FPL.

March 17, 2017

Mr. Wilbur Mayorga, P.E.
Chief, Environmental Monitoring and Restoration Division
Miami-Dade County Department of Regulatory and Economic Resources,
Division of Environmental Resources Management
701 NW 1st Court, 4th Floor
Miami, FL 33136-3912

RE: Florida Power & Light Company Site Assessment Report Submittal DERM case number HWR-851

Dear Mr. Mayorga:

Florida Power & Light Company (FPL) is pleased to provide you with a copy of the report entitled: "*Site Assessment Report; Ammonia in Surface Waters, Turkey Point Facility: March 17*", submitted in compliance with Paragraph 34.b., of Addendum 1 to the October 7, 2015 Consent Agreement between Miami-Dade County Department of Regulatory and Economic Resources, Division of Environmental Resources Management (DERM) and Florida Power & Light Company.

Should you have any questions or request additional information, please contact Steve Scroggs at (561) 694-4496 or me at (561) 691-2808 at your convenience.

Sincerely,

Wm Scott Burns for

Matthew J. Raffenberg
Sr. Director of Environmental Licensing and Permitting

CC: Lee Hefty, MDC DERM
Barbara Brown, MDC DERM
John Truitt, FDEP
Steve Scroggs, FPL
Wyatt Jenkins, FPL

ECRC-17-014959

Site Assessment Report

Ammonia in Surface Waters
Turkey Point Facility
March 17, 2017

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EXECUTIVE SUMMARY

An extensive sampling and analysis program was performed to assess the nature and extent of ammonia in surface waters at and near the Turkey Point Power Plant and adjacent Cooling Canal System. The sampling program included numerous surface water, porewater, canal and groundwater sampling locations as well as stratified surface water sampling and temporal sampling based on tidal cycles. A comprehensive nutrient and parameter analysis was performed from the samples collected. The assessment results were evaluated in detail and also in consideration of longer term synoptic analysis and other data to determine the nature and extent of ammonia at Turkey Point and bayward of the remnant, dead-end canals that connect with Biscayne Bay.

The evaluation of water quality within the cooling canal system (CCS) of the Turkey Point power plant was performed during this assessment. The results for the CCS showed that only low concentrations of ammonia (less than 0.1 mg/L) were present throughout the system. The evaluation of stratified surface water samples was also performed during this assessment. Stratification refers to horizontal water layers that can form due to differences in temperature and/or salinity. Stratification tends to inhibit water column mixing, which can prevent oxygen in the top layers from reaching the bottom layers, and this can increase the occurrence of ammonia. The assessment results showed that occurrences of higher ammonia values (greater than 0.5 mg/L) were limited to the bottom layers of waters that experienced stratified conditions with low dissolved oxygen in adjacent dead end canals connected to Biscayne Bay. Water samples collected from within the CCS exhibited no stratification and contained high levels of dissolved oxygen throughout the water column and across the CCS. These findings indicate that the CCS is not the source of the measured elevated ammonia samples collected at some of the adjacent dead end canals connected to Biscayne Bay.

The results of this comprehensive assessment and information relating to the nitrogen cycle indicate that the source of the elevated ammonia values in the area is attributable to the degradation of plant and animal material under anoxic conditions in areas with little or no mixing. The occurrence of ammonia also appears to be limited in extent vertically and horizontally tied to the locations of deep stagnant anoxic water bodies. While all sample sites in the Bay and CCS do not exhibit these anoxic characteristics and hence all had low ammonia levels, some of the deep canals sites and many of the groundwater and porewater sites were anoxic and the majority of nitrogen was in the form of ammonia. The areas studied at Turkey Point which possess these attributes and elevated ammonia are similar to many locations in coastal Southeast Florida. Regional studies of background surface water quality data for Biscayne Bay indicate that ammonia can be detected at many locations greater than 0.5 mg/L and that the concentrations can vary both temporally and spatially.

The following Site Assessment Report (SAR) details the extensive work and the results obtained by Florida Power & Light Company (FPL) for the Turkey Point area. The work was performed in accordance with the August 15, 2016 Addendum 1 to the October 7, 2015 Consent Agreement Addendum entered into with the Miami-Dade County Department of Regulatory and Economic Resources, Division of Environmental Resources Management (DERM). The data collected under this study indicates the presence of elevated ammonia values in excess of DERM surface water standards is not the result of point or non-point source contamination attributable to the Turkey Point Power Plant site. Rather the occurrence of elevated ammonia is the result of the conversion of organic nitrogen sourced from organic wetland soils, decomposition of wetland and aquatic plant material, atmospheric nitrogen fixation and natural microbial processes in anoxic, stagnate surface and groundwater environments similar to numerous other such occurrences documented along the coastal Biscayne Bay region. Additional assessment work associated with the August 15, 2016 Addendum 1 to the October 7, 2015 CAA is not warranted based on the SAP results. There is no evidence of any sources of ammonia being caused by FPL that warrant a Corrective Action Plan by FPL.

Key concepts and findings of the study include:

- ***Nitrogen Cycle*** - Ammonia is created by the degradation of organic nitrogen; for example, in the form of dead plant material or algae. In anoxic environments, ammonia concentrations are expected to be relatively high assuming a source of organic matter such as decaying plant material is available such as the case of the studied canals outside of the CCS.

- ***Stratification*** - In a well-mixed water body, oxygen is mixed throughout the water column resulting in a well-mixed oxic environment. In a poorly mixed water body, oxygen may stay near the surface and deeper water can become anoxic. In the data collected for SAR, all high ammonia values (> 0.5 mg/L) occurred under stratified conditions.

- ***Biscayne Bay*** - Samples collected in Biscayne Bay during this study were below the Miami-Dade County surface water standard for ammonia of 0.5 mg/L.

- ***Cooling Canal System*** - The type of nitrogen found in the CCS is primarily in the form of organic nitrogen. While total nitrogen concentrations were elevated (3 to 7 mg/L), no exceedance of the 0.5 mg/L surface water standard for ammonia was reported in samples collected from the CCS. The maximum observed ammonia concentration was 0.066 mg/L or 13 percent of the standard. The data indicate that the CCS is not a direct source of ammonia to adjacent remnant canals. While it is conceivable for ammonia to potentially seep into remnant canals, the ammonia concentrations in the CCS were very low, and therefore the CCS was not the direct cause of the elevated ammonia concentrations reported in the remnant canals. Rather, other sources of nitrogen (e.g., from adjacent wetlands and local decaying organic matter) could contribute to nitrogen concentrations in the dead end canals, and likely contribute most of it.

- ***Remnant and Dead-end Canals*** – Samples collected from these dead-end canals yielded elevated ammonia concentrations and low dissolved oxygen concentrations near the dead-end of the canals and in the lower portion of the water column. The sample stations nearest the dead end of the canal exhibited high stratification and poor mixing. Ammonia concentrations above 0.5 mg/L were observed in these areas. Samples collected in the more bayward end were less stratified and generally did not exceed the surface water standard for ammonia (>0.5 mg/L).

- ***Groundwater*** - All the groundwater samples contained ammonia. The monitoring wells located nearest Biscayne Bay had the lowest ammonia concentrations, possibly influenced by the low nitrogen concentrations found in the Bay.

- ***Porewater*** - Ammonia concentrations in porewater were variable at the different sampling locations in this study, but in general, those collected from open areas of Biscayne Bay were found to have lower ammonia concentrations than those in remnant dead-end canals.

SECTION 1 - INTRODUCTION AND BACKGROUND INFORMATION

This Site Assessment Report (SAR) has been prepared for the Florida Power & Light Company (FPL) Turkey Point power plant. Extensive assessment work was performed by FPL to address regulatory concerns associated with ammonia detected in the surface waters at and near Turkey Point. The assessment work detailed in this SAR was in response to the following documents:

- March 7, 2016 Memorandum titled "Report on Recent Biscayne Bay Water Quality Observations associated with FPL Turkey Point Cooling Canal System (CCS) Operations – Directive 152284" from Mayor Carlos A. Gimenez to the Miami-Dade County Board of County Commissioners;
- August 15, 2016 Addendum 1 to the October 7, 2015 Consent Agreement (CAA) entered into between the Miami-Dade County Department of Regulatory and Economic Resources, Division of Environmental Resources Management (DERM) and FPL;
- September 14, 2016 Site Assessment Plan (SAP) for ammonia prepared by FPL; and
- December 21, 2016 DERM comments and conditional approval of the SAP.

1.1 Project Objective

The purpose of this assessment was to define the nature and extent of ammonia previously detected in the surface waters at Turkey Point. Meeting this objective required the following actions:

- Monitoring nutrient concentrations in the pore water, groundwater, CCS and surfaces waters at Turkey Point;
- Defining the horizontal and vertical extent of ammonia in four specific areas at Turkey Point that included the Plant Complex and Northern CCS including the Turning Basin, Central CCS, Turtle Point and Vicinity and Southern CCS and Vicinity, including Card Sound Canal and the S-20 Canal;
- Evaluating the natural and anthropogenic sources of ammonia in Biscayne Bay in areas unrelated to Turkey Point; and
- Correlating the site specific and background area data to understand the nature and occurrence of ammonia in surface waters at Turkey Point.

1.2 Site Setting

Turkey Point and the FPL power plant are located adjacent to Biscayne Bay about 25 miles south of Miami, Florida. **Figure 1A** and **Figure 1B** show the site location and general area in relation to southeast Florida with an aerial and topographic background, respectively. Biscayne National Park is located to the east and north of the property and the Everglades Mitigation Bank (EMB) is located to the west and south. Further to the south of Turkey Point is Card Sound, which is part of Biscayne Bay, and this adjoins to Florida Bay and the Florida Keys. Further to the west of Turkey Point is the Everglades National Park. **Figure 2** shows a more detailed view of the vicinity.

The physiographic features of southern Dade County include the Atlantic Coastal Ridge located west of the power plant. A mixture of marls, fine sand, wetlands and marsh surround the plant. The area has flat terrain and natural poor drainage. The surface water and groundwater flow regimes of Dade County have been extensively altered by the construction of canals and other water management systems. This is also true for the Turkey Point area. Water management is a challenge in South Florida, which is further aggravated by large fluctuations in precipitation that are characteristic of the climate in the area. Droughts, floods and major storms are part of the natural water system. The wetlands in south Florida are primarily sustained by precipitation. The complex interactions of precipitation and evapotranspiration then become the primary set of controlling factors that regulate the condition of the wetlands.

The geologic formations of importance in south Dade County include the Miami Oolite and the Fort Thompson Formation. The composition and structure of these mostly calcareous/sandstone formations help determine the hydrology and geochemistry of the shallow groundwater in Dade County. Collectively these formations house the Biscayne aquifer, a water bearing unit that exists in Dade County including under Turkey Point. The Biscayne aquifer is a surficial (water table) aquifer that communicates directly with surface water bodies and contains fresh water and salt water depending on the location. The interface of fresh water and salt water is a natural occurrence in the Biscayne aquifer. Rainfall and water in the Everglades area replenish the fresh water found within the aquifer and the hydraulic gradient in the area of Turkey Point is generally from northwest to southeast.

Ecologically, considerable attention has been focused on restoration in south Florida. This includes the Comprehensive Everglades Restoration Plan (CERP) as well as other important programs such as FPL's EMB. Much of the restoration work necessarily deals with problems originally caused by previous development activities. Various drainage and flood control projects that date from the late 1800s resulted in changes to wetland areas. As early as the 1930s, salt water intrusion has been documented for South Florida. Many previous detrimental but now more beneficial anthropogenic influences have affected the area. The work associated with the CERP, EMP and other programs represent positive attempts to improve the hydrology of the area and increase natural freshwater sheet flow into Biscayne Bay.

Biscayne Bay is a shallow coastal lagoon where freshwater from south Florida mixes with salt water from the Atlantic Ocean. The bay is about 50 miles in length and varies in width from about 3 to 9 miles. At the north, the bay begins near the Oleta River State Park and extends to the south where U.S. Highway 1 connects the Florida mainland to Key Largo. The bay is an important and productive estuary that serves as a nursery for marine life. Seagrass and a large amount of fish, crustaceans, shellfish and numerous other invertebrates spend a portion of their lives in the bay's protective environment. The life cycle process begins with nutrients and fresh water flowing into the bay from inland areas.

The natural ecology of Biscayne Bay has been affected by extensive urbanization. This includes dredging, filling and bulk-heading that has limited fresh water flow into the bay. The ecology has also been affected by an increase in nutrient loading related to runoff, landfills, wastewater treatment plants and fertilizer use. These affects are more pronounced in the northern and central portions of the bay. The southern portion of Biscayne Bay, where Turkey Point is located, has experienced less development and detrimental effects. The larger anthropogenic impacts to the southern portion of the bay may be associated with the construction of the L31E canal / levee system and U.S. Highway 1. These resulted in significant alterations to the timing, locations and volumes in the amount of natural freshwater inputs into the bay.

1.3 Turkey Point Facility Operations

A total of about 30,000 acres of land comprises the area owned and managed by FPL at Turkey Point. Of this land, the Turkey Point power plant occupies 130 acres and the CCS an additional 6,000 acres. The general area is dominated by a natural habitat of freshwater and coastal wetlands. FPL acquired the Turkey Point property in 1964 and since then FPL has been one of the primary reasons the area was saved from intense development. The vast majority of the original Turkey Point land acquisition, about nine tenths, remains in its natural habitat of mangroves and fresh water wetlands. FPL maintains the land for the protection of the environment, wildlife and endangered species. This all occurred well prior to Biscayne National Park being established in 1980.

The first power generating units began operation at Turkey Point in the late 1960s. Power was initially produced using fossil fuel and then nuclear power units were brought online in 1972 and 1973. The existing CCS was constructed during this time period to provide heat exchange for the power plant. The interaction of surface water, groundwater and cooling water has always been important at Turkey Point. Similar to most power plants, heat exchange originally involved an interaction with surface water. This changed however in the early 1970s when FPL created a closed loop cooling system under an agreement with the US Department of Justice. The CCS at Turkey Point was then engineered so that cooling water for the power plant would remain within the CCS and not discharge into Biscayne Bay.

The CCS consists of about 163 linear miles of shallow-water canals that were designed and authorized to hydraulically communicate with the underlying Biscayne aquifer. This was necessary to provide a balance between heat exchange, evaporation and salinity. Over time an increase in the salinity has occurred in the canals and this eventually caused a hypersaline plume to migrate outward from the CCS. In addition to providing cooling for the power plant, the CCS and its warm saline waters have been important for repopulating the endangered American crocodile as well as providing an ideal habitat for other threatened species.

Located adjacent to the CCS is the FPL EMB that was established to assist in the responsible development, mitigation and protection of land in south Florida. FPL has worked closely with wetland experts and governmental agencies to design, build, and manage the wetlands to the highest standards. This ensures the wetlands will continue for future generations. The EMB covers approximately 13,500 acres strategically located between the Everglades National Park and Biscayne National Park. This allows the EMB to act as a corridor for wildlife to roam freely between the two parks while also promoting the growth of freshwater, saltwater and coastal vegetation and restoring more natural sheet flow of freshwater into Biscayne Bay.

SECTION 2 - TURKEY POINT SAMPLING PROGRAM

The plans for the extensive sampling and analysis work performed at Turkey Point were detailed in the SAP for ammonia prepared by FPL and dated September 14, 2016. This document described numerous sampling locations and extensive analytical procedures. Following the submittal of the SAP document, DERM requested additional sampling locations be included for Turkey Point. The DERM comments and approval of the SAP were presented in their letter dated December 21, 2016. In accordance with the DERM-approved SAP, the sampling program was designed to help characterize ammonia concentrations in four areas of the Turkey Point facility referred to as:

1. The Plant Complex and Northern CCS (includes the Turning Basin)
2. Central CCS
3. Turtle Point and Vicinity (includes the Turtle Point Canal)
4. Southern CCS and Vicinity (includes the Card Sound Canal and S-20 Canal)

The SAP originally proposed a list of 24 surface water sampling stations and this was subsequently expanded to include 23 additional sampling stations as requested by DERM. The additional stations included 9 groundwater and 15 surface water locations. Ten of the surface water sample stations were also scoped to include the collection of porewater samples.

2.1 Sample Groups

The DERM-approved sampling program consisted of groups or areas where aqueous samples were to be collected and included:

1. Groundwater samples collected from monitoring wells
2. Surface water samples collected from:
    a. Open areas of Biscayne Bay
    b. Remnant, dead-end canals
    c. The CCS, a closed-loop system
3. Porewater samples collected from just below the sediment surface water interface

Sampling stations established in the SAP and additional sampling stations requested by DERM are presented in **Table 1**. Sample station locations are depicted on **Figure 3A** and **Figure 3B**.

2.1.1 Groundwater

The groundwater monitoring network consists of nine groundwater monitoring wells. Two groundwater monitoring wells are located in the southwestern portion of the Plant Complex (North MW and South MW); three groundwater monitoring wells are in the area of the two aboveground storage tanks (ASTs) just north of the Turning Basin (FTF-NW, FTF-SW and FTF-SE) and at three groundwater monitoring wells are at approximate north/south trending locations near the shoreline interface with Biscayne Bay (MW-5, MW-3 and MW-4, from north to south). One monitoring well (C6-5) is located within the central portion of a shallow mud flat area that lies between the Grand Canal and the East Collector Canal. Monitoring well construction details are summarized below in **Table A**.

Table A – Well Construction Details

SAP ID	Total Well Depth	Casing Depth	Screen Length	Top of screen	Bottom of Screen	Open Hole Interval
FTF-SW	12	2	10	2	12	NA
FTF-NW	12	2	10	2	12	NA

SAP ID	Total Well Depth	Casing Depth	Screen Length	Top of screen	Bottom of Screen	Open Hole Interval
FTF-SE	12	2	10	2	12	NA
North MW	15	5	10	5	15	NA
South MW	18	8	10	8	18	NA
MW-3	44	22	NA	NA	NA	22-44
MW-4	47	22	NA	NA	NA	22-47
MW-5	41	22	NA	NA	NA	22-41
C6-5	90	ND	ND	ND	ND	ND

NA = Not Applicable   ND = Not Determined

2.1.2 Biscayne Bay

Six surface water stations collected from open areas of Biscayne Bay were collected. Three surface water sample locations are located just bayward of the Turning Basin entrance (TPBBBSW-PTB1, TPBBSW-6 and TPBBSW-10); one sample station (TPBBSW-7Tt) is located approximately 500 feet bayward of the mouth of Turtle Point Canal; two sampling stations are bayward of the mouths of the Card Sound and S-20 canals (TPBBSW-4 and TPBBSW-14), which meet at approximately the same point.

2.1.3 Remnant, Dead-end Canals

The Turning Basin (TB), Turtle Point (TP) Canal, S-20 Canal and Card Sound Canal are remnant, dead-end canals, have no direct surface water connection landward towards the Turkey Point plant and are tidally connected to Biscayne Bay. Given they are closed-ended waterways, water circulation patterns can tend toward stagnant conditions and the terminus as well as other stretches may be prone to accumulation of organic material. A stretch of the former Sea-Dade Canal (SDC) was also sampled which has no direct connection with Biscayne Bay.

2.1.3.1 Turning Basin Area

Three surface water sampling station locations are within the Turning basin (TPBBB-PTB2, TPBBB-PTB3 and TPBBSW-8). The Turning Basin is approximately 1,275 feet long and connects with Biscayne Bay on the east. The three sample stations were sampled at three different depth intervals within the dead-end canal.

2.1.3.2 Turtle Point Canal

Three surface water monitoring stations are located in Turtle Point Canal (TBBBSW-7B, TPBBSW-7M and TPBBSW-7T). The Turtle Point Canal is approximately 650 feet long and connects with Biscayne Bay on the east. Sample station locations are spatially distributed to help monitor water quality along the east/west axis of the canal extending from the canal terminus to the mouth.

2.1.3.3 Card Sound Canal

Three sample stations are located within Card Sound Canal. Starting at the canal mouth and moving away from Biscayne Bay towards the bermed terminus of the canal the stations are identified as TPBBCSC-M, TPBBCSC-Mid and TPBBCSC-B.

2.1.3.4 S-20 Canal

Nine sample stations are located along the S-20 Canal. Starting at the farthest point inland and proceeding towards Biscayne Bay the sample stations are identified as S20Get-Mid, S20Get-CCS, S20-Weir-Up, S20-Weir-Dwn, TPBBS20-B, TPSWC-8, TPSWC-7, TPBBS-Mid and TPBBS20-M. It is instructive to note that the S-20 Canal has a steel, sheet-pile weir constructed across it approximately 4,800 feet up-canal from the Crocodile Sanctuary. The sheet pile wall was driven into bedrock and provides a separation point between the fresher water portion of the S-20 Canal, the "Weir-Up" portion and the more brackish "Weir-Down" that connects with Biscayne Bay.

2.1.3.5 Former Sea-Dade Canal

The former Sea-Dade Canal (SDC) originally tied into the S-20 Canal to provide drainage and water transport. Under the provisions of the Everglades Mitigation Bank program, a portion of the SDC was plugged off from the S-20 and partially filled along segments of its reach; e.g. it is a remnant, dead-end canal with no flow. The two sample stations are identified as SDC-SWCCS and SDC-East.

2.1.4 Cooling Canal System (CCS)

Twelve surface water sample stations are located within the CCS and were selected to be representative of water that circulates through the CCS. One station (POUF) is at the outfall from the Turkey Point plant where water enters the head of the CCS; five sample stations (TPSWCCS-1, TPSWCCS-2, TPSWCCS-3, TPSWCCS-4 and TPSWCCS-7) are within the discharge side of the CCS; one (GcBr) is located at a small bridge that crosses the Grand Canal which is the main return water conveyance from the CCS to the Plant Complex; one sample station (TPSWCCS-5) is in the eastern most return circulation canal; one surface water sample station (MI-TCN) is located within a remnant creek that lies between the Grand Canal and the East Collector Canal; farther downstream in the Grand Canal towards the plant are two more sample stations (CNMI and TPSWCCS-6).

2.1.5 Porewater

Ten porewater samples were collected from beneath surface water at Turkey Point. One porewater sample was collected from each of the six Biscayne Bay sample stations; two from S-20 Canal sample stations (S20-Weir-Dwn and TPBBSW20-B) and two from Turtle Point Canal sample stations (TPBBSW-7M and TPBBSW-7Tt).

2.2 Groundwater Surface Water and Porewater Sampling Methods

2.2.1 Groundwater Sampling

Groundwater samples were collected following procedures detailed in the FPL Turkey Point Monitoring Plan project QAPP (July 2013) and FDEP SOPs FS2000 (General Water Sampling) and FS2200 (Groundwater Sampling). The permanent monitoring wells were sampled as part of the SAP effort using variable speed peristaltic pumps and new polyethylene (PE) tubing to collect samples. Wells with known screen intervals utilized the minimum purge volume technique, while wells with screen intervals that were not known (e.g. G6-5) employed the conventional purging technique (a flowchart that summarizes purging procedure options is presented in FS2000, Figure FS 2200-2). Depth to water was measured prior to purging and during purging to monitor draw-down and to optimize purging the rate. The PE tubing was placed at 1 to 2 feet (ft) above the well bottom for purging. Stabilization was monitored using a multi-parameter meter (YSI 556 or equivalent) and flow-through cell apparatus to measure temperature, pH, specific conductance, and dissolved oxygen following FDEP guidelines. In addition, dissolved carbon dioxide was measured using a colorimetric (phenolphthalein titration) field kit. Once purging was complete, the flow-through cell was removed and samples were pumped into pre-cleaned sample bottles provided by the laboratory. Where necessary, samples were field-filtered using a 0.45µm disposable filter.

2.2.2 Surface Water Sampling

Surface water samples were collected following procedures detailed in the project QAPP and FDEP SOPs FS2000 (General Water Sampling) and FS2100 (Surface Water Sampling). Surface water samples were collected from 1 ft below the water surface (T) and 1 ft above the bottom (B) except at a handful of shallow locations. Samples were collected using the same pump/tubing/meter set-up as with the groundwater samples. The primary difference between the groundwater and surface water protocols is that stabilization of field parameters is not required for surface waters. Once the equipment volume was purged, one reading was noted for the field parameters (same as for groundwater). Samples were collected in new sample bottles provided by the laboratory and field filtered, if necessary, per the analytical method.

2.2.3 Porewater Sampling

Porewater samples were collected following procedures detailed in the project QAPP and FDEP SOP FS2000 (General Water Sampling); FDEP does not have a specific SOP regarding porewater collection. At each porewater location, a PushPoint sampler (a 0.25-in by 3-ft stainless steel tube with slots cut into the side and a removable plunger to keep slots from clogging during insertion) was connected via PE tubing to a variable speed peristaltic pump. All PushPoint samplers were cleaned using FDEP SOP FC1000 procedures. Porewater samples for this event were collected at a depth of 30 cm into the sediment, unless refusal was encountered (bedrock, rubble) at a higher depth. Once the PushPoint sampler was inserted, water was pumped for several seconds to clear excess sediment from the tubing prior to collection, and a small volume was collected for temperature readings. Once the equipment was purged and the temperature was recorded, samples were collected into new sample bottles provided by the laboratory and field filtered, if necessary, per the analytical method.

For all samples collected (surface water, groundwater, and porewater), the pH of chemically preserved samples was tested upon collection. If needed, preservative was added to the sample and the number of drops added was recorded on the field datasheet. The water level was marked on each sample bottle to help the laboratory determine if the bottles had been sealed properly during transport. The sample bottles were then sealed in plastic bags, preserved in ice, and then stored per FDEP preservation requirements prior to laboratory analysis.

Field data sheets, sampling logs and field notes are provided as **Appendix B**.

2.3 Laboratory Analyses

The approved SAP parameter list is presented in **Table 2**. This list was developed based on FPL and DERM data, discussions with subject matter experts, and research into potential sources of ammonia.

Analysis of all surface water/sediment samples was performed by a National Environmental Laboratory Accreditation Program (NELAP) accredited laboratory. Laboratories previously employed were used to provide analytical continuity. Quality assurance and control procedures were maintained in accordance with NELAP and FDEP SOPs. The laboratory analytical reports were then reviewed by SAP team members experienced in evaluating the results.

Copies of the laboratory analytical reports are provided in **Appendix C**.

SECTION 3 - ASSESSMENT RESULTS

This section of the report provides an assessment of the data collected in the cooling canals and surrounding areas. Before providing a discussion of the specific data collected in the project area, a description of the processes that are important in ammonia formation and persistence in marine environments is provided. For purposes of this discussion, the CCS is considered to behave similarly to a marine environment due to its high salinity. Processes that are described in the following sub-sections include the nitrogen cycle and stratification.

3.1 Nitrogen Cycle

Nitrogen in the environment exists in many forms as shown in **Table B**. The important forms of nitrogen for the analysis of ammonia at Turkey Point are nitrate, ammonia (or ammonium ion) and organic nitrogen. The other forms shown in **Table B** are either intermediate forms that are unlikely to be observed at Turkey Point (e.g., nitrite) or end products such as nitrogen gas that are not considered significantly relevant to the discussion on ammonia.

Nitrogen cycling is the transformation between the forms of nitrogen shown in **Table B**. It is dependent on specialized groups of microorganisms, which carry out specific transformations. The rate at which transformations often occur is regulated by the presence or absence of dissolved oxygen. Below is a brief summary of the nitrogen cycle. A more detailed discussion of the different components of the nitrogen cycle is provided in **Appendix A**.

Table B – Aqueous Forms of Nitrogen

Form	Formula	Habitats
Nitrate	NO_3^-	Found in coastal upwelling zones and deep ocean
Ammonium ion (or Ammonia)	NH_4^+ (or NH_3)	Intermediate in decomposition of organic matter
Nitrite	NO_2^-	Found at the margins of oxic/anoxic regions; an intermediate in oxidation and reduction pathways
Nitrogen gas (dinitrogen)	N_2	Dissolved concentrations are high when in equilibrium with the atmosphere; available to N_2-fixing microorganisms
Nitrous oxide	N_2O	Intermediate in reductive pathway; also formed in nitrification in oxic/anoxic interfaces and anoxic and suboxic zones
Organic nitrogen	Multiple compounds	Complex organic matter with varying composition, including amino acids, nucleotides, peptides, proteins, and others
Source: Zehr and Kudela, 2011		

Only a few species of microorganisms have the ability to fix atmospheric nitrogen, such as cyanobacteria (blue-green algae), so most microorganisms require fixed bioavailable nitrogen in forms such as nitrate, ammonium, or organic nitrogen for growth. Ammonia is thought to be the preferred source of fixed nitrogen for phytoplankton, because its assimilation required relatively little energy (Gruber, 2008). Therefore, in a biologically healthy system, ammonia concentrations are low as the ammonia is used by the plants for growth.

Ammonia is created by the degradation of organic nitrogen (for example in the form of dead plant material or algae). The degradation rate is dependent on the quantity and type of organic material that is available; for example, phytoplankton cells are degraded more quickly than seagrass detritus (Herbert, 1999). In shallow water environments, nitrogen cycling in the benthic layer (primarily sediments and the water just overlying the sediment) can account for 20 to 80 percent of the nitrogen needed by phytoplankton for growth (Herbert, 1999).

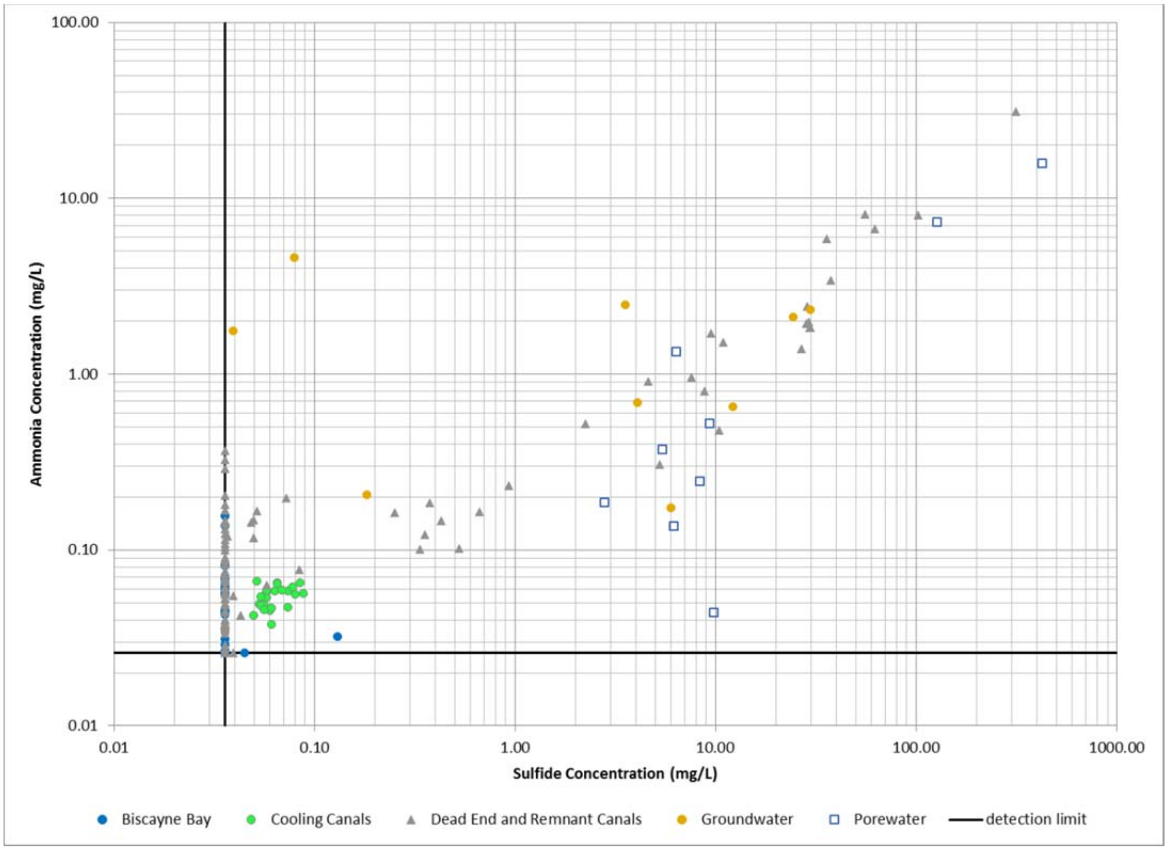
Nitrification is the aerobic oxidation of ammonium to nitrite and then to nitrate. Nitrification is catalyzed by aerobic bacteria (bacteria that only function in the presence of oxygen). In the absence of dissolved oxygen, nitrate is used by some bacteria as a source of energy rather than ammonia. This is known as denitrification. During denitrification, nitrate is reduced to nitrite and then nitrite is further reduced to a nitrogen gas, usually N_2. Anoxic microenvironments can occur within areas that have generally oxic surface sediments, allowing nitrification and denitrification to occur in close proximity (Herbert, 1999).

Instead of performing denitrification described above, some microbes employ a different pathway known as dissimilatory nitrate reduction to ammonium (DNRA). This process usually occurs in strongly reducing sediments (lacking free oxygen) and is enhanced by the presence of sulfate-reducing bacteria (highly reduced environments are often indicated by the presence of sulfides produced by sulfate reducing bacteria). DNRA has been found to be important, and sometimes the dominant fate for nitrate in some estuarine and coastal environments (Giblin et al., 2013). High DNRA rates have also been observed in warm regions with hypersaline conditions and high organic carbon to nitrate ratios (Gardner and McCarthy, 2009; Giblin et al., 2013). Unlike denitrification, DNRA conserves nitrogen in the system in the form of ammonia, allowing the nitrogen to be available for plant or microbial uptake.

3.2 Oxic and Anoxic Environments

In an oxic environment with plentiful oxygen, ammonia is either quickly taken up by microorganisms or vegetation or oxidized to nitrite then nitrate. The nitrate is then either used for cell growth or converted to nitrogen gas. In this environment, concentrations of total nitrogen should be relatively low.

In an anoxic environment, ammonia cannot be converted to nitrite and nitrate. In this environment, plants and bacteria will obtain their energy from other sources including iron oxides and sulfate. High concentrations of sulfides (a reduced form of sulfur) indicate highly reducing conditions. Under these conditions, you would expect ammonia to persist or to be re-formed from nitrate from the DNRA reaction (**Appendix A, Equation 7**). At Turkey Point, high ammonia concentrations were found in the presence of high sulfide concentrations, particularly in porewater and in the S-20 and Card Sound Canal located south of the CCS but samples collected in the CCS were found to have both low ammonia and low sulfide, indicative of well mixed oxic conditions. A plot of these data is presented as **Graph A**.



Graph A. Comparison between sulfide and ammonia, showing higher levels of ammonia under highly reducing conditions (high sulfides). Note that the data set contains 167 discrete samples, some of which were below detection levels and lie on the y-axis line.

3.3 Stratification

In most surface water bodies, oxygen is primarily obtained from the atmosphere by diffusion from the air into the water. In a well-mixed water body, the oxygen is mixed throughout the water column resulting in a well-mixed oxic environment. In a poorly mixed water body, the oxygen may stay near the surface and deeper water can become low in oxygen or anoxic (e.g., depleted of oxygen). One reason for poor mixing is the presence of stratification. Stratification refers to the variations in the vertical density of water where distinct horizontal layers exist that vary in density due to differences in temperature and or salinity. The degree of stratification is important in the analysis of water quality because stratification tends to inhibit mixing, which can prevent oxygen in the top layers from reaching the bottom layers.

The strength of stratification can be expressed in terms of the buoyancy frequency. The buoyancy frequency is best described by example. Imagine a stratified water body with a balloon full of water floating at a depth where it is neutrally buoyant. If the balloon is displaced up or down, it will oscillate about its neutrally buoyant position, eventually settling back to its original position. The frequency of oscillation is the buoyancy frequency. The larger the value, the stronger the stratification, and the more energy required for mixing to occur.

The buoyancy frequency is calculated as:

$$N = \sqrt{\frac{-1}{\rho_0}\frac{\Delta\rho}{\Delta z}g} \qquad \text{(Eqn. 1)}$$

Where:

N = buoyancy frequency (1/second)

ρ_o = average density (density was calculated from temperature and salinity using a linear approximation of the seawater equation of state[1])

$\Delta\rho$ = density difference

Δz = distance between sample depths applied to density difference between those two depths

g = acceleration of gravity (32.2 feet/second^2 or 9.81 meter/second^2)

Data collected in and around the CCS were collected at three depths when possible; 1 foot below the surface, near mid depth and 1 foot above the bottom. These data were used to calculate strength of stratification at each location using Equation 1. The average density was assumed equal to the mid-point value.

3.3.1 Stratification at Turkey Point

Data were collected at five areas in and around the plant site: in Biscayne Bay, in the CCS, in dead end and remnant canals, in groundwater, and in porewater. For the locations that were subject to tidal influences, data were collected at a low tide and at a high tide. Data were collected at a total of 38 surface water stations. At 28 stations, data were collected at multiple depths and for 16 of these at high and low tide. For each station with concentrations at multiple depths, the buoyancy frequency was calculated using **Equation 1**. Within the study area, buoyancy frequency *N* values ranged from 0.00 to 0.20. For discussion purposes, high ammonia was defined as being greater than 0.5 mg/L and low ammonia was defined as less than 0.5 mg/L[2]. All high ammonia values occurred under stratified conditions with a value of buoyancy frequency N values greater than 0.02. **Graph B** shows example density profiles for stations with no, low, and high stratification and how stratification can affect the ammonia concentration. In each example, a vertical profile indicates that the water is well mixed. The more horizontal the profile, the less well mixed and more stratified is the water. Most oxygen in the water column comes from the atmosphere. If the upper strata is well mixed (e.g., vertical profile in Graph B), there would be plentiful oxygen and the ammonia concentrations should be low. Since ammonia primarily occurs in areas with low dissolved oxygen, high ammonia concentrations are expected in areas that do not mix with surface waters (e.g., below horizontal profiles). Station TPBBSW-8B is unstratified (i.e., well mixed) and the ammonia concentration are low and fairly uniform with depth. Station TPBBSW-7M is stratified near the surface (i.e., low mixing of surface waters) and has a more uniform density near the bottom (i.e., bottom waters are well mixed). The ammonia concentrations are high below the stratification, but fairly uniform. Lastly, Station TPSWC-8-B is unstratified (i.e., well mixed) near the surface and stratified near the bottom. The well mixed surface layer has low ammonia concentrations, but high ammonia concentrations are located near the bottom below the stratification (where it is poorly mixed).

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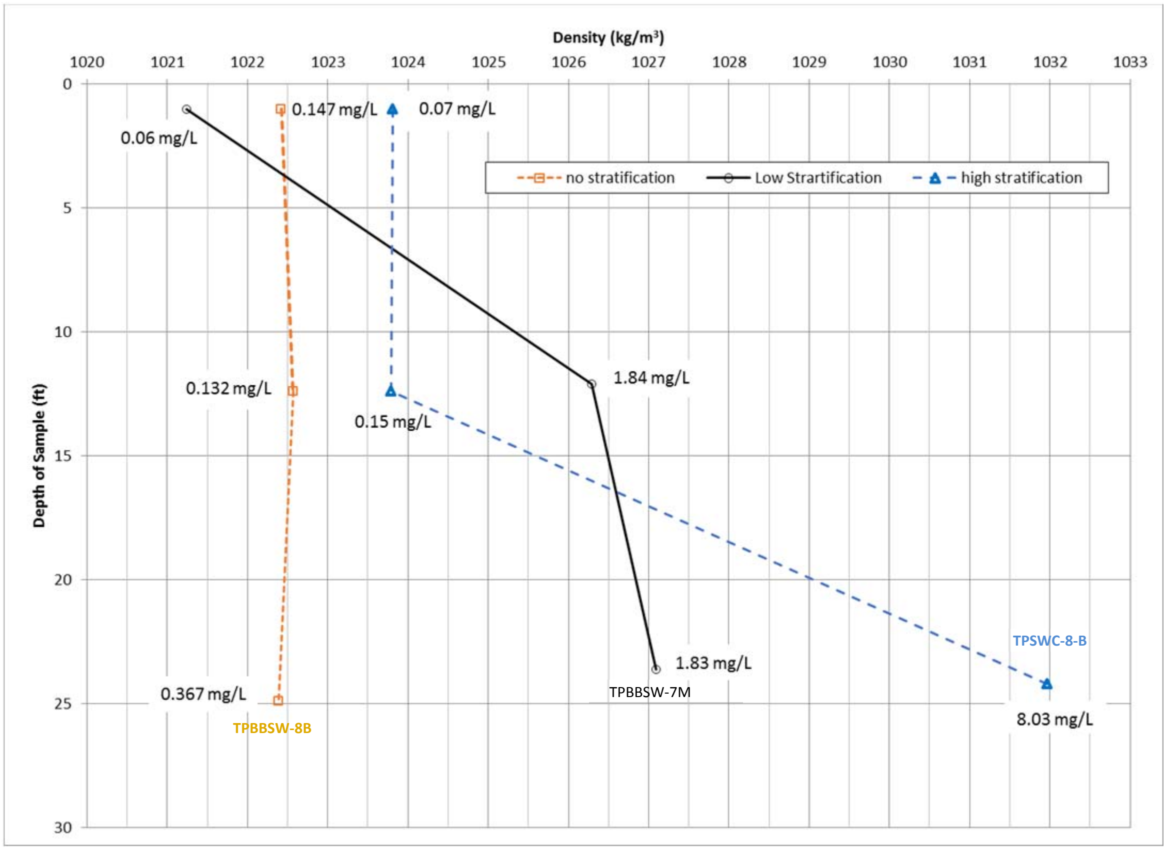
[1] Density was approximated as: density = 998.2+0.15(T-20)+0.78(S-0), where 998.2 is the density of freshwater at 20C, T is the temperature and S is the salinity. Units are kg/m^3.

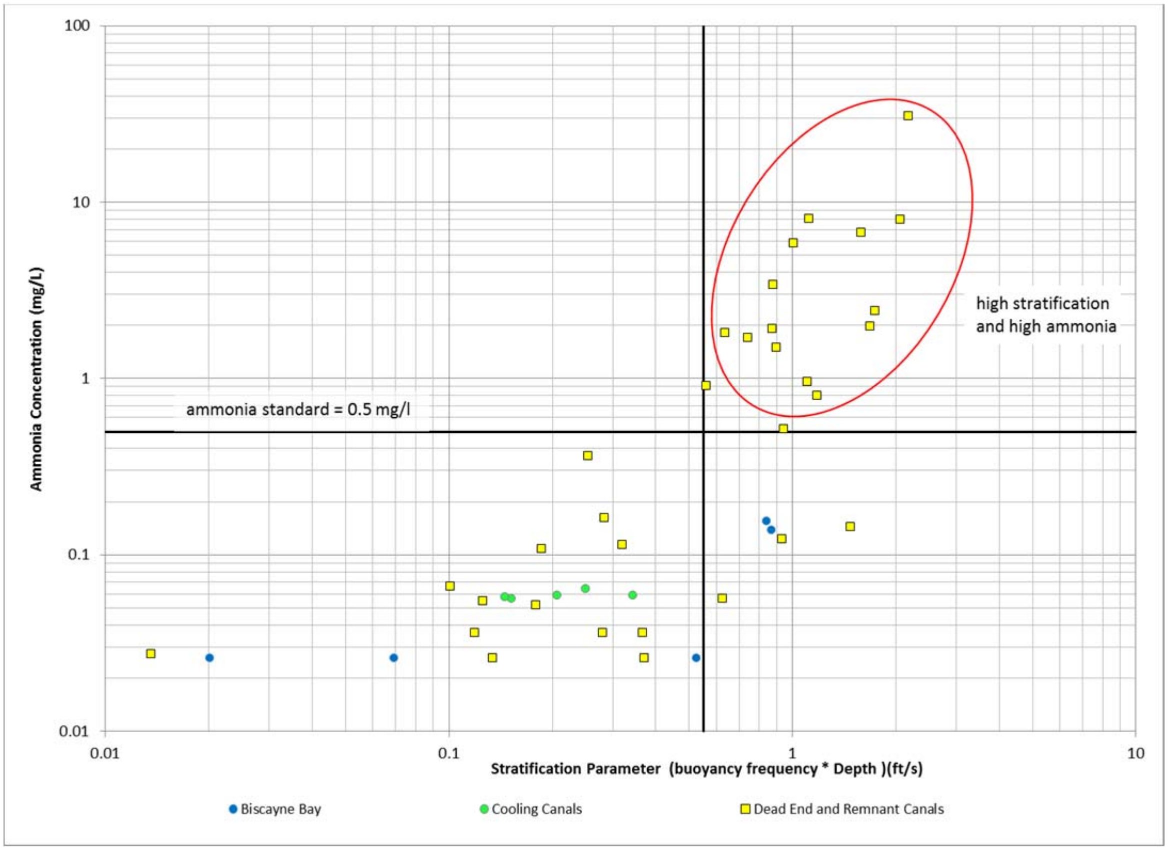
[2] The Miami-Dade County surface water standard for ammonia is 0.5 mg/L.



Graph B. Example of how Stratification affects Ammonia Concentration for Different Levels of Stratification. Station TPBBSW-8B has no stratification (high tide, N=0.01), Station TPBBSW-7M has low stratification (low tide, N= 0.026), and Station TPSWC-8-B has high stratification (high tide, N=0.081).

There are stations that were more stratified than Station TPBBSW-7M that had lower ammonia concentrations. The water depth at these stations tended to be shallower, e.g. less than 10 feet and were primarily located in the dead end canals south of the CCS.

Although deep water does not inhibit mixing, it does take more energy (e.g., from wind or flow velocity) to mix oxygenated surface waters to the bottom of a deep canal or water body. To account for depth, the buoyancy frequency was multiplied by total water depth to obtain a "stratification parameter." The resulting parameter provides an indication of the potential for vertical mixing in the water body. Large values (>0.55) would be indicative of inhibited mixing of oxygen to the bottom layers because either the water body is stratified or deep (or both), and small values (<0.55) would be indicative of a higher potential for mixing because of shallow water or lack of stratification. **Graph C** compares the "stratification parameter" to the ammonia concentration. The heavy lines on the figure divide the graph into four quadrants. Above the horizontal line, the concentration exceeds the Miami-Dade County surface water standard for ammonia (0.5 mg/L). To the right of the vertical heavy line, limited mixing appears to be occurring. Under highly stratified conditions with depleted oxygen concentrations, most of the nitrogen is found in the form of ammonia, suggesting that the ammonia found at such locations are likely to have been formed at that location, rather than transported from elsewhere.



Graph C. Ammonia Concentration Compared to "Stratification Parameter."

3.4 Groundwater

Groundwater was sampled at nine wells. Four of the wells are located northeast of the power block adjacent to the tank farm (FTF-SW, FTF-NW, FTF-SE, MW-5), two wells are located to the west of the power block between the intake canal and Biscayne Bay (MW-3, MW-4), two are located near the discharge to the cooling canal near the domestic waste water injection well (South MW, North SW), and one groundwater monitoring well (C6-5) is located in the area of Mud Island. **Figure 4** shows the locations of the nine groundwater monitoring wells with ammonia concentrations. A summary of groundwater analytical results is presented in **Table 3**.

The monitoring wells located near Biscayne Bay (MW-3, MW-4) have relatively low ammonia concentrations, while the monitoring wells located northeast of the power block adjacent to the tank farm have variable ammonia concentrations, with those wells closer to Biscayne Bay (FTF-SE, MW-5) having lower concentrations than those wells located further inland (FTF-SW, FTF-NW). Groundwater gradient data presented in the Site Conceptual Model for PTN (CRA, 2009) indicates that groundwater flows for shallow wells are from the Plant Complex towards the Turning Basin or Intake Canal so the wells do not appear to be influenced by quality in the Turning Basin. The two monitoring wells located farther inland (FTF-SW and FTF-NW) have higher concentrations (greater than 2.0 mg/L). The source of ammonia to these wells is unclear. The concentration of phosphorus in the wells is higher than in the surface water samples; a possible indicator of agricultural contamination, but not high enough to be of concern. The groundwater samples collected from these two monitoring wells were less saline than the monitoring wells located closer to Biscayne Bay (except FTF-SE, which has a similar salinity) indicating a potential source of water other than the Bay (possibly rainfall or surface runoff).

Sample C6-5 was collected from a 90-foot-deep monitoring well located in Mud Island. Groundwater at this location may be influenced by the CCS, as seen by the hypersaline conditions found in water at the depth sampled (hypersaline conditions are only observed in samples from the CCS and not observed in any other monitoring wells). The nitrogen was primarily in the form of ammonia, and its concentrations were above 2.0 mg/L.

Groundwater monitoring wells North MW and South MW are shallow wells (14 and 23 feet deep respectively) located near the permitted domestic wastewater injection well. The plant's domestic wastewater disposal well is 62 feet deep and receives between 10,000 to 30,000 gallons per day of treated effluent from the site's wastewater plant. Both of the monitoring wells had relatively high ammonia concentrations. They also contain freshwater at the depth sampled. It is possible that these wells are influenced by the domestic wastewater injection well, however, due to the comparatively low volume of water injected, the potential range of influence from the plant's domestic injection well is small, as compared to municipal injection wells found elsewhere. South MW has higher organic nitrogen concentrations, higher total nitrogen concentrations, and was the only monitoring well that yielded a groundwater sample greater than 2.8 mg/L (the reported concentration of total ammonia in South MW was 4.6 mg/L).

3.5 Biscayne Bay

Samples collected in the open areas of Biscayne Bay (TPBBSW-10, TPBBSW-7Tt, TPBBSW-14, and TPBBSW-4; see **Figure 5**) have low total nitrogen concentrations and higher dissolved oxygen concentrations. With the exception of samples collected from the bottom strata which had slightly reduced dissolved oxygen concentrations, samples collected just bayward of the Turning Basin entrance (TPBBSW-6 and TPBBBSW-PTB1) had low total nitrogen concentrations and higher dissolved oxygen concentrations. Samples collected in Biscayne Bay during this study met the Miami-Dade County surface water standard for ammonia (0.5 mg/L). A summary of surface water analytical results from Biscayne Bay is presented in **Table 4**.

3.6 Remnant, Dead-end Canals

Samples were collected at three sampling locations in the Turning Basin, three locations at Turtle Point Canal, three locations in Card Sound Canal, and at 11 locations within the S-20 Canal, the Crocodile Sanctuary, or in the former Sea-Dade Canal (**Figure 6**). A summary of analytical results from the these remnant, dead-end canals is presented in **Table 5**.

Samples collected in the Turning Basin area (TPBBSW-PTB3, TPBBSW-8, TPBBBSW-PTB2,), Turtle Point Canal (TPBBSW-7B, TPBBSW-7M, and TPBBSW-7T), and Card Sound Canal (TPBBCSC-B, TPBBCSC-Mid, and TPBBCSC-M), were found to have increased ammonia concentrations and decreased dissolved oxygen concentrations near the end of the remnant canals, in the lower portion of the water column, and at low tides. This is likely due to poor mixing/tidal flushing in these areas. In general, ammonia concentrations were greater than 0.5 mg/L when dissolved oxygen concentrations were less than 1 mg/L. Of these tidal areas, the sample collected at the bottom of TPBBSW-8, at low tide, had the highest ammonia concentration (6 to 8 mg/L)[3], very low dissolved oxygen concentrations (0.07 mg/L), and relatively high sulfide concentrations (36 mg/L). Samples collected in more bayward directions generally had higher dissolved oxygen concentrations at both high and low tides, and met the surface water standard for ammonia (0.5 mg/L).

[3] The ammonia range in this case refers to the dissolved ammonia concentration and the ammonium ion concentration.

Samples collected in the upper portion of the S-20 canal (S20Get-Mid, S20Get-CCS, S20Weir-Up, and S20Weir-Down, see **Figure 6**) exhibited some degree of stratification, with salinity increasing with depth. However, the depth of the canal was variable between these locations and only S20Get-CCS-B (the lowest sample at S20Get-CCS) had ammonia at concentrations greater than the surface water standard. Sample collected in the tidally influenced portion of the S-20 canal (TPBBS20-B, TPBBS20-MID, and TPBBS20-M-S) had ammonia concentrations below the surface water standard. Organic nitrogen concentrations were also low, with the possible exception of sample collected from the bottom of TPBBS20-MID at low tide.

Samples collected near the crocodile nesting area (TPSWC-7 and TPSWC-8, see **Figure 6**) had increased ammonia and decreased dissolved oxygen concentrations in the lower portion of the water column at low tides. Sediments are likely anoxic, and during low tides this area is drained only a few inches. During higher tides, the lower portion of TPSWC-8 also had elevated ammonia and poor dissolved oxygen conditions and may be influenced by the bottom sediments.

Samples collected from one of the sampling locations in the former Sea-Dade Canal (SDC-SWCCS) were from a highly reducing environment (as evidenced by high levels of sulfide and low dissolved oxygen). Sample SDC-SWCCS-B was collected from this remnant, dead-end canal, portions of which have been backfilled in accordance with the EMB conservation plan. The former SDC and sample point SDC-SWCCS-B are located south of the CCS. Water at this sampling location is highly stratified and moderately deep (11 feet). The lowest stratum has the highest ammonia concentrations (30 to 40 mg/L) of all the samples collected during this study. All of the nitrogen in the sample was in the form of ammonia; organic nitrogen, nitrate, and nitrite were not detected. Dissolved oxygen concentrations were relatively low (1.65 mg/L) and sulfide concentrations were high, indicating a reducing environment. Samples collected from SDC-East had low sulfide concentrations, higher dissolved oxygen concentrations, low total nitrogen concentrations, and met the surface water standard for ammonia. These locations are isolated from each other due to backfilling.

Two possible sources of ammonia to the remnant canals south of the CCS are agricultural runoff and decaying organic matter. Agricultural runoff can cause an increase in ammonia in two ways: as a direct contribution in the form of the ammonium ion, or cause excessive plant or algae growth that then results in a die off and increased decay producing ammonia. The presences of phosphate can be an indication of the presence of agricultural runoff, influences from organic soils in adjacent wetland areas, and/or decaying organic matter. In the canals south of the CCS, most of the samples for phosphorus (or orthophosphate) are at or near detection. Those few samples that are above detection correspond to high ammonia concentrations. These data are only a snapshot in time, so the results are not definitive but provide evidence that external sources could contribute to high ammonia in the canals located south of the CCS (e.g. the S-20 canal).

3.7 Cooling Canal System

The CCS is a closed loop system of canals and a shallow tidal flat-like area (Mud Island) that extends about 5 miles to the south of the PTN Plant Complex. **Figure 7** shows the location of samples collected in the CCS system and a summary of analytical results is provided in **Table 6**. However, due to the shape of the CCS, water could travel over 10 miles from the discharge point to the plant intake. The type of nitrogen found in the CCS is primarily in the form of organic nitrogen. Total nitrogen concentrations are relatively high (3 to 7 mg/L), but none of the data show any exceedances of the surface water standard for ammonia. The maximum observed ammonia concentration was 0.066 mg/L or 13 percent of the surface water standard for ammonia. The oxygen levels in the canal are all higher than 3 mg/L, sufficient for biologically-mediated activity to maintain low ammonia levels. Three samples collected in the canal system were sampled at multiple depths. None of the samples showed any stratification, indicating good mixing. The system is currently exhibiting hypersaline conditions.

Potential sources for nitrogen in the CCS are nitrogen fixation and direct assimilation of nitrogen species for cell growth. No ammonia was observed in the CCS at a concentration exceeding the surface water standard for ammonia during this study. Accordingly, the data does not support the conclusion that the CCS is the source of ammonia in the adjacent remnant canals.

3.8 Porewater Samples

Ammonia concentrations in porewater were variable at the different sampling locations in this study, but in general, those in open areas of Biscayne Bay were found to have lower ammonia concentrations than those in remnant or isolated canals. The locations where porewater samples were collected are depicted in **Figure 8** and a summary of analytical results are presented in **Table 7**.

Porewater collected from open areas of Biscayne Bay (TPBBSW-10, TPBBSW-7Tt, TPBBSW-14, and TPBBSW-4) and in one of the sampling locations bayward of the Turning Basin entrance (TPBBBSW-PTB1) met the surface water standard for ammonia. The porewater collected at TPBBSW-6, located bayward of the Turning Basin, had higher ammonia concentrations (1.3 to 1.7 mg/L). The porewater sample collected at the Turtle Point Canal (TPBBSW-7M) had high ammonia (7 to 9 mg/L), low dissolved oxygen (1.34 mg/L), and high sulfide (128 mg/L). However, the porewater sample collected at S20Weir was only slightly above the surface water standard for ammonia.

One porewater sample was collected from a highly reducing environment. It was collected at sampling site TPBBS20-B, located just west of the S-20 canal and west of the crocodile nesting area. This sample location is within a portion of the former SDC, in a stretch of former canal that is now isolated due to backfilling per the EMP and not connected to other canals. High levels of ammonia (16 to 20 mg/L) were found in this sample, and almost all of the nitrogen was in the form of ammonia (nitrate-nitrite concentrations were low and organic nitrogen was not detected). Dissolved oxygen concentrations were also low (0.5 mg/L) and sulfide concentrations were high.

A closer view of the respective four areas where all samples were collected is presented as **Figure 9**.

3.9 Nitrogen Speciation of FPL Data

The data described above was analyzed relative to the discussion on the nitrogen cycle described in Section 3.1. For each sample its relationship to the nitrogen cycle was included in **Table 8**.

3.10 Regional Studies Related to Ammonia

The surface water quality data for Biscayne Bay shows that ammonia concentrations have been recorded above the DERM criteria at many locations unrelated to Turkey Point. The data indicates that exceedances can be temporal and relatively localized in nature and the causes can be attributed to both anthropogenic and natural phenomenon. A number of water quality studies have been conducted for the bay and nearby area that relate to the data we are obtaining. Below summarizes this information.

Air and Water Quality Status and Trends in Miami- Dade County; DERM, September 2013

In 1979 the Biscayne Bay Surface Water Quality Monitoring Program (BBWQMP) was initiated. The program began with 47 sampling stations in the bay and then expanded to 117 stations that included 71 in the bay and its tributaries and 46 in the major canal systems. The report stated that water quality in all surface water is highly variable, and can be affected by a combination of natural factors, including geography, weather patterns, tides, season, and human-related actions.

The report noted that despite an ever-growing population surface water quality tended to be improving. However, adverse impacts caused by historical dredging and filling of wetlands and the construction of numerous drainage canals that transport nutrients to Biscayne Bay are still observed. Figure 10 and Figure 11 of the referenced DERM report are presented in **Appendix D** and depict the concentration and geographic distribution of inorganic nitrogen (NOX) and un-ionized ammonia (NH3), respectively. These figures illustrate the anthropogenic pattern within Biscayne Bay for data collected from 2005 through 2012.

Naturally Occurring Ammonia: South Florida Coast; Jerald S. Ault, Ph.D., Professor and Chair University of Miami Department of Marine Ecosystems and Society, April 2016

This presentation summarized the life cycle of marine life and the occurrence of ammonia in Biscayne Bay. The sampling results from 1992 to 2016 were also summarized in the document. Ammonia occurs naturally through breakdown of organic material and from man based sources including Plant detritus, organic soils, animal waste, fertilizers, landfills, septic tanks, and marinas. Figure 4 of that report, which showed many locations in Biscayne Bay and unrelated to Turkey Point where ammonia exceeded 0.5 mg/L, is presented as **Appendix E**.

Total Ammonia Concentrations in Soil, Sediments, Surface Water, and Groundwater Along the Western Shoreline of Biscayne Bay with the Focus on Black Point and a Reference Mangrove Site; Southeast Environmental Research Center - FIU, February 2001

This report described the elevated ammonia concentrations found in groundwater and surface water near the Black Point area. Not surprisingly, the ammonia appeared attributable to the Dade County landfills. The report concluded that freshwaters reaching the nearshore bay contains numerous nutrients, metals, hydrocarbons, pesticides, and herbicides from anthropogenic sources. High salinities were also reported during the study period but were associated with the weather (a dry winter). Conclusions could not be made concerning the effects of the ammonia exceedances in the bay. Interestingly the report also described natural ammonia production related to coastal mangroves.

Ecosummary Biscayne Bay; FDEP Southeast District, December 2002

This summary noted that trends in water quality data can be affected by a number of factors such as shifts from dry to wet years. Concerning the southern portion of Biscayne Bay, high nitrate and ammonia concentrations were reported as a result of episodic releases of nitrogen-laden stormwater through the South Florida Water Management District (SFWMD) primary canals, particularly Mowry and Princeton Canals and from groundwater. Thirty-one of the monthly values obtained over a six-year period were above 1.0 mg/L nitrate nitrogen, which was reported as extremely high for southeastern Florida waters. Sources of the nitrogen included high levels of ammonia nitrogen from County landfills and agricultural runoff.

Quality of Ground Water in the Biscayne Aquifer in Miami-Dade, Broward, and Palm Beach Counties, Florida, 1996-1998, with Emphasis on Contaminants; USGS, 2005

The study was part of the National Water Quality Assessment (NAWQA) Program and included results for 30 water supply wells and 32 monitoring wells located in the eastern parts of Miami-Dade, Broward, and Palm Beach Counties. The results of the study showed that concentrations of ammonia in ground water were relatively high compared to concentrations recorded in other NAWQA study areas. The median concentration for ammonia in public supply wells was 0.45 mg/L with a high level of 2.3 mg/L. The median concentration for ammonia in monitoring wells was 0.23 mg/L with a high level of 25 mg/L. The ammonia was attributed to human activities such as domestic waste and agricultural practices.

Water Quality Protection Program – Canal Demonstration Projects; Monroe County Sustainability and Projects Director, December 2015

This presentation summarized the projects focused on improving the water quality in the hundreds of man-made canals located in Monroe County. Dredge and fill activities created 170 miles of canals with over 300 miles of water-front property. Most of the canals were relatively long dead-end networks with little tidal flushing. The canals were also dredged deeper than natural inlets to maximize needed fill material and facilitate boating activities. The physical attributes of the canals allow for a preferential trapping of sea grass, increased decaying vegetation, reducing conditions, algae and nutrients. The restoration work in Monroe County has included the installation of weed barriers, culverts and backfilling canals to shallower depths.

There are many hundreds of miles of canals in Dade County that possess the same attributes as those in Monroe County but yet are not addressed by the same extensive and expensive restoration work described here. The available background data shows that natural phenomenon can regularly cause exceedances of the ammonia criteria. The detected exceedances appear to be temporal in nature and relatively localized spatially. Many such locations have been documented that are unrelated to Turkey Point.

SECTION 4 - SUMMARY OF FINDINGS AND CONCLUSIONS

An extensive sampling and analysis program has been completed by FPL to assess the nature and extent of ammonia in surface waters near the area of Turkey Point. This work was performed in accordance with the August 15, 2016 Addendum 1 to the October 7, 2015 CAA entered into between FPL and DERM. Details of the work were described in the SAP dated September 14, 2016 and approved by DERM with conditions on December 21, 2016. The conditions in the approval letter from DERM were incorporated in the SAP that was implemented. As evidenced in the following sections each of the four project objectives was met:

- Nutrient monitoring was completed in porewater, groundwater, CCS and surfaces waters at Turkey Point.
- The nature and extent of ammonia was assessed at four specific areas of Turkey Point, e.g., the Plant Complex and Northern CCS including the Turning Basin, the Central CCS, Turtle Point and Vicinity and Southern CCS and Vicinity, including Card Sound Canal and the S-20 Canal.
- An evaluation of natural and anthropogenic sources of ammonia in Biscayne Bay at areas unrelated to Turkey Point was conducted; and
- Correlation of the Turkey Point data to regional background area data was conducted and that review identified similarities the nature and occurrence of ammonia in surface waters at Turkey Point to other similar locals in Biscayne Bay.

The sampling program included numerous groundwater, surface water, porewater, and cooling canal sampling locations. The program included stratified surface water sampling and temporal sampling based on tidal cycles. The program also included a wide range of nutrient and parameter analysis to better correlate source and causal factors. The SAP specific analysis was evaluated with longer term synoptic results and other data to determine the nature and extent of ammonia in surface water at Turkey Point and just bayward of the remnant, dead-end canals that connect with Biscayne Bay. Each of the four Project

The results of the study are based on an analysis of the SAP data relative to the nitrogen cycle. Details of the nitrogen cycle are provided in **Appendix A**. Important aspects of the nitrogen cycle that affect the interpretation of the results are summarized below and include:

- Ammonia is primarily derived from the degradation of organic nitrogen (e.g., proteins, amino acids). The organic nitrogen is primarily from atmospheric nitrogen fixation from blue-green algae and the decay of organic matter (algae, seagrass ect.) that exist in in the canals and along its banks. The cooling canal system does not receive any significant nitrogen from plant activities or discharges.
- In the presence of oxygen, ammonia is quickly converted to nitrate which is readily used by plants. Therefore, in a biologically active system, concentrations of ammonia and nitrate should be low.
- In the absence of oxygen, the conversion from ammonia to nitrate is suppressed and ammonia can accumulate. In this case, if decaying organic nitrogen is available, higher concentrations of ammonia are possible.

In summary, based on the nitrogen cycle, ammonia concentrations should be low in aerobic biologically active systems and high in anaerobic conditions with available organic nitrogen. These were the important processes considered when reviewing the SAP data.

Groundwater. Groundwater data were collected from nine wells. The results of the analysis for these well are summarized below.

- All the shallow groundwater monitoring wells had elevated ammonia concentrations, except for MW-3 and MW-4, which are located outside of the plant facility immediately adjacent to Biscayne Bay. Wells MW-5 and FTF-SE had only slightly elevated ammonia concentrations (between 0.6 and 0.7 mg/L) and are located along the edge of the tank farm area near Biscayne Bay.
- Well C6-5 located in Mud Island was hypersaline, indicating a possible connection between the CCS and this well. No other wells were hypersaline, suggesting minimal or no connection to the CCS.
- Wells North and South MW both have relatively fresh water (salinity <1 SU) and elevated ammonia concentrations. The most likely source of freshwater to these wells is the wastewater injection well from the treatment plant located nearby. This is likely a localized effect. Because of the comparatively low volume of water injected, the potential range of influence from the plant's wastewater injection well is small, as compared to municipal injection wells found elsewhere.
- The source of ammonia to the other wells is unknown although adjacent wetlands may provide dissolved organic matter that could be converted to ammonia in-situ and influence groundwater in some wells.

Surface Waters. Surface water data were collected from Biscayne Bay, remnant dead-end canals, and the CCS. Below summarizes the findings of this assessment for surface waters:

- Open Bay samples all had low total nitrogen and no issues with ammonia and high dissolved oxygen concentrations. Samples collected from the bottom strata just bayward of the Turning Basin entrance had slightly reduced dissolved oxygen concentrations, but still met the surface water standard for ammonia (0.5 mg/L).
- The remnant canals, including the Turning Basin, Turtle Point Canal, and the Card Sound Canal, have more stratification and less mixing at the dead end of the canal, as compared to the mouth of the canal. Higher ammonia concentrations were observed at the deepest samples and low tide.
    - The atmosphere is the major source of oxygen to the system. Under stratified conditions, when mixing is inhibited, dissolved oxygen is low, allowing higher levels of ammonia to occur. Low oxygen conditions can also occur in deeper waters, since more mixing is required to mix oxygen deeper into the water column. This can occur where there is less water movement, such as at the dead end of canals.
    - Under highly stratified conditions with depleted oxygen concentrations, most of the nitrogen is found in the form of ammonia, suggesting that the ammonia found at such locations are likely to have been formed at that location from decaying organic matter near the sediment water interface, rather than transported from elsewhere.
- The canals located south of the CCS (e.g., S-20 and the former Sea-Dade Canal) could be influenced by adjacent wetland areas and native organic soils which contribute decaying organic matter that could provide a source of nitrogen to these areas.
- Ammonia concentrations in the CCS were very low, as were the nitrate concentrations.
    - In the CCS, mixing appeared to be good, as stratification was low and dissolved oxygen levels were relatively high (generally between 4 and 6 mg/L). Chlorophyll a

concentrations were relatively high (generally 100 to 300 mg/m^3), which indicates biological activity.

- Though it is possible for ammonia to enter the dead end of the remnant canals through seepage from groundwater, ammonia concentrations in the CCS were very low (<0.07 mg/L), and therefore, the CCS would not be the direct cause of high ammonia concentrations in adjacent remnant canals. If there were seepage of dissolved organic nitrogen, this nitrogen, after being diluted, would not be able to account for the majority of the ammonia measured in the dead end canals in the worst areas. Other sources of nitrogen (e.g., from adjacent wetlands and local decaying organic matter) could contribute to nitrogen concentrations in the remnant canals, likely most of it.

- Laboratory analysis confirmed no exceedance of the DERM ammonia standard in any surface water sample collected from Biscayne Bay or the CCS. Only samples collected from dead-end canals and only those samples collected from the bottom of the water column (not the mid- point or surface) yielded an exceedance of the ammonia standard. As previously explained, the observed presence of ammonia is consistent with nitrogen cycling of organic matter under in anoxic conditions such as are present at the bottom of a dead-end canal. **Table C** presents only the highest ammonia concentration at those dead-end canal sample stations with a surface water sample above the DERM standard. **Figure 6** presents all ammonia values at each sample station and further illustrates the isolated occurrence of ammonia and the stratified nature of the water column.

Table C - Dead-end Canal Sample Stations with Ammonia Values Greater than the DERM Surface Water Standard

Sample Station ID	Ammonia as N, Dissolved (mg/L)	Water Column Sample Interval	Location
SDS-SWCCS	31.00	Bottom	Isolated segment of former Sea-Dade Canal
TPSWC-8	8.07	Bottom	Crocodile Sanctuary
TPSWC-7	7.55	Bottom	Crocodile Sanctuary
TPBBSW-8	5.90	Bottom	Dead-End terminus of Turning Basin
TPBBSW-7M	2.43	Bottom	Mid-point of Turtle Point Canal
TPBBSW-7B	1.98	Bottom	Dead-end terminus of Turtle Point Canal
TPBBCSC-Mid	1.71	Bottom	Card Sound Canal at 45-degree bend (likely depositional sink)
TPBBBSW-PTB3	1.51	Bottom	Dead-end terminus of Turning Basin
TPBBCSC-B	0.96	Bottom	Card Sound Canal at the dead-end of the canal

Porewater. Porewater samples were collected in open areas of Biscayne Bay, in locations bayward of the Turning Basin entrance, in the Turtle Point Canal, within S20Weir, and within the former SDC. The results of the analysis for porewater samples are summarized below.

- Ammonia concentrations in porewater were variable at the different sampling locations in this study, but in general, those collected from open areas of Biscayne Bay were found to have lower ammonia concentrations than those in remnant or isolated canals.
- The porewater sample collected within the former SDC was from a highly reducing environment (as evidenced by high levels of sulfide and low dissolved oxygen). This highly reducing environment provided unfavorable conditions. High levels of ammonia (16 to 20 mg/L) were found in this sample, and almost all of the nitrogen was in the form of ammonia (nitrate-nitrite concentrations were low and organic nitrogen was not detected).

The results of this assessment and the information presented concerning the nitrogen cycle indicate that the source of the ammonia in the area of Turkey Point is attributable to the degradation of plant and animal material and to natural and anthropogenic phenomenon related to larger factors affecting Biscayne Bay. The ammonia also appears to be limited in extent. The occurrence of ammonia was more prevalent in some portions of the dead-end canals within deep anoxic low flow areas, with localized sources of organic nitrogen including plant detritus and algae.

The results obtained from the sampling program at Turkey Point are consistent with background data for Biscayne Bay collected in other studies along coastal Miami-Dade and Monroe counties. Ammonia can be detected at many locations and the concentrations seem to vary both temporally and spatially. In surface waters, the detection of ammonia in concentrations exceeding 0.5 mg/L can be difficult to duplicate. This is the nature of nutrients in Biscayne Bay attributable to both natural and anthropogenic factors.

The southern portion of Biscayne Bay, where Turkey Point is located, enjoys the highest surface water quality in the bay. FPL is one of the primary reasons that this portion of the bay has been spared from the intense development and anthropogenic effects that the central and northern portions of the bay have been exposed to. The larger effects to water quality in the bay relate to waterfront development and inland water management and land use practices that date from the late 1800s.

The data collected under this study indicates the presence of elevated ammonia values in excess of County surface water standards is not the result of point or non-point source contamination attributable to the Turkey Point Power Plant site. Rather the occurrence of elevated ammonia is the result of the conversion of organic nitrogen sourced from organic wetland soils, decomposition of wetland and aquatic plant material, atmospheric nitrogen fixation and natural microbial processes in anoxic, stagnate surface and groundwater environments similar to numerous other such occurrences documented along the coastal bay region. Additional assessment work associated with the August 15, 2016 Addendum 1 to the October 7, 2015 CAA is not warranted based on the SAP results. There is no evidence of any sources of ammonia being caused by FPL that warrant a Corrective Action Plan by FPL.

SECTION 5 - RECOMMENDATIONS

Based on the information obtained from this assessment, additional work is not recommended. A Corrective Action Plan is not necessary for the four areas studied at Turkey Point.

SECTION 6 - REFERENCES

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