March 1, 2017

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
	)	
FLORIDA POWER & LIGHT COMPANY	)	Docket Nos. 52-040 & 52-041
	)	
(Turkey Point Units 6 and 7)	)	

REVISED NRC STAFF TESTIMONY
OF ANN L. MIRACLE, DANIEL O. BARNHURST, PAUL D. THORNE, AND
ALICIA WILLIAMSON-DICKERSON CONCERNING CONTENTION 2.1
(Impacts of Deep Well Injection of Four Constituents in Cooling-Tower Blowdown)

Q1. Please state your names, occupations, and by whom you are employed.

A1(a). My name is Ann L. Miracle (ALM). I am employed as a Senior Scientist, Environmental Assessment Group, in the Earth Systems Science Division at the Pacific Northwest National Laboratory (PNNL) in Richland, Washington. I am employed by the Battelle Memorial Institute (Battelle), which manages and operates the PNNL facilities for the U.S. Department of Energy. I am providing this testimony under a technical assistance contract between the staff of the U.S. Nuclear Regulatory Commission (NRC) and PNNL. A statement of my professional qualifications is attached hereto. (NRC-003).

A1(b). My name is Daniel O. Barnhurst (DOB). I am a licensed Professional Geologist (P.G.) employed as a Hydrogeologist in the Environmental Technical Support Branch of the Division of Site Safety and Environmental Analysis (DSEA), in the Office of New Reactors (NRO) at the NRC. A statement of my professional qualifications is attached hereto. (NRC-004).

A1(c). My name is Paul D. Thorne (PDT). I am employed as a Senior Research Scientist in the Earth Systems Science Division at PNNL. I am employed by Battelle, which manages and operates the PNNL facilities for the U.S. Department of Energy. I am providing this testimony under a technical assistance contract between the NRC Staff and PNNL. A statement of my professional qualifications is attached hereto. (NRC-005).

A1(d). My name is Alicia Williamson-Dickerson (AWD). I am employed as an Environmental Project Manager in Licensing Branch 4 in the Division of New Reactor Licensing in NRO at the NRC. A statement of my professional qualifications is attached hereto. (NRC-006).

Q2. Please describe your current responsibilities.

A2(a). (ALM) As a Senior Scientist, I lead project teams in developing assessments under the National Environmental Policy Act of 1969, as amended (NEPA), for federal clients with actions associated with energy development or sustainability. In addition, I prepare aquatic ecology analyses, including ecotoxicology assessments, for NEPA documents, and consultation assessments under Section 7 of the Endangered Species Act and the Magnuson-Stevens Act.

A2(b). (DOB) As a hydrogeologist with the NRC I work as part of a team that evaluates safety and environmental hydrological impacts for new and operating nuclear reactors. For the last five years, I have worked almost exclusively performing hydrological evaluations for seven NEPA Environmental Impact Statements. These evaluations have included analyses of geologic and characterization data (*e.g.*, geologic studies, geologic and geophysical well logs, subsurface geophysics, aquifer tests, laboratory tests), analyses of numerical models of groundwater flow and contaminant fate and transport, hydrogeological conceptual model development, and determination of water use and quality impacts.

A2(c). (PDT) As a Senior Research Scientist and hydrogeologist specializing in subsurface fluid flow, I work to understand groundwater flow systems using tools such as well flow testing, wellbore geophysical logging, surface geophysics, rock sample characterization, borehole fluid chemistry, and numerical modeling of fluid flow in the subsurface. I have recently worked on the storage of carbon dioxide in deep saline aquifers, and on geothermal energy development.

A2(d). (AWD) As the Environmental Project Manager, I am responsible for the environmental review of the Florida Power & Light (FPL) application, submitted in June 2009, for combined construction permits and operating licenses (combined licenses or COLs) for the proposed Turkey Point Units 6 and 7.

Q3. Please explain what your duties have been in connection with the NRC Staff review of the license application for the proposed Turkey Point Units 6 and 7.

A3(a). (ALM) As part of my official responsibilities, I assisted the NRC Staff in its evaluation of the potential environmental impacts to aquatic ecological resources related to the Applicant's construction and operation of the proposed Turkey Point Units 6 and 7 and its associated facilities, including an assessment of toxicological impacts to aquatic resources. Further, I assisted in the preparation of the Staff Draft Environmental Impact Statement (DEIS), issued in February 2015 (NRC-007A-B), and the Staff Final Environmental Impact Statement (FEIS), issued in October 2016. NUREG-2176, Environmental Impact Statement for Combined Licenses (COLs) for Turkey Point Nuclear Plant Units 6 and 7, Final Report (October 2016) (NRC-008A-D).

A3(b). (DOB) As an expert in hydrogeologic characterization including groundwater flow and contaminant transport, I worked as part of a team of technical professionals to evaluate the potential groundwater impacts from building and operating the proposed Turkey Point Units 6 and 7 and associated facilities. This included preparation of groundwater hydrology sections of both the Staff DEIS, issued in February 2015 (NRC-007A-B), and the Staff FEIS, issued in October 2016 (NRC-008A-D). As it relates to this contention, I evaluated the potential impacts to groundwater quality from the proposed injection of station blowdown water and other liquid waste streams into the Boulder Zone—a cavernous, high-permeability South Florida geologic horizon located at depths of approximately 2,900 to 3,500 ft. in the Lower Floridan aquifer, which is described in detail below.

A3(c). (PDT) As an expert in groundwater flow and the movement of contaminants in the subsurface, I assisted the NRC Staff in its evaluation of potential groundwater impacts from building and operating the proposed Turkey Point Units 6 and 7 and associated facilities. I also assisted in the preparation of the Staff DEIS, issued in February 2015, and the Staff FEIS, issued in October 2016. As it relates to this contention, I assisted the NRC Staff in assessing the potential impacts to groundwater quality from the proposed injection of station blowdown water and other liquid waste streams into the Boulder Zone—a cavernous, high-permeability South Florida geologic horizon located at depths of approximately 2,900 to 3,500 ft. in the Lower Floridan aquifer. I assisted the NRC Staff with the evaluation of reports and other information related to observations of the upward movement of injected municipal wastewater from the Boulder Zone at deep well injection sites in Florida including the South District Wastewater Treatment Plant.

A3(d). (AWD) I was responsible for managing a team of technical experts, consisting of NRC Staff and contractors, who evaluate and analyze various resource areas considered in the NRC Staff environmental review of the proposed Turkey Point Units 6 and 7 COL application, which the NRC performs to fulfils the NRC's regulatory responsibilities under NEPA, as implemented in 10 C.F.R. Part 51. To document that review, I managed the completion and publication of the FEIS (NRC-008A-D).

Q4. What is the purpose of this testimony?

A4(a). (ALM) The purpose of my testimony is to explain conclusions reached in the FEIS concerning toxicological impacts to water resources and the information that supports those conclusions and to sponsor into evidence the exhibits identified in my testimony.

A4(b). (DOB) The purpose of my testimony is to explain how the Staff review documented in the FEIS supports the conclusion that there would be SMALL impact on groundwater resources resulting from deep injection of plant effluent and to sponsor into evidence the exhibits identified in my testimony.

A4(c). (PDT) The purpose of my testimony is to explain conclusions reached in the FEIS concerning impacts to groundwater resulting from deep injection of plant effluent and the information that supports those conclusions and to sponsor into evidence the exhibits identified in my testimony.

A4(d). (AWD) The purpose of my testimony is to sponsor into evidence the DEIS (NRC-007A-B), the FEIS (NRC-008A-D), and the supplement to the FEIS (NRC-049).

BACKGROUND INFORMATION REGARDING CONTENTION 2.1.

Q5. Are you familiar with Contention 2.1?

A5. (DOB, PDT, ALM, AWD) Yes, as reformulated by the Atomic Safety and Licensing Board (Board), Contention 2.1 reads as follows:

> The DEIS is deficient in concluding that the environmental impacts from FPL's proposed deep injection wells will be "small." The chemicals ethylbenzene, heptachlor, tetrachloroethylene, and toluene in the wastewater injections at concentrations listed in DEIS Table 3-5 may adversely impact the groundwater should they migrate from the Boulder Zone to the Upper Floridan Aquifer.

Florida Power & Light Co. (Turkey Point Units 6 & 7), LBP-16-03, 83 NRC 186 (2016). The standard the NRC Staff uses to determine whether an environmental impact is "SMALL" is set forth in A21-A25. Descriptions of the chemical constituents identified in Contention 2.1 are in

A17 and A30-A38. A general description of the stratigraphy of the Turkey Point site, including the Boulder Zone and the Upper Floridan aquifer, is in A15-A16. These constituents are ethylbenzene, tetrachloroethylene, toluene, which are volatile organic compounds (or VOCs) and heptachlor, a pesticide (hereafter referred to as the "Constituents").

Q6. If, hypothetically, the Constituents at the concentrations listed in FEIS Table 3-5 were injected directly into the Upper Floridan aquifer, which is an Underground Source of Drinking Water (USDW), what, in your professional opinion, would be the effect on human health?

A6. (ALM) As described in more detail below, if the concentrations of the Constituents as listed in FEIS Table 3-5, Expected Constituents and Concentrations Discharged to the Deep-Injection Wells, were directly added to the Upper Floridan aquifer and if the Upper Floridan aquifer was used for drinking in the region of the site, there would be no adverse human health impact as the concentrations do not exceed the EPA Maximum Contaminant Levels (often referred to as MCLs) for safe drinking water.

Q7. If, hypothetically, injectate were to rapidly migrate from the Boulder Zone to the Upper Floridan aquifer, will the groundwater quality be adversely impacted?

A7. (DOB, PDT) No.

Q8. What's the Staff bases for the answers to the hypothetical questions posed in Q7?

A8. (DOB, PDT) As will be described in detail throughout the rest of this testimony, in the FEIS the Staff addressed the impacts of rapid migration of injectate from the Boulder Zone into the Upper Floridan aquifer, which has been identified as an Underground Source of Drinking Water (USDW). As described in section 5.2.1.3, "Boulder Zone" and 5.2.3.2, "Groundwater-Quality Impacts," Appendix G.3.3.2, "Confirmatory Calculations of Potential Upward migration of Injectate from the Boulder Zone of the Lower Floridan Aquifer," and

Appendix E (FEIS App. E at E211-E213), the South District Wastewater Treatment Plant has implemented advanced treatment that has been determined by the EPA to be protective of health even if migration to an Underground Source of Drinking Water (USDW) occurs. Under these circumstances, concentrations of Constituents in effluent at the point of injection are below EPA Maximum Contaminant Levels and so low as to be protective of human health. Separate relative risk assessments performed by the EPA (TN4759; NRC-010) and a multi-disciplinary team of scientists and regulators (Bloetscher (2005) TN4756, NRC-011), indicate that impacts to human health from direct release to the Upper Floridan aquifer would be lowest for deep-well injection, and that dilution during migration would be substantial. In addition, the cooling water in the circulating water system will cycle through the cooling-towers for four cycles, and this will further reduce Constituent concentrations. Finally, FPL and independent Staff evaluations indicate that dilution would be expected to further reduce concentrations of Constituents even if rapid migration were to occur. Therefore, the Staff concludes that hypothetical rapidly-migrating injectate will not adversely affect the groundwater. The bases for this conclusion is further explained below in A26 through A68, and in A84 through A88.

Q9. What portion of the DEIS does Contention 2.1 dispute?

A9. (DOB, PDT) Contention 2.1 disputes the Staff conclusion in DEIS § 5.2.3.2 that operation of proposed Turkey Point Units 6 and 7 will result in a SMALL impact to groundwater quality.

Q10. What plant systems did the Staff consider in connection with Contention 2.1?

A10. (DOB, PDT) In connection with Contention 2.1, the Staff considered the circulating-water system, the cooling-towers, and injection wells for blowdown from the cooling-towers. The operation of these systems and interaction of these systems with the environment is explained in FEIS Section 3.2.2.2, 3.4.2.2, 3.4.2.3 and 3.4.4.2 (NRC-008A at 3-8 to 3-14, 3-30 to 3-32, 3-37 to 3-39).

Q11. How do those systems operate?

A11. (DOB, PDT) The circulating-water system removes waste heat from the facility and rejects that heat to the environment through the mechanical draft cooling-towers. A large portion of the cooling water will evaporate as it is circulated a maximum of four times through the cooling system. Make-up water will be added to the system to compensate for that lost to evaporation. Water in the cooling system that is no longer suitable for use (called "blowdown") would be combined with other plant effluent and returned to the environment by deep well injection. (FEIS at 3-9; NRC-008A at 3-9).

Q12. What is the source of cooling water for Turkey Point Units 6 and 7?

A12. (DOB, PDT) For Turkey Point Units 6 and 7, FPL's primary source of cooling water would be reclaimed wastewater from the Miami-Dade Water and Sewer Division South District Wastewater Treatment Plant. The reclaimed wastewater will be treated at the South District Wastewater Treatment Plant and then conveyed by pipelines to the Turkey Point site where it will receive further treatment at the FPL Reclaimed Wastewater Treatment Facility (adjacent to the proposed site) before it is used. The cooling system for Turkey Point Units 6 and 7 is more fully discussed in FEIS § 3.2.2.

Q13. How does FPL plan to use reclaimed water received from the South District Wastewater Treatment Plant?

A13. (DOB, PDT) The amount of reclaimed water to be received from the South District Wastewater Treatment Plant, diverted or lost through plant cooling related processes and injected to the Boulder Zone of the Lower Floridan aquifer is outlined in FEIS Table 3-6 (NRC-008A at 3-41) and in the FPL COL Application, Rev. 6, Part 3 – Applicant's Environmental

Report (Application Part 3) (ER), Table 3.3-1 and Figure 3.3-1 (NRC-016 at 3.3-5 to 3.3-6, 3.3-9 to 3.3-10). In summary, these are:

- Normal reclaimed wastewater supply received by Turkey Point Reclaimed Wastewater Treatment Facility - 50,481 gpm (72.7 Mgd)
- Normal and maximum circulating-water system makeup flow rate- 38,400 gpm (55.3 Mgd)
- Normal circulating-water system evaporation rate - 28,800 gpm
- circulating-water system cooling-tower blowdown rate - 9714 gpm
- Other system flows combined for discharge – 2747 gpm
- Normal discharge flow rate to deep injection wells- 12,461 gpm (17.9 Mgd).

Q14. How will reclaimed wastewater be disposed of after being used for cooling by Turkey Point Units 6 and 7?

A14. (DOB, PDT) As discussed in FEIS Section 3.4.2.3, reclaimed wastewater that is not lost to evaporation in the cooling-towers will be discharged as blowdown though deep injection wells. Before injection, it will be combined with other plant effluents in the blowdown sump (ER at 3.4-11). FPL plans to discharge this combined effluent (called “injectate”) into the Boulder Zone via underground injection wells. (FEIS at 2-48; NRC-008A at 2-48). The normal and maximum injection rates to the Boulder Zone when reclaimed water from the South District Wastewater Treatment Plant is used for cooling would be 18 Mgd. (FEIS at 3-32; NRC-008A).

Q15. What are the major aquifers and other subsurface features at the Turkey Point site?

A15. (DOB, PDT) The two major aquifer systems found in south Florida and at the Turkey Point site are the “surficial aquifer system” and the deeper “Floridan aquifer system” (FEIS at 2-47; NRC-008A at 2-47). The surficial aquifer system in the vicinity of the Turkey Point site is called the Biscayne aquifer and is present between ground surface and a depth of about 140 feet at the proposed site and is separated from the formations of the Floridan aquifer system by a thick sequence of low-permeability rock, collectively called the "Intermediate Confining Unit" which limits exchange of groundwater between these aquifer systems. (FEIS at 2-53; NRC-008A at 2-53).

Q16. Provide a brief overview of the depths and thicknesses of the portions of the Floridan aquifer system as they relate to deep well injection.

A16. (PDT, DOB) The Floridan aquifer system consists of several alternating layers of relatively permeable and impermeable rock that lie below the predominately low permeability "intermediate confining unit." The intermediate confining unit is more than 800 ft. thick at the Turkey Point site and separates the Floridan aquifer system from the relatively shallow Biscayne aquifer. The Floridan aquifer system contains three major hydrogeologic units, in descending order: the Upper Floridan aquifer (UFA), the Middle Confining Unit (MCU), and the Lower Floridan aquifer, which contains the Boulder Zone. (Most studies of the Floridan aquifer system refer to the Upper Floridan aquifer as the "UFA," and the Middle Confining Unit as the "MCU.") At the Turkey Point site, the Upper Floridan aquifer is 1010 ft. below ground surface, the top of the Middle Confining unit is 1,450 ft. below ground surface and it is 1465 ft. thick. The Boulder Zone occurs at a depth of 3030 ft. below ground surface. (*See* NRC-008A at 2-53 to 2-55) FEIS at 2-53. This is discussed in greater detail in A69-A72 and A92-A115 of this testimony.

Q17. What aspect of the impact of the proposed deep well injection of effluent does Contention 2.1 challenge?

A17. (DOB) Contention 2.1 asserts that four of the chemical constituents in the Turkey Point Units 6 and 7 blowdown "may adversely impact" groundwater quality if "they migrate from the Boulder Zone to the Upper Floridan Aquifer" after injection at the concentrations reported in Table 3-5, Expected Constituents and Concentrations Discharged to the Deep-Injection Wells, of the FEIS. As explained in A35, 62-64, and 118-119, injected blowdown is not likely to migrate horizontally from the point of injection to a location beneath actual users, and is not likely to migrate from the point of injection through the Middle Confining Unit, so the Constituents are not likely to migrate into the Upper Floridan aquifer.

Q18. How did the NRC Staff address the assertions made in Contention 2.1 in the FEIS?

A18. (DOB, PDT) Each issue that was raised in Contention 2.1 on the DEIS was fully addressed in the FEIS. To address the issues raised by the Joint Intervenors, the Staff added substantial discussions to the FEIS that were not in the DEIS. Site specific and regional conditions that may lead to or prevent upward migration of injected effluents is discussed in FEIS Sections 2.3.1.2 "Groundwater Hydrology", 5.2.1.3 "Boulder Zone", 5.2.3.2 "Groundwater –Quality Impacts", 7.2.2.2 "Groundwater-Quality Impacts" and Appendix G.3.3 "Confirmatory Calculations of Potential Upward Migration of Injectate from the Boulder Zone of the Lower Floridan Aquifer". (NRC-008A at 2-47 to 2-58, 5-20 to 5-29, 5-38 to 5-42, 7-16 to 7-17; NRC-008C at G-48). Risks associated with the injection of wastewater in Southeast Florida has been evaluated by the EPA (TN4759; NRC-010) and multi-disciplinary research teams (TN4756) (NRC-011) and modeling (TN4757) (NRC-012), and these matters are discussed in detail in FEIS §§ 5.2.1.3 and 5.2.3.2 (NRC-008A at 5-20, 5-38 to 5-42).

Q19. How did the Staff evaluate the Constituents named in Contention 2.1?

A19. (DOB, PDT) The potential for chemical constituents in the injectate to impact the Upper Floridan aquifer and the Underground Source of Drinking Water (USDW) is discussed in FEIS §§ 2.3.1.2, 5.2.1.3 and 5.2.3.2 (NRC-008A at 2-47 to 2-58, 5-20 to 5-29, 5-38 to 5-42). The chemicals that would be within the reclaimed water, including the four Constituents, are listed in FEIS Table 3-5, Expected Constituents and Concentrations Discharged to the Deep-Injection Wells, at the concentrations that would be expected at the point of injection. As explained in A73, an Underground Source of Drinking Water (USDW) is an aquifer or a portion of an aquifer in which Total Dissolved Solids in the groundwater is less than 10,000 mg/l, and which contains a sufficient quantity of groundwater to supply a public water system. *See* 40 C.F.R. § 144.3. As also explained below, groundwater in which Total Dissolved Solids is below 10,000 mg/l may still be unsuitable for drinking without treatment.

Q20. Please state the conclusion reached in the FEIS regarding the impact that deep well injection at Turkey Point Units 6 & 7 will have on groundwater resources and summarize the bases for that conclusion.

A20. (DOB, PDT, ALM) The Staff conclusion documented in FEIS Section 5.2.3.2 is that deep well injection of plant effluents will have a SMALL impact on groundwater quality, which is supported by analyses discussed in the FEIS indicating that:

- The concentration of the Constituents in FEIS Table 3-5, Expected Constituents and Concentrations Discharged to the Deep-Injection Wells, are below EPA Maximum Contaminant Levels. Maximum Contaminant Levels are enforceable standards for regulated contaminants in drinking water set by the EPA to be protective of human health (Safe Drinking Water Act, 42 U.S.C. § 300f et seq. at 969; TN1337; NRC-067 at 969). The Maximum Contaminant Levels for ethylbenzene, tetrachloroethylene, and toluene are set forth in 40 C.F.R. § 141.61(a), while the Maximum Contaminant Level for heptachlor is set forth in 40 C.F.R. § 141.61(c).
- The recent addition of high-level disinfection in the treatment of the wastewater at the South District Wastewater Treatment Plant instituted in accordance with state and Federal Underground Injection Control requirements would "provide an effluent quality that would not endanger USDWs" (Underground Injection Control Program Revision to the Federal Underground Injection Control Requirements for Class I Municipal Disposal Wells in Florida, 70 Fed. Reg. 70,513, 70,523 (Nov. 22, 2005) (NRC-021)) even if upward migration to an Underground Source of Drinking Water (USDW) occurs after

injection. Concentrations of the Constituents within reclaimed wastewater would be further reduced during the cooling process at Turkey Point Units 6 and 7.

- Significant vertical and horizontal migration of injected fluids away from the point of injection in the Boulder Zone is not expected at the Turkey Point site because of hydrogeological conditions and parameters of the Boulder Zone and Middle Confining Unit.

The following testimony will describe each of these points in greater detail.

Q21. How does the Staff determine if an impact is SMALL or greater than SMALL?

A21. (DOB) To make an impact determination, the Staff compares its evaluation of expected impacts from an action with the corresponding Commission definitions of impact findings. These definitions are provided in Summary of Findings on NEPA Issues for License Renewal of Nuclear Power Plants, 10 C.F.R. Part 51 Subpart A, Appendix B, Table B-1 footnote 3. Under the impact definitions, an impact is SMALL if, "[f]or the issue, environmental effects are not detectable or so minor that they will neither destabilize nor noticeably alter any important attributes of the resource."

Q22. In regard to deep well injection proposed for Turkey Point Units 6 and 7, what resources did the Staff evaluate?

A22. (DOB, PDT) The Staff FEIS impact finding pertains to water resources in the area of the plant that may be affected by deep well injection of effluent during operation of Units 6 and 7. Specifically, the Staff review included the Biscayne aquifer, the Boulder Zone and Upper Floridan aquifers of the Floridan aquifer system, and Biscayne Bay.

Q23. How did Staff reach its impact finding?

A23. (DOB, PDT) The Staff first evaluated how the proposed action might affect the resource. For example, the Staff considered the possibility that deep well injection could affect the quality of surrounding water resources. Then, to comply with NEPA, the Staff determined how these changes to water quality of surrounding aquifers could impact the "important attributes of the resource," such as availability or reliability, with respect to present and future known uses and users of the water (NUREG-1555, Standard Review Plans for Environmental Reviews for Nuclear Power Plants (Initial ESRP, 1999)) (NRC-061 At 2.3.2-1, 2.3.3-1).

Q24. Who are the users of groundwater in the area around the Turkey Point Units 6 & 7 site, where injection is proposed to occur and how do they use groundwater?

A24. (DOB, PDT) Groundwater uses and users are identified and discussed in § 2.3.2.2 of the FEIS (NRC-008A at 2-60 to 2-61). Due to saltwater intrusion, the Biscayne aquifer is too saline to be used without treatment as a potable water supply in the immediate vicinity of the proposed site and within 6 to 8 miles inland of the coastline. As a result, the public water-supply wells nearest to the proposed plant are located 6.8 to 7.7 mi west-northwest of the plant site and serve the City of Homestead. The potable water supply for the Florida Keys comes from Biscayne aquifer wells and an Upper Floridan aquifer well located west of Florida City (TN3649; NRC-013) approximately 9 mi west of the plant site (TN3649; NRC-013).

The Upper Floridan aquifer in southeastern Florida is generally brackish to saline depending on depth and distance from the coast (Reese 1994-TN1439; (NRC-014). An average TDS concentration of 5,451 mg/L was reported for the Upper Floridan aquifer at the Turkey Point site (FEIS at 2-71; NRC-008A at 2-71). The Upper Floridan aquifer in the immediate vicinity of the Turkey Point plant area is used to supply cooling-tower makeup water at a rate of about 12.6 Mgd to Turkey Point Unit 5 (FPL 2014-TN4058) (NRC-016). Since TDS in the Upper Floridan aquifer at the Turkey Point site is less than 10,000 mg/L, this aquifer is considered an Underground Source of Drinking Water (USDW), however, it is too saline in southeastern Florida to be used for drinking water without treatment (TN110; NRC-017 at 35). The closest offsite user of the Upper Floridan aquifer is the Ocean Reef Golf Club, located 7.7

miles southeast of the proposed site on North Key Largo. Here, water from the Upper Floridan aquifer is mixed with fresher water before being used for irrigation at a golf course. The Boulder Zone is used only for injection of municipal and industrial wastewater because of its isolation and high permeability, and the salinity of the water in it, which is similar to seawater (TN2255; NRC-018).

Q25. What is the role of the Staff impact determination in relation to Federal and State requirements for groundwater protection (*i.e.*, Safe Drinking Water Standards, and Underground Injection Control (UIC) Program requirements)?

A25. (DOB, PDT) The Staff responsibility under NEPA is to evaluate and disclose the potential impacts of constructing and operating the proposed Turkey Point Units 6 and 7 in the FEIS in order to inform the NRC decision of whether or not to grant the FPL application for combined licenses. While the NRC regulates the release of radiological constituents in plant effluent, responsibility for regulation of non-radiological pollutant discharges into receiving waters, including chemical constituents in the injected effluent, "rests by statute with the Environmental Protection Agency" (10 C.F.R. § 51.10(c)). In Florida, EPA has delegated this authority to the Florida Department of Environmental Protection or FDEP. In addition FDEP enforces the requirements of the UIC program. As part of the UIC Permit process, FDEP requires that applicants for Class I injection permits, such as FPL, demonstrate that deep injection will not negatively impact an Underground Source of Drinking Water (USDW). This must occur for each license that is granted for a UIC well.

EPA Drinking Water Standards and Potential Human Health Impacts

Q26. What are EPA drinking water standards?

A26. (ALM) The Environmental Protection Agency (EPA) sets standards for contaminant concentrations in drinking water as required by the Safe Drinking Water Act (42 U.S.C. § 300f et seq.;TN1337; NRC-067**)**. The EPA sets contaminant concentration standards for each contaminant by determining the Maximum Contaminant Level Goal that has no known adverse effect to human health. Risk to sensitive subpopulations are considered to determine a Maximum Contaminant Level Goal for a contaminant. Epidemiological and toxicological studies are used to determine human health safety levels for a contaminant, and a Maximum Contaminant Level is set for that contaminant as the enforceable standard for water in a public water system. For some contaminants, the Maximum Contaminant Level Goal is the Maximum Contaminant Level. The drinking water regulations also require regular water quality monitoring and methods for measuring contaminants in the water.

Q27. What is the significance of a Maximum Contaminant Level Goal vis-à-vis a Maximum Contaminant Level?

A27. (ALM) The Maximum Contaminant Level Goal is the maximum level goal for a contaminant in drinking water where there is no known or anticipated adverse effect on the health of persons, and which allows an adequate margin of safety. 40 C.F.R. § 141.2. The Maximum Contaminant Level represents the maximum allowed concentration of a contaminant in drinking water that is protective of human health, or at which no known health effects will occur (EPA, How EPA Regulates Drinking Water Contaminants; NRC-069). Maximum Contaminant Levels are set as close as possible to the Maximum Contaminant Level Goal, where the concentration of a contaminant can be treated with the best available treatment technology. Maximum Contaminant Level Goals are determined through consideration of human health. Maximum Contaminant Level Goals are not enforceable, and are set without consideration of the limits of detection and the capability of state-of-the-art treatment technologies.

Q28. Why are the EPA drinking water standards a good benchmark for determining that the wastewater injections will not adversely affect groundwater?

A28. (ALM) The drinking water standards set a limit for individual contaminants in order to protect human health. The standards apply to public water systems, which does not necessarily include treated wastewater for uses other than public drinking water. However, in the event the wastewater effluent comes into contact with drinking water resources, the use of drinking water standards would support an assessment of potential for adverse effects to human health.

Q29. What data for the concentrations of the Constituents in reclaimed wastewater did the Staff use in its analysis?

A29. A29. (ALM, DOB) Table 3-5, Expected Constituents and Concentrations Discharged to the Deep-Injection Wells, of the FEIS on page 3-39 shows the concentrations of heptachlor, ethylbenzene, toluene and tetrachloroethylene estimated to be present in effluent from Turkey Point at the injection wells. These concentrations for heptachlor, ethylbenzene, and toluene were determined by first selecting maximum values from sampling of South District Wastewater Treatment Plant effluent from 2007 to 2011. These concentrations reflect the pretreatment and secondary level treatment that wastewater at the South District Wastewater Treatment Plant received during this time. The value for tetrachloroethylene was selected from sampling performed at a reuse pilot project at the South District Wastewater Treatment Plant from water that received tertiary treatment and was considered more representative of water FPL expected to receive from the South District Wastewater Treatment Plant (L-2012-350 Attachment at Page 2-3 of 34; NRC-070). To determine the values reported in FEIS Table 3-5, Expected Constituents and Concentrations Discharged to the Deep-Injection Wells, FPL indicated that it adjusted the values selected from sampling data to account for concentration in the proposed Turkey Point mechanical draft cooling-towers due to evaporation of cooling water and dilution of the effluent prior to discharge via injection wells (FEIS at 3-37; NRC-008A at 3-37; L-2012-350 Attachment at Page 2 of 34). In addition, FEIS Table 3-5, Expected Constituents and Concentrations Discharged to the Deep-Injection Wells, footnote b, states, "Constituent concentrations were below Method Detection Limits in South District Wastewater Treatment Plant effluent samples collected in March 2013, July–August 2013, October 2013, and March 2014." (NRC-008A at 3-39)(FEIS at 3-39; *see also* FEIS at 5-21).

The detection limit for each compound or constituent is dependent on technology and methodology used to assess constituent concentration. The Method Detection Limit is the minimum concentration of a constituent that can be measured and reported with at least 99 percent confidence that the concentration is greater than zero, but that the exact concentration cannot be reliably quantified.

Q30. What is Heptachlor and what is its Maximum Contaminant Level?

A30. (ALM, DOB) Heptachlor is an organic constituent found in pesticides typically used for fire ant control. In water, heptachlor has an affinity for sediments, and is resistant to biodegradation. The US EPA describes the Maximum Contaminant Level Goal as zero (40 C.F.R. § 141.50(a)), and set the Maximum Contaminant Level at 0.0004 milligrams per liter (mg/L) of drinking water as protective of human health (40 C.F.R. § 141.61(c)) (EPA 2009-TN4901; NRC-037). The expected concentration of heptachlor discharged to the deep injection wells based on 2007-2011 sampling of reclaimed water from the South District Wastewater Treatment Plant is 0.000023 mg/L, which is more than seventeen times lower than the safe drinking water Maximum Contaminant Level (reported in Table 3-5, Expected Constituent and Concentrations Discharges to the Deep-Injection Wells, at 3-39 of the FEIS). Heptachlor in drinking water at a concentration that is more than seventeen times lower than the Maximum Contaminant Level for heptachlor would not have adverse effects on human health. As noted in the footnote to the table, samples collected during the 2013-2014 time span did not contain detectable heptachlor and reported the concentration as below detection limit. Therefore, any heptachlor present in the treated reclaimed water would pose no threat to human health.

Q31. What is the Method Detection Limit for heptachlor?

A31. (ALM) The Method Detection Limit for heptachlor is dependent on the specific equipment used to analyze the samples, and is therefore technology dependent (EPA Method 608 (NRC-060) states a Method Detection Limit of 0.000003 for specific chromatographic technology, but other technologies may have different Method Detection Limits). Further, the Method Detection Limit for individual samples can be determined only with reference to the equipment used to analyze those samples. In any case, however, the Method Detection Limit for heptachlor will be above zero.

Q32. What is the significance of the heptachlor Method Detection Limit in relation to its Maximum Contaminant Level Goal?

A32. (ALM) The Method Detection Limit for heptachlor is the minimum concentration that can be detected and measured with at a 99% confidence level that the value is above zero. Therefore, because the Method Detection Limit for heptachlor is set at a value above zero which is higher than the Maximum Contaminant Level Goal, it is not reasonable to expect current detection technology to show a value of zero and meet the Maximum Contaminant Level Goal of heptachlor.

Q33. What is Ethylbenzene and what is its Maximum Contaminant Level?

A33. (ALM, DOB) Ethylbenzene is an organic contaminant that is found in wastewater from industrial sources such as refineries, dry cleaners, and or others who use it as a degreasing agent. Ethylbenzene has a Maximum Contaminant Level Goal and Maximum Contaminant Level of 0.7 mg/L for safe drinking water. 40 C.F.R. §§ 141.50(b), 141.61(a). The expected concentration of ethylbenzene discharged to the deep injection wells based on 2007-2011 sampling of reclaimed water from the South District Wastewater Treatment Plant would be undetectable since all samples collected during this period were below the detection limit (NRC-008A at 3-39; FEIS at 3-39). As noted in the footnote to the table, samples collected during the 2013-2014 time span were also below the detection limit. In accordance with EPA Method 624 (EPA 1984-TN4899) (NRC-038), the detection limit for ethylbenzene should be at least 0.0007 mg/L. Therefore, any ethylbenzene that may be present in the reclaimed water would be at a concentration significantly lower than the safe drinking water Maximum Contaminant Level.

Q34. What is Toluene and what is its Maximum Contaminant Level?

A34. (ALM, DOB) Toluene is an organic contaminant that is found in wastewater from industrial sources such as refineries, dry cleaners, and others who use it as a degreasing agent. For safe drinking water, toluene has a Maximum Contaminant Level Goal and Maximum Contaminant Level of 1.0 mg/L. 40 C.F.R. §§ 141.50(b), 141.61(a). The expected concentration of toluene discharged to the deep injection wells based on 2007-2011 sampling of reclaimed water from the South District Wastewater Treatment Plant is 0.00174 mg/L, or over five hundred times lower than the safe drinking water Maximum Contaminant Level (FEIS Table 3-5, Expected Constituents and Concentrations Discharged to the Deep-Injection Wells, at 3-39; NRC-008A at 3-39). Toluene in drinking water at a concentration that is over five hundred times lower than the Maximum Contaminant Level for toluene would not have adverse effects on human health. As noted in the footnote to the table, analysis of samples collected during the 2013-2014 time span did not detect toluene and reported the concentration as below detection limit. Therefore, any toluene present in the treated reclaimed water would pose no threat to human health.

Q35. What is Tetrachloroethylene and what is its Maximum Contaminant Level?

A35. (ALM, DOB) Tetrachloroethylene, also known as tetrachloroethene, is an organic contaminant that is found in wastewater from industrial sources such as refineries, dry cleaners, and others who use it as a degreasing agent. Tetrachloroethylene has a Maximum Contaminant Level Goal of zero, and in drinking water is considered safe at levels below the Maximum Contaminant Level of 0.005 mg/L. 40 C.F.R. §§ 141.50(a), 141.61(a). The expected concentration of tetrachloroethylene discharged to the deep injection wells based on the representative value from the reuse pilot project at the South District Wastewater Treatment Plant is 0.00359 mg/L, or almost two times lower than the safe drinking water Maximum Contaminant Level (FEIS at 3-39; NRC-008A at 3-39). Tetrachloroethylene in drinking water at a concentration that is almost two times lower than the Maximum Contaminant Level for tetrachloroethylene would not have adverse effects on human health. As noted in the footnote to the table, analysis of samples collected during the 2013-2014 time span did not detect tetrachloroethylene and reported the concentration as below detection limit. Therefore, any tetrachloroethylene present in the treated reclaimed water would pose no threat to human health.

Q36. What is the Method Detection Limit for tetrachloroethylene?

A36. (ALM) The Method Detection Limit for tetrachloroethylene is dependent on the specific equipment used to analyze the samples, and is therefore technology dependent (EPA Method 624) states a Method Detection Limit of 0.0041 mg/L for specific chromatographic technology, but other technologies may have different Method Detection Limits. Further, the Method Detection Limit for individual samples can be determined only with reference to the equipment used to analyze those samples. In any case, however, the Method Detection Limit for tetrachloroethylene will be above zero.

Q37. What is the significance of the Method Detection Limit for tetrachloroethylene in relation to its Maximum Contaminant Level Goal?

A37. (ALM) The Method Detection Limit for tetrachloroethylene is dependent on the specific equipment used to analysis and is therefore technology dependent (EPA Method 624) states a Method Detection Limit of 0.0041 mg/L (TN4899; NRC-038 at 19), but this EPA Method Detection Limit is from 1984 and current technology can achieve lower Method Detection Limits). The Method Detection Limit for tetrachloroethylene is the minimum concentration that can be detected and measured with a 99% confidence level that the value is above zero. Even using current technology, the Method Detection Limit will be above zero. Accordingly, because the Method Detection Limit for tetrachloroethylene is above zero, the Method Detection Limit is higher than the Maximum Contaminant Level Goal, and it is not reasonable to expect current detection technology to show a value of zero to meet the Maximum Contaminant Level Goal of tetrachloroethylene.

Q38. How do the answers in A23-A37 regarding the concentrations of the Constituents support the Staff conclusion in the FEIS regarding groundwater quality?

A38. (ALM, DOB) Table 3-5, Expected Constituents and Concentrations Discharged to the Deep-Injection Wells, of the FEIS on page 3-39 shows calculated values of heptachlor, ethylbenzene, toluene and tetrachloroethylene concentrations in injected blowdown based on 2007-2011 samples taken from the South District Wastewater Treatment Plant. The table also refers to samples collected during 2013-2014, after high-level disinfection was implemented at the South District Wastewater Treatment Plant. The concentration of each constituent was below the detection limit for that constituent. Even without accounting for further reduction in Constituent concentrations due to the planned further treatment at the Reclaimed Water Treatment Facility and fate processes in the cooling water system proposed at Turkey Point, the concentrations in Table 3-5, Expected Constituents and Concentrations Discharged to the Deep-Injection Wells, of heptachlor, ethylbenzene, toluene, and tetrachloroethylene were either always below detection limits (ethylbenzene), or had concentration values that were well below the EPA drinking water standards for Maximum Contaminant Levels (NRC-008A at 3-39; FEIS at 3-39). These were further reduced to levels that were less than detectable limits after implementation of high-level disinfection at the South District Wastewater Treatment Plant.

Therefore, the impact on human health from cooling-tower blowdown water entering the groundwater through injection would be SMALL. The potential for further reduction in Constituent concentrations caused by cycling of reclaimed wastewater through the cooling water system at the Turkey Point site is discussed below.

EPA 2005 injection rules allow upwelling of injected effluent into an Underground Source of Drinking Water (USDW) if injected wastewater previously receives high-level disinfection. High-level disinfection at the South District Wastewater Treatment Plant and the cooling water processes at Turkey Point will further reduce the concentration of Constituents below that reported in FEIS Table 3-5, Expected Constituents and Concentrations Discharged to the Deep-Injection Wells.

Q39. How is treated wastewater currently disposed of at the South District Wastewater Treatment Plant?

A39. (DOB, PDT) The South District Wastewater Treatment Plant currently injects treated wastewater into the Boulder Zone using injection wells permitted through the FDEP UIC program. Injection rates of treated wastewater at the South District Wastewater Treatment Plant are around 97 Mgd.

Q40. What level of treatment does wastewater receive prior to reaching the South District Wastewater Treatment Plant and as part of the treatment processes at the South District Wastewater Treatment Plant?

A40. (DOB, PDT) The treatment of wastewater is in accordance with UIC requirements set forth by the EPA in 40 CFR 146.15. This rule requires wastewater at the South District Wastewater Treatment Plant to be subject to a treatment process that includes pretreatment and secondary treatment, both of which were also previously required and outlined in Florida Administrative Code Sections 62-625 (NRC-068) and 62-600.420(1)(d), respectively (NRC-025 at 453). EPA amended the UIC requirements in 2005 to require addition of a higher level than secondary level treatment process prior to injection of treated wastewater. This advanced treatment process is known as high-level disinfection (70 Fed. Reg. 70,513 at 70,524). This requirement is outlined in Florida Rule 62-600.440(a)-(f) and was implemented at the South District Wastewater Treatment Plant in 2013. Reclaimed wastewater sent to FPL for use as cooling water will receive pretreatment, secondary treatment, and high-level disinfection before being sent to the Turkey Point site (FEIS at 5-21; NRC-008A at 5-21).

Q41. Why were Federal UIC Program requirements for Class I municipal disposal wells amended in 2005?

A41. (DOB, PDT) As explained in the FEIS (FEIS at 5-20; NRC-008A) the program requirements were revised in order to provide a regulatory alternative to the previous "no-fluid-movement" requirement, which prohibited the movement of fluid injected by Class I municipal disposal wells from the Boulder Zone upward into an Underground Source of Drinking Water (USDW). Movement of injected fluid into an overlying Underground Source of Drinking Water (USDW) had been prohibited as a way to ensure that injection would not cause any Underground Source of Drinking Water (USDW) to exceed primary drinking water regulations or health based standards (NRC-021 at 70,513 and 70,526).

Q42. What was the need for a regulatory alternative to the "no-fluid-movement" requirement of the Federal UIC Program?

A42. (DOB, PDT) There are over 180 Class I municipal injection wells in Florida. These wells have been used as an alternative to surface disposal of treated domestic wastewater for over 20 years (TN4766; NRC-022 at 1). During that time, upwelling of injectate from the Boulder Zone to the overlying Underground Source of Drinking Water (USDW) has occurred at several Class I municipal disposal wells locations, including the South District Wastewater Treatment Plant. (FEIS at 5-23; NRC-008A at 5-23). Previously, facilities where migration into an Underground Source of Drinking Water (USDW) had occurred would have been forced to cease injecting and adopt an alternate wastewater disposal method. However, due to the severe local restrictions on wastewater disposal alternatives in Florida, the EPA revised the Federal UIC requirements for certain counties in South Florida to allow Class I wells to continue wastewater injection, even when upward migration had occurred, provided the injected wastewaters are given “pretreatment, secondary treatment, and high-level disinfection before they are injected” (TN4766; NRC-022 at 1; 40 C.F.R. § 146.15). The 2005 EPA requirements were designed to “provide an equivalent level of protection to USDWs that is afforded by the no-fluid-movement standard” by treating wastewater to “a level that is no longer a threat to USDWs” if it were to migrate from the injection zone to the Underground Source of Drinking Water (USDW) (NRC-021 at 70,513-5 to 70,51-5).

Q43. Is Miami-Dade County, where both the South District Wastewater Treatment Plant and Turkey Points Units 6 & 7 are located, in the area where the rule change was implemented?

A43. (DOB, PDT) Yes. Miami-Dade County is one of the 24 counties in South Florida included in the area affected by the EPA rule change (NRC-021 at 70,514; 40 C.F.R. § 146.15 (f)).

Q44. How were site-specific geology and geologic parameters considered as part of the 2005 rule change?

A44. (DOB, PDT) As explained in A14 and A15 , the Floridan aquifer system is the hydrogeologic unit that will both receive (Boulder Zone) and confine (the Middle Confining Unit) the injected wastewater. It is also where the Upper Floridan aquifer, which is the Underground Source of Drinking Water (USDW), is located. Miami-Dade County and other named counties were included in the 2005 rule change specifically because the carbonate rocks that compose the Floridan aquifer system and underlie these counties could contain faults, fractures, and solutions features that might provide preferential pathways for the movement of injected fluids from the injection zone, through the confining unit and upward into the Underground Sources of Drinking Water (USDW). Risk analyses performed in support of the rule change included models that evaluated the movement of injected wastewater and incorporated parameters specific to these units in Miami-Dade County (NRC-021 at 70,514).

Q45. Please explain the Staff's professional opinion of the EPA analysis of the potential impacts to human health made in connection with the 2005 revision to the Federal UIC requirements allowing for upward migration of treated wastewater.

A45. (DOB, PDT) In support of the rule change, the EPA conducted a relative risk assessment of wastewater disposal options in South Florida. The EPA relative risk assessment considered deep well injection, ocean disposal, surface discharge, and aquifer recharge of treated effluent in South Florida. This assessment was published in 2003 as "Relative Risk Assessment of Management Options for Treated Wastewater in South Florida" (TN4759; NRC-010). EPA used findings from this assessment to inform the revised rule. The assessment included consideration of chemicals or biological constituents within secondarily treated wastewater that might cause adverse impacts (known as "stressors") as well as a variety of exposure pathways, receptors and potential effects for each disposal method. This relative risk assessment was one of the risk assessments of deep well injection evaluated as part of the FEIS analysis and is discussed in FEIS § 5.2.3.2. (FEIS at 5-40; NRC-008A at 5-40).

Q46. Which of the "stressors" in wastewater were considered by the relative risk assessment to be the greatest risk to human health if migration to an Underground Source of Drinking Water (USDW) occurred?

A46. (DOB, PDT) In the risk assessment, the EPA evaluated the impact of representative "stressors," including organic and inorganic chemicals as well as biological pathogens, on human and ecological health. One of the representative organic stressors was tetrachloroethylene, or PCE (TN4759 at 3-16; NRC-010), which is one of the Constituents identified in Contention 2.1. While EPA considered chemical contaminants in the analysis, the EPA ultimately concluded that biological pathogens in wastewater were the greatest potential risk to the Underground Source of Drinking Water (USDW) (NRC-021 at 70,515).

Q47. Do the revised Federal UIC requirements address the removal of the contaminants other than pathogens that may be in municipal wastewater?

A47. (DOB, PDT) The *Federal Register* notice announcing the Final 2005 rule states that it was not necessary to target all potential contaminants within wastewater with the rule because Class I municipal wells are not allowed to inject wastewater unless it has been treated to a level that precludes endangerment. The *Federal Register* notice also notes that many contaminants in the wastewater are addressed through EPA's pretreatment regulations (NRC- 021 at 70,525).

Q48. How did the 2003 EPA risk assessment evaluate exposure paths for deep well injection that are applicable to this contention?

A48. (DOB, PDT) The models in the 2003 EPA risk assessment evaluated the same mechanisms for upward migration of injectate as the Staff did in the FEIS. These mechanisms include flow through the unfractured matrix of the Middle Confining Unit (referred to as "porous media flow"), rapid flow through preferential flowpaths in the Middle Confining Unit (such as a failed well or natural conduit), and mechanical failure of the injection system resulting in direct release into the Upper Floridan aquifer (TN4759; NRC-010 at 4-42 to 4-44).

Q49. How did the 2003 EPA risk assessment evaluate receptors for deep well injection that are applicable to Contention 2.1?

A49. (DOB, PDT) The EPA determined final concentrations of stressors at receptor locations based on the flowpaths described in A48. This included flow to the USDW and drinking water wells screened within the Upper Floridan aquifer.

Q50. What concentrations did the risk assessment modeling predict would occur at the USDW and the well within the Upper Floridan aquifer?

A50. (DOB, PDT) The models indicated that stressor concentrations that (1) might reach the Underground Source of Drinking Water (USDW), and (2) might reach a well in the Upper Floridan aquifer, would both be substantially below the EPA Maximum Contaminant Level (TN4759, NRC-010 at 4-44, Table 4-11 "Concentrations of Representative Stressors at USDWs and Hypothetical Wells"). For tetrachloroethylene specifically, EPA calculated that the initial concentrations would be reduced by 95 percent to 100 percent when they reached the Underground Source of Drinking Water (USDW) and the well within the Upper Floridan aquifer. As a result, the 2003 EPA study concluded that overall risk to human health from deep well injection was "[l]ow where there have been impacts to deep USDWs; however, exposure of current water supplies is unlikely" and that "risk[s] would be further reduced when [the] injected wastewater is treated to reclaimed water standards" (TN4759; NRC-010 at 8-17).

Q51. Why did the EPA conclude that overall risks associated with deep well injection of chemicals in treated wastewater would be low?

A51. (DOB, PDT) The EPA determined that the risk of injection of chemicals would be low for the following reasons: (1) the low concentration of chemical constituents within the injected wastewater and the reduction in concentration provided by secondary treatment and high-level disinfection, (2) the length of time estimated for injected wastewater to move vertically to an Underground Sources of Drinking Water (USDW), and (3) the reduction in concentrations which occur in the Boulder Zone (NRC-021 at 70,522).

Q52. According to the EPA, what impact would migration of injectate from Class I municipal wells have on the Underground Source of Drinking Water (USDW) if the injected wastewater has received high-level disinfection prior to injection?

A52. (DOB, PDT) In explaining the rule, the EPA concluded that adding high-level disinfection to the treatment of injected wastewater would:

- "provide an equivalent level of protection to USDWs as provided by the existing no-fluid-migration requirement of the Safe Drinking Water Act" (EPA Fact Sheet Explaining Rule Change 815-F-05-033; TN4766; NRC-022),
- be "as effective as confinement of fluids in protecting USDWs from the contaminants in the wastewater" (NRC-021 at 70,515),
- achieve the goal that "the movement of fluids into the USDWs, whether known or suspected, should not endanger the USDWs because the quality of the wastewater has been treated to a level that is no longer a threat to USDWs" (NRC-021 at 70,515),
- "not undercut the protection of USDWs or weaken the UIC Program requirements" (NRC-021 at 70,515).

This is discussed in FEIS § 5.2.1.3. (FEIS at 5-20; NRC-008A at 5-20).

Q53. What level of treatment has been implemented at the South District Wastewater Treatment Plant?

A53. (DOB, PDT) As explained in the FEIS, on April 29, 2004, FDEP and Miami-Dade County entered into a Consent Order to address issues including the "allegation of fluid movement associated with Class I injection wells at the County's South District Wastewater Treatment Plant (SDWWTP)" (TN4758 at 15; NRC-023). Under the Consent Order, the Miami-Dade Water and Sewer Division "was to treat wastewater at the SDWWTP to a higher level than secondary treatment, by providing additional treatment process, known as High-Level Disinfection" (TN4758 at 15; NRC-023). The High-Level Disinfection Facility at the South

District Wastewater Treatment Plant was completed and because operational in FY2013 (TN4758 at 15; NRC-023).

Q54. How is reclaimed wastewater treated prior to being injected into the Boulder Zone as cooling-tower blowdown?

A54. (DOB, PDT) Reclaimed wastewater received by FPL from the South District Wastewater Treatment Plant and injected into the Boulder Zone as cooling-tower blowdown will receive pretreatment, secondary treatment and high-level disinfection.

Q55. What does pretreatment entail?

A55. (DOB, ALM) Pretreatment is required for significant industrial users in order to remove contaminants in their waste streams that would not be consistently removed by processes at a municipal wastewater treatment facility (NRC-021 at 70,524). Federal UIC regulation require that pretreatment programs comply with or exceed standards set forth by the state of Florida in Florida Rule 62-625 (NRC-068), which were developed to ensure that contaminants are prevented from endangering the public. In addition, companies wishing to discharge water to the South District Wastewater Treatment Plant must obtain a permit and comply with Miami-Dade Water and Sewer Division Industrial Wastewater Pretreatment Program (IWP) which requires permit holders to meet Miami-Dade County sanitary sewer discharge standards set forth in 24-42.4 of county code. The permit holders are subject to monitoring and reporting requirements that mandate regular sampling and analysis. Specific pollutants limits are listed in 24-42.4(2)(d)(vi). This list includes a limit for PCE (tetrachloroethylene), which is one of the contention related constituents, that is higher than the maximum detected value reported by FPL (RAI response 5765, NRC-024).

Q56. What does secondary treatment entail?

A56. (DOB, ALM) Secondary treatment standards implemented by the state of Florida in Florida Rule 62-600 are more stringent than those set forth in Federal UIC requirements

(NRC-021 at 70,524). Secondary treatment is performed to remove total suspended solids and treat soluble organic matter and is required so that the higher standards of filtration and disinfection required of high-level disinfection may be achieved. In accordance with FAC 62-600 (TN1268; NRC-025), secondary treatment technologies must reduce total suspended solids to 20 mg/L or less, and have a 5-day carbonaceous biochemical oxygen demand of 20 mg/L, or must remove at least 90 percent of each of these pollutants, whichever is more stringent. This process removes suspended solids and soluble organic matter along with any contaminants that may have been adsorbed to them, including the Constituents listed in Contention 2.1. Concentrations reported (FPL RAI response 5765 Table 1 “Reclaimed Water Analytical Data” at Attachment Pages 5 to15; NRC-070) represent the concentrations of chemicals in effluent from the South District Wastewater Treatment Plant after water receives this secondary level of treatment. FPL used these concentrations to calculate the concentrations presented in Table 3-5, Expected Constituents and Concentrations Discharged to the Deep-Injection Wells, which represent the expected values of chemicals in water to be injected after being used for cooling and dilution at the Turkey Point site, including the Constituents listed in this contention.

Q57. What does High-Level Disinfection entail?

A57. (DOB, ALM) The Miami-Dade Water and Sewer Division describes high-level disinfection as a two-step process with wastewater first receiving added filtration followed by disinfection with chlorine (TN4758; NRC-023). Florida Rule 62-600.440(5)(a)-(f) further explains that this advanced treatment includes additional total suspended solids control beyond secondary treatment and treatment to reduce fecal coliform values to below detectable limits. Methods for disinfection include chlorine treatment with rapid and uniform mixing and minimum contact time, and maximum residual chlorine levels dependent on the total fecal coliform concentration (Fla. Admin. Code R. 62-600 -TN1268; NRC-025).

Q58. How could high-level disinfection at the South District Wastewater Treatment Plant reduce the concentrations of the Constituents listed in Contention 2.1?

A58. (DOB) A study of treatment processes at wastewater treatment plants concluded that a reduction of VOCs was correlated to mixing and other commonly used steps in the treatment process (Bell et. al., 1993 at 715; NRC-026). As required by 40 C.F.R. § 146.15(5)(b), high-level disinfection must include "rapid and uniform mixing" to create a minimum acceptable contact time with chlorine of 15 minutes for the purpose of disinfection.

Q59. How has the addition of high-level disinfection at the South District Wastewater Treatment Plant affected the concentrations of the Constituents in the treated wastewater that would be supplied to Turkey Point Units 6 & 7 for use as cooling water?

A59. (DOB, PDT) As explained earlier, FPL calculated the expected concentrations of the Constituents presented in FEIS Table 3-5, Expected Constituents and Concentrations Discharged to the Deep-Injection Wells, using concentrations from sampling performed from 2007 to 2011 at the South District Wastewater Treatment Plant, before high-level disinfection was implemented. During this time, measurements from the South District Wastewater Treatment Plant showed low but detectable concentrations for all constituents except ethylbenzene, which was below detection. In additional sampling performed at the South District Wastewater Treatment Plant from 2013 to 2014, after implementation of high-level disinfection, the concentrations of Constituents were below both the EPA Maximum Contaminant Level and the laboratory Method Detection Limit as indicated in the footnotes to FEIS Table 3-5, Expected Constituents and Concentrations Discharged to the Deep-Injection Wells (FEIS at 3-39; NRC-008A at 3-39). These more recent measurements better represent the concentrations expected in reclaimed water receiving high-level disinfection that will be received at Turkey Point Units 6 & 7.

Q60. How are the cooling-water system processes proposed for Turkey Point Units 6 & 7 accounted for in the concentrations of the Constituents presented in FEIS Table 3-5 and footnote (b) to Table 3-5?

A60. (DOB, PDT) FPL factored concentrations of chemicals in the Turkey Point mechanical draft cooling-towers due to evaporation of cooling water and dilution of the effluent prior to discharge via injection wells into the concentrations presented in FEIS Table 3-5, Expected Constituents and Concentrations Discharged to the Deep-Injection Wells. FPL did not consider other fate processes that will reduce concentrations of the Constituents during the cooling process at the Turkey Point site in calculating the concentrations reported in FEIS Table 3-5. Also, the concentrations reported in the footnote to Table 3-5, which were taken after the South District Wastewater Treatment Plant upgrade to high-level disinfection occurred, do not reflect concentration in the cooling-towers, dilution of effluent prior to injection or additional fate processes that would reduce concentrations

Q61. Please describe a significant fate process that would occur in the cooling-water system and further reduce the concentrations of the Constituents in reclaimed wastewater prior to injection at the Turkey Point site?

A61. (DOB, PDT) Volatilization will play a role in further reducing the concentrations of the Constituents as water moves through the Turkey Point Units 6 and 7 mechanical draft cooling-towers. Volatilization transfers contaminants from the aqueous phase directly to the gaseous phase and results in a reduction in aqueous contaminant concentrations. Methods that encourage volatilization are widely used as a way to remove volatile organic compounds (VOCs) from contaminated groundwater (Bediant, et al. 1993 at 218; NRC-028 at 218). Air stripping is one of the most commonly used volatilization methods. In air stripping, contaminated water is sprayed from the top of a tank and air is blown upward through the falling water. This process results in turbulence, which increases air exposure and strips VOCs from the water

(EPA Engineering Bulletin; NRC-029). This method is similar to how waste heat is “stripped” from cooling water within mechanical draft cooling-towers, which use mechanical fans to generate airflow across sprayed water (NRC030).

Q62. How might volatilization within the Turkey Point mechanical draft cooling-towers reduce concentrations of the Constituents in reclaimed wastewater?

A62. (DOB, PDT) A study of the application of air stripping to contaminated water found that volatilization efficiency increases dramatically as tower height, air turbulence and temperature increase (Huang and Shang at 52; NRC-031 at 51 to 52). Air stripping may be effective at removing greater than 98% of volatile organic compounds (VOCs) in contaminated water (EPA Engineering Bulletin; NRC-029). Both of these factors would likely increase the “stripping” of the low concentrations of volatile organic compounds (VOCs) in reclaimed water as it circulates four times through the cooling-towers at temperatures of greater than 110°F (ER Rev. 6, § 3.4.2.3.1 “Circulating Water System”; NRC-030 and Table 3.4-2 “Circulating Water System Cooling Tower Design Specifications per Unit”). As a result, it is likely that a significant proportion of any remaining tetrachloroethylene, ethylbenzene and toluene, even though concentrations of these chemicals are already below EPA Maximum Contaminant Levels and laboratory detection limits after receiving high-level disinfection at the South District Wastewater Treatment Plant, would be removed from the cooling-tower blowdown through the cooling process at Turkey Point Units 6 & 7.

Q63. What means could reduce the concentration of heptachlor in the circulating-water system at the Turkey Point site?

A63. (DOB, PDT) Heptachlor binds strongly to soil and is virtually insoluble in water (ATSDR reference; NRC-032). Once in water, heptachlor degrades primarily by chemical hydrolysis and photo-degradation. Studies have shown that concentrations in water will decline by 50% in between 1 to 3 days (EPA NPDWR 811-F-95-003r-T October 1995; NRC-033).

Chemical hydrolysis is the primary method of breakdown of heptachlor in water and is strongly influenced by the temperature of the system. As temperature increases, hydrolysis rates increase, causing contaminant concentrations to decrease (Bedient et al at 216; NRC-028 at 216). During the cooling-tower cycle, water temperatures will increase to as much as 110°F (ER Rev. 6, § 3.4.2.3.1 "Circulating Water System" and Table 3.4-2 "Circulating Water System Cooling Tower Design Specifications per Unit;" NRC-030), increasing the efficiency of hydrolysis and decreasing any heptachlor concentrations. Volatilization and photo-degradation are also processes that would reduce concentrations of heptachlor in water and would occur to some degree in the cooling-towers.

As a result these processes, it is likely that the concentration of any remaining heptachlor, which is below EPA Maximum Contaminant Levels and laboratory detection limits after receiving high-level disinfection at the South District Wastewater Treatment Plant, would be significantly reduced through the cooling-tower cycle at Turkey Point.

Q64. Considering probable reduction of Constituent concentrations within the cooling-tower cycle, what would be the potential impact of deep well injection at the Turkey Point site to actual users?

A64. (DOB, PDT) The nearest user of water from the Upper Floridan aquifer above the injection zone is the Ocean Reef Club, 7.7 miles southwest of the Turkey Point Units 6 and 7 site. Even if injected cooling-tower blowdown was assumed to be immediately available for use at this location, the Ocean Reef Club mixes all water withdrawn from the Upper Floridan aquifer to improve quality before use for golf course application. Water from the Upper Floridan aquifer is not used for drinking at this location. Exposure to significant concentrations of the Constituents at this location would not occur because of the very low potential concentrations and because exposure pathways are limited.

Q65. Could impacts to the Underground Source of Drinking Water (USDW) be greater than SMALL if injected blowdown with the concentrations of the Constituents listed in FEIS Table 3-5 migrate from the Boulder Zone to the Upper Floridan aquifer?

A65. (DOB, PDT) No, based on A54-A64, the Staff concludes that if injected cooling-tower blowdown were to migrate from the injection zone and into the Underground Source of Drinking Water (USDW) within the Upper Floridan aquifer, the impact of the Constituents would be SMALL.

Q66. Could impacts be greater than SMALL if injected cooling-tower blowdown were directly released into the Upper Floridan aquifer, which is an Underground Source of Drinking Water (USDW)?

A66. (DOB, PDT) No, based on A54-A64 and as further explained in this answer, the Staff concludes that if injected cooling-tower blowdown from the Turkey Point Units 6 and 7 site were released directly into the Underground Source of Drinking Water (USDW) within the Upper Floridan aquifer, the impact of the Constituents would remain SMALL. The concentrations of the Constituents presented in FEIS Table 3-5, Expected Constituents and Concentrations Discharged to the Deep-Injection Wells, would be further decreased by high-level disinfection treatment at the South District Wastewater Treatment Plant, fate processes at Turkey Point Units 6 and 7, and dilution prior to injection. When these effects are conservatively considered, the concentration of each Constituent would be only a small fraction of its respective EPA concentration limit (Maximum Contaminant Level) and not within the ability of laboratories to detect.

Q67. Please summarize the Staff reasons why migration of cooling-tower blowdown injected into the Boulder Zone into the Upper Floridan aquifer would not cause an impact from the Constituents that is greater than SMALL, even if the

concentration of the Constituents in the cooling-tower blowdown are those listed in FEIS Table 3-5.

A67. (DOB, PDT) For the impact of the Constituents to be greater than SMALL, changes to groundwater quality must be to a degree that is detectable and impacts uses or users. The Staff concludes that this will not occur due to the following factors:

- The 2003 EPA relative risk assessments indicate that the risk to human health is low for deep well injection even if water is directly released to the USDW and available at a hypothetical well. The EPA states that "risk would be further reduced when the injected wastewater is treated to reclaimed water standards" (TN4759; NRC-010 at ES-24). FEIS Table 3-5, Expected Constituents and Concentrations Discharged to the Deep-Injection Wells, represent concentrations of the Constituents calculated to be present at the point of injection after conservatively accounting for cooling-tower processes and dilution at the Turkey Point Units 6 and 7 site and treatment to reclaimed water standards at the South District Wastewater Treatment Plant.
- The 2003 EPA risk assessment (TN4759; NRC-010) determined that pathogenic microorganisms presented the greatest risk to USDWs, not other contaminants that may be in injected wastewater.
- In 2005, the EPA eliminated the "no-migration-rule," which prohibited upwelling of injectate to the USDW, for facilities in certain counties of Florida (including Miami-Dade County), provided facilities in these counties had implemented advanced treatment of wastewater known as high-level disinfection. EPA made the 2005 rule change with an understanding of the geology of south Florida, including the area of Turkey Point Units 6 and 7.
- The EPA stated that after injecting wastewater treated to high-level disinfection standards, "the movement of fluids into the USDWs, whether known or suspected,

should not endanger the USDWs because the quality of the wastewater has been treated to a level that is no longer a threat to USDWs" (EPA 2012 TN4782 at 16; NRC-035 at 16).

- High-level disinfection was implemented at the South District Wastewater Treatment Plant in 2013 (TN4758; NRC-023).
- High-level disinfection would reduce the concentrations of the Constituents in reclaimed wastewater at the South District Wastewater Treatment Plant to below those measured from 2007 to 2011, which were used to calculate the concentrations reported in FEIS Table 3-5, Expected Constituents and Concentrations Discharged to the Deep-Injection Wells.
- Turkey Point Units 6 and 7 will receive wastewater from the South District Wastewater Treatment Plant that has been treated to a high-level disinfection Standards. Table 3-5, Expected Constituents and Concentrations Discharged to the Deep-Injection Wells, footnote (b) indicates that the sampling conducted after high-level disinfection was implemented at South District Wastewater Treatment Plant indicated that concentrations of the Constituents were below detectable levels.
- Reclaimed water received from the South District Wastewater Treatment Plant will be cycled through the cooling-tower system at the Turkey Point Units 6 and 7 site up to four times. This cycling will substantially reduce any remaining concentrations of the Constituents through the process of volatilization, chemical hydrolysis and photo-degradation. As a result, and consistent with the EPA conclusion regarding reclaimed wastewater disposed of by deep well injection, cooling-tower blowdown injected into the Boulder Zone is not expected to impact the Underground Source of Drinking Water (USDW), even if migration occurs.

- In addition, the Upper Floridan aquifer is brackish and is not currently used for drinking within the area of the plant. The nearest user (the Ocean Reef Club 7.7 miles from the injection site) uses water from the Upper Floridan aquifer for golf course application after freshening it.

These factors support the Staff conclusion that the impact on groundwater resources from the injection of Constituents cooling-tower blowdown into the Boulder Zone at the Turkey Point 6 & 7 site would be SMALL, even in the event of upwelling or direct release to the Underground Source of Drinking Water (USDW) within the Upper Floridan aquifer.

<u>**Confining Capability of the Middle Confining Unit**</u>

Q68. How did the Staff document the environmental impacts of deep well injection of the cooling-tower blowdown in the FEIS?

A68. (DOB, PDT) NEPA obligates the NRC to describe the environmental effects of the proposed action. Therefore, the FEIS describes the injection environment and analyzes the most likely fate of the injected effluent at the Turkey Point Units 6 and 7 site.

Q69. What are the major aquifers at the Turkey Point Units 6 and 7 site?

A69. (DOB, PDT) Section 2.8 of the FEIS (FEIS at 2-208; NRC-008A at 2-208) describes the geologic features underlying the Turkey Point Units 6 and 7 site and § 2.3.1.2 (FEIS at 2-47; NRC-008A at 2-47) describes the groundwater hydrology. As indicated in A15 above, the two major aquifer systems found at the Turkey Point Units 6 and 7 site are the surficial aquifer system and the deeper Floridan aquifer system. As shown in Figure 2-19 (FEIS at 2-48; NRC-008A at 2-48), the uppermost surficial aquifer system in the vicinity of the Turkey Point Units 6 and 7 site is called the Biscayne aquifer and is present between ground surface and a depth of about 140 feet at the proposed site. An approximately 800 ft. thick sequence of low-permeability rock, collectively called the “Intermediate Confining Unit,” separates the Biscayne aquifer and the underlying Floridan aquifer system and limits exchange of groundwater between these aquifer systems. The deeper Floridan aquifer system consists of several alternating layers of relatively permeable and impermeable rock that lie below the predominately low permeability intermediate confining unit. (FEIS at 2-47 to 2-48; NRC-008A at 2-47 to 2-48).

Q70. What is the extent and what are the general characteristics of the Floridan aquifer system?

A70. (DOB, PDT) The Floridan aquifer system underlies an area of about 100,000 square miles in southern Alabama, southeastern Georgia, southern South Carolina, and all of Florida (Miller 1990-TN550; NRC-039). Vertically, the Floridan aquifer system at the Turkey Point Units 6 and 7 site consists of several alternating layers of relatively permeable and impermeable rock. The three major units of the Floridan aquifer system are, from shallowest to deepest; the relatively permeable Upper Floridan aquifer, a less permeable formation known as the Middle Confining Unit, and the highly permeable Lower Floridan aquifer (LFA). *See* FEIS at 2-53 (NRC-008A). Each of the major units is composed of several rock layers. Studies of the hydrogeology of south Florida referenced in the FEIS indicate that the Middle Confining Unit is often composed of three distinct rock layers, namely: an upper low-permeability confining zone known as MC1, a permeable zone called the Avon Park Permeable Zone within the Avon Park Formation, and a deeper low permeability confining zone known as MC2 (Reese and Richardson 2008-TN3436; NRC-040).

Q71. What portion of the Floridan aquifer will operation of proposed Turkey Point Units 6 and 7 affect? Please describe its characteristics.

A71. (DOB, PDT) Within the Lower Floridan aquifer in southern Florida there is a cavernous, high-permeability layer of fractured dolostone called the Boulder Zone (FEIS at 2-54; NRC-008A at 2-54), which is the zone identified for deep-well injection of blowdown water from the proposed Units 6 and 7 cooling-towers. The water in the Boulder Zone is very similar to modern seawater both in salinity and temperature. (FEIS at 2-54; NRC-008A at 2-54). A USGS report (Miller 1990-TN550; NRC-039) indicates that the Boulder Zone likely connects to the Atlantic Ocean at a depth of about 2,500 ft. about 25 mi off the coast of Miami. FEIS at 2-54. The salinity of the water in the Boulder Zone precludes any interest in it as a supply of freshwater. Meyer (1989-TN2255; NRC-018) indicated that natural flow within the Boulder Zone in eastern Florida is generally westward and is very slow- on the order of thousands of years to cross the Florida peninsula. (FEIS at 2-54; NRC-008A at 2-54).

Q72. Please characterize the water quality of the Upper Floridan aquifer.

A72. (DOB, PDT) The Upper Floridan aquifer is an important source of freshwater in parts of Florida. However, groundwater from the Upper Floridan aquifer at the Turkey Point Units 6 and 7 site and throughout southeast Florida is too saline to be used for drinking water without treatment, with dissolved solid concentrations greater than 2,000 mg/L (Renken et al. 2005-TN110; NRC-017). The Upper Floridan aquifer in southeastern Florida is generally brackish to saline depending on depth and distance from the coast (Reese 1994-TN1439; NRC-014). FPL reported an average TDS concentration of 5,451 mg/L for the Upper Floridan aquifer (FEIS at 2-71; NRC-008A at 2-71). The Upper Floridan aquifer is designated an Underground Source of Drinking Water (USDW) at the Turkey Point Units 6 and 7 site.

Q73. What is the definition of an Underground Source of Drinking Water (USDW)?

A73. (DOB, PDT) As defined in 40 C.F.R.§ 144.3, an Underground Source of Drinking Water (USDW) is an aquifer, or part of an aquifer, in which the total dissolved solids concentration is less than 10,000 mg/L.

Q74. Which users of water from the Upper Floridan aquifer are closest to the Turkey Point Units 6 and 7 site?

A74. (DOB, PDT) Seven golf courses in Southeast Florida use Upper Floridan aquifer water for irrigation (SFWMD 2013- TN3461; NRC-041). Two of these, the Ocean Reef and Card Sound Golf Clubs, are located approximately 7.7 and 9 mi southeast of the Turkey Point Units 6 and 7 site, respectively. FPL uses water from the Upper Floridan aquifer in the immediate vicinity of the existing Turkey Point Unit 5 for cooling-tower makeup water at a rate of about 12.6 Mgd (FPL 2014-TN4058; NRC-016). Several water treatment plants at different locations in South Florida desalinate brackish water from the Upper Floridan aquifer for domestic use. The Florida Keys Aqueduct Authority operates the desalinization plant nearest the Turkey Point Units 6 and 7 site. (TN3461; NRC-041). This Florida Keys Aqueduct Authority desalinization plant is located about 11 miles west of the proposed Turkey Point Units 6 and 7 injection site. (FEIS at 2-61; NRC-008A at 2-61).

Q75. Where are the nearest users of water from the Boulder Zone?

A75. (DOB, PDT) The Lower Floridan aquifer system, including the Boulder Zone, is not used for water supply in Florida. The Boulder Zone is used only for injection of treated municipal and industrial wastewater.

Q76. How prevalent is use of the Boulder Zone for injection treated municipal and industrial wastewater in Florida?

A76. (DOB, PDT) The FDEP has permitted over 180 Class I injection wells for injection of municipal and industrial wastewater into the Boulder Zone of the Florida aquifer system. The top of the Boulder Zone at the Turkey Point Units 6 and 7 site about 3,030 ft. below ground surface and is proposed for injection disposal of cooling-tower blowdown and other waste streams from Units 6 and 7. The Boulder Zone is currently used for treated municipal waste water injection at Miami-Dade Water and Sewer Division's South District Wastewater

Treatment Plant approximately 9 mi north of the Turkey Point Units 6 and 7 site (Maliva et al. 2007-TN1483; NRC-043) (FEIS at 2-61; NRC-008A at 2-61).

Q77. What is the purpose of the UIC permit process?

A77. (DOB, PDT) The purpose of the UIC Program for permitting wastewater injection wells is to provide a viable disposal method for wastewater while ensuring adequate protection for Underground Source of Drinking Water (USDW).

Q78. What requirements govern Class I injection wells in Florida?

A78. (DOB, PDT) FDEP regulations (Fla. Admin. Code 62-4-TN1084; NRC-042) require that injection wells be constructed, maintained, and operated so that the injected fluid remains in the injection zone. FDEP regulations also require permittees to monitor Class I injection wells so that if upward migration of injection fluids were to occur it would be detected before reaching an Underground Sources of Drinking Water (USDW).

Q79. What protective measures are required as part of the FDEP UIC Permit process?

A79. (DOB, PDT) The requirements of the UIC Permitting process are set forth in the FDEP Underground Injection Control Rule, Chapter 62-528, F.A.C. (NRC-019). Siting, testing and monitoring requirements under the FDEP UIC Program are incorporated into a three-stage permitting process.

First, applicants receive an Exploratory Well Construction Permit that requires complete characterization of site hydrogeology to ensure “underground formations have the natural ability to accept and confine the waste.” This characterization includes tests required by the UIC program including geologic characterization (coring), hydrogeological testing (pump tests, packer tests, laboratory testing of core), and a suite of geophysical logging.

The Exploratory Well Construction Permit is then converted to a Class I well construction permit, which requires 6 to 24 months of test operation with increased monitoring requirements.

During this period, injection testing is performed and response is measured within the receiving formation (here, the Boulder Zone) and at dual zone monitoring wells installed within and above the confining formation (here, the Middle Confining Unit) to evaluate the receiving formation's capacity to accept injected waste and the confining formation's capacity to confine injected waste. The monitoring wells are installed within 150 ft. of the injection wells with monitoring zones located below and above the Underground Source of Drinking Water (USDW). UIC Construction Permit conditions require that weekly samples be obtained from the wells for groundwater quality parameters (TDS, temperature, conductivity, solute chemistry, pH, radiological constituents, and water levels).

As described in FEIS § 3.2.2.2, wells would be designed and installed to prevent upwelling of injected effluent. Each injection well would be a 24-in. diameter steel well casing extending up to 3,500 ft. below grade. A typical injection well steel casing would be lined with 18 in. diameter glass-fiber-reinforced plastic, with a nonhazardous corrosion inhibitor in the annulus between the two. The annulus would be pressurized using a positive-seal packer located at the base of the casing and the pressure would be continuously monitored for leaks during operation. Its upper section would be reinforced with additional steel casings of increasing diameter as shown in the typical injection well cross section in Figure 3-8 (FEIS at 3-10; NRC-008A at 3-10). In addition, upwelling related to well construction issues is not expected at the Turkey Point Units 6 and 7 site because under newer well construction techniques, the pilot hole is cemented before the actual well is drilled (FEIS at 2-56; NRC-008A at 2-56).

Upon successful completion of construction testing and approval from the FDEP, the UIC Construction Permit for the injection well may be converted into an Operating Permit. Operating Permits may be renewed every 5 years and require monthly sampling of the parameters mentioned above, as well as testing to ensure the mechanical integrity of the well.

Mechanical integrity testing includes a video survey, annular pressure test, radioactive tracer survey, and high-resolution temperature logging. FPL performed onsite characterization and testing for the Turkey Point Units 6 and 7 site as part of the permit process for well EW-1, which is discussed in FEIS §§ 2.3.1.2, 5.2.1.3, and 5.2.3.2, the FPL report on the construction and testing of well EW-1 (TN1264; NRC-020), as summarized below in this testimony.

Q80. Please describe whether FPL would be granted a permit to inject blowdown into the Boulder Zone based only on the information described above which was obtained from 1 onsite well, EW-1?

A80. (DOB, PDT) As part of the permitting process, data will be gathered at each proposed well and monitoring well (12 wells, 6 monitoring wells) and each of these will undergo the same characterization, testing and monitoring as required under the FDEP UIC permit for EW-1 (FEIS at 5-41; NRC-008A at 5-41).

Q81. What is the purpose of the NRC evaluation of deep-well injection in the FEIS?

A81. (DOB, PDT) The purpose of the Staff evaluation of deep well injection presented in the FEIS is to determine the impacts to water resources that might reasonably occur if Units 6 and 7 are operated. This includes an understanding of the most likely fate of the cooling-tower blowdown once it is injected into the Boulder Zone. The NRC, however, does not license the construction and operation of the injection wells, nor does the NRC determine the adequacy of the geological strata in regard to UIC requirements. Rather, the State of Florida makes those determinations through its UIC permit process (Fla. Admin. Code 62-4-TN1084; NRC-042).

Q82. What did the Staff do to evaluate the confinement of injected wastewater in the saline Boulder Zone?

A82. (DOB, PDT) To evaluate the likelihood that injected wastewater would remain confined in the saline aquifers below the Upper Floridan aquifer, the Staff 1) reviewed studies that characterized the extent, thickness, and confining ability of the Middle Confining Unit and the causes and extent of upward vertical movement of injectate at other deep well injection sites, 2) examined information from drilling and characterization of the EW-1 exploratory well constructed at the proposed injection site including geophysical logs, lithologic descriptions of rock cores, and hydraulic properties from aquifer pump tests, 3) compared hydrogeological conditions and parameters at the sites at which upwelling occurred to conditions and parameters at the proposed site, 4) evaluated numerical modeling of flow of injected wastewater presented by the applicant and performed confirmatory calculations, and 5) considered the injection well testing and groundwater monitoring requirements of the FDEP UIC program.

The Staff documented its evaluation of the expected impacts of deep well injection in §§ 2.3.3.2 "Groundwater Quality," 5.2.3.2 "Groundwater-Quality Impacts," 7.2.2.2 "Groundwater-Quality Impacts," and Appendix G.3.3 "Confirmatory Calculations of Potential Upward Migration of Injectate from the Boulder Zone of the Lower Floridan Aquifer" of the FEIS (NRC-008A-C).

Q83. Please list and summarize the studies that Staff considered regarding the causes and extent of vertical and horizontal migration at injection sites in South Florida in order to evaluate the expected behavior of injected effluent at the Turkey Point Units 6 and 7 site.

A83. (DOB, PDT) The NRC Staff considered a number of studies as part of evaluating the impacts of injection at the Turkey Point Units 6 and 7 site. These are listed below according to the general category in which they pertain. This list is not comprehensive.

a) General characterization of the Floridan aquifer system

- Meyer, F.W. 1989. Hydrogeology, Ground-Water Movement, and Subsurface Storage in the Florida aquifer System in Southern Florida. U.S. Geological Survey Professional Paper 1403-G, Reston, Virginia. (Accession No. ML14342A006). (TN2255; NRC-018).

- Miller, J.A. 1990. Ground Water Atlas of the United States: Alabama, Florida, Georgia, and South Carolina. HA 730-G, U.S. Geological Survey, Reston, Virginia. (Accession No. ML101930591). (TN550; NRC-039).
- Reese, R.S. 1994. Hydrogeology and the Distribution and Origin of Salinity in the Floridan aquifer System, Southeastern Florida. U.S. Geological Survey Water-Resources Investigations Report 94–4010, Tallahassee, Florida. (Accession No. ML14287A476). (TN1439; NRC-014).
    - Studies from Meyer (1989 TN2255; NRC-018), Miller (1990 TN550; NRC-039), and Reese (1994 TN1439; NRC-014) set forth the regional hydrogeologic framework of the Floridan aquifer system and outlined the general depths, thicknesses, lithology, water quality, and flow characteristics and flow mechanisms of each of the three main units within this system. These are the Upper Floridan aquifer, the Middle Confining Unit and the Lower Floridan aquifer, where the Boulder Zone is located.
- Reese, R.S. and E. Richardson. 2008. Synthesis of the Hydrogeologic Framework of the Floridan Aquifer System and Delineation of a Major Avon Park Permeable Zone in Central and Southern Florida. U.S. Geological Survey Scientific Investigations Report 2007–5207, Reston, Virginia. (Accession No. ML14342A007). (TN3436; NRC-040).
- Williams, L.J. and E.L. Kuniansky. 2015. Revised Hydrogeologic Framework of the Floridan Aquifer System in Florida and Parts of Georgia, Alabama, and South Carolina. U.S. Geological Survey Professional Paper 1807, Reston, Virginia. (Accession No. ML16266A243). (TN4577; NRC-062).
    - Studies by Reese, R.S. and E. Richardson (2008 TN3436; NRC-040) and Williams, L.J. and E.L. Kuniansky (2015 TN4577; NRC-062) refined the understanding of the Floridan aquifer system. These studies revised and refined

the nature and extent of the upper confining zone known (MC1), the Avon Park Permeable Zone, and the lower confining zone (MC2) within the MCU.

b) Characterization of the Middle Confining Unit integrity and fluid migration

- Starr, R.C., T.S. Green, and L.C. Hull. 2001. Evaluation of Confining Layer Integrity Beneath the South District Wastewater Treatment Plant, Miami-Dade Water and Sewer Department, Dade County, Florida. INEEL/EXT-01-00046, Idaho National Engineering and Environmental Laboratory, Idaho Falls, Idaho. (Accession No. ML14216A601). (TN1251; NRC-044).
    - o This study is an independent review performed by the Idaho National Engineering Laboratory at the request of the EPA Region 4 using geology, hydrogeology, and geochemistry data provided by the EPA from the South District Wastewater Treatment Plant site. The purpose of the Starr study was to determine the causes of upward migration of injectate that had occurred at the South District Wastewater Treatment Plant and evaluate the confining ability of the Middle Confining Unit based upon a review of the dataset that had been provided.
- McNeill, D.F. 2002. A Geological Review of the Confining Capability of a Regional Dolomite Unit: Application to the MDWAS South District WWTP. Coral Gables, Florida. (TN4571; NRC-064).
    - o This study used lithologic and geophysical data from deep wells to characterize and demonstrate the importance of a dense, low permeability dolomite confining unit that occurs throughout South Florida and “may provide additional effective confinement of upwardly buoyant injected fluids” (TN4571 at i; NRC-064). The study provides specific attributes of core recovery, hydraulic conductivity, permeability, resistivity, and signatures from caliper, gamma, density, and sonic logs that may be indicative of this unit.

- FPL (Florida Power & Light Company) 2012. Report on the Construction and Testing of Class V Exploratory Well EW-1 at the Florida Power & Light Company Turkey Point Units 6 & 7. McNabb Hydrogeologic Consulting, Inc., Jupiter, Florida. (Accession No. ML14336A337). (TN1577; NRC-056).
    - FPL constructed exploratory well EW-1 on the site to determine the properties of the Boulder Zone and the confining nature of the overlying Middle Confining Unit that separates the Boulder Zone from the Upper Floridan aquifer. FPL constructed the exploratory well to a depth of 3,232 ft. below the drill pad. FPL evaluated water-quality samples, rock core, geophysical logging, video surveys and packer testing to determine the hydraulic parameters of the rock layers. Based on these data, the rocks encountered between depths of 1,535 and 3,232 ft. were divided into three distinct zones, each of which roughly coincide with the (1) MC1 and Avon Park Permeable Zone of the Middle Confining Unit, (2) MC2 of the Middle Confining Unit, and the (3) Boulder Zone of the Lower Floridan aquifer.
- Cunningham, K.J., C. Walker, and R.L. Westcott. 2012. "Near-Surface, Marine Seismic-Reflection Data Define Potential Hydrogeologic Confinement Bypass in the Carbonate Floridan Aquifer System, Southeastern Florida." In SEG (Society of Exploration Geophysicists) Technical Program Expanded Abstracts 2012, Society of Exploration Physicists, Tulsa, Oklahoma. *Available at* http://library.seg.org/doi/abs/10.1190/segam2012-0638.1. (TN4576; NRC-050).
- Cunningham, K.J. 2013. Integrating Seismic-Reflection and Sequence-Stratigraphic Methods to Characterize the Hydrogeology of the Floridan Aquifer System in Southeast Florida. U.S. Geological Survey Open File Report 2013-1181, Reston, Virginia. (Accession No. ML16172A124). (TN4573; NRC-051).

- Cunningham, K.J. 2014. Integration of Seismic-Reflection and Well Data to Assess the Potential Impact of Stratigraphic and Structural Features on Sustainable Water Supply from the Floridan Aquifer System. Open-File Report 2014–1136, U.S. Geological Survey, Davie, Florida. (Accession No. ML14342A048). (TN4051; NRC-052).
- Cunningham, K.J. 2015. Seismic-Sequence Stratigraphy and Geologic Structure of the Floridan Aquifer System Near "Boulder Zone" Deep Wells in Miami-Dade County, Florida. U.S. Geological Survey Scientific Investigations Report 2015-5013, Reston, Virginia. (Accession No. ML16172A125). (TN4574; NRC-053).
    - USGS scientists led by Kevin Cunningham have conducted multiple seismic-reflection studies in Southeast Florida to identify the presence and extent of faults or other natural vertical “karst collapse” features that could act as conduits for flow of injected wastewater across the Middle Confining Unit and into the Upper Floridan aquifer. Where possible, these studies were conducted near wastewater treatment and injection facilities including near the City of Sunrise, FL. and the North District and South District WWTP in Miami-Dade County.

c) Causes and extent of upwelling at deep well injection sites

- McNeill, D.F. 2000. A Review of Upward Migration of Effluent Related to Subsurface Injection at Miami-Dade Water and Sewer South District Plant. Final Report, Coral Gables, Florida. (TN4572; NRC-048)
    - This study used site-specific geological data and well construction records to determine the cause of upward migration of effluent that had been observed at the South District Wastewater Treatment Plant and predate the 2002 study discussed earlier.

- Maliva, R.G., W. Guo, and T. Missimer. 2007. "Vertical Migration of Municipal Wastewater in Deep Injection Well Systems, South Florida, USA." Hydrogeology Journal 15:1387–1396, New York, New York. (TN1483; NRC-043).
  - o This study evaluated whether upward migration of injectate resulted from flow through the unfractured matrix of the Middle Confining Unit or through natural or manmade pathways, such as fractures or improperly installed or failed wells. This was done through evaluation of geophysical sonic logs, hydraulic conductivity data from core-plugs at 29 South Florida injection well systems (including the South District Wastewater Treatment Plant), and solute-transport modeling using variable density numerical modeling.
- Walsh, V.M. and R.M. Price. 2008. "Tracing Vertical and Horizontal Migration of Injected Fresh Wastewater into a Deep Saline Aquifer using Natural Chemical Tracers." In *20th Salt Water Intrusion Meeting Proceedings, June 23–27, 2008, Naples, Florida*. U.S. Geological Survey, Ft. Lauderdale, Florida. (Accession No. ML15026A504). (TN3657; NRC-065).
- Walsh, V.M. and R.M. Price. 2010. "Determination of Vertical and Horizontal Pathways of Injected Fresh Wastewater into a Deep Saline Aquifer (Florida, USA) using Natural Chemical Tracers." *Hydrogeology Journal* 18(4):1027–1042, New York, New York. (TN3656; NRC-046).
  - o In these studies, the authors evaluated well construction, geologic and geochemical data to determine the causes and extent of upwelling detected at the Miami-Dade Water and Sewer Division North District and South District WWTPs.

d) Modeling of plume migration

- Dausman, A.M., C. Langevin, M.C. Sukop, and V. Walsh. 2008. "Saltwater/Freshwater Interface Movement in Response to Deep-Well Injection in a Coastal Aquifer." In Proceedings of the 20th Salt Water Intrusion Meeting, June 23-27, 2008, Naples, Florida. Accessed September 9, 2016, *Available at* http://conference.ifas.ufl.edu/swim/papers.pdf. (TN4757; NRC-012).
    - Dausman et al. (2008-TN4757) modeled migration of two plumes from the South District Wastewater Treatment Plant of wastewater injected into the Boulder Zone: one comprised of secondarily treated wastewater and another of wastewater receiving high-level disinfection, which has since been implemented along with additional filtration at the South District Wastewater Treatment Plant site. Modeling was performed to evaluate the potential vertical and horizontal extent of plume migration, compare impacts on aquifers of injection of wastewater receiving secondary and high-level disinfection treatment, and indicate dilution amounts that may be expected along flowpaths.
- Dausman, A.M., J. Doherty, C.D. Langevin, J. Dixon. 2010. "Hypothesis Testing of Buoyant Plume Migration Using a Highly Parameterized Variable-Density Groundwater Model at a Site in Florida, USA." Hydrogeology Journal 18(1):147-160. *Available at* http://link.springer.com/article/10.1007%2Fs10040-009-0511-6. (TN4760; NRC-047).
    - This study details the use of a highly parameterized variable density groundwater model simulating injection at the South District Wastewater Treatment Plant to determine whether upward migration resulted from either matrix flow through an unfractured Middle Confining Unit or rapid migration through natural or manmade pathways. The recent seismic work by Cunningham (cited above) that identified natural vertical features in the Middle Confining Unit was cited as one of the drivers for the study.

- RAI 6985, January 15, 2014. Florida Power & Light Company, Response to NRC Request for Additional Information Letter No. 072 (eRAI 6985)-SRP Section 11.02-Liquid Waste Management Systems. L-2014-02. (NRC-055).
    - FPL provided information about modeling and analysis of several scenarios performed to determine the expected vertical and horizontal extent of effluent migration. The scenarios in the analysis focused on the fate and transport of radionuclides over a 61-year injection period followed by a 41-year period with no injection, and used conservative assumptions that would tend to maximize the upward and outward migration of injected effluent.

e) Risk assessments of injected wastewater migration into the Underground Source of Drinking Water (USDW)

- EPA (U.S. Environmental Protection Agency) 2003. Relative Risk Assessment of Management Options for Treated Wastewater in South Florida. EPA-816-R-03-010, Washington, D.C. (Accession No. ML16266A248). (TN4759; NRC-010).
    - This risk assessment was performed to inform the 2005 EPA rule that amended the Underground Injection Control Program to eliminate the prohibition on upward migration into the Underground Source of Drinking Water (USDW) for facilities in select counties in Florida, including Miami-Dade County, where high-level disinfection had been implemented. The assessment considered chemicals and biological constituents within secondarily treated wastewater that might cause adverse impacts (known as “stressors”) and a variety of exposure pathways, receptors, and potential effects for each disposal method.
- Bloetscher, F., J.D. Englehardt, D.A. Chin, J.B. Rose, G. Tchobanoglous, V.P. Amy, and S. Gokgoz. 2005. "Comparative Assessment of Municipal Wastewater Disposal Methods in Southeast Florida." *Water Environment Federation* 77(5):480-490, Alexandria, Virginia. (TN4756; NRC-011).

- This report details the methods and results of a comparative assessment of wastewater disposal methods in southeast Florida that evaluated impacts of deep well injection to a variety of receptors based on multiple exposure routes. These routes included direct leakage of injection wells into the Biscayne aquifer and the Upper Floridan aquifer, as well as rapid vertical migration from deep injection wells into the Upper Floridan aquifer. (TN4756 Figure 3 at 484; NRC-011).

Q84. Please describe the constituents, transport models, exposure scenarios and receptors considered in the Bloetscher assessment.

A84. (DOB, PDT) Bloetscher et al (2005-TN4756; NRC-011) performed another comparative assessment of wastewater disposal methods in southeast Florida. As part of this study, Bloetscher evaluated impacts of deep well injection to a variety of receptors based on multiple exposure routes.

Q85. Please describe the portion of the Bloetscher study relevant to upward migration from the Boulder Zone into the Upper Floridan aquifer.

A85. (DOB, PDT) Bloetscher considered exposure routes that included rapid vertical migration from deep injection wells into the Upper Floridan aquifer and, even more conservatively, direct leakage of injection wells into the Biscayne aquifer and the Upper Floridan aquifer.

This Bloetscher study concluded that risks were “lower, in general, for injection well disposal, due to natural barriers between the injection point and population centers.” (2005-TN4756; NRC-011 at 489). The study also suggested that as distance from the injection well increased, risk to receptors decreased, with the lowest relative risk at distances of 5 mi (or greater).

Q86. What is the significance of the Bloetscher study in regard to the impacts from Turkey Point Units 6 and 7 injection?

A86. (DOB, PDT) The distance from an injection well Bloetscher identifies as the distance at which risk falls to a minimum bounds the migration distance expected for wastewater injected at Turkey Point Units 6 and 7, as predicted by modeling studies and discussed in FEIS § 5.2.3.1. The FPL evaluation of injectate behavior in regard to horizontal migration, which was independently verified by the Staff, indicated that Injected wastewater was not predicted to extend horizontally more than around 4 mi beyond the point of injection over the modeled timeframe. This indicates that risk would be low because the plume is not expected to migrate horizontally beyond the 5 miles indicated in the Bloetscher risk assessment. As such, risks would be even lower than those presented in the Bloetscher study.

Q87. Please list and briefly summarize the confirmatory analysis performed by the Staff on FPLs evaluation of the extent of vertical and horizontal migration of injected effluent at the Turkey Point Units 6 and 7 site.

A87. (DOB, PDT) Final Environmental Impact Statement for Combined Licenses (COLs) for Turkey Point Units 6 and 7, Volume 1, Appendix G.3 Supporting Hydrologic Documentation, § G.3.3 Confirmatory Calculations of Potential Upward Migration of Injectate from the Boulder Zone of the Lower Floridan Aquifer, pages G-48-52. October 2016.

- The Staff performed a separate confirmatory analysis of the modeling presented by FPL of the vertical and horizontal extent of injected plume migration. Results of this analysis are presented in § G.3.3 of Appendix G.

Q88. What do the studies of UIC deep injection sites show in regard to the migration of injected water?

A88. (DOB, PDT) Taken together, the studies reviewed by the Staff and the Staff independent confirmatory analyses indicate the following:

- Significant vertical migration of effluent out of the Boulder Zone due to flow through the matrix or natural pathways (fractures, faults) is not expected at the Turkey Point Units 6 and 7 site,
- If significant vertical migration of effluent occurred, it would not likely reach the Upper Floridan aquifer, which is the Underground Source of Drinking Water (USDW),
- The extent of horizontal migration of effluent within the Boulder Zone is not expected to extend to beneath the users of water in the Upper Floridan aquifer,
- If effluent migrated vertically to the Upper Floridan aquifer the concentration of Constituents would be undetectable due to dilution and risk would be low.

Causes and extent of previous instances of upward migration of injected wastewater

Q89. What factors related to the cooling tower blowdown water injected into the Boulder Zone affect the potential for upwelling?

A89. (DOB, PDT) An EPA study of 93 deep-well injection facilities in South Florida also indicates that fluid movement underground is influenced by buoyancy created by temperature and TDS differences between native and injected waters. Injection pressures, which are influenced by the geology and injection rates, can also induce upward migration (Underground Injection Control Program-Relative Risk Assessment of Management Options for Treated Wastewater in South Florida; Notice of Availability 68 Fed. Reg. 23,673 (May 5, 2003); (TN3658; NRC-045). In the modeling evaluation of vertical migration FPL indicated that the TDS of injected fluid and the Boulder Zone water would be 2.7 kg/m3 and 36.2 kg/m3, respectively. (FPL answer to RAI 6985, ML14017A019, January 15, 2014 at 71 and 74. NRC-066 at 71 and 74). Temperature of injected fluid and the Boulder Zone water would be 91ºF and 77º, respectively. (FPL answer to RAI 6985, ML14017A019, January 15, 2014 at 28 and 29; NRC-066 at 28 and 29). The expected higher temperatures and lower TDS of injectate compared to native water in the Boulder Zone will result in an upward flow potential due to lower density and greater buoyancy of the injected water.

Q90. How many wastewater injection sites in Florida have experienced upward migration of injected wastewater?

A90. (DOB, PDT) FDEP has permitted over 180 Class I injection wells for municipal and industrial wastewater disposal (FEIS at 2-55; NRC-008A at 2-55). Upward migration of reclaimed water has been detected at seventeen sites (Maliva et. al. at 1388; NRC-043). Migration had occurred into the Underground Source of Drinking Water (USDW) at eight of these, and three of these were in South Florida. One of these sites was the South District Wastewater Treatment Plant (Maliva et. al. at 1388 and Figure 1; NRC-043).

Q91. What do these studies indicate regarding whether observed upward migration of wastewater has reached the Upper Floridan aquifer?

A91. (DOB, PDT) Starr et. al. (TN1251; NRC-044) and the EPA relative risk assessment (TN4759; NRC-010), published in 2001 and 2003, respectively, indicated that in some places injected effluent has migrated as far upward as the Upper Floridan aquifer, which is an Underground Source of Drinking Water (USDW). However, more recent studies, such as Maliva et al (2007-TN1483; NRC-043) and Walsh and Price (2010-TN3656; NRC-046) have clarified that while migration has reached the Underground Source of Drinking Water (USDW) at some Class I injection facilities, no impact has been reported for the Upper Floridan aquifer in southeast Florida including at the South District Wastewater Treatment Plant.

Q92. Please explain the apparent discrepancy regarding upwelling of injected wastewater to the Upper Floridan aquifer?

A92. (DOB, PDT) Reese and Richardson reported that before 2008 the Avon Park Permeable Zone in southeastern Florida had been identified as the “lower part of the Upper Floridan aquifer in…the southern part of southeastern Florida.” (TN3436 at 2; NRC-040 at 2).

As a result, earlier studies considered the Avon Park Permeable Zone, where upwelling was detected, to be the lower part of the Upper Floridan aquifer. The most current studies indicate that the Avon Park Permeable Zone is separated from the Upper Floridan aquifer in South Florida by the upper confining unit of the Middle Confining Unit. A USGS revision of the Floridan aquifer System also determined that "in southern Florida, the APPZ is more isolated by thicker lower permeability rocks than elsewhere in the system and may act as a distinct aquifer within the system" (Williams and Kuniansky 2015-TN4577 at 64; NRC-062). The Middle Confining Unit is now recognized as being thicker than previously determined and encompassing a more distinct and permeable Avon Park Permeable Zone.

Using this refined understanding, the Staff and others have determined that upwelling documented at existing injection sites was not as vertically extensive as previously believed.

Q93. Please provide an example of how the previous interpretation of the Middle Confining Unit affected the understanding of the extent of vertical migration at the South District Wastewater Treatment Plant.

A93. (DOB, PDT) In Starr et al (TN1251; NRC-044), hydrostratigraphic unit contacts for the Upper Floridan aquifer, the Middle Confining unit and the Lower Floridan aquifer at the South District Wastewater Treatment Plant were based on a previous report from 1998. (TN1251 Figure 6 at 18; NRC-044). This report placed the top of the Middle Confining Unit at 1900 ft. below the ground surface. This contact between the Upper Floridan aquifer and Middle Confining Unit is around 900 ft. lower than determined in later studies of the South District Wastewater Treatment Plant (*see* TN3656 Figure 20; NRC-046) that are based on the re-evaluation of the Middle Confining Unit and Avon Park Permeable Zone presented by Reese and Richardson in 2008 (TN3436; NRC-040). As a result, in Starr et al the MC1 and the Avon Park Permeable Zone are assumed to part of the Upper Floridan aquifer and contamination detected at the 1500 ft. monitoring zone is assumed to be within the Upper Floridan aquifer, rather than the Avon Park Permeable Zone of the Middle Confining Unit. In his 2000 study of the Middle Confining Unit at the South District Wastewater Treatment Plant, McNeill also relies on the previous understanding of depths and thicknesses of the Middle Confining Unit. As a result, the units that are now recognized as the MC1 and the Avon Park Permeable Zone are assumed by McNeill to be part of the Upper Floridan aquifer.

Q94. What do studies indicate would occur if injected effluent did migrate upward through the MC2 and into the Avon Park Permeable Zone?

A94. (DOB, PDT) As discussed above, upwelling has occurred at the South District Wastewater Treatment Plant, however, according to Walsh and Price (2010), that upwelling reached no higher than the Avon Park Permeable Zone of the Middle Confining Unit. (TN3656 at unnumbered 11-15; NRC-046). To explain this, Walsh and Price present a conceptual model that postulates the vertical migration through the MC2 of the Middle Confining Unit is density driven due to salinity or temperature differences between the formation water and injectate. Walsh and Price also determined that if migration into the Avon Park Permeable Zone occurred, "the transport mechanism appeared to be a horizontal flow with mixing of ambient waters" which would likely diminish the buoyant forces and reduce the impact above the Avon Park Permeable Zone. (TN3656 at unnumbered 15; NRC-046). This conceptual model of horizontal flow in the Avon Park Permeable Zone overcoming the vertical flow component that dominated flow within the more confining Middle Confining Unit strata was also illustrated in a numerical modeling scenario by Maliva et al (2007-TN1483 Figure 5 at 1394; NRC-043). This indicates that even where migration through the bottom portion of the Middle Confining Unit has occurred, upwelling to the upper Middle Confining Unit and the overlying Upper Floridan aquifer is not likely. (FEIS at 2-57; NRC-008A at 2-57). This could partially explain why recent studies have indicated that upwelling to the Upper Floridan aquifer has not occurred at injection sites. (FEIS at 2-57; NRC-008A at 2-57).

Q95. Please explain how upwelling could reach an Underground Source of Drinking Water (USDW) and not reach the Upper Floridan aquifer, as A84, A85, and A86 indicate happened at the South District Wastewater Treatment Plant.

A95. (DOB, PDT) Upwelling may reach the Underground Source of Drinking Water (USDW) but not the Upper Floridan aquifer if upward migration reaches the Avon Park Permeable Zone and the Avon Park Permeable Zone is designated a Underground Source of Drinking Water (USDW) (TDS less than 10,000 mg/L). The depth at which groundwater TDS exceeds 10,000 mg/L may occur beneath the base of the Upper Floridan aquifer as it does at the South District Wastewater Treatment Plant. Therefore, upwelling into the Underground Source of Drinking Water (USDW) does not necessarily indicate that upwelling has reached the Upper Floridan aquifer. This is discussed in the FEIS at 5-23 (NRC-008A). Review of data from well EW-1 indicate that the base of the Underground Source of Drinking Water (USDW) and Upper Floridan aquifer occur around the same depth at the Turkey Point Units 6 and 7 site (TN1577 at 15; NRC-056).

Q96. What do studies and data from well EW-1 indicate about Avon Park Permeable Zone at the Turkey Point Units 6 and 7 site?

A96. (DOB, PDT) Reese and Richardson (2008-TN3436; NRC-040) show the top of the Avon Park Permeable Zone at a depth of approximately 1,700 ft. at a borehole south of Turkey Point Units 6 and 7, and missing at a borehole north of Turkey Point Units 6 and 7. The Avon Park Permeable Zone was not identified in the EW-1 borehole and may be missing at this location because it is mapped as becoming thinner to the south. To the extent, the Avon Park Permeable Zone exists at the Turkey Point Units 6 and 7 site, results from characterization at EW-1 indicate that the upper confining unit of the Middle Confining Unit may separate the Avon Park Permeable Zone from the Upper Floridan by approximately 250 ft. (FEIS Figure 2-17 at 2-48; NRC-008A). The absence of the Avon Park Permeable Zone at the Turkey Point Units 6 and 7 site would be consistent with the Reese and Richardson (2008) finding that the Avon Park Permeable Zone is missing at borehole S-3001 south of the Turkey Point Units 6 and 7 site (Reese and Richardson 2008-TN3436 at 49; NRC-040). Reese and Richardson (2008-TN3436 at 49; NRC-040) also states that "The [Avon Park Permeable Zone] is absent in areas close to the east coastline of southeastern Florida and the Florida Keys; for example, it is absent in wells W-16897 (fig. 17b), KWDIW-1 (fig. 17f), and S-3001." If the Avon Park Permeable Zone is missing at Turkey Point Units 6 and 7, then the thickness of the confining units is increased.

Q97. What are the potential causes of upward migration at wastewater injection sites?

A97. (DOB, PDT) Studies have evaluated whether observed migration was caused by flow through the matrix of the Middle Confining Unit or through pathways provided by either natural geologic features or well-related problems, such as improper installation or failure. (FEIS at 5-23; NRC-008A).

Q98. How would upward flow through the matrix of the Middle Confining Unit be possible?

A98. (DOB, PDT) Upward migration of buoyant wastewater could occur if the vertical hydraulic conductivity of the matrix of the Middle Confining Unit was high enough to permit flow.

Q99. What have previous studies concluded regarding the role played by vertical hydraulic conductivity of the Middle Confining Unit in the upwelling seen at the South District Wastewater Treatment Plant?

A99. (DOB, PDT) A number of studies have evaluated the role that hydraulic conductivity of the Middle Confining Unit at the South District Wastewater Treatment Plant may have played in vertical migration detected at that site.

In his 2000 study, McNeill determined that hydraulic conductivity values from the site were found to be above values that would indicate confinement. As a result, he concluded that "the rocks separating the injection zone (Boulder Zone) from the Upper Floridan Aquifer are not nearly as impermeable as earlier proposed" and result in actual migration times to the Upper Floridan aquifer that are 30 times faster than predicted by previous studies and in line with the actual migration times determined onsite. (TN4572 at 3; NRC-048). This led McNeill to conclude that the confining ability of the Middle Confining Unit "must be questioned." (TN4572 at 26; NRC-048).

Starr et al (TN1251; NRC-044) also evaluated the hydraulic conductivity of the Middle Confining Unit at the South District Wastewater Treatment Plant. Starr et al. also determined that hydraulic conductivity data for the Middle Confining Unit were "much higher than typical values for confining units." However, rather than concluding that the matrix of the Middle Confining Unit offered poor confinement, Starr et al. recognized that the dataset was not sufficient to support and analysis of the Middle Confining Unit. The Starr study stated that "a caveat to this interpretation is that the hydraulic characterization test methods employed may not adequately represent the less permeable hydrostratigraphic units, and hence the hydraulic data set may not adequately describe the actual site conditions." (TN1251 at iv; NRC-044). Starr et al also noted that values provided for their analysis were for total hydraulic conductivity, which can be much higher than vertical hydraulic conductivity and concluded that "the hydraulic conductivity data reviewed may not reflect the effective vertical hydraulic conductivity of the confining units above the Boulder Zone." (TN1251 at 38; NRC-044). Starr et al. also noted that the pattern of contamination at the site was not "…consistent with widespread upward migration of contaminated water through a highly permeable confining layer," which would be expected if vertical hydraulic conductivity of the Middle Confining Unit were generally high. (TN1251 at 25; NRC-044.

Q100. What did Maliva et al determine were the typical vertical hydraulic conductivity values sufficient to prevent matrix flow through the Middle Confining Unit?

A100. (DOB, PDT) Maliva et al incorporated the results from hydraulic conductivity data analysis of core-plugs at 29 South Florida injection sites into a variable density numerical modeling effort. The Maliva study determined that relatively thin zones of non-fractured dolostone with hydraulic conductivities in the 10^{-6} to 10^{-7} cm/sec range allow for minimal vertical migration. Maliva et al indicated that unfractured dolostones could provide effective confinement "to prevent wastewater from reaching the deepest USDW, irrespective of fracturing of underlying rock". (TN1483 at 1394; NRC-043).

Q101. Aside from flow through the matrix of the Middle Confining Unit, what could cause upward migration of injected wastewater?

A101. (DOB, PDT) Upward migration through the Middle Confining Unit could also result from either natural or man-made features that act to increase vertical conductivity through the otherwise confining unit.

Q102. To what mechanism did Starr et al attribute upward migration of injected wastewater at the South District Wastewater Treatment Plant site?

A102. (DOB, PDT) The Starr study stated that "the spatial patterns of contamination suggest that upward migration occurs along localized pathways such as wells that are not adequately sealed or natural conduits." (TN1251 at iv; NRC-044).

Q103. What did previous studies conclude in regard to the hypothesis that upwelling at the South District Wastewater Treatment Plant resulted from improperly installed wells?

A103. (DOB, PDT) At the South District Wastewater Treatment Plant, McNeill (2002-TN4571; NRC-064) indicated that upwelling likely occurred because 10 of 17 injection wells were drilled through but completed above the Dolomite Confining Unit at the base of the Middle

Confining Unit, effectively leaving an open hole and upward pathway through which injected effluent could migrate.

Walsh and Price 2010 (TN3656; NRC-046) determined that while natural features could not be ruled out, enhanced vertical flow pathways that allowed upwelling likely resulted from issues related to well installation or failure because effluent appeared to bypass deeper monitored intervals before being detected at higher depths. (FEIS at 5-25; NRC-008A).

Dausman et al. (2010-TN4760; NRC-047) agreed that Middle Confining Unit "heterogeneity cannot explain all the effluent migration" and indicated that upwelling at the South District Wastewater Treatment Plant can generally be attributed to "…flow through a channelized pathway caused by well construction." (TN4760 at 159; NRC-047).

Q104. What mechanism could cause upward migration to occur even if matrix hydraulic conductivities are low enough to create confining conditions and wells are properly installed?

A104. (DOB, PDT) Maliva et al. concluded that fracturing of the confining unit could create high vertical hydraulic conductivities and that "where fracturing is not significantly developed, low porosity dolostones and limestones provide effective vertical confinement of injected fluid" (TN1483 at 1395; NRC-043). As a result, Maliva et al. concluded that the focus of site evaluation should be on the "the extent and distribution of fracturing rather than analyses of the properties of the rock matrix." (TN1483 at 1395; NRC-043).

Q105. What studies have been performed to evaluate the existence of faults or fractures in the Middle Confining Unit been studies in Southeast Florida?

A105. (DOB, PDT) The USGS has conducted a number of recent seismic-reflection studies in southeast Florida to identify faults or other natural vertical "karst collapse" features that could act as conduits for flow of injected wastewater across the Middle Confining Unit and into the Upper Floridan aquifer. These studies were evaluated as part of the FEIS. (FEIS at 5-

25; NRC-008A). The studies indicate that if fault and collapse features are "present at or near wastewater injection utilities, these features represent a plausible physical system for the upward migration of effluent injected into the Boulder Zone to overlying EPA-designated USDW in the upper part of the Floridan aquifer system." (TN4574 at 24; NRC-053). In the most recent study, karst collapse features have been identified in the vicinity of the North and South District Wastewater Treatment Plants as well as locations beneath Biscayne Bay, and have been found to extend from the Middle Confining Unit to above the Upper Floridan aquifer. (Cunningham 2015-TN4574 at 13; NRC-053). Walsh and Price (2010- TN3656; NRC-046) reported that at the South District Wastewater Treatment Plant "no fracturing of the confining strata had been reported." (TN3656 at unnumbered 13; NRC-046)

Q106. Based on these studies, has upward migration resulted from flow of effluent through natural pathways in the Middle Confining Unit, such as faults or fractures?

A106. (DOB, PDT)At an injection well operated by the City of Sunrise in Broward County, a collapse structure was implicated in the observed migration of injected wastewater from the Boulder Zone to the uppermost permeable zone within the Lower Floridan aquifer. However, migration of contaminants above the Lower Floridan aquifer was not observed at this site. (Cunningham 2014-TN4051 at Figure 3; NRC-059). Migration above the Avon Park Permeable Zone and into the Upper Floridan aquifer resulting from natural features has not been definitively identified at any site in south Florida. (FEIS at 5-25; NRC-008A).

<u>**Subsurface characteristics at the proposed Turkey Point Units 6 and 7 site**</u>

Q107. In general, what testing did FPL perform at EW-1 and DZMW-1 at the Turkey Point Units 6 and 7 site to evaluate the confining capability of the Middle Confining Unit?

A107. (DOB, PDT) FPL performed testing during construction of EW-1 to evaluate whether effective vertical confinement is present below the base of the Underground Sources of Drinking Water (USDW). This testing included analysis of drill cuttings, rock cores, geophysical logging, and packer flow testing of selected intervals. Geophysical log data included caliper, gamma ray, spontaneous potential, dual-induction, borehole compensated sonic, video, flowmeter, fluid conductivity, and temperature data.

Q108. How are drill cuttings used in geologic investigations?

A108. (DOB, PDT) At EW-1 rock fragments collected during drilling, or "drill cutting samples", were collected at ten foot intervals throughout the Middle Confining Unit and at 5 foot intervals at the base. As described in the EW-1 report, the types of samples are collected to develop an understanding of "rock type, color, grain size, consolidation, porosity and fossils" during the drilling process. (TN1577 at 11; NRC-056). These samples are used for general and qualitative means and are not the sole basis used to determine the geologic or hydrogeologic parameters of a formation or the formations confining capability.

Q109. How were core samples from EW-1 used to evaluate the Middle Confining Unit?

A109. (DOB, PDT) Rock cores are cylindrical samples of rock removed from a borehole by a specialized cylindrical drill bit. The cores can show features such as fracturing or rock dissolution and can be tested for physical and chemical properties. Samples are also sent to a laboratory so that grainsize, porosity and permeability may be measured. At EW-1, FPL collected 20 samples from 10 cores from a depth of 1,721 ft. to 2,679 ft. in order to characterize the lower Middle Confining Unit. Core recovery was as high as 95.4 percent and average around 50 percent of the cored depth. This data was evaluated as part of the data collected from EW-1 to characterize the Middle Confining Unit.

Q110. What is geophysical logging and what does it indicate?

A110. (DOB, PDT) Borehole geophysical logging uses a sensor traveling through a borehole to measure the physical properties of the surrounding rock or soil. Down-hole geophysical measurements thus provide information about subsurface properties such as density, rock type, electrical properties, and the presence of fractures. This information is used to correlate geological formations from one borehole to another. The caliper log measures the diameter of the borehole. The closer the borehole is to the size of the drilling bit, the more competent the formation is at that depth. Sonic logs are used to determine rock porosity and are particularly useful in evaluating the integrity of confining layers within the Floridan aquifer system as noted in some of the studies summarized above.

Q111. What are in situ flow (packer) tests and what do they indicate?

A111. (DOB, PDT) Packer tests involve isolating a section of a borehole by placing a plug at each end of the interval to be tested, and then injecting or removing fluid from the isolated borehole section under controlled conditions and measuring both flow rates and pressure responses. The resulting data are analyzed to determine flow properties such as permeability and porosity. At EW-1, pumping tests of packer-isolated intervals from 1,930 to 1,950 ft., 1,970 to 1,972 ft., and 2,058 to 2,080 ft. below the drill pad resulted in low specific capacity values of 0.03, 0.003 and 0.05 gpm/ft., respectively. Specific capacity is calculated from a packer flow test by dividing the flow rate while pumping from the isolated section of the borehole by the stabilized drawdown (change in water level). In some tested zones, a large drawdown resulted from a low pumping rate, indicating low hydraulic conductivity. The packer test of the interval 1970 to 1992 ft. below the drill pad resulted in over 145 ft. of water level drawdown while pumping at 0.5 gpm. Other similar intervals include those beginning at 2,058, 2,220, 2,400, and 2,478 ft. (TN1577 Table 6 at 21; NRC-056).

Q112. What do the data from EW-1 at the Turkey Point Units 6 and 7 site indicate in regard to the hydraulic conductivity of the matrix of the Middle Confining Unit?

A112. (DOB, PDT) The EW-1 data indicate that the zone from 1,980 to 2,915 ft., is the lower confining interval of the Middle Confining Unit and is comprised of layers of limestone, dolomitic limestone and dolomite. Vertical hydraulic conductivities of 16 core samples from this interval were measured and showed that the hydraulic conductivities were as low as $1.6x10^{-6}$ cm/sec (FEIS at G-50; NRC-008C), which is within the range indicated by monitoring and modeling performed by Maliva et al to allow minimal migration, as discussed in A97-A98 above. (FEIS at 2-58; NRC-008A). The harmonic mean of the measured hydraulic conductivities was $5.54\ x10^{-6}$ cm/sec (FEIS at G-50; NRC-008C). The harmonic mean is the most appropriate hydraulic conductivity value for fluid flow perpendicular to a layered system (Freeze and Cherry 1979-TN3275 at 33; NRC-058).

Q113. Please describe any particularly competent confining layers within the Middle Confining Unit that were identified in the studies evaluated by the Staff.

A113. (DOB, PDT) McNeill 2002 described a dense, low permeability dolomite confining unit that was found throughout southeast Florida and was considered to be important in confining upwardly buoyant injected fluids. This unit is correlated across Southeast Florida including at the South District Wastewater Treatment Plant and through the area of the Turkey Point Units 6 and 7 site. This unit becomes deeper to the southwest and shallower to the northeast. (TN4571 Figure 6 at 12; NRC-064). Buoyant fluid encountering the base of this unit would be prevented from migrating further vertically and flow along the base to the northeast.

The McNeill 2002 study provides specific characteristics from well data that may be used to identify the presence of this unit including high core recovery, small caliper log measurement, hydraulic conductivity around 10^{-8} cm/sec, significant permeability contrast with surrounding units, distinct increases in both resistivity, gamma and density log signatures, and low sonic return velocities.

Q114. What do the data from EW-1 at the Turkey Point Units 6 and 7 site indicate regarding the presence of any zones similar to the confining zone described by McNeill 2002?

A114. (DOB, PDT) The data from EW-1 driller's logs, cores and geophysical logs show that the lower confining interval of the Middle Confining Unit is comprised of layers of limestone, dolomitic limestone and dolomite. Total porosities from laboratory analysis of core ranged from 27.4 to 43.4 percent. Nine cores were collected throughout this interval and recovery was high at three depths (between 85.7 and 95.4 percent). Thin zones of dolomite and dolomitized limestone occur at depths around 2650, 2915, 2960 and 3015 ft. below the ground surface. Key indicators on geophysical logs such small caliper measurement, gamma ray increase, and high sonic velocities indicate that several zones with characteristics similar to the dolomite confining unit described by McNeill occur at the Turkey Point Units 6 and 7 site.

Q115. What, in your professional opinion, do you conclude from the data on natural high vertical conductivity features collected for the Turkey Point Units 6 and 7 site?

A115. (DOB, PDT) While seismic data has been collected near the Turkey Point Units 6 and 7 site, there is no deep seismic data at the site. In the absence of seismic data, Cunningham (2015-TN4574; NRC-053) suggests that "other evidence for karst collapse includes borehole log signatures that indicate highly fractured rock" and that fractures would be indicated by "high travel times measured on borehole sonic log data." (TN4574 at 23; NRC-053). Maliva et al. (2007) used sonic logs from injection sites in south Florida to depict log signatures and travel times for both fractured and unfractured rock. (TN 1483 at 1392; NRC-

043). Sonic log signatures for unfractured rock demonstrate low (fast) transit times and low variability. Using this as a guide, the Staff evaluated return velocities in sonic logs obtained at well EW-1 at the Turkey Point Units 6 and 7 site and found sections of the Middle Confining Unit to have log signatures and transit times consistent with unfractured rock. (FEIS at 5-25; NRC-008A). Staff found that the zone from around 1,900 to 2,900 ft. bgs, which had been identified as the lower confining unit (MC2) within the Middle Confining Unit demonstrated travel times that were typically low with little relative variability. (TN1577 Appendix L BHC9; NRC-071).

Q116. What data did FPL evaluate at the Turkey Point Units 6 and 7 site to determine the confining ability of the Middle Confining Unit?

A116. (DOB, PDT) FPL performed an analysis of the expected pressure buildup in the Boulder Zone from planned wastewater injection to determine the potential for fracturing the confining rock layers (FPL 2014-TN3932; NRC-054). FPL calculated a maximum total pressure increase of 158 psi in the Boulder Zone from the combined injection pressure of 12 injection wells plus buoyancy of the injectate based on the its density and assuming a reclaimed water source. This is much lower than the calculated 1,235 psi minimum pressure that could create or open a fracture in the overlying confining zone (FPL 2013-TN3931; NRC-055). This is discussed in the FEIS at 5-26 and 5-39 (NRC-008A).

Q117. What did FPL conclude from these analyses?

A117. (DOB, PDT) Interpretation of the testing data identified the depth interval from approximately 1,930 to 2,915 ft. as the primary confining interval between the Boulder Zone injection interval and the base of the Underground Source of Drinking Water (USDW). FPL also determined hydrologic properties of aquifers and confining units during the drilling and completion of EW-1 (FPL 2012-TN1577; NRC-056) and DZMW-1 (FPL 2012-TN4053; NRC-057). The borehole information from geophysical logging and flow tests did not indicate the presence of enhanced vertical flow paths from either improper well construction or natural vertical pathways. As required by the FDEP UIC program, a short-term injection test was performed on EW-1 following its conversion to deep injection well DIW-1. Pressures were monitored at the injection well head and within the water columns of both zones of the dual-zone monitoring well located approximately 75 ft. from the injection well. The monitored interval depths are: 1) 1,400−1,420 ft. within the Upper Floridan aquifer, and 2) 1,850−1,870 ft. within the middle Floridan confining zone. Water was pumped into the injection zone for a total of 9 hr and 33 min at approximately 7,000 gpm. The results showed that there was a pressure increase of about 4 psi in the injection zone. The only measurable pressure response observed in either monitored interval was attributable to tidal influence (FPL 2014-TN4052; NRC-063).

Q118. How did FPL determine the extent of vertical migration that may occur as a result of flow through a competent Middle Confining unit matrix, including the buoyant forces described in A87?

A118. (DOB, PDT) FPL performed modeling and analysis of several scenarios to determine the expected vertical and horizontal extent of effluent migration. The scenarios in the analysis evaluated a 61-year injection period followed by a 41-year period with no injection, and used conservative assumptions that would tend to maximize the upward migration of effluent. (FPL 2013-TN3931; NRC-055) in support of the safety analysis of the proposed plants. One scenario FPL evaluated resulted in the determination that, in the absence of well-developed pathways, and considering buoyant forces, upward movement of injectate would be limited to approximately 300 ft. into the Middle Confining Unit. (TN3931 at 47; NRC-055)

Q119. What did Staff do to verify this determination of the potential extent of vertical migration?

A119. (DOB, PDT) The Staff performed a separate confirmatory analysis of the modeling presented by FPL. Results of this analysis are presented in § G.3.3 of Appendix G. The Staff verified that, in the absence of well-defined pathways, whether natural or man-made, and considering the buoyancy effects, upward migration of injectate from the Boulder Zone would likely be less than 300 ft. (FEIS at G-50; NRC-008C).

In the confirmatory modeling presented in the FEIS (at G-48; NRC-008C), the NRC Staff calculated the extent of upward migration of injectate from the injection zone through a competent Middle Confining Unit. The effective vertical hydraulic conductivity used in the calculations was based on the harmonic mean of the values determined from testing of core samples from the Middle Confining Unit at the EW-1 exploratory well. The harmonic mean is the most appropriate hydraulic conductivity value for fluid flow perpendicular to a layered system (Freeze and Cherry 1979-TN3275 at 33; NRC-058). Lower porosity decreases travel time in the calculations, so a conservatively low porosity value of 0.2 was used. These parameter values are documented in the "Report on the Construction and Testing of Class V Exploratory Well EW-1 at the Florida Power & Light Company Turkey Point Units 6 & 7" (FPL 2012-TN1577; NRC-056). The confirmatory analysis (Appendix G) determined that upward migration of injectate from the Boulder Zone would likely be less than 300 ft. These estimates of limited upward migration are supported by the conclusions from the studies of flow through the Middle Confining Unit discussed above in A44-A52, and A83-A106.

Q120. What is the Staff professional opinion of how would the upward hydraulic gradient would affect the injected blowdown water and the Constituents?

A120. (DOB, PDT) The injected blowdown, including the Constituents, would have to move upward through a 985 ft. thickness of the Middle Confining Unit to reach potentially permeable saline intervals including the Avon Park Permeable Zone if it is present at the site (*see* A94 above). Contaminants would then have to migrate upward through another 480 ft. of mostly low-permeability rock to reach the lowest Underground Source of Drinking Water (USDW) aquifer. The review team determined that without a preferential flow path such as an open borehole or permeable fracture zone, the rate of contaminant migration through the estimated 985 ft. of overlying low permeability sediments within the Middle Confining Unit would be extremely slow. Calculations presented in Appendix G.3.3 of the FEIS show that buoyant forces during injection would cause an upward hydraulic gradient (or driving force) sufficient to cause migration of the injected blowdown water only about 300 feet into the Middle Confining Unit over a 100-year period. This calculation is conservative because it does not account for the decrease in temperature and increase in salinity that will occur as the injectate mixes with water in the Boulder Zone and reduces the upward gradient. The concentration of each of the Constituents will also decrease over time through the process of dispersion.

Q121. Please describe your view of whether the data from EW-1 supports the hypothesis that injected blowdown water could migrate into the Upper Floridan aquifer.

A121. (DOB, PDT) As discussed, the Staff reviewed studies of the geologic and hydrogeologic characteristics that affect the ability of the Middle Confining Unit to confine injected wastewater, including several studies from sites where upward migration has occurred, such as the South District Wastewater Treatment Plant. The Staff evaluated the causes and extent of vertical migration and compared those findings with hydrogeologic data gathered from well EW-1 at the Turkey Point Units 6 and 7 site. As discussed throughout this part of the testimony, Staff determined that extent and properties of the Middle Confining Unit at the Turkey Point Units 6 and 7 site would act to confine the injected effluent. Data and observations were gathered through use of drill cuttings, rock cores, geophysical logging, injection pressure testing and packer flow testing of selected intervals. Geophysical log data included caliper, gamma ray, spontaneous potential, dual-induction, borehole compensated sonic, video, flowmeter, fluid conductivity, and temperature data. In addition, the lower portion of the Middle Confining Unit from about 1,900 ft. to 2,915 ft. below ground surface contained water with a high concentration of total dissolved solids, indicating a lack of groundwater flow between the Middle Confining Unit and the Upper Floridan aquifer. Data from geophysical logging, core analyses, and in situ flow (packer) tests also indicated that the interval from 1,900 to 2,900 ft. consists of dense limestone and dolomite with low permeability. The review team's evaluation of these data confirmed the presence of confining layers and a lack of evidence for extensive vertical pathways through the Middle Confining Unit. This is discussed in greater detail in FEIS § 5.2.1.3. As a result of these and other data discussed in A71-A121 we conclude that significant migration of injected wastewater out of the Boulder Zone is not expected.

Horizontal migration

Q122. What studies have been performed to determine the expected horizontal extent of the migration of injected wastewater in Southeast Florida?

A122. (DOB, PDT) Dausman et al. (2008-TN4757; NRC-012) modeled migration of two plumes from the South District Wastewater Treatment Plant of wastewater injected into the Boulder zone: one comprised of secondarily treated wastewater and another of wastewater receiving high-level disinfection, which has since been implemented along with additional filtration at the South District Wastewater Treatment Plant site. The Dausman (2008) study concluded that over a projected 148-year injection period (from 1983 forward) the resulting plume would extend "…outward about 13 mi from the site in the MFA, just beneath the UFA." (TN4757 at 52; NRC-012). The MFA, or Middle Floridan aquifer, is another name for the Avon Park Permeable Zone. Bloetscher et al (2005-TN4756; NRC-011), which is discussed in A82-A84 above, also assessed horizontal migration of injected wastewater.

Q123. What do models of horizontal migration of the injected wastewater from Turkey Point Units 6 and 7 predict?

A123. (DOB, PDT) FPL modeled several scenarios performed to determine the expected vertical and horizontal extent of effluent migration. The scenarios in the analysis evaluated a 61-year injection period followed by a 41-year period with no injection. In each scenario, injected wastewater was predicted to expand radially around the point of injection since injection rates would exert a stronger influence on flow than the negligible flow rates naturally occurring within the Boulder Zone. Injected wastewater was not predicted to extend more than around 4 mi beyond the point of injection over the modeled timeframe. (FPL Answer to RAI 6985 TN3932 at 84 to 85; L-2014-002 Attachment Page 84 of 193; NRC-054).

Q124. How do the differences in the injection rates and periods considered as part of this study for the South District Wastewater Treatment Plant and those proposed for the Turkey Point Units 6 and 7 site explain the difference in migration extent?

A124. (DOB, PDT) Injection rates at the South District Wastewater Treatment Plant are 97 Mgd. Injection at the Turkey Point Units 6 and 7 site would be around 20 percent of those at the South District Wastewater Treatment Plant (18 Mgd). Also, the injection period would be less than half that which was modeled by Dausman et al. (60 years vs 148 years). (FEIS at 5-27; NRC-008A). As a result, horizontal migration would reasonably be expected to be less than the 13 miles of outward migration predicted for the South District Wastewater Treatment Plant at higher injection rates and longer injection periods.

Q125. What did staff do to verify this determination of the potential extent of vertical migration?

A125. (DOB, PDT) The Staff performed a separate confirmatory analysis of the modeling presented by FPL and determined that migration of injected effluent from the Turkey Point Units 6 and 7 site would be similar to those predicted by FPL. (FEIS at G-48 through G-52; NRC-008C).

Q126. Based on the foregoing testimony, what does the Staff conclude regarding whether cooling tower blowdown injected at the Turkey Point Units 6 and 7 site would migrate outward to beneath the location of the nearest user of the Upper Floridan aquifer?

A126. (DOB, PDT) The nearest offsite user of the Upper Floridan aquifer us the Ocean Reef Club, approximately 7.7 miles from the Turkey Point Units 6 and 7 site. (FEIS at 2-61;

NRC-008A). Calculations and modeling discussed in EIS § 5.2.1.3 also indicate that horizontal flow of the plume within the Boulder Zone would be limited and would not extend to beneath the locations of the nearest offsite water-supply well in the overlying Upper Floridan aquifer (7.7 mi) or flow to surface water bodies, such as the Atlantic Ocean.

Overall Staff conclusions

Q127. Based on the foregoing testimony, what does the Staff predict will be the most likely result of injection of cooling tower blowdown into the Boulder Zone at the Turkey Point Units 6 and 7 site?

A127. (DOB, PDT) Based on the information presented in the foregoing testimony, Staff view is that the most likely scenario for the movement of injected effluent in the Boulder Zone is as follows: Because the injected wastewater would have a lower TDS content and an elevated temperature compared to the native water in the Boulder Zone, the injected wastewater would have a lower density than that native water, resulting in buoyancy. The natural gradient in the Boulder Zone is very small compared to the pressure developed at the injection point into the Boulder Zone by the injection pumps. Accordingly, the injected reclaimed wastewater will be forced in all directions from the injection point into the Boulder Zone. In addition, when reclaimed wastewater is used for cooling tower makeup, buoyant forces will dominate the small natural gradient due to the lower density warm injectate, resulting in an overall upward hydraulic gradient in the Boulder Zone. Upward flow of injected wastewater would nonetheless be inhibited by the more than 1,465 ft. thick sequence of predominately low-permeability rocks that lie between the Boulder Zone and the Underground Source of Drinking Water (USDW) aquifer (FPL 2012-TN1577; NRC-056). McNeill (2002-TN4571; NRC-064) evaluated the structure and extent of a unit he called the Dolomite Confining Unit, which occurs at the base of the Middle Confining Unit in southeast Florida. McNeill indicated that while there is local variability in the bottom depth of the Dolomite Confining Unit, the overall dip of the unit is to the southwest. This implies that as distance beyond the injection well increases, flow of buoyant injected effluent may be more influenced by the structure of the base of the confining unit rather than injection pressure. As a result, any migration within the Boulder Zone beyond the site would move northeast toward (but beneath) the Biscayne Bay and away from areas in which the upper aquifers are used. As mixing, cooling and dilution occur, buoyancy of the injectate will decrease, causing it to eventually be subjected to the slow westward movement of the native water within the Boulder Zone (Meyer 1989-TN2255; NRC-018).

Q128. What does the Staff conclude regarding the potential for injected effluent from Turkey Point Units 6 and 7 to migrate and impact uses or users of groundwater in the area of the site?

A128. (DOB, PDT, ALM) The Staff concludes that impacts resulting from deep injection of effluent at the Turkey Point Units 6 and 7 site will be SMALL because:

- Regional studies, site studies, and Staff evaluation and analysis indicates that the layers of low-permeability rock in the Middle Confining Unit will most likely provide adequate isolation of the Boulder Zone from the overlying Upper Floridan aquifer.
- Studies of other injection sites indicate that when upwelling through the Middle Confining Unit occurred, injectate has not migrated through the Middle Confining Unit into the Upper Floridan aquifer.
- Concentration of Constituents in FEIS Table 3-5 are below the EPA Maximum Contaminant Levels.
- More recent sampling data from the South District Wastewater Treatment Plant from 2013-2014 suggests that high-level disinfection of the reclaimed wastewater before leaving the South District Wastewater Treatment Plant has reduced concentrations of the Constituents to below detectable levels or Method Detection Limits.
- Concentrations of Constituents would be further reduced and diluted in the cooling tower process at the Turkey Point Units 6 and 7 site.

- Natural dilution of injected cooling-tower blowdown could significantly reduce the concentrations of the Constituents in the reclaimed water used for cooling.
- The evaluation of the extent and fate of injected cooling-tower injectate at the Turkey Point Units 6 and 7 site indicate it will not travel outward to beneath the location of current users of the Upper Floridan aquifer.
- Risk assessments indicate that risk to human health is low and that "distance has a major impact on risk" with the already low risk decreasing dramatically as distance from the injection well increases (Bloetscher et al. 2005-TN4756; NRC-011).
- UIC requirements will require FPL to fully characterize and test the Middle Confining Unit with the addition of each proposed injected well.
- The monitoring and testing requirements of the UIC program help to ensure that wells are properly installed and operating.
- The Boulder Zone is not considered a potential, current, or future source of irrigation or drinking water.

Accordingly, the Staff concludes that significant upwelling of injected cooling tower blowdown is not likely at the Turkey Point Units 6 and 7 site and that, if upwelling did occur it would not noticeably impact the Upper Floridan aquifer, which is the Underground Source of Drinking Water (USDW).

Q129. Does this conclude your testimony?

A129. A134. (ALM, DOB, PT, AWD) Yes.