LINKING SUBSTRATE ORGANIC MATTER AND WATER QUALITY TO INVERTEBRATE AND FISH POPULATIONS WITHIN A CONSTRUCTED WETLAND TREATMENT SYSTEM

by

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DEDICATION

This is dedicated to my wife and my entire family for the love, encouragement, and support shown to me during the many hours spent pursuing this goal. I love you all so much!

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Thank you to my parents Marion and Delores Sees for everything that they have done for me. May they continue to rejoice with the angels in Heaven. And thank you to my son, Jacob, daughter, Jenna and my wife, Evelyn, for all their support, love, and encouragement through the years. Without them, this would not have been possible.

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ABSTRACT

The Orlando Easterly Wetlands is a highly engineered and managed free surface flow constructed wetland treatment system that was constructed for the expressed purpose of removing nitrogen and phosphorus from municipal reclaimed wastewater. The system has been in operation since 1987 and is managed and maintained for water quality. Through the 33 years of operation, the system has accumulated tremendous amounts of organic matter through natural wetland processes. However, this organic matter has caused significant short-circuiting of water flow ultimately leading to the need for removal. Removal of the organics is expensive and time-consuming and results in a complete renovation of the wetland marshes. These renovation projects effectively remove the organics along with the plants and wildlife species that inhabit a given project area. My paper aims to link water quality, accreted organic matter, and wildlife diversity and abundance. I theorized that biodiversity within the system is influenced and driven by the constant input of dissolved nutrients and the associated organic matter accretion. Through substrate samplers, dip netting, and minnow traps, aquatic biota was sampled and correlated with water quality indicators such as chlorophyll-*a*, carbonaceous biochemical oxygen demand, ammonia, ortho phosphate, total kjedahl nitrogen, total nitrogen, and total phosphorus along with the depths of organic matter. The abundance of macroinvertebrates was strongly correlated with carbonaceous biochemical oxygen demand (r^2=0.91) and total nitrogen (r^2=0.88). Ammonia displayed a moderate positive correlation and depths of the accreted organic matter were weakly correlated. The presence and abundance of larger more mobile aquatic species were moderately correlated with levels of chlorophyll-*a (*r^2=0.702). OP and TP showed significant negative correlations (r^2 = -0.619, -0.628), respectively. Suggesting that as OP and TP concentrations decrease abundance increases. I also document the rapid recolonization of invertebrates within newly renovated marshes in the Orlando Easterly Wetlands and how this system provides outstanding biodiversity.

INTRODUCTION

Wetlands are commonly defined as “land or areas (such as marshes or swamps) that are covered often intermittently with shallow water or have soil saturated with moisture” (Merriam-Webster, 2020). But wetlands are so much more than just wet or saturated ground. They are productive, diverse ecosystems that can cleanse pollutants, stabilize water supplies, protect shorelines, and recharge groundwater aquifers (Mitsch and Gosselink, 1999).

Wetlands provide critical habitat for numerous birds and wildlife species. As much as 40% of the world's species live and breed in wetlands (Mwangi, 2018). In 1982, 80% of the American breeding bird population and more than 50% of the 800 species of protected migratory birds were estimated to rely on wetlands (Flynn, 1996). However, approximately 35% of the world's wetlands were lost at an accelerating rate between 1970-2015 and now more than 25% of all wetlands plants and animals are at risk of extinction (Ramsar, 2018). All 50 U.S. states have lost wetlands with Florida experiencing the greatest loss at more than 3.76 million ha, approximately 46% of its historic wetland area (Dahl, 1990).

In 1972, the Federal Water Pollution Control Act (Clean Water Act) was passed which governs pollution control and water quality of the Nation's waterways. The object of the CWA is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters (USEPA, 2015). Contained within this sweeping legislation is Section 404 which specifically addressed wetland protection. This regulation prohibited the release of any dredged or fill material into United States waters (including wetlands). Wetland protection was dramatically enhanced in 1977 when President Jimmy Carter issued Executive Orders 11988 and 11990, which ended federal assistance for the draining or filling of wetlands to avoid, or at least minimize, destruction of wetland habitat (Herrick, 2019). Then, in 1989 President George H. W. Bush established the National policy of "no-net loss of wetlands". This set the groundwork to replace each newly impacted wetland with a replacement wetland of the same size and with similar wetland functions and values (NRCS, 2020). These overarching policies along with other legislative bills in the CWA and the increased attention and appreciation of wetland functions and values helped to clear the way for the role of constructed wetland treatment systems.

Constructed wetlands are built for a wide variety of treatment purposes such as wastewater, mine drainage, urban stormwater, combined sewer, overflows, agricultural runoff, livestock and poultry wastes, landfill leachates, and for the mitigation of wetland loss (USEPA, 1999). These systems represent our ability to capitalize on natural wetland functions that can benefit both humans and the environment.

However, the term constructed wetland continues to be very broad and poorly defined. *Constructed wetlands* typically are engineered systems with highly controlled inputs of wastewater moving through a specific substrate using aquatic plants with controlled residence times to maximize nutrient uptake (Moshiri, 1993). These types of systems typically offer long detention times which allow sediments to settle out of the water column. Constructed wetlands are most commonly built to remove nitrogen (N) and phosphorus (P) where removal processes include sedimentation, soil adsorption, and detritus accumulation (Heliotis and DeWitt, 1983; Richardson, 1985; Reddy et al., 1999; Kadlec and Knight, 1996; USEPA, 2000).

These differ from *created wetlands* that are developed for wetland mitigation where an upland area has been scraped and contoured creating a wetland compensate for the loss of a permitted wetland. Often created or mitigation wetlands are also highly engineered, constructed and then planted with a variety of wetland vegetation that mimic natural wetlands. For our purposes here we will refer to these as “created” or “mitigation” wetlands to distinguish these from the former, constructed systems.

Constructed wetland treatment systems have three basic types: free water surface, horizontal subsurface flow, and vertical flow (Kadlec and Wallace, 2009). Free water surface (FWS) wetlands are defined as wetland systems where the water surface is exposed to the atmosphere. Most natural wetlands are FWS systems, including bogs (primary vegetation mosses), swamps (primary vegetation trees), and marshes (primary vegetation grasses and emergent macrophytes) (Moshiri, 1993). Horizontal subsurface flow wetlands typically employ a gravel bed where wetland plants are planted and water flows below the surface horizontally from inlet to outlet. Lastly, vertical flow wetlands distribute wastewaters across the surface allowing percolation through the root zone. (Kadlec and Wallace, 2009)

Within these wetlands, the main transformation processes for N are ammonification (organic nitrogen to ammonia), nitrification (ammonia to nitrate or nitrite), and denitrification, where nitrate (NO3) is converted to harmless nitrogen gas (N2), which composes 78% of our atmosphere (Kostel, 2020). Wetlands provide favorable conditions for denitrification (Cleemput et al., 2007).

Phosphorus is removed primarily through physical and chemical processes. Particulate P settles out through sedimentation, but much of the P enters wetlands in the dissolved form. Dissolved phosphorus accumulates in sediments by sorption (to aluminum and iron oxides and hydroxides) and precipitation (to form aluminum, iron, and calcium phosphates) (Kostel, 2020). However, wetland soils have a limited amount of phosphorus they can hold before the sorption sites become saturated. To continually remove P, new soils need to be "built" from remnant plant stems, leaves, root debris, and undecomposable parts of dead algae, bacteria, fungi, and invertebrates. The accretion of new material, or *muck* as it is commonly referred to, is a continual removal and storage process for phosphorus. The accretion of the new soils is due to biomass decay. The combination and interactions between processes are referred to as biogeochemical cycling (Kadlec, 1989).

As organic matter breaks down and decomposes, a percentage of P is released back to the water column (Reddy, 1983). This legacy P in the soil can contribute to the overall decline in nutrient removal efficiency. In created wetlands, there is little concern or consideration of this cycle, but in constructed wetlands designed to improve water quality, this release must be considered.

To slow the accretion of organic matter in constructed wetlands, various management techniques have been employed. Herbicides are applied to control and remove unwanted species that generate organic matter (Slayton, 2019). Prescribed fires have also been used to remove and reduce organic biomass before it falls into the water (White et al., 2008).

This accumulation of organic material and associated nutrients is an integral part of constructed wetland operation and understanding. The soil is where many of the hydrologic and biogeochemical processes that influence wetland function and ecology occur (Kolka & Thompson, 2006). Some muck is essential for a healthy, diverse ecosystem providing habitat for insect larvae and the numerous species that feed on them.

The City of Orlando, Florida constructed one of the first large-scale constructed wetland treatment systems for nutrient removal. The system provides outstanding wildlife habitat while also accreting significant depths of organic matter. Through the years, there have been numerous projects to remove the organic matter accumulation, but little concern has been given to the impacts of the accretion on fish and wildlife populations. So, is there a link between the depth of accreted material and the abundance and diversity of aquatic species within a constructed wetland treatment system?

STUDY SITE

The Orlando Easterly Wetlands (OEW), located in east-central Florida, is one of the world's first large scale constructed wetland treatment systems. The OEW, part of the St. Johns River floodplain, has constructed marshes at various levels ranging in elevation from 5.1-9.1 m above sea level. The climate is subtropical with approximately 127 cm/yr of rainfall. Most of this rain occurs during central Florida's rainy season, which is typically June through mid-October. The area was historically a wet prairie drained and cleared for cattle grazing, logging, and eventually, in the 1940s, a dairy farm pasture. In 1985, the 668-ha property was acquired by the City of Orlando and construction of one of the world's first large-scale constructed wetland treatment systems began soon thereafter (Wang et al., 2005). In July of 1987, the 485-ha constructed wetland treatment system began to receive municipal reclaimed wastewater flow from the Iron Bridge Regional Water Pollution Control Facility (IBRWPCF). As the newly constructed treatment cells began to fill with water, planting crews installed more than 2.1 million native wetland plants across the site (EPA, 1993).

Since startup, the OEW has been in near-continuous use receiving and treating reclaimed wastewater daily from the IBRWPCF. Flows have been continuously monitored and are listed in the table highlighting nutrient reductions in Appendix A. Since 1991, the OEW has received a daily average flow of 0.65 m^3/s. When the reclaimed water enters the OEW, it is equally dispersed into three distinct pathways (locally called flow trains) that sheet flow across the wetland marshes. The north, central, and southern flow paths (Figure 1) converge in the final treatment cell and empty out of the system through the D002 outfall structure. The water then flows via a canal discharging directly to the St. Johns River.

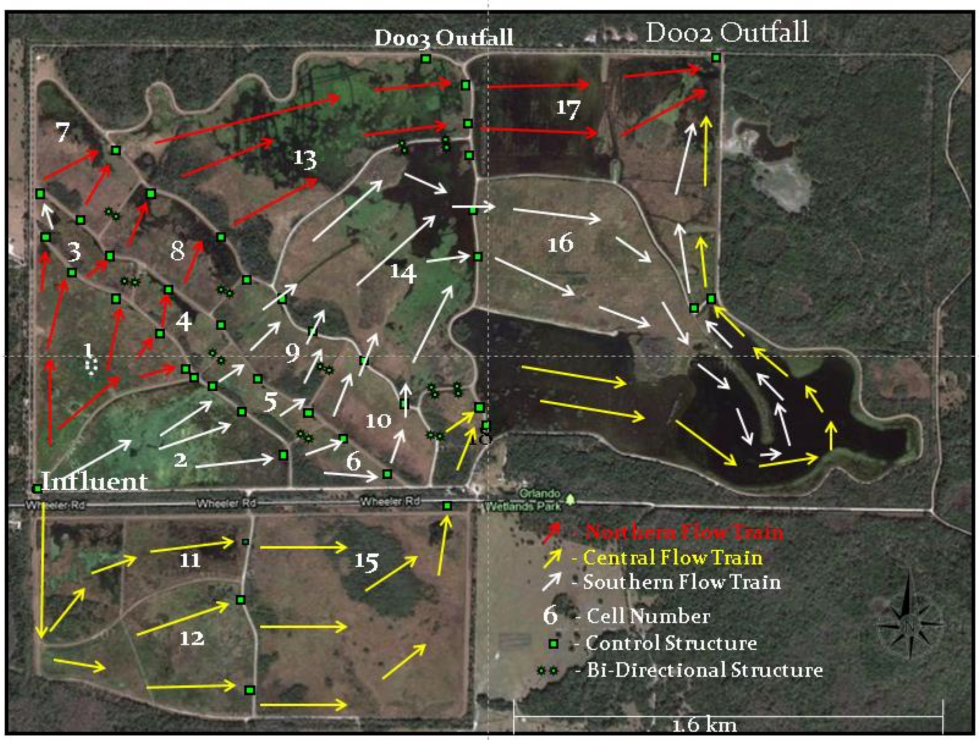

Figure 1. Aerial image and flow schematic of the OEW constructed wetland treatment system.

All three flow paths initially direct water through deep marsh habitat, originally planted with cattails (*Typha* spp.) and giant bulrush (*Schoenoplectus californicus*). Flow is then routed through a mixed marsh habitat planted with pickerelweed (*Pontedaria cordata*), duck potato (*Sagittaria lancifolia*), and other emergent aquatic plants, along with submerged aquatic plants such as southern naiad (*Najas quadalupensis*) and Illinois pondweed (*Potamogeton illinoensis*). Finally, the water flows through a hardwood swamp where more than 200,000 wetland trees like cypress (*Taxodium distichum*), pop ash (*Fraxinus caroliniana*), and water hickory (*Carya aquatica*) were planted. Typical photographs for the 3 habitats are presented in Figure 2. Once water filters through these various habitats, it collects in a final treatment cell and then discharges out of a concrete control structure (D002).

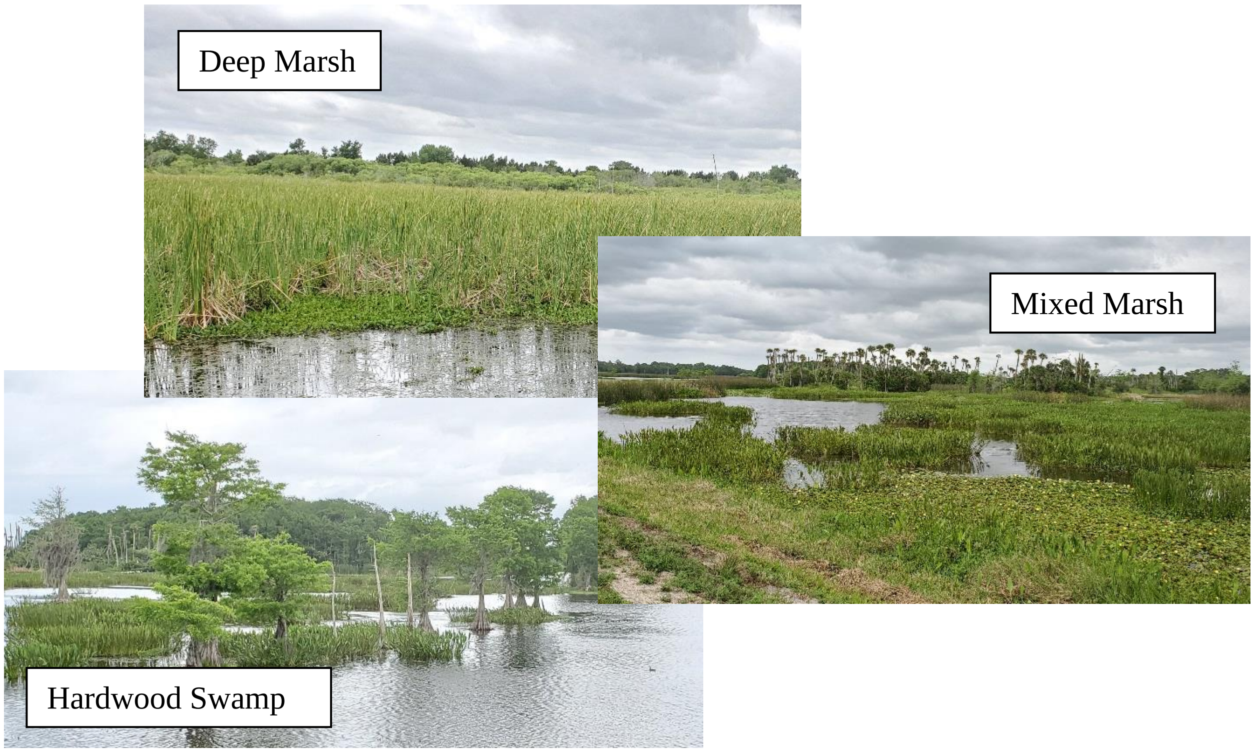

Figure 2. Typical site photographs of the deep marsh, mixed marsh, and the hardwood swamp habitats within the OEW.

The OEW system has demonstrated long-term, consistent removal of total nitrogen (TN) and total phosphorus (TP) well below the Florida Department of Environmental Protection's permitted discharge level of 2.31 and 0.2 mg/L, respectively. The average TN exiting the OEW from 1991 through the end of 2019 is 0.86 mg/L and TP is 0.61 mg/L (Appendix A) (Slayton, 2020). Figure 3 represents the TN and TP uptake profile as water flows through the OEW system. The profile demonstrates how most of the TN and TP are removed within the first 1,219 m of the 4,572-m-long flow train and that the system has the capacity to remove more TP before outfall concentrations are impacted.

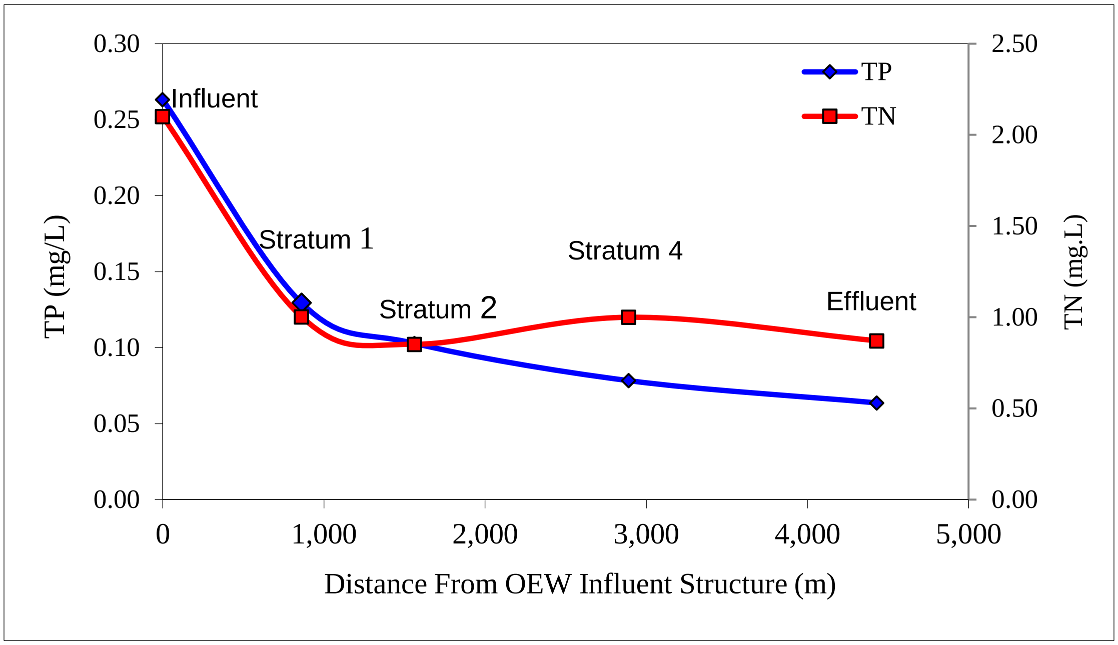

Figure 3. Total Nitrogen and Total Phosphorus uptake profile across the OEW System.

However, in 1999, fluctuations in TP concentrations were observed in the OEW's effluent. This led to a series of studies by the University of Florida which identified several issues with the OEW (2001) and its ability to remove TP long term. A dye tracer study found 5 of the 15 cells were operating at 30% hydraulic efficiency or less (Appendix B) (Martinez & Wise, 2001). The tracer study revealed the presence of hydraulic dead zones and a degree of short-circuiting within all the treatment cells. This was due primarily to the presence of accreted organic matter (AOM). The short-circuiting was causing flow to accelerate through the treatment marshes decreasing detention times and ultimately impacting nutrient removal. In addition, short circuiting was leading to a loss of sedimentation processes and may have increased scouring, sediment suspension, and turbidity in the water column.

Although AOM was identified as the root cause for much of the efficiency loss. Organic matter accretion, sedimentation, and chemical sorption are the dominant long-term mechanisms responsible for P storage in wetlands (Kadlec, 1989; Reddy et al., 1999; Richardson, 1999). Accretion provides P burial and provides new sites for P sorption. The accretion of organic matter is key to the success of the OEW but was also proving to be a source of significant problems for continued long-term P removal.

Another problem resulting from the accretion of organic matter was the shifting of wetland habitats. Within the OEW, cattail dominated marshes transitioned to shrub-dominated systems with primrose willow (*Ludwigia peruviana*) and Carolina willow (*Salix caroliniana*) as the primary dominant species. It is believed that the creation and compaction of AOM created conditions favorable for willows.

To slow these transitions, OEW staff used prescribed fire to remove cattail biomass. White (2008) and others demonstrated that 68.5% of the above-ground biomass was removed following a fire with little long-term water quality impacts. This method continues to be used in some of the OEW's monotypic cattail stands annually as part of the operation and maintenance (O&M) of the site.

But prescribed fires remove the standing dead biomass and not the AOM. The University of Florida study in 2001 identified that continued long-term P removal success of the OEW would require AOM removal within some of the most impacted cells. To accomplish this, mechanical equipment to physically remove the organics was recommended. Total treatment cell renovation projects would serve to lengthen hydraulic retention times, decrease nutrient loading to surface water from legacy P and slow the conversion of cattail marshes to shrub dominated systems.

Since that recommendation, the City of Orlando has systematically been renovating or "demucking" the 18 treatment cells (Figure 4). Each of these projects involves draining the surface water, installing dewatering pumps, scraping and piling of the accumulated organics and vegetation, allowing it to dry, removing it, regrading, reflooding and replanting with various native wetland plants. To date, more than $7 million have been spent renovating the OEW for continued P uptake. But throughout these dramatic projects, there has been little consideration of or understanding of the impact of AOM removal on wildlife populations.

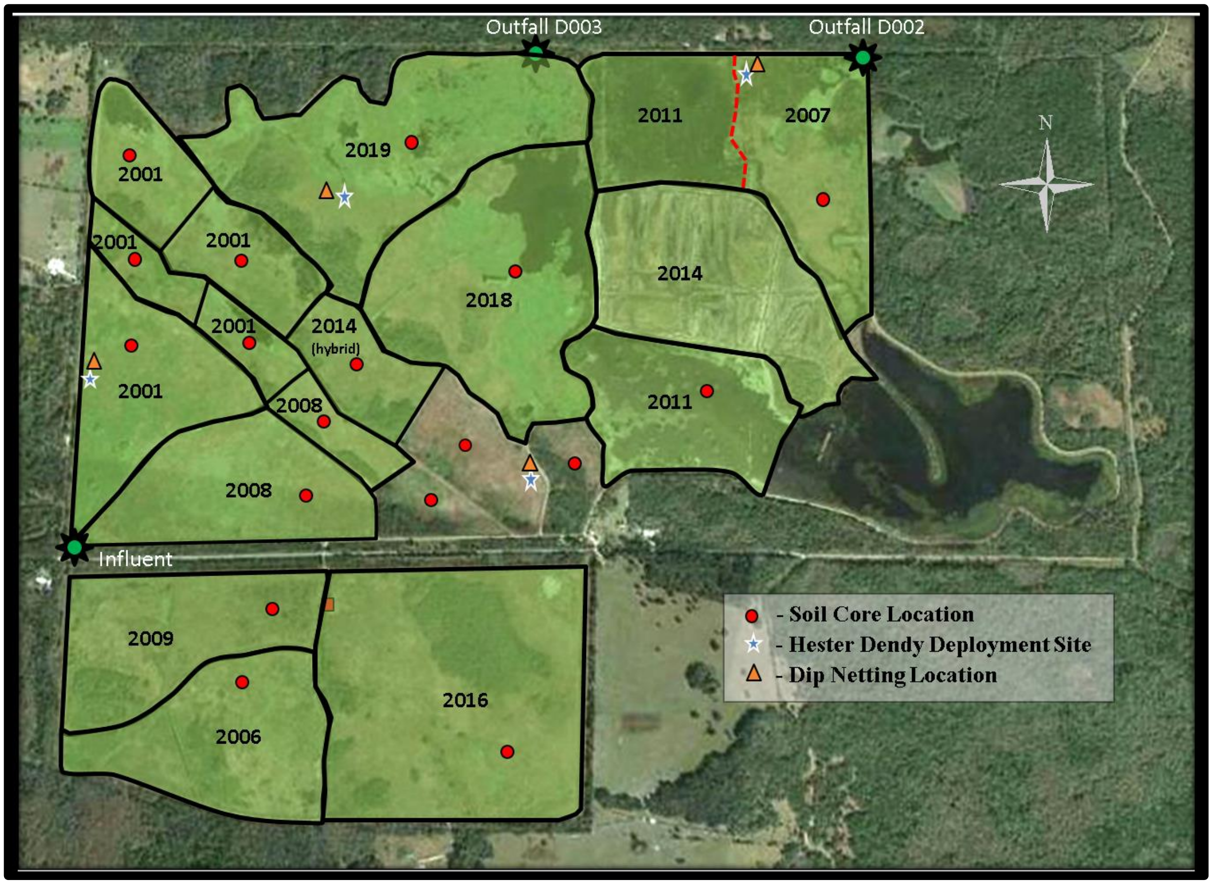

Figure 4. Timeline of wetland renovation projects within the 18 treatment cells of the OEW with soil core, Hester Dendy, and dip netting locations.

METHODS

Sediment Core Sampling

To better understand the impacts of removing the AOM on the aquatic biodiversity within the OEW system, I undertook a series of sampling efforts. The first step was to quantify the amount of AOM within the OEW's 18 treatment cells. To do this, I drove down clear acrylic core tubes (8.9 cm in diameter and 1.2 m long) through the accumulated organic material 10-15 cm into the native soils. The core tubes were then capped at the top and gently removed with the water, organic matter and native soil plug intact. Tubes were then capped at the bottom and allowed to settle for 5 minutes. In the field, I also made measurements and recorded them of the organic matter accumulation. Across the 485-ha system, one sample was collected from the approximate center of each of the 18 treatment cells on February 18, 19, and 20 of 2020 (Figure 4). Photos of individual core samples are in Appendix C and GPS locations and measurements are in Appendix D.

The top 12.7 cm were of the core were collected and then filtered through a 0.45-micron filter and allowed to dry for 12 hours at 100 ^{o}C. The subsamples were ground into a fine powder using a mortar and pestle and sent to the City of Orlando Water Reclamation Division's Environmental Laboratory for analysis. Using EPA Standard Methods 160.4 (USEPA, 1971), the Lab heated the samples in a muffle furnace for 4 hours. Percentage organic matter was then calculated gravimetrically based on the weight difference before and after burning at 550 ^{o}C. This test quantified the mass of all organic matter, leaving only inorganic minerals that are not volatile. Most plant-derived organic matter is between 45-55% organic and as such this test provides an estimate of the stored carbon within individual treatment cells.

These data also provided measurements for accretion rates within the OEW. This information was used to correlate accretion rates with the biodiversity measured to gain a better understanding of how wildlife is affected by the presence or absence of AOM.

Macroinvertebrate Dip Net Sampling

Evaluating the abundance and diversity of aquatic macroinvertebrates is often used as an indicator of the biological condition of a waterbody. Generally, waterbodies in good condition support a wide variety and high number of taxa. Samples that have little diversity or abundance typically indicate a less healthy or more polluted waterbody. To assess the diversity of the wetland cells, I constructed and installed Hester Dendy substrate samplers. The deployments were not successful in capturing accurate samples of invertebrates and were therefore not used in any calculations of OEW biodiversity (Appendix E).

Following this setback, I used a D-ring dip net to obtain representative biota in 4 of the 18 treatment cells based on the age of the AOM. For example, Cell 13 was completely renovated and de-mucked in 2019 and served as a <1 year of organic matter accretion reference. Cell 17 – 13 years, Cell 1 – 19 years and Cell 10 has never been de-mucked serving as a 33-year AOM reference. The dip net sampling occurred on March 29, 30, and 31 at approximately 10 am each day for consistency. At each location, four 0.3-m long sweeps along primarily cattail dominated marsh habitat were made with a Wildco® D-Frame aquatic dip net (30.5 cm W x 25.4 cm L x 55.9 cm, 500-micron net).

The sweep locations were placed near the approximate center of the cell close to one of the berm access roads for accessibility. After each sweep, net contents were emptied into large plastic containers and rinsed with purified, deionized water and transported to the lab for sorting, identification, and enumeration following the same protocols as the Hester Dendy sampling technique (Appendix E).

Fish Sampling

Fish and other aquatic organisms were sampled in the same locations as the dip net sampling. Traps were set in Cells 1, 10, 13, and 17 on March 2 and were emptied and reset daily March 3-5. Following a cursory review of results, Cell 14 was added to the minnow trapping sampling regime only. Cell 14 was renovated in 2018 and was reflooded January 2019 allowing 14 months of faunal recolonization before sampling March 9-12. At each site, Gee© minnow traps that are 41.9-cm long and 19.1 cm in diameter constructed of a 6.4 mm steel mesh with openings on both ends were used for the sampling. The trap offers a catch area equivalent to 0.3077 m^2. Five traps were deployed at each sampling location and monitored for 3 nights for a total of 360 hours (3 days x 24 hour x 5 traps) of sampling for each location. All fish/organisms were identified to species level, enumerated, recorded, and released (Appendix F).

Water Quality

Since the OEW has been in operation nearly continuously since 1987 (USEPA, 1993), there is a large volume of water quality data to consider. For this study, only the influent and effluent of each of the 5 treatment cells that biota sampling occurred in was considered. Monthly data from 2016 until the end of 2019 were selected as representative of current site conditions. The influent and the effluent values for each of the 4 cells monitored were averaged together obtaining a representative value used to correlate various water quality analytes to AOM depths and the presence of fish and invertebrates in the cells where they occur.

The water quality for these cells was obtained from the City of Orlando's Annual Compliance and Performance Review (Slayton, 2020), and is presented in Appendix G. Chlorophyll-*a*, carbonaceous biochemical oxygen demand (CBOD), ammonia (NH4), ortho phosphate (OP), total kjedahl nitrogen (TKN), TN, TP were the primary analytes of interest for this study. The average values for each of these cells were compared with the abundance data for each of the four age treatments.

<u>Statistical Analysis</u>

For the dip netting and the fish trapping sampling techniques, diversity was analyzed using Shannon, Simpson, and Fisher's Alpha Diversity scores using the statistical software R version 3.6.3 (R Core Team, 2020) and the vegan: Community Ecology Package (Oksanen et al., 2019) along with the Jaccard Index (Jaccard, 1942). Diversity was calculated using the Shannon diversity index (1964) using the following formula 1:

Formula 1: $$H' = \frac{N ln\, N - \sum(n_i ln\, n_i)}{N}$$

where N is the total number of species and n_i is the number of individuals in species i. Simpson's index (1949) was calculated using Formula 2.

Formula 2: $$D = \sum_{i=1}^{R}\left(\frac{n_i(n_i - 1)}{N(N - 1)}\right)$$

where n_i is the number of individuals in species i, and N is the total number of species in the sample. The value ranges from 0 to 1, with 0 representing infinite diversity and 1 representing no diversity, so the larger the value of D, the lower the diversity (Kiernan, 2014). Fisher's Alpha was calculated using Formula 3.

Formula 3: S=a*ln(1+n/a)

where S is the number of taxa, n is the number of individuals and a is Fisher's alpha (Fisher et al., 1943). Lastly, Jaccard's index (1942) was used to measure the similarity and diversity of the sample sets using Formula 4.

Formula 4: $$J(A,B) = \frac{|A \cap B|}{|A \cup B|} = \frac{|A \cap B|}{|A| + |B| - |A \cap B|}$$

where Jaccard's index of two finite sample sets (A, B) = the intersection divided by the size of the union of the sample sets.

A Whittaker rank/abundance curve was produced with the proportion of relative abundance on the Y-axis and the rank on the X-axis. This plot visually depicts both species richness and species evenness. A steep gradient indicates low evenness as the high-ranking species have much higher abundances than the low-ranking species. A shallow gradient indicates high evenness as the abundances of different species are similar (Whittaker, 1965).

Detrended correspondence analysis (DCA) plots were prepared using statistical software R version 3.6.3 (R Core Team, 2020) and the vegan: Community Ecology Package (Oksanen et al., 2019). DCA is a multivariate statistical technique developed by Mark Hill (1979) and is widely used to visualize population data set similarities in a 2-dimensional plot. The DCA plots calculate and graphically depict the distance between samples, thus, the closer the data points the more similar the samples are to each other.

RESULTS

From the sediment cores that were collected, AOM has a strong positive correlation with age (R^2=0.54, p= 0.0003, Figure 5). Core sample measurements, laboratory analyses, accretion amounts, accretion rates per year, total solids and volatile solids are presented in Table 1. The volatile solids are correlated to the age of the AOM (r^2=0.33, p= 0.011, Figure 6). As time progresses AOM builds in the wetland cells and percentage of organic matter increases. Volatile organic compounds measured only 1.8% of the total solids measured in Cell 13, whereas, Cell 10 and 18 (which have never been de-mucked in the 33 years since OEW startup) had greater than 70% volatile organics, demonstrating the effectiveness of the Cell 13 muck removal project which occurred during 2019. These data also suggest that in a little more than 11 years from muck removal that nearly 50% of a sample will be volatile organic matter.

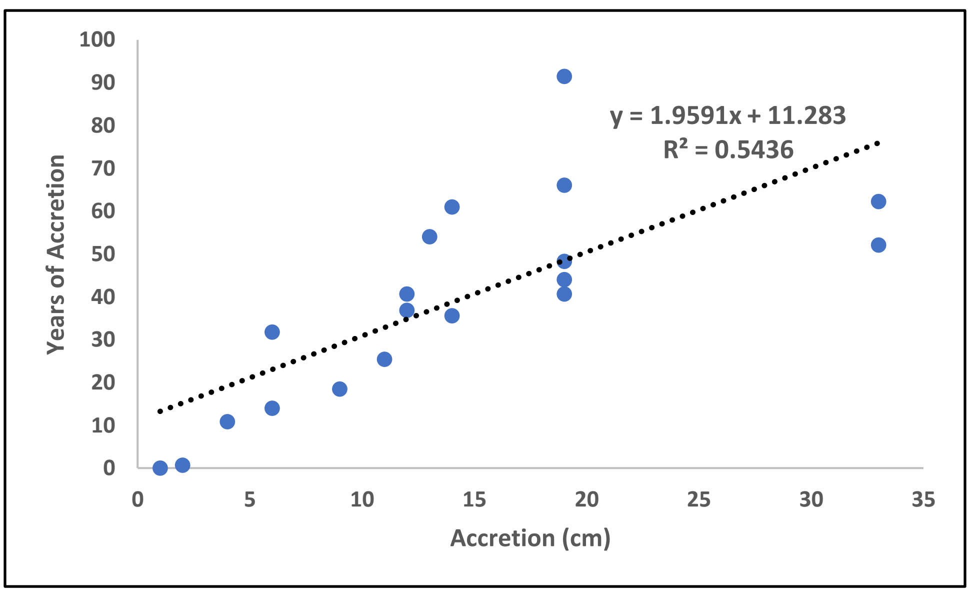

Figure 5. Correlation of time (years) for organic matter accretion and the total depth of accretion observed within the 18 OEW treatment cells.

Table 1. Orlando Easterly Wetlands accretion amounts and rates with total solids and volatile solids for each of the 18 treatment cells.

Location	Year of Renovation	Total Accretion (cm)	Accretion per Year (cm)	Total Solids (mg/kg)	Volatile Solids (mg/kg)	% Volatile Solids
Cell 1*	2001	91.4	4.8	970515	849734	87.60%
Cell 2	2008	40.6	3.4	911096	793171	87.10%
Cell 3	2001	40.6	2.1	863439	537019	62.20%
Cell 4	2001	43.9	2.3	978017	821165	84.00%
Cell 5	2008	36.8	3.1	921397	632420	68.60%
Cell 6	2006	61	4.3	936542	850624	90.80%
Cell 7	2001	66	3.5	946305	607812	64.20%
Cell 8	2001	48.3	2.5	986596	752100	76.20%
Cell 9	2014	31.8	5.3	965674	877307	90.80%
Cell 10*	1987	62.2	1.8	971930	782042	80.50%
Cell 11	2009	25.4	2.3	921067	751618	81.60%
Cell 12	2006	35.6	2.5	983760	856743	87.10%
Cell 13*	2019	0	0	998557	18376	1.80%
Cell 14	2018	0.6	0.3	997607	159747	16.00%
Cell 15	2016	10.8	2.7	977543	427186	43.70%
Cell 16	2011	18.4	2.1	982529	522927	53.20%
Cell 17*	2007	54	4.1	951569	628530	66.10%
Cell 18	1987	52.1	1.6	612446	439785	71.80%
Average		39.9	2.7	937588	628239	67.4%

* - represent treatment cells where biota was sampled

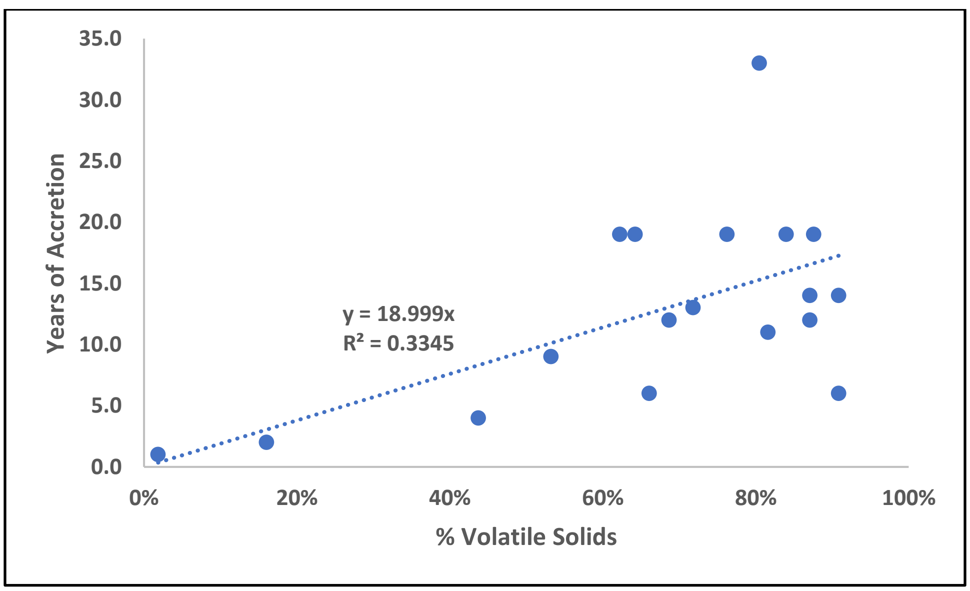

Figure 6. Correlation of volatile solids and AOM age within the 18 Orlando Easterly Wetlands treatment cells.

Invertebrate Results

The dip netting effort yielded 11 species in Cell 1 with 749 individuals counted. Cell 10 yielded 19 species with 147 individuals and Cells 13 and 17 had a diversity of 14 and 20 with 119 and 167 individuals, respectively (Table 2). Cell 17 had the highest Shannon Diversity and Fisher's Alpha Index values while Cell 10 had the highest Simpson Diversity Index value.

Table 2. Dip netting results for each cell with diversity metrics.

Common Name	**Order**	**Family**	**Cell 1**	**Cell 10**	**Cell 13**	**Cell 17**
Alderfly Larvae	Megaloptera	Sialidae		1		
Beetle 1	Coleoptera	Elmidae	1			
Beetle 2	Coleoptera	Dytiscoidea		35		
Damselfly	Odonata	Coenagrionidae	2	15	33	2
Damselfly-Spread wing	Odonata	Lestidae		3		4
Detritus Worm	Haplotaxida	Naididae		7		
Dragonfly	Odonata	?				1
Fishing Water Spider	Araneae	Dictynidae	2	3	1	4
Fly Larvae	Diptera	Tabanidae		1		
Golden Topminnow	Cyprinodontiformes	Fundulidae				1
Grass Shrimp	Decapods	Palaemonidae		1		6
Isopod	Isopoda	?			1	
Least killifish	Cyprinodontiformes	Poeciliidae	10	1	1	14
Leech	Arhynchobdellida	Hirudae			1	
Mayfly Larvae 1	Ephemeroptera	?		1		
Mayfly Larvae 2	Ephemeroptera	Leptohyphidae			3	5
Mayfly Larvae 3	Ephemeroptera	?	2			
Midge	Diptera	Chironomidae	74		9	2
Mosquito Larvae	Diptera	Culicidae				1
Mosquitofish	Cyprinodontiformes	Poeciliidae	2	2	1	2
Predacious Diving Beetle	Coleoptera	Dytiscidae	4	4	2	10
Sailfin Molly	Cyprinodontiformes	Poeciliidae				1
Salvinia Weevil	Coleoptera	Curculionidae		1		
Scud	Amphipoda	Gammaridae	616	37	36	67
Snail 1	Achatinoidea	?		3		
Snail 2	Basommatophora	Planorbidae			7	4
Snail 3	Basommatophora	?			1	
Spider	Araneae	Dictynidae		2		
Stick Bug	Hemiptera	Nepidae	4			
Tadpole	Anura	Ranidae		1		
Water Beetle	Coleoptera	Hydrophillidae				7
Water Boatman	Hemiptera	Corixidae			20	3
Water Mite	Trombidiformes	Hydrachnidia	32	4	3	23
Water Scavenger Beetle	Coleoptera	Hydrophilidae		25		9
Water Strider	Hemiptera	Gerridae				1
Diversity			**11**	**19**	**14**	**20**
Abundance			**749**	**147**	**119**	**167**
Extrapolated Abundance per m^2			**2048**	**402**	**325**	**457**
Shannon Diversity Index			**0.71**	**2.16**	**1.87**	**2.18**
Simpsons Diversity Index			**0.31**	**0.83**	**0.79**	**0.80**
Fisher's Alpha Diversity Index			**1.83**	**5.81**	**4.12**	**5.93**

Cell 1 is disproportionately skewed due to the high proportion of *Hyallela azteca* with more than 82% of the total abundance (Figure 7). Cell 10, 13, and 14 follow a typical curve. Cell 10 and Cell 17 had a large proportion of species with only one or two individuals present in the sample producing a long trailing curve in the plot. This suggests that these samples had more rare species and less abundant species.

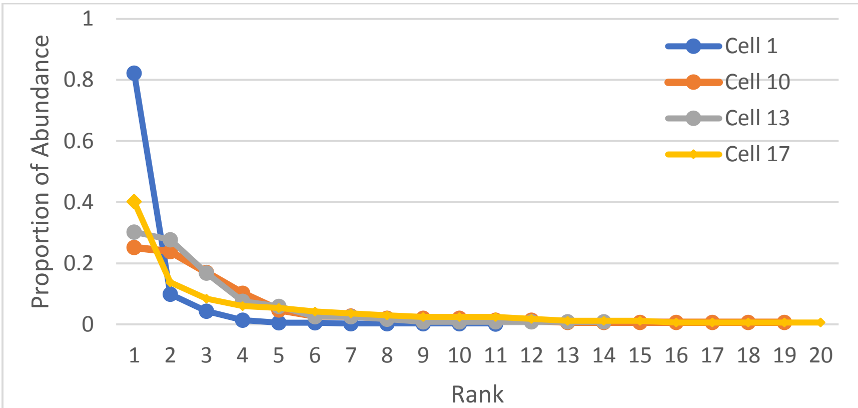

Figure 7. Whittaker rank-abundance plot for all dip netted species.

Each of the four cells was then compared using Jaccard's similarity coefficients. The coefficients are presented in Table 3 which quantifies that all four of the treatment cells are somewhat dissimilar to each other in terms of abundance and distribution of species. Cell 10 and 17 are the most similar with a coefficient of 0.375, whereas, Cell 1 and 13 are most dissimilar with a coefficient of 0.214. Similarly, a DCA ordination plot is presented in Figure 8. The cells are dissimilar to each other in terms of species types and abundance.

Table 3. Jaccard's similarity coefficient for dip netting results.

	Cell 1	Cell 10	Cell 13	Cell 17
Cell 1	1	0.308	0.214	0.313
Cell 10	0.308	1	0.286	0.375
Cell 13	0.214	0.286	1	0.294
Cell 17	0.313	0.375	0.294	1

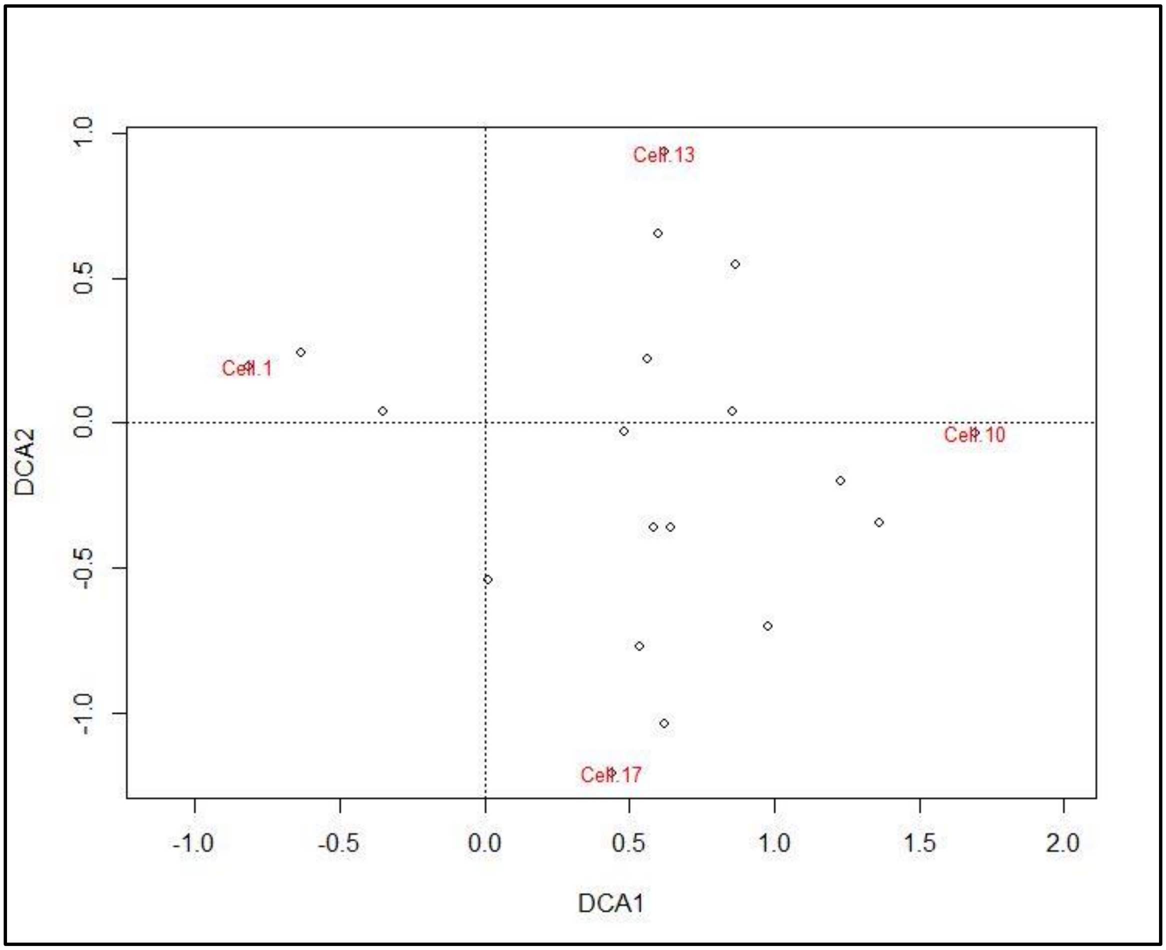

Figure 8. DCA ordination plot of Cells 1, 10, 13, and 17 of the OEW dip netting results.

Cell 1 is disproportionately skewed due to the overwhelming abundance of *H. azteca*. Cells 10 and 13 are evenly distributed and Cell 17 has the most species represented with *H. azteca* accounting for more than 40% of the species sampled.

Minnow Trap Sampling Results

In a similar manner as the analysis for the dip netting results, the fish trap data were also analyzed. Table 4 depicts the individual species data were collected along with the Shannon, Simpson and Fisher's alpha diversity index values. Cell 14 has the highest abundance with 291 individuals with cell 17 closely behind with 288 individuals. This is interesting as Cell 14 has been reflooded for 14 months since a complete renovation project. Cell 10 had the highest diversity with 13 species represented and has never been de-mucked during the OEW’s 33-year history. Cell 10 also has the highest Shannon and Simpson Diversity Index score, while Cell 13 has the highest Fisher’s Alpha score. Individual pie charts detailing species diversity for Cells 1, 10, 13, 14, and 17 are presented in Appendix H.

Table 4. Minnow trap results for cells 1, 10, 13, 14, and 17 with diversity, abundance and diversity metrics.

Scientific Name	Common Name	Cell 1	Cell 10	Cell 13	Cell 14	Cell 17
Anisoptera	Dragonfly Nymph					3
Aphredoderus sayanus	Pirate Perch				22	
Belostoma lutarium	Giant Water Bug		2		2	2
Cybister fimbriolatus	Predacious Diving Beetle	3	1	1	8	4
Fundulus chrysotus	Golden Topminnow	2	7		2	
Gambusia affinis	Mosquitofish	62	32		10	64
Heterandria formosa	Least Kilifish		2			
Hydrophilus triangularis	Water Beetle			1		
Jordanella floridae	American Flagfish				148	93
Lithobates grylio	Pig Frog		1	1		
Lithobates sphenocephalus	Southern Leopard Frog		1	4	5	5
Lucania goodei	Bluefin Killifish		1			
Nerodia fasciata	Banded Watersnake	1				
Notopthalmus viridescens piaropicola	Peninsula Newt			3	5	
Palaemonetes paludosus	Grass Shrimp	6	2		58	24
Poecilia latipinna	Sailfin Molly	1	28		23	81
Procambarus alleni	Crayfish	16	24		7	10
Regina rigida	Glossy Crayfish Snake	2				1
Seminatrix pygaea pygaea	Northern Florida Swamp Snake		1			
Siren intermedia complex	Eastern Lesser Siren	1	3	1	1	1
Diversity		**9**	**13**	**6**	**11**	**12**
Abundance		**94**	**105**	**11**	**291**	**288**
Extrapolated Abundance per m^2		**305**	**341**	**36**	**946**	**936**
Shannon Diversity Index		**1.17**	**1.78**	**1.59**	**1.63**	**1.63**
Simpson Diversity Index		**0.53**	**0.78**	**0.76**	**0.76**	**0.76**
Fisher's Alpha Diversity Index		**2.45**	**3.91**	**5.4**	**2.27**	**2.27**

Presented in Figure 9 is the Whittaker rank/abundance plot for the minnow trapping data. Again, all the cells exhibit a normal rank/abundance curve except for Cell 1. Mosquitofish (*Gambusia affinis*) dominate the biodiversity of this cell at more than 65%.

Jaccard's similarity coefficients were calculated (Table 5). Cells 1 and 13 had the highest percent of similar species at 37.5%. Cells 1&10 and 13&17 also displayed high similarities at 0.364. Cells 13 and 14 were the most dissimilar of 5 cells that were sampled at 0.154. The ordination plot (Figure 10) depicts the spatial dissimilarity distance in a 2-dimensional graph.

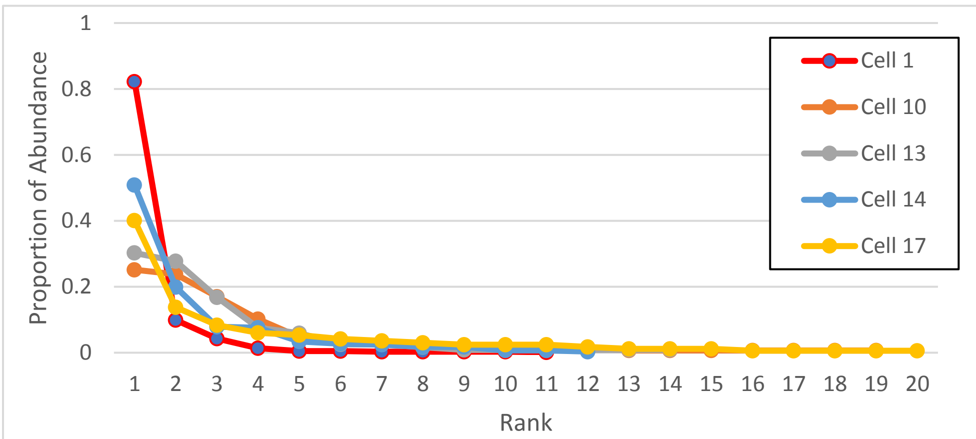

Figure 9. Whittaker rank-abundance plot for all minnow trapped species.

Table 5. Jaccard similarity coefficient for minnow trapping results.

	Cell 1	Cell 10	Cell 13	Cell 14	Cell 17
Cell 1	1	0.364	0.375	0.2	0.286
Cell 10	0.364	1	0.333	0.267	0.357
Cell 13	0.375	0.333	1	0.154	0.364
Cell 14	0.2	0.267	0.154	1	0.294
Cell 17	0.286	0.357	0.364	0.294	1

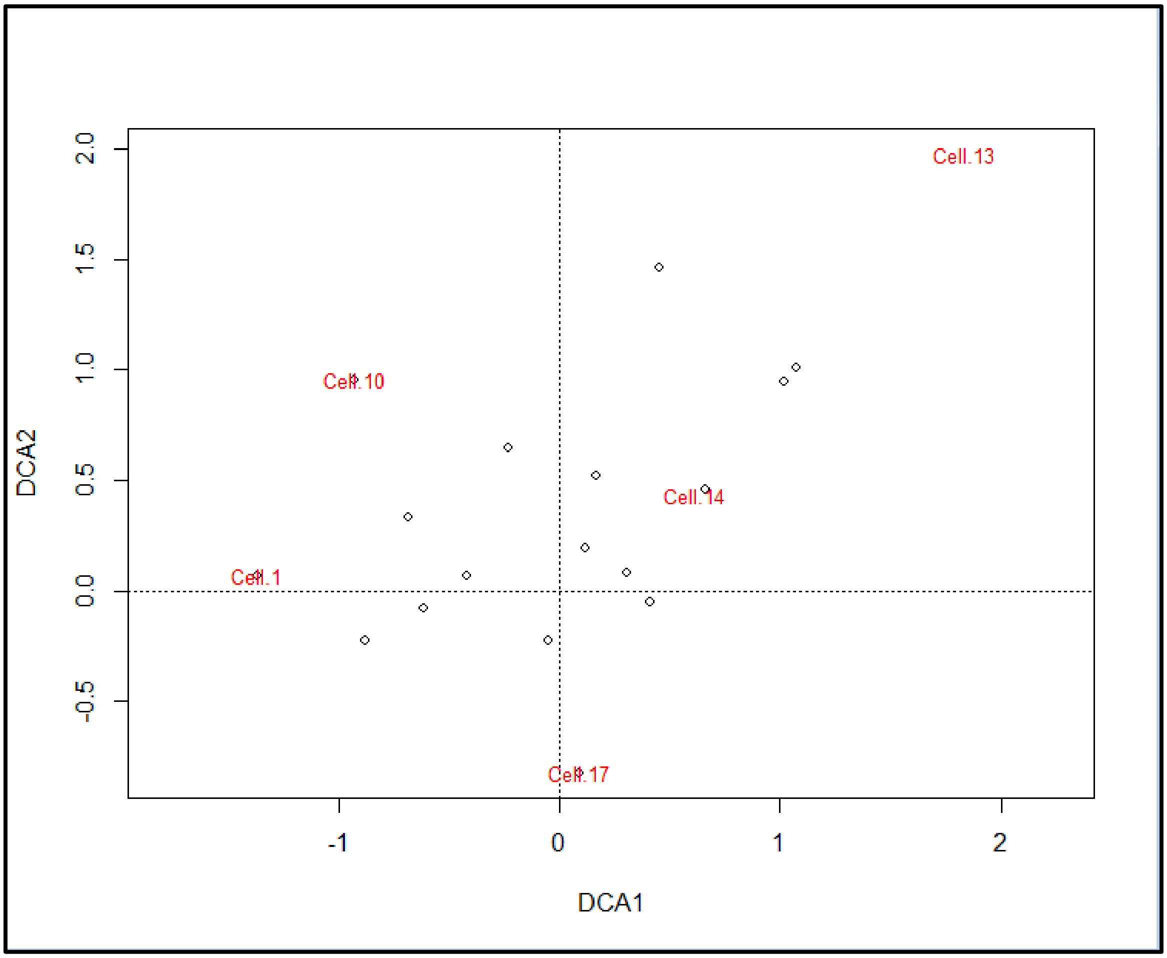

Figure 10. DCA ordination plot of Cells 1, 10, 13, 14, and 17 of the OEW fish trap results.

Chemical Analysis

Water quality within the 4 cells was calculated for various analytes using the average of the influent and the effluent values collected monthly from 2016 through 2019. The average value for each of the parameters was then correlated to species abundance to determine which parameters may play a role in shaping aquatic biodiversity. The average for various analytes of interest are presented in Table 6.

Table 6. Water Quality Data Summary for Cells 1, 10, 13, 14 and 17 of the OEW.

Analyte	Cell 1	Cell 10	Cell 13	Cell 14	Cell 17
CBOD	2.00	2.01	2.02	2.04	2.02
Chlorophyll-*a*	1.08	1.04	1.77	2.86	2.08
Ammonia	0.01	0.03	0.06	0.05	0.08
Ortho Phosphate	0.18	0.16	0.10	0.08	0.05
Total Kjedahl Nitrogen	0.80	0.63	0.79	0.72	0.87
Total Nitrogen	1.39	0.64	0.79	0.73	0.87
Total Phosphorus	0.20	0.17	0.12	0.10	0.08

Data are based on averages of monthly data from 2016 through 2019 presented in Appendix A. All analytes expressed as mg/L except chlorophyll-*a* expressed as (mg/m^3).

Chlorophyll-*a*, CBOD, NH4, OP, TKN, TN, TP, and the AOM depth were correlated with macroinvertebrate abundance from each of the 4 cells (Table 7). Using the adjusted r^2 value, CBOD (r^2 = 0.91) and TN (r^2=0.88) both showed strong positive correlations to the abundance of invertebrate observed in the OEW. NH4 had a moderate positive correlation (r^2 = 0.419), while AOM displayed a weak positive correlation (r2 = 0.30) to the abundance data. Chlorophyll-*a*, OP, TKN, and TP had no real correlation with macroinvertebrate abundance.

Table 7. Regression analysis results for water quality analytes correlation with dip netting abundance results.

	Multiple R	R^2 Value	Adjusted R^2	STND Error
Chlorophyll-*a*	0.52	0.271	-0.094	316.9
CBOD	0.969	0.939	0.908	91.8
NH4	0.783	0.612	0.419	231
OP	0.614	0.377	0.065	292.9
TKN	0.216	0.047	-0.43	362.3
TN	0.96	0.921	0.882	104.1
TP	0.673	0.453	0.18	274.4
AOM	0.729	0.532	0.298	253.9

Abundance data from the specimens collected in the minnow traps were also correlated with the water quality data (Table 8). None of the 8 parameters were significantly correlated (based on R^2 values) with species abundance observed in each of the 5 cells (1, 10, 13, 14, and 17) except for Chlorophyll-*a* (r = 0.702). OP and TP showed significant negative correlations (r = -0.619, -0.628) respectively. Suggesting that as OP and TP concentrations decrease abundance increases.

Table 8. Regression analysis results for water quality analytes correlation with minnow trapping abundance results.

	Multiple R	R^2 Value	Adjusted R^2	STND Error
Chlorophyll-*a*	0.702	0.493	0.324	0.62
CBOD	0.096	0.009	-0.321	1.26
NH4	0.415	0.172	-0.104	0.03
OP	-0.619	0.384	0.178	0.05
TKN	0.204	0.042	-0.278	0.1
TN	-0.187	0.035	-0.287	0.34
TP	-0.628	0.395	0.193	0.04
AOM Depth	0.099	0.009	-0.32	144.31

DISCUSSION

The OEW system, while primarily responsible for removing TN and TP from reclaimed wastewater is clearly meeting its nutrient reduction goals while at the same time providing wetland habitat and biodiversity. From field sampling completed during 1985-1989, Burney (1990) found that the OEW had higher biodiversity than surrounding wetlands. Anecdotal evidence such as bird observations reported on the ebird.org website provides data documenting higher avifauna diversity than surrounding wetlands with similar habitat. There is little doubt that the OEW is providing higher biodiversity than surrounding wetland areas and that the productivity of the wetlands is enhanced by the continual flow of nutrient-enriched wastewater. But are the nutrients and associated AOM limiting or increasing biodiversity?

Within the limited scope of this study, 55 species of wildlife were sampled. Abundance was highest in Cell 1 where nutrient concentrations are highest, with an extrapolated observance rate of more than 2,500 specimens per m^2. However, near the end of the system in Cell 17, where nutrient concentrations are lowest, more than 1,300 individuals per m^2 are estimated to be in abundance.

From the 18 sediment core samples collected, AOM was positively correlated with time. The highest accumulation rates were observed in Cell 9 with 5.3 cm per year. It is believed that this is because of site management practices. In 2014, Cell 9 underwent a drawdown and consolidation of AOM. The AOM was tilled into the soil as opposed to a complete removal like all other cells sampled in this study except for Cells 6, 10, and

18, which have never undergone a renovation. Except for this anomaly, Cell 1 has the second-highest accretion rate observed at 4.8 cm per year. This may suggest that continual flow of nutrients is accelerating productivity and thereby accelerating AOM production in the initial treatment cells.

As AOM builds within the OEW system, it can pose several significant problems. The renovation projects which will continue into perpetuity as part of the OEW's maintenance are extremely effective at removing AOM and associated P. In the case of Cell 13 which was renovated in 2019, only 1.8% of the sediment samples were organic in nature. Given the disruptive nature of the demucking projects it was assumed that AOM and biodiversity would be low following a cell renovation project. However, a total of 20 species were sampled in Cell 13 (with 0 cm of AOM and only 15 weeks following reflooding). This is the same number of taxa that was represented in Cell 1 with more than 91 cm of AOM, although, abundance in Cell 1 was greater. This is encouraging as the OEW's treatment cells rapidly recolonize with a diversity of aquatic species providing resources for consumers higher on the food chain thus helping to maintain the entire wetland ecosystem.

The data revealed that within the treatment cells after about 11 years of operational life, approximately 50% of the sediments are organic in nature. And even as the AOM depth accumulates, high biodiversity still exists as was the case with Cell 10 which has been accumulating organic matter for more than 33 years. So, it seems that in the OEW system, AOM neither degrades nor enhances biodiversity.

As expected, water quality within the OEW follows a gradient, with higher concentrations of N and P in the upstream cells and lower concentrations near the wetland's effluent. TN and TP averaged 1.39 and 0.2 mg/L in influent Cell 1 and 0.87 and 0.08 mg/L in effluent Cell 17, respectively.

Dip-net sampling showed that Cell 1 had the highest abundance of invertebrates with 749 individuals, along with the lowest diversity. As such, this cell also had the lowest score for all 3 of the diversity indices that were calculated. Cell 17 had the highest diversity and the highest Shannon and Fisher's Alpha diversity. These data fit with the narrative that diversity is higher in less-polluted waters but what is perplexing is that Cell 10, which has never been demucked in its 33-year history, had good diversity and evenness giving it the highest Simpson's Diversity Index score.

Of all the macroinvertebrates observed, the amphipod *Hyallela azteca* was the most commonly found in the samples. This was also true in 2001 when Christman (2002) of the University of Florida sampled the OEW. This epibenthic amphipod is a primary consumer feeding on feeds on plants, algae, and cyanobacteria (Figueroa-Sánchez et al., 2019) (Thorp & Rogers, 2015). Although, Voshell (2002) asserts that they are omnivores and feed primarily on detritus, which would make sense given the large amounts of detritus and AOM observed within the OEW. This species is of interest to ecotoxicologists as it is the primary crustacean used in North America for sediment toxicity testing (Poynton et al., 2018). High numbers of this organism point to healthy sediments which is the basis for a healthy ecosystem and high biodiversity.

As stated, Cell 1 has the highest nutrient concentrations of the 4 sites sampled, with an average TN and TP concentration of 1.39 and 0.20 mg/L respectively. Cell 10 and Cell 17 had similar diversity and abundance, while Cell 13 displayed the lowest diversity with 14 species represented. Jaccard's similarity coefficient and ordination plots show that all 4 sites are dissimilar from each other with Cells 10 and 17 being the most similar which is interesting given the location of Cell 10 in the middle of the OEW system and Cell 17 at the end.

Abundance data for the macroinvertebrates were compared to water quality data for their respective treatment cells. Chlorophyll-a, CBOD, NH4, OP, TKN, TN, TP, and AOM depth were compared. Of these analytes, CBOD and TN showed strong positive correlations (r^2 = 0.939 and 0.921, respectively) to macroinvertebrate abundance, while NH4 had a moderate (r^2 = 0.612), positive correlation, and AOM, a weak positive correlation (r^2 = 0.532). These data support the idea that macroinvertebrates are more sensitive to pollutants in the water.

For the minnow trapping effort, Cell 10, which has been accumulating AOM for 33 years, had the highest diversity and was the highest rated among both the Shannon and Simpson diversity indices. Cell 13 had the lowest diversity and abundance which was to be expected since it had only been flooded for a period of 6 weeks before the sampling effort. Cell 14, which was reflooded on January 31, 2019, following renovation, had the highest abundance with 946 individuals expected per m^2.

Cell 1 displayed a steep rank/abundance curve evidenced by the Whittaker plot indicating low evenness as the high-ranking species Mosquitofish had much higher abundance than the low-ranking species. This is a similar trend that was observed with the invertebrate amphipod *H. azteca.* Cell 1 and Cell 13 were the most similar, while Cells 13 and 14 were the most dissimilar to each other based on the Jaccard similarity coefficients. And the ordination plot depicted that Cell 13 was the most dissimilar from the other cells. So again, this points to the lack of a correlation in amount of AOM and species diversity or abundance as these cells all had a wide range of organic matter accumulation.

CBOD, NH4, OP, TKN, TP, AOM did not correlate with the abundance of wildlife captured in the minnow traps. Unlike the macroinvertebrates, the traps capture larger more mobile species that have a greater ability to move into areas with better water quality. However, chlorophyll-*a* exhibited a moderate positive correlation ($r^2 = 0.493$). Vanacker et al., (NEED YEAR) found that biodiversity increased up to a tipping point. As chlorophyll-*a* concentrations increased up to that point diversity increased, once that threshold was exceeded, diversity began to decline (2015). However, the tipping points that Moss et al., (2003) and Søndergaard et al., (2005) found were approximately 60 mg/m^3. The OEW's concentrations are well below that level with the highest observed average being 5.37 mg/m^3 measured at the discharge of Cell 13. So, we expect to find that concentrations of chlorophyll-*a* in the OEW do not negatively impact fauna, and in fact help to increase biodiversity at the low concentrations measured. Chlorophyll-*a* is a direct measure of the algae and phytoplankton concentrations in the water and correlates with nutrient concentrations, so it is intuitive that chlorophyll and wildlife are correlated.

CONCLUSION

The data presented within the scope of my paper do not conclusively link water quality with the accretion of organic matter within the OEW. But the data suggest that the accretion of organic matter does not have significant influence on the diversity or abundance of wildlife present. The water quality metrics presented do not provide definitive answers to what is driving the biodiversity within the OEW due to the lack of statistical rigor. But my paper provides interesting insights into the accretion of organic matter across the OEW and how wetland managers systematically remove it, thereby, resetting the renovated cells to time zero as far as AOM is concerned. Wetland renovations are extremely effective at removing organic matter from the soil and very rapid recolonization of macroinvertebrates and larger fauna were observed.

I found that the OEW exhibits high diversity and newly renovated cells recruit and repopulate rapidly. Cell 13, which had been flooded for approximately 6 weeks before sampling, had an extrapolated abundance of 361 specimens per m^2. Cell 14, which had been flooded for 14 months, had the highest abundance at 946 specimens per m^2 of all cells sampled using minnow traps.

It can be inferred that macroinvertebrate abundance is impacted by water quality with TN and CBOD having the greatest influence. These parameters did not have the same correlation on larger, more mobile species such as fish, reptiles, and amphibians that were collected with the use of minnow traps. Ammonia and the depth of accreted organic matter also showed correlations with macroinvertebrates that were not observed with the larger faunal species. Chlorophyll-*a* was the only analyte that had a positive correlation on the abundance of larger wetland animals sampled, suggesting that the productivity of the water column does relate to overall biodiversity.

These data are valuable to constructed wetland treatment system managers as they consider and weigh the ramifications of muck removal projects. These projects are highly disruptive and upset the ecological balance of the marshland undergoing renovation. But it is reassuring that constructed wetlands are becoming increasingly common and that they do offer a high degree of biodiversity. Additional studies are needed to validate and build on the cursory findings of my paper.

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APPENDICES

APPENDIX A

OEW TOTAL PHOSPHORUS AND NITROGEN LOADINGS AND REDUCTIONS

Appendix A. Total Nitrogen Loadings and Reductions Within the OEW

Year	Influent Flow (mgd)	Influent Conc. (mg/l)	Loading In (lbs/day)	Effluent Flow (mgd)	Effluent Conc. (mg/l)	Loading Out (lbs/day)	Percent Reduction from Influent to Effluent
1991	12.90	2.44	262.51	13.40	0.80	89.40	65.9%
1992	12.77	2.74	291.81	11.60	0.74	71.59	75.5%
1993	12.63	2.24	235.95	10.00	0.78	65.05	72.4%
1994	12.42	2.29	237.20	12.52	0.76	79.36	66.5%
1995	15.12	1.96	247.16	8.83	0.68	50.08	79.7%
1996	15.63	1.43	186.41	16.34	0.73	99.48	46.6%
1997	15.22	1.45	184.06	16.67	0.69	95.93	47.9%
1998	14.22	1.82	215.84	13.93	0.84	97.59	54.8%
1999	17.20	2.42	347.14	19.43	0.84	136.12	60.8%
2000	17.45	1.81	263.41	13.69	0.84	95.91	63.6%
2001	17.86	2.14	318.76	16.76	0.88	123.00	61.4%
2002	16.59	1.42	196.47	22.51	0.77	144.55	26.4%
2003	17.36	1.23	178.08	24.87	0.78	161.78	9.2%
2004	17.20	1.44	206.57	21.48	0.92	164.81	20.2%
2005	18.27	1.67	254.46	25.25	0.84	176.89	30.5%
2006	12.68	1.61	170.26	17.63	0.94	138.21	18.8%
2007	12.33	2.38	244.74	14.62	0.98	119.49	51.2%
2008	12.17	2.25	228.37	15.06	1.20	150.72	34.0%
2009	14.14	1.90	224.06	15.39	1.16	148.89	33.6%
2010	15.29	1.94	247.39	18.96	1.01	159.71	35.4%
2011	15.17	2.07	261.89	17.18	1.00	143.28	45.3%
2012	14.33	1.77	211.54	18.11	0.96	145.00	31.5%
2013	14.16	1.70	200.76	19.18	0.89	142.37	29.1%
2014	14.32	1.40	167.20	18.55	0.88	136.14	18.6%
2015	11.80	1.35	132.86	16.57	0.95	131.28	1.2%
2016	12.95	1.66	179.28	16.16	0.80	107.82	39.9%
2017	15.30	2.07	264.14	23.94	0.87	173.70	34.2%
2018	15.75	2.00	262.71	26.02	0.78	169.27	35.6%
2019	16.40	1.88	257.14	21.84	0.61	111.11	56.8%
Average	**14.81**	**1.88**	**230.28**	**17.47**	**0.86**	**125.12**	**43.0%**

Total Phosphorus Loadings and Reductions Within the OEW

Year	Influent Flow (MGD)	Influent Conc. (mg/L)	Influent Loading (lbs/day)	Effluent Flow (MGD)	Effluent Conc. (mg/L)	Effluent Loading (lbs/day)	TP Reduction from Influent to Effluent (%)
1991	12.90	0.23	24.74	13.40	0.09	10.06	59.4%
1992	12.77	0.24	25.56	11.60	0.06	5.80	77.3%
1993	12.63	0.18	18.96	10.00	0.06	5.00	73.6%
1994	12.42	0.20	20.72	12.52	0.05	5.22	74.8%
1995	15.12	0.18	22.70	8.83	0.05	3.68	83.8%
1996	15.63	0.12	15.64	16.34	0.05	6.81	56.4%
1997	15.22	0.14	17.77	16.67	0.04	5.56	68.7%
1998	14.22	0.14	16.13	13.93	0.05	6.27	61.1%
1999	17.20	0.32	45.90	19.43	0.06	9.72	78.8%
2000	17.45	0.30	43.66	13.69	0.06	6.85	84.3%
2001	17.86	0.24	35.75	16.76	0.070	9.78	72.6%
2002	16.59	0.235	32.51	22.51	0.075	14.08	56.7%
2003	17.36	0.207	29.97	24.87	0.070	14.52	51.6%
2004	17.20	0.240	34.48	21.48	0.060	10.75	68.8%
2005	18.27	0.401	61.10	25.25	0.088	18.53	69.7%
2006	12.68	0.330	35.22	17.63	0.129	18.97	46.1%
2007	12.33	0.276	28.38	14.62	0.066	8.05	71.6%
2008	12.17	0.210	21.31	15.06	0.062	7.79	63.5%
2009	14.14	0.153	18.04	15.39	0.041	5.26	70.8%
2010	15.29	0.134	17.09	18.96	0.041	6.48	62.1%
2011	15.17	0.159	20.16	17.18	0.036	5.16	74.4%
2012	14.33	0.194	23.19	18.11	0.036	5.44	76.5%
2013	14.16	0.285	33.66	19.18	0.037	5.92	82.4%
2014	14.32	0.464	55.41	18.55	0.079	12.22	77.9%
2015	11.80	0.247	24.31	16.57	0.075	10.36	57.4%
2016	12.95	0.295	31.86	16.16	0.051	6.87	78.4%
2017	15.30	0.146	18.63	23.94	0.068	13.58	27.1%
2018	15.75	0.154	20.23	26.02	0.049	10.63	47.4%
2019	16.40	0.311	42.54	21.84	0.053	9.65	77.3%
Average	**14.81**	**0.232**	**28.81**	**17.47**	**0.061**	**8.93**	**67.3%**

APPENDIX B

TABLE OF HYDRAULIC OPPORTUNITIES BY CELL

Appendix B. Table of Hydraulic Opportunities by Cell

Table 3.6 Hydraulic Opportunities by Cell

Cell #	Cell Hydraulic Efficiency η_i	Cell Volume V_i (Mgal)	Fraction of Total Volume θ_i	Volume-Based Hydraulic Opportunity γ_i	Cell Area A_i (acres)	Fraction of Total Area ψ_i	Area-Based Hydraulic Opportunity χ_i
1[a]	0.30	18.7	0.043	0.030	57	0.073	0.051
2	0.88	41.8	0.096	0.011	61	0.078	0.009
3	0.52	8.16	0.019	0.009	14	0.018	0.009
4	0.25	8.52	0.019	0.015	14	0.018	0.013
5	0.11	5.55	0.013	0.011	15	0.019	0.017
6	0.71	10.4	0.024	0.007	15	0.019	0.006
7	0.20	17.7	0.040	0.032	29	0.037	0.030
8	0.42	7.84	0.018	0.010	30	0.038	0.022
9	0.30	8.56	0.020	0.014	27	0.034	0.024
10	0.57	16.5	0.038	0.016	28	0.036	0.015
11	0.49	58.1	0.133	0.068	58	0.074	0.038
12	0.69	34.7	0.079	0.025	60	0.076	0.024
13	0.40[b]	83.4[b]	0.191	0.114	128	0.163	0.098
14	0.45[b]	74.9[b]	0.171	0.094	115	0.146	0.081
15	0.74	42.6	0.097	0.025	134	0.171	0.044
		V_T= 437.4		γ_T= 0.480	A_T= 785		χ_T=0.479

a: From 3rd experiment (11/17/00).

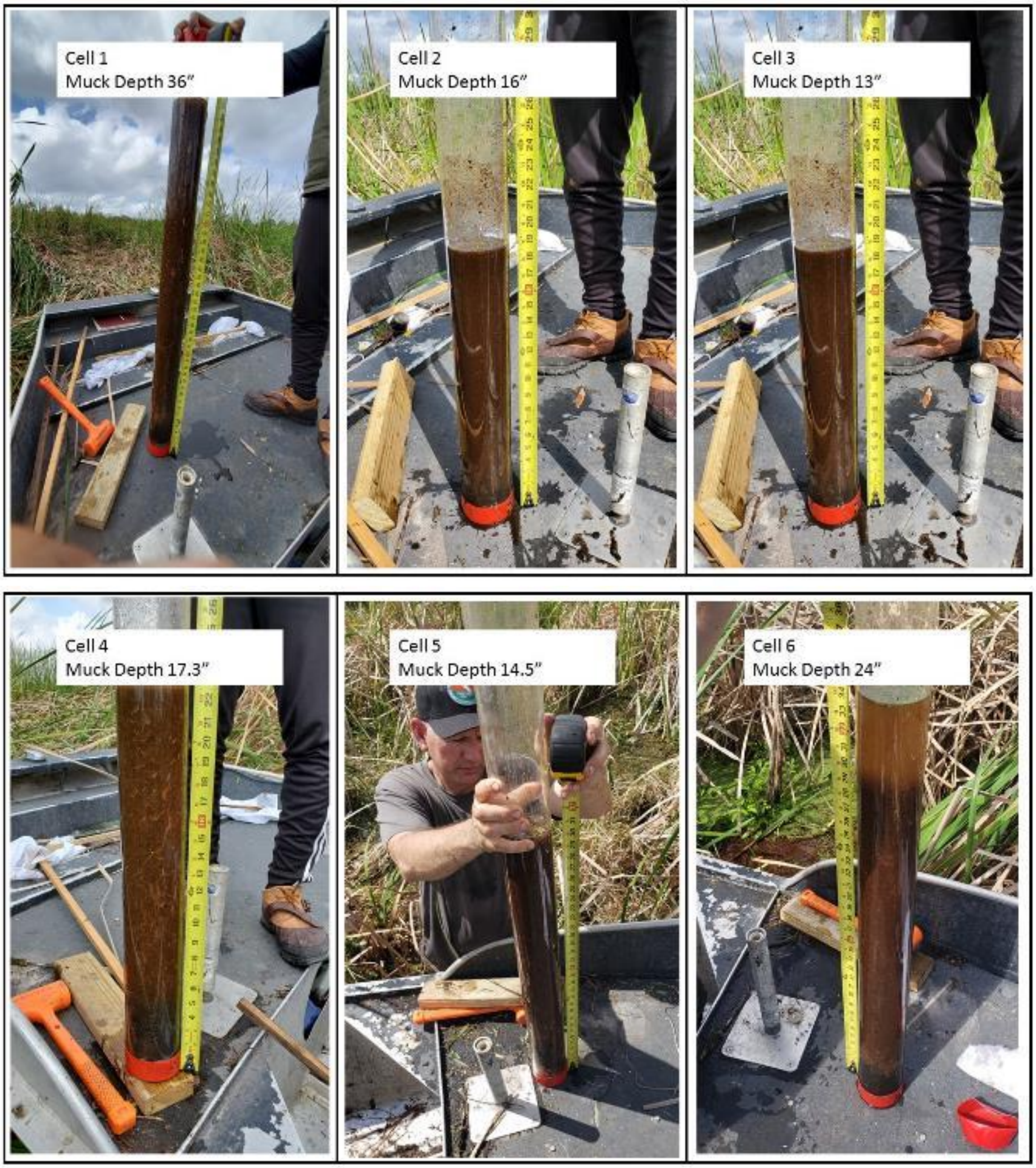
b: Values are assuming two feet average depth in these cells.

From: Christopher J Martinez, and William R Wise. "ANALYSIS OF HYDRAULIC PERFORMANCE OF THE ORLANDO EASTERLY WETLAND CELLS: TRACER STUDY RESULTS." Final Summary Report. University of Florida Gainesville, Florida, July 2001.

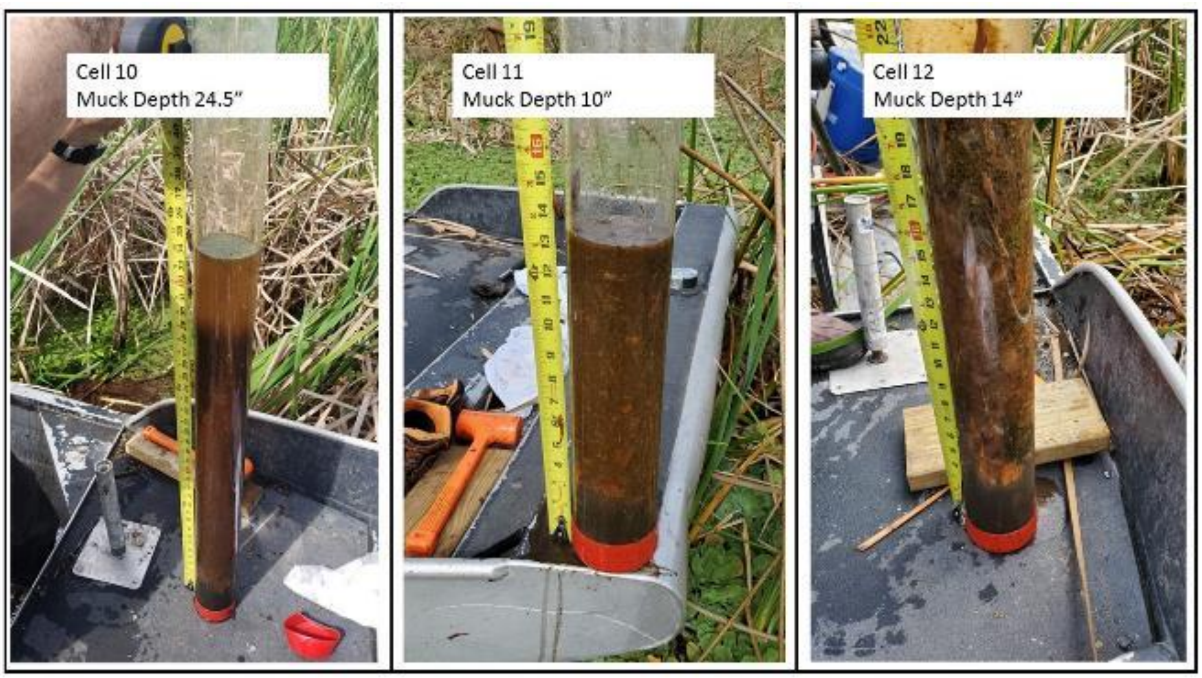
APPENDIX C

CORE SAMPLE PHOTOGRAPHS OF ALL 18 OEW TREATMENT CELLS

Appendix C. Core Sample Reference Photographs



Appendix C. Core Sample Reference Photographs Continued



Appendix C. Core Sample Reference Photographs Continued

APPENDIX D

CORE SAMPLE GPS LOCATIONS AND MEASUREMENTS TABLE

Appendix D. Core Sample GPS Locations and Measurements Table

Cell	Latitude	Longitude	Accreted Organic Matter (inch)	Accretion Rate (in/yr)	Years Since Demucking	Year of Renovation	Notes
1	28°34'29.45"N	81° 0'39.27"W	36	1.89	19	2001	
2	28°34'14.82"N	81° 0'18.73"W	16	1.33	12	2008	
3	28°34'38.57"N	81° 0'39.54"W	16	0.84	19	2001	
4	28°34'30.28"N	81° 0'27.31"W	17.3	0.91	19	2001	
5	28°34'20.92"N	81° 0'16.08"W	14.5	1.21	12	2008	
6	28°34'14.14"N	81° 0'6.14"W	24	1.71	14	2006	
7	28°34'48.12"N	81° 0'40.56"W	26	1.37	19	2001	
8	28°34'37.75"N	81° 0'26.44"W	19	1.00	19	2001	
9	28°34'27.42"N	81° 0'14.52"W	12.5	2.08	6	2014	Cell was dried and then disked, not demucked
10	28°34'17.51"N	80°59'58.84"W	24.5	0.74	33	1987	This cell has never been demucked
11	28°34'3.89"N	81° 0'29.25"W	10	0.91	11	2009	
12	28°33'56.73"N	81° 0'27.68"W	14	1.00	14	2006	
13	28°34'50.98"N	81° 0'8.72"W	0	NA	1	2019	
14	28°34'36.38"N	80°59'55.38"W	0.25	0.13	2	2018	
15	28°33'50.25"N	80°59'56.02"W	4.25	1.06	4	2016	
16A	28°34'25.91"N	80°59'35.15"W	7.25	0.81	9	2011	
16B			5.5	0.92	6	2014	
17	28°34'44.23"N	80°59'20.87"W	21.25	1.63	13	2007	
18	28°34'18.20"N	80°59'50.22"W	20.5	0.62	33	1987	This cell has never been demucked

APPENDIX E

HESTER DENDY SAMPLING METHODS AND RESULTS

Appendix E. Hester Dendy Sampling Methods and Results

Within the 4 biota sampling cells (1, 10, 13 & 17), Hester Dendy artificial substrate samplers constructed of eight 7.6 cm^2 Masonite® squares, 3.2 mm thick, assembled with threaded rod, were suspended in the water column at mid-depth. Each sampler provided a surface area of 0.03 m^2. Four artificial substrate samplers were installed at each site and left in place for a period of six weeks (February 12 – March 23) following protocols articulated in Waters et al., 2005. Quiescent zones within the treatment cells were selected to avoid scoured or rapidly flowing areas near control structures. The Hester Dendy samplers were deployed at ½ of the measured water depth (56-91 cm) for each of the 4 treatment cell deployment locations.

At the end of the six weeks, the Hester Dendy samplers were bagged, transported, and disassembled at the lab with all parts of the samplers washed and scraped using purified, deionized water into large collection tubs. Samples were then subdivided for easier handling, identification, and enumeration. All specimens were identified, enumerated and recorded using a National Optical 410 Stereo Microscopes with 10x to 30x magnification. The taxonomic resolution of the invertebrates identification was limited to at least order-level based on physio-morphic characteristics and to the family-level where possible.

During the collection, it was noted that all samplers deployed in Cells 1 and 10 were completely covered with detritus and organic matter. In Cell 17, 3 of the 4 samplers were covered and none of the samplers in Cell 13 were covered. It is believed that this covering significantly degraded the quality of the plates to be colonized by macroinvertebrates. This resulted in lower than expected numbers of diversity and abundance. Cell 1 was comprised of 8 individuals representing 3 species, Cell 10 had 3 individuals and only 1 species and Cell 17 found 21 individuals representing 6 species. Cell 13 experienced favorable colonization of the sampler plates with 82 individuals and 10 species represented. It is believed that only the Cell 13 sample is valid because of the clean condition (no detritus) of the samplers when retrieved. Also, the Cell 13 samples had numbers that more closely matched what would be expected in a freshwater marsh. The results from the Hester Dendy macroinvertebrate sampling are presented in Table 1.

Table 1. Hester Dendy sampler macroinvertebrate results

	Cell 1	Cell 10	Cell 13	Cell 17
Number of Species	3	1	10	6
Number of Individuals	8	3	82	21
Extrapolated Abundance per m^2	266	100	2731	699
Shannon Diversity Index	1.04	0	1.8	1.26
Simpson Diversity Index	0.63	1	0.78	0.59
Fisher's Alpha Diversity Index	1.74	0.53	2.99	2.81

No further analysis of this data was made. Following the disappointing results of this effort, dip net sampling was employed at the 4 sites to obtain macroinvertebrate diversity and abundance measurements.

APPENDIX F

REFERENCE PHOTOGRAPHS OF ALL SPECIES COLLECTED IN MINNOW TRAPS

Appendix F. Reference Photographs of all Species Collected in Minnow Traps

Pig Frog *(Lithobates grylio)*

Crayfish (*Procambarus alleni*)

Northern Florida Swampsnake (*Seminatrix pygaea pygaea*)

Banded Watersnake (*Nerodia fasciata*)

Glossy Crayfish Snake (*Regina rigida*)

Southern Leopard Frog (*Lithobates sphenocephalus*)

Predacious Diving Beetle
(Cybister fimbriolatus)

Giant Water Bug
(*Belostoma lutarium*)

Dragonfly Nymph
(Anax sp.)

Giant Water Scavenger Bug
(*Hydrophilus triangularis*)

Least killifish (*Heterandria Formosa*)

Bluefin killifish (*Lucania goodei*)

Western Killifish (*Gambusia affinis)*

Golden Topminnow (*Fundulus chrysotus*)

Sailfin Molly (*Poecilia latipinna*)

American Flagfish
(*Jordanella floridae)*

Pirate Perch (*Aphredoderus sayanus*)

Peninsula Newt
(*Notopthalmus viridescens piaropicola*)

Freshwater Leech
(*Xironodrilus appalachius*)

Southern Leopard Frog (*Lithobates sphenocephalus*)

Eastern Lesser Siren (*Siren intermedia complex*)

Grass Shrimp (*Palaemonetes paludosus*)

APPENDIX G

WATER QUALITY DATA FROM 2016 THROUGH 2019 FOR CELLS 1, 10, 13 AND 17 INFLUENT AND EFFLUENT

Appendix G. Water Quality Data from 2016 through 2019 for Cells 1, 10, 13, and 17 Influent and Effluent.

Orlando Easterly Wetlands
2016 - 2019 Internal Water Quality
Sample Point: Cell 1 In

Date	ALK	CBOD	CHLORO	CL	CON	DO	NH3	NH3U	NOX	OP	PH	SO4	STOC	TDS	TEMP	TKN	TN	TP	TSS
	mg/L	mg/L	mg/m^3	mg/L	uhmos	mg/L	mg/L	mg/L	mg/L	mg/L	s.u.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1/5/2016	140	< 2.0	< 0.80	78	568	7.03	0.03	< 0.01	0.46	0.160	7.34	21.8	7.44	320	25.5	0.91	1.37	0.162	< 1.0
2/2/2016	125	< 2.0	< 0.80	70	521	7.49	0.02	< 0.01	0.96	0.584	7.14	23.4	8.12	280	24.4	1.13	2.09	0.614	< 1.0
3/15/2016	138	< 2.0	< 0.80	81	603	6.10	0.06	< 0.01	1.06	0.085	7.17	26.1	6.42	348	26.0	0.84	1.90	0.395	< 1.0
4/5/2016	136	< 2.0	< 0.80	77	591	7.25	0.06	< 0.01	0.56	0.252	7.24	25.1	5.89	318	26.6	0.89	1.45	0.259	< 1.0
5/17/2016	149	< 2.0	< 0.80	84	656	6.72	0.02	< 0.01	0.57	0.240	7.34	22.6	5.97	346	28.4	0.74	1.31	0.228	< 1.0
6/14/2016	139	< 2.0	< 0.80	79	623	5.64	0.07	< 0.01	0.37	0.271	6.81	23.4	6.24	322	29.7	0.66	1.03	0.273	< 1.0
7/5/2016	128	< 2.0	1.51	78	637	7.52	0.06	< 0.01	0.88	0.243	7.28	25.0	6.87	310	30.7	0.61	1.49	0.283	< 1.0
8/2/2016	143	< 2.0	< 0.80	86	687	4.88	0.07	< 0.01	0.46	0.291	7.36	23.5	5.58	342	30.1	0.71	1.17	0.284	< 1.0
9/6/2016	108	< 2.0	< 0.80	67	564	5.71	0.05	< 0.01	2.09	0.122	7.00	24.8	7.33	290	30.1	0.81	2.90	0.149	< 1.0
10/4/2016	125	< 2.0	< 0.80	72	582	5.51	0.02	< 0.01	0.72	0.379	7.02	23.7	6.30	316	30.0	0.71	1.43	0.424	< 1.0
11/8/2016	134	< 2.0	< 0.80	78	607	6.68	0.02	< 0.01	0.49	0.445	7.15	23.7	5.56	314	27.7	0.78	1.27	0.450	< 1.0
12/6/2016	146	< 2.0	< 0.80	73	608	6.47	0.07	< 0.01	0.26	0.615	7.18	23.3	5.83	272	27.0	0.89	1.15	0.591	< 1.0
1/10/2017	138	< 2.0	< 0.80	78	579	7.59	0.02	< 0.01	2.15	0.245	7.16	23.6	6.13	336	24.6	1.18	3.33	0.240	< 1.0
1/17/2017	NS	NS	NS	NS	ND	ND	NS	NS	NS	NS	ND	NS	NS	NS	ND	NS	NS	NS	NS
2/14/2017	153	< 2.0	< 0.80	80	587	6.8	0.02	< 0.01	1.18	0.28	7.15	23.2	6.08	340	25.5	0.80	1.98	0.307	< 2.0
3/14/2017	139	< 2.0	< 0.80	80	611	6.78	0.02	< 0.01	0.78	0.086	7.28	23.7	5.98	338	26.1	0.70	1.48	0.101	< 1.0
4/5/2017	146	< 2.0	< 0.80	84	643	7	0.05	< 0.01	0.28	0.161	7.26	25.4	8.79	360	27.2	0.76	1.04	0.180	< 1.0
5/9/2017	146	< 2.0	< 0.80	82	637	5.42	0.07	< 0.01	1.06	0.067	7.4	22.9	5.98	246	27.6	0.71	1.77	0.082	< 1.0
6/13/2017	124	< 2.0	< 0.80	74	603	6.52	0.02	< 0.01	1.77	0.061	7.09	23.2	5.97	214	29.2	0.66	2.43	0.072	< 1.0
7/11/2017	116	< 2.0	< 0.80	68	583	6.29	0.04	< 0.01	3.47	0.054	7.02	22.4	6.88	288	30.3	0.78	4.25	0.083	< 1.0
8/7/2017	110	< 2.0	< 0.80	71	581	6.55	0.04	< 0.01	1.65	0.082	7.16	22.5	6.5	298	30.3	0.70	2.35	0.113	< 1.0
8/14/2017	NS	NS	NS	NS	ND	ND	NS	NS	NS	NS	ND	NS	NS	298	ND	NS	NS	NS	NS
9/19/2017	96	< 2.0	< 0.80	60	565	5.91	0.03	< 0.01	2.04	0.06	7.08	27.5	7.64	274	29.6	0.67	2.71	0.065	< 1.0
9/21/2017	NS	NS	NS	NS	536	7.08	0.05	< 0.01	2.25	0.052	7.32	NS	NS	NS	29.7	0.90	3.15	0.079	NS
10/3/2017	115	< 2.0	< 0.80	66	548	6.03	0.04	< 0.01	1.73	0.044	7.42	25.5	5.99	284	29.5	0.62	2.35	0.073	< 1.0
11/7/2017	130	< 2.0	< 0.80	71	ND	ND	0.07	< 0.01	1	0.063	7.17	23.2	6.16	324	28.5	0.72	1.72	0.062	< 1.0
n off line and	135	< 2.0	< 0.80	69	588	6.85	0.04	< 0.01	0.57	0.074	7.16	25.9	6.62	334	26.7	0.87	1.44	0.109	< 1.0
12/14/2017	NS	NS	NS	NS	515	8.41	0.05	< 0.01	1.69	0.068	7.29	NS	NS	NS	25.2	0.96	2.65	0.098	NS
1/9/2018	133	< 2.0	< 0.80	78	549	6.87	0.04	< 0.01	1.25	0.079	6.94	25.7	6.75	292	23.6	0.91	2.16	0.110	< 1.0
2/6/2018	137	< 2.0	< 0.80	76	527	7.02	0.03	< 0.01	0.85	0.175	7.03	24.3	6.96	300	24.4	0.80	1.65	0.196	< 1.0
3/5/2018	142	< 2.0	< 0.40	95	622	7.08	0.05	< 0.01	0.65	0.113	7.16	24.9	6.72	336	25.9	0.81	1.46	0.166	< 2.0
4/16/2018	141	< 2.0	1.07	81	620	6.16	1.35	0.01	1.31	0.544	7.09	25.4	9.19	262	27.3	2.98	4.29	0.545	< 1.0
5/1/2018	138	< 2.0	< 0.80	72	610	5.66	0.04	< 0.01	0.37	0.123	7.23	25.5	6.72	234	27.4	1.04	1.41	0.117	< 1.0
6/5/2018	121	< 2.0	< 0.80	73	577	6.15	0.04	< 0.01	1.07	0.111	7.1	25.1	6.7	290	23.9	0.96	2.03	0.123	< 1.0
7/17/2018	125	< 2.0	1.07	76	607	5.96	0.02	< 0.01	1.39	0.112	7.12	23.2	6.31	340	30.3	1.19	2.58	0.164	2.4
8/7/2018	117	< 2.0	< 0.80	72	593	6.7	< 0.01	< 0.01	2.11	0.077	7.02	24.9	6.46	284	30.3	1.26	3.37	0.098	< 1.0
9/11/2018	109	< 2.0	< 0.80	73	562	5.58	0.03	< 0.01	2.49	0.082	6.95	25.1	7.37	330	29.9	1.06	3.55	0.096	< 1.0
10/16/2018	134	< 2.0	< 0.80	73	630	6.17	0.04	< 0.01	0.62	0.155	7.12	25	6.45	328	29.9	0.79	1.41	0.201	< 1.0
11/7/2018	134	< 2.0	< 0.80	82	631	6.63	0.05	< 0.01	0.66	0.109	7.05	25.1	6.61	326	21.9	0.79	1.45	0.151	< 1.0
12/4/2018	134	< 2.0	< 0.80	84	622	6.16	0.04	< 0.01	0.38	0.232	7.02	24.3	6.41	224	27.2	0.69	1.07	0.268	< 1.0
1/8/2019	135	< 2.0	< 0.80	88.8	557	6.07	0.05	< 0.01	0.27	0.307	7.05	25.5	6.75	294	25.5	0.75	1.02	0.328	< 1.0
2/12/2019	124	< 2.0	1.07	76.1	559	7.29	0.10	< 0.01	1.69	0.227	7.04	24.7	7.39	320	25.1	1.06	2.75	0.271	< 1.0
3/5/2019	134	< 2.0	< 0.80	80.7	600	ND	0.09	< 0.01	0.78	0.368	7.09	25.4	7.50	334	26.4	1.08	1.86	0.370	< 1.0
4/2/2019	132	< 2.0	4.81	119.0	590	ND	0.09	< 0.01	0.22	0.409	7.13	25.3	7.12	412	26.6	0.84	1.06	0.448	< 1.0
5/7/2019	129	< 2.0	< 0.80	82.4	ND	7.11	0.09	< 0.01	0.30	0.414	7.15	25.9	6.67	332	28.5	0.69	0.99	0.428	< 1.0
6/4/2019	131	< 2.0	8.01	86.2	615	3.45	0.16	< 0.01	0.81	0.295	7.19	25.8	6.59	340	29.8	1.16	1.97	0.305	1.6
7/9/2019	110	< 2.0	1.07	71.7	ND	6.06	0.11	< 0.01	1.76	0.336	6.93	25.0	7.01	292	30.4	0.92	2.68	0.303	< 1.0
8/6/2019	110	< 2.0	< 0.80	73.9	573	5.48	0.11	< 0.01	1.71	0.307	6.94	25.3	7.02	296	30.2	0.96	2.67	0.335	< 1.0
9/10/2019	114	< 2.0	1.60	67.5	598	5.80	0.16	< 0.01	2.94	0.125	7.06	23.9	6.75	308	30.6	1.09	4.03	0.190	5.4
10/16/2019	126	< 2.0	1.07	69.7	587	6.30	0.06	< 0.01	1.33	0.252	7.55	24.8	6.55	310	29.5	0.73	2.06	0.227	< 1.0
11/12/2019	119	< 2.0	< 0.80	76.8	ND	7.05	0.04	< 0.01	1.83	0.144	6.38	27.9	6.61	294	28.1	0.74	2.57	0.182	< 1.0
12/3/2019	130	< 2.0	< 0.80	71.9	ND	7.47	0.03	< 0.01	1.21	0.093	6.72	29.8	6.61	306	27.9	0.98	2.19	0.119	< 1.0
Average	130	< 2.0	< 1.09	77	592	6.44	0.08	< 0.01	1.17	0.205	7.12	24.7	6.70	308	27.7	0.90	2.07	0.230	< 0.0

Orlando Easterly Wetlands
2016 - 2019 Internal Water Quality
Sample Point: Cell 1 Effluent

Date	CBOD mg/L	CHLOR mg/m^3	CL mg/L	CON uhmos	DO mg/L	NOX mg/L	OP mg/L	PH s.u.	TEMP mg/L	TKN mg/L	TN mg/L	TP mg/L	TSS mg/L
1/5/2016	< 2.0	0.99	509	0.17	0.03	0.01	0.016	7.02	18.0	0.72	0.73	0.046	< 1.0
2/2/2016	< 2.0	< 0.80	459	0.58	0.02	0.01	0.263	6.94	17.7	1.12	1.13	0.301	< 1.0
3/15/2016	< 2.0	0.90	559	0.31	0.06	< 0.01	0.236	6.77	21.8	0.66	0.66	0.257	< 1.0
11/8/2016	< 2.0	< 0.80	552	0.25	0.02	< 0.01	0.241	6.96	21.7	0.59	0.59	0.257	< 1.0
12/6/2016	< 2.0	< 0.80	545	0.09	0.03	< 0.01	0.335	6.81	20.5	0.57	0.57	0.342	< 1.0
1/10/2017	< 2.0	< 0.80	472	0.64	< 0.01	< 0.01	0.439	6.84	14.9	0.66	0.66	0.442	< 1.0
2/14/2017	< 2.0	0.85	531	0.35	< 0.01	< 0.01	0.295	6.97	18.2	0.60	0.6	0.318	5.0
4/4/2017	< 2.0	1.71	600	0.17	0.01	< 0.01	0.203	6.91	22.4	0.65	0.65	0.218	< 1.0
5/9/2017	< 2.0	0.85	596	0.64	0.04	< 0.01	0.055	6.78	20.4	0.55	0.55	0.052	< 1.0
6/13/2017	< 2.0	1.07	587	0.16	0.02	< 0.01	0.151	6.9	25.5	0.53	0.53	0.135	3.4
7/11/2017	< 2.0	1.60	568	0.32	0.07	< 0.01	0.052	6.82	27.4	0.56	0.56	0.070	< 1.0
8/7/2017	< 2.0	1.60	544	0.19	0.05	< 0.01	0.194	6.92	27.7	0.59	0.59	0.177	< 1.0
10/3/2017	< 2.0	< 0.80	487	0.20	0.07	< 0.01	0.146	6.94	25.7	0.50	0.5	0.157	< 1.0
11/7/2017	< 2.0	< 0.80	ND	ND	0.07	< 0.01	0.070	6.81	21.7	0.63	0.63	0.080	< 1.0
12/4/2017	< 2.0	< 0.80	511	1.91	0.04	< 0.01	0.066	6.84	18.8	0.53	0.53	0.076	< 1.0
1/9/2018	< 2.0	< 0.80	434	2.62	0.07	0.33	0.043	6.90	12.3	0.70	1.03	0.066	< 1.0
2/6/2018	< 2.0	< 0.80	450	1.09	< 0.01	0.01	0.184	6.80	16.4	0.48	0.49	0.180	< 1.0
3/5/2018	< 2.0	0.43	479	1.36	0.04	< 0.01	0.024	6.78	15.1	0.61	0.61	0.073	< 2.0
4/16/2018	< 2.0	< 0.80	558	0.53	0.07	< 0.01	0.098	6.90	21.1	0.82	0.82	0.104	1.3
5/1/2018	< 2.0	< 0.80	555	0.28	0.02	< 0.01	0.031	6.76	21.6	0.89	0.89	0.030	< 1.0
6/5/2018	< 2.0	1.28	559	0.15	0.03	< 0.01	0.042	6.71	27.2	0.88	0.88	0.046	< 1.0
7/17/2018	< 2.0	2.14	572	0.59	< 0.01	< 0.01	0.064	6.70	27.4	1.22	1.22	0.119	5.6
8/7/2018	< 2.0	1.07	559	0.27	0.05	< 0.01	0.092	6.83	27.9	1.38	1.38	0.117	< 1.0
9/11/2018	< 2.0	1.60	510	0.27	0.07	< 0.01	0.135	6.87	27.3	0.72	0.72	0.163	< 1.0
10/16/2018	< 2.0	1.07	601	0.16	0.07	< 0.01	0.114	6.85	25.7	0.58	0.58	0.128	< 1.0
11/7/2018	< 2.0	1.60	585	0.31	0.06	< 0.01	0.233	6.89	24.3	0.60	0.60	0.225	< 1.0
Cell 17 In is ad	< 2.0	1.60	568	0.48	0.04	< 0.01	0.331	6.98	22.9	0.62	0.62	0.368	2.2
1/8/2019	< 2.0	< 0.80	503	0.59	0.04	< 0.01	0.134	6.89	18.8	0.48	0.48	0.159	< 1.0
2/12/2019	< 2.0	< 0.80	520	1.17	0.16	< 0.01	0.245	6.86	20.9	0.65	0.65	0.218	1.3
3/5/2019	< 2.0	< 0.80	551	ND	0.07	< 0.01	0.266	6.87	21.7	0.84	0.84	0.273	< 1.0
4/2/2019	< 2.0	< 0.80	541	ND	0.06	< 0.01	0.357	6.95	20.9	0.59	0.59	0.367	< 1.0
5/7/2019	< 2.0	< 0.80	ND	0.01	0.09	< 0.01	0.482	6.92	24.2	0.61	0.61	0.521	< 1.0
6/4/2019	2.7	1.60	605	0.32	0.07	< 0.01	0.287	6.66	25.5	0.77	0.77	0.401	< 1.0
7/9/2019	< 2.0	1.07	ND	0.10	0.11	< 0.01	0.274	6.76	26.9	0.70	0.7	0.308	< 1.0
8/6/2019	< 2.0	1.60	555	0.14	0.12	< 0.01	0.355	6.83	27.4	0.62	0.62	0.332	< 1.0
9/10/2019	< 2.0	1.07	561	0.09	0.18	< 0.01	0.237	6.04	27.8	0.55	0.55	0.238	1.0
10/16/2019	< 2.0	1.07	543	0.32	0.07	< 0.01	0.320	6.81	24.6	0.49	0.49	0.346	< 1.0
11/12/2019	< 2.0	1.07	ND	0.43	0.05	< 0.01	0.098	6.39	22.8	0.62	0.62	0.113	< 1.0
12/3/2019	< 2.0	< 0.80	ND	0.63	0.02	< 0.01	0.109	6.71	17.4	0.55	0.55	0.108	< 1.0
Average	**< 2.0**	**< 1.08**	**536.5**	**0.54**	**< 0.04**	**< 0.02**	**0.154**	**6.86**	**21.9**	**0.70**	**0.72**	**0.168**	**< 1.5**

Orlando Easterly Wetlands
2016 - 2019 Water Quality Data
Sample Point: Cell 10 In

Date	CBOD mg/L	CHLORO mg/m^3	CON uhmos	DO mg/L	NH3 mg/L	NOX mg/L	OP mg/L	PH s.u.	TEMP mg/L	TKN mg/L	TN mg/L	TP mg/L	TSS mg/L
1/6/2016	< 2.0	1.67	517	1.71	0.01	< 0.01	0.104	7.08	17.0	0.62	0.62	0.128	< 1.0
2/3/2016	< 2.0	1.06	488	1.19	0.04	0.01	0.220	6.88	19.8	0.51	0.52	0.215	< 1.0
3/15/2016	< 2.0	< 0.80	561	1.30	0.05	< 0.01	0.200	6.94	22.2	0.68	0.68	0.247	< 1.0
4/6/2016	< 2.0	< 0.80	540	0.72	0.04	< 0.01	0.230	6.99	20.7	0.60	0.60	0.230	< 1.0
5/18/2016	< 2.0	1.01	597	0.54	0.04	< 0.01	0.208	6.99	24.2	0.70	0.70	0.277	< 1.0
6/15/2016	< 2.0	1.52	637	0.14	0.07	< 0.01	0.344	6.95	27.2	0.64	0.64	0.367	< 1.0
7/6/2016	< 2.0	< 0.80	643	0.19	0.04	< 0.01	0.276	6.80	28.5	0.68	0.68	0.331	< 1.0
9/7/2016	< 2.0	1.55	597	0.29	0.09	< 0.01	0.193	6.91	26.0	0.68	0.68	0.250	< 1.0
10/5/2016	< 2.0	1.82	581	0.42	0.10	< 0.01	0.213	6.88	26.1	0.56	0.56	0.242	< 1.0
11/10/2016	< 2.0	0.97	535	0.55	0.07	< 0.01	0.262	6.94	20.5	0.78	0.78	0.259	< 1.0
12/7/2016	< 2.0	0.81	532	0.77	0.05	0.01	0.485	7.02	21.1	0.75	0.76	0.482	< 1.0
1/11/2017	< 2.0	0.85	486	2.64	0.03	0.02	0.382	6.82	15.2	0.79	0.81	0.386	< 1.0
2/15/2017	< 2.0	0.85	522	1.44	0.02	< 0.01	0.453	6.88	18.8	0.36	0.36	0.403	< 1.0
4/5/2017	< 2.0	2.14	596	0.56	0.04	< 0.01	0.249	6.99	22.5	0.66	0.66	0.281	3.2
5/10/2017	< 2.0	< 0.80	604	0.73	0.04	< 0.01	0.033	6.80	20.2	0.49	0.49	0.053	< 1.0
6/14/2017	< 2.0	< 0.80	573	0.39	0.01	< 0.01	0.159	6.90	25.2	0.42	0.42	0.173	< 1.0
7/12/2017	< 2.0	1.60	569	0.36	0.04	< 0.01	0.048	6.72	27.3	0.60	0.60	0.042	< 1.0
8/8/2017	< 2.0	0.85	556	0.47	0.03	0.03	0.128	6.83	29.0	0.54	0.57	0.134	< 1.0
10/4/2017	< 2.0	< 0.80	491	0.36	0.04	< 0.01	0.088	7.03	24.6	0.49	0.49	0.093	1.4
11/8/2017	< 2.0	0.85	NS	NS	0.06	< 0.01	0.066	7.07	21.8	0.58	0.58	0.069	< 1.0
12/6/2017	< 2.0	< 0.80	524	1.82	0.03	0.04	0.093	6.98	19.4	0.58	0.62	0.092	< 1.0
1/10/2018	< 2.0	1.60	468	1.49	0.03	0.21	0.088	7.04	15.7	0.68	0.89	0.102	< 1.0
2/7/2018	< 2.0	1.07	514	0.95	< 0.01	0.03	0.152	6.84	17.3	0.79	0.82	0.163	< 1.0
3/7/2018	< 2.0	1.28	541	0.84	0.03	< 0.01	0.090	6.93	18.1	0.60	0.60	0.133	1.5
4/18/2018	< 2.0	0.85	542	0.66	0.03	< 0.01	0.020	6.95	19.1	1.01	1.01	0.042	< 1.0
5/2/2018	< 2.0	< 0.80	557	0.27	0.03	< 0.01	0.012	6.71	20.9	0.77	0.77	0.032	< 1.0
Cell 17 In is a	< 2.0	< 0.80	553	0.16	0.02	< 0.01	0.023	6.84	27.0	0.69	0.69	< 0.030	< 1.0
7/18/2018	< 2.0	1.60	562	0.31	< 0.01	< 0.01	0.033	6.78	27.4	0.67	0.67	0.054	< 1.0
8/8/2018	< 2.0	< 0.80	552	0.31	0.02	< 0.01	0.045	6.79	27.8	1.10	1.10	0.038	< 1.0
9/26/2018	< 2.0	< 0.80	566	0.36	0.01	< 0.01	0.116	6.93	26.0	0.64	0.64	0.114	< 1.0
10/17/2018	< 2.0	2.14	585	0.20	0.02	< 0.01	0.184	6.75	24.7	0.54	0.54	0.185	< 1.0
11/14/2018	< 2.0	1.60	597	0.43	0.03	0.01	0.196	6.82	23.3	0.48	0.49	0.193	1.3
12/5/2018	< 2.0	< 0.80	499	1.28	0.03	0.02	0.088	7.00	17.1	0.52	0.54	0.104	< 1.0
1/9/2019	< 2.0	2.14	486	1.88	0.04	0.03	0.189	6.88	17.0	0.55	0.58	0.206	2.3
2/13/2019	< 2.0	1.60	419	1.08	0.04	0.01	0.236	6.78	18.8	0.81	0.82	0.303	< 1.0
3/6/2019	< 2.0	1.07	481	ND	0.06	< 0.01	0.233	6.95	15.6	0.53	0.53	0.221	< 1.0
4/3/2019	< 2.0	1.07	508	ND	0.09	0.01	0.360	7.02	18.1	0.58	0.59	0.349	< 1.0
5/8/2019	< 2.0	< 0.80	ND	0.38	0.09	< 0.01	0.380	7.07	23.8	0.57	0.57	0.368	1.0
6/5/2019	< 2.0	1.07	653	0.25	0.04	< 0.01	0.376	6.90	26.4	0.59	0.59	0.371	< 1.0
7/10/2019	< 2.0	< 0.80	537	0.35	0.08	< 0.01	0.195	6.93	26.4	0.57	0.57	0.211	< 1.0
8/7/2019	< 2.0	< 0.80	550	0.31	0.13	< 0.01	0.279	6.96	26.7	0.64	0.64	0.269	< 1.0
9/11/2019	< 2.0	1.07	546	0.10	0.14	< 0.01	0.274	6.95	27.1	0.49	0.49	0.244	2.0
10/17/2019	< 2.0	< 0.80	560	0.50	0.05	< 0.01	0.406	7.21	24.4	0.46	0.46	0.425	< 1.0
11/13/2019	< 2.0	< 0.80	ND	1.05	0.03	0.02	0.123	7.15	20.5	0.47	0.49	0.147	< 1.0
12/4/2019	< 2.0	< 0.80	ND	3.40	0.02	0.04	0.120	7.60	14.0	0.50	0.54	0.122	< 1.0
Average	< 2.0	< 1.11	547.0	0.79	< 0.04	< 0.02	0.192	6.94	22.2	0.62	0.63	< 0.204	< 1.1

Orlando Easterly Wetlands
2016 - 2019 Water Quality Data
Sample Point: Cell 10 Out

Date	CBOD mg/L	CHLORO mg/m^3	CON uhmos	DO mg/L	NH3 mg/L	NOX mg/L	OP mg/L	PH s.u.	STOC mg/L	TEMP mg/L	TKN mg/L	TN mg/L	TP mg/L	TSS mg/L
1/6/2016	< 2.0	< 0.80	506	3.75	< 0.01	0.01	0.104	7.36	6.87	15.9	0.54	0.55	0.130	< 1.0
2/3/2016	< 2.0	< 0.80	491	2.42	0.05	0.01	0.175	7.37	7.06	19.3	0.50	0.51	0.167	< 1.0
3/15/2016	< 2.0	< 0.80	561	1.27	0.04	< 0.01	0.230	6.95	6.76	22.0	0.65	0.65	0.247	1.5
4/6/2016	< 2.0	1.60	530	1.04	0.04	< 0.01	0.230	6.97	6.11	19.7	0.57	0.57	0.208	2.2
5/18/2016	< 2.0	1.51	554	1.40	0.02	< 0.01	0.117	7.26	8.21	23.2	0.62	0.62	0.080	< 1.0
6/15/2016	< 2.0	1.05	639	0.78	0.03	< 0.01	0.133	7.03	7.20	26.4	0.50	0.50	0.162	< 1.0
7/6/2016	< 2.0	< 0.80	647	3.78	0.03	< 0.01	0.183	6.97	8.18	28.1	0.66	0.66	0.204	< 1.0
9/7/2016	< 2.0	< 0.80	595	0.46	0.03	< 0.01	0.154	7.04	6.80	25.0	0.64	0.64	0.188	< 1.0
10/5/2016	< 2.0	< 0.80	564	0.71	0.03	< 0.01	0.224	6.99	6.71	25.0	0.41	0.41	0.220	< 1.0
11/10/2016	< 2.0	< 0.80	519	1.89	< 0.01	< 0.01	0.243	6.86	5.52	19.2	0.66	0.66	0.239	< 1.0
12/7/2016	< 2.0	< 0.80	509	1.67	0.05	< 0.01	0.528	6.97	6.76	20.0	1.03	1.03	0.490	1.0
1/11/2017	< 2.0	< 0.80	478	3.97	0.02	< 0.01	0.404	7.01	5.62	14.2	0.81	0.81	0.380	< 1.0
2/15/2017	< 2.0	< 0.80	514	2.57	< 0.01	< 0.01	0.371	7.01	NS	18.2	0.56	0.56	0.356	< 1.0
4/5/2017	< 2.0	1.28	587	0.11	0.03	< 0.01	0.306	7.03	NS	21.8	0.70	0.70	0.315	1.3
5/10/2017	< 2.0	0.85	615	0.47	0.04	< 0.01	0.019	6.94	NS	20.9	0.56	0.56	0.058	< 1.0
6/14/2017	< 2.0	< 0.80	558	0.26	0.02	< 0.01	0.095	6.87	NS	24.9	0.43	0.43	0.119	< 1.0
7/12/2017	< 2.0	< 0.80	586	0.27	0.03	< 0.01	0.041	6.82	NS	27.0	0.50	0.50	< 0.030	< 1.0
8/8/2017	< 2.0	0.85	552	0.35	0.02	< 0.01	0.117	6.80	NS	28.2	0.54	0.54	0.042	< 1.0
10/3/2017	< 2.0	< 0.80	438	0.40	0.03	< 0.01	0.080	6.90	NS	24.9	0.51	0.51	0.087	1.0
11/8/2017	< 2.0	< 0.80	ND	ND	0.05	< 0.01	0.058	7.04	NS	21.2	0.54	0.54	0.069	< 1.0
12/5/2017	< 2.0	0.85	519	2.21	0.03	0.01	0.087	6.92	NS	19.0	0.56	0.57	0.098	< 1.0
1/9/2018	2.8	< 0.80	446	3.66	0.01	0.21	0.056	7.00	NS	12.9	0.72	0.93	0.063	< 1.0
2/7/2018	< 2.0	< 0.80	518	1.10	< 0.01	< 0.01	0.206	6.80	NS	16.7	0.80	0.80	0.201	< 1.0
3/6/2018	< 2.0	2.14	518	1.24	0.03	< 0.01	0.056	6.98	NS	15.8	0.56	0.56	0.078	< 1.0
4/17/2018	< 2.0	1.07	527	2.16	0.03	< 0.01	0.006	6.91	NS	18.1	0.83	0.83	0.043	< 1.0
5/2/2018	< 2.0	0.85	556	0.89	0.02	< 0.01	0.008	6.77	NS	20.8	1.23	1.23	< 0.030	1.0
6/12/2018	< 2.0	< 0.80	544	0.26	0.02	< 0.01	0.012	6.72	NS	26.9	0.81	0.81	< 0.030	< 1.0
7/18/2018	< 2.0	1.07	551	0.76	< 0.01	< 0.01	0.011	6.78	NS	27.4	0.73	0.73	< 0.030	< 1.0
8/8/2018	< 2.0	< 0.80	553	0.40	0.01	< 0.01	0.019	6.58	NS	27.8	0.94	0.94	< 0.030	< 1.0
9/26/2018	< 2.0	< 0.80	578	0.34	< 0.01	< 0.01	0.019	6.86	NS	26.3	0.58	0.58	< 0.030	< 1.0
10/17/2018	< 2.0	1.60	596	0.29	0.01	< 0.01	0.019	6.70	NS	24.8	0.52	0.52	0.032	< 1.0
11/14/2018	< 2.0	< 0.80	608	0.69	0.02	< 0.01	0.030	6.90	NS	23.3	0.49	0.49	0.043	< 1.0
12/5/2018	< 2.0	1.07	515	1.15	0.02	< 0.01	0.153	7.15	NS	18.1	0.53	0.53	0.210	< 1.0
2/13/2019	< 2.0	2.67	429	0.63	0.10	< 0.01	0.246	6.78	NS	19.4	0.70	0.70	0.311	< 1.0
3/6/2019	< 2.0	1.07	467	ND	0.09	< 0.01	0.162	6.88	NS	15.6	0.60	0.60	0.173	< 1.0
4/3/2019	< 2.0	< 0.8	495	ND	0.10	0.01	0.085	6.97	NS	17.3	0.58	0.59	0.222	1.5
5/8/2019	< 2.0	< 0.8	ND	0.43	0.09	< 0.01	0.263	7.01	NS	23.7	0.64	0.64	0.274	< 1.0
6/5/2019	< 2.0	1.07	657	0.91	0.01	< 0.01	0.240	6.86	NS	26.4	0.63	0.63	0.224	1.0
7/9/2019	< 2.0	1.6	ND	1.00	0.09	< 0.01	0.125	6.91	NS	26.2	0.79	0.79	0.131	2.0
8/6/2019	< 2.0	2.14	544	1.40	0.07	< 0.01	0.186	6.90	NS	26.3	0.56	0.56	0.187	1.6
9/10/2019	< 2.0	< 0.8	557	1.75	0.13	< 0.01	0.220	6.90	NS	27.0	0.58	0.58	0.235	3.1
10/17/2019	< 2.0	1.07	558	0.79	0.03	< 0.01	0.463	7.26	NS	24.0	0.44	0.44	0.471	1.2
11/13/2019	< 2.0	1.07	ND	1.73	0.03	< 0.01	0.165	6.75	NS	19.6	0.52	0.52	0.192	1.7
12/4/2019	< 2.0	< 0.8	ND	5.17	0.02	0.01	0.180	7.24	NS	12.2	0.50	0.51	0.180	< 1.0
Average	**< 2.0**	**< 1.0**	**546**	**1.34**	**< 0.02**	**< 0.02**	**0.136**	**6.95**	**6.8**	**21.9**	**0.64**	**0.65**	**< 0.143**	**< 1.1**

Orlando Easterly Wetlands
2016 - 2019 Water Quality Data
Sample Point: 13 In

Date	CBOD mg/L	CHLORO mg/m^3	CL mg/L	CON uhmos	DO mg/L	NOX mg/L	OP mg/L	PH s.u.	SO4 mg/L	TEMP mg/L	TKN mg/L	TN mg/L	TP mg/L	TSS mg/L
1/5/2016	< 2.0	1.00	484	3.04	0.08	< 0.01	0.116	7.15	6.40	15.4	0.70	0.70	0.133	< 1.0
2/2/2016	< 2.0	< 0.80	462	0.93	0.02	0.01	0.183	6.92	6.75	17.5	0.74	0.75	0.213	< 1.0
3/15/2016	< 2.0	2.50	555	0.18	0.05	< 0.01	0.199	6.77	6.94	21.7	0.80	0.80	0.241	< 1.0
4/5/2016	< 2.0	1.23	523	0.17	0.06	< 0.01	0.237	6.85	6.48	20.2	0.72	0.72	0.284	< 1.0
5/17/2016	< 2.0	< 0.80	619	0.13	0.04	< 0.01	0.042	6.73	6.87	24.0	0.54	0.54	0.050	< 1.0
6/14/2016	< 2.0	< 0.80	634	0.36	0.07	< 0.01	0.255	6.64	6.75	26.8	0.71	0.71	0.263	3.5
7/5/2016	< 2.0	< 0.80	624	0.07	0.06	< 0.01	0.174	6.75	9.33	27.5	0.50	0.50	0.172	< 1.0
8/2/2016	< 2.0	1.10	688	0.09	0.07	< 0.01	0.130	6.68	8.24	26.3	0.81	0.81	0.132	< 1.0
9/6/2016	< 2.0	< 0.80	600	0.52	0.03	< 0.01	0.105	6.83	6.72	25.7	0.57	0.57	0.228	< 1.0
10/4/2016	< 2.0	< 0.80	531	0.05	0.03	< 0.01	0.211	6.80	6.16	25.6	0.67	0.67	0.230	1.9
11/8/2016	< 2.0	1.00	542	1.69	0.04	< 0.01	0.245	6.54	5.83	20.2	0.64	0.64	0.244	< 1.0
12/6/2016	< 2.0	< 0.80	539	0.10	0.07	< 0.01	0.421	6.90	5.71	19.9	0.87	0.87	0.424	< 1.0
1/10/2017	< 2.0	0.85	444	3.20	0.04	< 0.01	0.395	7.08	6.42	11.9	0.54	0.54	0.426	< 1.0
2/14/2017	< 2.0	1.28	520	0.45	0.03	< 0.01	0.277	6.97	NS	17.4	0.63	0.63	0.318	< 1.0
4/4/2017	< 2.0	4.27	613	0.12	0.03	< 0.01	0.303	6.95	NS	23.2	0.80	0.80	0.298	< 1.0
5/9/2017	< 2.0	< 0.80	617	0.99	0.05	< 0.01	0.007	6.74	NS	21.1	0.67	0.67	< 0.030	< 1.0
6/13/2017	2.0	< 0.80	483	0.12	0.01	< 0.01	0.029	6.51	NS	25.3	0.67	0.67	0.053	2.4
7/6/2017	NS	NS	ND	ND	NS	< 0.01	NS	ND	NS	ND	0.79	0.79	0.083	NS
7/11/2017	< 2.0	1.60	599	0.10	0.08	< 0.01	0.027	6.58	NS	26.5	0.66	0.66	0.046	< 1.0
8/7/2017	< 2.0	< 0.80	518	0.17	0.06	< 0.01	0.023	6.91	NS	27.1	0.64	0.64	0.046	< 1.0
9/18/2017	< 2.0	< 0.80	490	0.13	0.06	< 0.01	0.049	6.87	NS	26.1	0.54	0.54	0.058	< 1.0
9/21/2017	NS	NS	514	0.15	0.05	< 0.01	0.076	6.69	NS	25.9	0.60	0.60	0.032	NS
10/2/2017	< 2.0	< 0.80	458	0.13	0.11	< 0.01	0.036	6.76	NS	25.2	1.49	1.49	0.093	1.7
11/7/2017	< 2.0	0.85	ND	ND	0.08	< 0.01	0.096	6.70	NS	21.7	0.63	0.63	0.068	< 1.0
12/4/2017	< 2.0	0.85	523	1.57	0.13	< 0.01	0.053	6.81	NS	18.5	0.86	0.86	0.096	< 1.0
12/14/2017	NS	NS	435	5.26	0.10	< 0.01	0.043	6.90	NS	10.2	0.91	0.91	0.056	NS
n off line and	< 2.0	1.07	396	4.25	0.02	< 0.01	0.068	7.01	NS	9.2	0.71	0.71	0.086	< 1.0
2/5/2018	< 2.0	8.00	501	1.41	0.02	< 0.01	0.165	6.85	NS	16.7	0.72	0.72	0.184	< 1.0
3/5/2018	< 2.0	2.35	450	0.95	0.17	< 0.01	0.062	6.83	NS	14.4	0.83	0.83	0.103	< 1.0
4/16/2018	< 2.0	1.60	562	0.30	0.09	< 0.01	0.025	6.83	NS	20.3	0.88	0.88	0.063	< 1.0
5/1/2018	< 2.0	1.07	548	0.33	0.04	< 0.01	0.010	6.68	NS	21.5	1.45	1.45	0.048	< 1.0
6/5/2018	< 2.0	1.71	544	0.10	0.04	< 0.01	0.020	6.56	NS	27.4	0.70	0.70	0.048	< 1.0
7/17/2018	< 2.0	2.67	549	0.33	0.05	< 0.01	0.021	6.52	NS	27.4	0.95	0.95	0.043	4.7
8/7/2018	< 2.0	< 0.80	548	0.26	0.01	< 0.01	0.015	6.60	NS	27.7	0.91	0.91	0.031	3.2
9/11/2018	< 2.0	< 0.80	476	0.42	0.01	< 0.01	0.016	6.61	NS	26.3	0.65	0.65	0.041	1.1
10/16/2018	< 2.0	< 0.80	598	0.31	0.03	< 0.01	0.018	6.71	NS	25.0	0.61	0.61	0.052	< 1.0
11/7/2018	< 2.0	< 0.80	593	0.21	0.03	< 0.01	0.059	6.66	NS	22.8	0.56	0.56	0.049	< 1.0
12/4/2018	< 2.0	3.20	549	0.23	0.04	< 0.01	0.179	6.74	NS	20.1	0.63	0.63	0.181	< 1.0
1/8/2019	< 2.0	< 0.80	476	0.95	0.04	< 0.01	0.241	6.68	NS	16.4	0.54	0.54	0.225	< 1.0
2/12/2019	< 2.0	2.14	503	0.89	0.09	< 0.01	0.272	6.74	NS	20.4	0.67	0.67	0.273	< 1.0
Average	**< 2.0**	**< 1.46**	**534**	**0.81**	**0.05**	**< 0.0**	**0.126**	**6.77**	**6.8**	**21.7**	**0.74**	**0.74**	**< 0.144**	**< 1.3**

Orlando Easterly Wetlands
2016 - 2019 Water Quality Data
Sample Point: 13 Out

Date	ALK		CBOD	LO	CL	CL	CON	DO		NH3		NOX	OP	PH	SO4	STOC	TEMP	TKN	TN		TP		TSS
	mg/L		mg/L	g/l	mg/L	mg/L	uhmos	mg/L		mg/L		mg/L	mg/L	s.u.	mg/L	mg/L	mg/L	mg/L	mg/L		mg/L		mg/L
1/5/2016	142	<	2.0		1.63	84.0	469	4.24		0.02	<	0.01	0.011	7.16	24.4	7.02	14.7	0.69	0.69	<	0.030	<	1.0
2/2/2016	131	<	2.0	<	0.80	72.1	455	2.74		0.03		0.01	0.023	7.38	24.0	6.62	18.2	0.61	0.62		0.042		2.6
3/15/2016	142	<	2.0		3.80	79.5	572	1.27		0.05	<	0.01	0.046	7.37	22.7	8.19	22.6	0.78	0.78		0.107		1.3
4/5/2016	128	<	2.0		1.69	77.3	483	1.35		0.05	<	0.01	0.012	7.07	16.1	7.25	20.2	0.85	0.85		0.042		1.7
5/17/2016	154	<	2.0		1.49	92.6	626	1.15		0.03	<	0.01	0.007	7.10	15.6	8.82	25.7	0.74	0.74	<	0.030	<	1.0
6/14/2016	159	<	2.0	<	0.80	86.1	641	0.71		0.04	<	0.01	0.010	6.90	10.7	8.82	28.4	0.75	0.75		0.044	<	1.0
7/5/2016	161	<	2.0		2.64	86.1	669	0.08		0.10	<	0.01	0.096	6.90	14.7	12.70	28.1	0.82	0.82		0.114		1.7
9/6/2016	164		2.6		2.11	84.8	656	0.07		0.54	<	0.01	0.430	6.84	16.7	10.50	25.5	1.49	1.49		0.582		2.0
10/4/2016	142	<	2.0	<	0.80	76.7	533	0.09		0.09	<	0.01	0.131	6.87	25.0	7.40	26.5	0.89	0.89		0.154	<	1.0
11/8/2016	137	<	2.0		1.49	79.8	556	0.60		0.05	<	0.01	0.104	7.01	28.8	8.23	21.2	0.78	0.78		0.133	<	1.0
4/4/2017	167	<	2.0		3.42	103	702	0.64		0.02	<	0.01	0.266	7.16	24.8	12.6	23.4	1.26	1.26		0.342		1.3
7/6/2017	NS		NS		NS	NS	ND	ND		NS	<	0.01	NS	ND	ND	ND	NS	0.75	0.75		0.041		NS
8/7/2017	90	<	2.0		2.14	67.1	510	0.20		0.06	<	0.01	0.020	6.85	18.8	8.45	28.1	0.75	0.75		0.032		1.0
9/18/2017	108	<	2.0		2.67	54.5	422	0.18		0.08	<	0.01	0.083	6.95	10.4	8.19	26.7	0.64	0.64		0.138		1.1
10/2/2017	126	<	2.0		3.42	61.1	486	1.16		0.06	<	0.01	0.027	7.17	20.6	8.11	25.6	0.71	0.71		0.053		2.0
12/14/2017	NS		NS		NS	NS	469	5.61		0.03	<	0.01	0.012	7.16	NS	NS	12.2	0.84	0.84	<	0.030		NS
1/8/2018	138	<	2.0	<	0.80	85.2	414	6.63		0.04	<	0.01	0.086	7.19	27.2	7.83	9.7	0.68	0.68		0.087	<	1.0
2/5/2018	139	<	2.0		1.10	85.7	506	2.80	<	0.01	<	0.01	0.062	6.97	24.8	9.06	16.9	0.79	0.79		0.071	<	1.0
6/5/2018	125	<	2.0		1.28	70.4	522	0.27		0.04	<	0.01	0.018	6.81	15.8	7.73	28.0	0.77	0.77	<	0.030	<	1.0
7/17/2018	147		2.1		5.87	69.8	530	0.46		0.01	<	0.01	0.027	6.73	8.40	8.14	27.8	0.97	0.97		0.053		2.3
8/7/2018	135	<	2.0		1.60	70.4	549	0.21		0.02	<	0.01	0.029	6.69	20.7	7.98	27.4	0.72	0.72		0.039		2.4
9/11/2018	123	<	2.0		2.67	64.1	497	0.22		0.09	<	0.01	0.045	6.73	18.9	8.12	26.6	1.00	1.00		0.076		1.0
10/16/2018	151	<	2.0		1.07	78.8	620	0.20		0.06	<	0.01	0.066	6.87	22.0	8.55	25.5	0.78	0.78		0.081	<	1.0
11/7/2018	157		2.1		2.67	87.6	630	0.22		0.08	<	0.01	0.088	6.76	25.7	8.28	23.5	0.78	0.78		0.084	<	1.0
12/4/2018	146	<	2.0		2.14	86.9	574	0.27		0.05	<	0.01	0.094	6.85	25.0	7.69	21.3	1.03	1.03		0.101	<	1.0
Average	140	<	2.0	<	2.09	78.4	545	1.31		0.07	<	0.01	0.075	6.98	20.1	8.53	23.1	0.83	0.84	<	0.101	<	1.4

Cell 17 In is actually Cell 13 Out and was taken off line and drained for complete renovation during 2019

Orlando Easterly Wetlands
2016 - 2019 Water Quality Data
Sample Point: 17 In

Date	ALK	CBOD	LO	CL	CL	CON	DO	NH3	NOX	OP	PH	SO4	STOC	TEMP	TKN	TN	TP	TSS
	mg/L	mg/L	g/l	mg/L	mg/L	uhmos	mg/L	mg/L	mg/L	mg/L	s.u.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1/5/2016	142	< 2.0		1.63	84.0	469	4.24	0.02	< 0.01	0.011	7.16	24.4	7.02	14.7	0.69	0.69	< 0.030	< 1.0
2/2/2016	131	< 2.0	<	0.80	72.1	455	2.74	0.03	0.01	0.023	7.38	24.0	6.62	18.2	0.61	0.62	0.042	2.6
3/15/2016	142	< 2.0		3.80	79.5	572	1.27	0.05	< 0.01	0.046	7.37	22.7	8.19	22.6	0.78	0.78	0.107	1.3
4/5/2016	128	< 2.0		1.69	77.3	483	1.35	0.05	< 0.01	0.012	7.07	16.1	7.25	20.2	0.85	0.85	0.042	1.7
5/17/2016	154	< 2.0		1.49	92.6	626	1.15	0.03	< 0.01	0.007	7.10	15.6	8.82	25.7	0.74	0.74	< 0.030	< 1.0
6/14/2016	159	< 2.0	<	0.80	86.1	641	0.71	0.04	< 0.01	0.010	6.90	10.7	8.82	28.4	0.75	0.75	0.044	< 1.0
7/5/2016	161	< 2.0		2.64	86.1	669	0.08	0.10	< 0.01	0.096	6.90	14.7	12.70	28.1	0.82	0.82	0.114	1.7
9/6/2016	164	2.6		2.11	84.8	656	0.07	0.54	< 0.01	0.430	6.84	16.7	10.50	25.5	1.49	1.49	0.582	2.0
10/4/2016	142	< 2.0	<	0.80	76.7	533	0.09	0.09	< 0.01	0.131	6.87	25.0	7.40	26.5	0.89	0.89	0.154	< 1.0
11/8/2016	137	< 2.0		1.49	79.8	556	0.60	0.05	< 0.01	0.104	7.01	28.8	8.23	21.2	0.78	0.78	0.133	< 1.0
4/4/2017	167	< 2.0		3.42	103	702	0.64	0.02	< 0.01	0.266	7.16	24.8	12.6	23.4	1.26	1.26	0.342	1.3
7/6/2017	NS	NS		NS	NS	ND	ND	NS	< 0.01	NS	ND	ND	ND	NS	0.75	0.75	0.041	NS
8/7/2017	90	< 2.0		2.14	67.1	510	0.20	0.06	< 0.01	0.020	6.85	18.8	8.45	28.1	0.75	0.75	0.032	1.0
9/18/2017	108	< 2.0		2.67	54.5	422	0.18	0.08	< 0.01	0.083	6.95	10.4	8.19	26.7	0.64	0.64	0.138	1.1
10/2/2017	126	< 2.0		3.42	61.1	486	1.16	0.06	< 0.01	0.027	7.17	20.6	8.11	25.6	0.71	0.71	0.053	2.0
12/14/2017	NS	NS		NS	NS	469	5.61	0.03	< 0.01	0.012	7.16	NS	NS	12.2	0.84	0.84	< 0.030	NS
1/8/2018	138	< 2.0	<	0.80	85.2	414	6.63	0.04	< 0.01	0.086	7.19	27.2	7.83	9.7	0.68	0.68	0.087	< 1.0
2/5/2018	139	< 2.0		1.10	85.7	506	2.80	< 0.01	< 0.01	0.062	6.97	24.8	9.06	16.9	0.79	0.79	0.071	< 1.0
6/5/2018	125	< 2.0		1.28	70.4	522	0.27	0.04	< 0.01	0.018	6.81	15.8	7.73	28.0	0.77	0.77	< 0.030	< 1.0
7/17/2018	147	2.1		5.87	69.8	530	0.46	0.01	< 0.01	0.027	6.73	8.40	8.14	27.8	0.97	0.97	0.053	2.3
8/7/2018	135	< 2.0		1.60	70.4	549	0.21	0.02	< 0.01	0.029	6.69	20.7	7.98	27.4	0.72	0.72	0.039	2.4
9/11/2018	123	< 2.0		2.67	64.1	497	0.22	0.09	< 0.01	0.045	6.73	18.9	8.12	26.6	1.00	1.00	0.076	1.0
10/16/2018	151	< 2.0		1.07	78.8	620	0.20	0.06	< 0.01	0.066	6.87	22.0	8.55	25.5	0.78	0.78	0.081	< 1.0
11/7/2018	157	2.1		2.67	87.6	630	0.22	0.08	< 0.01	0.088	6.76	25.7	8.28	23.5	0.78	0.78	0.084	< 1.0
12/4/2018	146	< 2.0		2.14	86.9	574	0.27	0.05	< 0.01	0.094	6.85	25.0	7.69	21.3	1.03	1.03	0.101	< 1.0
Average	140	< 2.0	<	2.09	78.4	545	1.31	0.07	< 0.01	0.075	6.98	20.1	8.53	23.1	0.83	0.84	< 0.101	< 1.4

Cell 17 In is actually Cell 13 Out and was taken off line and drained for complete renovation during 2019

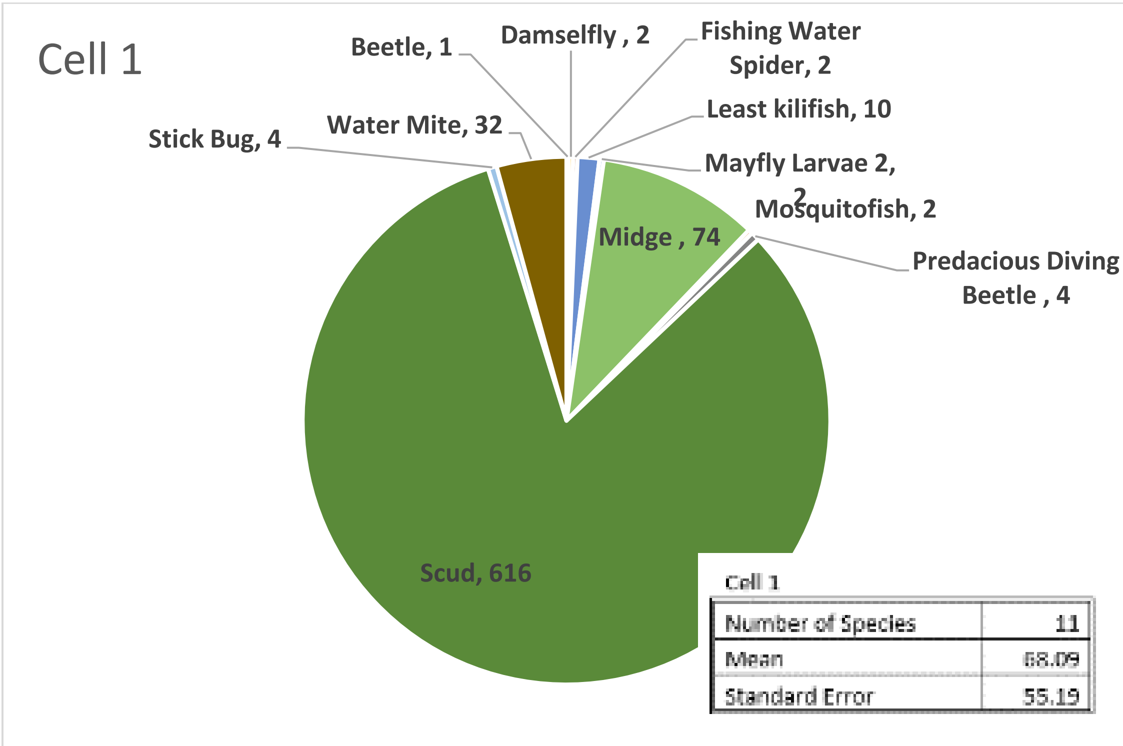
Orlando Easterly Wetlands
2016 - 2019 Water Quality Data
Sample Point: Cell 17 Out

Date	ALK mg/L	CBOD mg/L	CHLORO mg/m^3	CL mg/L	CON uhmos	DO mg/L	NH3 mg/L	NH3U mg/L	NOX mg/L	OP mg/L	PH s.u.	SO4 mg/L	STOC mg/L	TDS mg/L	TEMP mg/L	TKN mg/L	TN mg/L	TP mg/L	TSS mg/L
1/5/2016	142	< 2.0	2.48	84.4	465	2.31	0.37	< 0.01	0.02	0.021	6.74	20.3	8.10	310	15.0	1.15	1.17	< 0.030	< 1.0
2/2/2016	126	< 2.0	1.06	74.2	457	6.79	0.09	< 0.01	0.06	0.015	7.43	22.6	7.56	260	18.7	1.07	1.13	0.047	1.1
3/15/2016	128	< 2.0	1.38	79.5	536	1.16	0.14	< 0.01	< 0.01	0.025	7.22	22.1	7.92	312	23.4	0.90	0.90	0.075	< 1.0
4/5/2016	117	< 2.0	1.50	78.0	472	1.83	0.10	< 0.01	< 0.01	0.013	7.21	19.9	7.07	272	21.4	1.06	1.06	0.040	< 1.0
5/17/2016	117	< 2.0	3.04	91.9	595	1.35	0.04	< 0.01	< 0.01		7.12	19.7	9.21	322	26.5	0.85	0.85	< 0.030	< 1.0
6/14/2016	125	< 2.0	1.05	88.7	604	0.58	0.09	< 0.01	< 0.01	0.020	7.01	14.2	10.30	320	28.9	0.89	0.89	0.044	< 1.0
7/5/2016	124	< 2.0	1.52	87.6	824	0.14	0.10	< 0.01	< 0.01	0.028	7.06	15.5	8.96	312	29.7	0.82	0.82	0.038	< 1.0
8/2/2016	157	< 2.0	2.70	94.9	703	0.14	0.05	< 0.01	< 0.01	0.026	7.07	15.9	8.85	358	28.8	1.82	1.82	0.087	< 1.0
9/6/2016	153	< 2.0	4.23	87.6	639	0.24	0.05	< 0.01	< 0.01	0.026	7.00	17.9	9.36	352	26.4	0.92	0.92	0.064	< 1.0
10/4/2016	149	< 2.0	< 0.80	82.3	599	0.14	< 0.01	< 0.01	< 0.01	0.062	6.71	19.7	7.98	358	26.5	0.74	0.74	0.056	1.3
11/8/2016	131	< 2.0	1.01	76.9	498	2.84	0.03	< 0.01	< 0.01	0.025	7.20	23.6	7.78	318	20.9	0.77	0.77	0.044	1.1
12/6/2016	129	< 2.0	1.03	79.4	538	2.82	0.07	< 0.01	< 0.01	0.021	7.14	23.5	7.92	258	21.9	0.87	0.87	< 0.030	< 1.0
1/10/2017	145	< 2.0	1.28	85.0	471	4.09	0.07	< 0.01	0.05	0.068	7.19	25.7	8.39	352	13.2	1.25	1.30	0.077	< 1.0
2/14/2017	145	< 2.0	1.28	89.7	527	1.42	0.04	< 0.01	0.01	0.114	7.30	26.0	8.09	350	18.7	0.81	0.82	0.138	< 1.0
5/9/2017	109	< 2.0	< 0.80	108.0	595	4.37	0.05	< 0.01	< 0.01	0.017	7.17	26.0	11.20	178	23.0	0.80	0.80	0.046	< 1.0
6/13/2017	109	< 2.0	4.27	103.0	639	0.33	< 0.01	< 0.01	< 0.01	0.020	7.02	21.5	13.10	324	27.0	0.96	0.96	0.030	< 1.0
7/11/2017	132	< 2.0	3.74	77.1	567	0.17	0.03	< 0.01	< 0.01	0.009	7.06	13.7	9.63	280	28.6	0.72	0.72	0.035	< 1.0
8/8/2017	126	< 2.0	3.20	70.5	582	0.20	0.05	< 0.01	< 0.01	0.012	7.01	17.2	8.60	302	29.3	0.89	0.89	0.036	1.0
9/18/2017	116	< 2.0	7.48	58.3	475	0.49	0.10	< 0.01	< 0.01	0.013	7.21	15.1	7.78	224	27.8	0.70	0.70	0.063	1.5
9/21/2017	NS	NS	NS	NS	473	3.83	0.14	< 0.01	< 0.01	0.027	7.31	NS	NS	NS	27.4	0.81	0.81	0.042	NS
10/2/2017	112	< 2.0	2.56	51.6	484	1.02	0.10	< 0.01	< 0.01	0.038	7.10	15.3	7.79	250	26.4	0.68	0.68	0.060	1.4
11/6/2017	132	< 2.0	5.98	65.2	449	ND	0.18	< 0.01	0.03	0.059	7.02	19.6	8.59	278	24.5	0.96	0.99	0.069	1.5
12/4/2017	134	< 2.0	4.70	74.5	513	2.53	0.30	< 0.01	0.02	0.089	7.15	23.1	8.98	330	20.4	1.12	1.14	0.111	1.4
12/14/2017	NS	NS	NS	NS	430	6.88	0.32	< 0.01	0.08	0.035	7.23	NS	NS	NS	11.9	1.39	1.47	0.060	NS
1/8/2018	142	< 2.0	< 0.80	86.4	432	4.29	0.28	< 0.01	0.18	0.038	7.56	24.9	8.54	332	12.7	1.18	1.36	0.056	< 1.0
2/5/2018	139	< 2.0	2.14	81.5	522	5.22	0.10	< 0.01	0.04	0.081	7.16	23.4	8.42	292	18.7	0.86	0.90	0.102	< 1.0
Cell 17 In is actually	139	< 2.0	1.28	92.3	484	3.93	0.06	< 0.01	0.02	0.030	7.00	22.9	8.55	338	15.8	0.84	0.86	0.062	< 1.0
4/16/2018	124	< 2.0	1.07	98.4	564	0.64	0.07	< 0.01	< 0.01	0.018	6.91	23.0	10.60	328	21.6	1.32	1.32	0.040	< 1.0
5/1/2018	117	< 2.0	< 0.80	86.0	571	1.32	0.04	< 0.01	< 0.01	0.013	7.01	24.3	11.50	208	22.5	1.50	1.50	< 0.030	1.2
6/5/2018	124	< 2.0	1.71	77.5	531	0.22	0.03	< 0.01	< 0.01	0.021	6.93	16.8	8.63	286	28.1	1.03	1.03	0.048	< 1.0
7/17/2018	111	< 2.0	2.14	58.1	456	0.33	< 0.01	< 0.01	< 0.01	0.016	6.79	13.1	7.45	240	28.8	0.74	0.74	0.037	2.6
8/7/2018	128	< 2.0	1.60	68.8	518	0.23	0.02	< 0.01	< 0.01	0.025	6.88	17.8	7.31	278	28.9	1.22	1.22	0.043	< 1.0
9/11/2018	121	< 2.0	1.07	60.7	485	4.27	0.02	< 0.01	< 0.01	0.023	7.09	18.3	7.59	270	27.4	0.74	0.74	0.040	1.0
10/16/2018	144	< 2.0	1.60	73.1	577	0.36	0.04	< 0.01	< 0.01	0.047	6.99	17.0	8.05	260	25.6	0.74	0.74	0.077	< 1.0
11/7/2018	143	< 2.0	2.67	84.5	598	1.03	0.05	< 0.01	< 0.01	0.042	6.90	22.8	7.89	306	23.8	0.70	0.70	0.041	1.5
12/4/2018	138	< 2.0	2.14	92.2	552	0.43	0.03	< 0.01	< 0.01	0.021	6.76	25.0	7.73	228	21.7	0.62	0.62	< 0.030	1.3
1/8/2019	139	< 2.0	1.60	85.3	493	1.73	0.06	< 0.01	0.03	0.091	6.78	27.8	7	228	17.5	0.59	0.62	0.108	1.0
2/12/2019	123	< 2.0	1.07	76.4	492	0.51	0.13	< 0.01	0.03	0.152	6.90	21.8	7.49	302	20.9	0.78	0.81	0.180	1.3
3/5/2019	110	< 2.0	2.67	74.9	485	ND	0.07	< 0.01	0.02	0.04	7.01	28.0	7.98	98	21.6	0.93	0.95	0.050	1.6
4/2/2019	104	< 2.0	1.60	88.9	474	ND	0.07	< 0.01	0.01	0.024	7.00	26.1	7.77	302	20.7	0.68	0.69	< 0.030	1.5
5/7/2019	87	< 2.0	< 0.80	108	ND	0.36	0.25	< 0.01	< 0.01	0.01	6.87	25.9	8.58	284	24.9	0.88	0.88	0.049	1.2
6/4/2019	96	< 2.0	2.14	92.4	527	0.94	0.04	< 0.01	< 0.01	0.031	6.80	19.8	8.34	302	26.9	0.85	0.85	< 0.030	1.9
7/9/2019	98	< 2.0	2.14	69.5	ND	0.18	0.11	< 0.01	< 0.01	0.025	6.96	15.3	7.31	256	27.4	0.73	0.73	0.046	1.1
8/6/2019	117	< 2.0	1.07	63.7	491	0.15	0.10	< 0.01	< 0.01	0.022	6.99	14.2	7.07	266	27.3	0.65	0.65	< 0.030	< 1.0
9/10/2019	127	< 2.0	2.14	60.7	515	0.12	0.15	< 0.01	< 0.01	0.026	7.00	14.8	6.73	260	28.2	0.65	0.65	0.035	1.3
10/16/2019	133	< 2.0	< 0.80	75.7	535	0.39	0.05	< 0.01	< 0.01	0.024	7.47	18.7	7.41	300	25.1	0.54	0.54	< 0.030	< 1.0
11/12/2019	129	< 2.0	1.07	75.8	ND	0.53	0.04	< 0.01	0.01	0.02	6.90	12.6	7.09	316	21.3	0.58	0.59	0.048	< 1.0
12/3/2019	129	< 2.0	1.60	77.3	ND	2.52	0.03	< 0.01	0.05	0.014	6.58	22.1	6.59	310	14.6	0.70	0.75	< 0.030	< 1.0
Average	126.5	< 2.0	< 2.06	80.4	533	1.67	< 0.09	< 0.01	< 0.02	0.035	7.04	20.3	8.36	287.2	23.3	0.90	0.91	< 0.055	< 1.2

APPENDIX H

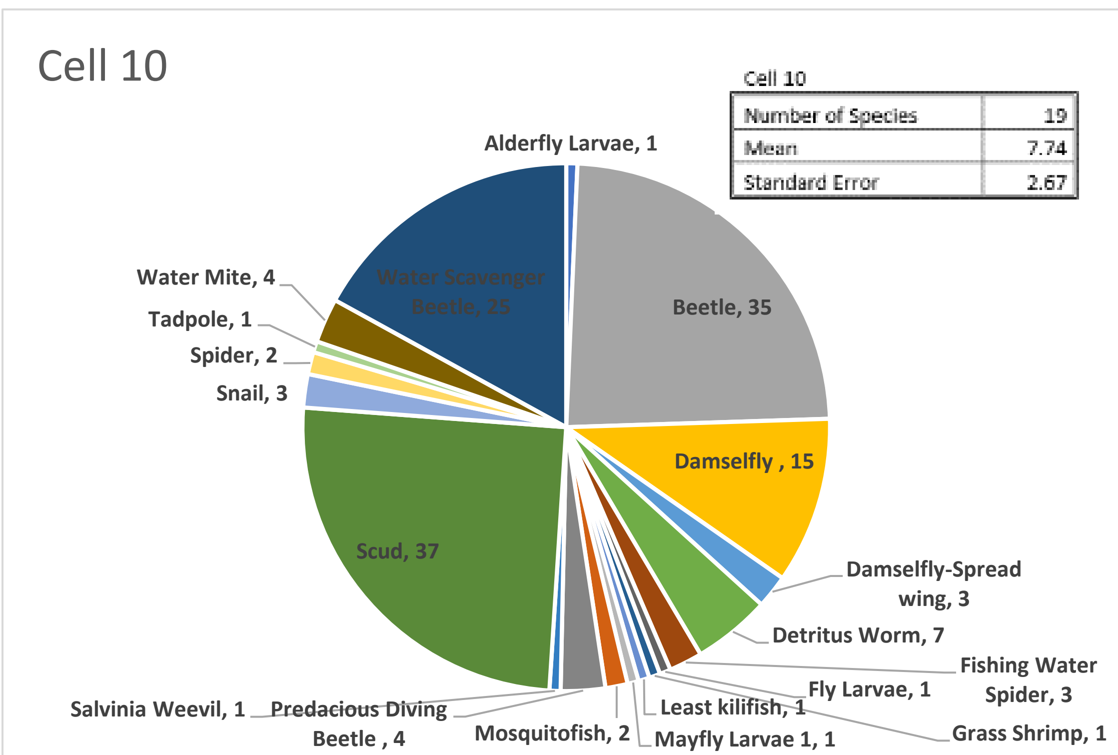
DIP NETTING AND MINNOW TRAPPING DIVERSITY BY CELL

Appendix H. Dip Netting Diversity and Abundance Results.



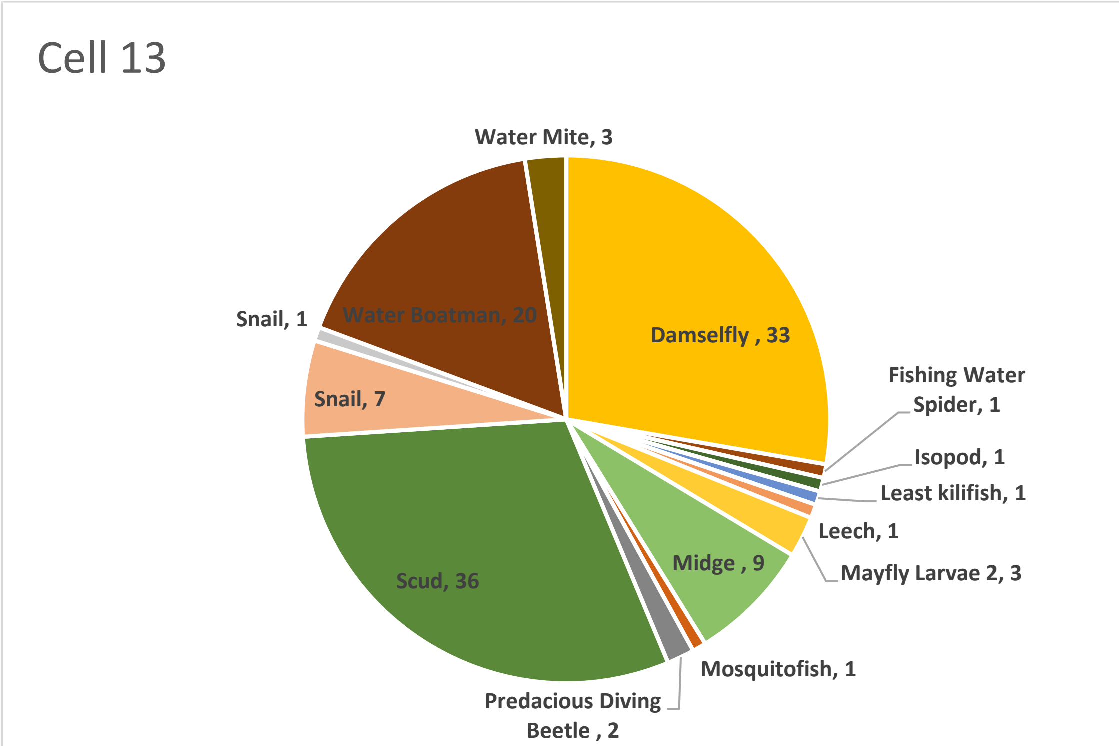
Cell 1

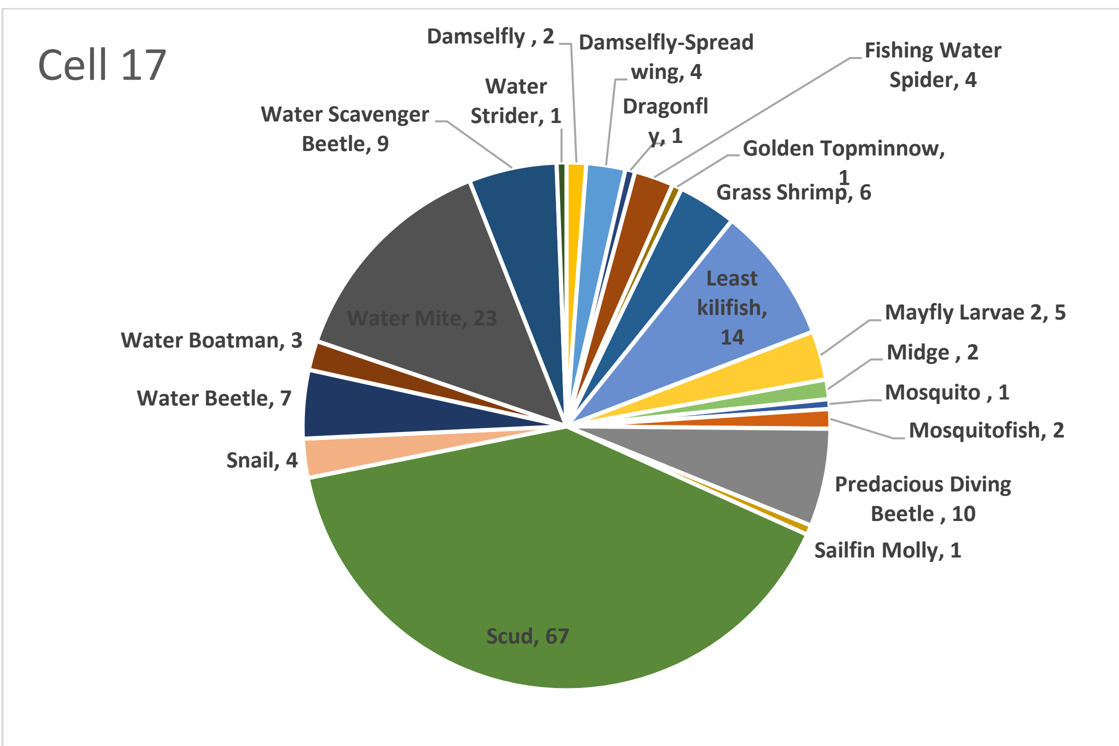
Number of Species	11
Mean	68.09
Standard Error	55.19



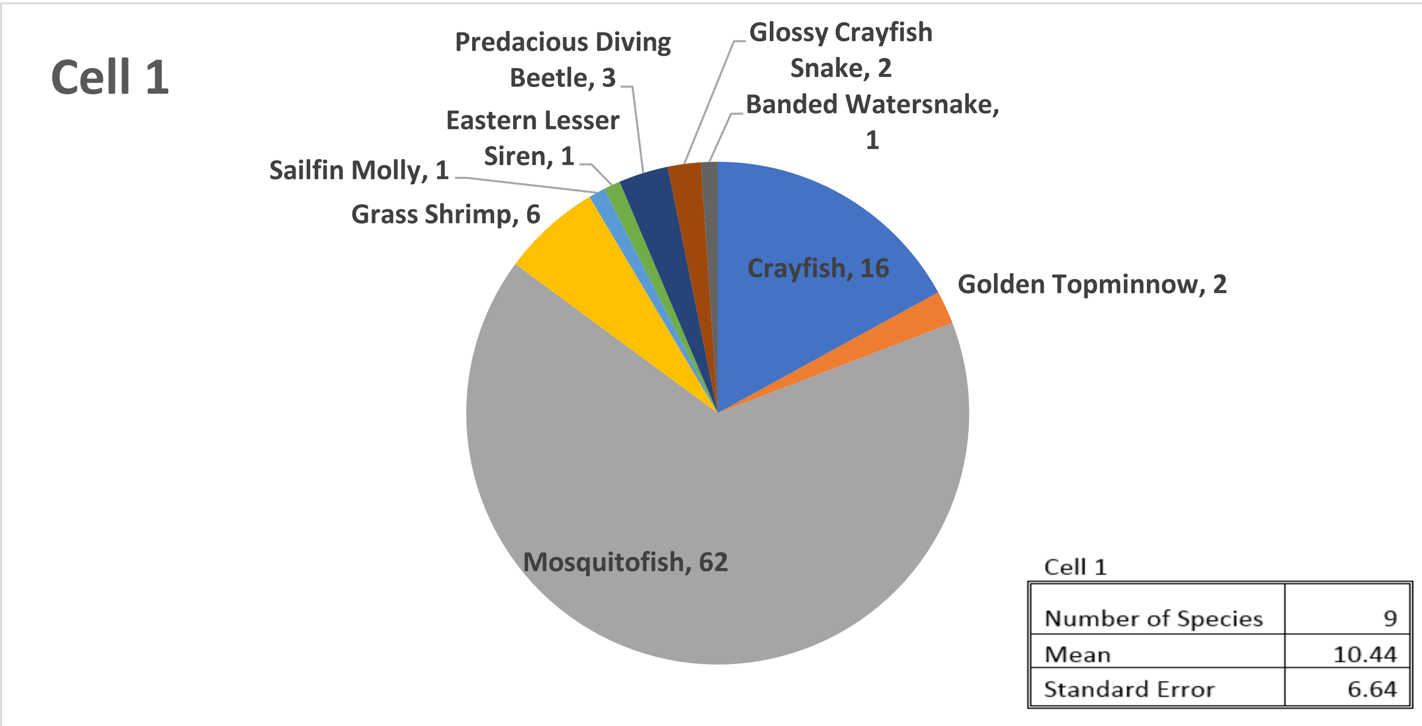
Cell 10

Number of Species	19
Mean	7.74
Standard Error	2.67


Cell 13
Water Mite, 3
Water Boatman, 20
Snail, 1
Damselfly , 33
Fishing Water Spider, 1
Isopod, 1
Least kilifish, 1
Leech, 1
Mayfly Larvae 2, 3
Snail, 7
Midge , 9
Scud, 36
Mosquitofish, 1
Predacious Diving Beetle , 2

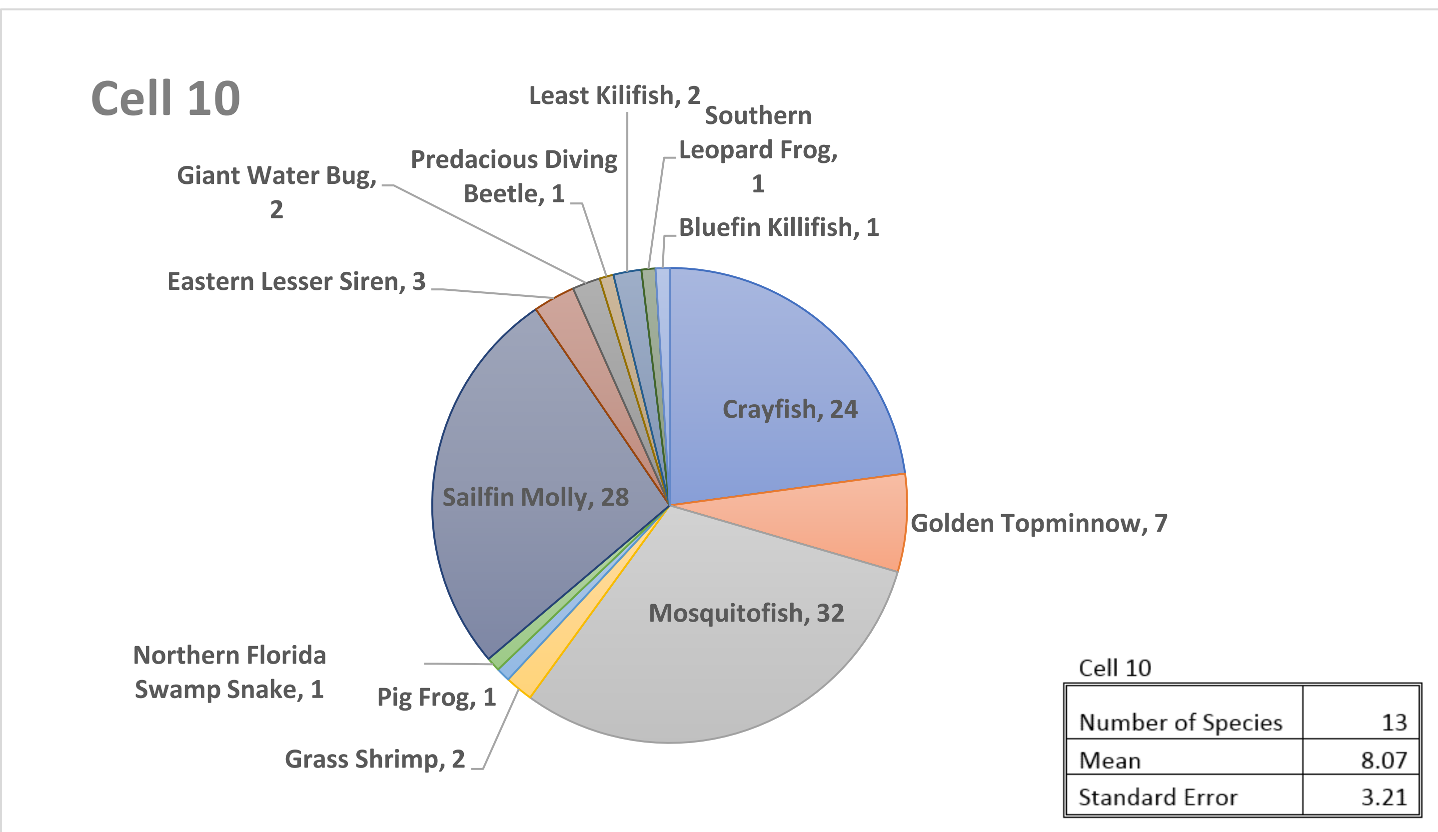

Cell 17
Damselfly , 2
Damselfly-Spread wing, 4
Fishing Water Spider, 4
Water Strider, 1
Dragonfly, 1
Water Scavenger Beetle, 9
Golden Topminnow, 1
Grass Shrimp, 6
Least kilifish, 14
Water Mite, 23
Mayfly Larvae 2, 5
Water Boatman, 3
Midge , 2
Water Beetle, 7
Mosquito , 1
Mosquitofish, 2
Snail, 4
Predacious Diving Beetle , 10
Sailfin Molly, 1
Scud, 67

Individual cell results for the minnow trap sampling.



Cell 1

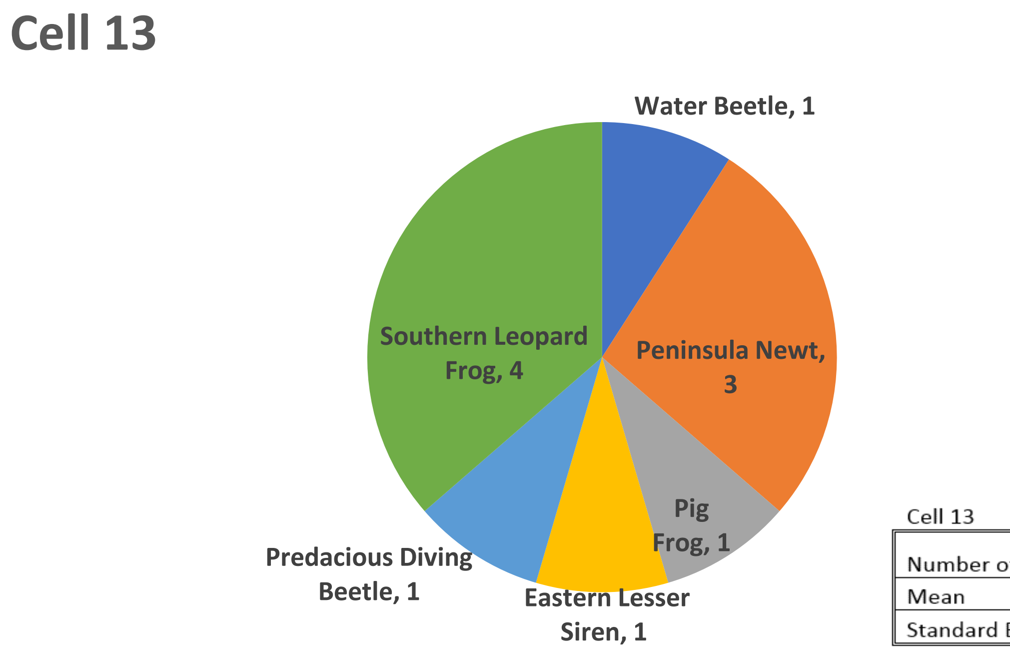
Number of Species	9
Mean	10.44
Standard Error	6.64



Cell 10

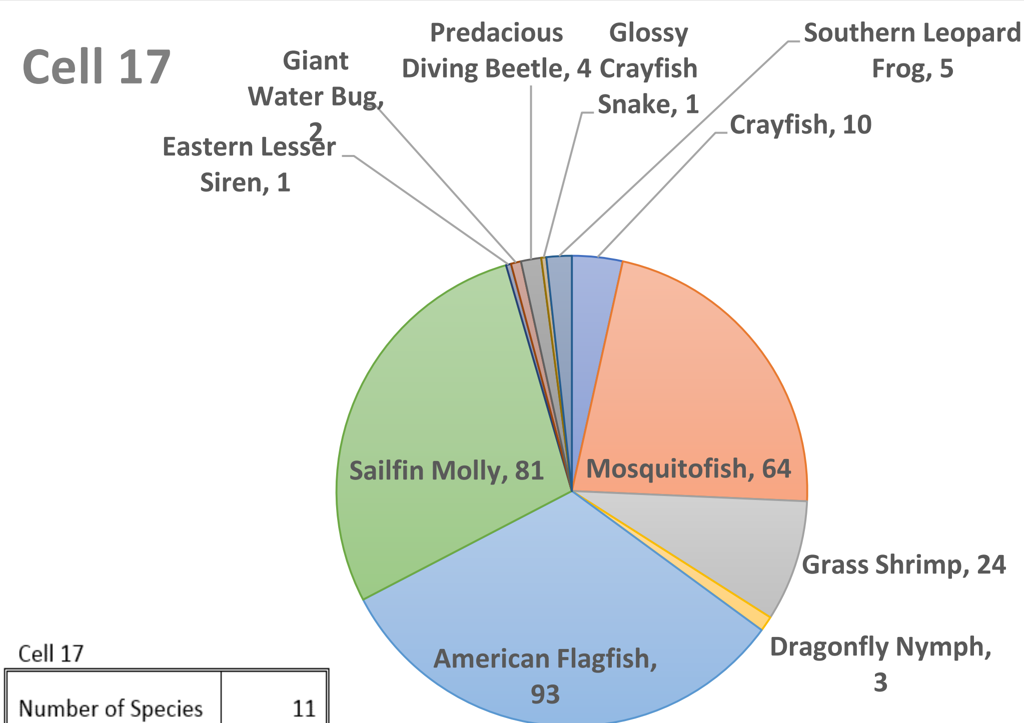
Number of Species	13
Mean	8.07
Standard Error	3.21

Individual cell results for the minnow trap sampling.



Cell 13

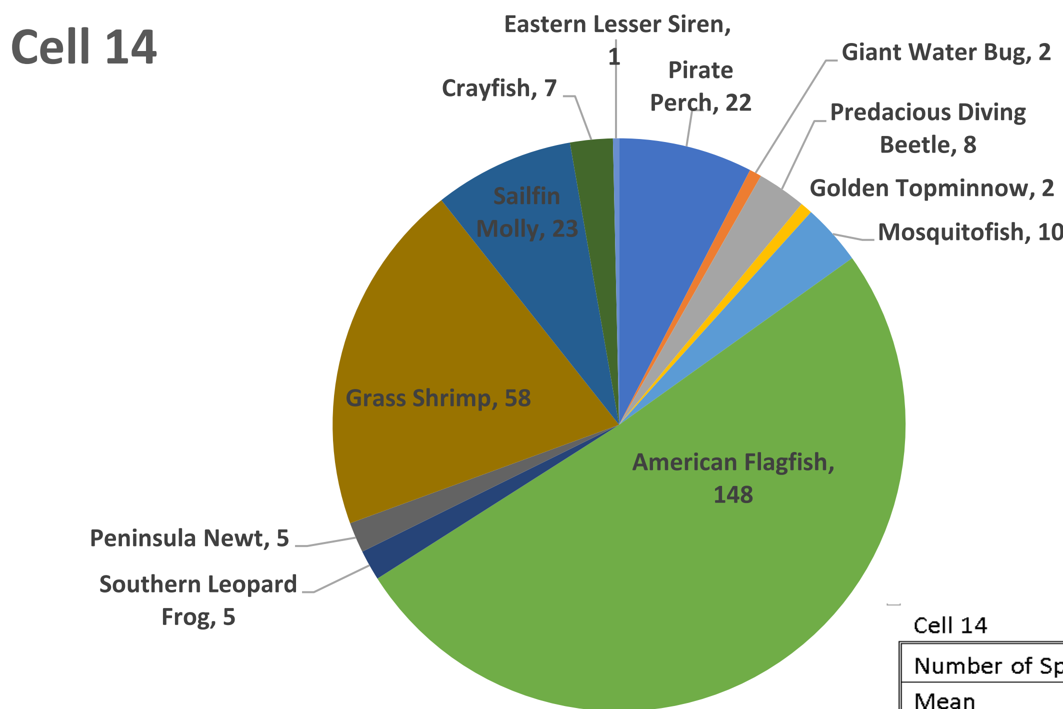
Number of Species	6
Mean	1.83
Standard Error	0.54



Cell 17

Number of Species	11
Mean	26.18
Standard Error	10.65

Individual cell results for the minnow trap sampling.



Cell 14

Number of Species	12
Mean	24.25
Standard Error	12.15