Crissy Field Marsh Expansion Study

FINAL REPORT

Prepared by

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1. INTRODUCTION AND BACKGROUND

1.1 SITE HISTORY

Historically, Crissy Field and the Marina Green were part of an extensive 127-acre backdune marsh that drained the Tennessee Hollow watershed to San Francisco Bay. Aeolian (sand-driven) transport from the west formed a sand spit to the east, and the mouth of the 150 ft wide entrance channel was located close to Marina Beach and sheltered from the predominant northwesterly waves. Anthropogenic changes to the wetland coincided with development of the Presidio, and the marsh was completely filled for the Panama-Pacific International Exposition of 1915. The marsh site was transferred to the National Park Service (NPS) in 1994, when the Presidio became part of the Golden Gate National Recreation Area (GGNRA). In November 1999 tidal action was introduced into a restored tidal marsh at Crissy Field.

Although a 30-acre footprint was initially recommended as the minimum size required to maintain natural functioning of a tidal backdune marsh, other constraints on the site limited the area of the tidal marsh to about 20 acres. Recognizing the increase in closure potential due the smaller footprint, the tidal prism was increased by expanding the relative area of sub-tidal habitat. The morphological response of the system was rapid, with flood- and ebb-tidal shoals developing at the landward and bayward ends of the inlet, respectively. Risk of closure increased as sand deposition in the channel and flood shoal continued, and in May 2001 natural closure and breaching occurred. The inlet channel has continued to close and re-open intermittently, with one unauthorized mechanical breach in the winter of 2001-2002 and a NPS breach in March 2003.

1.2 PROJECT OBJECTIVES

Per the request of the Presidio Trust, and in cooperation with the GGNRA and Golden Gate National Parks Conservancy (Parks Conservancy), Philip Williams and Associates, Ltd. (PWA) was hired to re-evaluate the relationship between marsh area and inlet dynamics. In particular, this study was to review and if necessary revise the estimate of the minimum area required to maintain continuous tidal function. The study also was to evaluate the potential for closure for an incrementally enlarged wetland. This study relies heavily on monitoring data collected over the past 2½ years by PWA and GGNRA/Parks Conservancy. The following sections summarize the approach we have adopted in estimating the potential for closure of the tidal inlet at Crissy Field and the results.

2. CONCLUSIONS AND RECOMMENDATIONS

As part of the present study, monitoring data collected from May 2001 through September 2002 were reviewed to improve our understanding of the morphological and hydrodynamic processes of the Crissy Field Marsh. Additionally, the stability of the tidal inlet was examined for existing conditions as well as various enlarged wetland sizes by application of a Quantified Conceptual Model (QCM). The model is not a precise engineering tool that explicitly simulates the sediment transport processes. Instead, the QCM is based on simple stability criteria, our understanding of the closure and breaching mechanisms, and easily computed parameters such as wave and tidal power as surrogates for complex sediment transport processes at the inlet. The model retains enough accuracy to be a useful tool for planning purposes. Application of the QCM to existing conditions resulted in the model simulating most (10 of the 13) documented closures over the 17-month period from 4/15/2001 to 9/31/2002. Results from this analysis lead to the following conclusions and recommendations.

Conclusions:

- Morphological evolution of the marsh-inlet-beach system through May 2001 has been documented in previous reports (PWA, 2001a; PWA, 2001b), but review of more recent monitoring data has improved our understanding of the inlet morphology and dynamics. The system appears to be in dynamic equilibrium, with the marsh presently in its transitional state as a mesotidal sandy coastal lagoon. Based on the limited amount of estuarine sedimentation data to date, we expect the site to maintain its present condition as an open water lagoon subject to intermittent closures for several decades.

- Inlet closure and breaching conditions have been quantified. The risk of closure is primarily driven by the joint probability of waves and tides, and depends parametrically on the size of the lagoon. Closures usually occur during neap tides when tidal scour is minimal. Natural re-opening typically occurs during the following spring tides, after inundation from the Bay increases water levels in the lagoon and surface flow during the ebb tides scours a new channel, typically near the location of the remnant inlet mouth.

- The maximum thalweg elevation of the inlet controls the low water elevation in the lagoon, and significantly affects the stability of the inlet. Monitoring data show that the high point of the thalweg usually occurs as it passes over the flood shoal, and that evolution of the shoal coincided with the reduction of inlet stability. Application of the QCM reveals that the ability of expanded wetlands to remain open is very sensitive to the low water elevation in the marsh. A key issue in applying the QCM to expanded wetland sizes was estimating the maximum thalweg elevation for these hypothetical cases. Under present conditions, sheet flow over the sandy flood shoal dominates. However, over the long-term, channel morphology may change and lower the thalweg elevation if cohesive material deposits replace sand in the flood shoal.

- Over the long-term, the effective tidal prism may diminish as estuarine sediments fill the sub- and inter-tidal areas of the lagoon and a vegetated marsh develops near Mean Higher High Water (MHHW), acting to reduce the natural scouring potential along the entrance channel. Presently, there is not enough monitoring data to establish precise estimates of sedimentation in the lagoon. In addition, other factors that will influence the character of the evolved site complicate a quantitative prediction of exact morphology. These include: local wind-wave action in the lagoon that may limit the aerial extent of high marsh; the accelerating rate of sea level rise; and, changes to the inlet morphology as cohesive estuarine sediments are deposited over the flood shoal and entrance channel. Application of the QCM indicates that the long-term stability of the inlet channel will be strongly influenced by the low water elevation in the fully evolved state.

- Based on our QCM analysis, continuous tidal action could be achieved over a typical year if the lagoon diurnal tidal prism were increased from its present value of 17 acre-feet (ac-ft) to approximately 56 ac-ft. Since the frequency of inlet closure is related to tidal prism intermediate wetland sizes are expected to experience intermittent closures, although less frequent than the existing Crissy Field marsh. For example, we expect an expanded lagoon with 39 ac-ft to close about once per year under typical wave conditions. These predictions are based on average wave conditions, and more frequent inlet closure is expected during unusually high energy wave events.

- Future expansions to the existing marsh should include enlarging the area near the flood shoal in a radial direction so that increases in its current footprint would not reduce tidal circulation by "pinching" off the southeast portion of the lagoon near the footbridge. Circulation in this area is of particular concern due to the 72-inch outfall that discharges stormwater into the lagoon. Poor circulation could reduce the effective tidal prism as well as worsen water quality in areas of the lagoon where tidal exchange is low. Marsh expansion near the flood shoal would tend to mitigate these effects.

- The precise geometry of an expanded wetland needs to be studied further, although some general comments regarding its planform and vertical profile can be made. Firstly, major excavation below the expected low water elevation would not increase the effective tidal prism or improve the stability of the inlet, and some cost savings may be realized by limiting excavation at or above this elevation. Secondly, expanded wetlands with low-gradient sides could increase ecological values by creating more mid and high marsh area, although this would require larger marsh area. However, low-gradient sides would require larger marsh area than steep sides in order to develop the same tidal prism.

- Temporary and long-term changes to the morphology of East Beach are expected following wetland expansion. Increases in the volumes of the ebb- and flood-tidal shoals will disrupt the delivery of sand east of the inlet until a new equilibrium is reached, and may lead to

temporary loss of beach width. Some of the expected loss of beach width will be recovered as natural sand by-passing increases after the ebb bar matures, but other long-term changes to the shoreline along East Beach may result in response to the new wave and tidal regimes that will occur under expanded wetland conditions.

Recommendations for additional study:

- Empirical relationships between throat morphology, shoal/thalweg elevation, lagoon area, and tidal prism are lacking for sandy coastal lagoons such as Crissy Field. Field data could be collected from reference sites to establish such relationships. This would refine the estimates of thalweg elevation for expanded wetland sizes – a key issue in apply the QCM to hypothetical cases.

- Improvements in the wave transformation matrix will refine the estimates of nearshore wave power and reduce the uncertainties in the QCM. Ideally, fully directional offshore wave spectra should be used to re-construct a revised transformation matrix.

- The wave record from the Point Reyes buoy limited the duration of the QCM simulations to about six years. Longer records of historical offshore wave data from the Monterey buoy could be re-formatted for input into the QCM, or a new wave transformation matrix could be constructed, for longer model simulations. This would refine estimates of the frequency of closure by including more infrequent wave events in the analysis.

- NPS should continue ecological monitoring at Crissy Field, which will inform the acceptable duration of inlet closure. Adequate tidal functions may not require a continuously open inlet, however a self-maintaining system may be desirable from a management perspective.

3. GOALS OF THE CRISSY FIELD MARSH

Future expansion of the marsh at Crissy Field should aim to achieve the overall goals of the approved Crissy Field Plan and Environmental Assessment (Jones & Stokes Associates, 1996). The goal for Crissy Field as articulated in the Crissy Field Plan is to "enhance the setting for recreation and visitor enjoyment while rehabilitating and preserving important historic resources and natural values."

The desired natural values of the marsh were described in Objective 2: "Enhance and expand existing natural resource values and capitalize on opportunities to restore dunes and a remnant of the historic tidal marsh. This objective includes:

- Re-establishing an ecologically viable self-sustaining tidal marsh requiring a minimum of human intervention and providing high-quality educational and interpretive opportunities;

- Providing for connection of the future restored riparian corridor to the marsh and allowing for future expansion of the marsh south of Mason Street;

- Restoring and enhancing native plant communities, expanding the native dune community to allow viable biological and coastal processes to occur, removing non-native vegetation, and providing access through sensitive dunes along designated paths; and

- Providing adequate protection for wildlife currently on the site and anticipated to occur as a result of planned improvements."

Based on the overall goal for Crissy Field and the objective defined for the marsh, three primary goals were identified for this study:

1. Tidal restoration and associated ecological functions are a primary goal.

2. Development of a self-sustaining marsh in the short- and long-term. Closure frequency and duration may change as siltation occurs, and the criteria for mechanical breaching should be applicable to the early and mature stages of the site.

3. The tidal restoration should accommodate existing recreational uses at East Beach.

The purpose of the present study is to determine the minimum tidal prism required to maintain continuous tidal action to the Crissy Field marsh, as well as to estimate the frequency and duration of inlet closures under intermediate wetland sizes. This information will help inform decision makers during later planning stages in order to increase the probability of meeting the goals and objectives articulated in the Crissy Field Plan.