ANNUAL BIOLOGICAL MONITORING REPORT
2011

PALMETTO HALL RECLAIMED WATER PROJECTS
Hilton Head Island, South Carolina

Pickerelweed and sawgrass: Golf Course Wetland

BALLANTINE
ENVIRONMENTAL RESOURCES

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Hilton Head Island, South Carolina

Submitted to
HILTON HEAD PUBLIC SERVICE DISTRICT

February 2012

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Executive Summary

THIS REPORT DESCRIBES THE RESULTS OF BIOLOGICAL MONITORING IN 2011 of two reclaimed water projects in Palmetto Hall, Hilton Head Island, South Carolina. Reclaimed water is advanced-treated domestic wastewater ("influent") that is discharged into natural wetlands. Since 1996, Hilton Head Public Service District has discharged reclaimed water in two freshwater wetlands – **the Forested Wetland** (formerly "Wooded Area") and the Golf Course Wetland (formerly "Grassy Area").

The report compares 2011 monitoring results with conditions in the baseline year 1999. In compliance with methodology required by South Carolina Department of Health and Environmental Control NPDES Permit, the following parameters were monitored: hydrology, vegetation, wildlife, significant negative impacts, and significant impacts from natural causes. Data was collected in early May ("growing season") and mid-November ("dormant season") of 2011.

MONITORING RESULTS AND RECOMMENDATIONS

- The foremost effect on the reclaimed water projects was low rainfall in the growing season. Annual precipitation was significantly below average during the critical season of vegetation growth and wildlife reproduction—April to August.
- The growing season rainfall deficit and reduced influent loading during the period and produced drier conditions in both wetlands. The reclaimed water was distributed to area golf courses for irrigation during this period.
- The PSD discharged 114% more influent into the wetlands than it discharged in the baseline. This "loading" primarily occurred during autumn and winter—periods of slow or dormant biological activity in the wetlands.
- The Forested Wetland, with 55% of the total acreage of the project area, received 60% of the reclaimed water. The Golf Course Wetland (45% of the total acreage) received 40% of available reclaimed water. This ratio of shared reclaimed water is closer to the preferred "acres-and-gallons parity" than in past years.
- Total water (rain and reclaimed water) loading in 2011 exceeded baseline totals in both wetlands. Note that the baseline year was a period of significant drought.
- In each wetland, the total water loading exceeded the normal long-term hydroperiod in nine months—substantially more than in the baseline.

- The growing season diversity of plant species in each wetland was the same as in the baseline.
- During 2011, no adverse effects associated with reclaimed water operations occurred in either the Forested Wetland or the Golf Course Wetland. Historical evidence proves that all changes in basal area, cover and importance values were due to normal and extreme natural events in years past, and were not caused by past or current reclaimed water operations.
- Monitoring has shown that reclaimed water significantly enhances the vegetation growth in the canopy, sub-canopy, shrub and groundcover, and surface water strata.
- Reclaimed water is an increasingly valuable resource for preserving wetlands. Recurring drought has altered the hydrology of aquatic systems, as well as general groundwater conditions on Hilton Head Island. The "sustainable recycling" of treated water is a proven method of conserving, and even saving, old-growth and rare communities such as the Forested and Golf Course Wetlands.

5.2. Recommendations

To sustain the integrity, effectiveness and benefits of the reclaimed water project, we recommend:

- Continue to provide reclaimed water according to the "acres and gallons" parity described above. This will sustain the rare, diverse sawgrass and bottomland hardwood communities, stimulate biological activity, and control invasive nuisance vegetation.
- Continue to critique the impact of the permit-mandated dry-down. Especially in the Golf Course Wetland, dry-down has severely stressed rare sawgrass community, stimulated the entry of invasive species, and lessened habitat diversity for aquatic wildlife. This impact has been more severe in this decade of recurring drought.
- The 2012 biological monitoring should continue the scientific protocol described in SCDHEC Surface Water Discharge Permit No. SC0046191 (modified 10/24/05). Ballantine Environmental Resources will produce Mid-year and Annual Biological Monitoring Reports. These reports will be submitted to the PSD. The 2012 Annual Report should be completed in February of 2013.

Todd H. Ballantine
Senior Environmental Scientist
Ballantine Environmental Resources Inc.
February 2012

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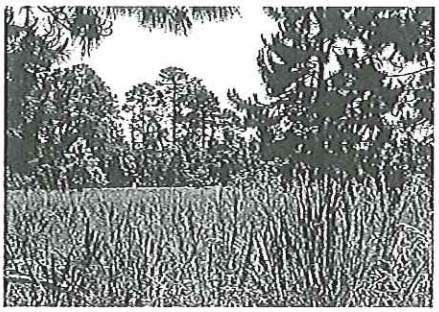


1. Introduction

THIS REPORT PRESENTS the results from biological monitoring of reclaimed water projects in Palmetto Hall, Hilton Head Island, South Carolina during 2011. The Hilton Head Public Service District ("PSD") discharged reclaimed water (advanced-treated domestic wastewater, or "influent") into two large freshwater wetlands – the "Forested Wetland" (called "Wooded Wetland" in the NPDES Permit) and "Golf Course Wetland" (called "Grassy Wetland"). The following report describes scientific findings during the period from January 1 through December 31, 2011.

The National Pollution Discharge Elimination System Permit (No. SC0046191) requires a specific biological monitoring protocol for the Palmetto Hall reclaimed water projects. The S.C. Department of Health and Environmental Control (SCDHEC) modified the NPDES permit on October 24, 2005. The permit revised maximum reclaimed water loading rates, monitoring criteria for vegetation, and the monitoring report schedule. In compliance with the permit, and to provide the complete biological data to Hilton Head Public Service District, this report presents the annual monitoring results for:

- **Wetland hydrology** – Monthly rainfall; monthly influent loading; comparison of total water (rain and influent) to the natural hydroperiod; and surface water depth and coverage.
- **Vegetation** – Canopy and groundcover species diversity, dominance, density, frequency and importance value; nuisance species; changes exceeding the range of "significant negative impact"; and observed endangered or threatened species.
- **Wildlife** – Macroinvertebrate species from observation and sampling; fish species from observation or sampling; and observed endangered or threatened species.
- **Impacts** – Natural causes (weather events, disease, insects, and invasive species; and human-induced impacts (litter, fill vegetation removal, or non-PSD discharges).

These monitoring results are compared with conditions in the 1999 baseline[1]. The report includes the executive summary, methodology summary, monitoring results, conclusions and recommendations, references, and appendixes.

Footnote:

[1] Annual and Baseline Monitoring Report for the Year 1999: Palmetto Hall Reclaimed Water Project, Hilton Head Island, South Carolina: Ballantine Environmental Resources, Inc., February 1, 2000.

2. Site Description

2.1. Geographic Location

Palmetto Hall is located on the northeastern-central portion of Hilton Head Island, in southeastern Beaufort County, South Carolina (Figure 2-1). The 750-acre residential community features two golf courses: the Arthur Hills Course and Robert Cupp Course. (Figure 2-2) The reclaimed water projects are located in wetlands contiguous to these facilities. The golf operations use reclaimed water for irrigation; the wetlands receive reclaimed water for ecological restoration. See the Annual and Baseline Report for 1999 for a detailed description of the physical and biological conditions of the projects.

2.2. Forested Wetland

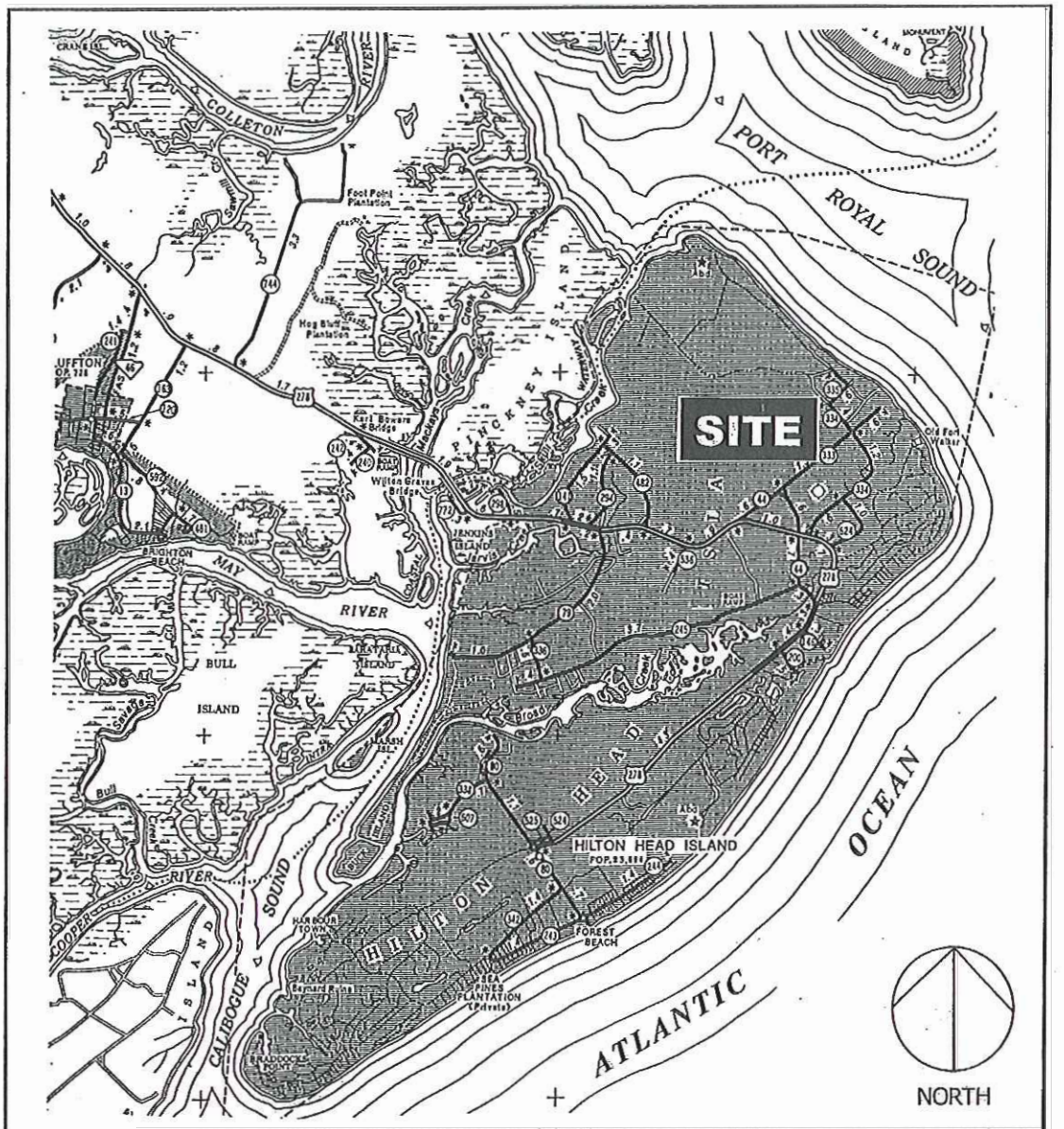
The Forested Wetland is approximately 119 acres in area. This system has an average elevation of 10-15 feet mean sea level (MSL). It is a virgin, emerging old growth (most trees 50 to >100 years old) palustrine (freshwater) forested, bottomland hardwood community with a seasonally and artificially flooded water regime. Reclaimed water is discharged from a header at the upper, western end of the wetland. Sheet-flow drains in an eastward direction through the wetland, then through off-site wetlands, on its way to Port Royal Sound (Figure 2-2).

2.3. Golf Course Wetland

The Golf Course Wetland is approximately 98 acres in area. The average elevation is 10-15 feet MSL. The linear wetland is an ancient interdune swale and part of the watershed draining into Port Royal Sound. This palustrine-emergent marsh and mixed forest includes the last great stand of sawgrass on Hilton Head Island. This wetland has a seasonally and artificially flooded and/or saturated water regime. A header at the southern end of the wetland discharges reclaimed water. Sheet flow (surface water) moves through the wetland in a northerly direction, then turns to the southeast toward the forested wetland (Figure 2-3).

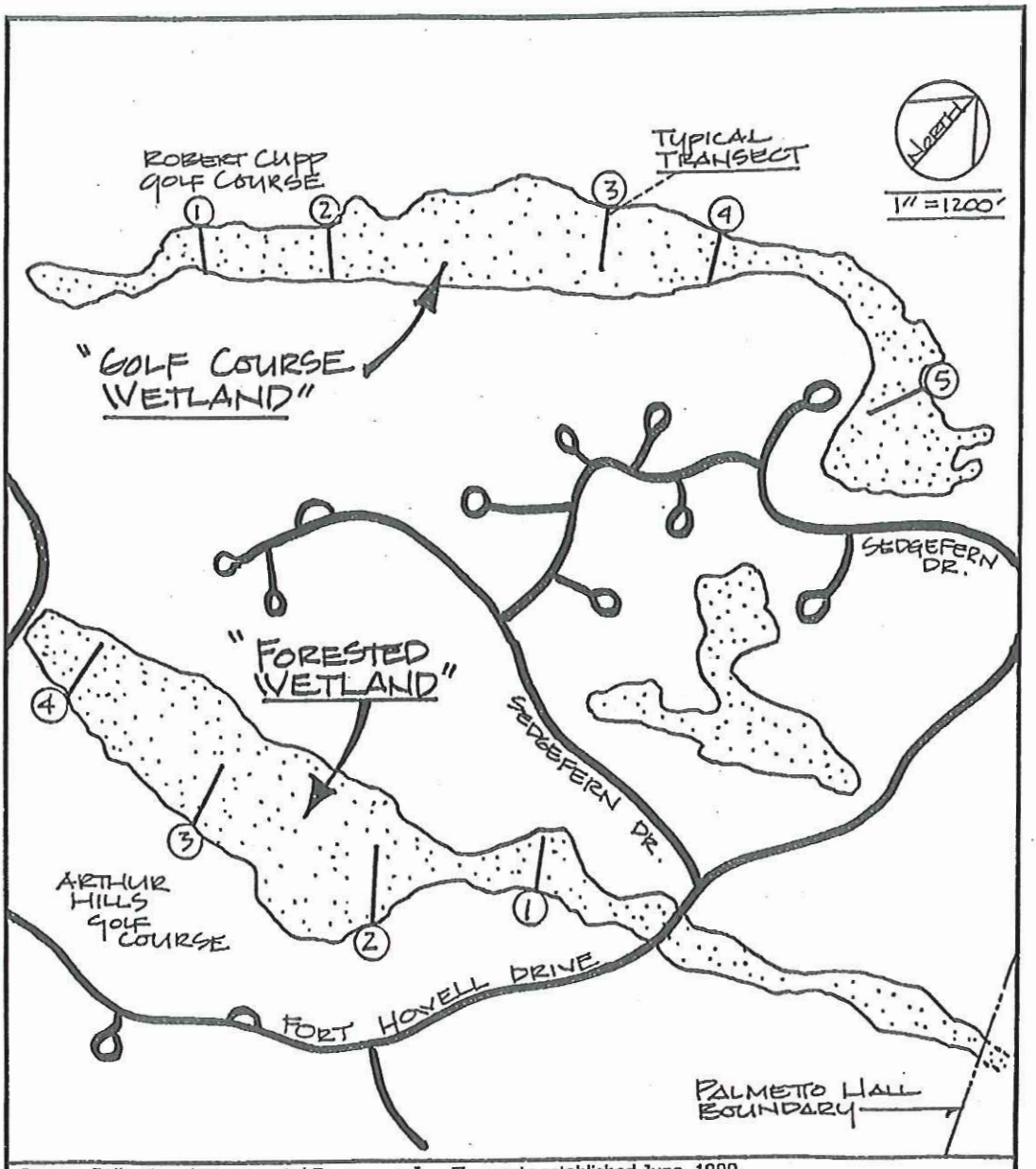
(Photos: Marianne Ballantine)

Figure 2-1
Site Location Map
Palmetto Hall Reclaimed Water Projects



Source: Hilton Head No. 1 PSD; S.C. Department of Transportation (1978). SCALE: 1" = 2 MILES

Figure 2-2
Wetlands Location
Palmetto Hall Reclaimed Water Projects
Showing Monitoring Transects

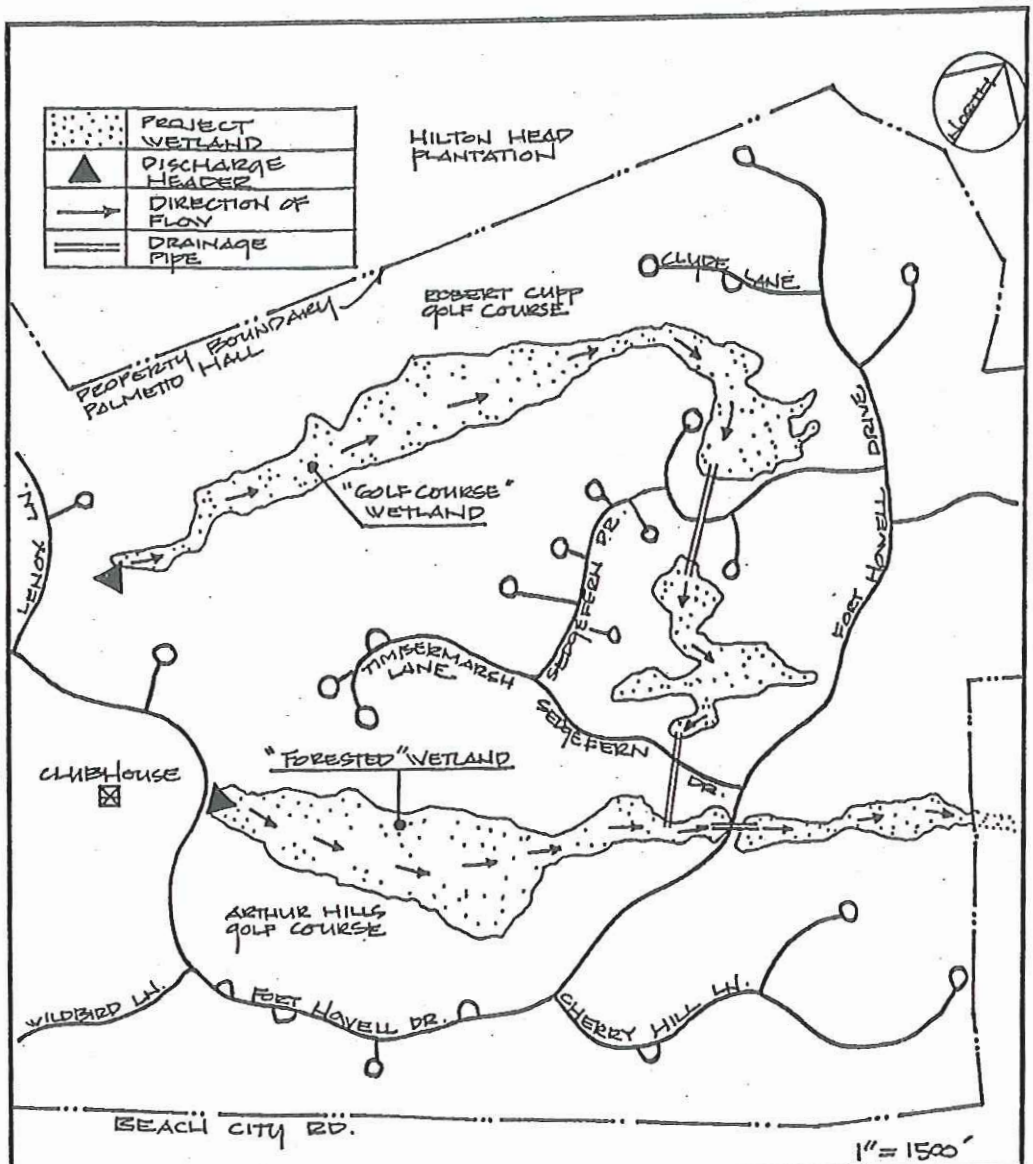


Source: Ballantine Environmental Resources, Inc. Transects established June, 1999.

Figure 2-3

Wetland Drainage

Palmetto Hall Reclaimed Water Projects



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

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

3. Methodology

3.1. Monitoring Schedule

We monitored the project-wetlands in the growing season – May 5-10, 2011; and the dormant season – November 15-20, 2011.

3.2. Protocol

The monitoring protocol is designed to collect data required in the NPDES permit and also to determine conditions that show the ecological health of the wetlands. Monitoring followed the line-transect and quadrat intercept method of data collection. In each project-wetland, we established transects with three permanent sampling quadrats on each transect. In the Forested Wetland, we measured conditions on four transects. In the Golf Course wetland, which is more elongated, we monitored on five transects. Conditions on these "stations" represent the composite of conditions on all quadrats along a specific transect.

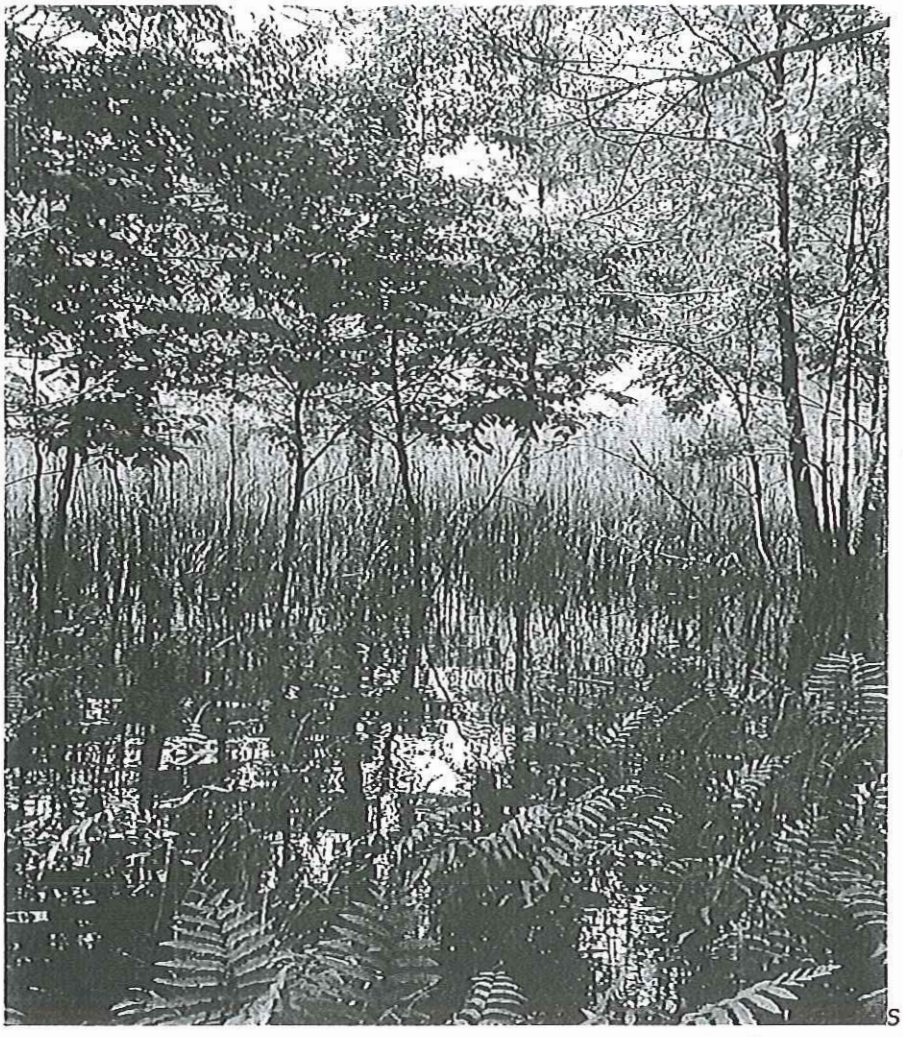
Data was collected as follows:

1. **Water depth:** Measured at each quadrat.
2. **Vegetation:** Measured at each quadrat. Dominance and density of canopy species was recorded in cen-acre (1/100 acre) quadrats. In the shrub and groundcover stratum, species dominance and density were measured in mil-acre (1/1000 acre) quadrats.
3. **Wildlife:** Macroinvertebrates (benthic, aerial and other) were assayed at each quadrat; and also identified along transects. Fish were identified visually or by netting. Other vertebrate species were identified visually or physically (by vocalizations, "sign," tracks, or trails).
4. **Significant impacts:** Wetland impacts from natural causes (weather events, invasive species, disease, insects, etc.) were documented for the year.

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 for 1999.

3.3. Reports

Reports with monitoring results for the two reclaimed water projects were published semiannually. The *Growing Season Report* (July 2011) described conditions in the peak period of biological production in each wetland. Normally, the wetlands are drier in summer, but have more wildlife activity. The following *Annual Biological Monitoring Report* compares scientific data collected in the growing and dormant seasons of 2011 with the 1999 baseline of environmental conditions in the project-wetlands. Ballantine Environmental Resources, Inc. submitted the reports to Hilton Head Public Service District for distribution to SCDHEC and other interested parties.



WATER MEANDERS through the long, shallow Golf Course Wetland. This community has three distinct plant communities. Seen here: blackgum and persimmon trees; sawgrass and maidencane; and Virginia chainfern in the forefront. *(Photo: Marianne Ballantine)*

4. Monitoring Results

4.1. Wetland Hydrology

4.1.1. Precipitation: Significantly lower for the year

The PSD recorded a total of 39.7 inches of rainfall in the project area for 2011 (Table 4-1). Precipitation was 22% below the 40-year average for Hilton Head Island (S.C. Water Resources Commission 1993). The 2011 rainfall also was lower than precipitation in the baseline (-2%).

Monthly rainfall occurred in a "peaks and valleys" pattern: significantly high in late winter and late summer; far below average through most of summer and autumn. The table shows this pattern and that monthly precipitation was below normal for 67% (eight months) of 2011. ***Significant:*** Precipitation was below average through the heart of the growing season – the critical period of vegetation development and wildlife reproduction. Reclaimed water loading had minimal benefit during this time because available water was diverted to area golf courses, according to contractual agreements. The most unusual precipitation for the year: virtually no rain in May (0.6 inches). This report will show that the 2011 rain deficit was the primary cause of any biological changes in the wetlands.

Table 4-1
Rainfall in 2011
Palmetto Hall Reclaimed Water Project
Totals are in Inches
Source: Hilton Head PSD

Month	2011 Rain	40-Yr. AV	+/-
January	2.76	3.74	-
February	3.56	3.42	+
March	4.31	4.04	+
April	1.52	2.95	-
May	0.57	3.76	-
June	3.70	4.99	-
July	4.41	6.19	-
August	8.94	7.75	+
September	3.35	5.80	-
October	3.21	2.86	+
November	1.62	2.36	-
December	1.75	2.86	-
Total:	**39.70**	**51.01**	-

"+" = Rain surplus; "-"= deficit, compared with the 40-year average.

4.1.2. Reclaimed Water Loading

In 2011, Hilton Head PSD discharged a total of 137.3 million gallons (MG) of reclaimed water into the two project wetlands. This volume of influent was 114% more influent than the amount discharged in the baseline. No flow occurred in the Golf Course Wetland from May through July due to low rainfall and the commitment of reclaimed water for golf irrigation. Flows in the Forested Wetland also were low May-July. The very dry conditions during this period affected biological activity. Reclaimed water did not cause any impact.

The Forested Wetland, with 55% of the gross acreage, received 60% of the influent (88.245 MG; 27.3 acre-inches). Flows occurred every month. This loading volume in 2011 was 37% more the baseline-volume.

The Golf Course Wetland, with 45% of the gross acreage, received 40% of the influent (49 MG; 18.4 acre-inches). No flow occurred from May through June. However, the 2011 loading total was 100% higher than in the baseline (no influent).

Table 4-2 summarizes the monthly influent loading for 2011.

Table 4-2
Influent Flows in 2011
Palmetto Hall Reclaimed Water Project
Flows are in Acre-Inches

Month	Forested	Golf Course	Total
January	4.14	2.34	6.48
February	3.13	2.60	5.72
March	2.75	2.27	5.01
April	3.43	2.78	6.22
May	0.01	0	0.01
June	0.01	0	0.01
July	0.01	0	0.01
August	2.72	2.02	4.74
September	2.20	1.96	4.16
October	0.95	1.87	2.82
November	1.50	12.51	14.00
December	6.43	4.69	11.12
Total:	**27.28**	**18.37**	**45.65**

Source: Hilton Head Public Service District

4.1.3. Total Water

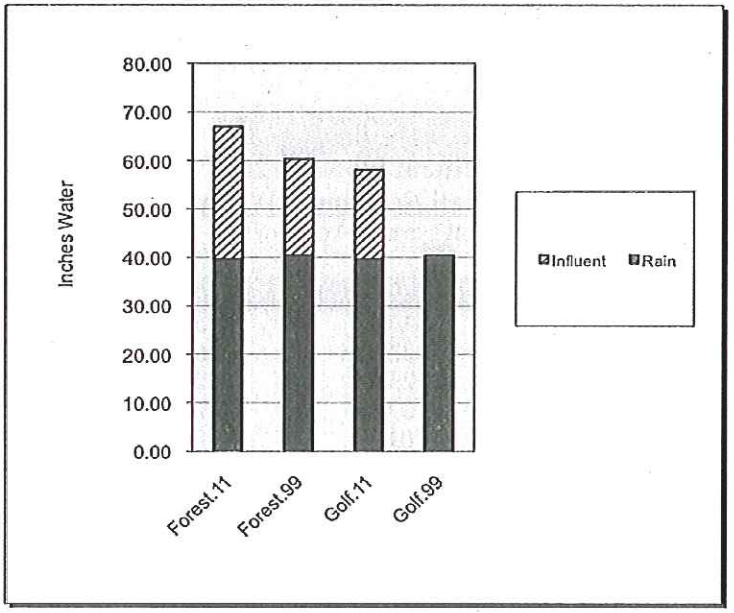
In 2011, cumulative loading of rainwater and reclaimed water ("total water") was higher in both wetlands, compared to the baseline (Figure 4-1). This trend has continued in most years, as the baseline was a year of incipient drought, and reclaimed water flows were lower.

Forested Wetland: This system received 67 acre-inches of total water, or 5.6 acre-inches per month (0.18 inch per day). 2011 total water was 59% precipitation; 41% reclaimed water. This year's total water loading was 11% higher than the amount received in the baseline; and 20% more water compared with the 40-year rainfall average.

Golf Course Wetland: This wetland received 58 acre-inches of total water, equal to 4.8 acre inches monthly (0.16 inches per day). In 2011, the ratio of rainfall to influent was 68% rain to 32% reclaimed water, and 14% more water than the 40-year average of 51.1 inches. This level of water was 100% higher than in the baseline (no flow).

Figure 4-1

Total Water Loading: 2011 & 1999 Baseline
Forested and Golf Course Wetlands
Palmetto Hall Reclaimed Water Project



The figure above shows that ***reclaimed water is a supplement to rainfall*** in the wetlands. The influent restores water lost through subterranean migration to retention basins in the watersheds; and offsets recurring drought impacts. In effect, the addition of reclaimed water rebalances ground and surface water levels in the Palmetto Hall drainage basin—creating a large-scale benefit to the landscape and its wildlife.

4.1.4. Total Water Compared to Hydroperiod

The hydroperiod—the annual water cycle of water timing, quantity, and distribution—is the primary limiting factor for vegetation and wildlife in wetlands. Table 4-1 (Page 8) shows that historically, Hilton Head Island's hydroperiod is characterized by four seasonal variations:

1. **Winter:** Moderate rainfall and negligible evapotranspiration[2].
2. **Early spring:** Less rainfall, but increasing evapotranspiration.
3. **Late spring through late summer:** The most rain and evapotranspiration.
4. **Autumn:** Descending rainfall and evapotranspiration.

Table 4-3 indicates that in the Forested Wetland, total water loading (in acre-inches) exceeded the hydroperiod in eight months—two more than in the baseline. In the Golf Course Wetland, total water loading exceeded the hydroperiod in nine months—five more than during the baseline. Reminder: the baseline period occurred during a year of drought.

Table 4-3
Loading of Total Water in 2011 and Baseline Compared to the Hydroperiod
Palmetto Hall Reclaimed Water Project

Wetland	Number Months Above Hydroperiod	Number Months Below Hydroperiod
Forested	9	3
Baseline	*6*	*6*
Golf Course	8	4
Baseline	*4*	*8*

Figures 4-2 and 4-3 (Pages 12-13) compare total water loading, by month in 2011 with the hydroperiod in each project-wetland. Noteworthy events: (a) total water exceeded the hydroperiod mostly in months with above-average rainfall and in the dormant season; (b) total water received in the wetlands was less than average for most of the months in the growing season.

[2] What is Evapotranspiration? Through the year, a high percentage of surface and groundwater is removed from wetlands by the atmosphere and vegetation. This ***evapotranspiration*** process occurs when water is changed into vapor by atmospheric pressure, wind, humidity, temperature, solar radiation, and release into the atmosphere through plant leaves and bark. The typical evapotranspiration rate in a coastal deciduous forest forms a bell curve, which increases exponentially in the first half of the year; peaks in July; and descends rapidly after August. Evapotranspiration removes an estimated ≥30 inches of water per year from the Palmetto Hall project wetlands (Thornthwaite and Mather 1955). This trend accounts for the normally lower water levels in the wetlands from April through October.

Figure 4-2

Total Water Loading in Inches
Compared to Hydroperiod
Forested Wetland
2011

Total water (TW) exceeded the hydroperiod in nine months. Surplus loading occurred in early spring, and mid-summer through the end of 2011. The added water reduced the impact of low rainfall during the critical growing season. Note the spike of TW in August, when rainfall was above average, golf course irrigation demand was low, and a surplus of reclaimed water was available for the wetland.

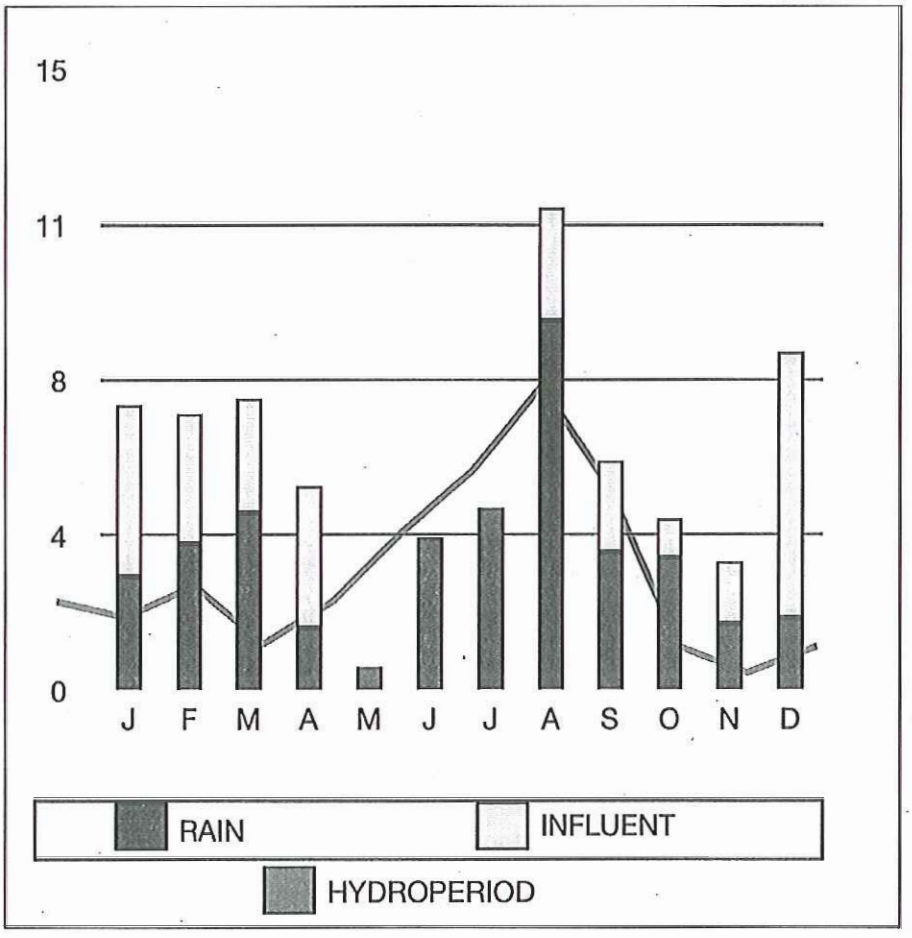
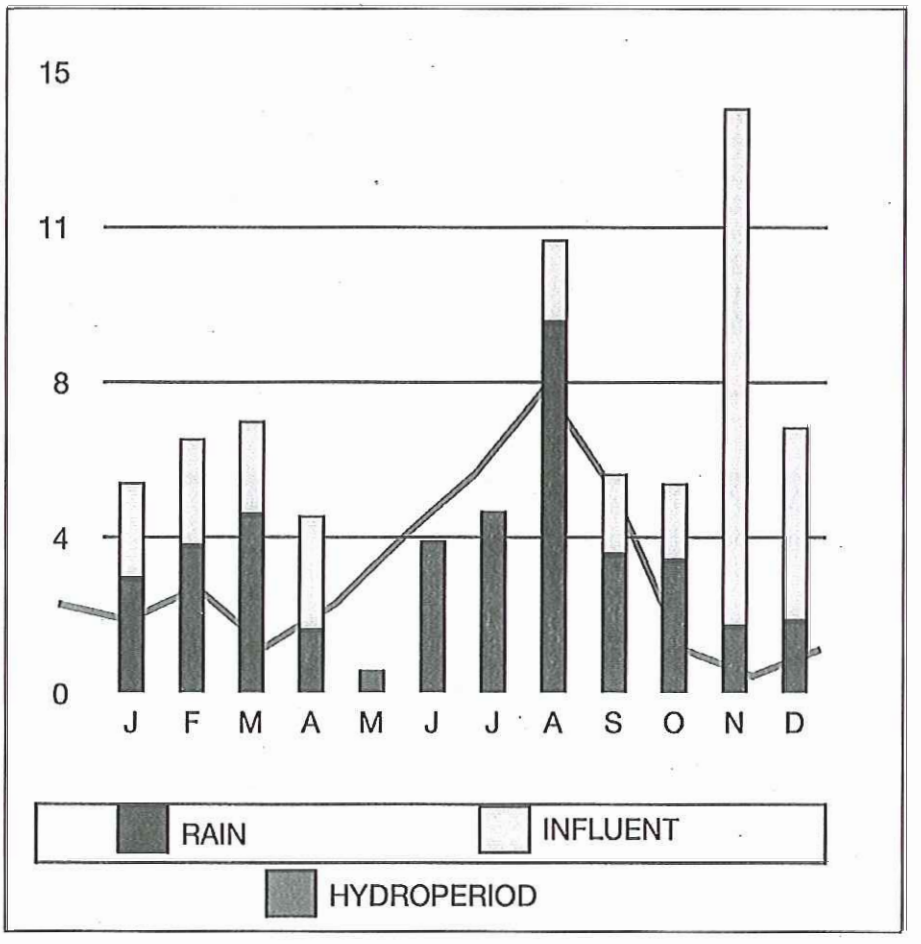


Figure 4-3

Total Water Loading in 2011
Compared to Hydroperiod
Golf Course Wetland

Total water loading exceeded the natural hydroperiod in 8 months during 2011. Although this graph appears similar to Figure 4-2, careful inspection shows that the Golf Course Wetland received less reclaimed water per month, and about 9 inches less through the year.

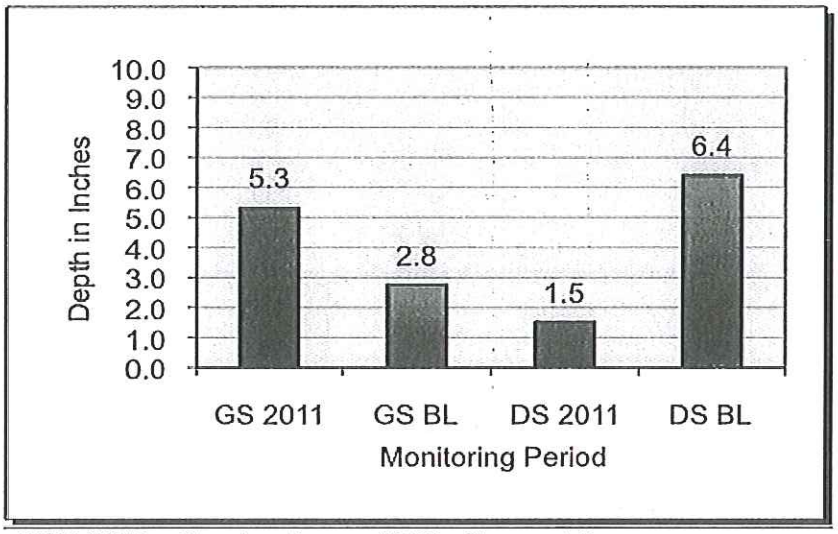


4.1.5. Surface Water Depth

In 2011 the average surface water depth was significantly higher in the growing season for each project wetland. This condition was the result of the higher reclaimed water loading rate in the first four months of 2011, less demand for irrigation on golf courses, and the lower evaportanspiration rate by wetland vegetation in late winter-early spring.

Figure 4-4

Average Surface Water Depth in 2011 & Baseline Forested Wetland



KEY: "GS" = Growing Season; "DS" = Dormant Season.
Bar numbers are inches of surface water.

SPRING WATER

The Forested Wetland had deeper surface water in the early growing season. This benefitted vegetation cover and wildlife diversity. Unlike conditions in the baseline, the surface water became progressively shallower through 2011.
(Photo: Marianne Ballantine)

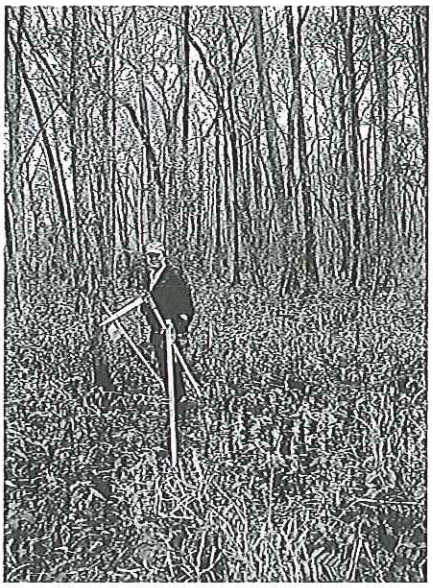
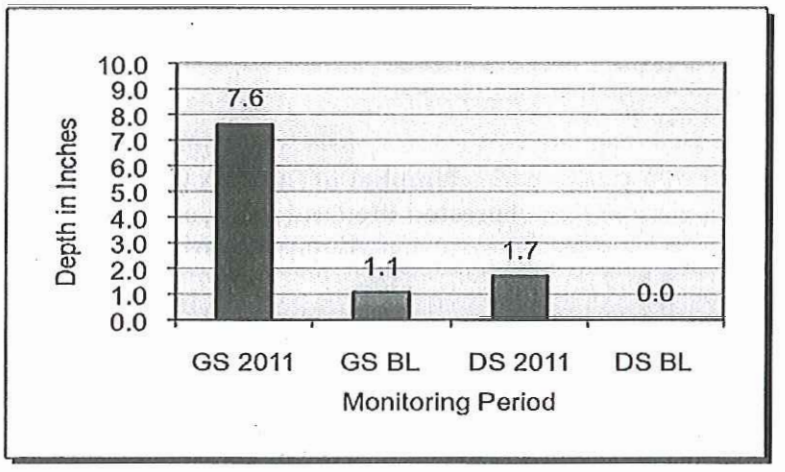


Figure 4-5

Average Surface Water Depth in 2011 & Baseline
Golf Course Wetland

DEEPER IN SPRING, SHALLOW IN FALL

The Golf Course project had highest water in the early growing season of 2011. Surface water in the dormant season was significantly lower—but still deeper that in the same period of the baseline.



Blackgum and maidencane show autumn colors in the Golf Course Wetland. The water level was less than one inch deep in the emerging pine flatwoods community, shown here. *(Photo: Todd Ballantine)*

4.1.6. Surface Water Distribution in Wetlands

In the baseline growing season, we measured the water depth at each quadrat on transects. The distribution of standing water in each wetland was calculated by tallying the absolute number of stations with a measurable water depth. Measurements in the growing and dormant seasons of 2011 are compared in Table 4-4. The percentage shown in the bottom row indicates the estimated surface water coverage over the wetland.

Table 4-4
Number of Stations with Surface Water
Forested Wetland and Golf Course Wetland 2011
Compared with Baseline

Forested Wetland			Golf Course Wetland		
2011 Growing Season	2011 Dormant Season	Baseline	2011 Growing Season	2011 Dormant Season	Baseline
12 of 12 Stations	5 of 12 Stations	10 of 12 Stations	13 of 15 Stations	5 of 15 Stations	7 of 15 Stations
Percent of Wetland Covered by Water			Percent of Wetland Covered by Water		
100%	42%	84%	87%	33%	47%

2011 compared to the baseline water levels (1999):

- The Forested Wetland was inundated with shallow water during the 2011-growing season. In the dormant season this community had surface water cover only in the middle and lower end the drainage basin. On average, this wetland was drier than in the baseline.
- In the growing season, the Golf Course Wetland had surface water throughout the community except in the wide, slightly elevated sawgrass marsh at the east end of the drainage basin. In the dormant season, two thirds of the Golf Course Wetland was dry. The slough-pond, located 400 yards from the diffuser system, was inundated through the year.

4.2. Vegetation

4.2.1. Significant Negative Impacts Determination

Table 4-5 summarizes and interprets the changes in vegetation values in the Palmetto Hall Forested and Golf Course Wetlands since the 1999 baseline. The analysis of changes uses the SCDHEC standard (modified October 24, 2005) for determining adverse environmental conditions in the wetlands receiving reclaimed water. Under the "significant negative impact" criteria, exceeding a specified average percentage decline in value *may* require proposed operational modifications to the project.

Table 4-5
Changes in Vegetation Values
Comparing Baseline 1999 and 2011
Forested Wetland and Golf Course Wetland

Stratum	SCDHEC Standard	Forested	Golf Course
Canopy	1. Forested Wetland: Total decline in basal area ≥15%?	NO	
	2. Golf Course Wetland: Total decline in basal area ≥20%?		NO
	3. Forested Wetland: Single station decline in basal area ≥30%?	YES	
	4. Golf Course Wetland: Single station decline in basal area ≥40%?		NO
	5. Forested Wetland: Total decline in basal area ≥10% indicating operational changes?	NO	
	6. Golf Course Wetland: Total decline in basal area ≥15% indicating operational changes?		NO
Shrub & Ground-cover	7. Forested Wetland: Total decline in cover & importance value (IV) ≥20%?	NO	
	8. Golf Course Wetland: Total decline in cover & IV (IV) ≥20%?		NO
	9. Forested Wetland: Single station decline in cover & IV ≥40%?	NO	
	Golf Course Wetland: Single station decline in cover & IV ≥40%?		NO
	10. Forested Wetland: Total decline in cover & IV ≥10% indicating operational changes?	NO	
	11. Golf Course Wetland: Total decline in cover & IV ≥15% indicating operational changes?		NO
"Significant Negative Impact" Indicated?		**NO**	**NO**
Operational Modifications Indicated?		**NO**	**NO**

For more information, refer to: NPDES Permit No. SC0046191, Part III, Page 27 of 38 (modified 10/24/05).

Finding: Changes in vegetation values were due only to natural causes. *See Page 18.*

FINDING: RECLAIMED WATER OPERATIONS CAUSED NO SIGNIFICANT NEGATIVE IMPACTS IN THE PALMETTO HALL WETLANDS

Standard 1. Total basal area has increased 99% in the Forested Wetland.

Standard 2. Total basal area has increased 58& in the Golf Course Wetland.

Standard 3. A single station decline of 55% in the Forested Wetland was caused by a natural cause—severe drought 8-10 ago.

Standard 4. In the Golf Course Wetland basal area increased on 4 of the 5 stations. The sole decline was caused by blow-down of a dominant pine. The loss of basal area (-24%) was less than the parameter of concern.

Standard 5. Total basal area increased 99% in the Forested Wetland.

Standard 6. Total basal area has increased 58% in the Golf Course Wetland.

Standard 7. Total cover and importance value in the Forested Wetland increased 131%.

Standard 8. Total cover and importance value in the Golf Course Wetland increased 58%.

Standard 9. In the Forested Wetland, the single station decline in cover and basal area of –72% was caused by severe drought-induced die off of subdominant red bay trees 12 years ago. Reclaimed water was not a cause.

Standard 10. The single station decline in cover and basal area did not exceed the SCDHEC standard.

Standard 11. The single station decline in cover and basal area did not exceed the SCDHEC standard.

Finding of No Significant Negative Impacts

During 2011, no adverse effects associated with reclaimed water operations occurred in either the Forested Wetland or the Golf Course Wetland. Historical evidence proves that all changes in basal area, cover and importance values were due to normal and extreme natural events in years past, and were not caused by past or current reclaimed water operations. In fact, monitoring has shown that reclaimed water significantly enhances the vegetation growth in the canopy, sub-canopy, shrub and groundcover, and surface water strata.

4.2.2. Species Diversity

In 2011, the species count in the Forested Wetland was lower than in the baseline in the growing and dormant seasons (Table 4-5). In the Golf Course Wetland, species diversity was lower in the growing season.

Table 4-6
Seasonal Plant Taxa Count in 2011 & Baseline 1999
Palmetto Hall Reclaimed Water Project

Season	Forested 2011	Forested Baseline	Golf Course 2011	Golf Course Baseline
Growing Season 2011	11	15	11	17
Dormant Season 2011	11	13	11	10
Seasonal Change	No Change	-2	No Change	-7
Percentage of Seasonal Change	0%	-13%	0%	-41%

Forested Wetland: Species diversity was lower than in the baseline through the year. Yet the baseline rate of decline was a higher %. Likewise, in the **Golf Course Wetland,** species diversity was less, but the taxa count did not decline from season to season. Why the difference? The baseline year (1998-1999) was centered in an extreme drought with low reclaimed water discharge rates and the wholesale dieback of species, from hardwood trees to floating vegetation.

Waves of sawgrass billow in the Golf Course Wetland, near the reclaimed water diffuser. This is a significantly rare community on the South Carolina coast. *(Photo: Todd Ballantine)*

4.2.3. Species Values Reveal the Health of Wetlands

One or two **indicator species** of vegetation may reveal the fundamental environmental characteristics and health of a plant community. The following analysis uses such predominant vegetation characteristics to summarize the four communities in the Palmetto Hall Reclaimed Water Project.

DOMINANCE, measured by areal cover, tells which species most successfully completes for sunlight. This in turn controls competition from other plant species and establishes unique habitat conditions. In the Forested Wetland, old-growth blackgum hardwoods and the large-leaved lizard tail dominate this cool, shaded community characterized by low evaporation and prevalent standing water. In the sunny Golf Course Wetland, rare sawgrass and lesser grasses dominate along with loblolly pine. But pines and grasses compete for sunlight in this community—and reclaimed water is needed to assure that common pines do not migrate and shade out the diverse understory.

DENSITY is the measure of crowding in the wetland. The more species crowd a square foot of wetland, the more they complete for water, nutrients and sunlight. High vegetation density also produces shelter for invertebrates, yet is an obstacle for vertebrates such as white-tailed deer or alligators. The low density of specific plant species indicates that certain conditions of soil, groundwater and sunlight are insufficient to support viable habitat. Examples of high density: duckweed on open, deeper water; sawgrass and lizard's tail in the understory; hardwoods in the Forested Wetland, and invasive pines in drier elevations of the Golf Course Wetland.

FREQUENCY is the measure of how often plant species occur in a certain area, such as our monitoring transects. The best example is seen in the Forested Wetland, where old-growth blackgum trees occur in 83% of the monitoring area. Conversely, in the Golf Course Wetland a variety of groundcover species occur most often: sawgrass, blue-flag iris, and maidencane grass. Special site conditions—sunlight, soil type, water level, and interspecies competition—affect the frequency of wetland vegetation.

IMPORTANCE VALUE is s the sum of the above three variables. In spite of the subjective name, this calculation provides the statistical "big picture" of the plant communities in the reclaimed water projects. Example: blackgum is the most "important" species in the Forested Wetland because it produces the most shade, the

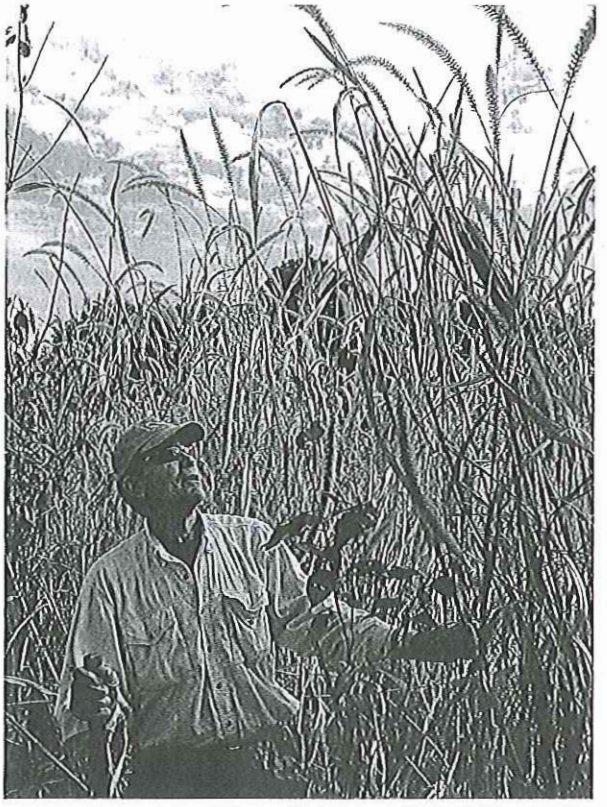
most mass, and occurs most frequently. For more information, refer to: NPDES Permit No. SC0046191, Part III, Page 27 of 38 (modified 10/24/05).

4.2.3. Endangered and Threatened Species of Vegetation

Listed either by the U.S. Fish and Wildlife Service or South Carolina Department of Natural Resources for Beaufort County, South Carolina, the sole plant species that could potentially inhabit the Forested Wetland and Golf Course Wetlands is pondberry *(Lindera melissifolia)*. A Federal and South Carolina endangered species, this evergreen shrub occurs in margins of swamps, open bogs, cypress-gum ponds, and sandy sinks. We did not observe pondberry in either project-wetland during the 2011 monitoring studies in the Palmetto Hall Forested and Golf Course Wetlands.

4.2.4. Nuisance Species of Vegetation

In 2011, we observed two nuisance plant species in Golf Course Wetland. **Giant foxtail** (*Setaria magma)* is a coarse annual grass that invaded the upper and central sectors of the Golf Course Wetland. This tall (6-20 ft.) grass out-competes with native wetland vegetation, withdraws surface and groundwater, and produces copious seeds that are not favored by native birds. **Maidencane** is a perennial invasive grass in the Golf Course Wetland. It displaces rare sawgrass and other productive aquatic plants. Prescribed fire and herbicides are not feasible controls of nuisance species in reclaimed water wetlands, which are near residential areas and are carefully managed for high water quality. **The concern:** these invasive species may degrade or eliminate the rare sawgrass community, especially during the dry-down period, which has stressed native vegetation in this wetland.



GIANT FOXTAIL in the Golf Course Wetland. This annual grass was invasive in 2010, but died back partially in 2011. *(Photo: Marianne Ballantine)*

4.3. Wildlife

4.3.1. Macroinvertebrates

Table 4-16 lists species observed in the 2011 growing and dormant seasons. The census of invertebrates was lower in each wetland, compared with the baseline.

Table 4-7
Macroinvertebrate Species Assay: 2011
Forested and Golf Course Wetlands

Species	Frequency	Forested	Golf Course	Habitat
Ant – Little Black	O	X	X	T
Ant - Fire	U		X	LL
Bumblebee – Northern	U		X	A
Butterfly – Palamedes Swallowtail	O	X	X	A
Damselfly – Doubleday's Bluet	U	X	X	E
Marsh Fly	C	X		WS
Midge – *Chironomid*	C	X		A
Millipede - *Narceus*	U	X		LL
Mosquito – Golden Saltmarsh	C	X	X	A
Scud (Amphipod)	O		X	SD
Stinkbug - *Brochymenus*	U		X	LL
Wasp - Paper	U		X	A
Water Strider - Common	U	X		E
Water Treader	O	X	X	WS
Total in 2011	**Mode: U**	**9**	**10**	**---**
Baseline 1999	Mode: U	12	12	---

Notes:
1. See Appendix C for a list of species observed since the baseline.
2. Key to species frequency: **N** = numerous (>75% of stations); **C** = common (50%-74% of stations), **O** = Occasional (25%-49% of stations); and **U** = Uncommon (1%-24% of stations).
3. Key to habitats: **A** = air; **E** = emergent vegetation; **LL** = leaf litter; **T** = tree; **WC** = water column; and **WS** = water surface.

2011 Compared to the Baseline

The majority of macroinvertebrate species listed in Table 4-16 inhabited the wetlands during the growing season. This has been the case each year since the baseline. The limiting factors for invertebrates in 2011 were: fluctuating surface water depth and distribution (area of water coverage), vegetation diversity and cover, and non-vegetated openings on the ground. Overall, invertebrates occurred much less frequently (16-33% less) than in the baseline. The rise and fall of diversity and population of species is tied to the three tiers of hydrology: frequency, duration, and depth of water. These factors declined significantly during the 2011-growing season.

In the Forested Wetland, the year's species count decreased 33% since the baseline. Deeper than average water in the growing season supported a limited diversity of aquatic species, but not terrestrial invertebrates that had become common in recent years with lower surface water.

In the Golf Course Wetland, water covered 7/8 of the acreage in the growing season. However, the emerging pine flatwoods community in the center of the drainage basin provides far less aquatic habitat for invertebrates.

4.3.2. Fish

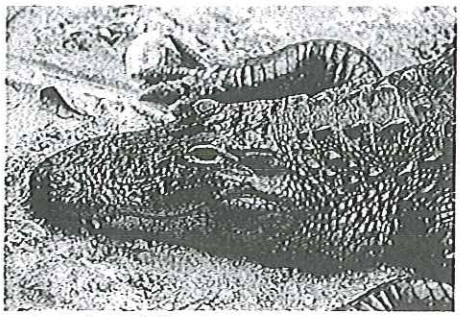
In 2011, we observed the indicator species, eastern mosquitofish *(Gambusia affinis)* in the Forested Wetland during the growing season. In the dormant season, this wetland was too dry to support a fish population. We observed no fish species in the Golf Course Wetland, although the surface water was deep enough growing season to support small fish species.

4.3.3. Other Vertebrates Observed

Species observed in 2011 (both project wetlands):

- **Amphibians:** Green treefrog.
- **Birds:** American crow, barred owl, Carolina wren, common coot, downy woodpecker, great egret, northern cardinal, pileated woodpecker, prothonotary warbler, red-shouldered hawk, red-winged blackbird, turkey vulture, white-eyed vireo, wood duck and yellow-rumped warbler.

- **Mammals:** Gray squirrel and white-tailed deer.
- **Reptiles:** American alligator, green anole, and yellow-bellied turtle.



American Alligator
Photo: Todd Ballantine

4.3.4. Endangered or Threatened Species

Listed either by the U.S. Fish and Wildlife Service and/or South Carolina Department of Natural Resources for Beaufort County, South Carolina, the species (excluding marine species) are:

- Bald eagle *(Haliateetus leucoephalus)* – Federally Threatened and S.C. Endangered
- Least tern *(Sterna antillarum)* – S.C. Threatened
- Wood stork *(Mycteria americana)* – Federally and S.C. Threatened

(Source: South Carolina Department of Natural Resources. Most recent update: 2006).

In 2011, none of these listed species appeared in the Forested or Golf Course wetlands during our monitoring studies.

4.4. Significant Impacts from Natural causes

The SCDHEC term ***significant impact*** means "an important harmful effect of one thing upon another." For biological monitoring of reclaimed water projects, we apply this parameter for impacts to hydrology, vegetation, or wildlife due to natural causes. These include hurricanes, tornadoes, other weather events, disease, insects, and other non-human activities. in wetlands. "Natural" impacts may be immediate or cumulative.

Table 4-17 summarizes the significant impacts to the project-wetlands in this reported monitoring year. It shows that the drought of 1998-2002 produced long-term effects on plant life in both wetlands. In the Forested Wetland, red bay blight and past fetterbush die-off are still visible. **In 2011, the foremost natural impact in both wetlands was the very low rainfall during the early to mid-growing season.**

Table 4-8
Significant Impacts from Natural Causes: 2011
Forested and Golf Course Wetlands
Palmetto Hall Reclaimed Water Project

Impact	Forested Wetland	Golf Course Wetland
Rainfall & Flooding	Significantly below-average rainfall in the early and mid-growing season.	Significantly below-average rainfall in the early and mid-growing season.
Rainfall & Drought	Drought (1998-2002) caused total mortality of red bay trees.	Long-term decline in co-dominant groundcover species on two stations was a cumulative impact from drought (1998-2002).
Disease	During the drought, stressed red bay trees fell prey to fungal and other infections.	No impact on plants or wildlife.
Insects	Ambrosia beetles attacked stressed, diseased red bay trees, resulting in 100% die-off during the drought.	No impact on plants or wildlife.
Hurricanes	No impact on plants or wildlife.	No impact on plants or wildlife.
Tornadoes	No impact on plants or wildlife.	No impact on plants or wildlife.
Other Weather	No impact on plants or wildlife.	No impact on plants or wildlife.
Invasive Species	No impact on plants or wildlife.	Giant foxtail grass invaded the upper and central portion of the wetland in 2010. In this year, this species died back by 50%

5. Conclusions & Recommendations

5.1. Conclusions

This report analyzed the results from biological monitoring in 2011 of two reclaimed water projects in Palmetto Hall, Hilton Head Island, South Carolina. The projects are located in the Forested Wetland and Golf Course Wetland. Ur monitoring findings from 2011 were compared with conditions in the 1999 baseline, and we assessed the data according to standards in the NPDES Permit for the project. Based on our scientific investigation, we offer the following conclusions.

1. The foremost effect on the reclaimed water projects was low rainfall in the growing season.
2. Annual precipitation significantly below average during the critical season of vegetation growth and wildlife reproduction—April to August.
3. The growing-season rainfall deficit and the reduced influent loading during the period produced drier conditions in both wetlands. Reclaimed water was distributed to area golf courses for irrigation.
4. The PSD discharged 114% more influent into the wetlands than it discharged in the baseline. This "loading" primarily occurred during autumn and winter—periods of slow or dormant biological activity in the wetlands.
5. The Forested Wetland, with 55% of the total acreage of the project area, received 60% of the reclaimed water. The Golf Course Wetland (45% of the total acreage) received 40% of available reclaimed water. This ratio of shared reclaimed water is closer to the preferred "acres-and-gallons parity" than in past years.
6. Total water (rain and reclaimed water) loading in 2011 exceeded baseline totals in both wetlands. It should be noted that the baseline year was a period of significant drought. In each wetland, the total water loading exceeded the normal long-term hydroperiod in nine months—substantially more than in the baseline.
7. The growing season diversity of plant species in each wetland was the same as in the baseline.
8. During 2011, no adverse effects associated with reclaimed water operations occurred in either the Forested Wetland or the Golf Course Wetland. Historical evidence proves that all changes in basal area, cover and importance values were due to

normal and extreme natural events in years past, and were not caused by past or current reclaimed water operations.

9. Monitoring has shown that reclaimed water significantly enhances the vegetation growth in the canopy, sub-canopy, shrub and groundcover, and surface water strata.
10. Reclaimed water is an increasingly valuable resource for preserving wetlands. Recurring drought has altered the hydrology of aquatic systems, as well as general groundwater conditions on Hilton Head Island. The "sustainable recycling" of treated water is a proven method of conserving, and even saving, old-growth and rare communities such as the Forested and Golf Course Wetlands.

5.2. Recommendations

To sustain the integrity, effectiveness and benefits of the reclaimed water project, we recommend:

1. Continue to provide reclaimed water according to the "acres and gallons" parity described above. This will sustain the rare, diverse sawgrass and bottomland hardwood communities, stimulate biological activity, and control invasive nuisance vegetation.
2. Continue to critique the impact of the permit-mandated dry-down. Especially in the Golf Course Wetland, dry-down has severely stressed rare sawgrass community, stimulated the entry of invasive species, and lessened habitat diversity for aquatic wildlife. This impact has been more severe in this decade of recurring drought.
3. The 2012 biological monitoring should continue the scientific protocol described in SCDHEC Surface Water Discharge Permit No. SC0046191 (modified 10/24/05). Ballantine Environmental Resources will produce Mid-year and Annual Biological Monitoring Reports. These reports will be submitted to the PSD. The 2012 Annual Report should be completed in February of 2013.

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7. Glossary

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

Benthic Characterized by living on the wetland ground or pond bottom.

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) or basal area (trees).

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

Dry-down A mandated period in which no reclaimed water flows into a wetland.

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.

Exotic Species A non-native plant or animal species.

Exponential Growth The growth of a population (example: duckweed) that increases by a fixed percentage over time. When plotted, this growth forms a J-curve.

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 leaf-bearing tree, such as blackgum.

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. Blackgum and sawgrass are indicator species in Palmetto Hall wetlands.

Invasive Species Non-native species of plants or animals that out-compete with native species in a specific habitat. Example: giant foxtail grass.

Keystone Species A species that affects other species in a community. Sawgrass is a keystone species in the Palmetto Hall Golf Course Wetland reclaimed water project.

Macroinvertebrate 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. Many songbirds that nest in Palmetto Hall's Forested Wetland spend winters in the Neotropical region.

Nuisance Species Any animal or plant species that is exotic, invasive and degrades the value and functions of natives species.

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

Pine Flatwood A forest community characterized by a low, flat topography and high groundwater. Characteristics are: a canopy of pines, a low shrubby layer, and a dense herbaceous layer

Reclaimed Water Advanced-treated domestic water discharged into wetlands to restore ecological functions, values, wildlife habitat, and human recreation opportunities.

Sheet flow Overland flow of water over a large area before entering a receiving stream.

Surface Plant A species of vegetation that keeps leaves above the surface of the water. Duckweed is a prevalent surface plant in the Palmetto Hall wetlands.

Total Water Reclaimed water plus precipitation received in a wetland of other receiving water during a defined period of time.

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.

8. Vegetation Inventory

FORESTED WETLAND

Common Name	*Scientific Name*
Alligatorweed	*Alternanthera philoxeroides*
Blackgum, Swamp Tupelo	*Nyssa biflora*
Cinnamon Fern	*Osmunda cinnamomea*
Climbing Hempweed	*Mikania scadens*
Creeping Primrose	*Ludwigia palustris*
Duckweed	*Lemna minor*
Fetterbush	*Lyonia lucida*
Gallberry	*Ilex glabra*
Groundsel, Sea Myrtle	*Bacharris halmifolia*
Lizard's Tail	*Saururus cernuus*
Loblolly Pine	*Pinus taeda*
Marsh Pennywort	*Hydrocotyle umbellata*
Red Bay	*Persea borbonia*
Red Maple	*Acer rubrum*
Sweetgum	*Liquidamber styraciflua*
Virginia Chainfern	*Woodwardia virginica*
Water Oak	*Quercus alba*
Water Pepper	*Polygonum hydropiperoides*
Wax Myrtle	*Myrica cerifera*
White Avens	*Geum canadensis*

Total: 20 Species

GOLF COURSE WETLAND

Common Name	*Scientific Name*
Alga, Water Net	*Hydodictyon sp.*
Blackgum, Swamp Tupelo	*Nyssa biflora*
Blue-flag Iris, Southern Blue-flag	*Iris versicolor*
Broomsedge, Bushy-beard Bluestem	*Andropogon glomeratus*
Cinnamon Fern	*Osmunda cinnamomea*
Climbing Hempweed	*Mikania scadens*
Common Reed	*Phragmites australis*
Duckweed	*Lemna minor*
Gallberry, Inkberry	*Ilex glabra*
Giant Foxtail	*Setaria magna*
Goldenrod, Flat-topped	*Solidago tenuifolia*
Loblolly Pine	*Pinus taeda*
Maidencane	*Panicum hemitomon*
Marsh Fern	*Thelypteris palustris*

Persimmon	*Diospyros virginiana*
Pickerelweed	*Pontedaria cordata*
Poison Ivy	*Rhus radicans*
Pond Pine	*Pinus palustris*
Redroot	*Lachnanthes caroliniana*
Sawgrass	*Cladium jamaicense*
Three-square	*Dulichium arundinaceum*
Virginia Chainfern	*Woodwardia virginica*
Yellow Nutsedge, Nutgrass	*Cyperus esculentus*

Total: 23 Species

9. Wildlife Inventory

FORESTED WETLAND

Common Name	*Scientific Name*
Macroinvertebrates (52 Species)	
Ant – Little Black	*Monomorium minimum*
Ant – Southern Fire	*Solenopsis geminata*
Butterfly – Clouded Sulphur	*Colias philodice*
Butterfly – Gulf Fritillary	Agraulis vanillae
Butterfly – Spicebush Swallowtail	*Papilo troilus*
Beetle – Leaf	*Chrysomelinae sp.*
Beetle – Predaceous Diving	*Dytiscus marginatus*
Beetle – Small Whirligig	*Gyrinus sp.*
Beetle – Vertical Diving	*Dytiscus verticalis*
Beetle – Water Scavenging	*Hydrophilus sp.*
Butterfly – Palamedes Swallowtail	*Pipilo palamedes*
Centipede	*Chilopod sp.*
Crane Fly	*Tipula sp.*
Cricket – Field	*Gryllus pennsylvanicus*
Dragonfly – Brown Darner	*Boyeria vinosa*
Dragonfly – Doubleday's Bluet	*Enallagma dubledayii*
Dragonfly – Elisa Skimmer	*Celimethis elisa*
Dragonfly – Green Clearwing	*Erythemis simpliciollis*
Dragonfly – Green Darner	*Anax junius*
Dragonfly – Swift Long-winged Skimmer	*Pachidiplax longipennis*
Dragonfly – Red Skimmer	*Libellul saturata*
Fly – Marsh	*Tentanocera sp.*
Fly – Long-legged	*Dolichopopid sp.*
Midge	*Chironomid sp.*
Midge – Green	*Tanytarsus sp.*
Millipede	*Glomexis sp.*
Mosquito – Black Salt Marsh	*Aedes taeniorynchus*
Mosquito – Salt Marsh	*Aedes taeniorhynchus*
Mosquito – Southern House	*Culex pipiens quinquefasciatus*
Mosquito – Treehole	*Toxorhynchites rutilus*
Moth – Dagger	*Acronicta sp.*
Nematode	*Chongaster gracilus*
Planthopper	*Delphacid sp.*
Snail – Little Pond	*Amnicola limnosa*
Snail – Hairy Wheel	*Gyraulus sp.*
Sowbug	*Isopoda sp.*
Spider – Crab	*Coriochne versicolor*
Spider – Crab	*Philodromus sp.*
Spider – Brown Daddy-long-legs	*Phalangium opilio*
Spider – Filistad	*Filistadae sp.*
Spider – Forest Wolf	*Lycosa gulosa*
Spider – Green Lynx	*Peucetia viridans*
Spider – Jumping	*Sitticus palustris*
Spider – Mabel Orchard	*Leucauge mabalae*

Spider – Sac	*Clubionidae sp.*
Spider – Six-spotted Fisher	*Dolmedess triton*
Thrip	*Thysanoptera sp.*
Water Flea	*Daphnia pulex*
Water Strider	*Gerris sp.*
Water Strider – Broad-shouldered	*Microvelia borealis*
Yellow Jacket – Eastern	*Vespula maculifrons*

Vertebrates (22 Species)

Amphibians:

Green Treefrog	*Hyla cinerea*

Birds:

American Crow	*Corvus brachyrhynchos*
American Robin	*Turdus migratorius*
Barred Owl	*Strix varia*
Cooper's Hawk	*Accipiter cooperii*
Downy Woodpecker	*Picoides pubescens*
Great Egret	*Ardea alba*
Eastern Pewee	*Contopus virens*
Northern Cardinal	*Cardinalis cardinalis*
Pileated Woodpecker	*Dryocopus pileatus*
Prothonotary Warbler	*Protonotaria citrea*
Tufted Titmouse	*Parus bicolor*
Red-shouldered Hawk	*Buteo lineatus*
White-eyed Vireo	*Vireo griseus*
White Ibis	*Eudocimus albus*
Wood Duck	*Aix sponsa*
Yellow-rumped Warbler	*Dendroica coronata*

Fish:

Eastern Mosquitofish	*Gambusia affinis*

Mammals:

Eastern Gray Squirrel	*Sciurus niger*
Marsh Rabbit	*Sylvilagus palustris*
White-tailed Deer	*Odocoileus virginianus hiltonensis*

Reptiles:

Southern Black Racer	*Coluber constrictor priapus*
Rough Green Snake	*Ophendrys taxispilota*

Total: 74 Species

GOLF COURSE WETLAND

Common Name	*Scientific Name*
Macroinvertebrates (41 species)	
Ant – Little Black	*Monomorium minimum*
Ant – Black Carpenter	*Camponotus pennsyvanicus*
Ant – Southern Fire	*Solenopsis geminata*
Beetle – Elmid	*Elmid sp.*
Beetle – Leaf	*Chrysomelinae sp.*
Beetle – Red Milkweed	*Tetraopes tetraophthalmus*
Beetle – Small Whirligig	*Gyrinus sp.*
Butterfly – Gulf Fritillary	*Agraulis vanillae*
Centipede – Soil	*Arenophilus bipuncticops*
Caddisfly – Large	*Phryganidae sp.*
Crayfish – Pond	*Procumbus blanding*
Damselfly – Doubleday's Bluet	*Enallagma doubledayii*
Dragonfly – Brown Darner	*Boyeria vinosa*
Dragonfly – Citrine Forktail	*Ischura hastata*
Dragonfly – Green Clearwing	*Erythemis simpliciollis*
Dragonfly – Green Darner	*Anax junius*
Dragonfly – Low-flying Amberwing	*Perithemis tenera*
Dragonfly – Swamp Spreadwing	*Lestes vigilax*
Dragonfly – White-tail	*Plathemis lydia*
Fly – Marsh	*Tentanocera sp.*
Grasshopper – Elegant	*Dichromorpha elegans*
Green Lacewing	*Chrysopidae sp.*
Midge	*Chironomid sp.*
Midge	*Culicoides sp.*
Midge – Green	*Tanytarsus sp.*
Millipede	*Narceaus sp.*
Mite – Chigger	*Trombicula sp.*
Mite	*Cryptocellus sp.*
Mosquito – Southern House	*Culex pipiens quinquefasciatus*
Mosquito – Salt Marsh	*Aedes taeniorhynchus*
Moth – Acrea	*Estigmene acrea*
Moth – Blind-eyed Sphinx	*Paonis excaecatus*
Planthopper	*Delphacid sp.*
Scud	*Hyalella azteca*
Stinkbug	*Brochymenus sp.*
Thrip	*Thysanoptera sp.*
Tick – Eastern Wood	*Dermacentor sp.*
Wasp – Paper	*Polistes sp.*
Water Flea	*Daphnia pulex*
Water Strider	*Gerris sp.*
Water Treader	*Mesovelia sp.*
Vertebrates (27 Species)	
Amphibians:	
Green Treefrog	*Hyla cinerea*

Birds:

American Coot	*Fulica americana*
American Crow	*Corvus brachyrhynochos*
Brown Thrasher	*Toxostoma rufrum*
Carolina Wren	*Thyrosaurus ludovicianus*
Common Moorhen	*Gallinula chloropus*
Great Blue Heron	*Ardea herodius*
Great Egret	*Ardea alba*
Eastern Bluebird	*Sialia sialis*
Fish Crow	*Corvus ossifragus*
Northern Bobwhite	*Colinus virginianus*
Osprey	*Pandion haliaetus*
Purple Finch	*Carpodacus purpureus*
Red-shouldered Hawk	*Buteo lineatus*
Red-winged Blackbird	*Ageleius phoeniceus*
Snowy Egret	*Egretta thula*
Yellow-rumped Warbler	*Dendroica coronata*
Turkey Vulture	*Cathartes aura*
White Ibis	*Eudocimus albus*
Wood Duck	*Aix sponsa*

Fish:

Eastern Mosquitofish	*Gambusia affinis*

Mammals:

Eastern Gray Squirrel	*Sciurus niger*
White-tailed Deer	*Odocoileus virginianus hiltonensis*

Reptiles:

American Alligator	*Alligator mississippiensis*
Eastern Cottonmouth	*Agkistrodon piscivorus*
Island Glass Lizard	*Ophiosaurus compressus*
Yellow-bellied Turtle	*Chrysemyis scripta scripta*

Total: 68 species