Leveraging Natural Resilience to Ensure Long-Term Sustainability of the Biloxi Marsh Complex: An Integrated Project

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Composite Map of the BMC
Richardson & Powell Surveys – 1840s
U. S. Surveyor General's Office

2.0 - Project Description

Project Summary

The goal of the Biloxi Marsh Complex (BMC) INTEGRATED PROJECT (Type E) is to leverage the BMC's natural durability and resiliency with coordinated sequential construction and operation of compatible restoration projects to synergistically extend the sustainability of the BMC both as a productive estuary and a natural surge buffer for the New Orleans metropolitan area. The 2017 Coastal Master Plan (CMP) final draft (2017 CMP, p. 162) acknowledges new information regarding the unique geography and geological history of the BMC. This project makes use of data collection and analysis undertaken in 2017-2019 (Day et al., 2019, in prep.) that provide additional location specific data to understand the processes contributing to current BMC land-loss, and why subsidence and relative sea level rise (RSLR) presents less of a threat to marsh survival here than elsewhere in the Mississippi River Deltaic Plain. The proposed Integrated Project will serve to supplement and augment existing, partially completed and proposed Projects affecting the BMC, including without limitation, the closure of MRGO below Bayou LaLoutre (PO-0038-SF) which is complete, PO-0030 (S. Lake Borgne shore protection, also complete), PO-0072 (4 miles west BMC shore protection, partially complete in 2013), PO-0148 (oyster reef), PO-0178 (5.5 miles of LaLoutre Ridge Restoration, not built), PO-0180 (1,548 ac. marsh creation southeast Lake Borgne), 001.RC.01 (20 mi. of LaLoutre Ridge Restoration, supersedes PO-0178 not built), 001.MC.06a (Breton Marsh Creation 5,248 ac. E. of Delacroix Island), 001.MC.07a (2,080 ac. marsh creation S. of Lake Borgne), and 001.DI.18 (Diversion into Central Wetlands near Violet). This Integrated Project is designed to function synergistically with the foregoing projects and is not dependent on a sediment source from the Mississippi River. Following implementation of the Integrated Project, natural processes are expected to sustain the BMC (see map on cover page).

Shapefiles (Google Earth Link attached as *CMP 2023 BMC.kmz* in side bar) **PDF must be downloaded to view Link**

The proposed Integrated Project includes the following elements (Note: majority of components of this Integrated Project are within the boundaries of the Biloxi WMA):

1) Marsh Creation and Marsh Nourishment with Reconstruction of Western BMC Beach Berm. This project element beneficially uses dredged material supplemented with additional sediment from Lake Borgne as needed, as well as leveraging natural processes. The reconstructed beach berm will provide containment and protection until the Rangia supply is restored and shell beaches become re-established. The overarching goal and objective of this project element is to mitigate continuing adverse hydrologic impacts initiated during the operation of the MRGO, namely a drastically reduced supply of coarse-grained shell beach material to the west BMC coast (Poirrier, 2019). Loss of erosion-resistant, gently sloping, shell armored beaches has increased shoreline retreat to over 50 feet/y in some places through a process in which the weakest soil of the marsh scarp, that beneath the rooted zone, is notched and hollowed out by waves. This has led to cascading failure of the over-steepened shoreface. In addition, this project element, which can be expanded, is estimated to initially create ~33 acres of new marsh, nourish another ~130 acres, and sustain thousands of acres near shore and in the interior marsh.

2) Hydrologic Restoration. This project element closes at least two growing east-west tidal routes that connect Lake Borgne and Chandeleur Sound using rock and/or earthen dams. The purpose and intent of this element is to build upon Element 1 by further reducing the hydrologic connectivity and erosional forces within the BMC interior allowing the BMC to benefit from natural sediment distribution processes.

3) Thin-layer Marsh Nourishment of Interior Wetlands. This project element utilizes slurried and sprayed sediments from interior ponds to nourish marsh adjacent to these ponds. This project element is estimated to create and nourish 510 acres of marsh. Once the hydrology of the BMC interior is stabilized this element will fortify pond edges to further reduce internal erosion and allow natural processes to sustain the BMC interior marshes.

Biloxi Marsh Complex. The BMC encompasses an area approximately 700 square miles (~450,000 acres) within the Lower Pontchartrain Basin in St. Bernard Parish (Cover Page). Much of the BMC is owned by two landowners, Biloxi Marsh Lands Corporation (BLMC) and Lake Eugenie Land & Development, Inc. (LKEU) owning approximately 235 square miles (~150,000 acres). By granting a free lease to the Louisiana Department of Wildlife and Fisheries for over 60 years, BLMC has opened over 50 square miles (~35,000 acres) to the public for recreational use as the designated Biloxi WMA. BLMC and LKEU have funded efforts to gather and evaluate existing data and to collect additional critical data resulting in new information supporting inclusion of the BILOXI INTEGRATED PROJECT in the 2023 Coastal Management Plan (2023 CMP).

BMC Ecosystem Services. The BMC supports a vast estuarine ecosystem of intermediate, brackish and saline marshes; shell beaches (Rangia clams on the oligohaline Lake Borgne side; Oysters on mesohaline Chandeleur Sound); 3000-year-old natural levees, chenier ridges and mounds constructed by native Americans topped with live oaks, oyster reefs, tidal bayous, inlets, lagoons, lakes, and bays. BMC is only 25 to 30 miles east/southeast and seaward of the City of New Orleans, thus has been a preferred destination for generations of residents of southeastern Louisiana and south Mississippi who have fished, trapped and hunted there. Large bays and shell keys on the eastern side of the BMC support some of the most dependably productive commercial oyster grounds in the United States.

The 20-mile-wide BMC peninsular platform separates Chandeleur Sound from Lake Borgne. This position explains why the BMC plays such an important role in buffering the City of New Orleans and its eastern suburbs from storm surge and waves (Westerink, 2013). During passage of Hurricane Katrina in August 2005, the best "actual event" ADCIRC model hind-cast indicates BMC marshes reduced maximum surge elevation at the south end of Lake Borgne by about 8 feet relative to that at Bay St. Louis, and decreased significant wave height by 6 feet. Given that the rebuilt New Orleans levees and flood walls are constructed only to a 100-year standard surge return frequency, retention of key natural buffers is crucial to the long-term survival of the City when more energetic storms strike in future (Bhatia et al., 2019).

Mississippi River Gulf Outlet (MRGO). The MRGO navigation channel extended over 50 miles from the Gulf Intracoastal Waterway southward through the BMC into Breton Sound cutting the majority of BMC off from land to the west and southwest. After the channel was constructed in the 1960s through the marsh south of Lake Borgne and across the Bayou LaLoutre natural levee ridges, it was repeatedly dredged to more than the 40-foot project depth until a rock dam was installed below the Bayou LaLoutre crossing in 2009. The MRGO had devastating effects on the BMC and played a major role in the flooding of the New Orleans area during Hurricane Katrina (Shaffer et al., 2009). The operations resulted in changes to salinity and hydrology that triggered continual and widespread degradation of the BMC, including the decline in Lake Borgne of the Rangia clam whose shells were important to erosion resistance of the western BMC beach berm (Poirrier, 2013, 2019). Despite the devastating effects of the MRGO, research conducted since 2017 indicates that the post-closure BMC is partially recovering and can become more resilient with restoration measures like those proposed in the BMC INTEGRATED PROJECT.

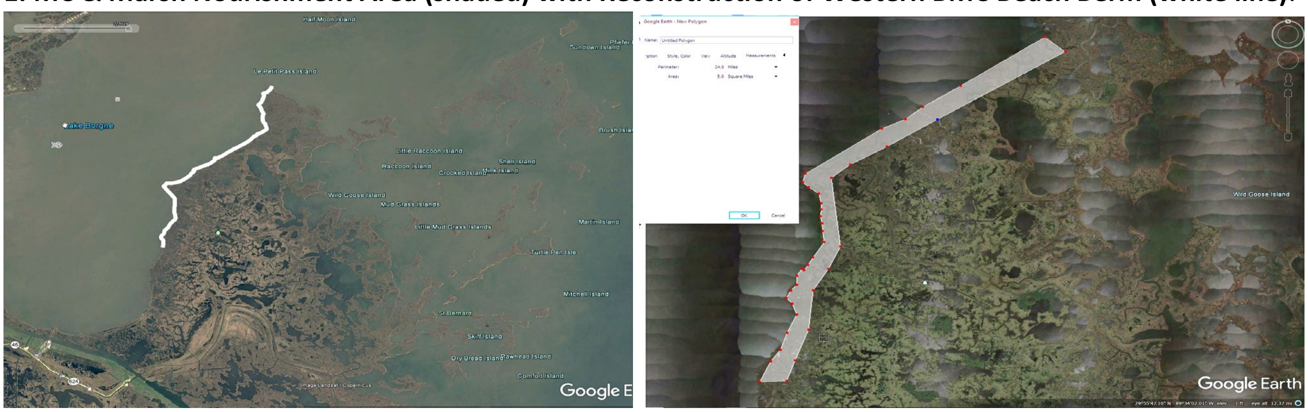
Natural Durability. The BMC is situated on a relatively stable geologic platform. The BMC occupies the eastern inland margin of the Mississippi delta. This zone lacks mobile salt at depth, is proximal to, but south of, the Baton Rouge fault system on the northern edge of the delta, and has experienced only 50 to 100 feet of deltaic deposition over the past 10,000 years (Jankowski et al., 2017; Olea and Coleman, 2014; Frederick et al., 2018). This compares with compactable Holocene sections more than 400 feet thick elsewhere in the delta. So, when vertical displacement velocities from 36 continuously-operating, high-precision GPS stations (mounted on buildings) were mapped across the entire deltaic plain, it was no surprise that subsidence in the BMC was estimated to range from 2.0 to 3.5 mm/y, with 2.4 mm/y for the center. This value is below the lower bound of the "plausible" subsidence range (4.4-6.5 mm/y) used in 2017 CMP modeling for the Breton Sound polygon (Reed and Yuill, 2017), but is similar to the current (1990-2015) Mississippi delta eustatic (global) sea level rise rate of 2.6 mm/y (Karegar et al., 2015).

Eustatic sea level rise combined with deep subsidence in the BMC adds up to 5 mm/y. This is a base relative sea level rise (RSLR) rate because natural biological and geological processes are also operating at and just below the marsh surface that can build up (aggrade) or lower (degrade) this surface, something that does not happen on the man-made surfaces supporting the continuous GPS receivers. So, the actual RSLR that marsh plants experience is locally reduced or increased depending on the net effect of upward sediment "accretion" and down-directed "compaction," also called "shallow subsidence" (Cahoon et al., 2006). These marsh surface dynamics have been monitored in the BMC for intervals of 10-15 years using the Sedimentation-Erosion-Table (SET) technique (Day et al., 2019, in prep.). Local differences, particularly in sediment supply to the marsh surface, were found to modify the base RSLR by up to +/- 10 mm/y in BMC marshes. Generally, BMC perimeter marshes are aggrading fast enough to offset deep subsidence and RSLR, and maintain a stable position in the tidal frame. However, some interior marshes that are subject to erosional forces and altered hydrology initiated by the MRGO are falling through the tidal frame.

Screening Criteria. The 2023 CMP New Project Development Guidelines and Criteria do not specifically address how the initial wetland health "starting point" is expected to affect long-term sustainability. Initial marsh elevation relative to the tidal frame (range) is a proxy for wetland health (Day et al., 2011). Programmatically, it is perhaps the best predictor of "the collective effects of project investments" going forward, which underpins the three Screening Criteria, and particularly the requirement that the proposed project will "continue to provide benefit in the face of sea level rise and subsidence without continued maintenance." As shown below, the INTEGRATED PROJECT proposed takes full advantage of individual projects that have already been incorporated into the 2017 CMP. With respect to the "magnitude of expected effects," it is possible to measure – rather than speculate about - the beneficial effects of decreasing Lake Borgne salinity and beach berm reconstruction on the western BMC shoreline because projects have already been constructed that allow prototype validation of theoretical benefits (e.g. MRGO closure, Lake Borgne breakwaters).

3.0 - Defined Project Attributes

1. MC & Marsh Nourishment Area (shaded) with Reconstruction of Western BMC Beach Berm (white line):

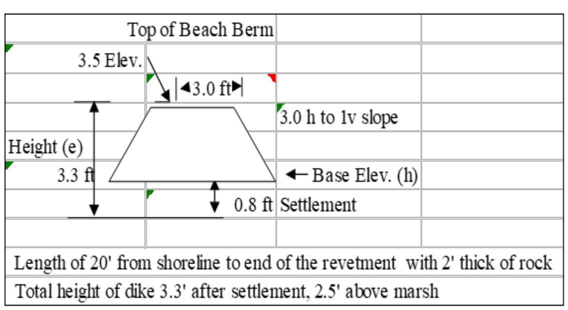


Preliminary Conceptual Design

Beach Berm Reconstruction Western Shoreline of the BMC: ~75,000 linear feet

Southern end: 29 degrees 56' 13.46" N, 89 degrees 34' 45.31" W; Northern end: 30 degrees 04' 37.68" N, 89 degrees 29' 01.06" W (NAD 83)

Conceptual Design



<u>Western BMC – Marsh Creation (MC) and Marsh Nourishment inside of Beach Berm</u>. ~5 square miles area. Marsh creation and marsh nourishment will be strategically implemented within this approximate 5 square mile area. Below is a figure identifying specific areas where sediments will be applied to marshes behind the reconstructed beach berm showing both MC and Marsh Nourishment sites. Sediment can be removed from the flotation channel during dredging and transported to the marsh by pipeline to fill ponds that have been formed by recent shoreline degradation, as well as sediment can be applied to the surface of the marsh by spraying a slurry of water, sand, and silt using the "Thin-Layer Placement" method also known as "Thin-Layer Sediment Addition" and "Marsh Nourishment". Any additional sediment needed can be obtained from Lake Borgne. The reconstructed beach berm will contain the applied sediment and protect the project allowing time for natural processes to re-establish. The proposed design is to increase marsh elevation to 8 cm to 10 cm above the current marsh level. Currently we estimate placing material ranging from less than 1.0 cm to ≥30 cm based upon current elevations and the amount of material needed to achieve the design marsh elevation. This dredged sediment addition to marshes will be beneficial as a mechanism for increasing marsh resilience (VIMS 2014). Thin-layer placement of dredge material will be used to increase soil surface elevation, to reduce waterlogging and porewater hydrogen sulfide toxicity and to increase soil redox potential and vegetation stem density, productivity and nutrient uptake (DeLaune et al., 1990; Mendelssohn and Kuhn, 2003; Croft et al., 2006). This Marsh Creation and Marsh Nourishment project element is estimated to create ~33 acres of new marsh, nourish ~130 and sustain thousands of acres near shore and in the internal marsh by greatly reducing the BMC's hydrologic connectivity to Lake Borgne.

Creation Sites	Acres	Lat./Long. (NAD 83)
1	6.57	29°56'37.36" N, 89°34'45.99" W
2	3.72	29°58'10.21" N, 89°34'06.92" W
3	7.65	29°59'07.17" N, 89°34'20.10" W
4	0.92	29°58'05.75" N, 89°34'05.92" W
5	0.99	29°58'22.18" N, 89°34'07.08" W
6	10	30°00'24.54" N, 89°32'44.16" W
7	0.31	29°56'29.54" N, 89°34'39.83" W
8	1.44	29°59'01.61" N, 89°34'15.81" W
9	0.5	29°57'49.16" N, 89°34'03.67" W
10	0.87	29°57'43.57" N, 89°34'04.03" W
Acreage	**32.97**	

Nourishment Sites	Acres	Lat/Lon (NAD 83)		Acres	Lat/Lon (NAD 83)
1	8.18	29°57'18.27" N, 89°34'23.63" W	**12**	1.54	29°58'34.75" N, 89°34'04.67" W
2	5.63	29°57'07.34" N, 89°34'33.97" W	**13**	1.12	29°58'26.79" N, 89°34'02.65" W
3	6.97	29°59'14.63" N, 89°34'10.61" W	**14**	1.82	29°58'49.64" N, 89°34'06.68" W
4	8.19	29°59'34.00" N, 89°33'29.60" W	**15**	0.7	29°58'43.83" N, 89°34'05.07" W
5	56.6	30°00'32.83" N, 89°32'06.62" W	**16**	3.81	29°56'53.62" N, 89°34'41.63" W
6	9	29°59'27.38" N, 89°34'19.93" W	**17**	0.87	29°56'33.83" N, 89°34'38.56" W
7	14.3	29°59'51.51" N, 89°33'08.55" W	**18**	1.1	29°56'57.23" N, 89°34'35.88" W
8	2.15	29°57'56.51" N, 89°33'58.95" W	**19**	1.28	29°57'01.14" N, 89°34'36.67" W
9	1.9	29°57'33.09" N, 89°33'59.70" W	**20**	0.58	29°59'20.48" N, 89°34'23.14" W
10	1.71	29°56'42.04" N, 89°34'40.45" W	**21**	0.68	29°59'18.13" N, 89°34'22.54" W
11	1.49	29°57'33.39" N, 89°34'12.65" W		129.62	

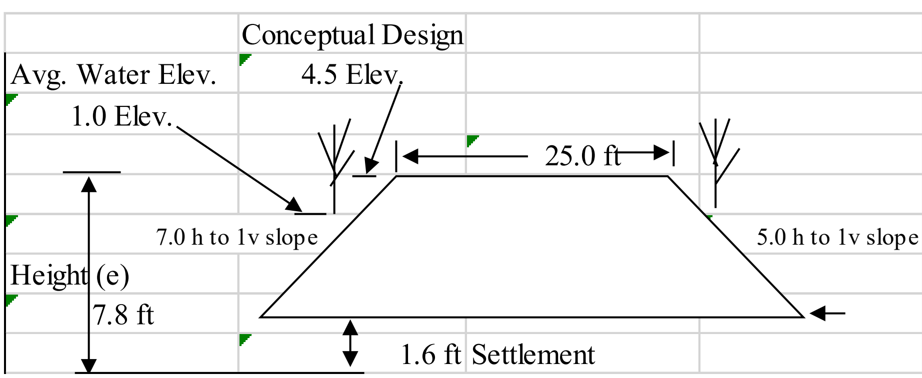
Note: White Shaded Areas = Marsh Creation; Grey shaded Areas = Marsh Nourishment

2. <u>Hydrologic Restoration of the Interior BMC</u>

A. Internal Dam (eastern BMC); location: 29 degrees, 59' 56.30" N, 89 degrees 29' 2.28" W (NAD 83),

B. Internal Dam (western BMC); location: 29 degrees; 56' 23.30" N, 89 degrees 32' 32.36'' W (NAD 83).

To restore hydrology in critical areas of the interior BMC, we have identified specific locations which need to be closed. We proposed closing these points with rock and/or earthen dams using the following conceptual design:



3. Thin-layer Marsh Nourishment of Interior Wetlands

Using the same method of Thin Layer Placement described above, we propose to apply sediments from the existing interior ponds to the adjacent marshes. As conceptualized, this project element is estimated to create and nourish 510 acres of marsh and can be expanded. Once the hydrology of the BMC interior is stabilized this element will fortify pond edges to further reduce internal erosion and allow natural processes to sustain the BMC interior marshes (grey shaded areas).

Conceptual Design

Sites	Acres	Lat./Long. (NAD 83)
1	56.38	29°55'18.74" N, 89°31'42.08"
2	258	29°54'28.16" N, 89°31'45.23"
3	34	29°53'59.44" N, 89°31'05.83"
4	72.6	29°53'59.99" N, 89°30'28.46"
5	11.2	29°55'17.33" N, 89°31'14.26"
6	15	29°54'59.80" N, 89°30'42.61"
7	33.5	29°57'05.31" N, 89°31'23.64"
8	16.2	29°57'55.66" N, 89°32'36.53"
9	7.13	29°56'22.75" N, 89°31'25.91"
10	5.48	29°56'11.00" N, 89°31'46.15"
Total Acreage	509.5	

Possible Phase Implementation

While each element of this proposed Integrated Project is conceptualized to act synergistically with each other and will serve to supplement and augment existing, partially completed and proposed Projects, due to budgetary constraints the projects can be implemented in phases or sub-phases. In the event that implementation in phase or sub-phase takes place, the projects will continue to function synergistically with each phase, subphase, each other and other project affecting the BMC.

Integrated Project Recap and Overview

- The proposed project was conceptualized after the collection of specific, localized new data which was analyzed by our team of scientists to identify the root causes of the degradation of the BMC[1], and to determine the BMC's critical restoration needs;
- The proposed Integrated Project combines defined attributes, while importantly augmenting and functioning synergistically with other past and future projects addressing the most critical needs of the BMC;
- This recently collected and evaluated specific and localized new data was obtained by our scientists using, among other tools, private SET-Accretion stations established dating back to 2003. To supplement its conclusions our team also examined the BMC's localized and regional geology[2] demonstrating the relative stable platform;
- Importantly, our team measured increased sedimentation below water and shoreline advance inside or shoreward of the rock dyke constructed as PO-072 and accretion on the marsh surface;
- The proposed BMC Integrated Project is designed to create and nourish almost 700 acres of marsh and can be expanded. Restoration of the natural beach berm and closure of key hydrologic passages will re-establish natural barriers to flow, thus allowing natural processes to reestablish thousands of acres near shore and in the interior marshes by protection from wave and tidal action;
- This Integrated Project's implementation will ensure that this valuable resource is given a chance to take advantage of natural processes currently at work allowing the BMC to continue its resiliency and to act as a storm surge barrier and critical marine estuary for the region;
- The importance of the BMC to the region, basin and sub-basin warrants the investment and the inclusion of this proposed Integrated Project in 2023 CMP.

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[1] Scientists recently determined the BMC suffers mainly from peripheral and internal erosion which was initially caused by salinity and hydrological changes by construction of the MRGO. Closure the western BMC shoreline from hydrologic connectivity with Lake Borgne will significantly reduce both peripheral and internal erosion addressing the critical need of the BMC. Additionally, the near shore topography of the BMC exacerbates wave fetch peripheral erosion which is particularly acute during periodic and seasonally frequent frontal passages (Day, et al., 2019, in prep.).

[2] CPRA's Subsidence Polygon 11 skews the subsidence and elevation change of the BMC (Day, et al., 2019, in prep.).

List of Refences and Links

2017 CMP, p. 162
http://www.biloximarshlandscorp.com/bmlc2/wp-content/uploads/2017/05/CPRA-2017-CMP-Page-162-Amended-Language-Adressing-the-Biloxi-Marsh-Complex-BMC.pdf
Poirrier, 2019
http://www.biloximarshlandscorp.com/bmlc2/wp-content/uploads/2017/05/Poirrier-2019.pdf
Westerink, 2013
http://www.biloximarshlandscorp.com/bmlc2/wp-content/uploads/2017/05/Westerink-2013.pdf
Bhatia et al., 2019
http://www.biloximarshlandscorp.com/bmlc2/wp-content/uploads/2017/05/Bhatia-et-al-2019-3.pdf
Shaffer et al., 2009
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Olea and Coleman, 2014
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DeLaune et al., 1990
http://www.biloximarshlandscorp.com/bmlc2/wp-content/uploads/2017/05/DeLaune-et-al-1990.pdf
Mendelssohn and Kuhn, 2003
http://www.biloximarshlandscorp.com/bmlc2/wp-content/uploads/2017/05/Mendelssohn-and-Kuhn-2003.pdf
Croft et al., 2006
http://www.biloximarshlandscorp.com/bmlc2/wp-content/uploads/2017/05/Croft-et-al-2006.pdf