PALMETTO HALL
RECYCLED WATER PROJECT

Hilton Head Public Service District

Hilton Head Island, South Carolina

2014-2015 BIENNIAL BIOLOGICAL MONITORING REPORT

Ballantine

ENVIRONMENTAL RESOURCES

Boulder, Colorado
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Contents

1. Introduction

THIS BIENNIAL REPORT analyzes results from two-years of biological monitoring of Recycled Water (RW), formerly called ("Reclaimed Water") projects in the Palmetto Hall community, Hilton Head Island, South Carolina. The Hilton Head Public Service District ("PSD") discharged RW (advanced-treated domestic dechlorinated influent) into two freshwater wetlands in the Palmetto Hall community: the Forest Wetland ("Wooded Wetland" in permit documents) and the Golf Course Wetland ("Grassy Wetland" in permit documents). The following report describes scientific findings during the period from January 1, 2014 through December 31, 2015. The PSD has discharged RW in the wetlands since the late 1990s.

The National Pollution Discharge Elimination System (NPDES) Permit (No. SC0046191) requires specific biological monitoring parameters for the Palmetto Hall RW projects. The S.C. Department of Health and Environmental Control (SCDHEC) modified the permit on October 24, 2005. The permit revised maximum RW loading rates, monitoring for vegetation, and the scientific report schedule. In compliance with the permit, and to maintain the ecological database, this report presents monitoring results for 10 ecological parameters: hydrological loading of recycled water, dry-down (no-flow) periods, climate effects, ecological change, hydro-period, vegetation conditions, wildlife and other changes exceeding the "threshold of concern," whether ecological or operational.

Consistent with the NPDES permit specifications, the following monitoring results are compared with conditions in the 1999 Baseline monitoring results (reported February 1, 2000). This report includes the site description, methodology summary, monitoring results, conclusions and recommendations, references and an appendices. The sustainable RW program has been in operation for the Hilton Head Public Service District since 1986—and in Palmetto Hall since 1999. RW is processed and distributed by Hilton Head Public Service District in two, large freshwater wetlands -- Forest and Golf Course to (1) provide additional uptake of water and nutrients; (2) eliminate discharges to other waters, such as tidal streams; and (3) enhance the natural hydrology and ecological conditions of the receiving wetlands, which have been

impacted by land development and climate change. This report describes that climate-driven impacts continue in this RW project area.

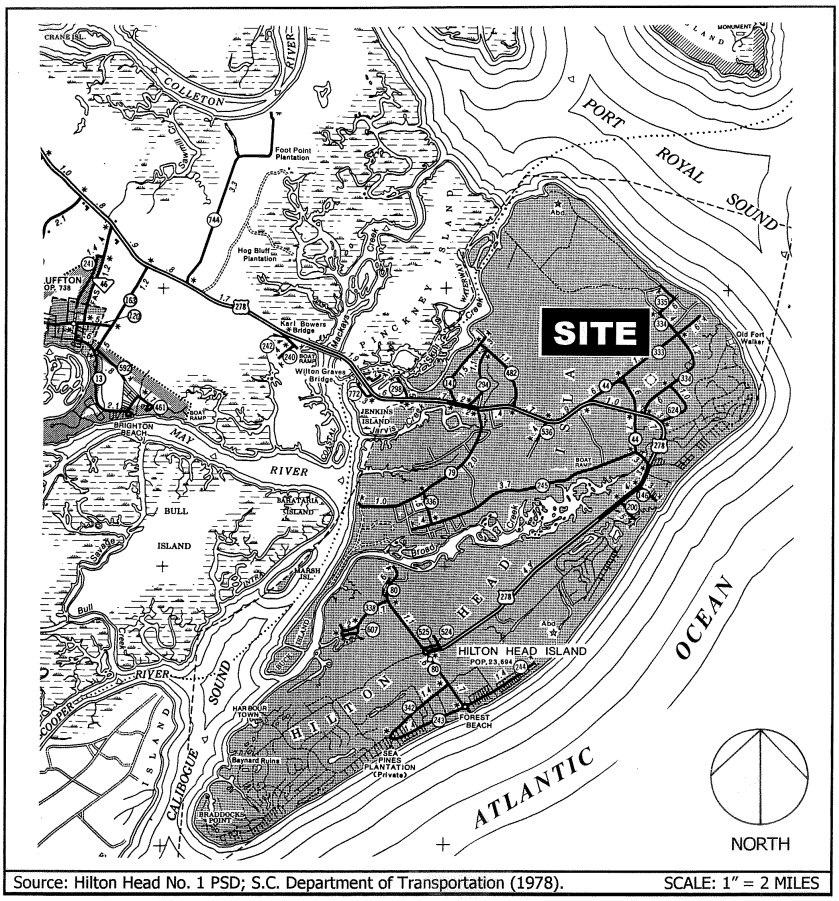
Since the Baseline, Ballantine Environmental Resources has consulted and conducted scientific measurement and reporting for the "Growing Season" (March 14 through November 17) and "Dormant Season" (November 18 through March 13). In compliance with the SCDHEC NPEDS permit for this RW project, our monitoring has reported data for the overall ecological condition, hydrology, vegetation, wildlife, and any other factors that may or do impact the RW project. The Conclusions and Recommendations assess the status of the wetlands and provide guidance for operational modifications, if practical, or justified environmentally.

2. Site Description

2-1. GEOGRAPHIC LOCATION

The RW projects are located in the private 750-acre residential and golf community of Palmetto Hall, on lower, northeastern Hilton Head Island, in southern Beaufort County, South Carolina (Figure 2-1). Palmetto Hall features two golf courses: the Arthur Hills Course and Robert Cupp Course. The RW projects are located in natural (not manmade) wetlands contiguous to these facilities (Figure 2-2). See the Annual and Baseline Report for 1999 for a detailed description of the physical and biological conditions of the projects. The map shows the site/location of the two project wetlands on northern Hilton Head Island. This area is associated with a prehistoric shoreline and wetland. Soils in the area are often "hydric"— easily saturated or inundated in rainstorms or floods.

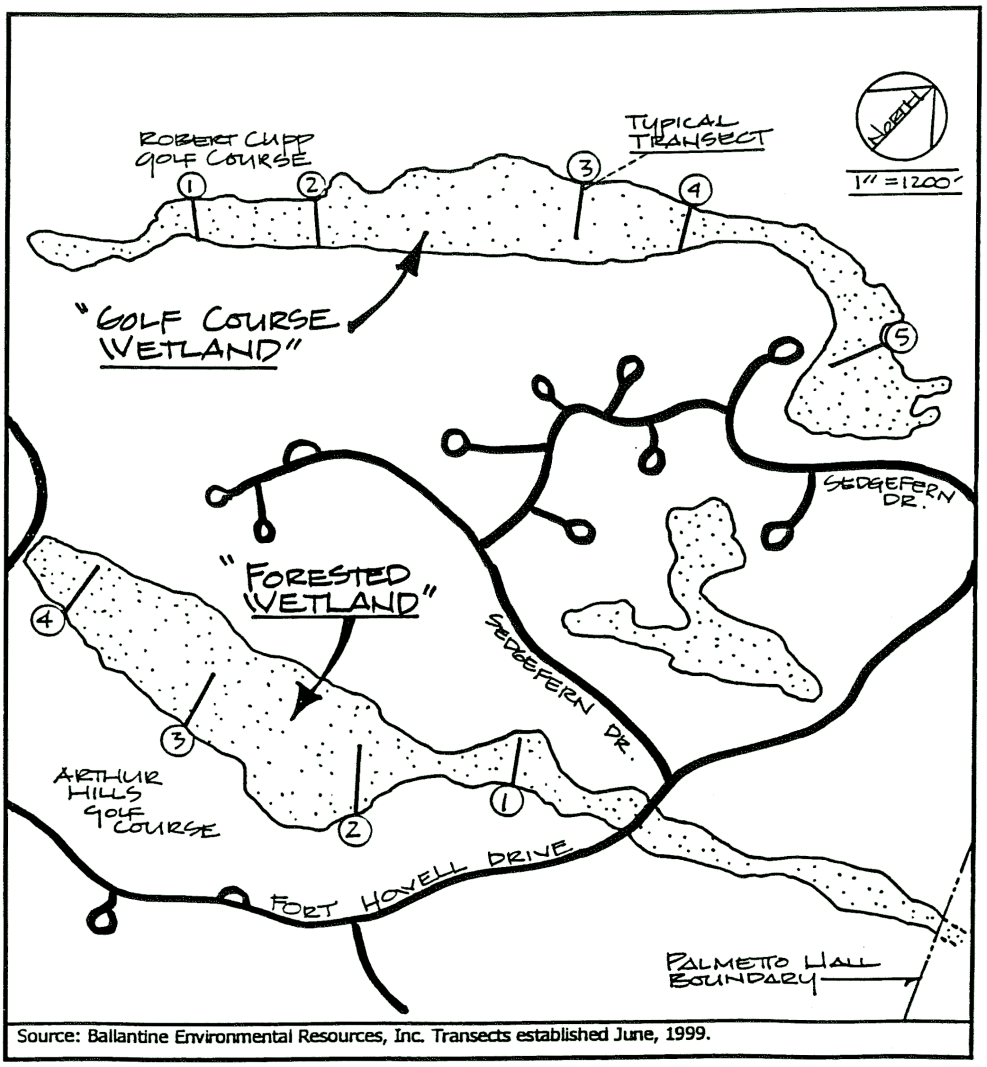
Figure 2-1. Location Map



2-2. FOREST WETLAND

The Forest Wetland is 119 acres in area. This linear basin has an average elevation of 10-15 feet mean sea level (MSL). It is a virgin old-growth hardwood forest association with most trees 50 to > 100 years in age—or technically: a palustrine-forest, bottomland hardwood community with a seasonally and artificially-flooded water regime. RW is discharged by aerial spray from a header at the western end of the wetland. One inch of RW throughout this wetland is equal to 2.4

2-2. Site Map: Forest Wetland

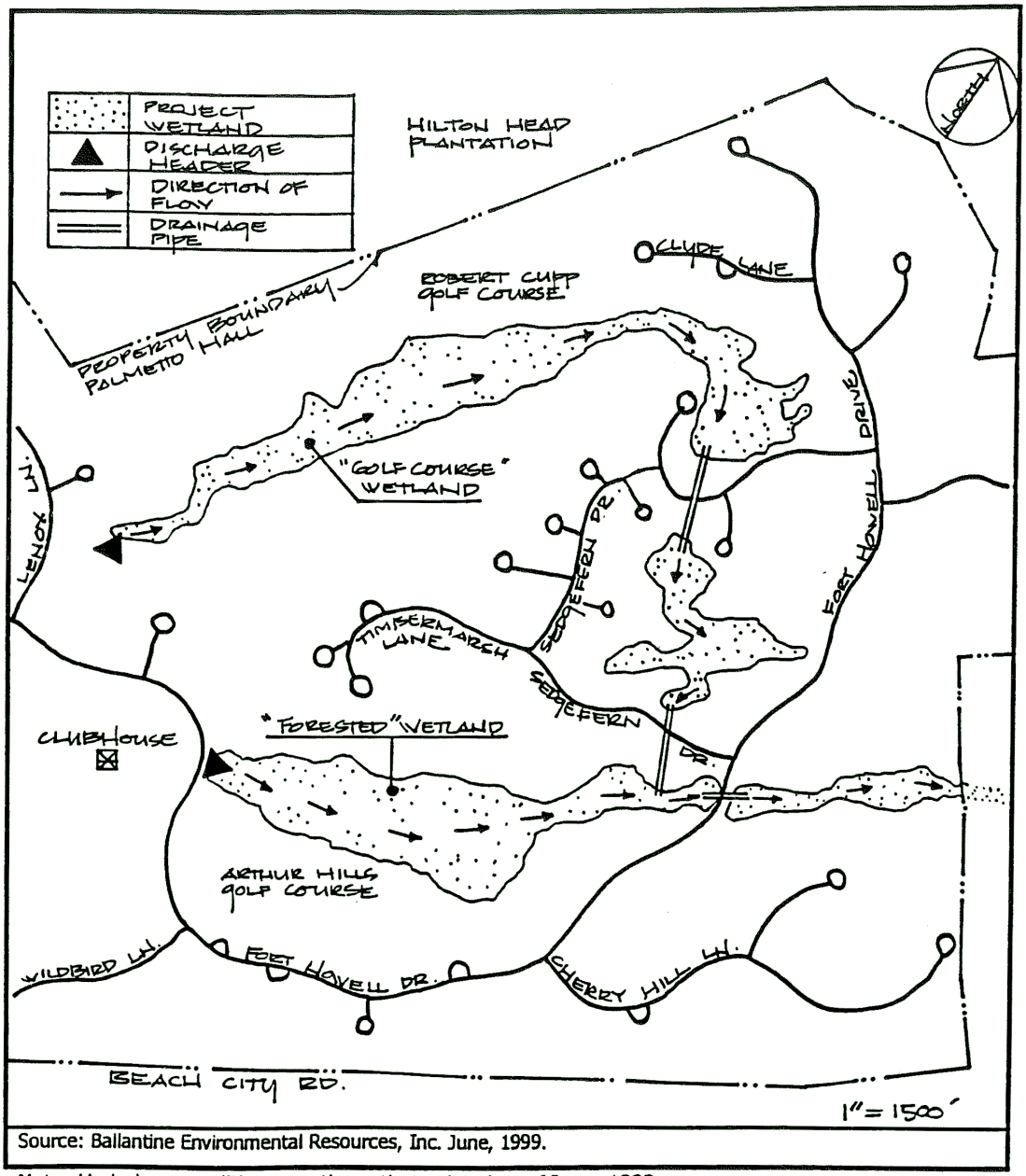


Source: Ballantine Environmental Resources, Inc. Transects established June, 1999.

million gallons. Sheet-flow drains in an eastward direction through the wetland, then through downstream off-site wetlands, on its way to Port Royal Sound (Figure 2-2).
Forest wetland boundaries have not changed. However, the native wetlands' interior communities *have* changed since the Baseline monitoring. The wetlands *have* changed more rapidly through ecological succession since the Baseline. The supply of RW has enhanced the rate of succession and vegetation growth—especially trees—since the Baseline. In contrast, the wetlands have been impacted by climate change effects including drought and flooding. This has impacted biodiversity of plant and wildlife. But regular RW flow has been a stabilizing resource supporting ecological succession and biological diversity of wildlife and plantlife.

2-3. GOLF COURSE WETLAND The Golf Course wetland is 98 acres in area with significant long-term water storage capacity and wildlife value. One inch of water throughout this wetland is equal to 2.7 million gallons. The average elevation is 10-15 feet MSL. The linear wetland is part of the watershed drainage via percolation and slow overland flow toward Port Royal Sound. The hydric soils on the northern wetland edge, adjacent to Sedge-fern Drive, are the eastern edges of the lower wetland that store groundwater at a high level through most of the year. The Golf Course Wetland is a palustrine-emergent marsh and palustrine-successional mixed pine-flatwood forest. A significant resource, in this wetland is the largest remaining sawgrass community on Hilton Head Island. The wetland has a seasonally and artificially flooded and/or saturated water regime. A header at the southern, upper end of the wetland discharges RW via low aerial spray. Sheet-flow moves through the wetland in a north-easterly direction, then turns to the southeast, and finally may discharge into the nearby Forest Wetland (Refer to Figure 2-3).

2-3. Golf Course Wetland



Source: Ballantine Environmental Resources, Inc. June, 1999.

Note: Hydrology conditions are those that existed as of June, 1999.

3. Monitoring Methodology

3-1. MONITORING SCHEDULE

As stipulated by the NPDES Permit No.SC0046191, Ballantine Environmental Resources monitored the project wetlands biennially in 2014 and 2015. We monitored hydrology, shrub and groundcover, and wildlife in the first week of May (growing season) 2015; and trees and vertebrate wildlife the third week of November 2015 (dormant season). The next monitoring is scheduled for April 2016.

Of note, in the period between the two monitoring cycles, South Carolina and less intensely, Hilton Head Island, was impacted by nor'easter storms leading to significant flooding. Hilton Head Island experienced beach erosion, and high-groundwater flooding due to the storms. The wetlands, however, are adapted to storms and high groundwater, and had no adverse natural impacts due to the storms.

3-2. MONITORING DATA

We used the line-transect and quadrat intercept method of data collection. In the Forest and Golf Course Wetland projects we maintain transects spanning the width of each wetland. Permanent sampling quadrat stations are established at equidistant point intercepts on the transects. Figures 2-2 and 2-3 show the location of monitoring transects in the project wetlands.

Our collected field data includes:

- ***Water depth*** measured at each station.
- ***Vegetation*** measured at each station. We recorded the diversity, dominance, and density of canopy species in cen-acre (1/100 acre) quadrats. In the shrub and groundcover stratum, we measured species diversity, dominance, and density in mil-acre (1/1,000 acre) stations.
- ***Wildlife:*** We identified macro-invertebrates (benthic, aerial and other) in stations and along transects. We recorded fish species identified visually or by netting in

appropriate habitats at stations. We also identified indicator vertebrates visually or physically (by vocalizations, "sign," tracks, or trails).

- ***Significant impacts:*** We documented wetland impacts from natural causes. Such impacts include flood, drought, storms, plant disease, invasive or "nuisance" species, and wildlife activity, as well as human impacts (e.g., trash dumping, mowing, vegetation removal, ditching or filling, or vandalism were also noted.

A detailed description of monitoring methods and calculations is provided in the "Palmetto Hall Reclaimed Water Project Description" (April 15, 1999), included in the Annual and Baseline Report.

3-3. REPORTS

The current SCDHEC NPDES permit requires biennial reports. However, as needed by Hilton Head PSD, Ballantine Environmental Resources provides additional monitoring, updates, outreach publications, and site investigation about the two RW projects.

This ***Biennial Biological Monitoring Report*** compares data collected in the growing and dormant seasons of 2014-2015 with conditions in the Baseline, according to parameters ascribed by the SCDHEC. We submit all reports to the Hilton Head PSD, which forwards the information to SCDHEC and other stakeholders. For more information contact:

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4. Monitoring Results by NPDES Wetland Parameters 2014-2015

PALMETTO HALL RECYCLED WATER (RW) PROJECT
Hilton Head Island, SC
NPDES Permit No. No.SC0046191
S.C. DHEC Monitoring Parameters
Forest Wetland and Golf Course Wetland
Palmetto Hall, Hilton Head Island, South Carolina
2014-2015 Conditions Compared with The 1996 Baseline Year

Parameter A. Hydroperiod

A-1. Biennial RW loading averaged annually compared to 40-year average rainfall and the Baseline.

The 40-year average rainfall, or "hydroperiod" for Hilton Head Island is **51** inches per acre per year (acre-inches). This is the Baseline against which to compare the sum of annual RW loading in inches plus rainfall in inches as recorded by Hilton Head PSD.

In 2014-2015 the Golf Course and Forest Wetlands received above-average rainfall: 13% above the historical 50-year mean. Precipitation was 15% percent higher in 2015, primarily due to an above-average rainfall in October related to an historic tropical storm, which caused massive flooding in central and upper South Carolina, and caused low-lying soils saturation on Hilton Head Island.

Over the two-year monitoring period, the project area received 90 acre-inches of RW, distributed as 69 inches in the Forest Wetland and 21 inches in the Golf Course Wetland.

Note: It is important to distinguish between flooding due to the uncontrolled stormwater vs. carefully managed long-term RW releases contained to wetlands in Palmetto Hall. Any flooding in the community was due to stormwater concentration in areas of hydric soils—but not due to RW-wetland operations. Several zones with hydric

Baratari Series soils, including those in Palmetto Hall, were developed for real estate. The location of poorly-drained, hydric Baratari soils in the community is well-known by soil scientists and is published on maps from the Natural Resources Conservation Service, formerly U.S. Soil Conservation Service (1980).

A-2. Depth of water in the RW wetlands. The average depth of water in the Forest Wetland was 6 inches,—twice as deep as in the Baseline (2.8 inches). The deepest water was 14 inches in the center channel of this bottomland system.

In the Golf Course Wetland, the average depth was 4 inches—shallower than in the Baseline (8 inches). The deepest water, 20 inches occurred in a depression area near the inflow pipe at the upper, east end of the wetland.

A-3. Distribution of Water in the Wetlands. Surface water covered 70 percent of the ground in the Forest Wetland and 50 percent of the Golf Course wetland. The Forest Wetland water was concentrated in a swale, the central channel that runs the length of the basin. The Golf Course Wetland, on the other hand, had concentrations of permanently standing water near the inflow pipe, a small pond on the eastern end of the wetland, and a shallow marsh in the low northeastern end of the large wetland. Here, water was flowing out of the wetland into the woods at the lower northeastern perimeter of the wetland, an area known as the Sawgrass Marsh. The water was approximately one inch deep, with slow, steady flow contained by woodlands on the wetland edge. Several homes are built close to this area, and encountered saturated soils. But there is no proof that recycled water was in direct contact with these properties.

A-4. Hydrology Compared to the Baseline. Surface water was less widespread and shallower than in the Baseline in each wetland. The effect of SCDHEC mandated dry-down (no flow) periods is likely to have substantially lowered the ground water tables in each wetland. However, it is noteworthy that shallow water was flowing out of the Golf Course Wetland as late as November 2015, six weeks after the above mentioned flood—an indicator of the limited capacity for water storage in this basin during large storm events. Of note: due to the recent dry-down, the wetlands provided more storage

capacity in recent flooding. This benefitted the ecological community and importantly, flood control for nearby residential areas.

Parameter B.
Canopy Species

B-1. Basal Area of Trees. Averaged for this sampling period, and compared with the Baseline, basal area of trees (flagged and measured biannually) has increased by 12 percent in the Forest Wetland and 8 percent in the Golf Course Wetland. The difference is a function of various species growth rates (e.g., longer-lived hardwoods, (Forest Wetland) or shorter lived softwoods (Golf Course Wetland), plus variable RW loading per wetland over time. It is highly probable that the hardwood-dominated Forest Wetland with slower-growing but longer-lived trees will eclipse the softwood-dominated Golf Course Wetland in basal area, longevity and overall biological diversity.

B-2. Density of Trees. On average, the mature Forest Wetland has sustained > 90 percent of all trees. Compare this durability to the Golf Course Wetlands pine-dominated community which has retained 70 percent of mature trees. This result portrays the difference between long lifespan hardwoods and successional softwood pines. Also compare the relative density of the different aged communities: hardwoods = 24-30 trees per acre; pines = 100-125 trees per acre.

In the Golf Course Wetland, where the forest is still at an early stage, we observed widespread succession by more densely aligned pines (loblolly and pond) and invasive Chinese tallow-trees at a rate exceeding 300 trees per acre. The mortality rates were less than 2 percent in the Forest Wetland and 5 percent in the Golf Course Wetland.

B-3. Importance Value. At the macro-level, the more mature Forest Wetland maintains a higher ecological importance because the trees have a slower growth rate and thus, more longevity (old-growth), higher resilience to damage and disease and more resistance to invasive species, and thus, a more diverse habitat value (cover/shelter and

food sources). The dominant species, in order of Importance Value are: swamp blackgum, red maple, sweet-gum, and loblolly pine. Chinese tallow-tree is an invasive species and has very little benefit ecologically. Currently this species is not spreading quickly in either project wetland.

The Golf Course Wetland is dominated by > 90 percent loblolly and pond pines, which are more short-lived and less productive for wildlife food and shelter. In addition, the open marsh areas, including communities of sawgrass, are shrinking by ecological succession and dewatering by trees. Small islands of hardwoods are emerging in this wetland—primarily in drainage corridors or small ponds. Conclusion: On a 100% value-scale of diversity and productivity, the stable old-growth Forest Wetland scores 80 percent; the transitional Golf Course wetland: 40 percent. This total includes the ongoing decline of the sawgrass savanna community.

Parameter C.
Shrub and Groundcover
Averaged for the wetland and compared to the Baseline

C-1. Species Diversity. Due to increasing canopy cover and shading, the population of groundcover species in the shrub-groundcover stratum has declined in both wetlands: -5 percent in the more stable Forest Wetland and -20 percent in the dynamically-changing Golf Course Wetland, since the Baseline. These responses are the result of (1) ecological succession over two decades; (2) climate events—flood, drought, wind; (3) and outcomes of operational stressors—in particular: dry-down requirements in the NPDES protocol. Since the Baseline, RW loading has mitigated what could have been the larger and more sudden decline in species diversity in both project wetlands due to recurring drought. Overall, the diversity of groundcover and canopy species in the Forest Wetland = 10-15 species, depending on season, climate events and RW loading. In the less-shaded Golf Course Wetland: biodiversity = 12 dominant-species.

Any declines in either wetland were not directly caused by RW loading. Two totally opposite conditions impacted these wetlands. First, The NPDES permit mandate for recurring dry-down periods has stressed the wetlands during the past growing

seasons for 5-10 years or more. This was especially impacting when the dry-down occurred during more frequent periods of drought. Second, the drier, degraded sawgrass community was defenseless during the recent flood, and suffered erosion. In essence: Dry-down = Die-back of groundcover vegetation. In turn, this decline impacted all portions of the wetlands.

C-2. Total Cover of Dominant Species. Averaged for the wetlands, total areal cover of dominant groundcover plants in the Forest Wetland maintained or increased 75 percent since the Baseline. For the Golf Course Wetland, the total cover, 65 percent, declined due to flooding and die-back. The rare sawgrass colony was especially impacted by adverse climate events.

C-3. Importance Value. This parameter is the comparative sum of relative dominance, (maximum 100 points), density (maximum 100 points), frequency (maximum 100 points) and wildlife habitat (maximum 100 points)—rated on an optimum score of 400 points per parameter. Since the Baseline, the old-growth Forest Wetland has maintained higher ecological value with the full hardwood canopy, in-tact shrub buffer, and mosaic of groundcover clusters and water channels. This system is 80 percent mature, with the increasingly stable, diverse and productive old-growth swamp forest. Therefore, estimated Importance Value of the Forest Wetland is 375.

The Golf Course Wetland ranks a lower Importance Value of 200—reflecting recent flood impacts and successional decline of the rare sawgrass savannah community in the past 3-5 years. Key RW operational impacts have been: NPDES permit-mandated dry-down, recurring drought, and recent flooding, which degraded the already declining sawgrass community.

Parameter D.
Nuisance Plant Species

Changes in environmental values and functions result from either positive stimuli (e.g., regular water flow) or negative impacts (drought, storm, or human impact). Either enhance or degrade a project wetland. Negative stimuli induce stress in wetlands, and the results are widespread and easily identified. The descriptions above highlight the successional changes in the RW wetlands, and whether these changes are natural or induced by RW operations. A significant goal and outcome of RW technology is to benefit the innate values and productive functions of the wetlands that receive RW. Nevertheless, certain liabilities may be associated with RW operations. One concern, as listed in the NPDES monitoring protocol, is the increase of "nuisance species" of invasive and non-native plants and/or wildlife that degrade the native wetland, water quality, and wildlife.

In the Palmetto Hall Wetlands nuisance species include: loblolly pine, (invasive; shades habitat; dewaters the wetland), invasive grasses such as giant foxtail and maidencane, (out-compete with native species); Chinese Tallow-tree, (highly invasive; poor food quality for wildlife;) and algae species, (lowers water quality; reduces habitat for diverse, more beneficial plants). As of 2014-2015 monitoring, we measured and assessed each of these species. Only loblolly pine is currently a clear and present threat to spread rapidly and change the ecological balance of the Palmetto Hall Golf Course RW wetlands at this time. This species is on a course to dominate the highly-stressed Golf Course marsh for a long time period. Averaged for the wetland, loblolly pines now shade more than 60 percent of the wetland and its rare savanna community—the northernmost sawgrass refuge in Beaufort County, SC. Beside out-competing with diverse groundcover and other canopy species, these pines also de-water the wetland via evapotranspiration, reducing biological activity and transforming the wetland into an increasingly less-diverse pine-flatwood community.

Parameter E.
Exceeding the Threshold of Concern: Canopy

Since the Baseline, Basal Area (B.A.) of trees has increased in the Forest Wetland by an average of 44 percent. High value hardwood trees make up over 90 percent of all canopy species. Swamp blackgum now accounts for 83 percent of B.A., followed by Sweetgum, red maple, and water oak. The total increase in dominance for all trees is 22 percent since the Baseline.

In contrast, B.A. in the Golf Course Wetland increased by 120 percent since the Baseline. There was no decline in canopy at any monitoring station of the pine-dominated Golf Course Wetland. Loblolly and/or pond pine B.A. increased on every monitoring station, for an average gain of 14 percent in each wetland. This growing dominance of conifers is evidence of normal, natural ecological succession. Thus: No threshold of concern for a parameter was exceeded—but two indicators of potential problems are apparent, as described below.

Concern: Future monitoring may indicate that operational changes—including tree thinning—are necessary in these wetlands in order to maintain biodiversity and maximum uptake of RW.

Concern: The dry-down mandate is more of an impact than a benefit in the wetlands. This requirement should be voluntary, not mandatory, or eliminated to reduce the likelihood of widespread dieback in droughts that are more common year by year. The only reason to retain dry-down is to temporarily prepare wetlands for future flood control —based on recommendations from the National Weather Service. (See Climate Change, Glossary).

Parameter F.
Exceeding the Threshold of Concern:
Shrub and Groundcover

Since the Baseline, the shrub-groundcover stratum remained stable: increasing growth and resisting climate impacts such as flood and drought. The Importance Value of this stratum increased an average of 15% in each wetland. The most durable locations were the entire Forest Wetland and the middle pine flatwood of the the Golf Course Wetland. In these areas, ecological changes were limited and isolated—except for the flood damage to the sawgrass savanna community, described above.

Parameter G.
Natural Causes

The primary natural causes of change in the Palmetto Hall RW wetlands were flooding and soil erosion, drought, and invasive species. Flooding occurred during the strong tropical storm described above. This event raised the surface level several feet for a short duration of several weeks. The values, functions and natural resources in the wetlands experienced only short-term disruption. The most significant impact was flooding in the lower eastern zones of the Golf Course Wetland. High water washed-out or silted over 40 percent of the groundcover. This formed new drainage channels which may impact surface water flow and vegetation re-growth, including sawgrass, in the next decade or longer. The most important species to be impacted by the flooding was the remnant savanna community of sawgrass. For decades the RW flows sustained this rare vegetation community and its wildlife inhabitants. Wide portions of the flood covered and washed-up or uprooted over 50% of the rare grassland, eliminating rootstock and hydric soils. This habitat will require restoration in order to recover the values and functions of a viable floodplain wetlands: of flood control, soil retention, aquatic wildlife habitat and more. Finally, because the Golf Course Wetland has become degraded, this

may impact its functions of nutrient uptake, sediment filtration, and wildlife habitat. The full scope of impact is not yet quantified. However, we will analyze the wetland in the next round of monitoring.

Parameter H.
Benthic Macro-Invertebrates

We sampled benthic macro-invertebrates in the growing and dormant seasons of the wetlands and compared species with the master inventory of species published at the end of this report. In general, samples in the dormant season produced fewer species. But in the most recent growing season the species count was lower than normal. It is probable that climate disruption of habitat impacted species diversity. Species identified included but were not limited to: amphipod sp., black salt marsh mosquito, carpenter ant, Chironomid midge, fire ant, golden salt marsh mosquito, salt palamedes swallowtail, scud, stinkbug sp., and water treader. This list is a sample of the species diversity in the RW wetlands—it is likely that a 10 percent sample of the actual population was visible to the human eye.

Parameter I.
Fish

Fish species were uncommon in the wetland ponds following the disruptive floods. However, we did identify golden salt-marsh mosquito larva in the deeper waters of each wetland. This species is common prey for wetland fish and an indicator that suitable water quality, volume, and food sources are available in the surface waters in these wetlands. We also observed egrets and herons hunting larger fish in the pools of the Forest Wetland and ponds of the Golf Course Wetland. This is an indication that in spite of disruption from flooding, fish and other aquatic organisms, survived in viable habitat of the RW wetlands.

Parameter J.
Endangered or Threatened Species

In the course of monitoring the Palmetto Hall wetlands, we observed no federally or state of South Carolina-listed endangered or threatened wildlife species in the Palmetto Hall RW wetlands. Potential species are: Heel-spitter clam, Northern myotis bat, and Red Knot.

Parameter K.
No Discharge Period In the Wetland

In 2014, no flow of RW was distributed in the Golf Course Wetland during the period between March and October. In 2015, the Golf Course Wetland received no RW flow from May through August. Impacts of this dry-down were partially mitigated by the flood.

Conclusions and Recommendations

CONCLUSIONS

This Biennial Report analyzed the results from biological monitoring in 2014 through 2015 of RW operations in the Palmetto Hall Forest and Golf Course Wetlands on Hilton Head Island, South Carolina. Comparison of the two-years' data with conditions in the baseline year 1999 leads to the following conclusions:

1. The most significant effect on the RW wetlands was historic flooding in October 2015. This natural event (tropical storm) caused surface water migration out of the Golf Course Wetland; the demise of the rare sawgrass savanna of the Golf Course Wetland; and groundwater flooding in nearby residential neighborhoods. These impacts were not caused or aggravated by RW operations.

2. The flood temporarily mitigated impacts in the wetlands, the foremost being mandatory dry-downs. In the past decade this restriction contributed to the decline of dominant vegetation and wildlife habitat—primarily, in the Golf Course Wetland and its rare sawgrass savanna. Long-term drought is the result of a complex of human causes (regulatory restriction) and natural cycles (below-average precipitation that has been ongoing since 1999, the Baseline year). The results—continuing through 2015—were increased "uptake", or evapotranspiration by vegetation; a lowered water table, and increased demand for irrigation using RW. The dearth of rainfall and RW for Palmetto Hall wetlands had caused the declines in values and functions of the wetlands—until recent flooding.

3. Input of RW has partly compensated for the significant drought impacts in the past. But in this recent year, RW input provided partial benefits in the "shoulder seasons"—January-March and October-December—when demand for water by vegetation and golf irrigation is least. At this time, RW flow may help restore the groundwater balance in the wetlands, improving long-term ecological conditions.

4. The wetlands do the best job of filtering and metabolizing RW when they are functional. The significant impact to functionality is the NPDES permit-mandated dry-down period of no RW flow to the wetlands. Our monitoring has documented that this restriction reduces the environmental benefits of the Palmetto Hall project. The impact is most severe during drought.

5. We saw no evidence of endangered species, or nesting by colonial wading birds. However, we did observe raptors and numerous international migratory songbirds in the Forest Wetland hardwood forest canopy: this proves that when well managed for water supply and conservation, the Palmetto Hall RW wetlands provide long-term conservation benefits.

RECOMMENDATIONS

1. Continue the monitoring program to maintain the biological database, comply with NPDES requirements and sustain ecological integrity of the Palmetto Hall Forest and Golf Course RW Wetlands.

2. Operational changes are recommended: To rectify significant natural and human impacts, eliminate the dry-down rule in the RW Wetlands. This action will; (1) help sustain critical functions of the wetlands, including water quality enhancement sought by the U.S. Clean Water Act; (2) preserve critical habitat for protected international migratory wildlife, such as the songbirds and raptors that currently use the wetlands.

3. Future monitoring reports should continue to detail specific impacts of climate change on the the RW Wetlands.

4. 2016 monitoring should adhere to accurate yearly field monitoring and biennial reporting, consistent and updated with past reports.

5. Recommendations will be aligned with the goals of improving RW efficiency and conservation benefits.

6. Hilton Head PSD should continue its successful outreach program to educate customers and the general public about the valuable Recycled Water Program pioneered on Hilton Head Island.

6. Glossary

Adsorption Accumulation of liquids or solids on the surface of leaves.

Basal Area The cross-sectional area of a tree trunk measured in square inches or square feet at 4.5 feet above ground.

Biennial A duration of two years.

Bottomland A low terrain that contains freshwater or a high water table.

Climate Change Any significant change in the measures of climate lasting for an extended period of time. Climate change includes major changes in temperature, precipitation, or wind patterns, among others, that occur over several decades or longer.

Colonial Wading Birds Herons, egrets and ibises and other long-legged water birds that nest in dense communities called "rookeries."

Cover The degree to which above-ground portions of vegetation cover the ground surface. Also called areal cover.

Dominance The measure of a plant species compared with other species, based on areal cover (groundcover) and caliper inches converted to basal area (trees).

Density The number of individuals of a species per unit area.

Dry-down A mandated period in which no Recycled Water flows into a wetland.

Drought A period of abnormally low rainfall that affects growing or living conditions.

Ecological Succession The process in which communities of plant and animal species in a particular area are replaced over time by a series of different and more complex communities.

Endangered Species A species of plant or animal that is in danger of going extinct.

Emergent Plant A plant with its lower part underwater and its upper part, usually leaves and flowers, above the water surface.

Evapotranspiration The process in which water is changed into vapor by atmospheric pressure, wind, humidity, solar radiation, and released through plant leaves and bark.

Flyway A globally fixed route along which birds (e.g., songbirds and waterfowl) migrate.

Frequency The distribution of individuals of a plant species in an area.

Growing Season The portion of the year that is frost-free.

Habitat A place where a plant or animal lives. A productive habitat provides sufficient food, cover and water.

Hardwood A broad-leaved tree such blackgum, red maple, or sweet gum.

Hydrology The properties, distribution and circulation of water.

Hydroperiod The average annual cycle of rainfall of a location.

Importance Value The relative influence of a plant species in a plant community, obtained by summing relative dominance, density and frequency.

Indicator Species A species that indicates whether an ecosystem is vibrant or degrading.

Keystone Species A species that affects other species in a community.

Macro-Invertebrate An animal species lacking a backbone and which can be seen without the aid of optical magnification.

Neotropical The geographic region including Central and South America.

NPDES National Pollution Discharge System permit under the Clean Water Act.

Old-growth Forest A forest community with large trees for the site and species type; multiple canopy layers; and wide spacing between trees. Example: the Palmetto Hall Forest Wetland.

Palustrine A freshwater community. Example: Palmetto Hall Golf Course Wetland.

Recycled Water Advanced-treated domestic water discharged into wetlands to restore ecological functions, values, wildlife habitat, and human recreation opportunities. Formerly named “reclaimed water.”

Surface Plant A species of vegetation that keeps leaves above the surface of the water.

Wetland An area that is inundated or saturated by surface or ground water at a frequency and duration to support vegetation adapted to saturated or flooded soil.

7. Wetland Vegetation

Inventory of Observed Plant Species: 1999-Present

FOREST WETLAND

Common Name	Scientific Name
Blackgum	Nyssa biflora
Broomsedge Bluestem	Andropogon virginicus
Bur Marigold	Bidens laevis
Button Bush	Cephalanthus occidentalis
Carolina Willow	Salix caroliniana
Climbing Hempweed	Mikania scandens
Cushion Moss	Leucobyrum glaucum
Creeping Primrose	Ludwigia palustris
Dog Fennel	Eupatorium compositifolium
Duckweed	Lemna minor
Duckweed	Lemna vadiviana
False Nettle	Boehmeria cylindrica
Fetterbush	Lyonia lucida
Floating Bladderwort	Utricularia inflata
Frog's Bit	Limnobium spongia
Gallberry	Ilex glabra
Grass-leaved Sagittaria	Sagittaria graminea
Highbush Blueberry	Vaccinium corymbosum
Lizard Tail	Saururus cernuus
Loblolly Pine	Pinus taeda
Maidencane	Panicum hemitomon
Marsh Pennywort	Hydrocotyle umbellata
Mosquito Fern	Azolla caroliniana
Netted Chainfern	Woodwardia areolata
Pickerelweed	Pontederia cordata
Persimmon	Diospyros virginiana
Poison Ivy	Toxicodendron radicans
Pond Pine	Pinus serotina
Primrose Willow	Ludwigia peruviana
Red Bay	Persea borbonia
Red Bay/Swamp Red Bay	Persea palustris
Red Maple	Acer rubrum
Red-root	Lachnanthes caroliniana
Royal Fern	Osmunda regalis

Shade Mudflower	Micranthemum umbrosum
Southern Blueflag Iris	Iris versicolor
Spanish Moss	Tillandsia usneiodes
Sweet Gum	Liquidamber stryaciflua
Switch Grass Panicum	Panicum virgatum
Virginia Chainfern	Woodwardia virginica
Walter's Sedge	Carex walteri
Water Net	Hydrodicton sp.
Water Pennywort	Hydrocotyle ranunculoides
Water Pepper	Polygonum hydropiperoides
Waxmyrtle	Myrica cerifera
Wingstem	Verbesina occidentalis
Wolffia (Water Meal)	Wolffia punctata
Yellow Cyperus	Cyperus flavescens

Total: 47 Species

GOLF COURSE WETLAND

Common Name	Scientific Name
Black-Gum	Nyssa biflora
Blue-green Algae	Lyngbya sp.
Bracken Fern	Pteridium aquilinum
Broomsedge Bluestem	Andropogon virginicus
Bur marigold	Bidens laevis
Carolina Willow	Salix caroliniana
Cattail (Tall)	Typha latifolia
Chinese Tallowtree	Sapium sebifera
Cinnamon Fern	Osmunda cinnamomea
Climbing Hempweed	Mikania scandens
Cushion Moss	Leucobyrum glaucum
Dahoon Holly	Ilex cassine
Duckweed	Lemna vadiviana
False Nettle	Boehmeria cylindrica
Fetterbush	Lyonia lucida
Floating Bladderwort	Utricularia inflata
Gallberry	Ilex glabra
Giant Cane	Arundinaria gigantea
Giant Plume Grass	Erianthus gigantea
Loblolly Pine	Pinus taeda
Maidencane	Panicum hemitomon
Marsh Pennywort	Hydrocotyle umbellata
Mosquito Fern	Azolla caroliniana
Netted Chainfern	Woodwardia areolata

Persimmon	Diospyros virginiana
Pickerelweed	Pontederia cordata
Plume Grass	Setaria magna
Poison Ivy	Toxicodendron radicans
Red Maple	Acer rubrum
Red Bay	Persea borbonia
Red-root	Lachnanthes caroliniana
Royal Fern	Osmunda regalis
Saw Palmetto	Serenoa repens
Sawgrass	Cladium jamaicense
Sedge sp.	Carex sp.
Smartweed (Dense-flower)	Polygonum densiflorum
Soft Rush	Juncus effusus
Southern Blueflag Iris	Iris versicolor
Spanish Moss	Tillandsia usneiodes
Swamp Dewberry	Rubus hispidus
Swamp Knotweed	Polygonum hydropiperoides
Virginia Chainfern	Woodwardia virginica
Virginia Creeper	Parthenocissus quinquefolia
Water Milfoil	Myriophyllum sp.
Water Net Algae	Hydrodictyon sp.
Water Pennywort	Hydrocotyle ranunculoides
Water Spider Orchid	Habenaria repens
Waxmyrtle	Myrica cerifera
Wolffia (Water Meal)	Wolffia punctata

Total: 48 Species

8. Wetland Wildlife

Inventory of Observed Animal Species: 1999-Present

FOREST WETLAND

Common Name:	Scientific Name:

VERTEBRATES

Amphibians: 4 Species

Green Treefrog	Hyla cinerea
Southern Dusky Salamander	Desmognathus auriculatus
Southern Chorus Frog	Pseudracis nigrata
Southern Leopard Frog	Rana sphenocephala

Birds: 29 Species

American Robin	Turdus migratorius
Barred Owl	trix varia
Blue Jay	Cyanocitta cristata
Carolina Chickadee	Parus carolinensis
Carolina Wren	Thyrothorus ludovicianus
Chuck-Will's Widow	Caprimulgus carolinensis
Common Crow	Corvus brachyrhynchos
Common Grackle	Quiscalus quiscula
Downy Woodpecker	Picoides pubescens
Eastern Phoebe	ayornis phoebe
Gray Catbird	Dumetella carolinensis
Great Blue Heron	Ardea herodias
Great Egret	Casmerodius albus
Green-backed Heron	Butorides striatus
Northern Cardinal	Cardinalis cardinalis
Osprey	Panodiun haliaetus
Pileated Woodpecker	Dryocopus pileatus
Red-bellied Woodpecker	Melanerpes carolinus
Red-shouldered Hawk	Buteo lineatus
Red-tailed Hawk	Buteo jamaicensis
Rufous-sided Towhee	Pipilo erythrophthalmusi
Snowy Egret	Egretta thula
Tufted Titmouse	Parus bicolor
Turkey Vulture	Cathartes aura
Yellow-bellied Sapsucker	Sphyrapicus varius

Yellow-rumped Warbler	Dendroica coronata
Wood Duck	Aix sponsa
Wood Stork	Mycteria americana
White Ibis	Eudocimus albus

Fish: 1 Species

Eastern Mosquitofish	Gambusia affinis

Mammals: 4 Species

Eastern Gray Squirrel	Sciurus carolinensis
Raccoon	Procyon lotor
White-tailed Deer	Odicoileus virginianus hiltonensis

Reptiles: 6 Species

American Alligator	Alligator mississippiensis
Five-lined Skink	Eumeces fasciatus
Green Anole	Anolis carolinensis carolinensis
Southern Black Racer	Coluber constrictus priapus
Eastern Cottonmouth	Agkistrodon piscovorus-piscovorus
Northern Copperhead	Agkistrodon contrortrix-mokasen

Macro-Invertebrates

Arachnids: 16 Species

Black and Yellow Argiope Spider	Argiope aurantia
Brown Daddy-long-legs	Phalangium opilio
Carolina Wolf Spider	Lycosa carolinensis
Comb-footed Spider	Anelosimus studiosus
Chigger (Harvestmite)	Trombicula sp.
Dwarf Spider	Ostearius melonopyius
Forest Wolf Spider	Lycosa gulosa
Golden Silk Spider	Nephila clavipes
Jumping Spider	Metaphidippus galathen
Mabel Orchard Spider	Leucauge mabelae
Sheetweb Spider	Linyphiinnia sp.
Six-spotted Fishing Spider	Dolomedes triton
Thin-legged Wolf Spider	Pardosa sp.
Water Mite	Hygrobates sp.
Water Spider	Argyronera aquatica
White Micranthena Spider	Micranthena mitrata

Copepods: 2 Species

Calanoid Copepod	Copepoda sp.
Diaptomus Copepod	Diaptomus sp.

Crustaceans: 2 Species

Isopod	Asellus sp.
Scud	Hyalella azteca

Diplopods: 2 Species

Millipede	Sirobolid sp.
Millipede	Platydesmid sp.

Insects: 46 Species

American Dagger Moth	Acronicta americana
Angular-winged Katydid	Microcentrum retinerve
Black-faced Skimmer Dragonfly	Libellul cyanea
Black Salt marsh Mosquito	Aedes taeniorynchus
Broad-shouldered Water Strider	Microvelia borealis
Brown Daddy-long-legs	Phalngium opiolo
Chironomid midge	Chironomid sp.
Common Water Strider	Gerris remigis
Crane Fly	Tipula sp.
Creeping Water Bug	Pelocoris sp.
Deerfly	Chrysops sp.
Earwig	Foricula sp.
Elmid Beetle	Stenelnis lateralis
Field Cricket	Gryllus pennsylvanicus
Fire Ant	Solenopsis gominata
Golden Salt marsh Mosquito	Aedes solicitans
Green Clearwing Dragonfly	Erythemis simpliciollis
Green Darner Dragonfly	Ajax junius
Green Midge	Tanytarsus sp.
Green Water Strider	Gerris sp.
Katydid	Pseudophyllinae sp.
Marsh Fly	Tetanocera sp.
Mydas Fly	Mydas clavatus
Mud Dauber Wasp	Sceliphron caementarium
Leaf Beetle	Donacia sp.
Leafhopper	Cicallid sp.
Long-legged Fly	Dolichoplus longipennis
Love Bug	Plecia neartica

Nessus Sphinx Moth	Amphion nessus
Northern Katydid	Pterophylla camefolia
Palamedes Swallowtail Butterfly	Pterourus palamedes
Periodical Cicada	Magicicada sp.
Planthopper	Delphacid sp.
Scarab Beetle	Scarabaedid sp.
Southern House Mosquito	Culex pipiens quinquefaxciatus
Small Whirligig Beetle	Gyrinus sp.
Southern Spread-wing Damselfly	Lestes austalis
Summer Mosquito	Aedes atlanticus
Tree-hole Mosquito	Aedes triseriatus
Water Boatman	Corixa sp.
Water Lily Leaf Beetle	Donacid sp.
Water Strider – Broad-shouldered	Microvelia borealis
Water Strider	Gerris marginatus
Water Treader	Mesovelia mulsanti
White Fly	Aleyrodid sp.
Widow Dragonfly	Libelulla lucoasa
Yellow Jacket	Vespula sp.

Isoptera: 1 Species

Eastern Subterranean Termite	Reticulitermes flavipes

Mollusca: 1 Species

Hairy Wheel Snail	Gyraulus hirsutus

Tadpole Shrimp: 1 Species

Tadpole Shrimp	Triops longicaudatus

Water Fleas: 1 Species

Water Flea	Daphnia pulex

Total: 110 Species

GOLF COURSE WETLAND

Common Name:	Scientific Name:

VERTEBRATES

Amphibians: 1 Species

Green Treefrog	Hyla cinerea

Birds: 37 Species

American Black Duck	Anas rubripes
American Coot	Fulica americana
American Robin	Turdus migratorius
Anhinga	Anhinga anhinga
Bald Eagle	Haliaeetus leucocephalus
Black-crowned Night Heron	Nycticorax violacea
Blue Jay	Cyanocitta cristata
Carolina Chickadee	Parus carolinensis
Carolina Wren	Thyrothorus ludovicianus
Cedar Waxwing	Bombycilla cedrorum
Common Crow	Corvus brachyrhynchos
Common Grackle	Quiscalus quiscula
Common Yellow-shafted Flicker	Colaptes auratus
Eastern Bluebird	Sialia sialis
Great Blue Heron	Ardea herodias
Great Crested Flycatcher	Myiarchus crinitus
Great Egret	Casmerodius albus
Great Horned Owl	Bubo virginianus
Green-backed Heron	Butorides striatus
Moorhen (Common Gallinule)	Gallinula chloropus
Northern Cardinal	Cardinalis cardinalis
Osprey	Panodiun haliaetus
Peregrine Falcon	Falco peregrinus
Pileated Woodpecker	Dryocopus pileatus
Red-bellied Woodpecker	Melanerpes carolinus
Red-winged Blackbird	Agelaius phoeniceus
Red-shouldered Hawk	Buteo lineatus
Ruby-throated Hummingbird	Archilochus colubris
Rufous-sided Towhee	Pipilo erythrophthalmusi
Snowy Egret	Egretta thula

Tufted Titmouse	Parus bicolor
Turkey Vulture	Cathartes aura
Yellow-billed Cuckoo	Coccyzuz americanus
Yellow-rumped Warbler	Dendroica coronata
Wood Duck	Aix sponsa
Wood Stork	Mycteria americana
White Ibis	Eudocimus albus

Fish: 1 Species

Eastern Mosquitofish	Gambusia affinis

Mammals: 4 Species

Eastern Gray Squirrel	Sciurus carolinensis
Raccoon	Procyon lotor
River Otter	Lutra canadensis
White-tailed Deer	Odicoileus virginianus-hiltonensis

Reptiles: 4 Species

American Alligator	Alligator mississippiensis
Eastern Cottonmouth	Agkistrodon piscivorus-piscovorus
Green Anole	Anolis carolinensis carolinensis
Yellow-bellied Slider	Chrysemys scripta scriptai

Macro-Invertebrates

Arachnids: 9 Species

American Dog Tick	Dermacento variablis
Forest Wolf Spider	Lycosa gulosa
Dwarf Spider	Mycriphantinae sp.
Golden Silk Spider	Nephila clavipes
Pirate Wolf Spider	Pirata piraticus
Red Freshwater Mite	Limnocharus americana
Six-spotted Fishing Spider	Dolomedes triton
Wasp Spider	Halcti sp.
Water Mite	Hygrobates sp.

Crustaceans: 4 Species

Scud	Gammarus fasciatus
Scud	Hyalella asteca
Sow Bug	Oniscus asellus

Water Flea	Daphnia pulex

Insects: 35 Species	**Insects: 36 Species**
American Dagger Moth	Aconicta americana
Black Carpenter Ant	Camponotus pennsylvanicus
Black Fly	Simulium sp.
Black Salt marsh Mosquito	Aedes taenorhynchus
Citrine Forktail Damselfly	Ischnura hastata
Chironomid Midge	Chironomid sp.
Condylostylid Long-legged Fly	Condylostylid sp.
Common Water Strider	Gerris remigis
Crawling Water Beetle	Peltodytes lengi
Deerfly	Chrysops sp.
Eastern Malaria Mosquito	Aedes quidrimaculatus
Eastern Tent Moth	Malicosma americanum
Field Cricket	Gryllus pennsylvanicus
Green Clearwing Dragonfly	Erythemis simplicollis
Green Darner Dragonfly	Anax junius
Green Midge	Tanytarsus sp.
House Fly	Musca domestica
Leaf Beetle	Donacia sp.
Lightning Bug	Lampyrid sp.
Marsh Fly	Tetanocera sp.
Meadow Grasshopper	Convuphalinae sp.
Net-winged Damselfly	Argia sp.
Pale Bluet Dragonfly	Enallagma hastata
Periodical Cicada	Magicicidada sp.
Plant Bug	Mirid sp.
Planthopper	Delphacid sp.
Red Skimmer Dragonfly	Libellula saturata
Shore Fly	Ephyrdid sp.
Southern House Mosquito	Culex pipiens quinquefaxciatus
Spotless Nine-spotted Ladybug	Coccinella novemnota franciscana
Swift Long-winged Skimmer	Pachydiplax longipennis
Thrip	Thysanoptera sp.
Water Scorpion	Ranatra sp.
Water Strider – Broad-shouldered	Microvelia borealis
Whirligig Beetle	Dineutes americanas

Isoptera: 1 Species

Eastern Subterranean Termite	Reticulitermes flavipes

Worms: 2 Species

Earthworm	Lumbricus terristis.
Flatworm	Dugesia tigrina

Mollusks: 3 Species

Hairy Wheel Snail	Gyraulus hirsutus
Little Pond Snail	Amnicola limnosa
Winkle Snail	Vivaparus intertextus

Total: 100 Species

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