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A WATERSHED ANALYSIS OF PERMITTED COASTAL WETLAND IMPACTS AND MITIGATION ASSESSMENT METHODS WITHIN THE CHARLOTTE HARBOR NATIONAL ESTUARY PROGRAM

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Abstract: *From 2004 to 2008, 1,834 Environmental Resource Permits were issued for development projects in coastal wetlands within the Charlotte Harbor National Estuary Program. We evaluated 118 sites utilizing three wetland functional assessment methods (WFAMs): Hydrogeomorphic Method (HGM), Wetland Rapid Assessment Procedure (WRAP), and Uniform Mitigation Assessment Method (UMAM). All functioned as designed and produced similar assessments of wetlands but yielded different mitigation results. The study results showed that HGM was most effective in identifying and quantifying wetland functions of coastal wetlands. UMAM and WRAP are useful but delivered mitigation ratios less than one in both function and area, resulting in net wetland losses. The wetland area lost over the study period was small relative to total wetland area, but the permitted wetland elimination is gradually reducing the extent of wetlands. The process relocates wetland functions out of impacted watersheds toward off-site mitigation areas. The WFAM site evaluations indicated an equal or greater balance of ecosystem functions within the total service area when utilizing off-site mitigation. However, there is loss of wetland area and function in the donor watershed and an increase in function, but not area, of wetlands in the receiving watershed.*

Key Words: Charlotte Harbor, coastal wetlands, mangroves, mitigation, salt marsh, wetland functional assessment, HGM, UMAM, WRAP

This study: 1) identifies regional effects of current wetland permitting processes and programs of compensatory wetland mitigation; 2) evaluates the success of state and local mitigation strategies implemented in the Charlotte Harbor National Estuary Program (CHNEP) study area, focusing on coastal marine and estuarine habitats; and 3) provides suggestions for improving mitigation for wetland loss. Management criteria and implementation success are assessed for both public and private mitigation lands.

Restoration and maintenance of high environmental quality should sustain the coastal economic base for tourism, fishing, recreation and the quality of life for area residents (CHNEP CCMP 2010). It is essential that the wetland regulatory process maintain and protect these resources. The pace of changes in the coastal wetlands of the CHNEP is not distinguishable with large scale mapping tools and requires close examination of the wetland regulatory and mitigation processes to be observed and measured.

TABLE 1. Comparison of the variables evaluated for the three wetland functional assessment methods.

HGM 14 Variables	UMAM 3 Variables	WRAP 6 Variables
Degree of Marsh Dissection	Location & Landscape Support	Wildlife Utilization
Proportion of Tidally Connected Edge to Total Edge	Water Environment	Wetland Canopy
Total Effective Patch Size	Community Structure (vegetation and/or benthic)	Wetland Ground Cover
Hydrologic Regime		Habitat Support/Buffer
% Cover by Typical Plant Species		Field Hydrology
Nekton Habitat Complexity (# different habitat types)		Water Quality Input & Treatment
Wildlife Habitat Complexity (# different habitat types)		
Surface roughness (Manning's; 3 sub-components)		
Mean Total % Vegetative Cover		
Mean Vegetative Structure Index		
Mean Width of Marsh		
Relative Exposure Index (fetch)		
Distance to Navigation Channel or 2 m Depth		
Soil texture		

Wetland Functional Assessment Methods (WFAM) are procedures that are designed to evaluate current wetland functions and predict potential changes to a wetland's functions that may result from proposed activities. In this study we evaluated the apparent success of assigned mitigation actions by the use of the current prevalent wetland mitigation functional assessment methods (WFAMs). These are the federal Hydrogeomorphic Methodology (HGM) (Shafer et al., 2002), the State of Florida's Uniform Mitigation Assessment Method (UMAM) (Florida Department of Environmental Protection, 2004), and the South Florida Water Management District's Wetland Rapid Assessment Procedure (WRAP) (Miller and Gunsalus, 1997). WRAP was also employed by the US Army Corps of Engineers (USACOE) for a time period ranging from January 1, 2002 to December 31, 2008. A summary of the variables collected in each WFAMs provided in TABLE 1.

Prior to beginning the study, Environmental Resource Permits (ERPs) within the CHNEP were inventoried. ERPs available as electronic files from the Florida Department of Environmental Protection (FDEP), the South Florida Water Management District (SFWMD), and the Southwest Florida Water Management District (SWFWMD) for the study period of January 1, 2004 to December 31, 2008 were reviewed. The review revealed that 10,186 ERP permitting actions occurred within the study area. The watersheds with the most permitting activity were the Caloosahatchee River in the SFWMD (28% of the total) and the Peace River in the SWFWMD (25%). Permitting activities occurring in costal wetland habitats or at the coastline account for

18%. of the permits. The coastal watersheds with the most active permitting activities were the Caloosahatchee River (27% of coastal actions) and the Pine Island Sound/ Matlacha Pass watershed (23%). The least active coastal permitting occurred in the Myakka River (4%) and Dona and Roberts Bays (5%) watersheds.

MATERIALS AND METHODS—*Site selection*—The Wetland Functional Assessment Method (WFAM) assessment process began with the selection of an Environmental Resource Permit (ERP) based on the proximity of the project to tidally influenced wetlands, and on whether or not wetland impacts were anticipated. Aerial photos for each study site, dating as far back as 1998, were downloaded from county websites and saved as part of the site study file. Physical access to the site was then determined and sites were accessed via road, trail or charter boat. In three cases the property owner could not be determined or contacted so the sites were assessed from the nearest public access (road, right-of-way, or waterway). A total of 118 sites were selected for the WFAM assessment, as shown in FIG. 1. For this study, a site identification number was given to each site based on the date of assessment and the number of sites assessed that day. The distribution of projects assessed was determined to some degree by the facility of finding pertinent permit information.

Equipment—Equipment used in the field included: a Trimble GPS unit with ArcGIS ArcPad software, digital camera, functional assessment field data sheets, functional assessment "reference sheets", field guides, binoculars, aerial photos, and YSI water quality sensor. The water quality sensor was incorporated into the project in 2008, as it became available from another study.

Study Personnel—WFAM field assessment, office evaluations and data analysis were conducted by the authors, James Beever as Principal Planner and the Whitney Gray as Environmental Scientist.

WFAM scoring—Each site was determined to be pre-construction or post-construction of the permitted project. Data sheets for each assessment method were filled out by study scientists and the same information was entered into the GPS unit. Flora and fauna observed at the site were recorded. Photographs were taken at each, with emphasis on the project area, wetland vegetation, alterations of vegetation, and wildlife observed. Surrounding conditions were recorded for spatial context.

If the site being assessed was in the pre-construction state, data sheets were also completed for the post-construction state as predicted by the conditions of the permit, as defined in the protocols for each WFAM. If the site was assessed post-construction, data sheets were also completed for a pre-construction condition based on historical aerial photos and staff reports from the permit file. Local knowledge was sometimes helpful in this process as well.

The total time at each site doing all three functional assessment methods as a team averaged approximately one hour.

Water quality—Measurements of water temperature, dissolved oxygen, pH, and salinity were taken at each site starting in 2008 when the water quality meter was acquired.

Data Management and Analysis—Following the field visit, all collected data, photographs and measurements were downloaded and stored in appropriate Access, Excel and Geo- databases. The data sheets were completed in the office because some information in the functional assessments was more efficiently determined from the desktop. Scores from the functional assessments were then entered into databases that summarized wetland impacts and mitigation. Finally, a narrative was written for each site summarizing the conditions at the time of assessment; the nature of the project being permitted; the wildlife, wetland canopy, and wetland groundcover observed at the

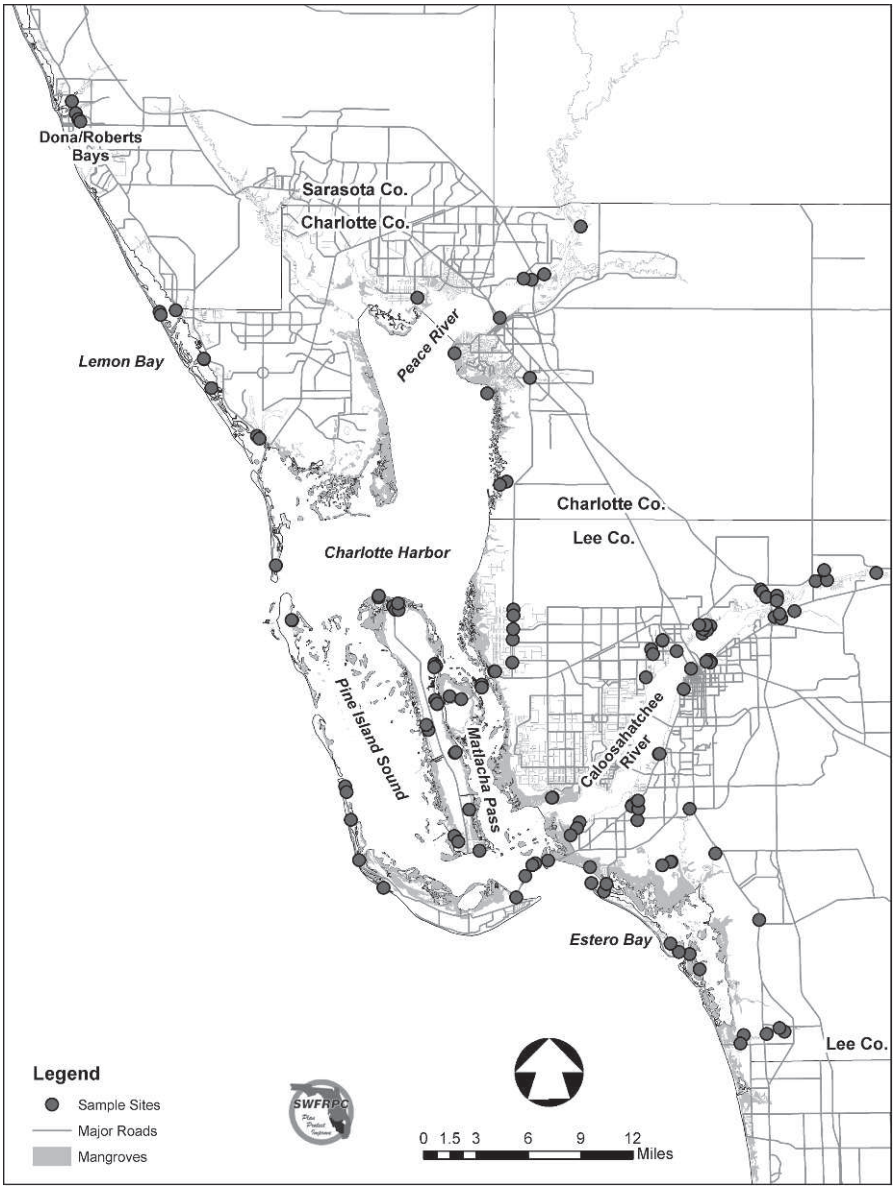

FIG. 1. Location of Project Sample Sites.

site; the habitat support around the site; and the hydrology of the site. The conditions predicted for either post- or pre-construction state, were recorded.

RESULTS—*Sites evaluated*—The locations of the site visits are displayed on FIG. 1. The number and size of study sites are summarized by watershed, county and construction status in TABLE 2. The sites were distributed in 9 of the

TABLE 2. Summary of the number and size of WFAM assessment sites by watershed and county within the study area.

	No. of Projects				Wetland Size			
	Pre-Project	Post-Project	Total	%	Total (ha)	Min. (ha)	Max (ha)	Ave. (ha)
Watershed								
Dona/Roberts Bays	0	4	4	3%	1.0	0.073	0.45	0.25
Lemon Bay	0	8	8	7%	0.5	0.004	0.26	0.06
Charlotte Harbor/ Gasparilla Sound	5	5	10	8%	2.3	0.004	1.86	0.23
Peace River	4	1	5	4%	29.7	0.069	18.62	5.93
Pine Island Sound	8	3	11	9%	36.9	0.012	29.98	3.35
Matlacha Pass	16	1	17	14%	44.3	0.004	21.45	2.61
Caloosahatchee R.	33	5	38	32%	64.3	0.000	22.14	1.69
San Carlos Bay	3	4	7	6%	1.9	0.012	0.96	0.28
Estero Bay	14	4	18	15%	18.2	0.004	6.94	1.01
Total	83	35	118	100%	199.1	<0.000	29.98	1.69
County								
Sarasota	0	4	4	3%	1.0	0.073	0.45	0.25
Charlotte	6	13	19	16%	32.3	0.004	18.62	1.70
Lee	77	18	95	81%	165.8	<0.000	29.98	1.74
Total	83	35	118	100%	199.1	<0.000	29.98	1.69

CHNEP watersheds, with 33 of the 118 site located in the Caloosahatchee River watershed and 15% were in Estero Bay (TABLE 4). Of 118 sites examined, 81% were in Lee County, 16% were in Charlotte County, and 3% were in Sarasota County. Seventy percent of projects were assessed in the pre-construction condition, and 30% in the post-construction condition. A total of 199 hectares of wetlands were evaluated at the study sites, ranging in size from less than 0.004 hectares to 30 hectares.

It is important to note that if a project site contained two or more distinct wetland types, each was assessed separately. Also, some projects contained on-site mitigation which was assessed separately.

Project types—The types of projects assessed are provided in TABLE 4. The largest category of projects was residential, comprising almost 17% of the assessment locations. However, when all dock, dock-related and marina projects are added to residential projects, this total increased to 25% of all projects. Roadway projects made up almost 16% and shoreline hardening projects and recreation projects each made up 8% of all projects. Preservation projects comprise the same proportion of projects (4%) as riprap additions.

Habitat types—Habitat types at each location of a functional assessment were assigned according to Florida Land Use Cover Classification System (FLUCCS) number (Florida Department of Transportation, 1999), as shown in TABLE 3. Mangroves (FLUCCS 612) made up the largest category of habitat

TABLE 3. Summary of the number and size of WFAM assessment sites by wetland type and Florida Land Use Cover Codes (FLUCC) within the study area.

		No. of Projects			Wetland Size			
Primary Habitat	FLUCC	Subtotal	Total	%	Total (ha)	Min. (ha)	Max. (ha)	Ave. (ha)
Exotic Wetland Hardwoods	6100		1	1%	2.1	2.076	2.08	2.08
Littoral Shelf	6510		1	1%	0.1	0.134	0.13	0.13
Mangroves			75	64%	91.9	0.004	29.98	1.22
Mangrove Forest	6120	3						
Mangrove Fringe	6120	55						
Mangrove Swamp	6120	13						
Mangroves	6120	2						
Mangrove Overwash Island	6120	1						
Basin Mangrove Forest	6120	1						
Saltmarsh, Tidal Flats and Saltern								
Marsh	6420	3	24	20%	99.2	<0.000	22.14	4.13
Salt Marsh	6420	12						
Tidal Marsh	6420	2						
Low Marsh	6421	1						
High Marsh	6434	4						
Tidal Flat	6510	1						
Saltern	7203	1						
Shoreline	7100		2	2%	0.1	0.012	0.12	0.07
Submerged	6450		15	13%	5.7	0.004	1.86	0.38
Total			118	100%	199	<0.000	29.98	1.69

assessed at 63%. Within that category, mangrove fringe made up 46%. Other types of mangrove habitat encountered included basin mangrove forest, mangrove overwash island, mangrove swamp and mangrove forest. The salt marsh category included saltern, high marsh, low marsh and tidal flats, and comprised 20% of all habitats assessed.

Area of wetlands reviewed—Of the 118 sites visited, a total of 199 hectares of coastal wetlands were subject to review for potential impacts. The largest area of coastal wetlands on a project site was 30 hectares. A total of 21.5 hectares of on-site coastal wetland loss was permitted in the 5 year timeframe. This is a 11% of loss between the pre-construction condition and post-project condition.

The largest on-site loss for a single project site was 4.5 hectares. On average a permit included 0.2 hectares, or roughly one half acre, of coastal wetland loss. This fits a general pattern of many small impacts of less than 0.2 hectares each summing to a larger total area of 21.5 hectares.

Plant and animal species observed—One hundred ninety four plant species were observed in the 118 project sites reviewed. This includes 73% native plants, 22% non-native plants, and 5% of debated origin.

TABLE 4. Summary of the number and size of WFAM assessment sites by project type within the study area.

Project Type	No. of Projects		Wetland Size			
	Total	Percent	Total (ha)	Min. (ha)	Max. (ha)	Ave. (ha)
Boardwalk	2	2%	2.8	0.061	2.70	1.38
Bridge	1	1%	0.1	0.093	0.09	0.09
Commercial	4	3%	3.6	0.024	0.00	0.90
Dock	16	14%	1.4	0.004	0.45	0.09
Dock/seawall	3	3%	0.3	0.036	0.12	0.09
Filling	1	1%	0.1	0.134	0.13	0.13
Flood Control	3	3%	0.1	0.004	0.03	0.02
Mangrove Alteration	1	1%	0.1	0.065	0.06	0.06
Marina Impact	11	9%	7.5	0.008	2.65	0.68
Mitigation	5	4%	27.0	0.077	21.45	5.40
Navigation	12	10%	30.6	0.004	18.62	2.55
Parking Lot	1	1%	0.3	0.336	0.34	0.34
Preservation	4	3%	45.2	0.911	22.14	11.31
Recreational	9	8%	0.9	0.004	0.27	0.10
Residential	20	17%	69.9	0.008	29.98	3.50
Riprap	4	3%	0.1	0.008	0.02	0.01
Roadway	18	15%	9.0	<0.000	5.50	0.50
Seawall	2	2%	0.1	0.004	0.08	0.04
Stormwater Treatment	1	1%	0.2	0.202	0.20	0.20
Total	118	100%	199	<0.000	29.98	1.69

A wide variety of wildlife (184 species) was observed, directly or indirectly, during project site visits, including 10 mammal species, 55 bird species, 8 reptile species, 3 amphibian species, 36 fish species, 44 terrestrial invertebrate species, 28 marine/aquatic invertebrate species. The invertebrates include 15 butterfly, 2 moth, 7 dragonfly, 4 damselfly, 7 other insect, nine crab, 13 crustacean species, and 17 mollusks species (TABLE 5).

WFAM scores—The variables assessed in the three WFAM are listed on TABLE 1. All calculated WFAM scores are tabulated on TABLES 6 through 8. TABLE 6 shows the scores for pre-construction conditions, followed by TABLE 7

TABLE 5. Animal species totals observed at study sites.

Species Group	No. of Species	No. of Occurrences
Total Terrestrial Invertebrates	44	110
Total Marine/Aquatic Invertebrates	28	87
Total Fish	36	170
Total Amphibians	3	3
Total Reptiles	8	29
Total Birds	55	221
Total Mammals	10	38
Total	184	658

TABLE 6. Summary of WFAM pre-project scores by wetland type within the study area.

Habitat Category	No. of Projects	Wetlands (ha)	Mean Pre-Project Scores		
			HGM	UMAM	WRAP
Exotic Wetland Hardwood	1	2.1	0.54	0.43	0.63
Std Dev Exotic Wetland			n/a	n/a	n/a
Min. Exotic Wetland			0.54	0.43	0.63
Max. Exotic Wetland			0.54	0.43	0.63
Littoral Shelf	1	0.13	0.31	0.27	0.42
Std Dev Littoral			n/a	n/a	n/a
Min. Littoral			0.31	0.27	0.42
Max. Littoral			0.31	0.27	0.42
Mangrove	75	91.9	0.81	0.72	0.72
Std Dev Mangrove			0.12	0.15	0.16
Min. Mangrove			0.23	0.15	0.09
Max. Mangrove			0.98	0.97	0.99
Saltmarsh	24	99	0.69	0.58	0.66
Std Dev. Saltmarsh			0.17	0.21	0.17
Min. Saltmarsh			0.38	0.17	0.36
Max. Saltmarsh			0.95	0.93	0.97
Shoreline	2	0.13	0.73	0.82	0.72
Std Dev. Shoreline			0.18	0.12	0.30
Min. Shoreline			0.60	0.73	0.50
Max. Shoreline			0.86	0.90	0.93
Submerged	15	5.7	0.42	0.56	0.57
Std. Dev Submerged			0.17	0.17	0.19
Min. Submerged			0.15	0.30	0.29
Max. Submerged			0.82	0.83	1.00
All Projects	118	199	0.73	0.67	0.69
St. Dev All Projects			0.19	0.18	0.17
Min. All Projects			0.15	0.15	0.09
Max. All Projects			0.98	0.97	1.00

with the post-construction conditions. The change between pre-construction and post-construction scores are provided in TABLE 8.

HGM, UMAM, and WRAP scores range from 0 to 1.0. Using HGM, the mean wetland functional assessment score for pre-construction site evaluation was 0.72, with a standard deviation of 0.19 and a range of 0.98 to 0.15. In most cases HGM scored the pre-construction wetlands as having a higher functional score than the other two methods. The mean UMAM pre-construction functional assessment score was 0.66 with a standard deviation of 0.18 and a range of 0.97 to 0.15. Generally, UMAM scored the pre-construction wetlands as having a lower functional score than the other two methods. Using WRAP, the mean pre-construction score was 0.69 with a standard deviation of 0.18 and a range of 1.0 to 0.09. During the course of this study, all visited site were determined to be jurisdictional wetlands by both the authors and permitting

TABLE 7. Summary of WFAM post-project scores by wetland type within the study area.

Habitat Category	No. of Projects	Wetlands (ha)	Mean Post-Project Scores		
			HGM	UMAM	WRAP
Exotic Wetland Hardwood	1	2.1	0.48	0.22	0.47
Std Dev Exotic Wetland			n/a	n/a	n/a
Min. Exotic Wetland			0.48	0.22	0.47
Max. Exotic Wetland			0.48	0.22	0.47
Littoral Shelf	1	0.13	0.30	0.22	0.39
Std Dev Littoral			n/a	n/a	n/a
Min. Littoral			0.30	0.22	0.39
Max. Littoral			0.30	0.22	0.39
Mangrove	75	91.9	0.72	0.60	0.63
Std Dev Mangrove			0.21	0.19	0.18
Min. Mangrove			0.00	0.00	0.00
Max. Mangrove			0.96	0.93	1.00
Saltmarsh	24	99	0.65	0.47	0.58
Std Dev. Saltmarsh			0.25	0.28	0.23
Min. Saltmarsh			0.00	0.00	0.00
Max. Saltmarsh			0.95	0.92	1.00
Shoreline	2	0.13	0.55	0.53	0.59
Std Dev. Shoreline			0.47	0.42	0.30
Min. Shoreline			0.22	0.23	0.37
Max. Shoreline			0.88	0.83	0.80
Submerged	15	5.7	0.41	0.50	0.54
Std. Dev Submerged			0.12	0.12	0.15
Min. Submerged			0.15	0.32	0.32
Max. Submerged			0.62	0.67	0.81
All Projects	118	199	0.65	0.55	0.60
St. Dev All Projects			0.23	0.21	0.19
Min. All Projects			0.00	0.00	0.00
Max. All Projects			0.96	0.93	1.00

agency staff. One reviewer of the study suggested that WRAP scores <0.25 generally indicate that an area is not a jurisdictional wetland (J. Beever, Personal Communication, 2012).

Utilizing SPSS, the pre-construction scores from all three methods were significantly correlated with each other using 0.01 level two-tailed tests for Pearson's Correlation Coefficient, Kendall' s tau-b, and Spearman's rho. HGM scores were significantly different from WRAP (sig. 0.003) and from UMAM (sig. <0.001) scores. In contrast, UMAM and WRAP pre-construction scores were not determined to be statistically significantly different (sig. 0.018) among all projects.

As shown on TABLE 7, the mean post-construction score using HGM was 0.65, with a standard deviation of 0.23 and a range of 0.96 to 0. Generally, HGM gave the post-construction mitigation and on-site enhanced and/or

TABLE 8. Summary of WFAM pre-project scores minus post-project scores by wetland type within the study area.

Habitat Category	No. of Projects	Wetlands (ha)	Mean Pre- Minus Post Project Scores		
			HGM	UMAM	WRAP
Exotic Wetland Hardwood	1	2.1	0.06	0.21	0.16
Std Dev Exotic Wetland			n/a	n/a	n/a
Min. Exotic Wetland			0.06	0.21	0.16
Max. Exotic Wetland			0.06	0.21	0.16
Littoral Shelf	1	0.13	0.01	0.05	0.03
Std Dev Littoral			n/a	n/a	n/a
Min. Littoral			0.01	0.05	0.03
Max. Littoral			0.01	0.05	0.03
Mangrove	75	91.9	0.09	0.12	0.10
Std Dev Mangrove			0.20	0.17	0.15
Min. Mangrove			−0.51	−0.25	−0.43
Max. Mangrove			0.72	0.79	0.63
Saltmarsh	24	99	0.05	0.11	0.08
Std Dev. Saltmarsh			0.19	0.22	0.19
Min. Saltmarsh			−0.24	−0.27	−0.19
Max. Saltmarsh			0.56	0.47	0.76
Shoreline	2	0.13	0.18	0.29	0.13
Std Dev. Shoreline			0.28	0.30	0.00
Min. Shoreline			−0.02	0.07	0.13
Max. Shoreline			0.38	0.50	0.13
Submerged	15	5.7	0.00	0.06	0.03
Std. Dev Submerged			0.15	0.11	0.07
Min. Submerged			−0.36	−0.13	−0.10
Max. Submerged			0.31	0.24	0.19
All Projects	118	199	0.07	0.11	0.09
St. Dev All Projects			0.20	0.18	0.15
Min. All Projects			−0.51	−0.27	−0.43
Max. All Projects			0.72	0.79	0.76

preserved wetlands a higher functional score than the other two methods. Using UMAM functional wetland analysis, the mean post-construction wetland functional assessment score for all projects was 0.55, with a standard deviation of 0.21, and with a range of 0.92 to 0. The mean post-construction score using WRAP was 0.60, with a standard deviation of 0.19 and a range of 1.0 to 0. All three methods were significantly correlated with each other using 0.01 level two-tailed tests for Pearson's Correlation Coefficient, Kendall' s tau-b, and Spearman's rho. HGM scores were significantly different from WRAP (sig. <0.001) and UMAM scores (sig. <0.001). The UMAM and WRAP post-construction scores were statistically significantly different (sig. <0.001).

The difference between pre- and post-construction WFAM scores reflect the difference in wetland functions that occur as the result of the activities

TABLE 9. Summary of WFAM scores for mitigation for those projects that proposed mitigation.

Mitigation Category	No. of Projects	Wetlands (ha)	HGM	UMAM	WRAP
On-Site Mitigation	24	135.0	0.81	0.75	0.79
Std Dev			0.2	0.36	0.4
Min			0.31	1.0	1.0
Max.			1.00	0.21	0.16
Off-Site Mitigation	17	12.85	0.93	0.92	0.92
Std Dev			0.11	0.13	0.13
Min.			0.71	0.68	0.66
Max.			1.0	1.0	1.0
All Projects	30*	147.85			

* Eleven projects had both on-site and off-site mitigation.

(filling, dredging, wetland removal) of the project. The mean difference between pre- and post-construction UMAM functional assessment scores for all projects was 0.12 with a standard deviation of 0.18, with a range of 0.79 to −0.27. The mean difference between pre- and post-construction WRAP functional assessment scores for all projects was 0.09 with a standard deviation of 0.15, and a range of 0.76 to −0.43. The mean difference between pre- and post-construction HGM functional assessment scores for all projects was 0.07 with a standard deviation of 0.20, and a range of 0.67 to 0. Seventy percent of the reviewed sites were in pre-construction condition and the future condition was projected per the WFAM method utilized. Thirty percent of the reviewed projects had been constructed and the pre-construction condition was obtained from the permit information provided by the agency or in the case of incomplete permitting files obtained from mapping and comparison to immediately adjacent wetlands.

HGM was not significantly different than WRAP (sig. 0.12), but was significantly different than UMAM (sig. 0.001). UMAM and WRAP methods were statistically significantly different in their results (sig. 0.006) for all projects.

Mitigation—Of the 118 projects, a total of 30 proposed some form of mitigation, as shown TABLE 9. This included 13 projects with on-site mitigation, six projects with off-site mitigation, and 11 projects with both on-site and off-site mitigation. The total area of all on-site mitigation was 135 hectares. Off-site mitigation totaled 12.85 hectares, principally at the Little Pine Island Wetland Mitigation Bank.

The Little Pine Island Wetland Mitigation Bank has a service area that includes most of the CHNEP coastal area. Two sites utilized as mitigation credits for permits on Little Pine Island Wetland Mitigation Bank were assessed for the study. Mean assessment scores there were: HGM 0.90 ± 0.04; UMAM 0.89 ± 0.02; and WRAP 0.93 ± 0.04.

To calculate the functional units of mitigation that need to be balanced in the permitting process, the total wetland area assessed was multiplied by its

functional assessment score. We expected that the post-construction functional units would be equal to or greater than the number of functional units lost (i.e. no net loss). There are two ways that functional units could be lost: if no mitigation was implemented or required; or if the functional units lost by completion of the project were greater than the functional units generated by mitigation.

A mitigation ratio is the comparison of the difference in wetland functional capacity or wetland area provided by the wetland prior to the project and the wetland functional capacity or wetland area remaining after the project including the mitigation provided as part of the project. The mitigation ratio for all UMAM scores was 1.5 with a standard deviation of 3.26. This was skewed by four projects with high or very high mitigation ratios generated by large on-site wetland preserves on Pine Island. The mitigation ratio for all HGM scores was 1.61 with a standard deviation of 3.45. The mitigation ratio for all WRAP scores was 1.61 with a standard deviation of 3.5. If the four unusual projects with high or very high mitigation ratios generated by large on-site wetland preserves on Pine Island are removed from the analysis, then the mitigation ratios for each method would be: for HGM equal to 1.1, with a standard deviation of 0.88; for UMAM equal to 1.02, with a standard deviation of 0.91; and for WRAP equal to 1.08, with a standard deviation of 0.93. Utilizing t-tests, the mitigation ratios generated for all projects were not statistically significantly different between HGM, UMAM, and WRAP.

Of the twelve projects that utilized an off-site mitigation area, often a mitigation bank, 54% were located in a different watershed (as defined by the Water Management District), than the bank and 46% were within the same watershed as the bank.

Eighty-three percent of off-site mitigation was located at Little Pine Island Mitigation Bank in the Matlacha Pass watershed, 8% at the Island Park Mitigation Bank in the Estero Bay watershed, and 9% in the Dinkins Bayous area in Pine Island Sound.

Discussion—The study results indicate that all three wetland functional assessment methods function as designed, and produce results that are similar in their assessment of coastal wetlands, but yield somewhat different mitigation results (Table 6).

The actual measured rate of permitted/authorized wetland loss in this study from the 118 projects reviewed by on-site visits was 4.3 hectares. This is 0.01 percent of the 32,028 hectares of coastal wetlands in the CHNEP (Beever et al., 2011). If the average rate of real wetland area loss of 0.19 hectares per project is applied to the total 1,834 coastal ERP Permit Actions over the five year study period, this would hypothetically project a wetland loss rate of approximately 68 hectares per year. However, the wetland functional assessment balance would indicate no loss of wetland functions, since enhancements and preservations were occurring in other already extant wetlands at on-site and off-site mitigation areas.

Based on the study results, the projected hypothetical loss rate is 0.2% of the total current wetlands habitat in the CHNEP (Beever et al., 2011). This is below the margin of error in aerial photography mapping of these habitat resources (Kautz et al., 2007; SFWMD, 2006; SWFWMD, 2011). Because this loss is primarily occurring in urban landscapes, such as the Caloosahatchee River, Peace River, and Captiva Island, the relatively small wetland loss may already be overlooked in the land use/land cover mapping method utilized to map these resources.

While the loss of wetland area and functional appears relatively small over the five-year period examined compared to the total extent of wetlands that continue to exist, the permitted wetland elimination is gradually reducing the total extent of coastal wetlands in watershed of the CHNEP. This is in contrast to the perception of the public and regulatory entities that no wetland functional loss occurring as a result of the balancing process used in the functional assessment tools. Additionally, wetland functions are being relocated out of impacted watersheds and into the watershed that is able to provide the approved off-site mitigation in the category of coastal wetland habitats that are being impacted. While the functional assessment evaluation shows a mathematical balance for the total service area that is equal or greater for a project that utilizes a mitigation bank, there is a measured loss of wetland area and function in the donor watershed, with the potential for increase in function but not area of wetlands created in the receiving watershed. HGM was effective in quantifying functions of coastal wetland ecosystems (mangroves, salt marsh, intertidal and subtidal) within the CHNEP study area as a result of its measured objective variables and calibration to the wetland type being reviewed. UMAM and WRAP provided to be of utility but generally delivered a mitigation ratio in both functions and area that is less than one, which allowed for systematic net loss of both wetland function and area.

The use of any functional assessment method with off-site mitigation, including mitigation banks, can result in a balance of wetland functions being retained if the actual performance of the mitigation and the time lag to achieve the final mitigation state are accounted for. However, it can also result in a net loss of wetlands area and/or a net loss of wetland function while appearing on the ledger to have been an equivalent trade of mitigation for loss of function from the permitted impacts. This can occur in six different but potentially co-occurring ways including:

1. Relocation of the wetland functions out of the watershed.
2. The loss of area and functions to conservation easement mitigation credits that do not increase function or area of wetlands.
3. The presumption that the final wetland functional assessment score for the mitigation bank will be 1.0.
4. Creation of an inverse mitigation ratio. Wetlands to be impacted are assessed as having a low functional score, while the promised mitigation

wetland is granted a 1.0 perfect score. As a result, for example, three hectares of impacted wetland may be offset by one hectare of mitigation wetland.

5. Insufficiency of mitigation credit purchase tracking.
6. Existence of unidentified wetlands that sustain impacts that are never mitigated.

CONCLUSIONS—Based on the study results, the authors provide the following ten suggestions for improving mitigation for coastal wetland impacts in the CHNEP study area. The suggestions are not presented in order of importance, as utilization of any of the suggestions will improve the wetland mitigation process.

1. A handheld GPS device with GIS capability and digital functional assessment worksheets should be used when conducting functional assessments of wetlands to improve the speed and accuracy of data collection and allow field data to be digitally linked to site latitude/longitude. Additionally, use of a spreadsheet designed to compile and calculate functional assessment scores in the office for pre-site visit review and post-site visit processing can reduce time needed to complete functional assessments, improve accuracy and generate permanent documentation of the results. Utilizing the GPS, GIS and spreadsheet methods allows the HGM to be conducted within the time range of a rapid assessment method.
2. HGM is the most appropriate method for conducting wetland functional assessments for regulatory purposes because of the thorough scientific review involved in developing the method. HGM has been documented to be the most objective, complete, replicable, and accurate of the three assessed wetland functional assessment methods (Brinson, 1993; Brinson et al., 1997). However, it is the authors' opinion that in Florida and the CHNEP study area, it is unlikely that HGM will replace UMAM in the near future, principally due to non-scientific, legal and legislative reasons.
3. UMAM should include a real mitigation success weighting factor based on empirically measured success rates of the types of mitigation used as offsets. A major limitation of functional assessment imbalance is the assumption that completed mitigation will ultimately perform as well as natural un-impacted wetlands of the same type. It is very difficult to create wetland mitigation that will achieve the same level of functions as an area that has never been disturbed (Kusler and Kentula, 1990). WFAM scores utilized in calculating future mitigated wetland conditions need to be based on empirical evaluation of actual completed wetland mitigation areas. Calculating more accurate scores is now possible because many mitigation wetlands exist for both on-site and off-site efforts, including mitigation banks (Reiss et al., 2007). These completed mitigation sites could be used to determined a measure by which mitigation is balanced in

the permit review process. For example: if a proposed mitigation area is performing at a 0.9 UMAM functional assessment level, in order to offset the impacts to 10 hectares of a pre-construction wetland having a UMAM score of 0.62, a total of 6.9, not 6.2, functional assessment units would be needed to offset the functional losses. This is needed because the mitigation wetlands would only be performing 90% of the functional capacity of a natural wetland of the same type.

4. Conservation easements and preservations, alone, should not receive wetland functional mitigation credits. This study and others (Brown and Lant, 1999; Brumbaugh and Reppert, 1994; Dahl, 2005; Environmental Law Institute, 2004; Reiss et al., 2007) have shown that the practice of granting mitigation credit solely for filing a conservation easement encourages net wetland loss in both function and area. Conservation easement mitigation credits do not increase wetland functions, area, or offset the permanent loss. Conservation of mitigation, designed to offset wetland impacts in perpetuity, is not a separate component of physical mitigation activities, whether the goal is enhancement, restoration or creation (Federal Register, 1995). The value of permanent conservation should be incorporated into the mitigation activity and not treated an accomplishment that provides real physical functions (Brown and Lant, 1999; Dennison and Schmid, 1996; Eggers, 1992; Kusler and Kentula, 1990; Reiss et al., 2007). This might increase the costs of mitigation, but would minimize net loss of wetland functions associated with both on-site and off-site mitigations that rely solely on preservation as the mitigation method.
5. All mitigation options within the local watershed should be required to be examined before seeking options outside the watershed, to reduce in-watershed loss of wetland area and functions (USACOE and USEPA 2008, Federal Register (1995). Keeping the critical hydrologic, water quality, biological, social, and environmental justice issues associated with mitigation within the same watershed as the impacts it is essential for maintaining wetland functions. Sequencing "in-watershed first" also enhances avoidance and minimization of impacts during project design, because less abundant sources of wetlands for credits would be available within a given watershed to offset large scale wetland impacts.
6. A full tracking system of mitigation credits should be developed and implemented, to ensure that permitted mitigation is actually performed for both on-site and off-site mitigation plans. The importance of mitigation tracking is emphasized by the relatively low percent of mitigation plans implemented for current and long-term projects, particularly when projects are approved by one agency but reviewed and regulated by another agency. The results of this study indicate that, currently, there is not adequate linkage between mitigation needs, calculated credits or mitigation bank credits purchased to satisfy that need. The need for mitigation tracking has also been identified by USACOE, US Fish and

Wildlife Service (USFWS), university and legal experts in previous studies (Brown and Lant, 1999; Brumbaugh and Reppert; 1994; Dahl, 2005; Environmental Law Institute, 2004; Reiss et al., 2007).

7. All three functional assessment methods, HGM, UMAM and WRAP, should be adjusted to increase, not decrease, the total number of hectares of mitigation required, if the goal is to assure no net loss of wetlands and restoration of past wetland losses. The results of this study indicated that a balance sheet of pre- and post- project functional assessment scores does not equate to a balance of wetland mitigation or achieve no net loss of wetland area or functions. The ratios used in wetland mitigation permitting prior to the development of functional assessment tools were not arbitrary. They were based on time lag, probability of performance, distance from impacted wetlands, and the recognition that wetlands play a vital role in a landscape context. In the past, the greater-than-one-to-one ratios achieved a no-net-loss of wetlands for the projects reviewed. Significant areas of wetlands were protected, restored, and put into management using ratio methods. In contrast, the current inverse ratios generated by the functional assessment methods result in net losses of wetland area and function. This is particularly apparent when exotic plant cover effects in the pre-construction wetlands are over-stated in "best professional judgment" weighted assessments.
8. Photographic evidence of the absence of wetlands should be required for all permit applications involving shoreline alterations. The photographs should include aerial, ground-level and from the water view. This study showed that most permit applicants and reviewers correctly identify the presence of wetlands and potential impacts for proposed activities. However, 6% of the projects reviewed contained wetlands that were not indicated as present, did not consider those wetlands in the permitting process, and were not require to mitigate for those wetland losses.
9. Mangrove trimming and other activities that damage wetland functions should cease in conservation easement mitigation areas, to maintain benefits to water quality, fish and wildlife. This study and others found that a major reason for failure of long-term mangrove mitigation was due to trimming for aesthetic views (Beever and Loflin 1989; Beever et al., 2011). If regulatory agencies are unable or unwilling to enforce this functional degradation, alternate mitigation should be required.
10. Rip-rap as an alternative shoreline habitat should be examined scientifically, to compare its function to natural and other types of shorelines, including living shorelines containing vegetation. Historically, the shoreline of the CHNEP was not naturally hard lime rock and the native invertebrate communities of nearshore bottoms are adapted to soft sand and mud sediments, seagrass beds, algae beds and oyster bars. There has been a regulatory presumption that rip-rap provides valuable hard surface habitat for coastal benthic organisms, the fish and wildlife that feed upon them, and water quality benefits from filter feeding. However, through the course of this study, the predicted enhanced of benthic communities by rip-rap was not

observed. A variety of negative habitat effects associated with rip-rap were observed, including habitat for non-native invertebrates, inadequate rooting areas for emergent vegetation, stunted growth in mangroves, and habitat for drift and filamentous algae representative of high nutrient conditions.

In conclusion, wetland functional assessment methods were developed to improve wetland regulatory and mitigation processes, above ratio/area methods which mandated multiple hectares of mitigation in return for a single hectare of wetland loss. The goal was to ensure no net loss of wetland area and functions. While this study showed that functional assessment methods do work, the overall effects of using the WFAMs is to cause a gradual loss of wetland area and functions in donor watersheds, with a slow increases in wetland functions, but not area, in receiving watersheds. Implementing the suggestions provided above could enhance achievement of the original "no net loss" intent of wetland functional assessment methods, and contribute to future protection, and perhaps restoration, of coastal wetlands within the CHNEP.

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