A Mussel (Unionidae) Survey in Selected Martin County Wetlands, Culminating in Site-Specific Total Ammonia Nitrogen Criteria

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1 EXECUTIVE SUMMARY

The Florida Power and Light (FPL) Martin Power Plant has the capability to provide seepage water to two wetlands (Northwest Mitigation Area [NWMA] and Barley Barber Swamp) that are located adjacent to its associated cooling pond. While release of the seepage water would assist in maintaining a healthy hydroperiod in the wetland systems, FPL was concerned that Total Ammonia Nitrogen (TAN) in the seepage water could potentially exceed the recently adopted TAN water quality criteria.

On January 10 and 11, 2018, an EPA and FDEP-approved semi-quantitative mussel (Unionidae) survey was conducted at three wetland sites (test sites, including NWMA East, NWMA West, and the Barley Barber Swamp) and at one flowing slough (Black Bottom Slough, a control site), all located in Martin County. The purpose of the survey was to determine, with 95% confidence, whether Unionid mussels were present or absent in the test wetlands. Additionally, the control system was sampled to determine if the method could successfully locate Unionids from an area where habitat conditions were more conducive to Unionid propagation. Because no Unionid mussels (neither live, un-weathered shells, nor weathered shells) were found at any of the test wetlands, the Total Ammonia Nitrogen (TAN) Recalculation Procedure for Site-specific Criteria Derivation was subsequently utilized to provide for a more accurate, yet protective TAN criterion for these particular wetlands (EPA, 2013). Therefore, the Site-Specific Alternative TAN Criteria for the NW Mitigation Area and Barley Barber Swamp was determined using **Equation 1**.

EPA (2013) recommends use of this CCC (Chronic Criterion Magnitude) formula for the condition where mussels are absent and Early Life Stage (ELS) fish protection is required (**Equation 1)**.

Equation 1. EPA Recalculated Chronic Criterion Magnitude for TAN.

$$CCC = 0.9405 \times \left(\frac{0.0278}{1 + 10^{7.688-pH}} + \frac{1.1994}{1 + 10^{pH-7.688}}\right) \times MIN\left(6.920, \left(7.547 \times 10^{0.028\times(20-T)}\right)\right)$$

The 30-day average TAN value shall not exceed the average of the values calculated from the above equation, with no single value exceeding 2.5 times the value from the equation. Criteria values shall not be exceeded. For purposes of TAN criterion calculations, pH is subject to the range of 6.5 to 9.0. The pH shall be set at 6.5 if measured pH is < 6.5 and set at 9.0 if the measured pH is > 9.0.

Information supporting this Type 2 Site-Specific Alternative Criteria for TAN is provided in this document and in the Plan of Study for this project (Frydenborg and Frydenborg, 2017).

2 BACKGROUND AND INTRODUCTION

The Northwest Mitigation Area (NWMA) (predominantly an intermittent herbaceous marsh) and Barley Barber Swamp (a forested wetland) are both located in Martin County, adjacent to the Florida Power and Light Martin Plant cooling pond **(Figure 2-1**).

FPL is obligated to provide water for wetlands hydration in the NWMA, and to maintain minimum flows within the Barley Barber Swamp. The primary water source for wetlands hydration is the seepage collection system located around the perimeter of the Martin Plant cooling pond. The seepage collection system is necessary to protect the structural integrity of the berm surrounding the cooling pond and consists of underground seepage collection, piping, and 29 sumps equipped with pumps that can discharge either to the wetlands, to nearby waterbodies, or back into the cooling pond.

The NWMA is a 1,200 acre mitigation area that includes both isolated herbaceous wetlands, forested cypress communities, and uplands previously used for pastureland (**Figure 2-1** through **Figure 2-4**). This area was restored and enhanced to compensate for anticipated wetlands loss from the Martin Plant expansion, and approved by the State Siting Board in 1991. The NWMA project included hydration of 166 acres of restored/enhanced wetlands, and 167 acres of created wetlands, including 16 acres of ponds used for wood stork (*Mycteria americana,* a threatened species) habitat, for a total of 333 acres of wetlands. The project was designed to add berms and control structures that would direct seepage water from Sumps 25 and 26 (combined discharge pipe) to the east side of the NWMA to inundate this area up to 26.5 ft., NGVD. A control structure in the northwest corner of the east side overflows to the west side of the NWMA. Water from Sump 24 is discharged to the west side of the NWMA and inundates this area up to 24 ft. NGVD. Water from the NWMA eventually flows southwest to Black Bottom Slough and discharges off-site to the L-65 Canal and then to the St. Lucie (C-44) Canal. The normal operating protocol is to pump water to the NWMA from May through January, and to discontinue pumping February – April, allowing yearly hydrologic processes (seasonal desiccation) to be maintained. The hydration of 333 acres of wetlands, including providing wood stork habitat, indicates a net positive environmental benefit associated with the sump discharges. **For purposes of this study, the NWMA was sampled at two sites (East and West)**.

The Barley Barber Swamp is a 400-acre natural freshwater wetland that was set aside as a nature preserve when the plant was originally constructed in the late 1970's. The Water Use Agreement with the South Florida Water Management District requires FPL to maintain natural minimum flow levels within the swamp. Six sumps provide water to Swamp, three of which (Sumps 15, 16 and 20) currently discharge only to the Swamp (**Figure 2-5**). The other three sumps (17 – 19) can discharge to either the cooling pond or the Swamp.

Water quality data were collected during a period when discharge from Sumps 25/26 and 24 was permitted by FDEP Secretarial Order (to assist in mitigation of a 2016 St. Lucie Harmful Algal Bloom). The results indicated that TAN was rapidly assimilated by the wetlands to low levels within 150 m of the discharges (see Frydenborg and Frydenborg, 2017, and **Chapter 7)**. These results were consistent with other studies, which noted that TAN is rapidly assimilated in wetlands (from 58% to 92%) via nitrification, denitrification, vascular plant uptake, and volatilization (California State University, 2009). Note that the **sumps ceased discharging to the mitigation areas in October 2016**, approximately one year and three months prior to the mussel survey.

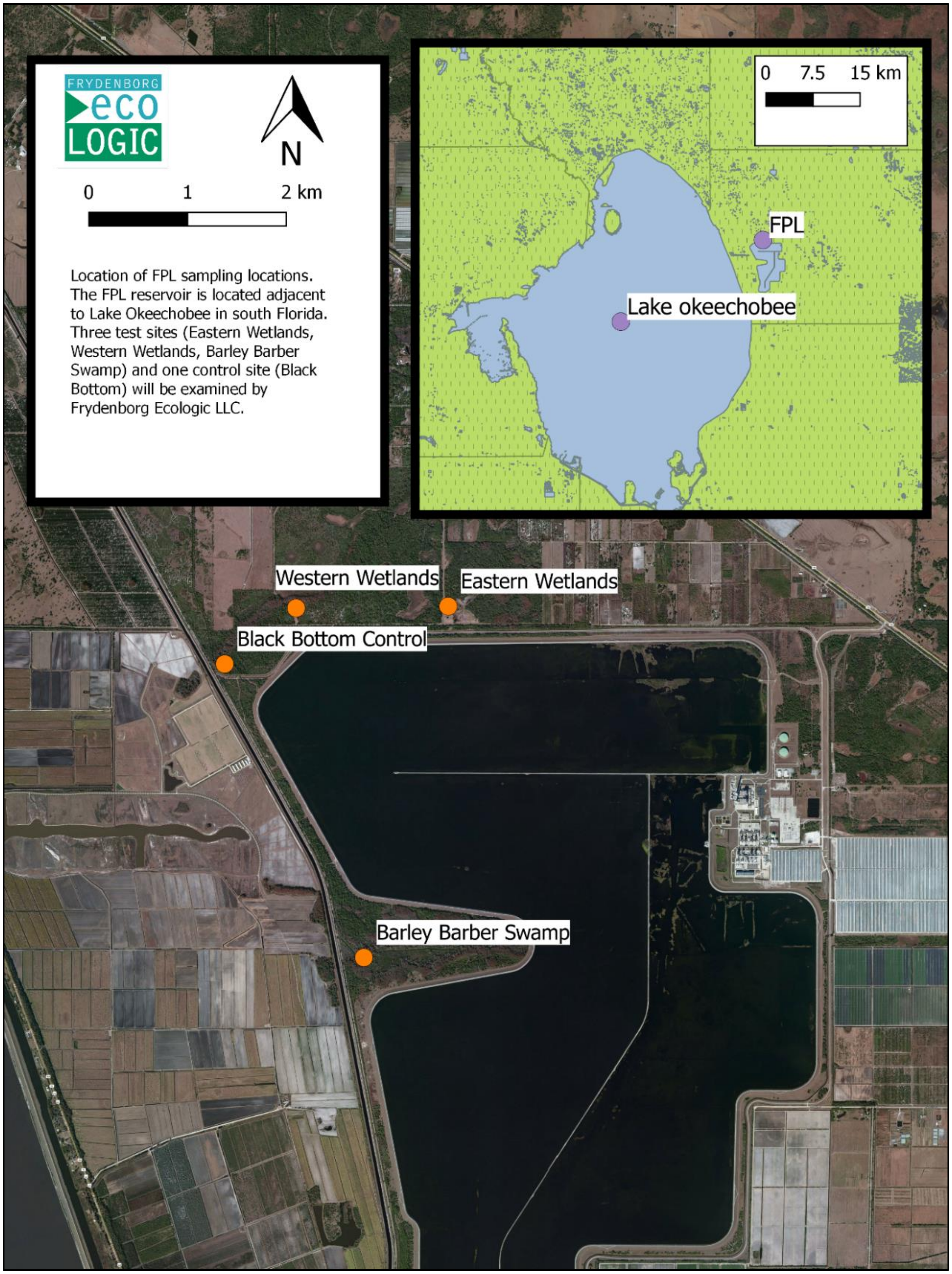


Figure 2-1. Overview of the FPL study area, including locations of mitigation wetlands, Barley Barber Swamp, and control stream.

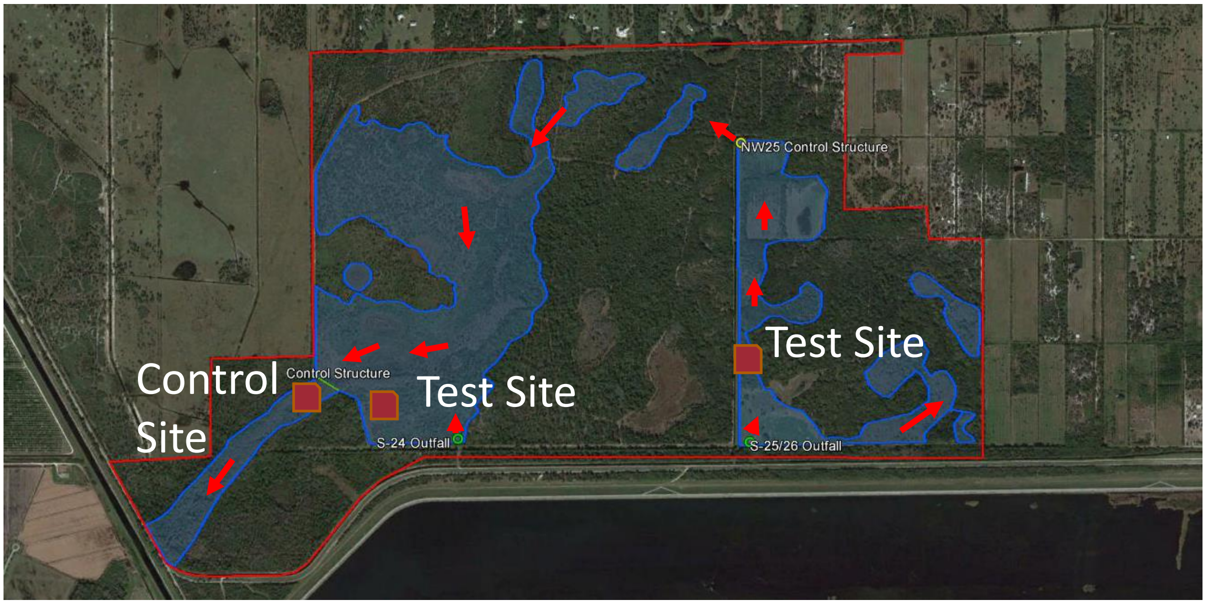


Figure 2-2. Northwest Mitigation Area, including Eastern and Western wetlands, showing intended elevation/ extent of wetland hydration and flow path (red arrows). Note locations of NWMA area Test Sites and Black Bottom Slough Control Site.

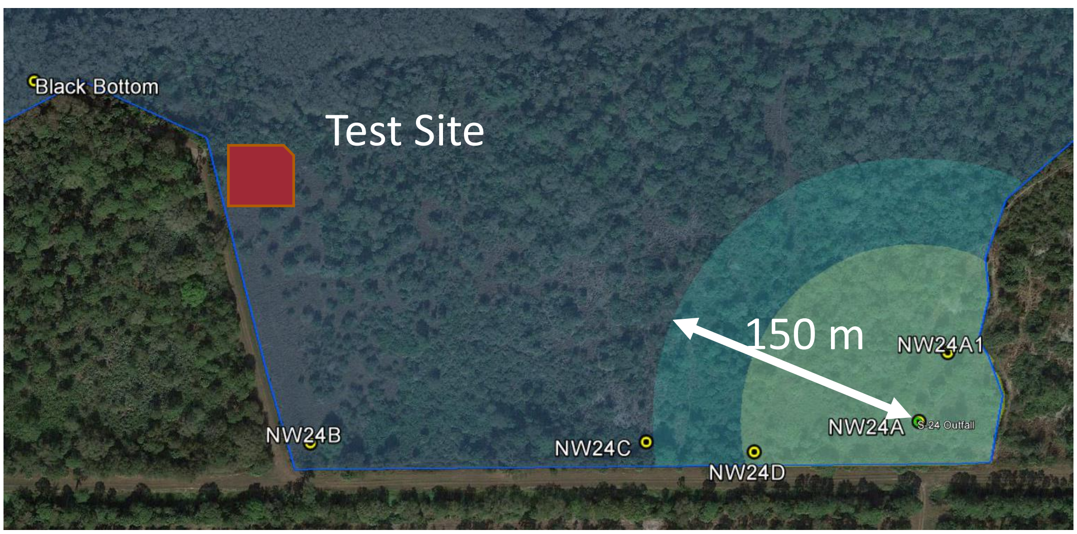


Figure 2-3. Northwest Mitigation West Wetland, showing Test Site in relation to 150 m radius from Sump 24. Since the intent of the study was to determine if unionid mussels were present in the wetlands based on factors other than the discharges, the test sites were established at areas sufficiently removed from the discharges (greater than 400 m) to ensure that previous discharges had not influenced potential mussel recruitment.

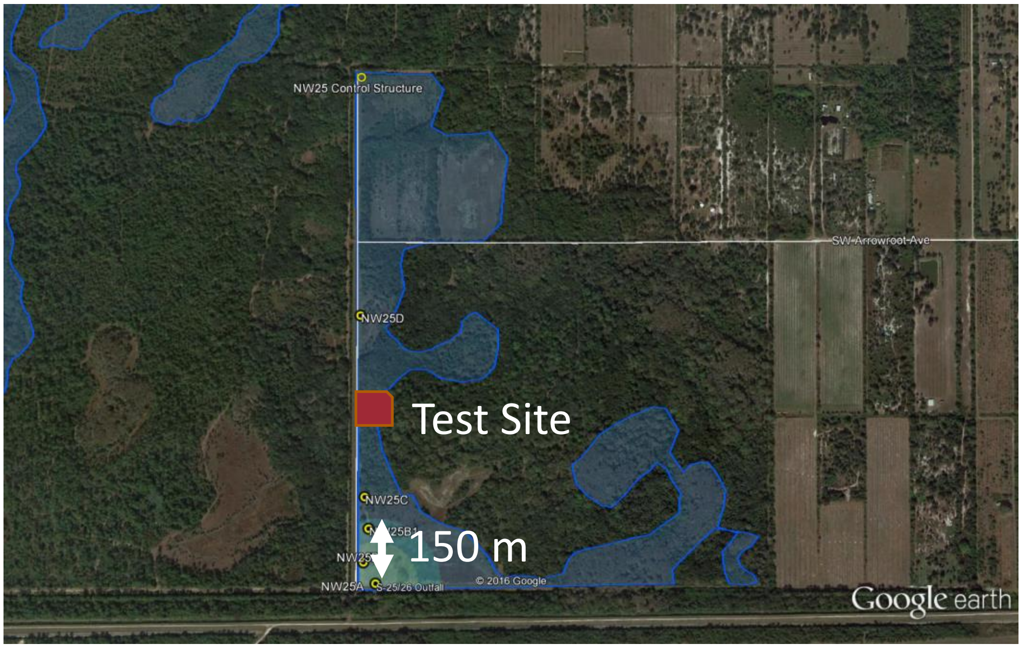


Figure 2-4. Northwest Mitigation East Wetland, showing Test Site in relation to 150 m radius from Sump 25/26. Since the intent of the study was to determine if unionid mussels were present in the wetlands based on factors other than the discharges, the test sites were established at areas sufficiently removed from the discharges (greater than 400 m) to ensure that previous discharges had not influenced potential mussel recruitment.

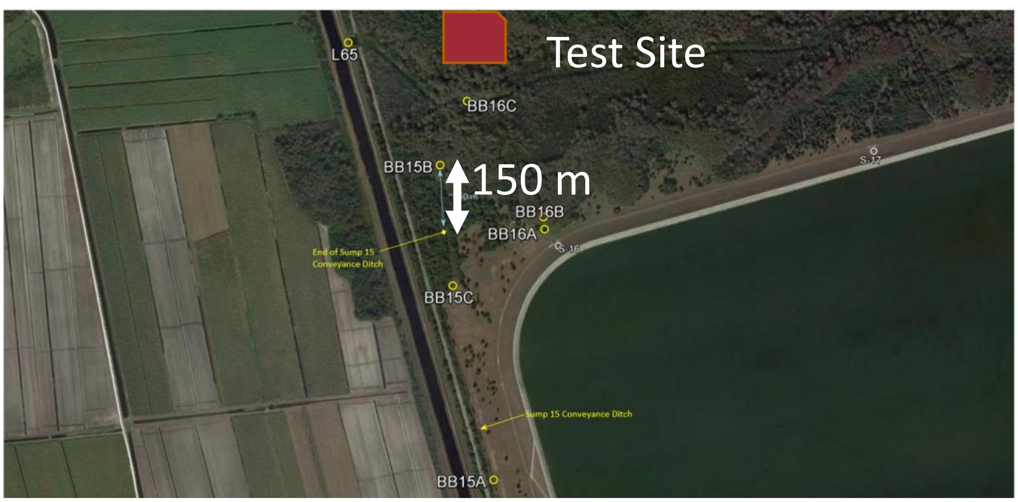


Figure 2-5. Barley Barber Swamp, showing Test Site in relation to 150 m radius from Sump 15 ditch discharge. Since the intent of the study was to determine if unionid mussels were present in the wetlands based on factors other than the discharges, the test sites were established at areas sufficiently removed from the discharges (greater than 400 m) to ensure that previous discharges had not influenced potential mussel recruitment.

2.1 Purpose of Study

There are six unionid species that may potentially be found in the vicinity of the Martin County study area (see below), however, previous invertebrate studies have found **NO unionid species** present in the test wetlands (EPA, 1991). Unionid taxa usually inhabit permanent waterbodies such as lakes, ponds, and creeks. The study area mitigation wetlands have been designed to go dry, generally for at least 3 months each year. This suggests that the frequent desiccation of the mitigation wetlands may prevent colonization and establishment of unionid taxa. Although one species, *Uniomerus carolinianus,* is known to be drought tolerant, it potentially could not tolerate such extended periods of desiccation. Additionally, benthic substrates required for success of these species include sand, mud, and detritus. This suggests that the extensive root systems associated with the study wetlands may interfere with colonization of these species. Additionally, because unionids require a fish host to reproduce, the frequent desiccated conditions, which preclude permanent fish presence, would also impact unionid success.

EPA conducted an Environmental Impact Study prior to approving the NPDES permit for the expansion of the Martin County plant (EPA, 1991). During the study, benthic invertebrate samples of the St. Lucie Canal, man-made ditches, and the mitigation wetlands yielded the presence of two non-unionid clams, including *Corbicula* sp. (a non-unionid exotic clam) and *Eupera* sp. (now known as *Musculium* sp., a non-unionid fingernail clam).

The information presented above provided evidence to suggest that unionids would potentially not be present in the test wetlands, yet could occur in perennial systems (*e.g.*, Black Bottom Slough) located downstream of the wetlands. Therefore, Frydenborg and Frydenborg (2017) designed a semi-quantitative wetland mussel survey of the area to determine if mussels are present at the 95% confidence limit. This Plan of Study was subsequently approved by both FDEP and EPA. As per the Mussel Plan of Study, if mussels were not present, the TAN Recalculation Procedure for Site-specific Criteria Derivation would be utilized to provide for a more accurate, yet protective TAN criterion for these wetlands.

3 Information on Mussel Species (Unionidae) Potentially Occurring in Martin County

Information on unionid species potentially occurring in Martin County, but not previously found in the actual study area, is found in **Table 3-1** (Williams et al., 2014). Photos of each species are shown in **Figure 3-1** through **Figure 3-6**. None of the mussel taxa potentially occurring in Martin County are listed as threatened or endangered.

Table 3-1. Species name, habitat, conservation status, and notes on unionid mussels that potentially occur in Martin County (from Williams et al., 2014)

Species	Habitat	Conservation Status	Notes
Anodonta couperiana	Streams, lakes, canals; sand, mud, organic substrates	Stable throughout range, not listed	Host generalists, susceptible to mite infestations
Elliptio jayensis	Creeks, rivers, marshes, ponds, lakes; mud, sand, gravel, rubble substrates	Stable throughout range, not listed	Most common mussel in Peninsula

Species	Habitat	Conservation Status	Notes
Toxolasma paulum	Creeks, rivers, lakes; sand, sandy mud substrates	Stable throughout range, not listed	Host presumed to be sunfish, susceptible to mite infestations
Uniomerus carolinanus	Creeks, rivers, ponds, marshes, spring runs, swamps, lakes; mud, sand substrates	Stable throughout range, not listed	Drought tolerant, only known subterranean mussel in Florida
Utterbackia imbecillis	Creeks, rivers, ponds, marshes, swamps, lakes; mud, sand substrates	Stable throughout range, not listed	Host generalists, introduced to south Florida from north Florida counties
Villosa amygdalum	Creeks, rivers, ponds, marshes, spring runs, lakes; mud, sand, detritus substrates	Stable throughout range, not listed	Hosts unknown, susceptible to mite infestations

Figure 3-1. *Anodonta couperiana (from* Williams et al., 2014)*.*

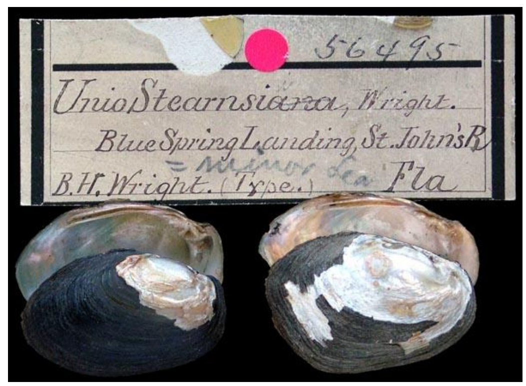


Figure 3-3. *Toxolasma paulum (from* Williams et al., 2014).

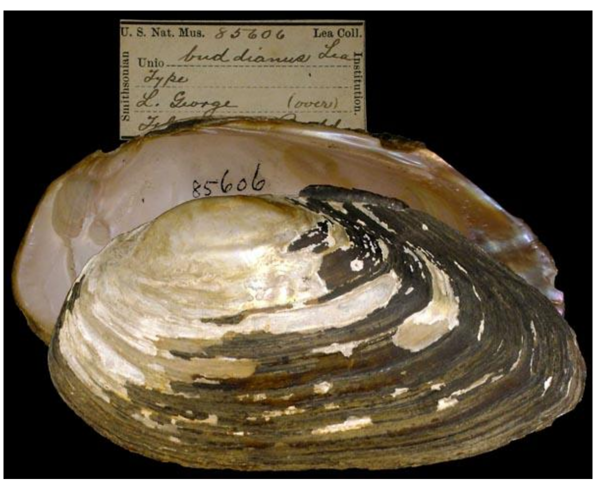


Figure 3-2. *Elliptio jayensis (from* Williams et al., 2014).

Figure 3-4. *Uniomerus carolinianus (from* Williams et al., 2014).

Figure 3-5. *Utterbackia imbecillis (from* **Williams et al., 2014).**

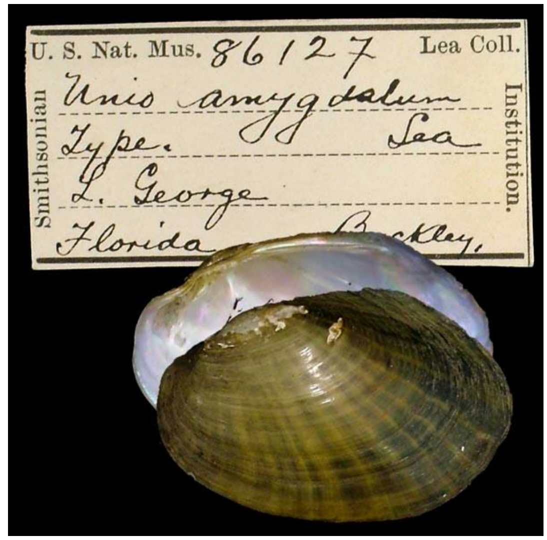


Figure 3-6. ***Villosa amygdalum (from*** **Williams et al., 2014)**.

4 SAMPLING DESIGN AND METHODS

A literature search, which included academic, EPA, and US Fish and Wildlife recommended survey techniques, found that there are existing mussel survey methods developed for lakes and rivers, but not for wetlands (Carlson et al., 2008, USEPA, 2013). These methods were summarized in (Frydenborg and Frydenborg, 2017), and the Plan of Study was subsequently approved by both FDEP and EPA..

Frydenborg and Frydenborg (2017) selected a Modified FDEP Wetland Condition Index technique to provide a **systematic, semi-quantitative** framework for surveying mussels potentially present in the FPL wetlands (FDEP, 2014). Three test areas were sampled, including two in the mitigation wetlands (NW Mitigation East and NW Mitigation West) and one in the Barley Barber Swamp. Since the intent of the study was to determine if unionid mussels were present in the wetlands based on factors other than the discharges, the test sites were established at areas sufficiently removed from the discharges (greater than 400 m) to ensure that previous discharges had not influenced potential mussel recruitment. A nearby perennial stream (Black Bottom Slough) was sampled as a control site to help determine that the technique can locate mussels where habitat conditions are appropriate (permanent waterbodies with proper substrate and fish hosts).

At each site, three fifty meter transects were surveyed for the presence of unionid mussels, conducted by Beck Frydenborg and Russel Frydenborg. Each transect involved the careful inspection of an area two meters wide by 50 meters in length, for a total of 100 m^2 being examined for each transect, or 300 m^2 for each site. With four sites being sampled, the study involved inspecting, in detail, approximately 1,200 m^2 of area for the presence of unionids (after demonstrating the method to be effective, one control transect inspection was not conducted).

Where appropriate, data were recorded for each two by five-meter area associated with a transect (zero to 5 m, 5 to 10 m, 10 to 15 m, *etc*.) (see **Appendix** for data sheet). Transects were spaced > 10 meters apart from each other. Along each transect, mussels were searched for visually, tactilely with gloved hands, and by digging into the substrate with a sampling shovel. The single live mussel found at the control site was gently handled, photographed, its presence along the transect location was recorded, and then it was returned to similar a habitat just beyond the transect location. None of the potential mussels present were listed species. **If live mussels or mussel shells had been observed in the wetlands, but in areas outside of the transects, they would have been recorded. However, no mussels were observed in the test wetlands either inside or outside the transects.**

4.1.1 Transect Placement and Mussel Habitat

Transect placement was guided by balancing the selection of habitats that were representative of the wetlands while attempting to bias the exact location of each transect towards the most suitable mussel habitat, if available. Suitable habitat for mussels was defined as damp or wet areas with sand/mud/detritus, free from thick vegetation and roots that would prevent mussels from burrowing into the sediment or detritus. The transects, where possible, were situated where vegetation was less dense in deeper areas that could have improved soil moisture or a longer hydroperiod. The concept was to search for the mussels where there was the best chance they would be found.

For example, the NWMA marshes were characterized by thick, rooted, emergent vegetation (e.g., *Andropogon, Panicum*, etc.), with very few areas of substrate (sand, mud, detritus) conducive to unionid recruitment and development. While conducting the first transect at NWMA East, it was noted that the transect bisected a slightly lower elevation, slough-like area, with an organic substrate. The area had recently become desiccated, and dead *Pomacea paludosa* (apple snail) shells were observed in the slough-like area. The subsequent transects in NWMA East were conducted in this slough-like area because conditions there were more likely to support Unionids. NWMA West was also covered with emergent vegetation (e.g., *Sagitteria*, *Panicum*, *Cladium*). There were limited areas with root-free organic substrate, however, the NWMA West transects were located so that some those areas would be sampled. The Barley Barber Swamp vegetation was dominated by *Taxodium distichum*, *Woodwardia virginiana*, and *Acrostichum danaeifolium*, but with a paucity of non-vegetated sand or detritus habitat. However, several small organic substrate areas with minimal macrophyte roots were included in the transects. Finally, Black Bottom Slough was sampled where conditions (flow, substrate, presence of fish hosts) were most likely to host mussels, and not in the nearby floodplain, which did not have flow and was covered in a dense layer of decaying organic matter. An example transect scheme is illustrated in **Figure 4-1**.

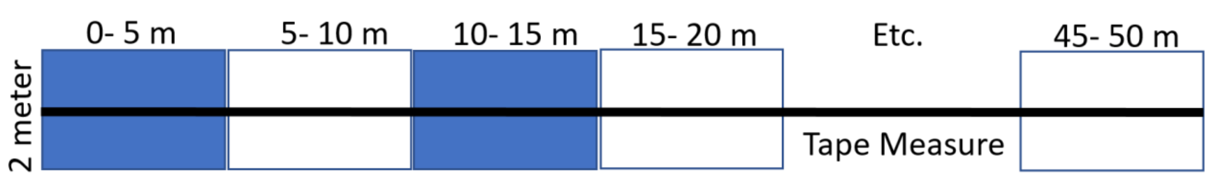


Figure 4-1. Schematic diagram of modified Wetland Condition Index transects for wetland unionid survey.

The search area was calculated following the guidance in Smith (2006). The probability of detecting at least one individual was set at 0.95, the search efficiency at 0.2, and the mussel density at 0.05 individuals per meter squared. The search efficiency (β) was set low to be conservative given the lack of previous studies that have quantified search efficiency by using excavation for this system. As the potential mussel species are common and regularly observed to exist at high densities given appropriate conditions, a density (µ) of approximately one individual per 20 square meters was assumed to be appropriately conservative. **Equation 2** was used to calculate the search area (*a*) given the previously stated assumptions for search efficiency and mussel density:

Equation 2. Probability of detecting at least one mussel.

$$P(detecting\ at\ least\ one\ individual) = 1 - e^{-\beta a \mu}$$

Based on the previously stated inputs, a search area of 299.6 square meters was determined to be required to detect at least one individual with a 95% probability.

4.2 Transect Locations and Photos

The geo-spatial information (transect locations) for the study is found in **Table 4-1**, and photos of the transects are found in **Figure 4-2** through **Figure 4-15**.

Table 4-1. Geospatial information for mussel survey transects.

Treatment	Site	Transect	Start Lat	Start Long	End Lat	End Long
Test	NW Mitigation East	A	27.07611111	-80.59527778	27.0761111	-80.595
Test	NW Mitigation East	B	27.07611111	-80.595	27.0763889	-80.5952778
Test	NW Mitigation East	C	27.07694444	-80.59527778	27.0772222	-80.5955556
Test	NW Mitigation West	A	27.07527778	-80.61055556	27.0752778	-80.6105556
Test	NW Mitigation West	B	27.07527778	-80.61055556	27.0752778	-80.6105556
Test	NW Mitigation West	C	27.07555556	-80.61083333	27.0758889	-80.6103611
Test	Barley Barber Swamp	A	27.0456944	-80.6044444	27.0333333	-80.6046389
Test	Barley Barber Swamp	B	27.04583333	-80.60444444	27.0461111	-80.6046667
Test	Barley Barber Swamp	C	27.04611111	-80.60461111	27.0455556	-80.6042222
Control	Black Bottom Slough	A	27.07694444	-80.61222222	27.0766667	-80.6122222
Control	Black Bottom Slough	B	27.07666667	-80.61194444	27.0763889	-80.6122222
Control	Black Bottom Slough	C	Transect not sampled			

Figure 4-2. NW Mitigation Area Eastern Wetland, transect A. Soils consist of the Pineda-Riviera-Boca series, which are level and poorly drained soils of sloughs or freshwater marshes (USDA, 1978).

Figure 4-3. NW Mitigation Area Eastern Wetland, transect A, close up of routine shovel sediment sample for inspection. Soils consist of the Pineda-Riviera-Boca series, which are level and poorly drained soils of sloughs or freshwater marshes (USDA, 1978).

Figure 4-4. NW Mitigation Area Eastern Wetland, transect B. Soils consist of the Pineda-Riviera-Boca series, which are level and poorly drained soils of sloughs or freshwater marshes (USDA, 1978).

Figure 4-5. NW Mitigation Area Eastern Wetland, transect C, a lower drainage that leads to Woodstork habitat. Soils consist of the Pineda-Riviera-Boca series, which are level and poorly drained soils of sloughs or freshwater marshes (USDA, 1978).

Figure 4-6. NW Mitigation Area Western Wetland, transect A. Soils consist of the Pineda-Riviera-Boca series, which are level and poorly drained soils of sloughs or freshwater marshes (USDA, 1978).

Figure 4-7. NW Mitigation Area Western Wetland, transect B, close up of routine shovel sediment sample for inspection. Soils consist of the Pineda-Riviera-Boca series, which are level and poorly drained soils of sloughs or freshwater marshes (USDA, 1978).

Figure 4-8. NW Mitigation Area Western Wetland, transect C. Soils consist of the Pineda-Riviera-Boca series, which are level and poorly drained soils of sloughs or freshwater marshes (USDA, 1978).

Figure 4-9. Barley Barber Swamp, transect A. Soils consist of the Floridana-Jupiter-Hilolo series, which are level, poorly drained or very poorly drained soils of sloughs or freshwater marshes (USDA, 1978).

Figure 4-10. Barley Barber Swamp, transect B. Soils consist of the Floridana-Jupiter-Hilolo series, which are level, poorly drained or very poorly drained soils of sloughs or freshwater marshes (USDA, 1978).

Figure 4-11. Barley Barber Swamp, transect C. Soils consist of the Floridana-Jupiter-Hilolo series, which are level, poorly drained or very poorly drained soils of sloughs or freshwater marshes (USDA, 1978).

Figure 4-12. Black Bottom Slough (control), transect A. Soils consist of the Pineda-Riviera-Boca series, which are level and poorly drained soils of sloughs or freshwater marshes (USDA, 1978).

Figure 4-13. Black Bottom slough (control), transect B, near V-notch weir.

Figure 4-14. Black Bottom Slough (control), transect B. Soils consist of the Pineda-Riviera-Boca series, which are level and poorly drained soils of sloughs or freshwater marshes (USDA, 1978).

Figure 4-15. Black Bottom Slough (control), transect B.

5 MUSSEL SURVEY RESULTS

Results from the mussel survey, which was conducted on January 10 and 11, 2018, are found in **Table 5-1.**

Table 5-1. Results from the mussel survey conducted on January 10 and 11, 2018.

Treatment	Site	Transect	Number Live/ Unweathered/or Weathered Unionids	Notes
Test	NW Mitigation East	A	0	
Test	NW Mitigation East	B	0	Observed dead Planorbella, Pomacea, Oronectes/Cambarus
Test	NW Mitigation East	C	0	Observed dead Planorbella, Pomacea
Test	NW Mitigation West	A	0	
Test	NW Mitigation West	B	0	
Test	NW Mitigation West	C	0	
Test	Barley Barber Swamp	A	0	
Test	Barley Barber Swamp	B	0	
Test	Barley Barber Swamp	C	0	
Control	Black Bottom Slough	A	1	Single unweathered Elliptio jayensis
Control	Black Bottom Slough	B	22	Elliptio jayensis: 1 live, 20 unweathered; Utterbackia imbecillis: 1 unweathered
Control	Black Bottom Slough	C	NA	Transect Not Conducted, method appeared effective where habitat conditions were appropriate

Because no live, un-weathered, or weathered mussels were observed at any test site (either within or outside of the transects), the method indicated, with 95% confidence, that mussels do not occur in the test wetlands. This was not unexpected, as conditions in the wetlands, which include periodic desiccation, absence of host fish, and unsuitable substrate (thick fibrous root mats associated with emergent vegetation), were not conducive to mussel recruitment and propagation. Note that 22 unweathered mussel shells and one live mussel were found in Black Bottom slough (the control site), demonstrating that the method appeared to be effective at capturing unionids in areas where habitat conditions were more conducive to mussel recruitment and propagation.

6 TAN RECALCULATION WITH MUSSELS AND SALMONIDS ABSENT

EPA (2013) provided a recommended alternative TAN criteria recalculation procedure that may be used when it can be demonstrated that mussels (Unionidae) and salmonid fish (*Oncorhynchus spp*., which do not occur in Florida) are absent from a waterbody on a site-specific basis. This section provides a brief summary of the process EPA used when they developed the alternative TAN criteria recalculation procedure (EPA, 2013).

6.1 TAN RECALCULATION PROCEDURE FOR SITE-SPECIFIC CRITERIA DERIVATION

The water quality standards (WQS) regulation at 40 CFR § 131.11(b)(1)(ii) provides states with the opportunity to adopt water quality criteria that are "…modified to reflect site specific conditions." As with any criteria, site-specific criteria must be based on a sound scientific rationale in order to protect the designated use and are subject to review and approval or disapproval by EPA (EPA, 2013). The recalculation procedure for site-specific criteria derivation is intended to allow site-specific criteria that differ from national criteria recommendations (*i.e.,* concentrations that are higher or lower than national recommendations) where there are demonstrated differences in sensitivity between the aquatic species that occur at the site and those that were used to derive the national criteria recommendations (EPA, 2013). The national dataset may contain aquatic species that are sensitive to a particular pollutant, but these or comparably sensitive species might not occur at the site (*e.g*., freshwater mussels are included in the national ammonia dataset but may not be present at a particular site) (USEPA, 2013). In the case of ammonia, where a state demonstrates that mussels are not present on a site specific basis, the recalculation procedure may be used to remove the mussel species from the national criteria dataset to better represent the species present at the site (USEPA, 2013). For example, many of the commonly occurring freshwater bivalves (*e.g*., pea clam) are more closely related to the non-unionid fingernail clam, *Musculium* (which is the fourth most sensitive genus in the national dataset for the chronic criterion) than to the unionid mussels *Lampsilis* and *Villosa* (which are the two most sensitive genera in the national dataset for the chronic criterion) (EPA, 2013).

6.2 EPA Chronic Criterion Magnitude Recalculation for Ammonia when Unionid Mussels are Absent and Early Life Stage Fish Protection Is Necessary

Although Unionidae were absent in the test wetlands, it is possible that fish from more permanent waterbodies may swim into the wetlands during periods when water is present. When unionid mussels are absent and Early Life Stages (ELS) of fish require protection, EPA calculated the **Chronic Criterion Magnitude (CCC)** to be 6.508 mg TAN/L at pH 7 and 20° C (USEPA, 2013). EPA found that the lowest Genus Mean Chronic Value (GMCV) was 6.920 mg TAN/L for the temperature invariant vertebrate genus *Lepomis,* and the most sensitive invertebrate GMCV was 7.547 mg TAN/L for *Musculium* (fingernail clam) (USEPA, 2013). The ratio of the CCC to the most sensitive GMCV (*Lepomis* sp.) when unionid mussels are absent is 0.9405, or 6.508 mg TAN/L divided by 6.920 mg TAN/L (USEPA, 2013). At pH 7 and 20°C, the CCC when mussels are absent and ELS protection is required is expressed as follows:

$$CCC = 0.9405 \text{ x MIN}(6.920, (7.547 \text{ x } 100.028\text{x}^{(20-T))})$$

EPA found that this function remained constant at a CCC equal to 6.508 mg TAN/L at 0-21.3° C because the most sensitive GMCV was for the temperature invariant genera *Lepomis* (USEPA, 2013). At temperatures greater than 21.3° C, the GMCV for the invertebrate *Musculium* (*i.e*., 7.547 mg TAN/L) became the most sensitive, and the CCC decreases with increasing temperature (USEPA, 2013).

The EPA CCC formula, applicable to all pH values, for the condition where mussels are absent and ELS fish protection is necessary is:

$$CCC = 0.9405 \times \left(\frac{0.0278}{1 + 10^{7.688-pH}} + \frac{1.1994}{1 + 10^{pH-7.688}}\right) \times MIN\left(6.920, \left(7.547 \times 10^{0.028\times(20-T)}\right)\right)$$

The CCC for a variety of conditions is found in **Table 6-1**, Examples of the recalculated proposed CCC at near worst-case temperatures, between pH values from 7 to 8 SU, is in **Table 6-2**.

Table 6-1. Chronic TAN Criterion (CCC) recalculations for Site-Specific Criteria (EPA, 2013). The equation and this output represents the basis behind the requested SSAC.

Chronic Criterion Duration (30-day average) at pH 7 and 20°C (mg TAN/L)	**Chronic Criterion Magnitude (CCC) Fish ELS Present**	**Chronic Criterion Magnitude (CCC) Fish ELS Absent**
Mussels Present	1.9	1.9
Mussels Absent	**6.5***	7.1
No single value shall exceed 2.5 times the CCC.		
Frequency: Criteria values not to be exceeded.		

*Proposed SSAC.

Table 6-2. Examples of near worst-case temperature and pH-Dependent Values of the CCC (Chronic Criterion Magnitude) when Unionidae and salmonid fish are absent but ELS fish present at a temperature of 30° C between pH of 7 and 8 SU (EPA, 2013).

pH (SU) at temperature of 30° C	CCC TAN Criteria (mg/L)
7.0	3.7
7.1	3.6
7.2	3.4
7.3	3.2
7.4	3.0
7.5	2.8
7.6	2.5
7.7	2.3
7.8	2.0
7.9	1.8
8.0	1.5

7 DOWNSTREAM WATERS PROTECTION

Water quality data were collected during a time period when discharge from Sumps 25/26 and 24 was permitted by FDEP Secretarial Order (to assist in mitigation of a 2016 St. Lucie Harmful Algal Bloom). Complete data are provided in the Appendix.

Total Ammonia Nitrogen (TAN) and metered parameters were measured on July 14/15, August 3, August 17, August 30, September 14, 2016. Decay of TAN with distance from the sump discharge is shown in **Figure 7-1** through **Figure 7-3**.

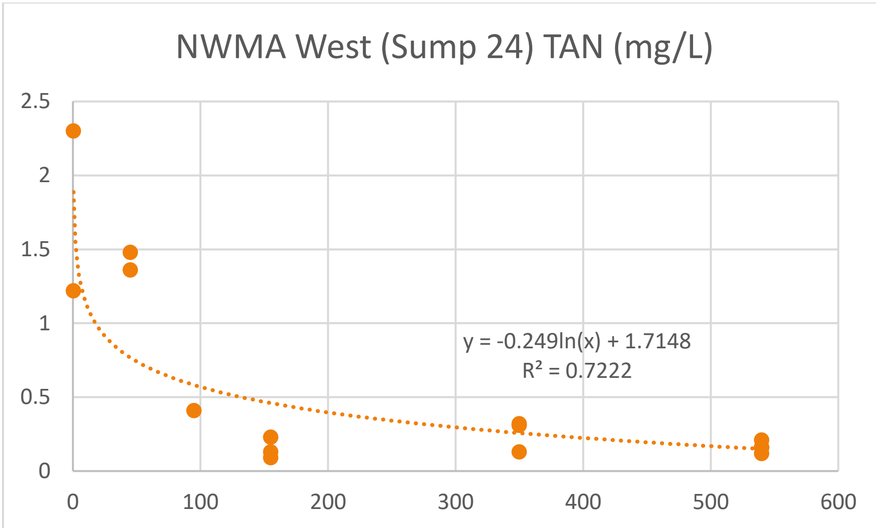


Figure 7-1. Decay of TAN in NWMA West (Sump 24) with distance from Sump 24. During 5 sampling events, TAN was exceeded only at the sump and at the site located 45 m from the sump.

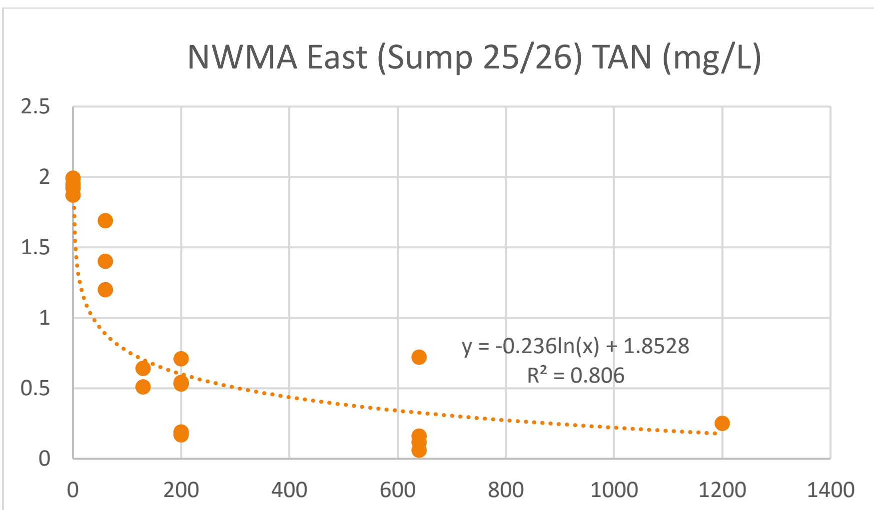


Figure 7-2. Decay of TAN in NWMA East (Sump 25/26) with distance from Sump 25/26. During 5 sampling events, TAN was exceeded only at the sump and at the site located 60 m from the sump.

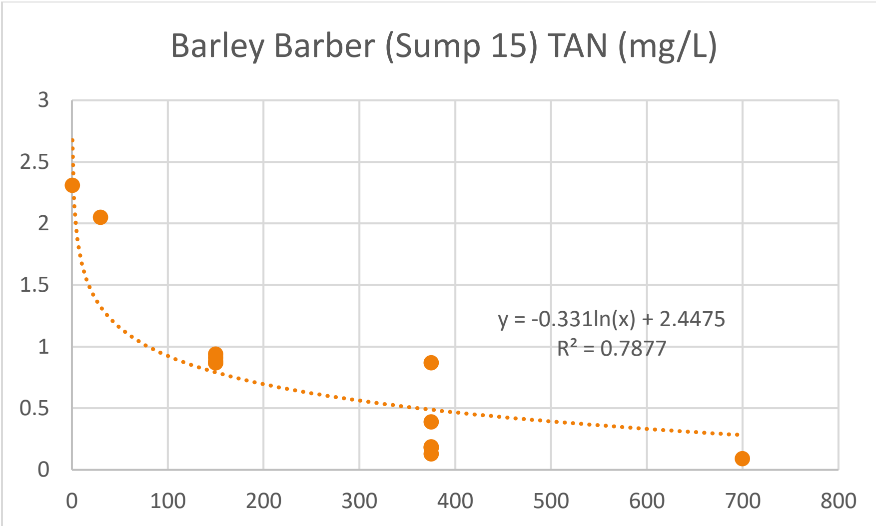


Figure 7-3. Decay of TAN in Barley Barber (Sump 15) with distance. Note that water from Sump 15 travels approximately 150 m via a ditch before reaching the swamp. During 5 sampling events, TAN was exceeded at the discharge point and at the site located 30 m from the discharge, and on one out of five samples at the 150 m point.

These data indicate that FDEP's recently adopted Total Ammonia Nitrogen (TAN) criteria were exceeded immediately adjacent to the sump discharges, but complied with the statewide TAN criterion within approximately 100-150 m from the sump discharges. These observations are consistent with other studies, which noted that TAN is rapidly assimilated in wetlands via nitrification, denitrification, vascular plant uptake, and volatilization (California State University, 2009). Data from Georgia indicated that ammonia removal efficiencies in wetlands ranged from 58% to 92% (California State University, 2009). Therefore, these data indicate that downstream waters where suitable mussel habitat exists, such as Black Bottom Sough, will be fully protected.

8 Spatial Extent of the TAN SSAC

The SSAC is proposed to include the entire NW Mitigation Area and the Barley Barber Swamp (**Figure 8-1**). This information is available in an ArcGIS Shapefile titled "area_for_new_TAN_criteria", which was provided to FDEP.

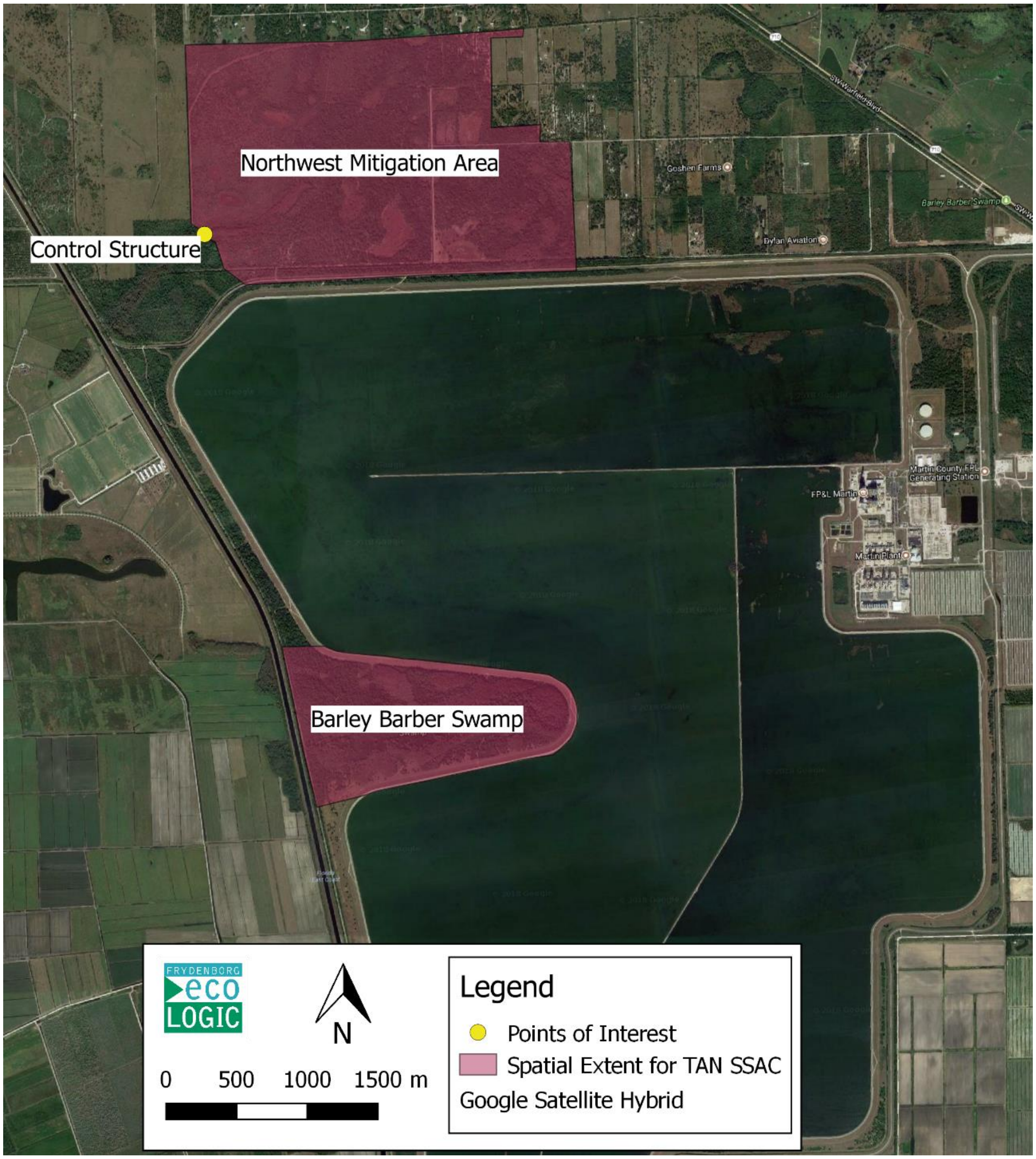


Figure 8-1. Extent of the requested TAN SSAC for the Northwest Mitigation Area and Barley Barber Swamp.

9 CONCLUSIONS

An FDEP and EPA-approved Plan of Study to assess the presence or absence of Unionid mussels, at the 95% confidence limit, found that no mussels were present in the FPL test wetlands. Therefore, the EPA pre-approved TAN recalculation (for the CCC) is a scientifically defensible and protective site-specific TAN criterion for the wetlands.

The EPA CCC formula for the condition where mussels are absent and ELS fish protection is required is:

$$CCC = 0.9405 \times \left(\frac{0.0278}{1 + 10^{7.688-pH}} + \frac{1.1994}{1 + 10^{pH-7.688}}\right) \times MIN\left(6.920, \left(7.547 \times 10^{0.028\times(20-T)}\right)\right)$$

The 30-day average TAN value shall not exceed the average of the values calculated from the above equation, with no single value exceeding 2.5 times the value from the equation. For purposes of TAN criterion calculations, pH is subject to the range of 6.5 to 9.0. The pH shall be set at 6.5 if measured pH is < 6.5 and set at 9.0 if the measured pH is > 9.0.

Additional information regarding Type II SSACs is presented in the **Appendix**.

10 LITERATURE CITED

California State University (2009). Ammonia Removal in Wetlands : a Literature Review.

Carlson, S., Lawrence, A., Blalock-Herod, H., McCafferty, K., and Abbott, S. (2008). FRESHWATER MUSSEL SURVEY PROTOCOL FOR THE SOUTHEASTERN ATLANTIC SLOPE AND NORTHEASTERN GULF DRAINAGES IN FLORIDA AND GEORGI.

EPA (1991). Final Environmental Impact Statement on the Proposed Issuance of a New Source National Pollutant Discharge Elimination System Permit for the Martin Coal Gasification/Combined Cycle Project Florida Power & Light Company.

EPA (2013). Aquatic life ambient water quality criteria for ammonia- freshwater.

FDEP (2014). Standard Operating Procedures incorporated by reference in Rule 62-106, F.A.C. Florida Dept. Environmental Protection.

Frydenborg, B.R., and Frydenborg, R.B. (2017). Plan of Study: A Mussel (Unionidae) Survey in Selected Martin County Wetlands.

Smith, D.R. (2006). Survey designs for detecting rare freshwater mussels. JNABS *25*, 701–711.

USDA (1978). Soil survey of Martin County, Florida.

USEPA (2013). Technical Support Document for Conducting and Reviewing Freshwater Mussel Occurrence Surveys for the Development of Site-specific Water Quality Criteria for Ammonia.

Williams, J.D., Butler, R.S., Warren, G.L., and Johnson, N.A. (2014). Freshwater mussels of Florida. (University of Alabama Press).

11 APPENDIX

11.1 SAMPLING DATA SHEET

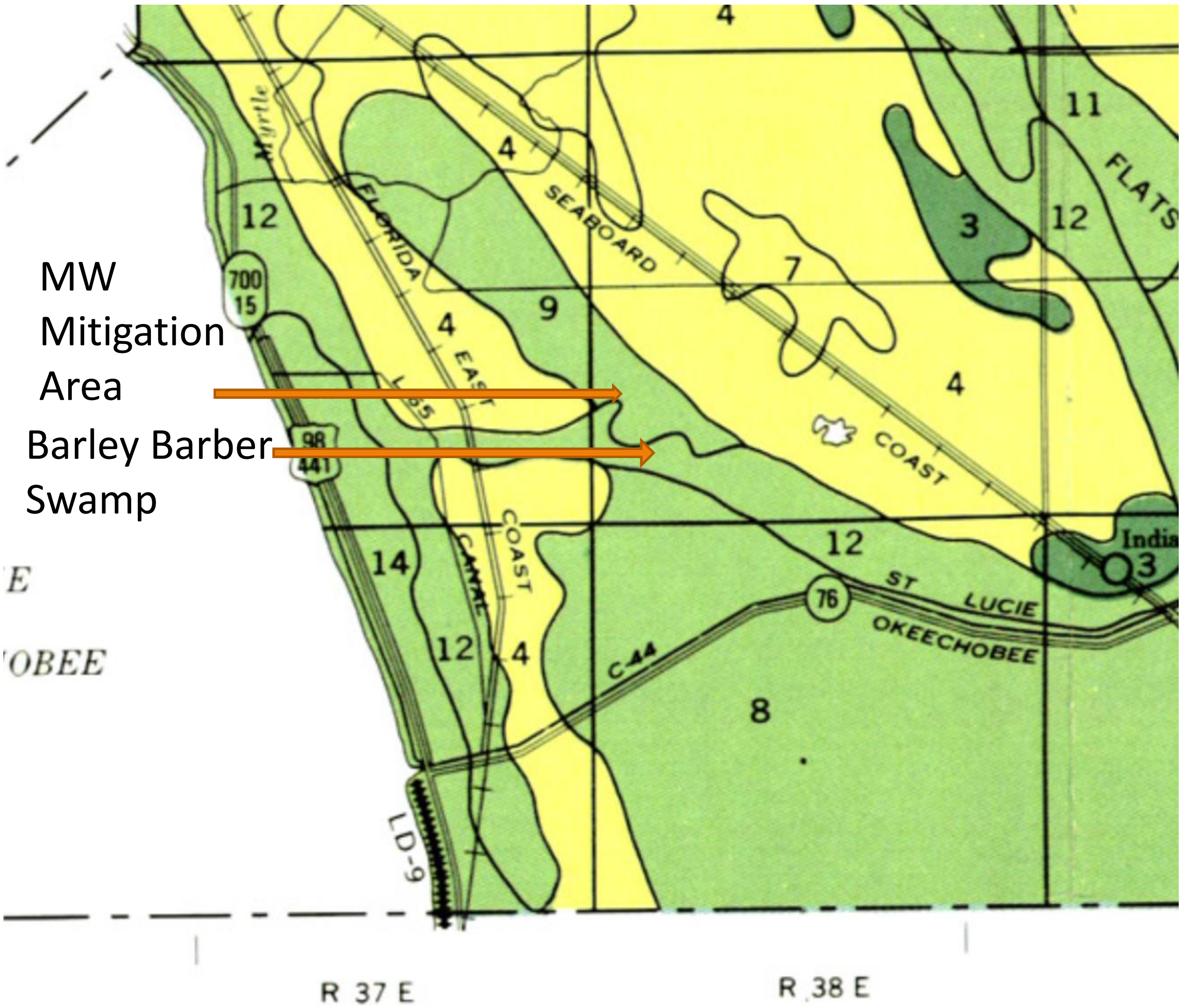
FRYDENBORG ECOLOGIC WETLAND MUSSEL SURVEY FIELD SHEET

Waterbody:	Date:	County:	Storet Number:
Analyst:		Signature:	
Station and Transect Number			

Instructions: Indicate count of live, un-weathered, or weathered shells and ID

UNIONID SPECIES	Meter Mark 0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	Specimen collected (check)
Anodonta couperiana											
Live											
Un-weatherd shells											
Weathered shells											
Elliptio jayensis											
Live											
Un-weatherd shells											
Weathered shells											
Toxolasma paulum											
Live											
Un-weatherd shells											
Weathered shells											
Uniomerus carolinanus											
Live											
Un-weatherd shells											
Weathered shells											
Utterbackia imbecillis											
Live											
Un-weatherd shells											
Weathered shells											
Villosa amygdalum											
Live											
Un-weatherd shells											
Weathered shells											

11.2 Excerpts from USDA Soil map of Martin County showing relative locations of study sites



11.3 EPA Checklist of Key Elements in a Mussel Survey Protocol to Assure Suitability

This EPA checklist provides a list of key elements that were considered when selecting or reviewing a suitable protocol for determining whether mussels are present or absent at a particular site. Responses for each item were provided as part of the approval process by FDEP and EPA.

11.3.1 Preliminary Information

- The surveyor/contractor is qualified to survey the geographic area, waterbody type, and potential mussel fauna of the region (i.e., The surveyor/contractor has been pre-approved to conduct mussel surveys in the region/state and has provided adequate credentials/certifications including number of hours worked or trained, etc.).

- **Response: Russel Frydenborg, President of Frydenborg EcoLogic, has 39 years of experience in conducting ecological surveys in Florida and identification of Florida benthic macroinvertebrates, including mussels. He and Senior Scientist, Beck Frydenborg, are certified to conduct the Stream Condition Index, a freshwater invertebrate sampling and interpretation framework that Russ Frydenborg helped develop and implement. Russel Frydenborg, with Beck Frydenborg providing Quality Control for invertebrate sorting, recently passed a periodic field audit to demonstrate proficiency with the BioRecon procedure, which involves field identification of a variety of freshwater invertebrates, including bivalves, when present.**
- The objective of the study is clearly stated.
- **Response: The following was the study objective for this wetlands mussel survey: To determine whether freshwater Unionid mussels are present or absent at these wetland sites at the 95% confidence interval.**
- The definitions of presence and absence are clearly defined.
- **Response. Absence of unionid mussels consists of a 5% or less probability that they occur in the study wetlands (live individuals or un-weathered shells) as determined through the equation provided above.**
- The waterbody or watershed/region of interest was investigated to determine if any occurrence data (via historical records, other survey data, etc.) indicate mussels are/were present.
- **Response: This information was provided in Chapter 3. Mussels have not been found in these wetlands.**
- The surveyor/contractor has all appropriate state and federal permits (e.g., in the case of a rare species being found).
- **Response: There are no threatened or endangered species living in Martin County that could potentially be adversely affected by the study, and therefore, no permits required.**
- A thorough study plan has been developed with proper quality assurance/quality control elements and a safety plan.
- **Response: The Plan of Study (Frydenborg and Frydenborg, 2017) satisfies this requirement. Frydenborg Ecologic Quality Assurance and Safety Plans are on file.**
- The study plan has been prepared in cooperation with, reviewed by, or approved by an individual with demonstrated expertise in conducting mussel studies as well as a state natural resources or federal U.S. Fish and Wildlife Service official.
- **Response: Frydenborg EcoLogic consulted with the FDEP Water Quality Standards Program to ensure the quality of the proposed study.**

11.3.2 Study Design

- The study area is thoroughly delineated (i.e., a map has been created showing all aspects of relevance within the area of interest such as study boundaries, vertical and horizontal instream demarcations, quadrats/cells to be sampled, etc.).
- **Response: Site maps showing the test and control sites in relation to the discharges were provided. Since the intent of the study was to determine if unionid mussels are present in the wetlands based on factors other than the discharges, the proposed test sites were established at areas sufficiently removed from the discharges (400 m) to ensure that elevated TAN did not influenced potential mussel recruitment.**

- The study area is thoroughly described (e.g., coordinates of location, qualitative and quantitative instream features, water quality, channel stability, impoundments, riparian features, road crossings, and other unique natural and anthropogenic features) in relation to the stream/segment that would be subject to any resulting site-specific criterion.
- **Response: The site-specific TAN criterion is requested to apply to the specified wetlands.**
- If the study area does not encompass the entire site for which site-specific criteria are to be developed, the study plan explains how the results of the survey can be extrapolated to the entire site.
- **Response: The study areas were representative of the wetlands involved, with effort taken to bias sampling at areas more likely to contain mussels.**
- The survey method is thoroughly described and appropriate for the waterbody and potential mussel fauna present, and relevant research studies are cited to support the sampling approach, design, and method.
- **Response: There are no published mussel survey methods that are relevant for periodically desiccated wetlands. After reading the EPA survey requirements, Frydenborg EcoLogic adapted FDEP Wetland Condition Index methods to develop an approach that is semi-quantitative and repeatable by other investigators.**
- The method includes more than one surveyor, and surveyor names are provided with an indication of the level of training or experience of each surveyor.
- **Response: Russel Frydenborg and Beck Frydenborg will conduct the survey. Both are certified to conduct the Stream Condition Index, a freshwater invertebrate sampling and interpretation framework that Russ Frydenborg helped develop and implement. Russel Frydenborg, with Beck Frydenborg providing Quality Control for invertebrate sorting, recently passed a periodic field audit to demonstrate proficiency with the BioRecon procedure, which involves field identification of a variety of freshwater invertebrates, including bivalves, when present.**
- The proposed sampling date(s) fall within the recommended time frame for the region and mussel fauna potentially present (e.g., April to October or other time frame based on current research information).
- **Response: The survey occurred on January 10 and 11, 2018, after a five month period of hydrated conditions from late summer rains.**

11.3.3 Reporting

- A final report has been prepared containing author contact information, study objective(s), and a thorough description of protocol, survey results/findings, and conclusions.
- **Response: This information is provided in this report. www.frecologic.com**
- All forms/field data sheets have been provided. A provision for continued monitoring of the site/stream segment is included in the study plan if results indicate that mussels are absent. The provision stipulates the return frequency and protocol and provides a scientific justification.
- **Response: All forms/field data sheets have been provided to FDEP. Upon FDEP's request, mussel surveys of the wetlands could occur every 5 years..**
- A provision for documentation with appropriate authorities and archives (e.g., U.S. Fish and Wildlife Service, state natural heritage programs, academic institutions) is included in the study plan if results indicate that mussels are present.
- **Response: This information is provided in this report.**

11.4 Type II SSAC Requirements

The following contains excerpts from Chapter 62-302.800 with responses to assist regulatory authorities.

A description of the physical nature of the specified waterbody and the water pollution sources affecting the criterion to be altered.

> **Response: This was provided in the current document or (Frydenborg and Frydenborg, 2017).**

A description of the historical and existing water quality of the parameter of concern including, spatial, seasonal, and diurnal variations, and other parameters or conditions which may affect it. Conditions in similar water bodies may be used for comparison.

> **Response: This was provided in Frydenborg and Frydenborg (2017).**

A description of the historical and existing biology, including variations, which may be affected by the parameter of concern. Conditions in similar water bodies may be used for comparison.

> **Response: This was provided in the current document or (Frydenborg and Frydenborg, 2017).**

A discussion of any impacts of the proposed alternative criteria on the designated use of the waters and adjoining waters.

> **Response: This was provided in the current document. Because EPA recommended criteria recalculation procedures, based on the sensitive species likely to occur in the waterbody, were followed to develop the SSAC, there is reasonable assurance that there will be no adverse affects on the designated use.**

In making the demonstration required by this paragraph (c), the petition shall include an assessment of aquatic toxicity, except on a showing that no such assessment is relevant to the particular criterion. The assessment of aquatic toxicity shall show that physical and chemical conditions at the site alter the toxicity or bioavailability of the compound in question and shall meet the requirements and follow the Indicator Species procedure set forth in *Water Quality Standards Handbook* (December 1983), a publication of the United States Environmental Protection Agency, incorporated here by reference. If, however, the Indicator Species Procedure is not applicable to the proposed site-specific alternative criterion, the petitioner may propose another generally accepted scientific method or procedure to demonstrate with equal assurance that the alternative criterion will protect the aquatic life designated use of the waterbody.

> **Response: This was provided in the current document. Because EPA recommended and vetted procedures were followed, reasonable assurance is provided that there will be no adverse affects on the designated use.**

The demonstration shall also include a risk assessment that determines the human exposure and health risk associated with the proposed alternative criterion, except on a showing that no such assessment is relevant to the particular criterion. The risk assessment shall include all factors and follow all procedures required by generally accepted scientific principles for such an assessment, such as analysis of existing water and sediment quality, potential transformation pathways, the chemical form of the compound in question, indigenous species, bioaccumulation and bioconcentration rates, and existing and potential rates of human consumption of fish, shellfish, and water. If the results of the assessments of health risks and aquatic toxicity differ, the more stringent result shall govern.

> **Response: The very low levels of TAN associated with the site specific criteria are not associated with human risk and the criteria values were created by EPA to protect the most sensitive species that could be expected in the wetlands.**

The demonstration shall include information indicating that one or more assumptions used in the risk assessment on which the existing criterion is based are inappropriate at the site in question and that the proposed assumptions are more appropriate or that physical or chemical characteristics of the site alter the toxicity or bioavailability of the compound. Such a variance of assumptions, however, shall not be a ground for a proposed alternative criterion unless the assumptions characterize a factor specific to the site, such as bioaccumulation rates, rather than a generic factor, such as the cancer potency and reference dose of the compound. Man-induced pollution that can be controlled or abated shall not be deemed a ground for a proposed alternative criterion.

Response: The EPA recommended procedures for establishing site-specific criteria were followed, which involve identifying the most likely occurring sensitive receiving water biota.

The petition shall include all information required for the Department to complete its economic impact statement for the proposed criterion.

Response: Because FPL operates the sumps to protect the integrity of the cooling pond berm, there is no additional cost to provide the water to the adjacent wetlands for seasonal ecological enhancement.