Emerald Ocean Engineering

Project GreenShores, Phase II
Site Description and Hydrodynamic Climate

Prepared for
Ecosystem Restoration Support Organization, Inc.

By

David D. McGehee, P.E., M.Oc.E

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107 Ariola Drive
Pensacola Beach, FL 32561

bigwave@emeraldoe.com
(8500 932 - 9111

Introduction

Project Greenshores is a habitat restoration effort intended to create emergent and submerged saltmarsh vegetation and oyster habitat. The project site is located at 30E 25' N, 87E 12' W on the Northwest shore of Pensacola Bay, FL. Pensacola Bay is an irregular shaped, deep water bay (up to 40 ft) protected from the Gulf of Mexico by a sandy barrier, Santa Rosa Island (Figure 1). The natural Bay shoreline is fringed by wide, shallow sand flats between 3 and 5 ft deep. The project is sited on ~ 1 mile of urbanized, revetted shoreline between the Port of Pensacola to the west southwest and the northern terminus of Pensacola Bay Bridge to the east northeast. The eastern, Phase I of the project was completed in 2003; Phase II is scheduled for construction in 2005 (Figure 2).

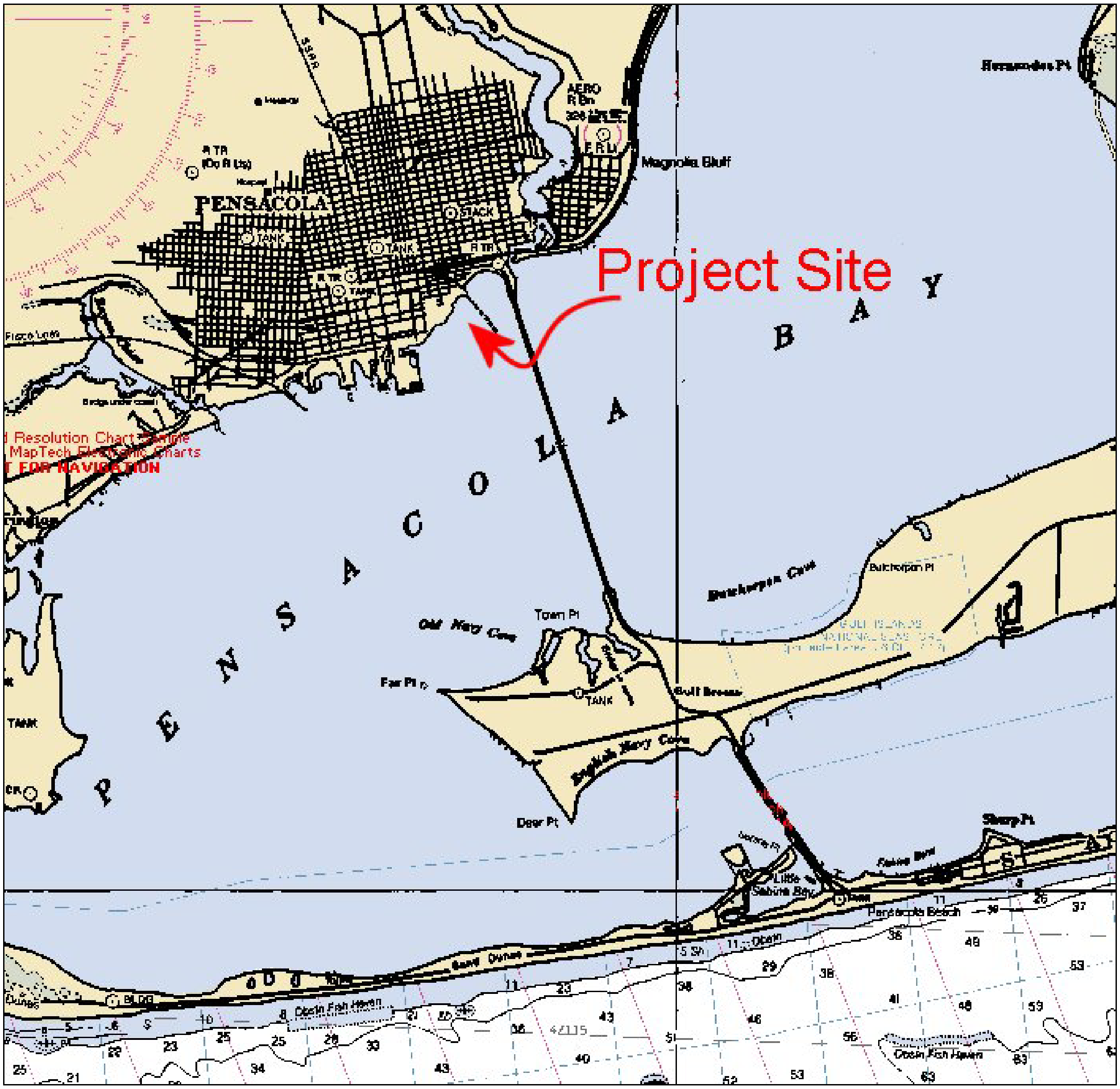

Figure 1. Phase II location map

Figure 2. Phase I and Phase II site

Phase II Site Description

Phase I was constructed on a classic pocket beach – a crescentic sediment cell between two headlands – where wave refraction tends to keep sediment contained and the profile stable (Figure 3). Though the Phase II site is also bound by hard structures at either end, is not a classic pocket beach. A revetted embankment divides the shoreline into 2 sediment regimes. The shoreline to the west of Hawkshaw Lagoon is revetted to below Mean High Water and is sediment starved. The shoreline to the east of the Lagoon is a dry beach with an accumulation of sand extending about 300 ft bayward against the Muscogee Wharf. A storm drain at the eastern edge of the Lagoon may be the source of some or all of this sediment. The shoreline and offshore contours are not parallel because the sand flat extends much farther bayward on the western side. Finally, the channel and marina on the western end are potential sediment sinks.

The Phase II site is bound on the east by the Muscogee Wharf and the west by a navigational channel adjacent to the Port of Pensacola. Remnant piles extend about 2000 ft SSE from Muscogee Wharf to a detached concrete pier segment in 20 ft of water. A recreational marina is immediately west of the project shoreline. In between is the artificially created Hawkshaw Lagoon, a narrow water body artificially created between the normal shoreline and a revetted berm. The Lagoon was intended to be tidal but the entrance has frequently silted in. Just west of the lagoon, an abandoned outfall extends across the sand flat to at least -6 ft MLLW and possibly beyond. The offshore bathymetry varies significantly along the project length; an irregular-width

Figure 3. Aerial view of Phase I (preconstruction) and Phase II

sand shelf extends about 600 ft southward on the eastern end, and over 2000 ft bayward on the western end. The sand shelf, or flat, has a mild slope from the shore to about the – 6 ft MLLW contour, then drops more steeply to about – 12 ft MLLW on its southern and western sides. The deeper water on the western side serves as the entrance channel for the marina. Two tongues of deeper water extending into the sand flat on the western end were probably dredged at the same time as the entrance channel. About 3000 ft offshore there is a second drop off to the 20 + ft depths typical around the port and mid-bay.

Hydrodynamic Design Parameters

Waves and Water Levels

A hydrodynamic climate analysis was performed for Phase I of the project, located immediately eastward on the other side of Muscogee Wharf (McGehee, 2001b). Table 3 from that report, below, provides the typical (approximately, the annual mean) and normal design (highest expected without tropical storms or hurricanes) values for wind, significant wave height (Hs), peak wave period (Tp), and average wave period (Ta).

The typical design wave for Phase I was stability purposes was determined to be 1 m (3.3 ft) Hs with a 5-sec peak period. The exposure of Phase II is nearly identical to that at Phase I – it is slightly more protected from the WSW by the port, and slightly less protected from the east by the Pensacola Bay Bridge causeway. However, refraction will bring the waves from the WSW relatively undiminished into the eastern side of the Phase II project. This recommended design wave for Phase II is increased to 1.2 m (3.9 – 4.0 ft) Hs, 5-sec Tp, with an equal probability of approaching from the East or the WSW.

Table 1. Typical and Normal Design Wind and Wave Conditions (from McGehee, 2001)

Direction	Fetch (nm)	Typical wind (kt)	Typical Hs (ft)	Typical Tp (s)	Typical Ta (s)	Design wind (kt)	Design Hs (ft)	Design Tp (s)	Design Ta (s)
E	11	10	0.5	1.4	1.2	35	3.2	4.2	3.7
ESE	5	10	0.3	1.1	1.0	30	1.5	2.4	2.1
SSE	4	10	0.3	1.1	1.0	30	1.4	2.3	2.0
S	3	10	0.3	1.1	1.0	30	1.3	2.1	1.9
SSW	6	10	0.3	1.1	1.0	35	1.5	2.4	2.1
WSW	5	10	0.4	1.4	1.2	45	3.7	5.1	4.5

Pensacola Bay is a micro tidal estuary with a mixed diurnal/semi diurnal tide - that is sometimes there are two highs and two lows in a day and other times only one of each. The nearest National Ocean Service (NOS) tide gage is at the Port of Pensacola, about 1 nm to the west of the project. The following data from NOS show the mean tide range for Pensacola Bay is 1.27 ft.

HIGHEST OBSERVED WATER LEVEL (09/20/1926) = 8.80 FEET
MEAN HIGHER HIGH WATER (MHHW) = 1.27 FEET
MEAN HIGH WATER (MHW) = 1.23 FEET
MEAN TIDE LEVEL (MTL) = 0.64 FEET
*NATIONAL GEODETIC VERTICAL DATUM-1929 (NGVD) = 0.26 FEET
MEAN LOW WATER (MLW) = 0.04 FEET
MEAN LOWER LOW WATER (MLLW) = 0.00 FEET
LOWEST OBSERVED WATER LEVEL (01/06/1924) = -2.30 FEET

As for Phase I, it will be assumed that performance during extreme events is not a requirement of the project, so rigorous, quantitative, and site-specific hurricane statistics will not be provided. However, project survival is a goal, so general guidelines for some parameters will be provided, based upon transformation of statistics for Navarre Beach on Santa Rosa Island (McGehee, 2001). These statistics are derived from extremal analysis and presented as predicted values for varying return periods. The return period of an event is the inverse of the probability of that event occurring in any one year; i.e., a 50-year event has a one in 50 chance of occurring in any year. There is no difference in the return period statistics at Phase II from those derived for Phase I, which are reproduced below. Since the waves will be depth limited, design waves are provided for two depths: the present -3 ft and – 6 ft MLLW contours

Table 2 - Simple Estimates of Storm Surge Probabilities (from McGehee, 2001)

Return Period	10 Year	25 Year	50 year	100 Year
Surge (ft)	2	3 (.9 m)	4	5
H_b (ft), d_b = 3'	5	5 (1.5 m)	6	7
H_b (ft), d_b = 6'	7	8 (2.4 m)	9	9

Currents and Sediment Transport

Currents under normal and typical conditions will be similar to those at Phase I. On an average summer day, longshore current speeds along the typical Bay shoreline would include a 0.1 -0.2 kn tidal component that varies in magnitude and direction with tidal cycle, a 0.1 -0.2 kn wind shear component that would set to the west, and a radiation stress component of about half the wind component. Net currents will fluctuate from zero to about ▂ kn. During typical winter storms, longshore currents along an unobstructed stretch of bay shoreline could approach 1 kn, but the project site is sheltered by headlands. A reasonable selection for the typical design current would be ½ kn.

Currents during extreme events may play a significant role on the constructed project. During storms and hurricanes, there are sufficiently strong onshore winds to generate large, long period waves in deeper water. When these waves reach the outer edge of the sand flat, they break and cause *set up* - a rise in the mean water level - at the outer edge of the sand flat relative to the mean water level at the shore. (This effect is separate from the larger scale storm surge, which raises water level uniformly across the flat.) The elevated water surface at the outer edge of the flat, together with the mass transport associated with the highly non-linear waves *on* the flat, create a significant hydraulic gradient that generate *set-up induced currents*

The wave-induced hydraulic potential is highest at the outer edge of the flat where the waves are breaking. This hydraulic gradient drives the water shoreward, but it eventually is blocked by the rising beach profile. The result is a strong current that lines up with the wind and wave direction at the outer portion of the sand flat, but turns shore parallel closer to the beach. It must return ■downhill,● which is toward deeper water where waves are not breaking and set-up is not occurring. In this case, that path is toward the marina entrance channel. Flow velocities are strong enough to entrain considerable volumes of suspended sediment. When the water reaches the deeper water of the channel, its velocity decreases and the sediment load is dropped. This same process has been observed on coral reef flats of similar geometry (McGehee 1994, McGehee and Boc, 1997). Shortly after its construction at the back of a reef flat, Agat Harbor was about ¼ filled with sediment, overnight, during a moderate tropical storm.

The geomorphic evidence of this process in Pensacola Bay is the presence of numerous *sand waves* on the sand flats (Figure 4). Sand waves are shallow, large-scale (spacing of hundreds to thousands of ft), wave-like bed-forms associated with a certain type of bed-load sediment transport. Their distinctive profiles are steep on the downstream face, shallow on the trailing edge. They form under steady currents with a relatively narrow range of intermediate velocities - approximately from 1 ft/sec to less than 1.5 ft/sec (~ ½ kn) for this size sand. At lower velocities, i.e., those due to normal tidal currents, perhaps aided by surface wind shear, ripples with spacing less than ~1 ft will form on an initially flat sand bed. At higher velocities, sand dunes with spacing intermediate to ripples and sand waves may form. At even higher velocities, bedforms begin to be eroded; eventually a near flat bed will re-form. Not only can sand waves be clearly seen in aerial photographs of the sand flats at nearly every location around the Bay, they appear at various, often crossing angles, indicating reversals in current direction at different times. (Figure 5).

Remnant sand waves at the Phase II site (see Figure 3) indicate that significant sediment transport has occurred sometime in the past. The low amplitude of the sand waves compared to more exposed sites in the Bay mean that the process is less pronounced here or had occurred relatively earlier.[1] The potential for setup-induced currents is lower for the Phase I site than the Phase II site because the segmented breakwaters extend across the arc between the headlands and there is no deep water channel extending near the shoreline. Even if the process occurs, currents may not reach significant magnitudes at the Phase II site under its existing configuration because 1) the outer face of the sand flat is not particularly steep nor entirely shore parallel, 2) the bottom is not actually flat but has a mild slope, and 3) the water depth on the flat during a storm surge is deep enough to preclude the strongest currents. However, duplication of the Phase I planform at the Phase II site would significantly amplify the process because the breakwaters at the outer face of the flat would increase set up while the sand beds for emergent grasses would be essentially flat and shallower.

Summary

The design parameters from Phase I can be utilized for Phase II, except that the design wave for typical storms will be increased from 3.3 ft to 4 ft. The 50-year return period conditions are a 4 ft storm surge occurring at mid tide with a 6 ft breaking wave height at the present – 3 ft MLLW contour and a 9 ft breaking wave at the present – 6 ft MLLW contour. The general planform used for Phase I should not be utilized for Phase II because of the risk of deposition into the adjacent navigation channel under certain conditions.

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[1] There is a dynamic component of the phenomenon, related to the seiching of the basin formed by the sand flat boundaries, which should favor larger sand flats. Also, the more rectangular the basin is, the stronger the effect.

REFERENCES

McGehee, David D., 2001; “Hydrodynamic Climate for Navarre Beach State Park,” Contractor Report to the Florida Department of Environmental Protection, Emerald Ocean Engineering, Pensacola, FL, March, 2001

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