Appendix 5-3: Annual Permit Report for the Holey Land Wildlife Management Area

Permit Report (October 1, 2012–September 30, 2013)
Permit Numbers: 06,500809209 and 06,501191549

Cheol Mo

Contributor: John Shaffer

SUMMARY

Based on Florida Department of Environmental Protection (FDEP) permit reporting guidelines, **Table 1** lists key permit-related information associated with this report. **Table 2** lists the attachments included with this report. **Table A-1** in Attachment A lists specific pages, tables, graphs, and attachments where project status and annual reporting requirements are addressed. This annual report satisfies the reporting requirements specified in the permit.

Table 1. Key permit-related information.

Project Name:	Holey Land
Permit Numbers:	06,500809209 and 06,501191549
Issue and Expiration Dates: Permit 06,500809209: Permit 06,501191549:	 Issued: 10/1/1984; Expires: N/A (in Operation Phase) Issued: 9/5/1986; Expires: N/A (in Operation Phase)
Project Phase:	Operation
Permit Specific Condition Requiring Annual Report:	Conditions listed on pages 8–11 of the permit
Reporting Period:	October 1, 2012–September 30, 2013
Report Lead:	Cheol Mo cmo@sfwmd.gov 561-682-2106
Permit Coordinator:	John Shaffer jshaffe@sfwmd.gov 561-682-6308

Table 2. Attachments included with this report.

Attachment	Title
A	Specific Conditions and Cross-References
B	Water Quality and Sediment Data
C	Hydrologic Data
D	Holey Land Wildlife Management Area 2013 Annual Cattail Monitoring Report

INTRODUCTION

The Holey Land Wildlife Management Area (WMA) is a 35,350-acre (14,140-hectare) impoundment located in the southwest corner of Palm Beach County, Florida. In 1989, the South Florida Water Management District (SFWMD or District) started collecting water samples at the inflow structure (G-200A), outflow structures (G-204, G-205, and G-206), and interior stations (**Figure 1**). In 1991, the Florida Fish and Wildlife Conservation Commission began conducting annual cattail surveys. In October 2005, Hurricane Wilma severely damaged the inflow pump station (G-200A). Although G-200A remains inoperable, since October 2005, limited surface water inflow capacity has been available through the G-372HL box culvert. For practicality, reporting of inflow data was switched to G-372HL, which has been the only source for surface water inflow to the Holey Land WMA since G-200A was damaged.

Although water quality samples are not collected from G-372HL, water quality grab samples continue to be collected at G-200A. The three outflow structures (G-204, G-205, and G-206) are monitored quarterly.

Since April 2008, there have been no surface water inflows to the Holey Land WMA, and no outflows have occurred since January 2006. Essentially, the Holey Land WMA has become rainfall-driven, and no longer functions as a flow-through system. The area dries out routinely and rehydrates, depending on rainfall amounts.

The initial water regulation schedule called for water levels varying from 11.5 to 13.5 feet National Geodetic Vertical Datum of 1929 (feet NGVD29) and permit requirements stated that a minimum water level of 9 feet NGVD29 must be maintained in the seepage ditches of the Holey Land WMA. However, there have been subsequent revisions of the water schedules to lower levels, and, in 2005, the seepage canal on the northern and northeastern sides of the Holey Land WMA was widened and deepened to become the inflow canal for Stormwater Treatment Area 3/4 (STA-3/4). The only remaining seepage ditch structure for the Holey Land WMA is G-203 (stage monitoring station G203D), which is located on the southeastern side, adjacent to STA-3/4.

More background information and the status of the Holey Land WMA water regulation schedules are presented in the *2013 Annual Cattail Monitoring Report* (Attachment D).

SURFACE WATER QUALITY DATA

The current monitoring program adheres to the September 20, 2005 minor modification letter from the FDEP to the SFWMD. Quarterly water quality grab samples were collected at the site upstream of G-200A (water quality station G200 in Miami Canal) and at the sites upstream of the three outflow structures G-204, G-205, and G-206 (water quality stations, G204, G205, and G206, respectively) (**Figure 1**). *In situ* measurements of physical parameters (water temperature, specific conductance, and pH) were recorded. Grab samples were analyzed for nutrients (total Kjeldahl nitrogen (TKN), inorganic nitrogen (nitrate + nitrite), and total phosphorus). Total nitrogen was calculated by adding TKN and inorganic nitrogen measurements. Water quality data for federal Water Year 2013 (WY2013, October 1, 2012–September 30, 2013) are summarized in **Tables 3** through **6**. Individual water quality monitoring measurements are included in Attachment B.

There were no exceedances of the Class III Standard for specific conductance[1] measured at the four monitoring sites. Two pH[2] measurements taken at G206 on November 7, 2012, and July 23, 2013, were 5.9 units. However, during WY2013, the three outflow monitoring sites were generally isolated pools of water, and the value was not more than one unit below the average pH of the sites (6.5 units, back calculated from average of the exponential values) during WY2013. All other pH measurements were between 6.0 and 8.5 units, meeting the Class III standard. Moreover, specific conductance measured on the sampling events were 79 and 88 microsiemens per centimeter (µS/cm), respectively, while the area average was around 500 µS/cm, appears to indicate that the sampled water was collected from temporary pools of rainfall.

Total phosphorous (TP) levels observed at the upstream inflow water quality monitoring station (G200) were generally lower than levels observed within the Holey Land WMA at the outflow structures. Higher nutrient levels were observed at the water quality monitoring station G204, which dries out more frequently than G205 and G206 due to the higher topography of the location.

[1] Class III Standard: Shall not be increased more than 50% above background or to 1275 µS/cm, whichever is greater.

[2] Class III Standard: Shall not vary more than one unit above or below natural background of predominantly fresh waters and coastal waters as defined in paragraph 62-302.520(3)(b), F.A.C. or more than two-tenths unit above or below natural background of open waters as defined in paragraph 62-302.520(3)(f), F.A.C., provided that the pH is not lowered to less than 6 units in predominantly fresh waters, or less than 6.5 units in predominantly marine waters, or raised above 8.5 units. If natural background is less than 6 units, in predominantly fresh waters or 6.5 units in predominantly marine waters, the pH shall not vary below natural background or vary more than one unit above natural background of predominantly fresh waters and coastal waters, or more than two-tenths unit above natural background of open waters. If natural background is higher than 8.5 units, the pH shall not vary above natural background or vary more than one unit below natural background of predominantly fresh waters and coastal waters, or more than two-tenths unit below natural background of open waters.

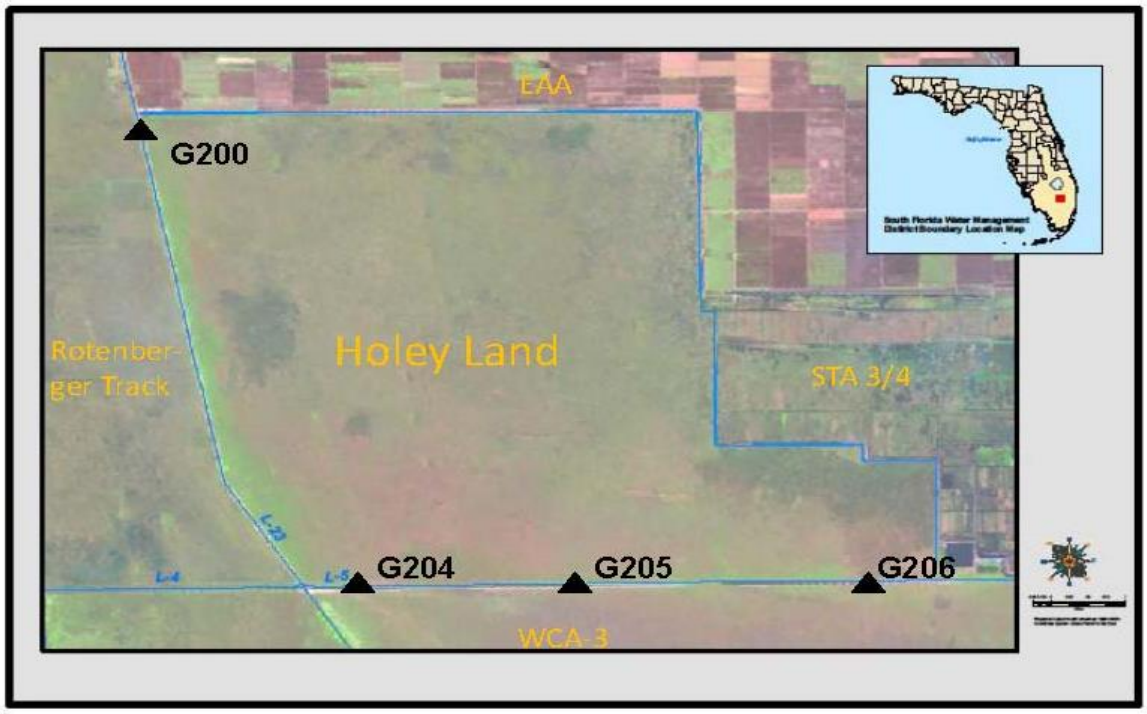

Figure 1. Holey Land Wildlife Management Area (WMA) water quality monitoring locations.

Table 3. Summary of water quality data at G-200 for federal Water Year 2013.

Parameter [a]	Sample Type	First Datum	-	Last Datum	Sample Number	Minimum	Maximum	Median	Average	Standard Deviation
PHYSICAL										
Water Temperature (ºC)	field	11/7/12	-	7/23/13	4	22.1	30.0	25.3	25.7	3.9
Specific Conductance (µS/cm)	field	11/7/12	-	7/23/13	4	449	714	590	586	123
pH (SU)	field	11/7/12	-	7/23/13	4	7.20	7.50	7.20	7.26[b]	NA
NUTRIENTS										
Total Nitrogen (mg/L)	grab	11/7/12	-	7/23/13	4	1.18	1.80	1.49	1.49	0.27
Total Kjeldahl Nitrogen (mg/L)	grab	11/7/12	-	7/23/13	4	1.16	1.60	1.43	1.40	0.19
Nitrate+Nitrite (as N mg/L)	grab	11/7/12	-	7/23/13	4	0.017	0.202	0.062	0.086	0.086
Total Phosphorus (mg/L)	grab	11/7/12	-	7/23/13	4	0.013	0.028	0.015	0.018	0.007

NA: not applicable.

a. Key to units: ºC – degrees Celsius; mg/L – milligrams per liter; N – nitrogen; SU – standard units; and µS/cm – microsiemens per centimeter.

b. Back calculated from the average of exponential values.

Table 4. Summary of water quality data at G-204 for federal Water Year 2013.

Parameter [a]	Sample Type	First Datum	-	Last Datum	Sample Number	Minimum	Maximum	Median	Average	Standard Deviation
PHYSICAL										
Water Temperature (ºC)	field	11/7/12	-	7/23/13	4	20.4	28.4	23.0	23.7	3.9
Specific Conductance (µS/cm)	field	11/7/12	-	7/23/13	4	209	656	582	507	210
pH (SU)	field	11/7/12	-	7/23/13	4	6.50	7.10	6.95	6.81[b]	NA
NUTRIENTS										
Total Nitrogen (mg/L)	grab	11/7/12	-	7/23/13	4	1.40	10.96	3.53	4.86	4.20
Total Kjeldahl Nitrogen (mg/L)	grab	11/7/12	-	7/23/13	4	1.40	10.96	3.53	4.86	4.20
Nitrate/Nitrite (as N mg/L)	grab	11/7/12	-	7/23/13	4	<0.005	<0.005	<0.005	<0.005	NA
Total Phosphorus (mg/L)	grab	11/7/12	-	7/23/13	4	0.025	0.589	0.045	0.176	0.276

NA: not applicable.

a. Key to units: ºC – degrees Celsius; mg/L – milligrams per liter; N – nitrogen; SU – standard units; and µS/cm – microsiemens per centimeter.

b. Back calculated from the average of exponential values.

Table 5. Summary of water quality data at G-205 for federal Water Year 2013.

Parameter [a]	Sample Type	First Datum	-	Last Datum	Sample Number	Minimum	Maximum	Median	Average	Standard Deviation
PHYSICAL										
Water Temperature (ºC)	field	11/7/12	-	7/23/13	4	20.4	28.4	23.9	24.1	3.7
Specific Conductance (µS/cm)	field	11/7/12	-	7/23/13	4	136	605	486	428	223
pH (SU)	field	11/7/12	-	7/23/13	4	6.40	6.90	6.85	6.69[b]	NA
NUTRIENTS										
Total Nitrogen (mg/L)	grab	11/7/12	-	7/23/13	4	1.07	3.01	2.49	2.27	0.83
Total Kjeldahl Nitrogen (mg/L)	grab	11/7/12	-	7/23/13	4	1.07	2.98	2.45	2.24	0.82
Nitrate/Nitrite (as N mg/L)	grab	11/7/12	-	7/23/13	4	<0.005	0.078	0.011	0.027	0.036
Total Phosphorus (mg/L)	grab	11/7/12	-	7/23/13	4	0.025	0.123	0.046	0.060	0.044

NA: not applicable.

a. Key to units: ºC – degrees Celsius; mg/L – milligrams per liter; N – nitrogen; SU – standard units; and µS/cm – microsiemens per centimeter.

b. Back calculated from the average of exponential values.

Table 6. Summary of water quality data at G-206 for federal Water Year 2013.

Parameter [a]	Sample Type	First Datum	-	Last Datum	Sample Number	Minimum	Maximum	Median	Average	Standard Deviation
PHYSICAL										
Water Temperature (ºC)	field	11/7/12	-	7/23/13	4	19.1	28.4	23.8	23.8	4.3
Specific Conductance (µS/cm)	field	1/15/13	-	7/23/13	3	797	647	356	361	284
pH (SU)	field	11/7/12	-	7/23/13	4	5.90	7.10	6.35	6.16[b]	NA
NUTRIENTS										
Total Nitrogen (mg/L)	grab	11/7/12	-	7/23/13	4	1.09	2.42	1.60	1.68	0.61
Total Kjeldahl Nitrogen (mg/L)	grab	11/7/12	-	7/23/13	4	1.09	2.38	1.59	1.66	0.59
Nitrate/Nitrite (as N mg/L)	grab	11/7/12	-	7/23/13	4	<0.005	0.044	0.005	0.016	0.020
Total Phosphorus (mg/L)	grab	11/7/12	-	7/23/13	4	0.014	0.225	0.032	0.075	0.100

NA: not applicable.

a. Key to units: ºC – degrees Celsius; mg/L – milligrams per liter; N – nitrogen; SU – standard units; and µS/cm – microsiemens per centimeter.

b. Back calculated from the average of exponential values.

SEDIMENT QUALITY DATA

During the reporting period, sediment samples were collected at four interior marsh locations (HOLYSD1, HOLYSD2, HOLYSD3, and HOLYSD4) (**Figure 2**). Sediment data for federal Water Year 2013 (October 1, 2012–September 30, 2013) is summarized in **Table 7**. Individual sediment quality monitoring measurements are included in Attachment B.

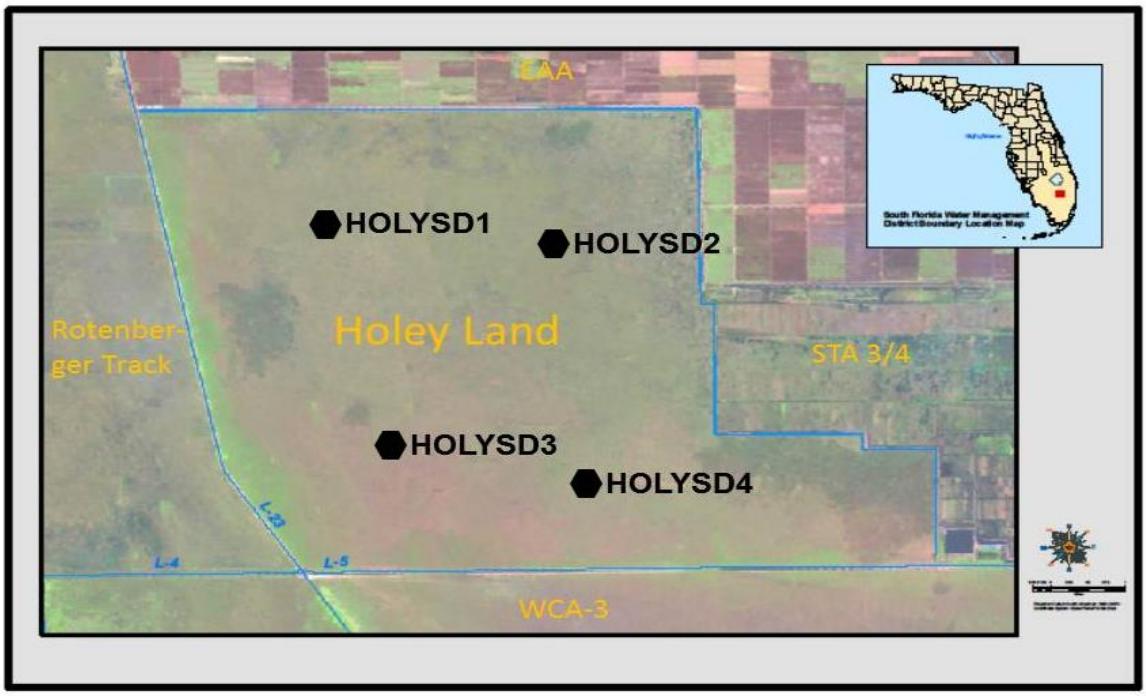

Figure 2. Holey Land WMA sediment monitoring locations.

Table 7. Summary of Holey Land WMA sediment data for federal Water Year 2013. [Note: mg/kg – milligrams per kilogram.]

Parameter	Units	Sampling Date	Monitoring Station			
			HOLYSD1	HOLYSD2	HOLYSD3	HOLYSD4
Antimony	mg/kg	5/30/2013	<0.410	<0.560	<0.530	<0.480
Arsenic	mg/kg	5/30/2013	6.090	4.940	3.870	4.480
Beryllium	mg/kg	5/30/2013	0.140	<0.090	<0.084	<0.077
Cadmium	mg/kg	5/30/2013	0.087	<0.110	<0.110	<0.096
Chromium	mg/kg	5/30/2013	7.40	4.90	2.90	3.30
Copper	mg/kg	5/30/2013	4.40	5.30	2.50	2.90
Lead	mg/kg	5/30/2013	4.70	11.30	2.60	3.50
Mercury	mg/kg	5/30/2013	0.093	0.087	0.071	0.110
Nickel	mg/kg	5/30/2013	5.00	4.60	2.20	3.10
Selenium	mg/kg	5/30/2013	2.26	3.60	2.40	2.50
Silver	mg/kg	5/30/2013	<0.021	<0.028	<0.026	<0.024
Thallium	mg/kg	5/30/2013	<0.082	<0.110	<0.110	<0.096
Zinc	mg/kg	5/30/2013	5.2	<4.5	<4.2	<3.8

FLOW DATA

In 1989, the District started collecting water samples at the inflow structure G-200A (flow monitoring station G200A), outflow structures G-204, G-205, and G-206 (flow monitoring stations G204, G205, and G206, respectively), and interior stations. In October 2005, Hurricane Wilma severely damaged the inflow pump station (G-200A) and rendered it inoperable. Since that time, only limited surface water inflow capacity has been available through the G-372HL box culvert (flow monitoring station G372HL) (**Figure 3**). Since April 2008, there has been no surface water inflow at G-372HL. During the reporting period, gate opening records indicate that G-372HL was not opened. There have been no outflows since January 2006 at the outflow structures except a small flow (4.96 acre-feet) at G-205 in July 2013.

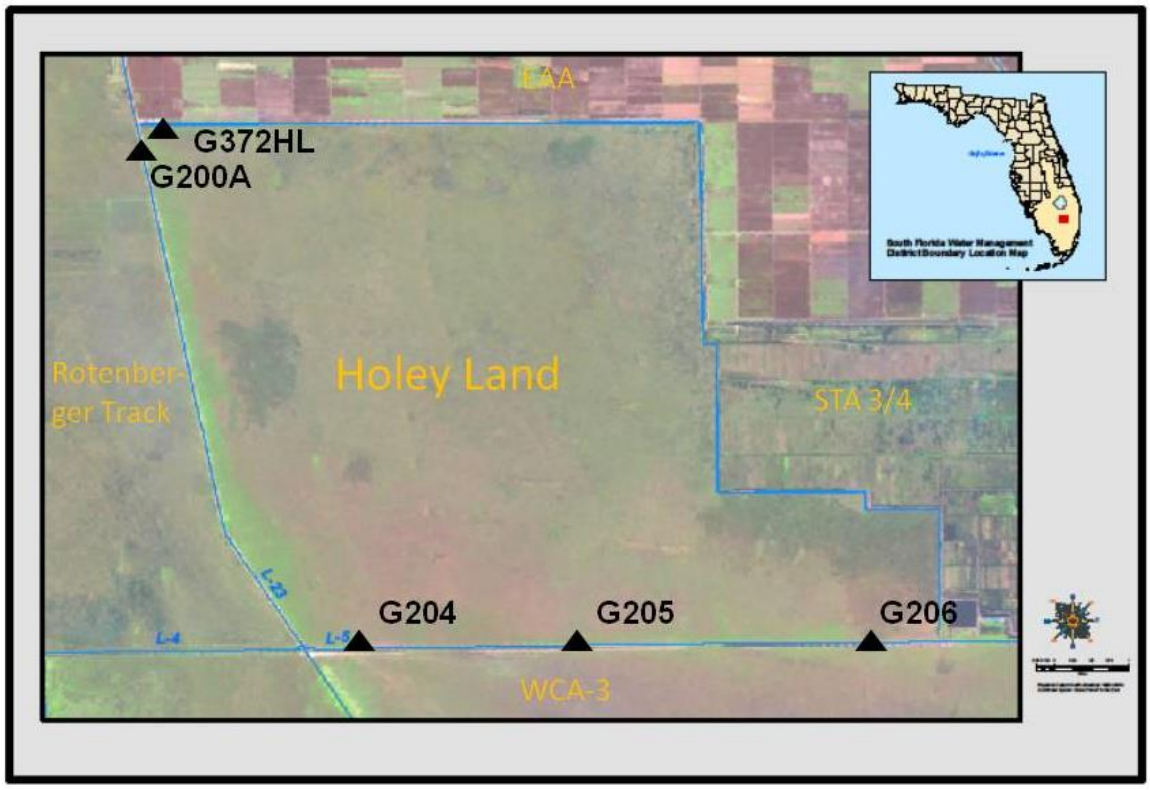

Figure 3. Holey Land WMA flow monitoring locations at the inflow and outflow sites.

STAGE DATA

Within the Holey Land WMA, water stages were monitored at two marsh stations (HOLEY1 and HOLEY2), one groundwater monitoring station (HOLEY_G), one interior perimeter canal site G-203 on the eastern side (stage monitoring station G203D), and on the upstream side of each of the outflow structures G-204, G-205, and G-206 (stage monitoring stations G204_H, G205_H, and G206_H, respectively) (**Figure 4**).

The permit specifies, "For operational decisions, the average stage in the Holey Land will be defined as the water level in the interior pond at station G-203, located on the eastern boundary of Holey Land, four miles south of the north levee." The intention of this location was to measure stage at a location that was far enough away from the inlet and outlets that it would not be significantly influenced by changes in the inlet or outlet operations. Because the Holey Land WMA has become rainfall-driven and no longer functions as a flow-through system, water levels fluctuate naturally with rainfall events.

All stage data collected at the stations shown in **Figure 5** for federal Water Year 2013 (October 1, 2012–September 30, 2013) are summarized in **Table 8**. Additional information about the stage data is included in Attachment C.

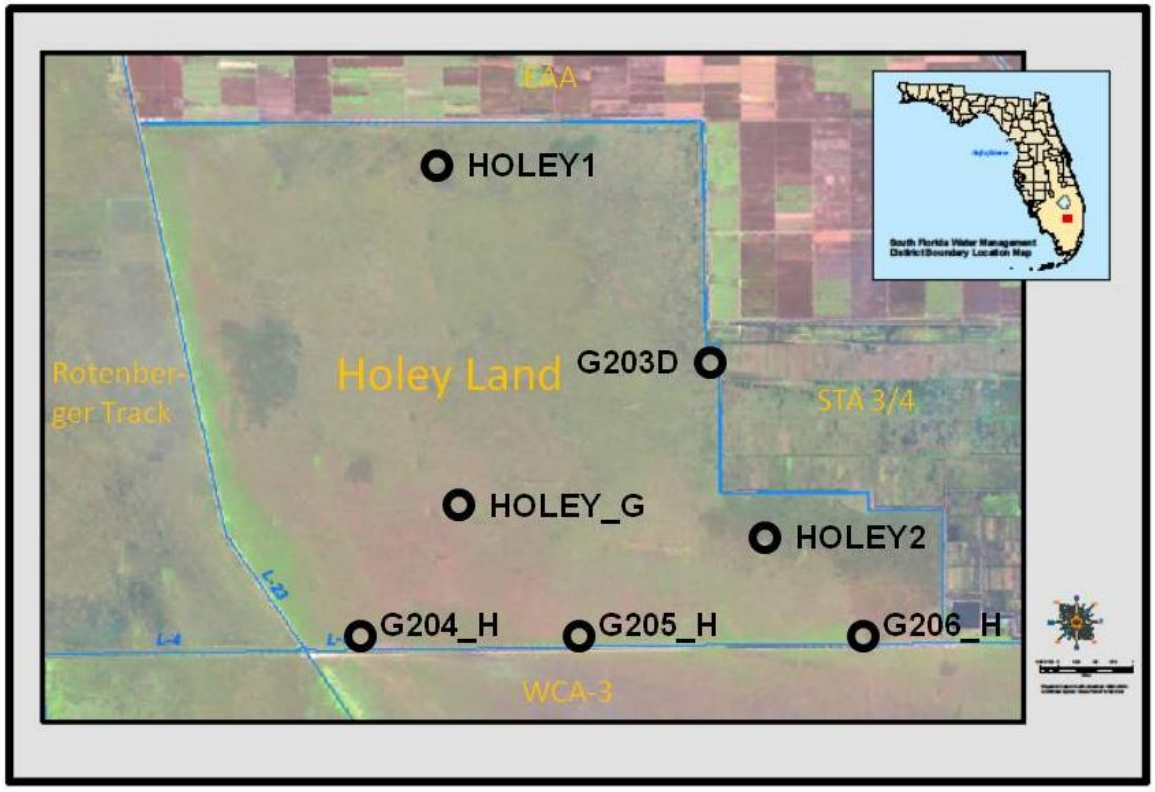

Figure 4. Holey Land WMA stage monitoring locations.

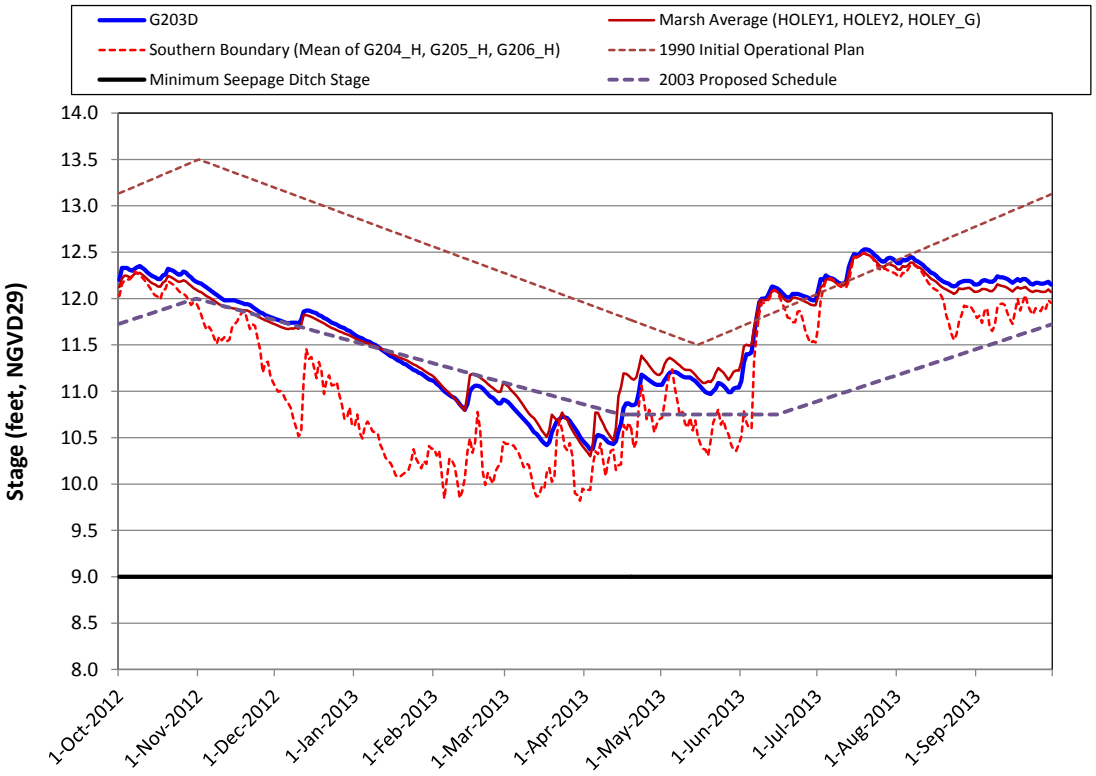

Figure 5. Daily stages in the Holey Land WMA for federal Water Year 2013. [Note: feet, NGVD29 – feet National Geodetic Vertical Datum of 1929.]

Table 8. Summary of mean daily stage data in feet NGVD29 from the Holey Land WMA for federal Water Year 2013.

Station	Statistics	Oct. 2012	Nov. 2012	Dec. 2012	Jan. 2013	Feb. 2013	Mar. 2013	Apr. 2013	May 2013	Jun. 2013	Jul. 2013	Aug. 2013	Sep. 2013	WY2013 Total
G203D	Maximum	12.35	12.17	11.87	11.61	11.11	10.90	11.18	11.21	12.13	12.53	12.45	12.24	12.53
	Mean	12.28	11.97	11.76	11.37	10.96	10.64	10.74	11.09	11.90	12.35	12.27	12.19	11.63
	Minimum	12.18	11.79	11.63	11.12	10.80	10.42	10.37	10.97	11.11	12.09	12.13	12.15	10.37
HOLEY_G	Maximum	12.35	12.16	11.94	11.70	11.55	11.51	11.93	11.84	12.17	12.54	12.44	12.25	12.54
	Mean	12.27	11.97	11.80	11.58	11.34	11.23	11.44	11.65	12.01	12.37	12.28	12.18	11.84
	Minimum	12.18	11.82	11.71	11.42	11.05	10.93	10.82	11.52	11.61	12.14	12.13	12.13	10.82
HOLEY1	Maximum	12.20	12.01	11.73	11.50	11.08	10.82	11.26	11.11	11.96	12.39	12.29	12.10	12.39
	Mean	12.13	11.82	11.63	11.33	10.90	10.39	10.69	10.85	11.79	12.22	12.12	12.03	11.49
	Minimum	12.03	11.65	11.52	11.09	10.65	10.06	9.93	10.56	11.19	11.98	11.98	11.98	9.93
HOLEY2	Maximum	12.31	11.97	11.79	11.48	11.09	11.06	11.35	11.36	12.11	12.50	12.39	12.06	12.50
	Mean	12.12	11.82	11.62	11.29	10.94	10.62	10.78	11.26	11.86	12.29	12.15	12.00	11.56
	Minimum	11.99	11.66	11.49	11.07	10.66	10.17	10.08	11.15	11.36	11.88	11.96	11.95	10.08
G204_H	Maximum	12.29	12.09	11.87	11.44	10.65	10.45	12.07	11.93	12.14	12.47	12.38	12.20	12.47
	Mean	12.21	11.90	11.66	10.60	10.14	10.14	10.87	11.14	11.77	12.29	12.21	12.11	11.42
	Minimum	12.11	11.71	11.49	10.09	9.79	9.79	9.90	10.34	10.42	12.06	12.05	12.05	9.79
G205_H	Maximum	12.36	12.15	11.62	10.42	10.74	10.72	10.51	10.80	12.12	12.55	12.45	12.20	12.55
	Mean	12.26	11.83	10.76	10.21	10.22	10.23	10.23	10.42	11.70	12.37	12.25	12.14	11.22
	Minimum	12.15	10.90	10.00	9.92	9.86	9.86	9.95	10.16	10.55	12.09	12.06	12.06	9.86
G206_H	Maximum	12.25	11.80	11.09	10.49	10.94	10.89	10.61	11.02	12.05	12.45	12.31	11.75	12.45
	Mean	11.87	11.07	10.52	10.25	10.27	10.24	10.22	10.42	11.35	12.15	11.68	11.35	10.95
	Minimum	11.44	10.54	10.06	9.96	9.86	9.81	9.92	10.15	10.51	10.93	10.55	10.84	9.81

RAINFALL AND EVAPORATION DATA

Rainfall was measured at S8_R and adjacent stations (S3_R and S7_R), along with pan evaporation at S7_E (**Figure 6**).

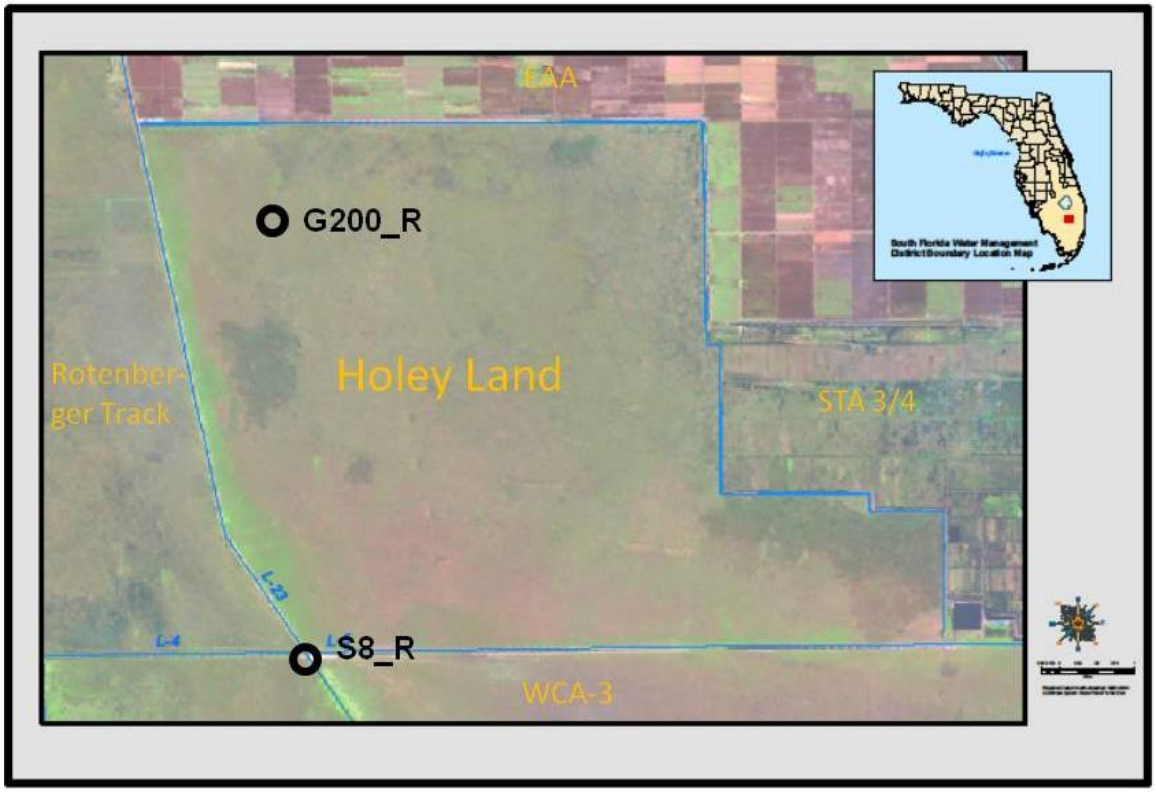

Figure 6. Holey Land WMA rainfall/evaporation monitoring locations.
(Not shown: Station S3_R, which is located at the S3 pump station, about 25 miles north of S8_R, and S7_R/S7_E, which is located about 15 miles east of S8_R)

To show seasonal patterns, a comparison of monthly total rainfall and monthly total evaporation for federal Water Year 2013 is presented in **Figure 7**. Monthly total rainfall data at S3_R, S7_R, and S8_R are summarized in **Table 9.** Rainfall data at the G200_R gauge was reported in the federal Water Year 2010 and Water Year 2011 annual reports, but has not been available since federal Water Year 2012, and is consequently not shown in this report. S7_R gauge data, which was reported until federal Water Year 2009, was used instead. Monthly total evaporation data is summarized in **Table 10**. Additional information on the rainfall data is included in Attachment C.

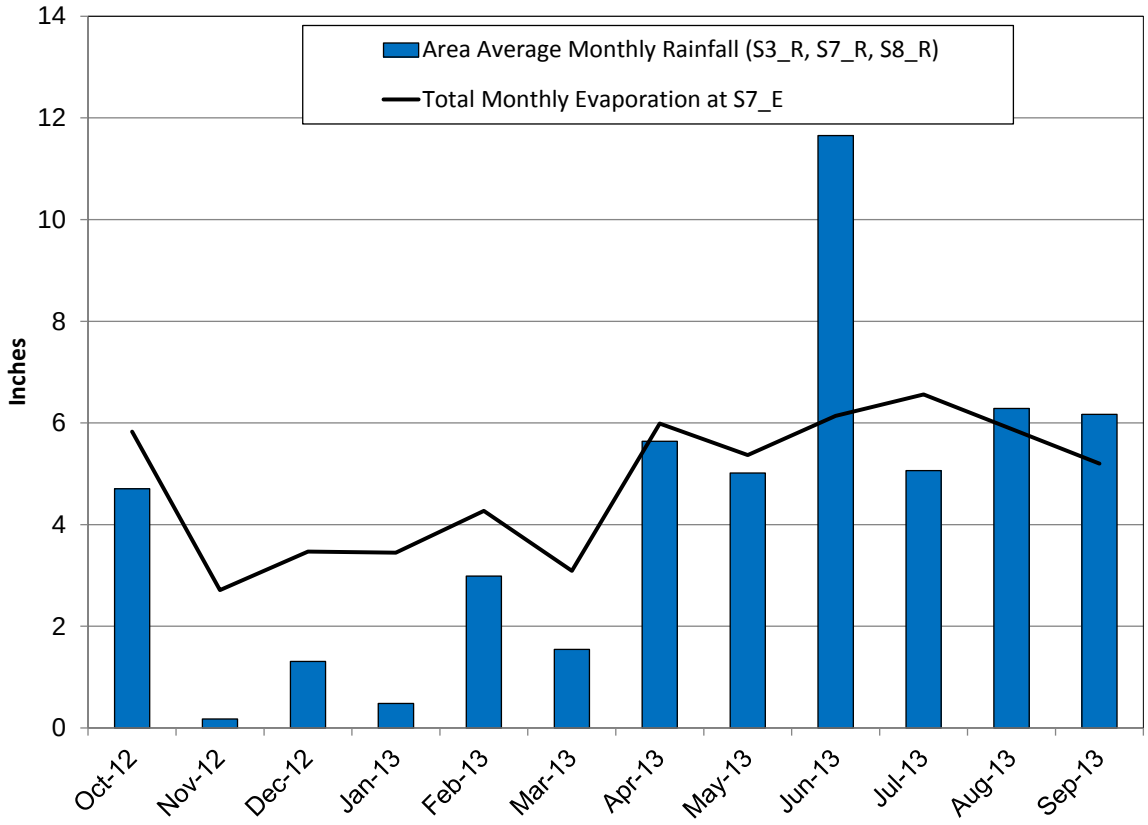

Figure 7. Average monthly rainfall in the Holey Land WMA (average of S3_R, S7_R, and S8_R) compared to monthly evaporation at S7_E for federal Water Year 2013.

Table 9. Summary of daily rainfall data and monthly sums (in inches) in the Holey Land WMA for federal Water Year 2013. [Note: Numbers in parentheses after "M" denote the number of missing daily values.]

Station	Statistics	Oct. 2012	Nov. 2012	Dec. 2012	Jan. 2013	Feb. 2013	Mar. 2013	Apr. 2013	May 2013	Jun. 2013	Jul. 2013	Aug. 2013	Sep. 2013	WY2013 Total
S3_R	Maximum	1.09	0.14	0.59	0.99	3.24	1.56	0.62	1.45	1.44	1.14	0.52	1.53	3.24
	Mean	0.13	0.01	0.05	0.05	0.13	0.06	0.09	0.20	0.33	0.21	0.07	0.21	0.13
	Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Sum	3.95	0.19	1.50	1.15	3.62 (M 8)	2.00	2.66	6.23	9.96	6.64	2.19	6.27	46.36 (M 8)
S7_R	Maximum	1.13	0.10	0.17	0.08	1.06	no data	no data	no data	no data	0.37	3.13	1.74	3.13
	Mean	0.12	0.01	0.01	0.00	0.11	no data	no data	no data	no data	0.06	0.32	0.23	0.11
	Minimum	0.00	0.00	0.00	0.00	0.00	0.00	no data	no data	no data	0.00	0.00	0.00	0.00
	Sum	3.84	0.19	0.26	0.12	2.98	(M 27)	(M 30)	(M 31)	(M30)	0.77 (M 17)	9.88	6.80	24.84 (M 135)
S8_R	Maximum	1.63	0.07	1.81	0.09	1.38	0.69	2.25	0.97	3.53	1.33	2.07	1.92	3.53
	Mean	0.20	0.01	0.07	0.01	0.08	0.04	0.29	0.12	0.45	0.25	0.22	0.18	0.16
	Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Sum	6.32	0.15	2.16	0.18	2.36	1.09	8.62	3.80	13.35	7.78	6.79	5.43	58.03

Table 10. Summary of daily pan evaporation data and monthly sums (in inches) in the Holey Land WMA for federal Water Year 2013.

Station	Statistics	Oct. 2012	Nov. 2012	Dec. 2012	Jan. 2013	Feb. 2013	Mar. 2013	Apr. 2013	May 2013	Jun. 2013	Jul. 2013	Aug. 2013	Sep. 2013	WY2013 Total
S7_E	Maximum[a]	0.36	0.32	0.61	0.58	0.80	0.69	1.11	0.76	0.44	0.50	0.33	0.36	1.11
	Mean[a]	0.19	0.13	0.18	0.18	0.22	0.28	0.35	0.32	0.26	0.24	0.23	0.19	0.23
	Daily Average	0.19	0.09	0.11	0.12	0.14	0.10	0.19	0.17	0.20	0.21	0.20	0.17	0.16
	Minimum[a]	0.09	0.03	0.06	0.06	0.05	0.08	0.00	0.00	0.08	0.12	0.08	0.08	0.00
	Sum	5.83	2.71	3.47	3.45	4.27	3.09	5.99	5.37	6.14	6.56	5.88	5.20	57.96

a. Cumulative values from one to five days.

Attachment A: Specific Conditions and Cross-References

Table A-1. Specific conditions, actions taken, and cross-references presented in this report for the Holey Land Wildlife Management Area project (ERP permits 06,500809209 and 06,501191549a).

Specific Condition	Description	Applicable Phase	Action Taken	Reported in 2015 SFER Vol. III, App. 5-3 in:			
				Narrative (page #s)	Figure	Table	Attachment
5	Maintain normal water level in seepage ditches (no lower than +9 feet NGVD29)	Operation	Not applicable. Seepage ditches were extensively modified and water regulation schedules were changed. Daily stages are monitored and reported.	2, 12	4, 5	8	C
Page 8 of 11 in permit	Long-term water quality monitoring [b]	Operation	Quarterly water quality monitoring conducted and reported.	2, 3	1	3 - 6	B
Page 9 of 11 in permit	Sediment monitoring [b]	Operation	Annual sediment sampling conducted and reported.	9	2	7	B
Page 10 of 11 in permit	Vegetation monitoring [c]	Operation	Annual vegetation monitoring conducted and reported.	2			D
Page 10 of 11 in permit	Report volume of rainfall	Operation	Rainfall monitored and reported.	2, 15	6 - 7	9 - 10	C
Page 10 of 11 in permit	Report volume of water pumped	Operation	Flow monitored and reported.	2, 11	3		C

a. All conditions required for permit 06,500809209 also apply to permit 06,501191549.

b. For revised monitoring plan changes from FDEP, see minor permit modification document, dated September 20, 2005.

c. For vegetation reporting requirements see "Exhibit C" of the agreement between South Florida Water Management District and the Florida Game and Fresh Water Fish Commission, dated June 28, 1990.

Attachment B: Water Quality and Sediment Data

This project information is required by the Holey Land Wildlife Management Area permits (06,500809209 and 06,501191549), and is available upon request.

Attachment C: Hydrologic Data

This project information is required by the Holey Land Wildlife Management Area permits (06,500809209 and 06,501191549), and is available upon request.

Attachment D: Holey Land Wildlife Management Area 2013 Annual Cattail Monitoring Report

This report, dated June 26, 2013, was provided to the District by the Florida Fish and Wildlife Conservation Commission, and is required by the Holey Land Wildlife Management Area permits (06,500809209 and 06,501191549).

HOLEY LAND WILDLIFE MANAGEMENT AREA
2013 ANNUAL CATTAIL MONITORING REPORT

Erik Eckles
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Florida Fish and Wildlife Conservation Commission
Sunrise, Florida
June 26, 2013

INTRODUCTION

Holey Land Wildlife Management Area (WMA) is a 35,350 acre wetland in the southwest corner of Palm Beach County, Florida. The area was originally a marsh of dense sawgrass (*Cladium jamaicense*) with scattered shrubs and sloughs (Davis 1943); however, unnatural alteration of the area's hydropattern began when the Miami Canal was excavated (1907-1917) along the western border of the area. After the authorization of the Central and Southern Florida Project for Flood Control and Other Purposes in 1948, the canal was deepened and the L-5 levee was constructed creating the southern border of Holey Land and blocking sheetflow to the south (Light and Dineen 1994). By the late 1960s, these changes, in combination with the conversion of marsh to farmland in the north and east, had altered the area's hydropattern and caused significant changes in the plant communities (Cornwell and Hutchinson 1974).

In 1968 the area was leased to the Florida Fish and Wildlife Conservation Commission (FWC) for fish and wildlife management purposes. Pursuant to that objective, from 1974 to 1975, 54 artificial islands ranging from 0.3 to 0.5 acres in size were created by dredging muck from the marsh, leaving behind a small pond adjacent to each island. This was part of an Everglades-wide program, initiated by sportsman

Francis “Franny” Taylor to mitigate for the loss of tree island habitat caused by muck fires (Shortemeyer 1980).

A 1983 interagency agreement between FWC, the South Florida Water Management District (SFWMD), and the Florida Department of Environmental Regulation identified hydropattern improvement as a goal for restoration in Holey Land. Subsequently, in the late 1980’s, a system of levees, canals, and pumps was built that allowed managers to pump water from the Miami Canal into the area to achieve desired water levels. This system was fully functional by 1990 and the initial water schedule, which called for water levels varying from 11.5-13.5 feet above mean sea level (MSL), was achieved in June 1991. A topographic survey performed in 1992 revealed that the average elevation was 11.1 ft MSL, 0.4 ft lower than the previous estimate of 11.5 ft MSL prompting managers to lower the water regulation schedule to 11.0-13.0 ft MSL in July 1993. The elevation in Holey Land also ranges as much as four feet, a result of muck fires burning away organic soil during extreme dry periods. Extended high water levels in Holey Land can drown out typical marsh species in these deep pockets, creating an opening in the landscape susceptible to invasion by cattail (*Typha spp.*) (Newman et al. 1998). In early 1995, the schedule was dropped to 10.5-12.0 ft. MSL in an attempt to slow the proliferation of cattail.

Both of the major changes in the schedule were done informally and a revised schedule similar to that adopted in 1995 is under review by the FWC and SFWMD, as is a formal Memorandum of Understanding. Conforming to a revised schedule has been hindered by the fact that the G200A pump station has been defunct since 2005, eliminating the ability to deliver clean water to Holey Land.

METHODS

The cattail survey method used from 1992-2003 was initiated after an attempt to use color infrared photography failed due to a combination of low cattail density and poor survey timing (Gilbert 1991). Two separate surveys conducted via helicopter were used to determine cattail coverage by first delineating boundaries of cattail monocultures and then sampling these areas to determine aerial percent cattail coverage. Cattail stands were first located by systematically traversing the entire area. Global Positioning System (GPS) readings were taken at all extensive areas of cattail growth. After completing this initial survey, each of the areas of extensive cattail growth previously located were revisited and mapped by taking GPS readings along their perimeters.

The second phase employed an aerial point-sampling scheme that utilized a 4 x 5 grid of crosshairs to systematically select 20 sample points. This grid was copied onto an 8.5" x 11" sheet of clear plastic and provided to two biologists observing from either side of the helicopter. Sampling was conducted at different altitudes, depending on the size of the area sampled (e.g., observations were made at lower altitudes in areas with smaller cattail stands to ensure that samples were taken within the boundaries of the area surveyed), by holding the grid at arm's-length (as nearly parallel to the ground as possible given the configuration of the helicopter) and recording the number of points where the cross-hairs landed on the various vegetation types surveyed. The vegetation types were classified as cattail, sawgrass, brush, open water, or other. Each biologist took 10 sets of 20 sample points totaling 400 sample points in each area (200 sample points per biologist). The number of points landing on cattail, divided by the total number of sample points, provided the percent aerial cattail coverage in each sampling

area. The field map produced using the GPS coordinates recorded along the boundary of each sampling area was transformed into an area layer that provided measurements of total acreage within each area. The total cattail coverage in Holey Land WMA was the sum of the resulting estimates of cattail coverage in the individual sampling areas. Estimates of cattail coverage were computed using the 35,350 acre base map.

In 2004 the point intercept method was adopted in an effort to obtain more accurate and less subjective data (Owensby 1973). The survey involves two biologists, one on each side of the helicopter, selecting a specific point on the helicopter skid and looking directly down past that point at the vegetation below at evenly spaced points. The surveys are performed in May and involve flying 12 transects, collecting data at all 372 points for a total of 744 data entries (prior to 2010, there were 369 points for a total of 738 data entries). At each point the observer records one of five different categories: cattail, sawgrass, brush, open water, and other. These categories were changed in 2005 to sawgrass, cattail, wax myrtle (*Myrica cerifera*), Brazilian pepper (*Schinus terebinthifolius*), red maple (*Acer rubrum*), willow (*Salix caroliniana*), and other. In 2007 a "burned" category was added to account for a 13,395 acre wildfire that occurred on April 1, 2007, one month before the survey. The helicopter is flown at an altitude of 200 feet and at a speed of approximately 80 miles/hour. The number of points where cattail is observed is divided by the total number of points and multiplied by 100 to provide a percent coverage of cattail. The percentage is multiplied by the total acres surveyed to calculate total acres of cattail.

In 2005, the FWC contracted Florida Natural Areas Inventory (FNAI) to conduct a vegetation survey of Holey Land WMA (Figure 1) via remote sensing of aerial

photographs. They digitized as many community types as possible and ground-truthed each polygon identified during their remote sensing. They found 25.5% (9,025.22 acres) of the area to be cattail monoculture, which is consistent with the sampling results from 2004-2006.

RESULTS

The results of the 2013 survey estimate that 14.8% of the area is covered by cattail (Table 1; see Figure 1 for sample locations and results). The acreage covered by cattail was calculated to be 5,226 acres. This indicates a slight decrease in estimated cattail coverage from 2012 (16.9%), and significantly less than what was estimated in 2004 (27.0%).

DISCUSSION

Cattail coverage increased rapidly over the course of the initial hydrological restoration of Holey Land, aided by the higher water regime schedules. During this time, cattail invaded sloughs and open-water areas that were created when muck fires burned the peat and sawgrass rootstock. These muck fires also released large amounts of nutrients. Sawgrass can survive total submergence for up to six weeks, but is adversely affected by high water and a combination of increased water depth, extended hydropatterns, and increased nutrients will promote the growth of cattail over sawgrass (Newman et al. 1998).

Determining the cattail coverage from the air continues to be subjective due to different biologists participating in the surveying each year and the varying appearance of

cattail throughout the area and years, e.g., the area's soil moisture at any given time and location can affect the "greenness" and detectability of cattail. The survey shows a clear trend of decreasing cattail coverage in Holey Land WMA through 2010, although in recent years the cattail population may have stabilized around 15% total coverage (Figure 2). The decrease through 2010 could be attributed to the lowered water schedule. The stabilization since that time could be attributed to the population adjustment to the decrease in hydroperiod length due to the overall reduction of water deliveries since the G200A pump station was decommissioned in 2005. The slight decrease in cattail coverage observed from 2012 (16.9%) to 2013 (14.8%) is statistically insignificant, and is likely a continuation of the pattern of small changes in cattail population due to varying rainfall amounts in different years (Figure 3).

Cattail would be expected to spread again and possibly encroach into the dominant sawgrass expanse in Holey Land WMA if extreme high water levels or extremely long hydroperiods are adopted (Newman et al. 1998). Because regular water deliveries have not been made, Holey Land has generally had lower than normal water levels. This has allowed shrub encroachment over much of the area, and one reason for the decrease in cattail may be replacement by Carolina willow or wax myrtle, (Figure 1). These dry conditions also increase the probability of muck fires which could create more suitable conditions for cattail expansion. The FWC is working with the SFWMD to ensure that the primary focus in Holey Land is to restore water levels and hydroperiods that are closer to historic levels in order to achieve a healthier natural community.

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Table 1. Cattail surveys in the Holey Land WMA, 1991-2012.

Year	Actual Acres Surveyed	Cattail Acres (95% C.I.)	Estimated % of Cattail Coverage in WMA
1991 [1]	N/A	538	N/A
1992	4,640	1,456 (990-1920)	4.1
1993	12,814	3,838 (2,890-4,823)	10.9
1994	19,460	5,434 (3,928-6,961)	15.4
1995	19,253	6,534 (5,321-7,731)	18.5
1996	19,657	6,706 (5,064-8,346)	19.0
1997 [2]	21,987	9,092 (7,398-10,772)	25.7
1998 [2]	20,937	9,987 (7,935-11,208)	28.3
1999 [2]	21,850	10,392 (7,377-13,401)	29.4
2000	22,442	11,195 (10,750-13,804)	31.7
2004	35,350	9,545 (8,484-10,605)	27.0
2005	35,350	7,848 (6,514-9,182)	22.2
2006	35,350	8,060 (6,999-9,120)	22.8
2007	35,350	6,850 (5,819-7,897)	19.4
2008	35,350	5,508 (4,596-6,434)	15.6
2009	35,350	6,108 (5,142-7,074)	17.3
2010	35,350	3,706 (2,928-4,484)	10.5
2011	35,350	6,297 (5,323-7,271)	17.8
2012	35,350	5,987 (5,034-6,939)	16.9
2013	35,350	5,226 (4,325-6,128)	14.8

[1] Visual estimates of cattail given in Gilbert (1991).
[2] Cattail surveys performed in the fall rather than in the spring.

Figure 1. Results of the 2013 cattail survey overlaid on top of the 2005 FNAI survey.

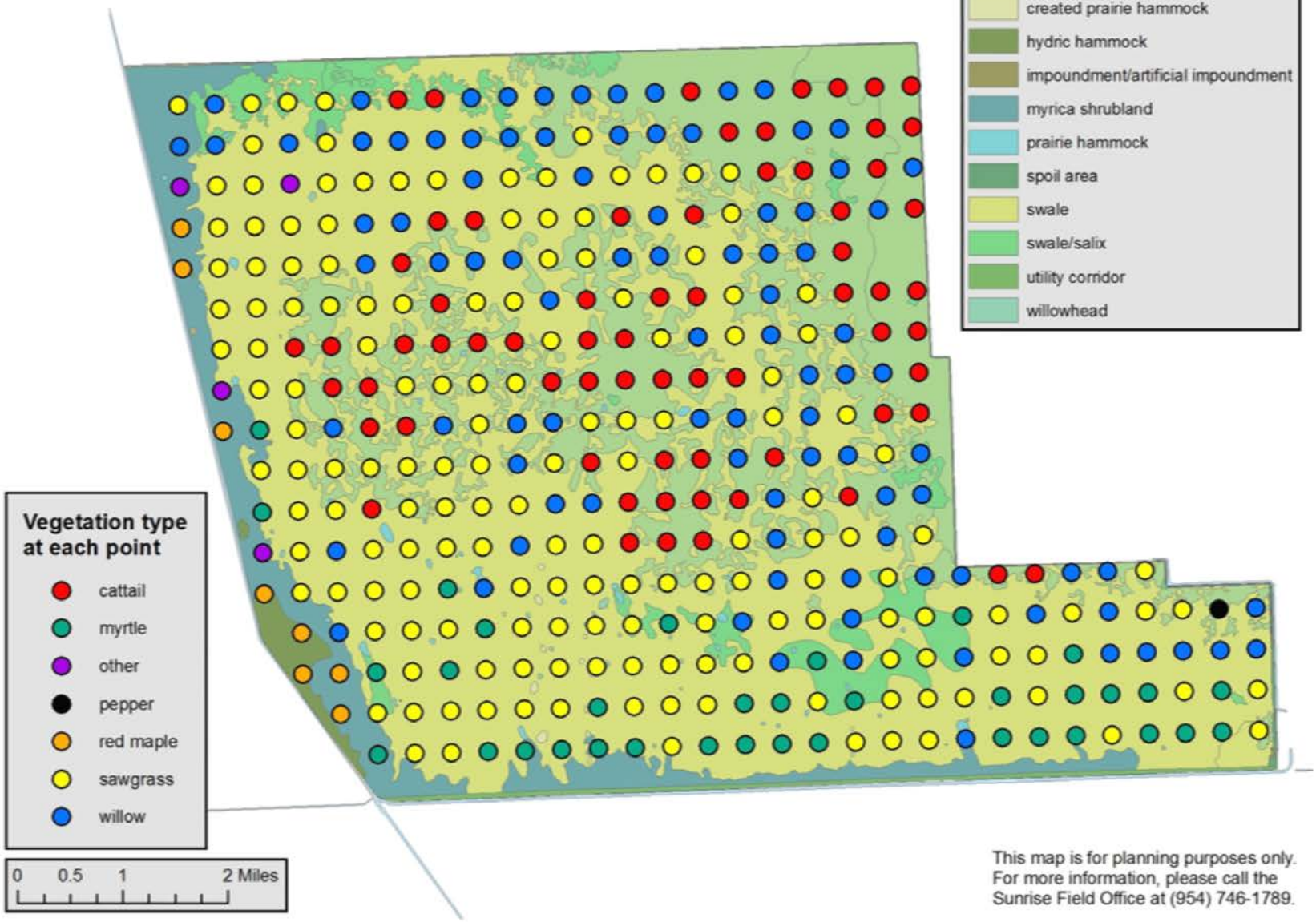

Figure 2. Cattail Coverage in Holey Land WMA

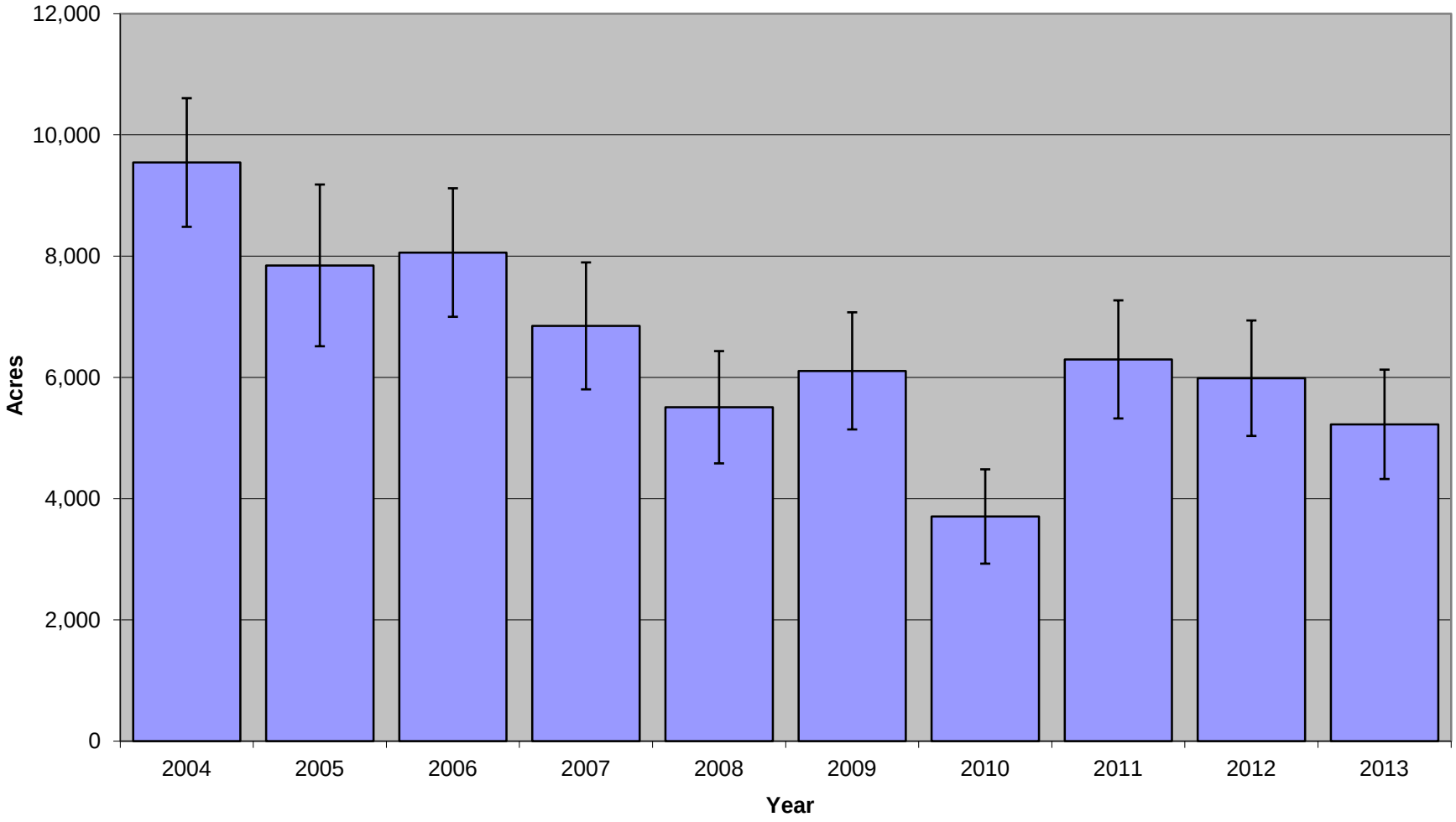

Figure 3. Holey Land WMA stage level (G203) water levels from 2012 and 2013, average weekly water levels for 1990-2012, average ground elevation, closure criteria and the schedule.