UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

Before the Atomic Safety and Licensing Board

In the Matter of	)	
	)	Docket Nos. 52-040-COL
Florida Power & Light Company	)	52-041-COL
	)	
Turkey Point Units 6 and 7	)	ASLBP No. 10-903-02-COL
(Combined License Application)	)	

PRE-FILED DIRECT TESTIMONY OF MR. DAVID MCNABB

Introduction

Please state your name and business address.

1. My name is David McNabb. My business address is 4600 Military Trail, Suite 116, Jupiter, Florida 33458.

Please state your employer and position.

2. I am president of McNabb Hydrogeologic Consulting, Inc.

Please describe your professional qualifications and experience.

3. My professional qualifications and educational experience are summarized in the resume provided in Attachment A to this testimony. In brief, I am a licensed professional geologist in the State of Florida, and have worked as a geologist in Florida for 24 years. From 1992 to 1995, I worked at the Florida Department of Environmental Protection (FDEP), reviewing and evaluating deep injection well construction, well testing engineering reports, construction progress reports, and monthly operating reports. I also performed annual inspections of Class I injection well facilities, reviewed well permit

applications, and reviewed proposed well construction and testing plans. From 1995 until the present, I have worked at CH2M Hill, Arcadis, Inc., LBFH, Inc., and now at McNabb Hydrogeologic Consulting Inc.

4. For nearly my entire professional career, I have focused on the siting, design, construction oversight, testing, and permitting of deep injection wells in Florida, specifically "Class I" injection wells such as those proposed at Turkey Point. During my career as a private consultant, I have obtained, on behalf of my clients, approximately 35 to 40 underground injection control permits from the FDEP.

5. For example, I was responsible for the design, permitting, construction oversight, testing and reporting for the Class I injection well systems at the City of Lake Worth Water Treatment Plant, the City of Key West Richard A. Heyman Environmental Protection Facility, and the FPL West County Energy Center, all of which inject into the Boulder Zone in south and southeastern Florida.

Please describe your involvement in the Turkey Point Units 6 and 7 project.

6. I have provided design, permitting and construction oversight services for a 3,230 foot deep exploratory well (EW-1), and a dual-zone monitor well, at the Turkey Point Units 6 & 7 (Turkey Point) proposed site. I am also the author of 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-005 (EW-1 Report)). In addition, I submitted an affidavit in this proceeding to support FPL's December 15, 2015 Motion for Summary Judgment.

What is the purpose of your testimony?

7. My testimony addresses three things. First, I describe how data from EW-1 indicates that wastewater from Turkey Point will be confined in, or near, the Boulder Zone and is extremely unlikely to contaminate the underground source of drinking water (USDW). Second, I discuss how the design of Turkey Point's injection wells will contribute to such confinement. Third, I discuss how well monitoring programs put in place by Turkey Point will enable FPL and the FDEP to address the extremely unlikely scenario of leaks or migration of Turkey Point wastewater into the USDW.

Summary

Please summarize your conclusions.

8. It is my professional opinion that:

- The data taken from EW-1 indicates the presence of rock with low hydraulic conductivity above the injection zone that will serve to confine injected fluids and prevent their significant upward migration.
- The injection wells are designed to prevent the development of leaks from the injection wells. Additionally, the well design allows for the detection of any leaks in the unlikely case that a leak was to develop.
- The monitoring programs that FPL is required by regulation to put in place will enable FPL and the FDEP to respond to leaks, if any, in a timely fashion.
- For these reasons, I agree with the FEIS's conclusion that "significant upwelling of injected wastewater is not likely at the Turkey Point site and that, if upwelling did occur it would not noticeably impact overlying USDW aquifers." NRC-008A (FEIS) at 5-21.
- For these reasons, I also agree with the FEIS that the environmental impact of injected wastewater from Turkey Point will be "small," (*see* NRC-008A (FEIS) at 5-39 to 42), if any.

Discussion

An Analysis of Data from EW-1 Demonstrates that Wastewater Injected into the Boulder Zone Will Be Confined below the USDW.

What is EW-1?

9. EW-1 is an exploratory well that was drilled under my direction to evaluate the local hydrogeology near that well for appropriate confining intervals that are likely to impede the upward migration of wastewater injected into the Boulder Zone at the Turkey Point site. We performed this evaluation to satisfy FDEP permitting regulations, which required FPL (as a Class I injection well applicant) to: 1) demonstrate that the hydrogeologic environment is suitable for wastewater injection; 2) demonstrate that there is a confining zone with sufficient areal extent, thickness, lithological, and hydraulic characteristics to prevent fluid migration into USDWs; and 3) provide sufficient data, such as geophysical logs, lithologic cores, physical core analysis, borehole video television surveys, water samples, and drill stem tests (also known as packer tests) to adequately demonstrate the confining characteristics of the bed. The FDEP was satisfied that FPL met these requirements, and in July 2013 issued a permit to convert EW-1 into an injection well to begin operational testing. FDEP Notice of Permit (July 29, 2013) (ML16278A746).

How will the FDEP be involved in reviewing the injection wells at Turkey Point?

10. The FDEP reviews data collected during construction of wells prior to allowing operation of the injection well system. In order to grant approval to begin operating an injection well, the FDEP will have to independently determine that sufficient confinement exists at the site to prevent upward migration of injected fluids into the USDW. If, in the opinion of the FDEP, there will not be sufficient confinement at the site, they would not grant

approval to begin operating the injection well and no operating permit would be issued for the injection well system. Additionally, once the injection well system begins operating, FPL is required to submit operating reports on a monthly basis. These reports contain operating and monitoring data from both the injection well and the dual-zone monitor well. FDEP reviews the reports for any signs of failure of the confinement that would allow injected fluids to migrate into a USDW.

Other than supervising the drilling, what was your involvement in EW-1?

11. I also directed the EW-1 testing and sampling program. In addition, I assisted FPL in designing the EW-1 well itself, and obtaining the permit from the FDEP authorizing FPL to construct the well and perform testing on it. The EW-1 well was permitted as an exploratory well, but it will be converted to an injection well upon the issuance of an additional FDEP permit.

What analyses were performed on EW-1 and what data were collected?

12. Our data collection and analyses followed standard procedures in the industry, which I have used when performing similar analyses for more than 20 wells that the FDEP has permitted and that are successfully operating today.

13. Specifically, with respect to EW-1 we collected drill cutting samples every 10 feet or less as the well drilling progressed. From these samples, we obtained the rock type, color, grain size, porosity, fossil content, and consolidation of the subsurface rock formations. These descriptions were useful when determining the geologic formations penetrated by the well bore and identifying rock-types with low permeability that may make up a confining unit.

14. We also collected water samples at 90 foot intervals. Those samples provided local measurements of the specific conductance, total dissolved solids, chloride, ammonia and Total Kjeldahl Nitrogen (TKN) of water in the pilot hole. We used that information to help determine where the base of the lowermost USDW is located. For example, for a system to be considered a USDW, it must have less than 10,000 mg/l of total dissolved solids.[1] Water with more than 10,000 mg/l of total dissolved solids is not considered a USDW.

15. In addition, we collected a total of ten 4-inch diameter rock cores during drilling between the depths of 1,721.5 and 2,679 feet. Each of the cores consisted of limestone, dolomitic limestone or dolomite.

16. A total of 20 discrete samples from the cores underwent laboratory analysis. The analysis of the core samples confirmed that the rock strata between 2,026.4 and 2,677 feet had low hydraulic conductivity (low permeability) and that the area is confining in nature. The core collected between 1,721.5 and 1,734.5 feet appeared to have moderate permeability and is less confining in nature than the cores collected at greater depths.

17. In addition, geophysical logs were performed to provide data about the physical properties of the subsurface. Geophysical logging involves lowering various data collecting tools into the well during construction over intervals of interest. In the case of EW-1, caliper, gamma ray, dual-induction, spontaneous potential, borehole compensated sonic, video, flowmeter, fluid conductivity, and temperature geophysical logs were performed over the interval from 1,535 to 3,230 feet to evaluate the confining

[1] 40 CFR § 144.3.

characteristics of the rock. Review of the caliper and borehole compensated sonic logs indicated an absence of vertically extensive or significant fracturing within the interval from 1,930 to 2,915 feet. The borehole compensated sonic log also showed that this same interval has a relatively low porosity when compared to the intervals above and below. Review of the flowmeter, fluid conductivity and temperature logs suggests there are no significant water producing zones between a depth of 1,930 and 2,915 feet. These data demonstrate that the interval from 1,930 to 2,915 feet is confining in nature.

18. We used data from the geophysical logs to select intervals for packer testing to determine the hydraulic characteristics of the rock strata within the test intervals and to allow collection of water samples from each test interval.

What is packer testing?

19. Packer testing is performed for all Class I injection well construction projects in Florida to evaluate water quality and hydraulic characteristics of a selected test interval. Packer testing is conducted by lowering two inflatable packers[2] to the selected test interval. The packers are lowered to the correct depth using a drill pipe that is hollow on the inside and has holes in the drill pipe in the interval between the two packers. When the two packers are inflated (one at the base of the selected test interval and one at the top of the test interval), the interval between the two packers becomes isolated from the rest of the borehole. Since there are holes in the hollow drill pipe between the two packers, by pumping water from the drill pipe we collect water samples that we know came from the test interval.

[2] A packer is a device that can be run into a wellbore with a smaller initial outside diameter that then expands externally to seal the wellbore. By using an upper and a lower packer to seal the wellbore, the interval between the two packers becomes isolated from the rest of the wellbore.

20. We also collected pumping rate and water level drawdown data from the test interval. These pumping rate and water level drawdown data are used to characterize the confining nature of the test interval. For example, if we are able to pump water from the test interval at a high rate with little water level drawdown (i.e., pump from the test interval at 75 gallons per minute with only 30 or 40 feet of water level drawdown), the test interval would be characterized as being productive and not confining in nature. Conversely, if we are able to pump from the test interval at only a low rate and have significant water level drawdown (i.e., pump from the test interval at only 25 gallons per minute with 80 or 90 feet of water level drawdown), the test interval would be characterized as being non-productive and confining in nature.

What did you conclude after reviewing the EW-1 data?

21. After reviewing the EW-1 data, I concluded that the subsurface hydrogeology at the Turkey Point site consists of three main hydrogeologic units: the Biscayne Aquifer, the Intermediate Confining Unit, and the Florida Aquifer System (consisting of the Upper Floridan Aquifer, the Middle Confining Unit, and the Lower Floridan Aquifer).

22. The Biscayne Aquifer occurs from just below land surface to a depth of approximately 140 feet. *See* NRC-008A (FEIS) at Figure 2-19. It consists primarily of layers of sand, shells, and limestone, with the base of the aquifer identified by the presence of clay-rich silt.

23. The Intermediate Confining Unit at the Turkey Point site covers the interval from the base of the Biscayne Aquifer to a depth of 1,010 feet. *See* NRC-008A (FEIS) at Figure 2-19. The Intermediate Confining Unit separates the Biscayne Aquifer from the Floridan

Aquifer System and consists of interbedded clays, silt, sand, calcareous limemuds, and limestone.

24. Below the Intermediate Confining Unit, the Floridan Aquifer System—which consists of the Upper Floridan Aquifer, the Middle Confining Unit, and the Lower Floridan Aquifer—extends from 1,010 feet to a depth beyond 3,230 feet (the bottom of well EW-1). *See* NRC-008A (FEIS) at Figure 2-19.

25. Within the Floridan Aquifer system, the Upper Floridan Aquifer consists of permeable limestone, dolomitic limestone, and dolomite, and is used as a source of drinking water in some municipalities. The Upper Floridan Aquifer (which contains the lowermost USDW) extends from a depth of 1,010 feet to approximately 1,450 feet, as identified by packer testing water quality data and the geophysical logs. *See* NRC-008A (FEIS) at Figure 2-19. Accordingly, the bottom of the deepest USDW was estimated to be at a depth of 1,450 feet. *See* NRC-008A (FEIS) at 2-54.

26. Directly below the USDW, at a depth of 1,450 to 2,915 feet is the Middle Confining Unit, consisting of fine-grained limestone, dolomitic limestone, and dolomite, and which includes the Avon Park Permeable Zone (APPZ) at a depth of approximately 1,700 feet. *See* NRC-008A (FEIS) at Figure 2-19. These two formations (the Middle Confining Unit and APPZ) are not part of the Upper Floridan Aquifer, are located below the base of the lowermost USDW at the site, and thus are not part of the USDW. Accordingly, the Middle Confining Unit is not a source of drinking water. Confinement of injected wastewater from Turkey Point will be provided collectively by the 1,465 feet of strata between the base of the USDW (at a depth of 1,450 feet) and the top of the Upper Floridan Aquifer (at a depth of 2,915 feet). The portion of the Middle Confining Unit

that is below the APPZ contains the lowest permeability strata and forms a main confining zone that is approximately 985 feet thick, and is present from depths of approximately 1,930 to 2,915 feet. *See* NRC-008A (FEIS) at 5-27, 5-39.

27. Below the Middle Confining Unit is the Lower Floridan Aquifer, consisting of permeable dolomite, dolomitic limestone, and limestone. The Lower Floridan Aquifer is not a source of drinking water. The portion of the Lower Floridan Aquifer that is highly permeable is known as the Boulder Zone. *See* NRC-008A (FEIS) at Figure 2-19.

28. Turkey Point will inject wastewater into the Boulder Zone, which is approximately 1,550 feet below the base of the deepest USDW. *See* NRC-008A (FEIS) at 5-39.

What is the importance of the Boulder Zone's high permeability?

29. The high permeability of the Boulder Zone prevents significant pressure from building up during injection by allowing the wastewater to preferentially move laterally, instead of upwards where the low permeability rock impedes movement.

What characteristics are necessary to demonstrate that wastewater will be confined?

30. Generally, a confining zone is a vertical interval that acts to prevent upward movement of injected fluids. It accomplishes this through its relatively low vertical hydraulic conductivity and lack of vertically extensive fractures. If water pumped into the highly permeable Boulder Zone encounters a confining zone, the water preferentially spreads in the direction of least resistance, which is laterally rather than vertically through the confining zone.

How do you know that a 1,465 foot confining zone is present at Turkey Point?

31. Data from several of the EW-1 tests prove the presence of that confining zone. Specifically:

- The drill cuttings show that this interval contains fine-grained limestone, dolomitic limestone, and dolomite with low permeability consistent with the characteristics of a confining zone.
- Rock cores collected in this interval consisted of fine grained dolomitic limestone and limestone. While some of the core samples showed the presence of porosity, the individual pores within the rock were generally not connected to each other, resulting in low permeability, which is consistent with a confining zone.
- Geophysical logs demonstrated a lack of significant water-producing intervals within the confining zone. Additionally, the geophysical logs demonstrated an absence of faulting or vertical fractures. The absence of water-producing intervals coupled with the absence of faults or vertical fractures suggest confinement.
- Data from the geophysical logging was used to select intervals for packer testing. The packer testing was used to confirm that the interval shown to be confining by geophysical logs was indeed confining in nature.

In your professional opinion, will wastewater from Turkey Point that is injected into the Boulder Zone be confined such that it will not enter the USDW?

32. Yes. Injected fluid would need to travel vertically through the 1,465-foot Middle Confining Unit before it could reach the USDW. Given the permeability of the Boulder Zone, the low permeability of the confining unit, and the absence of faulting or vertical fractures, injected fluids will not move significantly upward into the USDW.

Is the data from EW-1 sufficient to support the existence of a confining area at each injection well at the Turkey Point site?

33. Yes. The Turkey Point injection wells will all be located within a radius of less than one mile from EW-1. The geology of Southeast Florida does not vary significantly over short distances, i.e. within a few miles.

34. Indeed, the design of multi-well injection well systems in South Florida is always based on the geology of the first well that is constructed at the site, because it is understood that the geology in that area lacks variability over short (less than a few miles) distances. It is also important to note that the FDEP does not rely on testing from one injection well to demonstrate confinement for an entire multi-well injection well system. Instead, Turkey Point is required to demonstrate the presence of a confining zone for each individual injection well. Therefore, prior to permitting, each of the proposed injection wells that Turkey Point wants to construct at the site must undergo a suite of testing similar to that performed for EW-1 (collection of drill cutting and rock core samples, performance of geophysical logging and packer testing) to demonstrate the presence or absence of a confining zone. *See also* NRC-008A (FEIS) at 5-41.

In his affidavit responding to FPL's Motion for Summary Judgement, Mr. Quarles alleged that the core sample data taken in EW-1 indicates low recovery and high porosity and thus does not show vertical confinement. Quarles Third Affidavit at ¶¶ 18, 22. Do you agree?

35. Mr. Quarles is incorrect. The core samples taken from EW-1 indicate vertical confinement in the Middle Confining Unit consistent with the other EW-1 data.

- With regard to Mr. Quarles' assertion that the high porosity is an indication of a lack of vertical confinement, the core descriptions provided in Appendix M of the EW-1 Report (FPL-005B) indicate the presence of porosity, yet low permeability. This is because the individual pores in the core samples are not all interconnected. If they were all interconnected, fluids could readily flow through the rock. However, since the pores are not interconnected, fluid flow through the rock is greatly impeded.

- With regard to Mr. Quarles' assertion that the low core recovery is an indication of a lack of vertical confinement, there is no correlation between core recovery and the presence or absence of vertical confinement. Core recovery refers to the percentage of rock core recovered for the interval that underwent coring. For example, if a ten-foot interval underwent coring and only one foot of rock core was recovered, the core recovery would be ten percent. However, this is by no means an indication that the remaining nine feet of the cored interval is a void or lacks the presence of rock. Many things can happen to negatively impact rock recovery. During the coring process, a portion of the core can become wedged inside the core barrel in a manner that does not allow the core to move upward inside the core collection device (the core barrel), thus preventing collection of additional core even as the remaining core interval is drilled. Additionally the presence of relatively soft rock (which incidentally is typically good confinement due to low permeability) can reduce core recovery, as it can get washed away during the coring process. Also, core that has been collected in the core barrel can sometimes fall out of the core barrel while the core barrel is being pulled up the borehole to land surface.

- It also is important to note that not once during the coring process was there a bit-drop, a term used when a void is encountered during drilling or coring that indicates the drill bit or the core barrel freely fell through a void or cavity.

How do the porosity measurements, ranging from 27.4% to 43.4% of the core samples (FPL-005A at 026), impact your finding of confinement?

36. As mentioned previously, porosity is not a true measure of the confining ability of the core samples. If the individual pores within the rock are not interconnected, the rock can have a high porosity, yet prevent fluids from migrating. As shown on Table 5 of the EW-1 report (FPL-005A), numerous core samples underwent laboratory analysis for vertical hydraulic conductivity. FPL-005A at 026. The vertical hydraulic conductivity measurements ranged from a high of 5.4×10^{-4} cm/second to a low of 1.1×10^{-6} cm/second. FPL-005A at 026. This range is indicative of confinement. These data, when combined with the other data sources that consistently indicate the existence of a confining interval from 1,930 to 2,915 feet, leave no doubt of the confining characteristics of this interval.

Mr. Quarles has also alleged that the failure of packer tests may indicate voids and fractures in the bedrock. Quarles Third Affidavit at ¶¶ 20-22. Do you agree?

37. No. The "failed" packer test occurred when the inflatable packers were unable to fully seal against the borehole wall, thus not isolating the test interval and allowing water from above and/or below the test interval to flow into the test interval during the test. The particular tests where this occurred were taking place in a large diameter borehole that required that sleeves be placed on the inflatable packers to increase the diameter of the packers. In many instances, these sleeves decreased the ability of the inflatable packers to conform to the configuration of the borehole, preventing isolation of the test interval.

38. It is also clear that failed packer tests do not indicate voids and fractures, because sometimes a slight adjustment in the depth of the test interval can be the difference between a failed or successful packer test, with some fine-tuning resulting in a successful demonstration of confinement. For example, test number 14 on Table 6 of the EW-1 Report (FPL-005A), which was attempted over the interval from 2,480 to 2,502 feet, was terminated because the packers were not isolating the test interval. FPL-005A at 28. However test number 19, which was performed on an interval two feet shallower (2,478 to 2,500 feet), was able to isolate the test interval and demonstrated confinement. FPL-005A at 28. If voids or fractures were the cause of the test number 14 failure, these minor adjustments would not have caused test number 19 to succeed.

<u>The Injection Wells Will Be Constructed to Prevent Leaks.</u>

How will Turkey Point's injection wells be constructed?

39. FPL must obtain permits from the FDEP to construct and perform testing on each of its proposed wells. FPL will construct those wells in accordance with the conditions of their

permits and the requirements of Florida Administrative Code (FAC) 62-528. The wells will be constructed of multiple concentric steel casings, each with a wall thickness of 3/8 or 1/2 inch, cemented into place. The inside and outside of each casing, except the smallest (24 inch) casing, will be fully encased in cement. A fiberglass reinforced plastic (FRP) injection liner, selected for its corrosion resistance, will be inside the smallest casing. The annular space between the smallest casing and the injection liner will be sealed at the base of the tubing and at the surface and filled with a corrosion inhibiter, protecting the inside of the 24-inch diameter casing from corrosion. Each casing will be cemented from the base to the land surface to prevent movement of fluids into or between the USDW, maintain groundwater quality in aquifers above the injection zone, and protect the casings from corrosion. The graphic in Attachment B to this Testimony shows these characteristics.

Mr. Quarles alleges that other injection wells in the state of Florida have failed, thus "wastewater injection wells can fail and result in vertical migration of wastewater." Quarles Third Affidavit at ¶ 39. Do you envision similar problems with the wells at Turkey Point?

40. I do not. It is true that vertical migration of injected fluid has occurred at very few injection well sites in Florida. Each of those systems was built at least 25 years ago, when construction techniques were different. In the past, construction through the confining intervals at a site involved drilling a pilot hole through the confinement, performing testing on the pilot hole, then reaming the pilot hole to a larger diameter to accommodate installation of the steel casing through the confinement. This process can result in a double borehole if, while reaming the pilot hole, the reaming drill bit does not directly follow the pilot hole. You then have a large diameter borehole that the casing

was installed into and an open pilot hole through the confinement that can act as a direct conduit for injected fluid to move upward.

41. Over the last approximately 25 years, the construction process through the confinement is the same as described above with the addition that now, after performing testing on the pilot hole, the pilot hole is backplugged with cement, thus eliminating any possibility for the development of a double borehole and the associated risk of creating a conduit for fluid to move upward. This technique was used for the construction of EW-1 and will be used for all of the proposed injection wells at Turkey Point. This construction technique, coupled with the demonstrated vertically extensive confinement at the site provides me with complete confidence that injected fluid will not migrate through the confinement zone. In addition, as explained below, FPL will continuously monitor the wells to detect leaking.

Mr. Quarles has stated that FPL should have conducted formation pressure tests and cement bond logs. Quarles Third Affidavit ¶ 43. Do you agree?

42. I disagree that formation pressure tests should have been conducted during construction of EW-1. Formation pressure testing is something that occurs in the oil industry when drilling in formations that are suspected to be under very high pressure, and it is completely inapplicable to drilling for deep injection wells in Florida. Formation pressure testing is performed by simply measuring the pressure within a rock formation as a safety measure to ensure that as a formation is penetrated during drilling, extreme pressure in the formation does not result in a blowout at the surface which could result in injury or death to driller or drill rig hands. The formations penetrated during construction

of EW-1 are all well known to not be under high pressure and therefore do not pose a threat of injury or death to the drillers or drill rig hands, so such testing is unnecessary.

43. In addition, contrary to Mr. Quarles' statement, we did perform a cement bond log on the final casing (the casing that penetrates the confining zone) of EW-1. A copy of the cement bond log was included in the EW-1 Report (FPL-005C). *See* FPL-005C, Appendix L. The cement bond log demonstrated the presence of cement behind the final casing through the entire confining zone.

Groundwater Monitoring Will Identify and Resolve Any Wastewater Leaks or Migration into the USDW.

Please describe the well monitoring program that FPL will put in place.

44. FPL will implement a comprehensive program to detect leaks and migration from the injection wells at an early stage. This starts with a groundwater monitoring program. In compliance with FDEP regulations, FPL will rely on dual-zone monitor wells, with sampling and monitoring from two different depths. Consistent with state regulations, the monitor wells will be located 75 feet from the injection wells. *See* NRC-008A (FEIS) at 5-39 to 5-40. These wells will detect upward fluid movement or leaks, before any drinking water is impacted, by providing water samples and water level data from two zones: one near the base of the USDW and one below the base of the USDW near the top of the confining unit. *See* NRC-008A (FEIS) at 3-25. The water samples will be collected on a weekly basis during the first six months to two years of operation and monthly thereafter, in accordance with FDEP regulations. After collection, the water samples will be analyzed for numerous parameters meant to detect any changes in the water that would indicate fluids migrating upward from the injection zone. The

continuous water level analysis may also identify changes in water quality, providing an opportunity to identify vertical fluid migration or leaks. Ultimately, the FDEP-required monitoring would be sufficient to detect leaks or upward migration before significant releases to the Upper Floridan Aquifer. *See* NRC-008A (FEIS) at 5-40.

45. FPL will also continuously monitor the injection wells for leaks by monitoring the pressure of the sealed annular space between the final casing and the injection tubing, in accordance with FDEP requirements. FAC 62-528.425(1)(b). In addition to this continuous monitoring, each injection well will undergo mechanical integrity testing a minimum of every five years, again in accordance with FDEP requirements. FAC 62-528.425(1)(d). The mechanical integrity test includes: a video survey of the injection tubing and injection zone; a pressure test where the annular space between the final casing and the FRP injection tubing is pressurized, typically to approximately 150 psi; and performance of a high-resolution temperature log and radioactive tracer survey on the well. Data from these tests will be summarized in a report that also includes the previous five years of operating and monitoring data with an interpretation of such data. The FDEP will review this operating data every five years as part of the well permit renewal process.

46. If any of these methods were to indicate an anomaly, FPL and its regulators would closely look at the monitoring data to identify any leaks or upward migration.

Mr. Quarles has stated that the FDEP requirement to perform mechanical integrity tests every five years is insufficient as "a well can fail at any time," and "[o]nly through groundwater monitoring and the identification of contamination in the upper monitoring wells during periodic sampling events, will FP&L know that the well has failed." Quarles Third Affidavit at ¶ 44. Do you agree?

47. No. Mr. Quarles' argument ignores an important part of the well monitoring program—the continuous pressure monitoring. As I have noted previously, FPL will continuously monitor the injection wells, specifically by monitoring the pressure of the sealed annular space between the 24-inch diameter final casing and the injection liner. Using this method, any break in the final casing, FRP injection tubing, or seal at the base or the top of the FRP injection tubing, would be detected immediately. This monitoring will identify any leak in the well, including leaks into the Biscayne Aquifer or the Upper Floridan Aquifer (and thus the USDW). The groundwater monitoring and mechanical integrity test supplement this continuous monitoring. Additionally, continuous water level monitoring in the upper and lower monitoring intervals of each dual-zone monitor well will allow detection of conditions that may be related to upward migration of injected fluid. If water level data from the dual-zone monitor wells were to indicate anomalous conditions, FPL and its regulators would be alerted to closely look at the monitoring data to identify if any leaks were present.

Mr. Quarles also asserts that groundwater monitoring will be insufficient to detect wastewater that has moved horizontally then migrated upwards. Quarles Third Affidavit at ¶ 47. Do you agree?

48. No. First, as Dr. Maliva's Testimony in this proceeding explains, extensive horizontal migration coupled with vertical migration into the USDW is exceedingly unlikely. Second, state regulations dictate that dual-zone monitor wells be located near the

injection wells for a reason—because injectate does not migrate far from the well. The greatest potential for upward fluid migration occurs very near the injection well where the greatest injection pressure occurs. As the fluid moves laterally away from the point of injection, the injection pressure very quickly dissipates, reducing the likelihood of upward migration.

49. Single dual-zone monitor wells in the area with the greatest potential for vertical fluid migration (i.e., immediate vicinity of the injection well) has long been the FDEP monitoring requirement, is consistent with USEPA rules and norms, and is appropriate based on the very low risks injection wells pose in South Florida and the outstanding safety record of Class I injection wells in South Florida. Mr. Quarles has provided no technical evidence to show that the current monitoring requirements are inadequate for the Turkey Point site.

Please describe how FPL would respond if leakage of a well or upward migration was detected.

50. FPL would have to report the event to the FDEP. FAC 62-528.415(4)(a). FPL and the FDEP then would work together to remedy the cause of the migration or leak. FDEP would likely require FPL to enter into a consent order allowing FDEP to compel FPL to undertake certain remedies by FDEP-mandated deadlines. The remedy may then involve: performing additional mechanical integrity or other tests on the injection wells; deepening the injection wells and installing a deeper injection casing; increasing the density of the injected wastestream to equal or exceed the density of the Boulder Zone water; or removing one or more injection wells from service. The FDEP may even order an injection well to be plugged or abandoned, but there are sufficient injection wells

planned for Turkey Point 6 & 7 to compensate for injection wells removed from service. FPL may also increase the frequency of the data collection at the monitoring wells.

Mr. Quarles has alleged that FPL must address a remediation plan in the event that the wastewater contaminates the USDW. Quarles Third Affidavit at ¶ 46. What is your response to this claim?

51. The development of a remediation plan would be premature at this stage and is not required under Federal or State Underground Injection Control rules. In the extremely unlikely case that upward migration through the confinement zone were to occur, the migration would be detected by the lower monitor zone before the fluid could reach the USDW. In the case of the Turkey Point dual-zone monitor well, the top of the lower monitor zone is located over 400 feet below the base of the lowermost USDW at the site. This would allow time for the development of a plan to prevent migration into the USDW. The mechanical integrity of the injection wells associated with the monitor well that were showing signs of fluid migration would be investigated and the well(s) in question would potentially be removed from service. Additionally, continuous pumping from the impacted lower monitor zone could be implemented to prevent injected fluid from reaching the USDW.

52. All of these are potential options for a remediation plan, but they are dependent on the cause of the migration. It would be premature for FPL to create a remediation plan at this time with no knowledge of how upward migration might occur in the future.

Conclusion

Please summarize the opinions you are offering in this Testimony.

53. It is my professional opinion that wastewater injected into the injection zone at this site will not migrate from the injection zone into a USDW. This is based upon the clear demonstration of confinement at the site as shown by several independent data sources, which include drill cutting samples, core samples, and most importantly geophysical logs and packer tests results. Data collected during construction of EW-1 demonstrated an absence of significant fluid production within the confining zone and an absence of faults or fractures.

54. The construction techniques used for EW-1, and that will be used for all of Turkey Point's proposed injection wells, were designed to ensure that the wells will be constructed in a manner that cannot result in the development of any conduits that would allow migration of fluid through the confining zone.

55. Additionally, FPL will know if a leak occurs, and can respond to prevent any impact on the USDW. The monitoring system to be installed by FPL includes continuous pressure monitoring of the injection wells that would immediately indicate a failure in the well casing, injection tubing, or packer at the base of the well. Groundwater sampling and water level monitoring at the dual-zone monitor wells would also provide an early warning system to indicate fluid migration is occurring well ahead of fluid migrating into the USDW. If the monitoring wells were to indicate fluid migration were occurring, preventative actions could be implemented to prevent the USDW from being impacted by injected fluid.

56. For these reasons, I agree with the FEIS's conclusion that "significant upwelling of injected wastewater is not likely at the Turkey Point site and that, if upwelling did occur it would not noticeably impact overlying USDW aquifers." NRC-008A (FEIS) at 5-21. I also agree with the FEIS that the environmental impact of injected wastewater from Turkey Point will be "small," (*see* NRC-008A (FEIS) at 5-39 to 42), if any.

I, David McNabb, swear under penalties of perjury that the foregoing testimony is true and correct to the best of my knowledge and belief.

Signature

2/27/17

Date

Project Related Experience

McNabb Hydrogeologic Consulting, Inc. (2006-present)
President/Hydrogeologist- Provide hydrogeologic consulting services with emphasis on deep injection well and aquifer storage and recovery systems design, permitting and construction oversight services.

City of Key West Class I Deep Injection Well System – Provided mechanical integrity testing and operating permit professional services for deep injection wells IW-1 and IW-2 at the Richard A. Heyman Environmental Protection Facility since 2009.

City of Key Largo Class I Deep Injection Well System – Provided mechanical integrity testing professional services for deep injection well IW-1 at the Key Largo Wastewater Treatment Plant.

Fort Pierce Utilities Authority Water Treatment Facility Industrial Deep Injection Well IW-2 – Provided consulting services for design and permitting of Class I Industrial deep injection well IW-2 at the Authority's Water Treatment Facility.

Florida Power & Light Turkey Point Exploratory/Injection Well – Provided design, permitting and construction oversight services for a 3,230 foot deep exploratory well and dual-zone monitor well at the FPL Turkey Point site. The wells were constructed to Class I injection well standards with a 24-inch diameter final casing and 18-inch diameter FRP injection tubing. Provided permitting services for the conversion of the exploratory well to a Class I deep injection well. Assisted FPL in the preparation of injection well system (12 injection wells and 6 dual-zone monitor wells) preliminary construction schedule.

Florida Power & Light West County Energy Center Deep Injection Well System – Provided design, permitting, construction oversight and expert witness services for the deep injection well system at the FPL West County Energy Center. The system consists of two Class I deep injection wells constructed to a depth of 3,400 feet and a dual zone monitor well. The wells were completed with a 20-inch diameter final casing and 16-inch diameter FRP injection tubing. Also provided mechanical integrity testing and injection well system permit renewal services.

City of Lake Worth Class I Industrial Deep Injection Well System – Provided design, permitting and construction oversight services for a 3,300 foot deep injection well system for disposal of reverse-osmosis concentrate. The well is used for disposal of reverse-osmosis concentrate.

Imperial Irrigation District Deep Injection Wells – Provided construction oversight services for construction of two 2,750-foot deep Class I deep injection wells at the El Centro Generation Center in El Centro, California.

Okeechobee Utility Authority Deep Injection Well – Provided construction oversight services for construction of a 3,200-foot deep Class I deep injection well and associated 2,000 foot deep dual-zone monitor well at the Cemetery Road Wastewater Treatment Plant.

City of West Palm Beach Dual-Zone Monitor Wells – Provided construction oversight services for construction of three 2,300-foot deep dual-zone monitor wells associated with the Class I deep injection well system at the East Central Water Reclamation Facility. The project included the plugging and abandonment of three monitoring tubes that are no longer in service.

Martin County Utilities North W/WWTF Dual-Zone Monitor Well – Provided design, permitting and construction oversight services for construction of one 2,229-foot deep dual-zone monitor well associated with the Class I deep injection well at the North Water/Wastewater Treatment Facility. The project included the plugging and abandonment of two monitoring tubes that are no longer in service.

City of West Palm Beach Injection Wells IW-1 through IW-7 – Provided mechanical integrity testing professional and operating permit services for seven deep injection wells at the East Central Water Reclamation Facility.

Fort Pierce Utilities Authority Water Treatment Facility Industrial Deep Injection Well IW-1 – Provided consulting services for mechanical integrity testing of Class I Industrial deep injection well IW-1 at the Authority's Water Treatment Facility.

Fort Pierce Utilities Authority Island Water Reclamation Facility Deep Injection Well IW-1 – Provided consulting services for operating permit renewal and mechanical integrity testing services of Class I deep injection well IW-1 at the Authority's Island Water Reclamation Facility.

Port St. Lucie Northport Industrial Deep Injection Well – Provided consulting services for mechanical integrity testing of a Class I Industrial deep injection well IW-1 at the City's Northport Wastewater Treatment Plant.

Port St. Lucie Southport Deep Injection Well – Provided consulting services for mechanical integrity testing of a Class I deep injection well IW-1 at the City's Southport Wastewater Treatment Plant.

Florida Power & Light West County Energy Center Injection Well System Operational Testing Services and Operating Permit Services – Provided FPL with Operational Testing Services. This included preparation of the Request for Operational Testing for both injection wells, preparation of an Operations and Maintenance Manual for the deep injection well system, on-site deep injection well system operation training, and monitoring data analysis. Also provide professional services to obtain an operating permit for the injection well system and renewal of the operating permit.

Charlotte County Burnt Store Class I Industrial Deep Injection Well – Provided design, permitting and construction oversight management services for a 3,268-foot deep Class I Industrial deep injection well for disposal of reverse osmosis concentrate and treated wastewater at the Burnt Store Water Treatment Facility. Also provided operating permit renewal services for deep injection well IW-1 at the facility.

Charlotte County Zemel Road Landfill Industrial Deep Injection Well – Provided consulting services for mechanical integrity testing and operating permit renewal for the Zemel Road Landfill deep injection well.

Charlotte County East Port Deep Injection Well IW-1 – Provided consulting services for mechanical integrity testing of East Port Water Reclamation Facility deep injection well IW-1.

LBFH, Inc. (2003 – 2006)
Hydrogeology Manager
Hydrogeology manager focused primarily on deep injection well, Aquifer Storage and Recovery (ASR) well, and production well design, permitting and construction management projects. Duties included groundwater-related project business development and project management for deep injection well, shallow injection well, aquifer storage and recovery well, and production well projects.

City of Key West - Project manager for the design, permitting, construction contract negotiation services, and construction oversight for deep injection well IW-2 at the Richard A. Heyman Environmental Protection Facility. The 3,000-foot deep well was completed on time on budget.

Florida Keys Aqueduct Authority Class I Industrial Deep Injection Well System – Provided design and permitting services for a Class I Industrial deep injection well facility for disposal of reverse osmosis concentrate. The deep injection well was designed with a cemented annulus between the tubing and packer.

Charlotte County Utility East Port Deep Injection Well – Provided mechanical integrity testing engineering services for the East Port wastewater disposal deep injection well in 2005.

Charlotte County Utility West Port Deep Injection Well – Provided mechanical integrity testing and well modifications design services for the West Port wastewater disposal deep injection well in 2005. Also provided injection wellhead redesign services to reduce operating pressures.

Martin County Tropical Farms Class I Industrial Deep Injection Well System – Project manager for the design, permitting and construction oversight for two Class I Industrial deep injection wells used for disposal of reverse osmosis concentrate and treated wastewater.

Charlotte County Utility Burnt Store Class I Industrial Deep Injection Well – Provided mechanical integrity testing engineering services for the Burnt Store reverse osmosis concentrate disposal deep injection well. Obtained FDEP approval for increased injection well capacity.

City of Belle Glade - Provided mechanical integrity testing engineering services for the Belle Glade wastewater disposal deep injection well. Provided monitor well repair engineering services for the City's dual-zone monitor well. Repair included installation of an FRP liner after the lower monitor zone steel casing had developed holes due to corrosion.

Florida Power & Light Exploratory West County Energy Center EW-1 - Provided services during construction and reporting services for an exploratory well designed to investigate the hydrogeology of the West County Energy

Center site. Successfully negotiated with FDEP to allow the conversion of the well to a single-zone monitor well when drilling conditions made completion of the well as designed (by others) infeasible.

Village of Royal Palm Beach – Project manager for the design and construction of a new production well and rehabilitation of 3 Surficial Aquifer production wells.

Arcadis, Inc. (2002 – 2003)
Deep Injection Well Services Program Manager

Served as the firm's program manager for deep injection well design, permitting, and construction oversight projects. Duties included project business development for deep injection well projects. Additional responsibilities included technical quality control of Groundwater Program projects.

CH2M HILL, Inc. (1995 – 2002)
Project Manager and Hydrogeologist

Was responsible for managing projects involving siting, design, construction oversight, testing, and obtaining permits for deep injection wells and ASR wells. Work included siting and design of injection wells and ASR wells, preparation of Florida Department of Environmental Protection (FDEP) injection well permit applications and responses to requests for information, development and interpretation of deep injection well and ASR well construction and testing programs, preparation of construction contract documents and management of well construction contracts. Other responsibilities included providing resident observation services during well construction and testing, and preparation of well construction completion reports. Communication with clients and contractors was an integral part of the responsibilities.

City of Key West – Project manager of a $4.8 million deep injection well facility. Responsibilities included design of the injection well facility, preparation of permit applications, management of field personnel, communications with the FDEP, and management of the budget for the project. The project was completed under budget and on schedule. Also prepared the FDEP-approved plugging and abandonment plan for a 2,000 foot deep exploratory well located approximately 1 mile from the injection well site.

Lee County Fort Myers Beach WWTP Deep Injection Well Facility – Served as construction manager for the construction of an injection well and dual-zone monitor well for the City of Fort Myer's wastewater treatment plant. Trained staff to provide daily resident observer services and provided on-site supervision during testing and key portions of construction. Was responsible for interpretation of test data and selected the casing setting depths, the injection zone, and monitor zones for the facility. Prepared FDEP required casing seat approval requests and the Engineering Report summarizing the construction and testing of the injection well facility.

City of Fort Myers – Provided construction services during the construction of Fort Myer's test production well, which is the City's first Floridan Aquifer production well constructed to supplement surficial aquifer water supply. Responsible for interpreting test data and selecting appropriate production intervals.

City of Fort Lauderdale – Provided construction services during the construction of Fort Lauderdale G.T. Lohmeyer deep injection well IW-4 and dual-zone monitor well MW-3. Was responsible for communication with the contractor and regulatory agencies, interpretation of test data, and preparation of the engineering report summarizing the construction of testing of the wells.

City of Delray Beach Production Well – Provided well construction supervision when the rehabilitation of production well 24 encountered technical difficulties. Productivity of the well had decreased significantly following rehabilitation efforts by a well drilling contractor. Advised the City to change contractors as a result of non-performance and provided technical assistance for improving the productivity of the well. The specific capacity of the well doubled as a result of the technical assistance.

Town of Highland Beach – Project manager for the design, permitting, and construction of two Floridan Aquifer production wells. The wells were constructed as Test Wells to fast-track the construction of the wells to assess water quality and aquifer characteristics on which to base the reverse osmosis water treatment plant design. The wells were converted to Production Wells via the SFWMD permitting process after completion and during the plant design.

City of Boynton Beach ASR Facility – Served as project manager for the feasibility, siting, subsurface design, and permitting of a 3.0 MGD treated water ASR Facility. The Facility is used to assist the City with reducing withdrawals of water from its Surficial Wellfield during dry periods. Managed the evaluation of land and source-water availability, water quality and hydrogeologic information, and regulatory issues related to the project. Coordinated groundwater modeling to determine well spacing to maximize stored water recovery and evaluate potential impacts to adjacent users.

City of Delray Beach ASR Facility – Took over project management after the previous project manager left CH2M HILL. Responsibilities included management of the completion of the installation of the ASR facility and completion of obtaining an FDEP construction permit for the project. Prepared and managed the cycle testing program, which allowed the client to receive the benefits of the ASR facility while still in the cycle testing phase.

City of West Palm Beach ASR Facility – Served as project manager for modification of the City's existing ASR Facility. Designed modifications to the ASR facility to allow storage of up to 8.0 MGD of disinfected surface water. Coordinated resident observation services during construction of the modifications. Completed the project with less than a 0.25% change order for the approximately $700,000 project.

Served as construction manager during construction of the City's ASR Facility prior to modification. Coordinated all construction and testing with numerous contractors and plant personnel to ensure these services were properly performed with the least amount of disruption to plant operations. Responsible for interpreting test data and selecting the appropriate ASR zone. Coordinated communication with regulatory agencies and the City, and prepared a Cycle Testing Plan and an O&M manual for the new ASR Facility.

City of Delray Beach ASR Facility – Took over project management after the previous project manager left CH2M HILL. Responsibilities included management of the completion of the installation of the ASR facility and completion of obtaining an FDEP construction permit for the project. Prepared and managed the cycle testing program, which allowed the client to receive the benefits of the ASR facility while still in the cycle testing phase.

MDWASD South District WWTP Injection Well Facility – Prepared annual water quality analysis reports for MSWASD, which presented interpretations of water quality data from deep monitoring wells. The reports were used to monitor the injection well system at the South District Wastewater Treatment Plant and evaluate fluid migration indicators at the site.

Florida Department of Environmental Protection, Underground Injection Control (1992-1995)
Professional Geologist
Responsibilities included the review and evaluation of Class I and Class V injection well and ASR well permit applications and proposed well construction and testing plans. Also responsible for reviewing well construction and testing engineering reports, weekly construction progress reports, monthly operating reports, and performing annual inspections of Class I injection well facilities. Interaction with consultants and key utility staff were instrumental in resolving regulatory issues.

Mobil Oil Corporation (1987-1992)
Exploration Geologist
Was responsible for conducting large-scale regional geologic studies to assess the hydrocarbon potential of numerous Mesozoic rift basins. Also conducted short-term and long-term mapping projects for much of Southeast Asia and South America, using conventional and computer-aided design.

Education
1985, B.S. Geology, Indiana University
1991, M.S. Geology, University of Texas at Arlington

Attachment B

Typical Well Design