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 REBUTTAL TESTIMONY OF DR. ROBERT G. MALIVA

Introduction

Please state your name and business address.

1. My name is Dr. Robert G. Maliva. My business address is 1567 Hayley Lane, Suite 202, Fort Myers, FL 33907.

Please describe your employer and position.

2. I am currently a Principal Hydrogeologist at WSP | Parsons Brinkerhoff, where I have worked since August 2016. I am a Registered Professional Geologist in Florida and Texas.

Have you previously submitted testimony in this proceeding?

3. I previously provided sworn direct testimony in this proceeding, Pre-Filed Direct Testimony of Dr. Robert G. Maliva (FPL-003).

In addition to your work described in your Pre-Filed Direct Testimony, what have you done to prepare this Pre-Filed Rebuttal Testimony?

4. I have reviewed the Intervenors' Initial Written Statement of Position Regarding Contention 2.1, as well as the Prefiled Initial Testimony of Mr. Quarles (Quarles Prefiled Initial Testimony). I have also reviewed the Nuclear Regulatory Commission (NRC) Staff Initial Statement of Position and the NRC Staff Testimony Concerning Contention 2.1. Lastly, I have reviewed the Pre-Filed Direct Testimony of Mr. McNabb (FPL-002), as well as the Pre-Filed Direct Testimonies of Mr. Paul Jacobs (FPL-001) and Dr. Christopher Teaf (FPL-004).

What is the purpose of your Rebuttal Testimony?

5. The purpose of my Rebuttal Testimony is to address portions of the Quarles Prefiled Initial Testimony regarding the possibility that wastewater from Turkey Point will migrate into the Upper Floridan Aquifer.

Summary

Please summarize your opinions.

6. It is my professional opinion that effective confinement exists at the Turkey Point site and that there is essentially no environmental (human health) risk associated with the injection of wastewater containing the contaminants in question (ethylbenzene, toluene, tetrachloroethylene, and heptachlor) at concentrations below drinking water standards. The confinement analysis performed to date, plus the data that will be collected during the construction of additional injection and monitor wells, exceeds all regulatory requirements, industry standards, and historical practices in South Florida.

7. Mr. Quarles' argument that seismic-reflection analysis should be performed is specious. Such analyses are extremely expensive and would not provide actionable information. There is no evidence that the ancient (several million years old) subsurface deformation features reported by the USGS are hydraulically active (i.e., allow for enhanced vertical flow). Therefore, even if a seismic-reflection survey was performed and such ancient deformation features were detected at the Turkey Point site, it would not provide a sufficient technical basis to revise the planned injection well system.

8. Mr. Quarles' testimony has a fundamental flaw in that it confuses several issues, jumping from the unlikely migration of water into the Upper Floridan Aquifer to human exposure, with no discussion of the pathway between the two. It is my opinion that there is not even a remotely plausible scenario whereby the injected wastewater at Turkey Point could contaminate the public potable (tap) water supply, posing an environmental risk. Mr. Quarles' speculation that environmental risks associated with the planned wastewater injection is greater than "small" cannot be technically supported.

Discussion

Has anything in Mr. Quarles' Prefiled Initial Testimony caused you to doubt the conclusions stated in your direct testimony?

9. No. Mr. Quarles has provided no new data or technical insights that would cause me to doubt my opinions.

Do you still believe that it is highly unlikely that the wastewater injected into the Boulder Zone at Turkey Point will migrate upward into the USDW?

10. Yes. In my professional opinion, it is highly unlikely that wastewater injected into the Boulder Zone will migrate into the USDW. There is essentially no possibility that the

injection of wastewater into the Boulder Zone would result in chemicals at issue in Contention 2.1 entering the potable water supply and causing health impacts.

<u>The Hydrogeology at Turkey Point</u>

Mr. Quarles describes the Boulder Zone as a "cavernous karst limestone bedrock formation." Quarles Prefiled Initial Testimony at A3. How would you describe the Boulder Zone?

11. The Boulder Zone is an interval of fractured dolomitic strata in which caverns open after drilling due to borehole wall collapse. Actual caverns (open voids), as indicated by bit drops during drilling, are rare.

Mr. Quarles also claims that recent studies have shown that the Middle Confining Unit is "now characterized as consisting of two 'semi-confining' units because of their tendency to leak." Quarles Prefiled Initial Testimony at A15. Is that correct?

12. The Middle Confining Unit is divided into two units separated by a high transmissivity interval near its top, which is referred to as the Avon Park Permeable Zone (APPZ), as recently characterized by the U.S. Geological Survey (*see* FPL-024 at 007). However, the entire Middle Confining Unit meets the Environmental Protection Agency's (EPA) definition of "confining" beds with respect to injection well systems as it is "a body of impermeable or distinctly less permeable material stratigraphically adjacent to one or more aquifers" (40 C.F.R. § 146.3). It is an exercise in semantics as to whether the Middle Floridan Aquifer is called a "*confining*" or a "*semi-confining*" unit. Our modeling results show that the Middle Confining Unit is sufficiently confining. While some small leakage would likely occur into the bottom of the Middle Confining Unit, the top of any wastewater that migrates would still be over 1,000 feet below the base of the

USDW after 100 years. Paragraphs 37-45 of my Pre-Filed Direct Testimony (FPL-003) address this modeling, and its results, in greater detail.

Well EW-1

Mr. Quarles claims it is insufficient to rely on data from one exploratory well to support a determination as to the likelihood of confinement. Quarles Prefiled Initial Testimony at A14. Do you agree?

13. No. Due to the multi-million dollar cost of drilling an exploratory well, no Class I injection well system in South Florida has ever had multiple exploratory wells. Such an expense cannot be seriously contemplated for an injection well system in which the constituents of concern are present at concentrations below drinking water standards. As I discussed in my prior testimony (Maliva Direct Testimony (FPL-003) at ¶¶ 19-20), an injection well impact assessment is not an academic research project. Drilling additional exploratory wells would yield limited additional value, certainly not commensurate with the expense. Additionally, data from other injection well sites (the South District Plant and Florida Keys Aqueduct Authority Roger Dean Water Treatment Plant) were considered in my confinement analysis.

Mr. Quarles says that the low percent bedrock recoveries from EW-1 demonstrate a lack of confinement. Quarles Prefiled Initial Testimony at A10, A11. Do you agree?

14. No, that statement is false. As I explained in my prior testimony (Maliva Direct Testimony (FPL-003) at ¶ 23), core recovery has no relationship to the effectiveness of confining strata. Poor core recovery is common during injection well drilling due to the cored material falling out of the core barrel during recovery of the core, or the core barrel becoming clogged during drilling by a piece of harder rock jammed in the barrel. The modern drill rigs used for injection wells continuously monitor drilling parameters such

as penetrate rate, weight on bit, and rotation rate. The presence of large voids, such as suggested by Mr. Quarles, would have resulted in a bit drop during drilling (i.e., rapid fall of the drill string into the void) that would have been detected. Such a bit drop clearly did not occur during the EW-1 coring, so there are no such large voids.

Mr. Quarles says that the high percent porosity of the bedrock intervals from EW-1 demonstrate a lack of confinement. Quarles Prefiled Initial Testimony at A10, A12. Do you agree?

15. No. Mr. Quarles' statement is false and contrary to basic hydrogeology. High porosity values do not indicate a high permeability and poor confinement. For example, clays have both high porosities and very low permeabilities, and can thus serve as highly effective confining units. The key variables controlling permeability are pore size (more particularly, pore throat diameters) and the amount of interconnected porosity. The effects of porosity on confinement were incorporated into my groundwater model (Maliva Direct Testimony (FPL-003) - Confinement Analysis 2: Groundwater Model). Simulations using actual porosity data from EW-1 indicate that very effective confinement is likely present.

Mr. Quarles says that the inconclusive straddle packer testing from EW-1 indicates a lack of confinement. Quarles Prefiled Initial Testimony at A10, A13. Do you agree?

16. No. As I explained in my prior testimony (Maliva Direct Testimony (FPL-003) at ¶ 24), the failure of a packer to isolate a test interval could be due to multiple reasons, such as leakage between the packer and borehole wall or bypass flow within the formation around a packer element. No inferences on aquifer properties can be made from the fact that a test interval could not maintain pressure.

What is conclusion do you draw from the EW-1 data?

17. Based on the EW-1 data, and my groundwater modeling, there is a very low probability that upwards migration of wastewater could occur into the Upper Floridan Aquifer at Turkey Point.

Seismic-Reflection Studies and Geological Structures

Mr. Quarles states that FPL's failure to use seismic-reflection analysis "is unjustifiable," as it shows whether injected wastewater is likely to migrate into the USDW. *See* Quarles Prefiled Initial Testimony at A14-A15. First, do seismic-reflection surveys reveal the upward migration of water?

18. No. Seismic-reflection surveys may indicate the presence of faults or other subsurface features, but not the likelihood of upward migration of water. Seismic-reflection surveys involve the transmission of sound or seismic waves through the ground. Seismic waves travelling downwards through the earth may be reflected off the boundary between materials with different acoustic impedances, which are the products of the seismic wave velocity and density of the rock. The recorded data in the seismic-reflection method are the two-way travel time for waves to reach reflectors and return to a receiver or multiple receivers at the surface. The depth to each reflector can be calculated based on the known seismic velocities of the materials penetrated by the waves and the two-way travel time. The seismic data are commonly processed to generate two-dimensional profiles of the subsurface reflectors. Seismic profiles, through the geometry of the mapped reflectors, can reveal faults, folds, collapse structures, flat-lying strata, and other structural and sedimentological features.

19. The existence of faults and other geologic features (e.g., folds and collapse structures), however, is not indicative of groundwater migrating upward. Such features could be

more permeable, equally permeable, or less permeable than the adjacent un-impacted strata. Some faults are actually impermeable and act to seal off aquifers and hydrocarbon reservoirs. No inferences can be made on the vertical migration of water from the presence of subsurface faults and other geological features identified in seismic-reflection surveys.

Is a seismic-reflection analysis required before the use of a Class I injection well? Why or why not?

20. No, they are never required. Seismic-reflection surveys that can penetrate through to the Boulder Zone would not provide data on the hydraulic properties (transmissivity and vertical hydraulic conductivity) of the surveyed strata that are needed for confinement analyses. There is no technical justification for employing the technology to address the issues in this case.

If such an analysis cannot determine whether water will migrate, then why has the USGS performed those studies?

21. The USGS has performed seismic-reflection surveys in Florida since the 1970s for a variety of scientific research purposes, but it does not help identify whether or not wastewater will migrate. Seismic-reflection surveys are used by the USGS because of the valuable basic geological data they can provide. The occurrence of wastewater migration at the North and South District Plants was another opportunity for the USGS to apply its technology. But this is the only example of which I am aware where the USGS used it in an attempt to study wastewater migration. As a scientist, I applaud the USGS for the outstanding, high-quality data they collected regarding the structural history of Florida. However, the results of that investigation did not demonstrate that the technique

can be used as a tool for predicting the potential for vertical migration of water from the Boulder Zone, as Mr. Quarles' Prefiled Initial Testimony suggests. There is simply no evidence that the structures the USGS identified are hydraulically active features that would allow for enhanced vertical flow.

Mr. Quarles states that the Cunningham 2012 article and its seismic reflection data demonstrate that fractures and faults "render bedrock layers ineffective as confining layers." Quarles Prefiled Initial Testimony at A15. Is that true?

22. No. Seismic reflection data do not provide information on the hydraulic properties of strata. Cunningham (2015, Plate 1) (FPL-008B) shows that some injection wells at the South District Plant were actually drilled through karstic paleo-collapse structures. Yet the geophysical log data from an injection well (IW-12) drilled through one of the identified structures shows no evidence of widespread fracturing of the confining strata associated with upwards fluid migration in South Florida (Attachment 1). There is no suggestion that the collapse structures have impacted the properties of the confining strata.

23. Additionally, as I noted in my prior testimony (Maliva Direct Testimony (FPL-003) at ¶ 73), I designed and permitted an injection well (East Central Regional Wastewater Treatment Plant IW-7[1]) at a site in which a large subsurface deformation (fault or fold) passed through the injection wellfield. The data (historical monitoring and on the extent of the upward of migration of wastewater) collected during the drilling of IW-7 indicate

[1] My prior testimony mistakenly referred to the East Central Regional Wastewater Treatment Plant as the East *Coast* Regional Wastewater Treatment plant.

that the structural feature has not compromised the confining unit. In that case, the injected wastewater invaded zone was still over 650 feet below the base of the USDW.

Mr. Quarles claims that faults or natural conduits are responsible for vertical migration at the South District Plant. Quarles Prefiled Initial Testimony at A15. Do you agree?

24. No. Mr. Quarles has provided no evidence supporting this hypothesis. The pattern of multiple separate plumes of wastewater, the presence of wastewater in upper monitoring zones but not lower zones in the same well, and the absence of significant fracturing in the confining zone strata in the injection wells, all suggest that well construction issues were the likely cause of the vertical migration.

In summary, do you believe that seismic-reflection surveys are necessary at Turkey Point?

25. No. There is no technical justification for performing seismic-reflection surveys at the Turkey Point site, because there is no evidence that the ancient (several million years old) subsurface deformation features reported by the USGS are hydraulically active (i.e., water flow features). Mr. Quarles merely speculates that that they might be hydraulically active. Even if the seismic-reflection surveys identified ancient deformation features at Turkey Point, without additional studies showing hydraulic activity (enhanced vertical hydraulic conductivity) there would be no reason to avoid wastewater injection.

<u>The Middle Confining Unit</u>

Mr. Quarles claims that a few studies (Reese & Richardson (2008) (FPL-024), Walsh & Price (2009) (FPL-028), Starr (2001) (FPL-026), and Cunningham (2015) (FPL-008)) show that the confining properties of the Middle Confining Unit are doubtful. Quarles Prefiled Initial Testimony at A16. Do you agree with this interpretation?

26. No. The results of all of these studies were not diagnostic as to the properties of the Middle Confining Unit, and the results of these studies are not transferrable to Turkey Point.

Mr. Quarles states that Starr (2001) (FPL-026) and Cunningham (2015) (FPL-008) also undermine your own finding that "'matrix hydraulic conductivities of the limestone and dolostones that constitute the confining strata between the injection zone and the base of the USDW in South Florida are sufficiently low to retard significant vertical fluid movement' and that minimal vertical migration would occur through sections where vertical hydraulic conductivity was 10^{-6} cm/sec or less." Quarles Prefiled Initial Testimony at A16. Do you agree?

27. No. The results of the modeling performed for my 2007 paper "Vertical migration of municipal wastewater in deep injection well systems," (FPL-013) and the modeling performed for the Turkey Point site indicate that *unfractured* strata have a sufficiently low hydraulic conductivity to effectively retard vertical fluid migration.

Mr. Quarles states that the Starr study concludes that up to 40 percent of FPL's injected fluids could contaminate the UFA. Quarles Prefiled Initial Testimony at A20. Do you agree with that interpretation?

28. Mr. Quarles' interpretation is clearly false. The Starr report was published in 2001 (*see* FPL-026), long before FPL ever contemplated using the Boulder Zone for wastewater disposal at Turkey Point.

Does site specific analysis at the South District Plant indicate the absence of a geologic confining layer at the South District Plant?

29. No. The key takeaways from studies of wastewater migration at the South District Plant are:

- Site specific data show that rapid vertical migration of injected fluids occurred at the site.
- The upwards migration occurred through several separate plumes.
- Some upwards migration was unequivocally due to well construction issues. Walsh and Price (2010) (FPL-028 at 004 (discussing the BZ cluster)).
- The pattern of wastewater migration bypassing the deeper monitoring zone is most likely due to well construction issues. Dausman et al. (2010) (FPL-009 at 009).
- The available geological and geophysical data from the South District Plant indicate that the confining strata are largely intact with limited fracturing.

All of these data suggest that the vertical fluid migration was most likely due to well construction issues. Mr. Quarles has not advanced any reason to think otherwise.

Mr. Quarles also claims that the presence of highly weathered bedrock, surrounding the wells, contributed to the vertical migration at the South District. Quarles Prefiled Initial Testimony at A29. Please respond.

30. I have been working on injection wells in South Florida for over 20 years and have studied all the relevant literature. I have never seen nor heard of significant "highly weathered bedrock" within the Middle Confining Unit, which is the area of concern for vertical migration. I do not know what Mr. Quarles is referring to.

In your prior testimony, you stated that Turkey Point's wastewater would only travel a minimal amount in the Boulder Zone, but Mr. Quarles notes that Dausman determined that "over a projected 148-year injection period (from 1983 forward) the resulting plumes would extend 'outward about 13 miles from the site in the MFA [Middle Floridan

Aquifer].'" Quarles Prefiled Initial Testimony at A22, A26. Is Dausman's study applicable to the injection wells at Turkey Point?

31. The Dausman et al. study cited by Mr. Quarles ("Saltwater/freshwater interface movement in response to deep-well injection in a coastal aquifer") (INT-017) is a four-page extended conference abstract, not a full-length peer-reviewed paper, so great care has to be taken when interpreting the limited presented results. Key modeling issues concerning boundary conditions are not provided in the abstract, particularly whether or not the regional southeastwards flow in the Upper Floridan Aquifer was included in the model, which would affect the rate and direction of fluid migration. The type of hydraulic connection between the Boulder Zone and APPZ (previously referred to as the Middle Floridan Aquifer) is also not addressed. There is too limited information for me to opine as to the validity of Dausman's modeling.

32. It is clear, however, that Dausman's model was calibrated against the upwards migration that occurred at South District Plant, as it appears to simulate upward migration with extremely leaky conditions (occurring rapidly throughout the 0.85 mile by 0.85 mile grid cells, as opposed to along discrete features such a wells or faults) and simulates injection over a 148-year period at a rate about 5 times greater than that proposed for Turkey Point. It also does not consider the thicker confining zone at Turkey Point and deeper-cased injection wells. For these reasons, no inferences can be drawn for Turkey Point from the Dausman study.

What level of dilution would be expected from wastewater that has migrated through a confining unit (of a size similar to that at Turkey Point) into the USDW and subsequently into a potable water source?

33. If the wastewater migrated upwards through a small diameter conduit (e.g., unplugged borehole or open fracture) then minimal dilution might occur during vertical migration once the conduit was been flushed of native groundwater. However, the dilution of wastewater that would occur once the wastewater reached a pumped production well located miles from the conduit would be enormous. A pumped well draws in water from all directions (360 degrees). The contribution from a contaminant source in any one direction would be minute.

Is there anything else that you would like to address in Mr. Quarles' testimony?

34. Throughout his testimony, Mr. Quarles badly confuses three similar-appearing but distinctly and critically different issues:

- Injected fluids entering a regulatory "Underground Source of Drinking Water" (USDW),
- Injected fluids entering an aquifer that is locally used as a drinking water source, and
- Injected fluid constituents actually entering the drinking water supply (i.e., potable or tap water) and resulting in human exposure and potential health impacts.

It is a huge jump to go from the very unlikely event that injected wastewater will migrate into a USDW zone that is not used for drinking water supply to actual human exposure, much less at a concentration and duration sufficient to cause adverse health impacts. Multiple independent barriers exist that will protect the public health. One additional barrier I have not previously described is that the Floridan Aquifer System USDW is

brackish (not directly potable) and has to be treated by a reverse-osmosis desalination facility before it can be used as potable water, which would remove the contaminants of concern. Another barrier is the low concentration of the chemicals at issue in the wastewater.[2]

35. As I noted above, Mr. Quarles also claims that the upwards migration experience at the South District Plant portends migration into the drinking water supply at the Turkey Point site. However, even at the South District Plant wastewater did not migrate into the Upper Floridan Aquifer. Based on a detailed investigation of both the North and South District Wastewater Treatment Plant sites, Walsh (2012) concluded that "[n]o evidence was observed at either site of injected wastewater migration to the Upper Floridan aquifer, which is used as a municipal water supply and for aquifer storage and recovery."[3] Walsh (2012) (FPL-063 at 009).

36. In summary, a series of independent barriers exist in this case between the point of injection and theoretical human exposure to chemicals in injected water at concentrations and durations sufficient to cause an adverse health impact, which include:

- The confining strata between the injection zone and Upper Floridan Aquifer zones used for potable water supply.
- The horizontal separation of the injection well site and the nearest existing or planned Upper Floridan Aquifer production wells, which is over 10 miles.

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[2] Chemicals at levels below their MCLs are not a regulatory concern, even if they enter a USDW. The overriding requirement of federal and state Underground Injection Control (UIC) regulations is that injection shall not *endanger* a USDW. Endangerment is defined as causing an exceedance of a primary drinking water standard (maximum contamination level; MCL). Since the concentrations of the chemicals of concern are below their MCLs in the wastewater, as discussed by Dr. Teaf, their introduction into a USDW would not be a regulatory violation.

[3] Walsh, V. M. (2012). Geochemical determination of the fate and transport of injected fresh wastewater to a deep saline aquifer. Ph.D. Dissertation, Florida Internal University, Miami, Florida. *FIU Electronic Theses and Dissertations.* Paper 692, available at http://digitalcommons.fiu.edu/etd/692.

- The groundwater flow direction in the Upper Floridan Aquifer, which at the Turkey Point site is away from all existing and planned Upper Floridan Aquifer potable water supply wells.

- Contamination attenuation processes that occur in the wastewater after injection, including the enormous dilution that would occur at an Upper Floridan Aquifer wellfield. Production wells draw water from a 360 degree area and only a small fraction would be from the direction of any one potential contamination source. Additionally, organic chemicals undergo natural biodegradation in groundwater environments.

- The water treatment plant processes for Upper Floridan Aquifer water (a brackish water source) in South Florida includes reverse osmosis desalination, which greatly reduces the concentrations of organic chemicals.

- Final testing of potable water (after treatment), which would detect the constituents of concern before long-term exposure could occur.

37. It is inconceivable how Mr. Quarles could reach the conclusion that the four chemicals at issue here, in concentrations below drinking water standards, could bypass all of the above barriers and cause a human health impact. Accordingly, the health risks in this case would best be described as infinitesimal or non-existent.

Does this conclude your rebuttal testimony?

38. Yes.

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

Signature

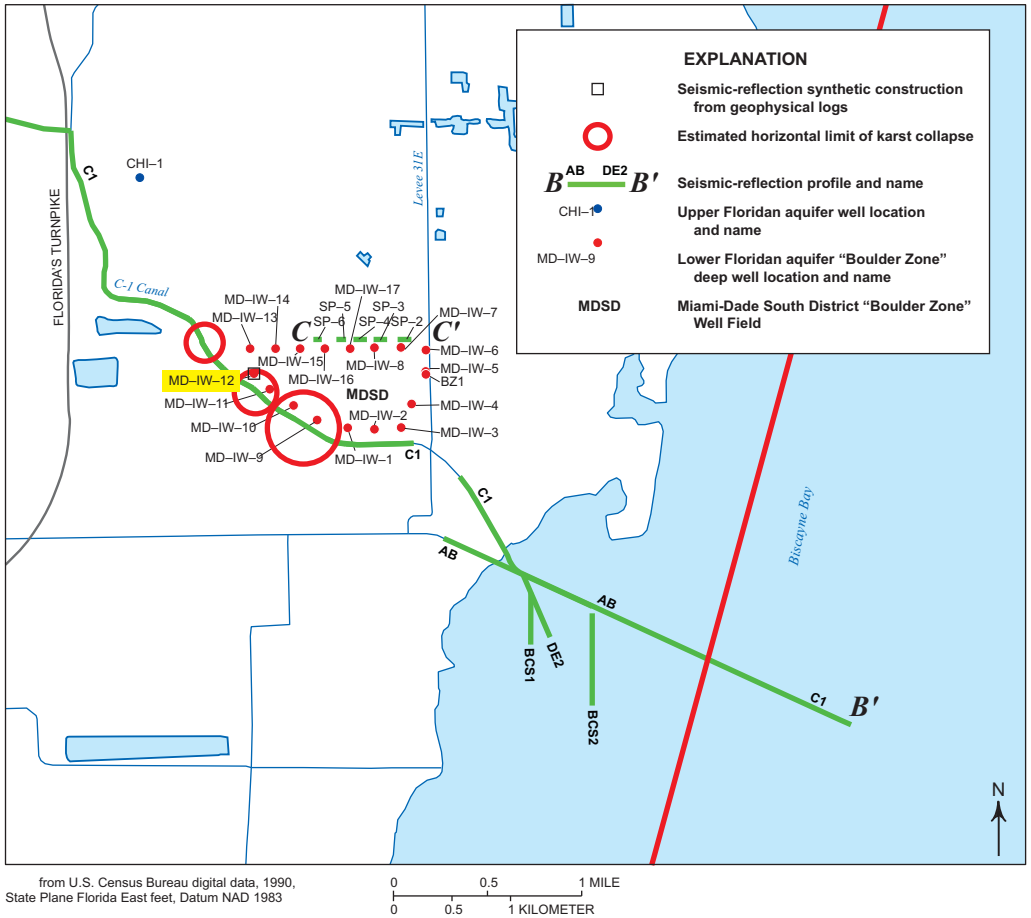
3-23-17

Date

ROBERT G. MALIVA
LICENSE
No. 1549
STATE OF
FLORIDA
PROFESSIONAL GEOLOGIST

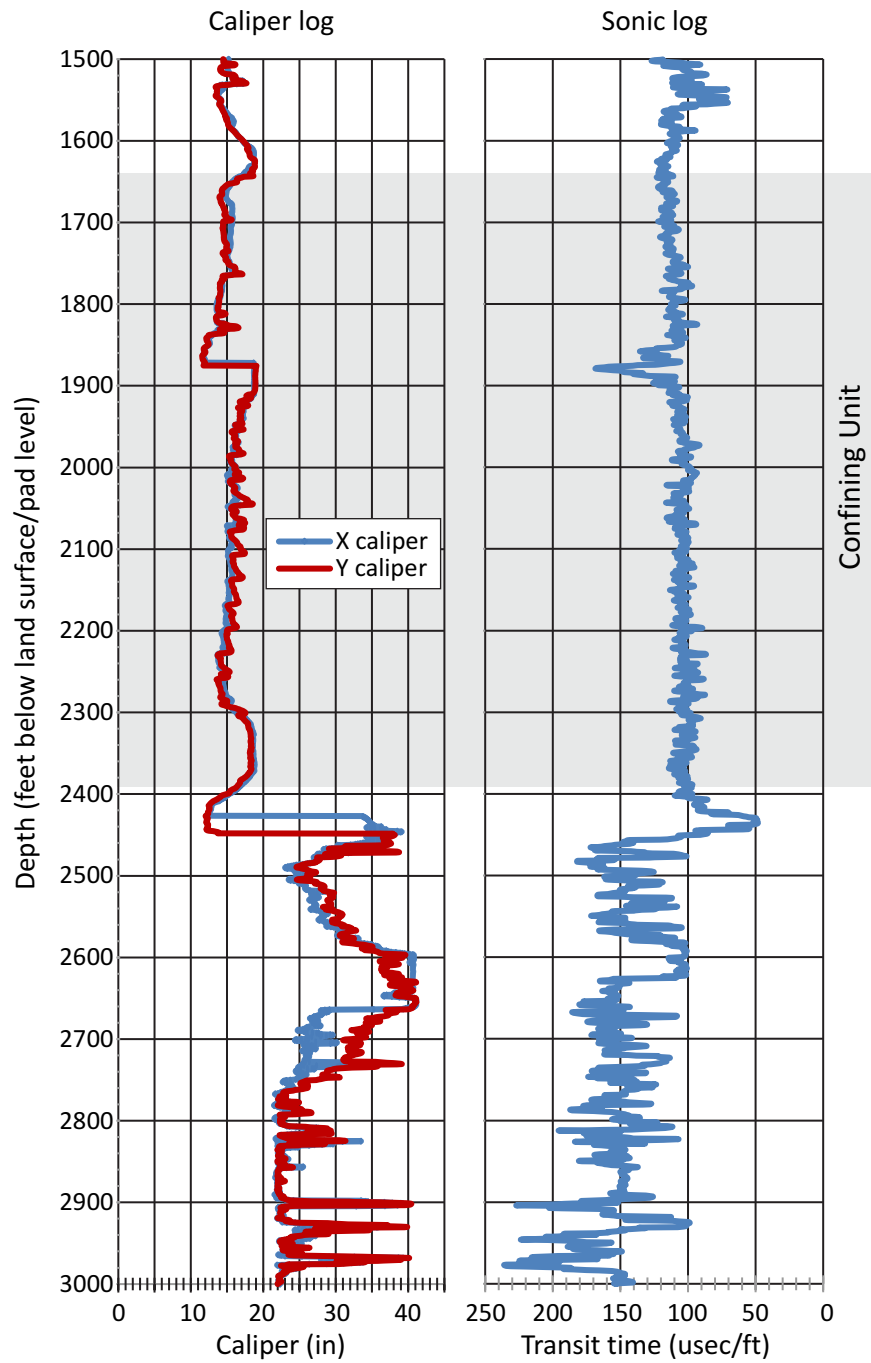
Attachment 1

Miami-Dade SDWWTP IW-12 geophysical logs



Location map showing that well IW-12 is located with a (paleo) karst collapse structure. Source: Cunningham (2015; Plate 1)

Geophysical logs of the confining zone in well IW-12 show that it has minimal fracturing and associated enhanced hydraulic conductivity, which would be manifested by sharp increases in borehole diameter and sonic transit times..



Source: SFWMD DBHYDRO site (https://www.sfwmd.gov/science-data/dbhydro)