exposed individual would be a negligible fraction of the already small dose from fish consumption alone. In other words, even if you added the dose from these other pathways, it would not result in a material increase in the overall dose. *See* CHM-12-005 (ENT000329); Consolidated Edison, An Evaluation to

Demonstrate the Compliance of the Indian Point Reactors with the Design Objectives of 10 CFR Part 50, App. I, Vol. 1 – Main Report at 39-40, 74 (ENT000330).

Q148. Beginning on page 24, line 16 of his prefiled testimony, Mr. Gundersen cites the National Research Council "BEIR VII" report (RIV000093), and states that this report concludes "that every exposure to radiation, regardless of how small, produces a corresponding increase in the likelihood of cancer" and therefore any release from Indian Point into the Hudson River "could increase the incidence of cancer to those exposed through recreational activities, such as swimming." Does this statement impact your conclusions about the potential for human health impacts?

A148. (CJP, FOH) No. In fact, the BEIR VII report confirms the inconsequential nature of the dose from the Indian Point groundwater and storm water pathway. The BEIR VII report endorses the "linear-no-threshold" hypothesis, which conservatively assumes that at low doses a simple proportionate relationship exists between radiation dose and cancer risk, even though epidemiology studies do not find this relationship to be statistically significant at low doses. *See* BEIR VII Report at 6-10, 14 (RIV000093). The linear-no-threshold hypothesis forms the basis for NRC's radiation protection regulations in 10 C.F.R. Part 20. *See* Final Rule, Standards for Protection Against Radiation, 56 Fed. Reg. 23,360, 23,360-61 (May 21, 1991) (ENT000358).

For purposes of the linear-no-threshold hypothesis, the BEIR VII report defines low doses as doses up to about 10,000 mrem (0.1 Sv). BEIR VII Report at 2 (RIV000093). The BEIR VII model predicts that approximately 1 person in 100 would be expected to develop cancer from a dose of 10,000 mrem above background, while approximately 42 of the 100 individuals would be expected to develop cancer from other causes. BEIR VII Report at 8 (RIV000093).

Applying the BEIR VII report's linear no-threshold model, the risk from 0.0002 mrem (the 2010 the total annual radiation dose to a hypothetical maximally exposed individual from groundwater and storm water releases) is 1 additional incidence of cancer in 5 billion. In other words, if 5 billion people (almost the entire world's population) were maximally exposed to groundwater releases from Indian Point, one additional incidence of cancer would be expected. But because 0.0002 mrem is the dose to the hypothetical maximally exposed individual, 1 in 5 billion actually overstates the risk from groundwater and storm water releases. It is unrealistic to assume that many people are eating 3 or 4 pounds of Hudson River fish each month for an entire year. *See* IPEC ODCM Pt. II, § 2.4.3, at 15 (ENT000307). Thus, the BEIR VII model conclusively demonstrates that the low dose consequences from SFP leaks have no material negative human health effects.

Q149. Beginning on page 6 of her prefiled testimony (RIV000061), Dr. Stewart refers to an application by United Water to build a desalination plant that proposes to take water out of the Hudson River to supply drinking water, and states that Indian Point poses "a clear and imminent threat" to this facility and that "Sr-90, H-3, and Cs-137 leaks will need to be stopped and some decontamination efforts will need to be taken before the water in the Hudson near Indian Point is consistently safe for human consumption." Do these statements impact your conclusion that human health impacts are small?

A149. (CJP, FOH) No. Indian Point is not required to account for a *potential* future water use in its dose calculations to demonstrate compliance with NRC and EPA regulations. However, if a desalination plant becomes a reality, then a potable water pathway will be included in routine effluent calculations pursuant to the ODCM. *See* IPEC ODCM at D 3.5.1 - 2 (ENT000307). The annual required "Land Use Census" will ensure this is accomplished if plans

to build this plant go forward, just as it would capture any other environmental changes that suggest the need for reevaluation of effluent or environmental monitoring. *See* IPEC ODCM at D 3.5.1 - 2 (ENT000307).

In any event, it is highly unlikely that the facility proposed by United Water would result in any material change in the already small public dose resulting from liquid effluent releases from Indian Point including groundwater releases. United Water New York has developed a Draft Environmental Impact Statement and Water Supply Permit Application for the Haverstraw Water Supply project that proposes to use water from the Hudson River estuary down river from Indian Point. *See* United Water DEIS (RIV000101); United Water Supply Permit Application (ENT00320A-D). As indicated in the DEIS, United Water conducted a radionuclide sampling program for the Haverstraw Water Supply, with results presented in Table 2-4 of its Draft Environmental Impact Statement. *See* United Water DEIS at 2-9 (RIV000101).

The results of United Water's sampling program include Hudson River water samples collected in 2007 and 2008, a period which would reflect any Indian Point SFP leak groundwater releases to the Hudson River. Notably, all EPA drinking water standards for radionuclides were met in *untreated* water. In particular, strontium-90 was measured to average 0.68 picocuries/liter as compared to an EPA standard of 8 picocuries/liter and tritium averaged 36 picocuries/liter as compared to an EPA standard of 20,000 picocuries/liter. *See* United Water DEIS at 2-9 (RIV000101). For tritium only one of 11 samples showed the presence of tritium and at a level of 0-397 picocuries/liter. *See* United Water DEIS at 2-9 (RIV000101). Furthermore, the gross beta activity of 10.8 picocuries/liter identified in the United Water DEIS is very likely due to the presence of potassium in the water which is reported as 21 milligrams/liter. *See* United Water DEIS at 2-5 (RIV000101). Hudson River estuarial water is brackish due to the mixture of sea

water with fresh water. Sea water contains potassium at typical levels of 390 milligrams/liter, which results in a beta activity of 290 picocuries/liter. *See* DOE, UCRL-TR-214061, Radioactivity of Potassium Solutions: A Comparison of Calculated Activity to Measured Activity from Gross Beta Counting and Gamma Spectroscopy Ref. UCRL-TR-214061, at 3-4 (July 26, 2005) (ENT000359). Natural potassium includes the isotope potassium-40 which is radioactive and forms a significant part of our natural background. In summary, United Water's sampling confirms the conclusion that radionuclide releases from Indian Point are so small as to have no detectable effect on the levels of radionuclides in the river from non-plant-related sources.

Furthermore, the proposed desalination facility plans to treat the brackish water using reverse osmosis, which will remove salts and pass pure water. United Water DEIS at 2.2.2.2 (RIV000101). Although any tritium, being part of the water molecule, will pass through the reverse osmosis membrane, other radionuclides will be removed and be returned to the Hudson River along with the other salts, such as sodium and potassium. Tritium at a concentration of 36 picocuries/liter would result in a dose less than 1×10^{-2} mrem/year based on a comparison with the EPA drinking water standard. *See* 40 C.F.R. § 141.66, Tbl. A.

Q150. Beginning on page 3 of her prefiled testimony, Dr. Stewart states: "Both Sr-90 and Cs-137 have half-lives of approximately 30 years and so can be expected to remain in the system for over 150 years or 5 half-lives. A careful study of the temporal and spatial distribution of these isotopes should be conducted before water from the Hudson River is considered safe for human consumption." Do you agree with this conclusion?

A150. (CJP, FOH) No. Although Dr. Stewart suggests that more sampling is necessary in the area directly adjacent to Indian Point and to the intake of the proposed desalination facility

to verify temporal and spatial variability, this would merely further confirm that the origin of measured amounts of strontium-90 and cesium-137 in samples taken from the Hudson River was from historic fallout from atmospheric testing of nuclear weapons. The residence time of radionuclides discharged from Indian Point to the Hudson River will be determined more by dilution and flushing out of the Hudson River than by radioactive decay alone. Thus, the statements made by Dr. Stewart about the amount of time strontium-90 and cesium-137 from Indian Point will remain in the Hudson River "system" is a gross exaggeration.

In fact, more recent testing as part of a pilot study for the desalination plant reported in the December 2011 Water Supply Permit Application by United Water has already confirmed this result. *See* United Water Supply Permit Application at § 4, at 4-5 to 4-7; *id.* § 4, App. B, Tbl. 1A at 1; Tbl. 1B at 6; Tbl. 2A at 13; Tbl. 2B at 18. (ENT00320A-D). Specifically, the Water Supply Permit Application provides a few additional data points for the period 2007 to 2008. The results are consistent with the somewhat smaller set of data provided in Table 2.4 of the Haverstraw Draft Environmental Impact Statement for the same period.

The Water Supply Permit application also presents results from more recent tests performed on raw water taken from the Hudson River and processed in a pilot plant project from December 2010 to July 2011. United Water, Water Supply Permit Application at § 4, at 4-5; *id.* § 4, App. B, Tbl. 1B at 6; Tbl. 2B at 18. (ENT00320A-D). Results are presented for the concentrations in the input water to the reverse osmosis ("RO") system and the concentrated waste stream out from the reverse osmosis system. *See* United Water, United Water Supply Permit Application § 4, at 4-5; *id.* § 4, App. B, Tbl. 1B at 6; Tbl. 2B at 18 (ENT00320A-D). Radionuclide data for raw water is in the same general ranges as for the 2007 to 2008 period, and a comparison of the input stream to the reverse osmosis system with the waste output stream

shows minerals and radioactive components except tritium are concentrated in the waste stream, as expected. *See* United Water, United Water Supply Permit Application § 4, at 4-5; *id.* § 4, App. B, Tbl. 1B at 6; Tbl. 2B at 18 (ENT00320A-D). These data confirm that the concentrations of radioactive elements at the intake to a potential water processing facility are well below EPA drinking water standards and that the use of reverse-osmosis will remove most of what is present. *See* EPA, Basic Information about Radionuclides in Drinking Water at 3 of 4 (ENT000360). Further, these concentrations are primarily the result of and the sum of natural background radioactivity and residual weapons testing fallout, with no observable contributions from the Indian Point releases.

In summary, these empirical data show that any increase in dose to the public due to the operation of a United Water reverse-osmosis water treatment facility at Haverstraw would be very small, and radionuclide levels in the drinking water produced would be a very small fraction of EPA's drinking water standards. Moreover, required sampling after treatment will determine whether the water is safe regardless of the isotopes' temporal and spatial distribution. *See* FSEIS at A-95 (NYS00133D).

Q151. On page 23 of Mr. Gundersen's prefiled testimony and pages 3 to 5 of Dr. Stewart's prefiled testimony, they state that strontium-90 bioaccumulates and therefore could impact Hudson River fish in the future. Do these statements impact your conclusion about the potential for environmental impacts?

A151. (FOH) No. All of the factors presented by Dr. Stewart with regard to varying radionuclide behavior in the human body or accumulation in biota consumed by humans are already taken into account by Entergy in its dose assessment. The dose calculations performed by Entergy, which are consistent with guidance given in NRC Regulatory Guide 1.109, assume

that bioaccumulation occurs at the point of the maximum conceivable discharge, prior to mixing and dilution by the ebb and flow of the Hudson River estuarine system. Thus, the dose calculations very likely overestimate actual doses received by people who consume fish and other organisms harvested from the Hudson River. IPEC ODCM Pt. II, § 2.6, at 16 (ENT000307).

Further, Mr. Gundersen's and Dr. Stewart's conclusions are overly simplistic. Whether or not exposures of fish to Indian Point releases of strontium-90 (and other radionuclides) result in a material "impact" to Hudson River fish in the future will depend on the dose rate delivered to the fish. Mr. Gundersen and Dr. Stewart make no effort to estimate the dose rate to fish from Indian Point releases of strontium-90 and other radionuclides. As discussed above, I have performed such an assessment and conclude that dose rates are orders of magnitude below the 1 rad/day guidelines used to assess the potential for ecologically significant impacts. *See* Hoffman, Entergy Aquatic Biota Calculations (ENT000323). In addition, an ecological dose rate and risk assessment performed by NYSDEC that examined the total amount of all radionuclides monitored in Hudson River fish, including strontium-90 from fallout and radium-226, thorium-232, and uranium-238 from natural sources, and concluded that the combined total dose rate would be two to five orders of magnitude below the 1 rad/day dose rate used as a screening benchmark for ecological protection of aquatic biota. NYSDEC Strontium Study at 8 (ENT000321).

Q152. On page 23 of Mr. Gundersen's prefiled testimony, Mr. Gundersen references strontium-90 and strontium-89 data from the 1970s and 1980s and states that this data "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." Do you agree with this statement?

A152. (FOH) No. The implication by Mr. Gundersen that 1970s and 1980s measurements of strontium-89 and strontium-90 in fish of the Hudson River are connected to releases from the Indian Point nuclear power station is without scientific basis. It is well known that measurable levels of strontium-90 in the bones of fish and carapace of shellfish are typically the result of widespread fallout from atmospheric testing of nuclear weapons from 1945 through 1963, with additional above-ground nuclear tests by France conducted during the 1970s and by China until 1980. *See* Steven Simon, Andre Bouville, and Charles Land, Fallout from Nuclear Weapons Tests and Cancer Risk, 94 Sci. Am. 48-57 (2006) (ENT000361); UNSCEAR, Sources and Effects of Ionizing Radiation, Report to the General Assembly [("UNSCEAR 2000 Report")] Vol. I, Annex C (2000) (Exposures to the public from man-made sources of radiation) (2000) (ENT000362).

The presence of strontium-89 (half-life of 50.6 days) detected sporadically in Hudson River fish and shellfish in 1974 and 1977 is an indication that such fallout occurred within a period of several months, not that releases were from the Indian Point. In the NYSDEC Strontium Study, there were no statistically significant differences in strontium-90 concentrations in fish bone between the three locations for non-migratory resident fish species. NYSDEC Strontium Study at 6 (ENT000321). This is consistent with what would be expected from widespread weapons fallout deposition and subsequent run-off of strontium-90 into surface

streams and rivers. *See* UNSCEAR 2000 Report Vol. I, Annex C (ENT000362). The NYSDEC findings from the 2007 radiological surveillance study were also consistent with what I would expect to see for strontium-90 originating in fallout from historic testing of nuclear weapons.

Q153. On page 24 of his prefiled testimony, Mr. Gundersen states that the NYSDEC Strontium Study conclusion that there is no difference between fish near Indian Point and upstream failed to note "other possible upstream sources of Strontium-90, especially the Knolls Atomic Power Lab (KAPL)." Does Mr. Gundersen's statement call the findings in the NYSDEC Strontium Study into question?

A153. (FOH) No. It is clear from the NYSDEC Strontium Study (ENT000321) and its references that the source of strontium-90 detected in fish and shellfish from the Hudson River originated from widespread fallout from atmospheric testing of nuclear weapons from 1945 through the 1980s. Further, there is no indication that any strontium-90 releases from the Knolls Atomic Power Lab contributed to the lack of a significant difference among the concentrations of strontium-90 in the samples taken at different locations upstream and downstream from Indian Point by NYSDEC in 2007. Although the NYSDEC Strontium Study was a "one-time" investigation, the concentrations of strontium-90 reported in fish bone and the carapace of blue crab are consistent with what would be anticipated from fallout and run-off into streams and rivers and the subsequent bioaccumulation of strontium-90 into fish and invertebrates. Finally, regardless of the source, the study found that the dose impact was orders of magnitude below the guidelines used to assess the potential for ecologically significant impacts. NYSDEC Strontium Study at 8 (ENT000321).

Q154. On page 9 of his prefiled testimony, Mr. Gundersen states that "the Unit 2 SFP leak-collection box installed in 2007 failed in 2010 to meet its intended design function to collect any radioactive leaks." Do you agree with his statement?

A154. (DMM, MJB) No. Mr. Gundersen's statements are incorrect for several reasons. As an initial matter, temporary devices were installed in 2005 immediately after moisture associated with shrinkage cracks was observed. Site Investigation Report at 94 (ENT00331B). The permanent stainless steel Leak Collection Device was installed and operational in February 2006 to contain the identified moisture. Site Investigation Report at 95 (ENT00331B). More importantly, the Leak Collection Device has successfully functioned as intended since that time by monitoring and containing SFP leakage. In this regard, it has provided an IP2 SFP-specific monitoring system, which in addition to the Long-Term Groundwater Monitoring Program well network, provides data which may be indicative of a potential leak. These data have been used in this manner as the trigger for further investigations, as discussed above. In addition, any flow into the Leak Collection Device is completely captured and precluded from entering the groundwater outside the SFP. After capture and testing, this water is discharged through a monitored pathway. *See* Site Investigation Report at 95 (ENT00331B).

Q155. On pages 25, lines 18 to 19 of his prefiled testimony, Mr. Gundersen states: "Remediation of the radiological contamination via extraction wells is a far superior approach for handling the contamination and leak issues at Indian Point." Do you agree with this statement?

A155. (DMM, MJB, CJP) No. As discussed above, GZA has and continues to recommend, Monitored Natural Attenuation as the preferred remediation action for Indian Point, a conclusion also approved by both NRC Staff and NYSDEC. *See* May 13, 2008 NRC

Inspection Report at 17 (RIV000067); NYSDEC 2008 Community Fact Sheet at 1 (ENT000345). Monitored Natural Attenuation is a recognized and proven remedial action that allows natural processes to reduce contaminant concentrations. This approach provides the most appropriate balance between site-specific benefits and risks, particularly considering ALARA guidelines.

During the early stages of the project, GZA considered other potentially applicable remedial approaches in addition to Monitored Natural Attenuation, primarily focusing on groundwater extraction technologies. This initial work was documented in a July 19, 2006 Hydraulic Control Plan (ENT000363), which provided a preliminary overview of GZA's then-current thinking on the feasibility of limiting radionuclide migration from the SFP source areas through extraction. As recommended in this plan, a pilot pumping test was subsequently conducted proximate to the IP2 SFP (pumping well RW-1) in October 2006. This test showed that it was likely possible to effectively capture the tritium plume around the IP2 SFP.

However, the detection of strontium near the pumping well shortly after the testing was performed also demonstrated that pumping was more likely than originally predicted to cause strontium migration from IP1 to IP2. Such pumping-induced migration would lead to partitioning and thus adsorption of strontium to the subsurface geologic materials, resulting in increased residual contamination over an additional acre of land between IP1 and IP2. This finding demonstrated that there was at least one additional substantial disadvantage to this remedial approach than originally understood. As a consequence, the pumping test report was never finalized. Subsequent evaluations led to the selection of Monitored Natural Attenuation over groundwater extraction as the preferred remedial action for the site. This conclusion was

reached in consultation with NRC Staff and NYSDEC. *See* May 13, 2008 NRC Inspection Report at 17 (RIV000067); NYSDEC 2008 Community Fact Sheet at 1 (ENT000345).

Q156. Mr. Gundersen relies on the Supplemental Report of the Public Oversight Panel Regarding the Comprehensive Reliability Assessment of the Vermont Yankee Nuclear Power Plant (July 20, 2010) ("Vermont Yankee Report") to support a statement on page 19 of his prefiled testimony that Entergy's "failure to adequately fund maintenance contributes significantly to the likelihood of radiological leaks at Indian Point." Do you agree with Mr. Gundersen's characterization of the referenced report, and his assertion that Entergy is not committing adequate resources to maintain its nuclear generating stations?

A156. (DMM, TCE) No. Other than a passing reference to the Indian Point Independent Safety Evaluation ("ISE") Report (July 31, 2008) ("ISE Report") (ENT000364), the Vermont Yankee Report says nothing about Entergy Nuclear Operations or the operation of or conditions at Indian Point. *See* Supplemental Report of the Public Oversight Panel Regarding the Comprehensive Reliability Assessment of the Vermont Yankee Nuclear Power Plant, July 20, 2010 (RIV000088). A review of the ISE Report, which is quoted in the Vermont Yankee Report, demonstrates that Mr. Gundersen's characterization of Entergy's maintenance funding is incorrect. To provide context, the ISE Report resulted from Entergy's commission of a panel of experts (the "ISE Panel") to conduct "an independent evaluation of Indian Point's safety, security and emergency preparedness." ISE Report at 6 (ENT000364). The ISE Panel, consisting of distinguished experts in the nuclear field with no professional ties to Entergy or Indian Point, "represented virtually every facet of nuclear plant safety, security and emergency preparedness, from a variety of vantage points, and with full independence." ISE Report at 6

(ENT000364). The ISE Panel specifically concluded that Indian Point had been adequately maintained:

> The Panel found that Indian Point nuclear safety meets the U.S. nuclear industry highest standards in most respects. *Indian Point nuclear operations are conducted competently and professionally, plant safety systems are well maintained, reliable and are backed with full resource commitment by the plant owner*. Control Room operations—a key indicator of plant nuclear safety culture—were observed frequently by the Nuclear Safety Team and other ISE Panelists and found to be consistently professional and effective. *Indian Point management, at all levels, is clearly attentive to nuclear safety*.

ISE Report at 146 (emphasis added) (ENT000364). The ISE did find that while station personnel paid close attention to the plant safety systems, there were some deficiencies in the physical condition of some non-safety parts of the plant, but were unrelated to SFPs or associated systems. ISE Report at 11 (ENT000364). Indeed, the ISE Report also found that Entergy has more recently made a significant effort to improve in this area, finding that "Entergy has invested heavily in improving the overall material condition of the plant." ISE Report at 47 (ENT000364).

XV. CONCLUSIONS

Q157. Please summarize your testimony and the bases for your conclusions regarding Contention RK-EC-3/CW-EC-1.

A157. (DMM, ABC, TCE, MJB, CJP, FOH) The NRC Staff FSEIS appropriately concluded that new information regarding radionuclide leaks from IP1 and IP2 SFPs into the groundwater and Hudson River ecosystem, is not significant. The Intervenors have provided no information demonstrating the environmental impacts from such leaks on human health, groundwater quality, and ecological resources are anything other than SMALL, as defined by 10 C.F.R. Part 51, Appendix B, Table B-1.

Entergy extensively studied the hydrogeology and the groundwater flow mechanisms at Indian Point, and installed a broad network of groundwater monitoring wells in order to routinely monitor the movement of radionuclides in groundwater that are principally the result of past releases of water from IP1 and IP2 SFPs, and also to help detect future releases of radionuclides into groundwater. As a result of this monitoring, Entergy has determined that some of the groundwater beneath the site contains detectable levels of radionuclides, principally tritium (mostly resulting from past IP2 SFP leakage), and strontium (resulting from the now-empty and drained IP1 SFPs). This leakage has resulted in low levels of tritium and strontium reaching the river, in amounts orders of magnitude below federal regulatory dose limits for planned and unplanned radiological effluent releases. Thus, as we previously explained in detail, impacts to human health, groundwater quality, and Hudson River ecological resources due to radionuclides in site groundwater have and will continue to be SMALL—*i.e.*, impacts are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource.

Q158. Does this conclude your testimony?

A158. (DMM, ABC, TCE, MJB, CJP, FOH) Yes.

Q159. In accordance with 28 U.S.C. § 1746, do you state under penalty of perjury that the foregoing testimony is true and correct?

A159. (DMM, ABC, TCE, MJB, CJP, FOH) Yes

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

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