Middle Harbor Enhancement Area

Construction Period and Long-term Monitoring, Maintenance and Adaptive Management Program

Prepared for:

U.S. Army Corps of Engineers
San Francisco District

and

Port of Oakland

Prepared by:

Winzler & Kelly
Consulting Engineers
200 Pine Street, Suite 600
San Francisco, CA 94104
415 283-4970

and

Merkel & Associates, Inc.
5434 Ruffin Road
San Diego, CA 92123
(858) 560-5465

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Appendices

APPENDIX 1: DESIGN REQUIREMENTS AND COMMITMENTS, PERFORMANCE STANDARDS AND GOALS, AND PROJECT CONDITIONS FOR THE MHEA
1.0 MANAGEMENT PLAN OVERVIEW

As a component of the implementation of the Middle Harbor Enhancement Area (Figure 1-1) development, several monitoring efforts must be undertaken to verify that existing resources are protected and desired future resources are developed. These programs include those specifically required by mitigation measures of the Oakland Harbor Navigation Improvement (-50’) Project Final Environmental Impact Statement/Environmental Impact Report (FEIS/EIR), U.S. Fish and Wildlife Service (USFWS) Endangered Species Act (ESA) §7 Biological Opinion (BO) (1-1-98-F-43), National Marine Fisheries Service (NMFS) ESA §7 BO, and/or 1st Phase Coastal Zone Management Act (CZM) Consistency Determination.

In addition, monitoring and maintenance elements include commitments to the Habitat Technical Advisory Committee (TAC) to verify and ensure that particular elements of the project are implemented and are successful. The monitoring program also includes a number of construction period and post-construction period monitoring elements intended to verify design/engineering modeling assumptions thus allowing any required modifications to be made that are required to achieve project goals. This adaptive management program has been developed for the present project to aid in achieving the tight design and construction tolerances necessary to achieve the habitat objectives of the project. The plan does not address standard construction management controls that are required for any construction project, but rather focuses only on those elements that are inherently complex, have limited history of application, or are considered to have elements which may require fine-tuning in order to be most successfully applied in the MHEA.

In the event that not all habitat goals are achieved within the MHEA, the TAC is to be reconvened to review the habitat values developed. Based on this review, the TAC and resource and regulatory agencies are to advise the U.S. Army Corps of Engineers (Corps) and Port of Oakland (Port) as to whether further pursuit of the original habitat objectives would be prudent in light of potential damage to developed habitats and the degree to which anticipated and unanticipated values have been achieved. The TAC and agencies may advise that the values achieved are acceptable surrogates to the original goals, additional work should be conducted towards meeting the original habitat objectives, or alternative goals should be set that capitalize on conditions developed in the MHEA.

Finally, this monitoring, maintenance, and management program outlines the necessary long-term requirements to ensure that the site continues to function as designed and that all requirements for monitoring and maintenance are identified and implemented in a timely fashion.

To achieve the desired purpose, it is essential that monitoring data be collected, reported, reviewed, and applied to design, construction and management decisions in a timely manner. The management program discussed in this document includes an integrated adaptive management component that
Figure 1-1. Middle Harbor Enhancement Area Locator Map
ensures the information collected will be used appropriately to better the outcome of the MHEA development. The proposed monitoring elements provide the essential reporting components necessary to facilitate adaptive management.

1.1 PROGRAM REQUIREMENTS

This management program must accomplish a number of functions. First, it must identify the monitoring program to be completed throughout the project construction, habitat establishment, and lifetime of the MHEA. Second, it must identify the maintenance requirements for the habitat during various phases of establishment. Third, it must provide an estimate of the site monitoring, maintenance, and management costs and responsibilities on which to base future management agreements. Finally, it must identify triggers for future actions that may be required based on monitoring results.

1.1.1 Monitoring Requirements

This monitoring program is designed to provide information essential to guide the desired implementation and long-term habitat development and management of the MHEA. In accordance with commitments made to the TAC, monitoring is to be performed during construction to verify hydrodynamic modeling results, as well as consolidation and sediment subsidence predictions. Additionally, commitments have been made within the TAC Agreement to monitor biological colonization and to provide the TAC an opportunity to review and comment on the MHEA monitoring plan. The plan is to be similar to the monitoring program developed and being implemented for the Batiquitos Lagoon Enhancement Project. The 1st Phase CZM Consistency Determination (CD) includes a commitment by the Corps and Port to monitor and report on habitat development during years 1, 2, 3, 5, and 10 following MHEA construction. Pursuant to Term and Condition 5(d) of the USFWS BO, monitoring of shallow unvegetated subtidal area, shallow channels, eelgrass habitat and eelgrass reference areas shall be conducted at least annually for a period of not less than 10 years following completion of the MHEA and interim reports shall be submitted annually. Similarly, annual monitoring of the MHEA is required by Regional Water Quality Control Board (RWQCB) Order No. 00-110 for the 50 foot deepening project.

The TAC will be afforded the opportunity to review and evaluate the MHEA monitoring data. Therefore, the monitoring data must be collected, analyzed, summarized, and presented in a timely fashion so that TAC input may be meaningfully incorporated into the decision making process for any corrective measures.

1.1.2 Site Management Requirements

As requirements of the BOs, TAC Agreement, and 1st Phase CD, the MHEA is to be maintained and managed in perpetuity as a natural shallow water habitat. This management plan shall be reviewed and approved by the USFWS, as a condition of the BO. The TAC shall have the opportunity to review and comment on the management plan. Finally, the management plan is an integral element of the 2nd Phase CD to be reviewed and considered by the BCDC.

Site management must include provisions for scheduled and as-needed maintenance as well contingencies for addressing unforeseen maintenance needs. In the short-term, the TAC has identified the need to provide a post-construction “warranty period” during which corrective measures are implemented to address unforeseen construction or design problems in addition to the
scheduled maintenance program. In the long-term, the TAC has requested that the MHEA management obligation be transferred to an entity with the capabilities and expertise to best manage the site for its habitat values. The division of responsibilities between the various parties involved and the fiscal responsibilities of the parties for implementation of the management program are described below.

1.1.3 Financing Obligations and Implementation Responsibilities

The Corps and Port are charged with the construction of the MHEA as a part of the Port’s 50-foot channel deepening project. The MHEA project includes construction of a containment structure, placement of dredged materials, installation of a number of hard and soft habitat features, and modification of existing features of Middle Harbor that would otherwise conflict with the desired conversion of Middle Harbor from a deep water harbor to a wildlife habitat area. The Port is also completing work within the surrounding uplands as a part of its Vision 2000 program. This work includes the Berths 55-58 Container Yard and Middle Harbor Shoreline Park (MHSP) projects. While being designed to be compatible and integrate with the MHEA, these projects are distinct efforts being undertaken by the Port and are non-federal projects. This coordinated effort to develop compatibility along land use interfaces has been extremely beneficial to planning and design as well as engineering efforts, however, it has resulted in some complexity with respect to defining specific areas of management obligation.

The Port is responsible for all aspects of construction and operations of non-federal projects under the Vision 2000 project. These obligations are not addressed in this document. While the federal/non-federal project responsibilities within the MHEA are not distinct, as a practical matter, the boundary may be generally described as the mean high tide line within the finished MHEA project except as indicated in Figure 1-2.

The Corps and Port have a shared obligation as federal and local sponsors of the 50-foot deepening project to implement all aspects of the MHEA project as they pertain to requirements for site preparation, construction, and continuing obligations mandated as a condition of site use as a dredged material disposal/re-use area. These include monitoring, maintenance, and area management. Federal/non-federal areas of responsibility shall be further defined through the Project Cooperation Agreement (PCA) between the Corps and the Port.

At some time after site construction, long-term site management, including monitoring and maintenance, shall be turned over to a third party manager, yet to be determined. This document also describes the responsibilities of this future manager. The ultimate management entity may potentially take possession of the site prior to the completion of the long-term monitoring program, however, design performance monitoring tasks may remain with the Port and Corps to ensure continuity and application of data through adaptive management.

Requirements for financing the MHEA include obligations for funding initial MHEA implementation, monitoring, corrective actions, maintenance, and contingencies. In addition, financial obligations extend to providing appropriate funding to implement long-term site management concurrent with the transfer of management responsibility to a third-party manager. These commitments are outlined in the TAC Agreement, the 1st Phase CD, and the Corps’ Addenda to the CD.

(revised 5-02)
Figure 1-2. Boundary of the MHEA Management Area
1.2 MANAGEMENT PROGRAM STRUCTURE

1.2.1. Management Plan Format

This management plan is divided into several sections that address the monitoring program, maintenance program, and long-term management structures separately. In addition, there are discussions of distinct phases of work within the individual plan sections. While this plan provides some separation between monitoring and maintenance discussions, it has been prepared in this format to aid in the use of the document as a desk reference for plan implementation.

Monitoring work is divided into five phases and is presented as summaries of the work to be performed during each phase. More detailed descriptions of the monitoring protocols will be submitted to the regulatory agencies.

Maintenance work described in this plan is similarly broken down by phases and is described as a regular maintenance activity or a triggered activity based on monitoring program results. The maintenance elements are described based on anticipated needs based on the present degree of information available. As the site develops a history, maintenance frequency, actions, and objectives may change in response to developing habitat goals or recurrent conditions and system responses to past management actions.

This management plan is designed to provide the necessary flexibility required to appropriately modify site monitoring, maintenance, and management in response to increasing data and understanding of the developing system. This is accommodated through the final sections of the plan which address site management issues including management and management reporting responsibilities, and remedies available to address issues that arise over the course of the project implementation, establishment period, and long-term management program. Anticipated recurrent and intermittent maintenance are incorporated as an element of the project so that future permits and approvals will not be required to complete work performed in accordance with that anticipated at the time of establishment. It is essential that management actions, including such needs as maintenance dredging, or avian island reconstruction, be considered as a part of the project so that actions may be taken in an efficient and timely manner as dictated by the habitat needs of Middle Harbor. This programmed maintenance is discussed further in the specific management sections.

1.2.2. Program Manager

This monitoring program is to be completed under a Port staff member who will serve as overall monitoring program manager. The program manager will be charged with ensuring that all elements of the monitoring program are coordinated among the individuals involved and that appropriate sampling and analyses are completed. The program manager will ensure that the monitoring program and adaptive management elements are fully implemented and that information is appropriately disseminated to the involved parties including the TAC, agencies, site manager (once selected), design team, and construction managers and contractors, as may be appropriate for the particular materials. The program manager will be responsible for coordinating any necessary meetings or reviews to ensure that information may be applied in a timely fashion where data are to be used to make construction period adjustments in design elements.

The program manager is also charged with implementing a quality assurance program that addresses data collection, interpretation, and application to design modifications or performance evaluations.
1.2.3. Quality Assurance Program

The implementation of this monitoring and management program requires the integration of a broad range of data into a decision-making process in order to evaluate design elements and make modifications as required or to assess performance of the site. It is essential that the quality of each element of the work be maintained in order to provide accurate and reliable sources of information. For this reason, a quality assurance program will be developed and implemented by the program manager. The program will include the following elements:

1) An identification of the methods employed for each monitoring element and the sampling, measurement, or other error associated with the methods.
2) Adequate capabilities, equipment resources, and technical expertise must be possessed by the team conducting the data collection and analyses to provide quality data and interpretation.
3) A detailed technical report summarizing all pertinent information necessary to evaluate the methods employed in sampling and analyses must be provided along with any calculations completed or assumptions made.
4) A review committee shall be provided with the monitoring data, analyses, conclusions, and any resultant recommendations for modifications to the proposed implementation plans.
5) A updated, chronological report shall be prepared which outlines the details of each adaptive management modification made in order to evaluate the information in future adaptive management actions.

1.3 SUCCESS GOALS AND REQUIREMENTS

1.3.1 MHEA Program Goals and Objectives

The overall goal for the Middle Harbor Enhancement Area is to provide a mosaic of habitats: shallow water, eelgrass beds/shallow flats, deep channels/basins, sand beach (as part of Middle Harbor Shoreline Park), hard bottom, coastal salt marsh, avian high tide refugia, and buffers between public access and habitats that has a greater value to natural resources and the public than does the existing Middle Harbor area.

Defined objectives for this goal have been set by guidance from the TAC as the following:

1. Design habitat to be self-sustaining to the degree possible;
2. Provide a system that is principally comprised of eelgrass and unvegetated shallow waters;
3. Provide marsh and beach habitat, recognizing that some habitat values may be limited by managed public access and education/interpretive activities;
4. Create a productive shallow water habitat;
5. Provide new beach area that will also provide storm refuge to birds; and
6. Provide protected shorebird roosting sites that are largely unvegetated or that support low-lying vegetation consistent with shorebird use (both on the shoreline and on islands).

1.3.2 Success Criteria and Performance Standards

Many of the MHEA objectives have been stated in the form of performance standards or commitments in the various documents governing the project work. These are identified in Table 1-
1. Performance goals, criteria for success in achieving the goal, methods to assess the parameter are summarized within Table 1-1. While multiple success thresholds have been established for some project goals, Table 1-1 only addresses the highest threshold for any project element. All of the lower thresholds are identified in Appendix 1 and would only become important in determining the degree to which project commitments have been achieved if project success falls short of the highest objective. A summary of all standards that are lower than the highest imposed by any approvals or commitments is provided in Appendix 1.

To evaluate success, it is essential that both the timeframe(s) of the evaluation and method(s) used be established. In some instances, clear direction has been provided with regards to success assessment. Where these exist, they have been adopted in this program. However, in other instances these have not been specified and appropriate evaluation methods and periods have been selected by the design team.

Table 1-1. Performance standards and commitments for the MHEA.

<table>
<thead>
<tr>
<th>NO</th>
<th>PERFORMANCE Standards and Commitments</th>
<th>WHEN AND HOW DETERMINED</th>
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</table>
| 1  | Provide a new 3-5 acre marsh to provide bird foraging opportunities and educational/interpretive benefits. | When:  
1) completion of final construction;  
2) 10 years after initiation of dredging.  
How:  
1) topographic survey (at construction);  
2) assessment of vegetation and avian use (over 10 year) |
| 2  | Create a minimum of 55 acres of habitat suitable for eelgrass habitat development, 110 acres of other shallow water, | When:  
1) completion of final construction  
2) completion of site suitability evaluation and warranty period  
How:  
1) hydrographic and topographic survey (at construction);  
2) measurement and assessment of physical conditions developed, as well as comparison to modeling results |
| 3  | Provide new public access beach area that will also provide storm refuge to birds. | When:  
1) To be completed as part of Berths 55-58/Middle Harbor Shoreline Park work.  
How:  
1) Confirm beach construction under Port’s project by completion of topographic survey. |
| 4  | Provide improved bird habitat, with reduced predators and human disturbance through construction of four avian islands, each being a maximum size 5,000 sq. ft. and by providing a protected area along the shoreline of the UP Mole. | When:  
1) completion of final construction;  
2) 10 years after initiation of dredging.  
How:  
1) topographic survey (at construction);  
2) assessment of vegetation and avian use (over 10 year) |
| 5  | Provide 4-8 acres of hard bottom habitat (approximately 4 acres presently exists) | When:  
1) completion of final construction.  
How:  
1) topographic survey (at construction);  
2) assessment of vegetation and avian use (over 10 year) |

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6 Create a minimum of 15 acres of eelgrass habitat within 10 years after initiation (start of dredging) of project not including that planted in the previous 3 years.

When:
1) completion of 10 year post-construction monitoring program.

How:
1) annually evaluate eelgrass cover and density throughout site and reference areas using side-scan sonar and diver verification;
2) compare eelgrass cover with reference areas to control for natural interannual variability in eelgrass.

7 Provide an estuarine community within MHEA that is of higher productivity and greater diversity than the existing community of Middle Harbor. Provide a habitat that is more highly productive than existing conditions and provides a net increase in habitat value.

When:
1) completion of 10 year post-construction monitoring program.

How:
1) evaluation of plant, invertebrate, fish, and avian communities relative to baseline Middle Harbor conditions reported in prior studies.

8 Increase habitat benefits for aquatic birds and most particularly the least tern colony, by increasing habitat and the productivity of fisheries. Of specific interest is the enhancement of least tern prey species which may improve foraging opportunities for terns.

When:
1) completion of 10 year post-construction monitoring program.

How:
1) evaluate availability of forage species and size classes consumed by avifauna, and specifically least terns.

9 Provide a greater number of fish than existing conditions

When:
1) completion of 10 year post-construction monitoring program.

How:
1) evaluation of fish communities relative to baseline conditions reported in prior studies.

1.4 Adaptive Management

The MHEA is to be implemented and managed through the application of adaptive management principles. This approach has been dictated by the relatively unique nature of the project and limited data on projects of similar scale and complexity in San Francisco Bay from which to draw essential design and performance information. The adaptive management program includes various elements including both construction period adaptive design and implementation as well as long-term adaptive management to address habitat maintenance needs. Construction period adaptive management elements are associated with design assumption verification and design refinement during the initial construction periods that are necessary to support the development of the MHEA in accordance with the project goals as outlined in the prior section. These goals are to be achieved through development of a site for which the design and engineering has been governed by a habitat design criteria model summarized below. The adaptive management elements are further integrated into the monitoring program which measures the progress of the system against references or pre-determined expectations. Based on the outcome of the monitoring and data analysis, decisions may be made regarding the performance of the monitored element relative to expectations, and the need or desirability to alter the site conditions, conceptual model, or the performance goals. The process for adapting the project based on monitoring is addressed in this section.
Adaptive management for the long-term maintenance program is also contemplated to ensure that appropriate maintenance is accomplished to ensure the viability of the MHEA. These elements of the adaptive management program are further described in this section.

### 1.4.1. Habitat Design Criteria Model

**Eelgrass and Shallow Water**

The MHEA is principally designed around the creation of two basic features: eelgrass habitat and shallow water habitat. Baseline biological investigations completed in 1997 demonstrated that these two habitats provided greater habitat values than did existing deeper water harbor environments (Entrix, Inc. 1997. Habitat Evaluation for Oakland’s Harbor Navigation Improvements (-50’ Project)). With eelgrass and shallow water habitats as anchors, additional ancillary features were incorporated into the MHEA design to provide habitat diversity and to foster greater utility of the system by ecologically important and educationally beneficial resources.

The controlling factors in the design are primarily physical constraints within the system and relative levels of uncertainty in the performance of certain physical models and construction tolerances. While it is anticipated that creation of shallow water habitat from deep water harbor environments will be relatively simple, the establishment of conditions suited to eelgrass growth is less certain. For this reason, an effort has been made to maximize opportunities to restore eelgrass throughout the MHEA with the anticipation that some lesser level of success will be achieved. This approach has been taken since failure to create eelgrass habitat would result in the creation of unvegetated shallow water habitat, a resource that has been demonstrated to be more valuable than the deeper water baseline conditions of Middle Harbor (Entrix, Inc. 1997).

Specific objectives in the MHEA design include: maintaining bottom light environments suitable to support eelgrass; and ensuring that the site maintains adequate circulation to prevent significant settlement of sediment from the water column, while keeping current velocities and wave environments below thresholds for resuspension and transport of Meritt sand surface sediments. The MHEA was designed to fit within the bounds of the available Middle Harbor area and various features were adjusted to optimize water circulation, depth, and velocity conditions suitable for eelgrass growth.

The greatest uncertainty to achieving desired habitat objectives resides in the design predictions made regarding sediment consolidation rates and extent and predictions regarding hydrodynamics of the system. At present, the design and engineering of the system has addressed the information needs for these items through predictive modeling and calibration of models against existing conditions and available data. However, given the importance of these factors to achieving the desired objectives, an adaptive implementation and management approach to the project has been developed. The design incorporates modifiable control points and phased construction with feedback monitoring and model result verification loops. The project plan incorporates opportunities for plan modifications to respond to enhanced information quality and model predictions based on the monitoring programs.

Figure 1-3 provides a schematic conceptual design model for the MHEA eelgrass habitat. Within the model the relative quality of predictions and certainty of elements is noted. Also noted, where possible are the quantitative design standards. These standards may be expressed as limits or targets where absolute limits are not available.
A comparable model for shallow water has not been developed since the default habitat that results in areas where eelgrass does not become established is shallow water. The targeted design criteria for MHEA habitats are the same for shallow water and eelgrass, however it is contemplated that not all areas will achieve all aspects of the criteria essential to support eelgrass. In some instances, such as the channel system within the MHEA, some aspects of the design criteria are sacrificed to enhance the qualities of other areas. These areas would still result in generating shallow water habitat conditions that are principally distinguished from the deep water habitat conditions presently occurring in the Middle Harbor by a coarser sediment, higher energy, and increased light environment.

Marsh Habitat
The MHEA includes the construction of a small marsh which is designed to provide improved foraging habitat for birds and an interpretive and educational amenity to complement the adjacent shallow water habitat and the Middle Harbor Shoreline Park. Unlike several other marsh restoration programs, this marsh is not designed to provide habitat for sensitive species, in that it is too small to provide adequate protection for nesting species, and such uses would conflict with the public access considerations inherent in the intended design. To be successful in achieving the principal goals of this marsh, several elements of the design must be considered. First, marsh elevations must be achieved over at least 3-5 acres of the MHEA within the southeastern corner of the site. Second, sediments must be of a silt/clay nature rather than a sandy nature. The site must be protected from erosive energies of either waves or currents but must receive regular tidal flushing. Finally, the site must support native marsh flora in an amount adequate to promote the use of the area by marshland associated avifauna for foraging purposes. A conceptual model of the marsh habitat design criteria is provided in Figure 1-4. An interspersed mixture of vegetated marsh, salt pannes, and mud flats over 3-5 acres would satisfy the performance criteria for this element.

Avian Islands
Avian islands are designed to provide protected areas available for bird loafing, foraging, or roosting that are relatively protected from predators and disturbance by a permanent water barrier. The design of these islands has been developed based on observing other avian use areas within the San Francisco Bay. Through these observations and those made in other systems, it was determined that the size, shape, substrate, elevation off of the water, and adjacent habitat types all play roles in determining what birds are likely to use an island and to what extent the islands are to be used. While certain patterns of use were observed, there was also a high degree of variability in the observations that suggested a degree of chance and habituation as well.

To maximize the potential for benefiting a diverse assemblage of avian species and minimizing monotypic aggregations of aggregations of common gull species, the islands have been designed to be of relatively low stature, small in scale, topographically complex, lacking in significant vegetation, and have substantial portions of the islands intermittently inundated. Figure 1-5 provides a conceptual design model for these island features.

Other Habitat Features
None of the other habitat features are particularly unique in their construction or have complex design elements associated with them. For this reason, conceptual design models have not been presented for these features.
Figure 1-3. Conceptual Design Model For MHEA Eelgrass Habitat.
Figure 1-4. Conceptual Design Model For MHEA Marsh Habitat
Figure 1-5. Conceptual Design Model for MHEA Avian Islands.

- **Avian Island Topographic Relief**
- **Variable and Small Supratidal Crest Area (-500 ft. SMLW)**
- **Sculpted Supra-Tidal Crest Area (<5000 SF/EA)**
- **Salvaged Quarry Stone and Bedding Gravel Materials**
- **Consolidation of Dredged and In Situ Material (Modeled)**
- **Non-erosive in Higher Energy Areas**
- **Non-vegetated Islands**
- **Over-built Elevation (Estimated at 4 ft Above Design Elev.)**
- **Island Location for Hydrodynamic and Habitat Benefits**
- **Isolation from Public Access**
- **Surrounding Habitat Features Aiding in Select Bird Usage**
- **Wave and Current Environments (Modeling)**
- **Interim and Final Topographic Relief**
- **Island Shape, Material and Foundation Support**
- **Excludes Mammalian Predators**
- **Design Island Crest Elevation (+6 to +10 ft MLLW)**
- **Scour to Prevent Development of Vegetation**
- **Uneven Sides Slopes (1:1 to 10:1)**
- **Temporary and Final Topographic Relief**
- **Provides Supra-Inter-, and Subtidal Benefits**
1.4.2. Adaptive Management for Design Elements

Several elements of the MHEA design are based on design criteria, assumptions, and modeling that are not standard to large-scale dredging and construction projects. Rather, these elements are derived from observations made in the field, and both empirical and theoretical applications in smaller restoration efforts. As a result, there is some residual uncertainty in the predictions made with respect to design and implementation of the MHEA. This uncertainty is to be addressed through an adaptive design and construction process that relies on monitoring of earlier phases of work to provide guidance to later phases. The monitoring program focuses on data collection, hydrodynamic and settlement model validation, and analyses needs essential to reducing engineering and construction uncertainty. Table 1-2 identifies the specific design elements requiring additional data collection and potential adaptive management adjustments to achieve successful enhancement. Those elements addressed in Table 1-2 are distinct from the performance standards addressed in Table 1-1 in that they are not measures for evaluation of success, but are rather elements for which additional information is necessary to refine project designs.

Table 1-2. Design and engineering issues requiring adaptive management.

<table>
<thead>
<tr>
<th>DESIGN ISSUES</th>
<th>PURPOSE AND GENERAL APPROACH</th>
<th>MONITORING APPROACH</th>
<th>PLAN SECT.</th>
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</thead>
</table>
| Standing wave at sheetpile wall      | Predictions of standing waves at the containment wall have been made based on numerical modeling. The solution which allows some water/energy penetration through the wall is one that has been successfully implemented elsewhere. However, to refine navigational safety measures and direct any remedial actions, a monitoring program is proposed to identify the extent to which a wave field is developed at the wall and to suggest solutions based on empirical observations. If required, such modifications as adding cautionary signage and navigational aids, or adding additional relief may be used to further decrease navigational risks. | 1. Wave gages  
2. Video monitoring of wave field  
3. Conduct numerical modeling calibrated against wave gage and video results to test various wave environments | 2.5.1      |
| Placed material and existing bay mud sediment consolidation | Because of the narrow bathymetric range suited to the growth of eelgrass within San Francisco Bay, the predictability of consolidation of placed material and existing unconsolidated material within the MHEA is of critical importance. To best account for the settlement of unconsolidated native material and the consolidation of placed material, an adaptive management element has been incorporated into the placement of fill. This includes several components such as: 1) layering of sand and mud materials to improve dewatering; 2) two phases of material placement separated by a long period of consolidation; and 3) monitoring of consolidation rates to develop consolidation curves for the individual fill lifts and cumulative fill. Consolidation data are to be collected during fill placement and during the allotted consolidation period. Using these data, the fill consolidation predictions made during final | 1. Monitor fill lift stratigraphy  
2. Monitor lift specific consolidation and sediment pore pressures at fixed instrument platforms  
3. Conduct repeated bathymetric surveys | 2.5.2-3     |
If necessary, modifications will be made to the final fill phase plans based on empirical data collection and post-calibration of modeled consolidation. These changes would allow any required fill adjustments to be made during the final fill and sculpting phases of work.

Hydrodynamics for the MHEA have been derived using model predictions. Models are more fallible when complex systems are examined and narrow margins of error are required such as in the MHEA. To address the uncertainty in model predictions a period of empirical data collection, model verification, and model and/or design adjustment is to be used. This will occur by examining the hydrodynamic conditions developed in the MHEA following the first (bulk) fill phase and using these data to validate model predictions for the final site design conditions. If necessary, the model will be recalibrated to predict empirical measures observed both in the existing and post-bulk placement conditions. Models will then be re-run on the final MHEA design to determine if circulation and wave penetration and scour design criteria are still predicted to be met.

If necessary, the final design will be adjusted through realignment of channels, adjusting the aperture dimensions, or altering the location of fish enhancement structures to protect localized areas of predicted scour.

Eelgrass will persist and grow within a narrow range of conditions developed in shallow waters of protected bays and estuaries. Developing the appropriate physical conditions for such growth has been a primary objective of the MHEA design efforts. The environmental criteria targeted in design efforts have included: 1) maintaining flow velocities between 1 and 20 cm/sec with a preferred target being 10-16 cm/sec; 2) maintaining depths between –4 and 0 ft. MLLW over the maximum area of the MHEA while maintaining appropriate hydrodynamics; 3) maintaining surface sediments at approximately 0.15-0.25 mm diameter; 4) maintaining wave intrusion with no significant wave scour of desired surface sediments or significant elevation of turbidity; 5) maintaining canopy level photosynthetically active radiation (PAR) levels over shallow flats at or above those found in reference eelgrass areas (nominally approx. 8 E/m²/day); 6) maintain conditions which result in peak daily temperature maxima below 30°C; 7) maintaining rates of accretion or erosion below 2 cm/mo. with limited long-term rates of change; and 8) maintaining adequate flushing to ensure that dissolved oxygen levels are kept above an average of 5 ppm and the MHEA is adequately flushed to prevent the accumulation of macroalgae.

If necessary, various changes in the site design may be made to modify conditions to improve the conformance of the developed site conditions to the design criteria. However, because some criteria are conflicting, such as maximum

<table>
<thead>
<tr>
<th>Hydrodynamic model verification and adjustment:</th>
<th>Site suitability for eelgrass habitat creation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. tidal flows</td>
<td>Eelgrass will persist and grow within a narrow range of conditions developed in shallow waters of protected bays and estuaries. Developing the appropriate physical conditions for such growth has been a primary objective of the MHEA design efforts. The environmental criteria targeted in design efforts have included: 1) maintaining flow velocities between 1 and 20 cm/sec with a preferred target being 10-16 cm/sec; 2) maintaining depths between –4 and 0 ft. MLLW over the maximum area of the MHEA while maintaining appropriate hydrodynamics; 3) maintaining surface sediments at approximately 0.15-0.25 mm diameter; 4) maintaining wave intrusion with no significant wave scour of desired surface sediments or significant elevation of turbidity; 5) maintaining canopy level photosynthetically active radiation (PAR) levels over shallow flats at or above those found in reference eelgrass areas (nominally approx. 8 E/m²/day); 6) maintain conditions which result in peak daily temperature maxima below 30°C; 7) maintaining rates of accretion or erosion below 2 cm/mo. with limited long-term rates of change; and 8) maintaining adequate flushing to ensure that dissolved oxygen levels are kept above an average of 5 ppm and the MHEA is adequately flushed to prevent the accumulation of macroalgae.</td>
</tr>
<tr>
<td>2. waves</td>
<td>If necessary, various changes in the site design may be made to modify conditions to improve the conformance of the developed site conditions to the design criteria. However, because some criteria are conflicting, such as maximum</td>
</tr>
</tbody>
</table>

1. Deployed current and wave gages
2. Doppler velocity transects
3. Tidal current monitoring
4. Towed and fixed position instrument array monitoring of turbidity, temperature, PAR, DO, salinity, and depth
5. Direct measures of erosion/accretion rates.
6. Hydrodynamic and sedimentation-erosion processes modeling

(revised 5-02)
Middle Harbor Enhancement Area Monitoring and Adaptive Management Plan

Eelgrass Habitat Restoration Program

Temperature and depth range, an analysis of any changes will include consideration of other effects and the final design will balance design criteria for greatest degree of optimization.

Eelgrass restoration is to be performed within the MHEA to achieve the following goals: 1) establish a source of plant material that can further expand via seeding or vegetative means to populate more of the MHEA; 2) enhance the rate of eelgrass spread within the MHEA in order to attain eelgrass cover criteria in a timely fashion; and 3) promote habitat development to improve productivity and diversity of MHEA communities.

To maximize the success of restoration efforts, a two phased planting program is proposed. This effort includes: 1) a first phase planting using a series of test plots scattered over all habitat types represented in the MHEA; 2) monitoring to determine the areas of successful eelgrass establishment, rates of expansion, and damage resulting in donor eelgrass beds; 3) mapping of the most effective areas to focus additional planting; and 4) a second phase of planting to further expand eelgrass beds within areas that are demonstrated to be best suited to supporting eelgrass.

The first phase planting and subsequent evaluation of success in the pilot transplants is expected to yield some differences in preferred planting area than are presently envisioned. These results will be used to modify the areas of a second phase of planting as necessary to ensure that this phase of work is most successful at enhancing eelgrass coverage within the MHEA. The second phase of eelgrass transplanting is to occur approximately one year after the Phase 1 planting effort and will be guided by the results of this initial pilot program.

1.4.3. Adaptive Management for Long-term Site Maintenance Actions

The MHEA is designed to be as self-sustaining as practical and thus should not require regular maintenance beyond scheduled minor maintenance such as trash removal, navigational aids cleaning and repairs, and weed abatement. However, it is contemplated that intermittent major maintenance will be required to reconstruct avian islands and to complete maintenance dredging. The specific requirements for these actions are not fully known today and therefore will be governed by an adaptive management approach. This approach is considered essential to ensure on-going habitat viability within the MHEA. Table 1-3 identifies the specific management elements and adaptive management actions to be taken to direct maintenance activities. Those maintenance elements that are considered to be part of the project description and which are being considered as a part of the MHEA description are discussed along with defining characteristics. Future maintenance work that would result in a change in the habitat type from the agreed upon design would not be covered by initial project approvals.
### Table 1-3. Maintenance actions requiring adaptive management.

<table>
<thead>
<tr>
<th>DESIGN ISSUES</th>
<th>PURPOSE AND GENERAL APPROACH</th>
<th>MONITORING APPROACH</th>
<th>PLAN SECT.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bird Island and Marsh Containment</td>
<td>Avian islands are to be constructed as rock islands on placed fill foundations of varying support capacity. Some of these islands are primarily designed as habitat features while some are to principally to serve as sediment or water training features during and/or after construction. The geotube marsh containment structure, like the islands, is to be constructed on top of a newly placed fill. It is anticipated that islands and marsh containment barrier will subside to some degree and will be subject to deformation during seismic events. To address normal subsidence these structures have been designed to be constructed to higher elevations and allowed to settle into the fill based on recommendations of the project geotechnical engineer. The initial subsidence estimates will be confirmed during the first 18 months following construction and if necessary, the islands will be raised to accommodate excessive subsidence. However, seismic deformation has not been addressed in the initial construction design due to cost considerations. Instead, islands and the containment berm are to be monitored and reconstructed should deformation occur and use by birds or physical system needs warrant their reconstruction. Monitoring is to be completed to provide information on bird usage, and any deformation that occurs. Reconstruction of will occur when structures decline in biological values to the extent that less than four islands supporting a total of less than 5,000 square feet of high quality avian use area are left, or deterioration results in physical decline in functionality as a wave barrier, or current training structure. The reconstructed island form will be dictated by a combination of the initial design and observed utility of the structures for their biological and physical intended purposes. As a maintenance action contemplated as an element of the project, the islands would not be reconstructed beyond the original design scale or footprint. Similarly, reconstruction of the marsh containment berm shall be performed based only on an identified need. The marsh has been designed to be developed within a relatively sheltered area of the MHEA and it is not contemplated that high erosional forces will occur in this area following construction of the MHEA. For this reason, even subsidence of the construction containment may not result in a significant threat to the marsh. If serious erosion is identified, then the marsh berm may be reconstructed. The character and extent of reconstruction of this berm are not currently known. As such, any reconstruction that exceeds the original design materials or footprint, would need to be separately permitted as an enhancement effort.</td>
<td>1) Elevational survey of avian islands and containment berm every six months for the first 18 months following construction. 2) Elevational survey of avian islands and containment berm during years 1, 2, 3, 5, and 10 following the first 18 months post-construction. 3) Elevational survey of islands and the marsh containment berm following seismic events during long-term maintenance. 4) Avian surveys including island usage.</td>
<td>2.6.1, 2.7.1, 2.8.1</td>
</tr>
</tbody>
</table>
**Maintenance Dredging**

During the first 18 months following construction, the conditions of the final fill are to be monitored using bathymetric surveys completed every six months. During this period, if excessive shifting of sediments occurs, some dredging and/or reconfiguration of armored shoals and islands may be required to remove initial sediment deposits or redistribute sediment within the MHEA as dictated by monitoring results. This would be completed as part of the initial construction work.

Dredging to remove areas of accumulated sediments from within the completed MHEA is anticipated to be required as an essential maintenance action. This maintenance dredging would be expected to be completed similar to dredging of sediments from berths and navigation channels, as a maintenance action dictated by accretion to the point at which the conditions are no longer suitable to achieve the function of the facilities. However, as an adaptive management element, it is desirable to allow natural geomorphic forms to develop within the MHEA and only remove sediments that accumulate in a location or manner that impede the natural development of the system, or threaten to reduce the principal habitat features to be developed within the MHEA. Such maintenance dredging may result in slightly differing contours than were initially designed. This does not alter the intent that this is a contemplated maintenance activity. Further, maintenance dredging shall not be completed unless it is deemed to be in the best interest of the MHEA when considering the entire site. Prior to the commencement of any maintenance activities that could significantly disturb, remove, or alter any of the major target habitat types, (i.e., eelgrass, reef, tidal marsh, or avian islands) the resource agencies are to be consulted and a majority consensus will be reached that the activity would provide a greater benefit to the habitat than detriments.

To be considered maintenance dredging within this evolving system, the following conditions must be met:
- **1)** No more sediment than has been accreted above initial construction period volumes may be removed;
- **2)** No sediment may be removed from below the grades of the original design channel system, although channel migration is allowable;
- **3)** No sediment in excess of initial construction volumes may be redeposited within the MHEA.

**Vegetation Control**

The expansion of exotic vegetation within marshlands or establishment of vegetation on the avian islands that significantly restricts avian use is undesirable and will be controlled. To accomplish effective vegetation control, it will be necessary to conduct monitoring to determine the extent of vegetation problems and to conduct control activities as conditions warrant. For exotic species control, various techniques may be most applicable depending upon the degree of infestation, the species, and the nature of the habitat.

<table>
<thead>
<tr>
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<tbody>
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</tr>
</tbody>
</table>

| 1) Conduct regular surveys of marsh habitats and identify any exotic species infestations on an annual basis; |
| 2) Conduct surveys of islands on an annual basis and identify |
area in which the infestation occurs. Similarly, the need to remove vegetation from islands must weigh the degree of island growth, relative to the available island resources. Only vegetation that is seen as an impact to the availability of suitable island habitat should be removed. Various methods of control should be contemplated and a program for control should be developed to address the specific conditions that are encountered within the MHEA.

All vegetation control efforts to maintain native marsh vegetation or control vegetation growth on islands is a maintenance element of the project.

1.5 SUCCESS ASSESSMENT AND ADAPTIVE MANAGEMENT DECISION MAKING

1.5.1. Success Metrics to be Considered

Table 1-1 identified the standards against which success of the MHEA project would be evaluated. To further present these standards in a measurable form, Table 1-4 establishes specific criteria against which success or failure may be measured.

Table 1-4. Success assessment methods and criteria to be applied.

<table>
<thead>
<tr>
<th>STANDARD</th>
<th>METRIC</th>
<th>REFERENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marsh:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1) 3-5 acre marsh</td>
<td>Area of veg/unveg. marsh complex</td>
<td>Absolute measure</td>
</tr>
<tr>
<td>2) enhanced bird foraging</td>
<td>Abundance, diversity of marsh/shorebirds</td>
<td>Baseline MH condition</td>
</tr>
<tr>
<td>3) educational/interpretive benefits</td>
<td>Increased bird use over existing</td>
<td>Baseline MH condition</td>
</tr>
<tr>
<td>Eelgrass Potential/Shallow Water:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1) 55 acres of habitat suitable for eelgrass development</td>
<td>Total area meeting eelgrass habitat design parameters or lesser parameters in natural beds</td>
<td>Absolute plus Crown Beach/Bayfarm reference</td>
</tr>
<tr>
<td>2) 110 acres of other shallow water</td>
<td>Shallow water, minus eelgrass potential habitat</td>
<td>Absolute measure</td>
</tr>
<tr>
<td>Beach:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1) new public access beach;</td>
<td>Beach constructed under MH Shoreline Park</td>
<td>N/A</td>
</tr>
<tr>
<td>Avian Islands:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1) four islands each with a maximum size of 5,000 sq. feet</td>
<td>Island counts and areas</td>
<td>Absolute measure</td>
</tr>
<tr>
<td>2) protected shoreline areas on UP Mole</td>
<td>Confirm protected shoreline in MHSP</td>
<td>Absolute measure</td>
</tr>
<tr>
<td>Hard Bottom Habitat:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1) 4-8 acres of hard bottom habitat</td>
<td>Area of hard surface below 0 MLLW (some will be part of MHSP)</td>
<td>Absolute measure</td>
</tr>
<tr>
<td>Eelgrass Habitat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1) 15 acres of eelgrass habitat within 10 years after initiation (start of dredging) of project</td>
<td>Area of eelgrass cover exceeding 5% total cover as determined by side-scan and computer contouring</td>
<td>Coverage is adjusted to conditions observed at the Crown Beach/Bayfarm reference areas</td>
</tr>
</tbody>
</table>
Habitat Productivity and Diversity:
1) greater density of benthic infauna
2) greater density of fish
3) greater diversity of benthic infauna
4) greater diversity of epifauna
5) greater diversity of fish
6) greater overall diversity

Habitat Benefits for Birds:
1) increased utilization of area by waterbirds
2) increased productivity of forage fish of all consumable sizes and species
3) increased productivity of forage fish of the species and size classes consumed by least terns

Fish:
1) greater number of fish than existing under baseline conditions

1.5.2 Evaluation of Success Milestones

Success evaluations are to be completed as a part of an annual reporting effort during the course of monitoring. A clear determination as to whether or not the success criteria has been met shall be presented along with quantitative data providing an indication as to the degree of success or failure. Those metrics assessed during the course of the year are to be evaluated relative to ultimate success milestones. Each successive report shall provide a cumulative summary of performance of each metric relative to the ultimate success criteria. This will provide a basis for analyzing trends and variability in the metric. When evaluating success, the variance of the metric between sampling events will be considered. Where practical, data are to be presented both in tabular and graphic forms.

An element of the evaluation shall include a consideration of the extrinsic conditions that may be influencing the performance of the MHEA. Where comparisons are made to baseline conditions rather than reference areas, interannual variability must be considered and it is useful to examine other data-sets collected over the same time-frame to evaluate the potential that conditions observed at the MHEA may be reflective of broader regional trends rather than site specific conditions.

1.5.3 Adaptive Management Decisions and Contingencies

The degree to which success is achieved across each evaluation metric is expected to vary; Some parameter will meet and/or greatly exceed the objectives rapidly and other parameters will just meet or fail to meet the criteria during the evaluation period. As a part of the long-term monitoring and reporting program, an overall assessment of the project’s achievement of various objectives, expectations, and conditions or commitments will be performed. This assessment will identify specifically which elements over and under-achieved and will be provided to the TAC. Based on this assessment and monitoring data, the TAC will evaluate the project as a whole relative to the underlying goal of creating a high value habitat in central San Francisco Bay. The TAC and agencies may make recommendations for supplemental actions or adaptive management to improve conditions or replace values that are inadequately achieved by the project.
In some instances, corrective measures to address shortfalls may be identified, however the implementation of these measures could have adverse ramifications on other, potentially unexpected values that have been developed. Prior to implementing adaptive management changes that may impact existing values, it will be necessary to determine whether the potential benefits of the modification outweigh the resource values developed. If it is determined that the values achieved should be protected, then it would be necessary to evaluate alternative adaptive management options or the appropriateness of the original goals.

The Port and Corps have committed to implementing corrective actions, unless they conclude after consultation with the TAC, regulatory and resource agencies that the benefits of the created habitat are comparable to achieving the plan’s original goals and/or that corrective measures are likely to diminish rather than increase habitat values.
2.0 MONITORING PROGRAM

2.1 MONITORING PROGRAM OBJECTIVES

The monitoring component of the MHEA management plan is designed to accomplish the following objectives.

- Ensure compliance with construction period restrictions designed to protect existing resources occurring in the project area;
- Provide means of verifying model predictions and engineering assumptions at a period in the construction process at which point adaptive management design adjustments may be made to improve the performance of the MHEA;
- Provide early post-construction data on the performance of the completed MHEA relative to predicted conditions so that necessary modifications and repairs may be made as a part of the construction program and long-term maintenance requirements may be appropriately funded;
- Provide early post-construction data on site suitability for initiation of eelgrass and marsh habitat planting programs;
- Ensure compliance with habitat development objectives through implementation of a 10 year long-term physical and biological monitoring and reporting program;
- Provide continuing monitoring essential to ensuring that the site maintenance program is implemented in a manner that provides continued long-term viability of the MHEA; and
- Identify anticipated maintenance requirements and schedules for the MHEA.

2.2 MONITORING PROGRAM PHASING

The MHEA monitoring program is divided into five phases designed to provide information essential to either guiding development of the site, or assessing compliance with various regulatory requirements. In some instances, these phases include both monitoring and adaptive management elements. Monitoring conducted under each phase is discussed in section 2.3. Each of the monitoring elements is referenced back to the specific project conditions (Appendix 1) that the monitoring and/or adaptive management elements are designed to address.

2.2.1 Phase 1. Construction Restriction Compliance

The construction compliance phase includes monitoring required to ensure compliance with construction period restrictions. This monitoring shall be integrated with the overall 50-foot deepening project to minimize costs and duplication of effort. This monitoring phase shall occur during the primary periods of construction including the construction of the MHEA containment structure, bulk fill placement period, and the final fill placement period. Monitoring shall be conducted to ensure compliance with turbidity restrictions imposed by the Regional Water Quality Control Board, herring spawn protection measures within the Middle Harbor fill area, and BO-required monitoring study of least tern foraging areas, including dredged sediment deposition within Middle Harbor. A separate least tern monitoring program for the 50’ dredging project is being prepared as a part of the 50’ project plans.

2.2.2 Phase 2. Design Verification and Refinements

Phase 2 monitoring is a MHEA specific monitoring component designed to address the uncertainties inherent in the fill placement and consolidation, as well as hydrodynamic modeling of the system. This monitoring phase is to be completed over a period that overlaps somewhat with the Phase 1
monitoring and the bulk fill and the final filling phases within the MHEA. It is intended to provide feedback on settlement properties of the bulk-fill and hydrodynamic and water column properties against which model predictions may be verified or adjusted. In addition, the Phase 2 monitoring program includes elements which address concerns over the sheetpile containment wall generating a standing wave field in the main shipping channel.

To be useful, this phase of monitoring is directly linked to an adaptive management element in which the final design may be adjusted as necessary to meet the overall design objectives.

2.2.3 Phase 3. Site Suitability Evaluation / Warranty Period

Phase 3 monitoring would occur following the placement and sculpting of the final sand cap fill and the mud fill in the marsh portion of the MHEA of the site. This monitoring program would provide continued feedback on settlement conditions within the MHEA fills and would provide information on site stability for revegetation. This monitoring period focuses on: 1) structures (bird islands, fish enhancement structures, marsh containment, etc.); 2) erosion and accretion (locations and rates of scour and shoaling); and 3) suitability for implementation of the eelgrass and marsh restoration planting efforts. The Phase 3 monitoring interval would serve as a warranty period during which time the overall physical stability of the site and potential for meeting long-term enhancement objectives would be evaluated. In addition, this phase would provide an opportunity to verify the rates of sedimentation and/or erosion within the system as predicted during the feasibility study and design and adjust the long-term maintenance program, as appropriate. As with Phase 2 monitoring, an adaptive management element has been incorporated so that any necessary adjustments to the site revegetation program may be made prior to implementation of large-scale habitat planting efforts.

2.2.4 Phase 4. Performance Evaluation Period

This phase of the monitoring program is intended to verify the successful achievement of the habitat development criteria outlined for the MHEA. This period is to be initiated upon the completion of the first phase planting of eelgrass within the MHEA and shall continue for a period of 10 years post-second phase planting. The monitoring program includes a minor physical component as well as a more intensive biological component. The program specifically focuses on assessment of physical changes (e.g. bathymetry, surface sediment properties and mobility, water column properties) that may affect long-term habitat conditions as well as biological components that directly assess the development of habitats and target resources within the MHEA. Biological elements to be monitored include: eelgrass and marsh habitat development; biological community development focusing on fish, benthic, and avian resources including the brown pelicans and least terns. Site management may be transferred to a third party during this period.

2.2.5 Phase 5. Long-term Management Period

Phase 5 provides for post-construction monitoring during the long-term management period. It is designed to identify the status of the site relative to established maintenance triggers that will ensure the completion of an efficient and effective maintenance program. This program includes monitoring of bathymetry, navigation aids and signage, habitat structures and shoreline interface areas, as well as public access and habitat use conflicts. The long-term management period monitoring program includes a reporting component in order to provide a means of tracking habitat maintenance requirements and performance. Monitoring and maintenance during this phase shall be the obligation of the long-term site manager.
2.3 Monitoring Program Timing and Sampling Locations

2.3.1 Schedule of Monitoring/Management Phases

The implementation schedule for the specific elements of each monitoring phase is outlined in subsequent sections. The overall schedule for the monitoring phases is outlined in Table 2-1. The monitoring program includes work associated with initial construction, a habitat development period, and a long-term maintenance period. Overall, the construction monitoring program is anticipated to occur over a period of 4.0 to 4.5 years depending upon the rate of construction, fill consolidation, and site stabilization following the final fill placement and sculpting. The habitat performance evaluation period would occur over an additional 10-year period. The maintenance period monitoring would start coincident with the performance evaluation monitoring period and would continue indefinitely.

Monitoring to be conducted during each of the scheduled phases of work is described in the following sections.

2.3.2 Monitoring Program Sampling Locations

Within the various monitoring phases, a number of sampling stations are proposed to be used to investigate physical, chemical, and biological conditions to aid in tracking the status of the site over time. While it is anticipated that some monitoring stations will need to be relocated as project work progresses and more detailed information becomes available, it is relevant to identify the locations where monitoring efforts are expected to occur as of the present time. The preliminary sampling stations, transects, and areas to be used for monitoring are illustrated in Figure 2-1. Again, some of these stations are subject to revision and must be confirmed or even relocated prior to initiation of the monitoring efforts.

An effort has been made to consolidate monitoring effort and equipment both through scheduling work so that it may be coordinated and to reduce mobilization and equipment costs so that elements of the project do not conflict with each other. Further, various equipment is to be mounted in close proximity to other equipment so that data may be more readily integrated and interpreted together.
Table 2-1. Overview Schedule for Monitoring Phases.
MONITORING PROGRAM STATIONING
FOR
MIDDLE HARBOR ENHANCEMENT AREA

FIGURE 2-1
2.4 CONSTRUCTION RESTRICTIONS COMPLIANCE (CONSTRUCTION PERIOD)

2.4.1 Water Quality

Objectives:
- Ensure that water quality objectives, as established in the FEIR/S, BO, and RWQCB certifications are complied with. These include:
- Deploy silt curtains if the TSS concentration within 100 feet of the site (i.e. within 100 feet bayward of the MHEA containment dike) exceeds 1,500 mg/L more than 10 percent of the time as measured with continuous monitoring equipment;
- Comply with the requirements on water quality imposed through RWQCB state water quality certification and waste discharge requirements incorporated in RWQCB-San Francisco Region Order No. 00-110.

Duration:
- During active construction of the MHEA.

Frequency:
- Monitoring frequency is subject to the requirements of RWQCB-San Francisco Region Order No. 00-110.

Data to be collected:
Total suspended solids (TSS) are to be sampled in accordance with a Receiving Water Monitoring Plan as specified within RWQCB-San Francisco Region Order No. 00-110.

Analyses and reporting to be completed:
- TSS concentration reporting subject to the requirements of RWQCB-San Francisco Region Order No. 00-110.

Actions to be taken based on monitoring:
- Implement sediment control measures, such as silt curtains, to ensure compliance with water quality standards (Condition C-3); or
- Work with RWQCB on development of alternative compliance criteria based on a risk-based assessment of impacts; or
- Take other steps as determined prudent through coordination with RWQCB and in conformance with Order No. 00-110 to control discharges.

2.4.2 Biological Windows and Surveys

Objectives:
- Ensure the protection of sensitive biological resources during the course of project implementation.
- Conduct monitoring required to provide information necessary to ensure protection of herring spawn (Condition C-4); and
- Conduct monitoring necessary to determine effects of placement of material at MHEA on least tern foraging as required by the BO (Condition C-5).

Duration:
• Total duration of 2 years during placement of material at MHEA. Beginning at the initiation of dredged material placement within MHEA;
• Ending at the completion of dredged material placement and dredging activities within MHEA.
• The least tern foraging study shall be conducted over the first two years of dredging for the 50-foot deepening project and shall be extended to subsequent years if deemed necessary through coordination with the USFWS. This plan is provided as a separate document and focuses principally on the 50’ deepening project.

Frequency:
• Herring spawn monitoring shall be conducted through weekly contact with CDFG monitors and on-board observer on the dredge during the herring spawn season (12/01 through 03/01) and ancillary observations made during the completion of turbidity monitoring intervals;
• Least tern monitoring shall be conducted weekly during the period in which terns are present and material placement occurs in Middle Harbor (04/15 through 09/01).

Data to be collected:
• Occurrence of herring spawning within the project area;
• Least tern foraging activities within MHEA.

Analyzes and reporting to be completed:
• A map of herring spawn within the project area and an activity setback boundary shall be prepared and coordinated with the CDFG in the event that herring spawn in the project area during any season. This work falls under the auspices of the 50’ deepening project;
• A report shall be prepared that evaluates least tern foraging activities within and outside dredging areas and the MHEA during material placement. The report shall include a map of foraging activities and an analysis of tern foraging activities. This work falls under the auspices of the 50’ deepening project.

Actions to be taken based on monitoring:
• In the event that herring spawns occur within the MHEA, discharges within 200 meters of the spawning area will be stopped for two weeks. (Condition C-4)
• Actions relative to the findings of the least tern foraging study fall under the auspices of the 50’ deepening project.

2.5 DESIGN VERIFICATIONS AND REFINEMENTS (CONSTRUCTION PERIOD AND INTERPHASES)

2.5.1 Sheetpile Jetty Reflected and Penetrated Waves

Objectives:
• Conduct monitoring required to provide field data on reflecting and penetrating wave properties at sheetpile wall containment structure and make recommendations regarding navigation safety. (Condition C-1)
• Evaluate solutions to residual standing wave concerns in the navigation channel if any are identified. (Condition R-2)
• Evaluate need for any modifications to MHEA habitat area behind sheetpile wall to address penetrating wave energies.
Duration:

- Total duration shall be a 1 to 2 month period occurring 6-9 months after completion of construction of the jetty. Work shall be coincident with other hydrodynamic field data collection (See Section 2.5.4);
- This would allow adequate time to ensure that reasonably significant storm events and vessel wakes could be observed.

Frequency:

- Wave data shall be collected constantly during the monitoring period with a frequency of 2 Hz. Video images shall be collected during the daytime every hour with a duration of approximately 5 minutes each hour. Wave data shall be collected synchronously with recording video images.

Data to be collected:
- Wave data using fixed outer wave stations.
- Video-images using a deployed video camera.

Analyses and reporting to be completed:

- Wave data and video-images shall be processed and analyzed.
- Wave conditions and effects of the openings in sheetpile wall shall be determined.
- Numerical modeling results shall be compared with the measured data.
- A report shall be prepared that evaluates wave conditions at the sheetpile wall for various ambient wave and vessel wake conditions.

Actions to be taken based on monitoring:

- Recommendations for a system of warnings for small and pleasure crafts (buoys, marks, signs, etc), if the risk of reflected waves is significant. (Condition R-2)
- If there is significant scour on the inside of sheetpile wall and it is determined to be adverse to the overall project goals, then modify adjacent habitat area to stabilize or otherwise protect areas against scour.

2.5.2 Sediment Fill Stratigraphy and Material Placement

Data will be collected and reported by the construction contractor and Contracting Officer.

Objectives:

- Ensure that sediment is placed in a multiple lift layered fill as specified by the bulk fill plan to ensure predictable consolidation and final proposed bathymetry may be achieved (Condition C-1);
- Monitor and record sediment placement from various dredged cells to provide a general characterization of sediment fills within the MHEA in order to assist in predicting consolidation of materials (Condition C-1, P-1, P-5, P-8, P-10);
- Provide information essential to making any required adaptive modification of final fill plan to achieve desired final bathymetric conditions within the project site to support desired habitats and a stable environment (Condition D-3, P-1, P-5, P-8, P-10).
Duration:
• Total duration approximately 1 year concurrent with bulk fill placement;
• Beginning at the initiation of dredged material placement within MHEA;
• Ending at the completion of the bulk fill placement period.

Frequency:
• Weekly progress reviews during period of material placement into Middle Harbor;
• Bathymetry at the completion of each fill lift as specified by the bulk fill placement and layering specifications. (This work will be performed by the construction contractor.)

Data to be collected:
• Dredging cell source and material placement locations within the MHEA; This information will be provided by the Contracting Officer of the U.S. Army Corps of Engineers).
• Bathymetry of the individual fill layers as they are placed. (This work will be performed by the construction contractor.)

Analyses and reporting to be completed:
• A fill map shall be generated using dredged material source and placement data integrated with bathymetric survey data;
• Data is to be used to ensure correct material placement; to assess bulk fill consolidation; and in conjunction with settlement studies to extrapolate from sediment consolidation monitoring data relevant to the larger MHEA project area.
• Data are to be reported prior to placement of each subsequent fill lift. Data shall include a multi-layered material placement mapping of each of the MHEA fill lifts and associated bathymetric data.

Actions to be taken based on monitoring:
• During bulk fill placement, adjust fill placement if sediment layering objectives or fill patterns specified are not being achieved (Condition D-1, C-1);
• Record detailed layered bathymetry using a CAD system to allow for ease of tracking and extrapolation from consolidation data collected during the bulk fill consolidation period. (Condition D-3).

2.5.3 Bulk Fill Consolidation and Settlement

Objectives:
• Determine consolidation rates and coverage extent for the various filling phase of the MHEA (Condition C-1);
• Provide data for adjustment of subsequent fill plans to ensure achievement of final design bathymetric conditions (Condition D-3, P-1, P-5, P-8, P-10).

Duration:
• Total duration will be approximately three years including: 1) bulk fill placement period (approximately 1 year); 2) interim period between bulk and final fill placement (1 year); 3)
final fill placement period (0.25 years); final fill consolidation period (0.5 years), and; 4) final sculpting period (0.25 years);

- Prior to initiation of fill placement, work will begin with the establishment of four monitoring platforms supporting consolidation monitoring instrumentation; Monitoring platforms will be installed by the construction contractor.
- During fill placement, probes are to be placed at prescribed fill strata to track sediment settlement and residual pore pressures;

  **Frequency:**
  - Monitoring of settlement platforms will be completed at the completion of each fill during fill placement and once every three months during the consolidation period;
  - Bathymetric surveys of each fill lift will be completed within one week of fill placement for each lift by the construction contractor;
  - Within one month following the final placement of bulk fill, sediment coring will be completed at each consolidation monitoring station.
  - Bathymetric surveys will be completed at the beginning, mid-point, and end of the bulk fill consolidation periods to evaluate settlement rates.

**Analyses and reporting to be completed:**
- A fill map will be generated using dredged material source and placement data integrated with bathymetric survey data. Sediment consolidation curves will be generated from the bulk fill settlement station data;
- Using settlement data, and fill material stratigraphy, fully consolidated bulk fill contours will be predicted and used to adjust final fill plans as needed.
- Data will be reported semiannually during placement and consolidation periods.

**Actions to be taken based on monitoring:**
- A final technical memorandum will be prepared outlining any required fill depth modifications necessary in the final fill placement to achieve initial site elevation goals or alternative goals as dictated by biological and hydrologic investigations (Condition D-2, D-3, P-1, P-5, P-8, P-10).
- During the consolidation period, adjust final fill plans as necessary to address deviation in consolidation curves from those predicted during design to achieve habitat objectives. Final fill plans will be modified as needed within 60 days of completion of the bulk fill monitoring program. Surface sculpting plans will be modified as needed within 60 days of the completion of the final fill monitoring program (Condition D-2, D-3, P-1, P-5, P-8, P-10).
2.5.4 Hydrodynamic Model Verification and Adjustment

Objectives:
- Identify flow velocity patterns and wave conditions in the Middle Harbor and compare with numerical model predictions (Condition C-1);
- Conduct post-placement calibration of numerical models and conduct further design verification runs for final design conditions to be completed following first fill placement (Condition C-1);
- Develop recommendations for any design modifications required for final fill placement and surface sculpting and/or modification of the containment structure entrances to ensure achievement of desired habitats and stable site conditions (Conditions D-3, P-1, P-5, P-8, P-10).

Duration:
- Total duration will be approximately 1 year;
- Beginning after first bulk fill placement;
- Ending prior to final fill placement.

Frequency:
- Current velocity monitoring at fixed stations will be performed using instruments deployed over not less than a two week period, encompassing at least one strong spring tide approximately 6 months into the bulk fill settlement period;
- Wave height and direction will be monitored over a two month period, 6 months after the bulk fill placement and during a two month period 6 months later. Additional monitoring will be conducted if storm waves and differential wave attacks are not observed during the established monitoring periods;
- Tidal delay and muting will be assessed over both spring and neap tide periods using instrument deployments over two separate two week periods.
- Current velocity transect monitoring shall be conducted at the beginning of the bulk fill settlement period, and again approximately 6 months later. During each of these 2 sampling periods, monitoring will be conducted during one strong ebb tide and one strong flood tide period and during weak ebb and flood tide conditions.
- Suspended sediment concentration should be collected at fixed stations in synchrony with current velocity measurements.

Data to be collected:
- Current velocities and suspended sediment concentrations at fixed monitoring stations;
- Current velocities along several transect lines;
- Wave height and direction at fixed monitoring stations within and outside of the MHEA.

Analyses and reporting to be completed:
- Calibration curves will be prepared for hydrodynamic models to test predictions made during the design period;
- Design period models will be recalibrated using measured field data and will be run to predict the final fill conditions;
• Model predictions based on the recalibrated modeling will be compared to design period modeling to identify any substantive changes in the predicted hydrodynamic conditions of the MHEA in a completed state.

Actions to be taken based on monitoring:
• A final technical memorandum will be prepared which discusses differences between the design period models and the actual hydrodynamic conditions developed in the bulk fill condition. The memorandum will identify any differences between the observed hydrodynamics and model predictions for the final fill conditions and recommend any appropriate design modifications based on modified hydrodynamic modeling predictions. The memorandum will address deviations from prior models, issues of site stability including erosion, and accretion areas and rates (Conditions D-3, P-1, P-5, P-8, P-10);
• Final fill and surface sculpting plans will be reviewed in conjunction with the hydrodynamic model results and any recommendations for modifications needed to adapt final design to improve success potential shall be completed within 60 days of completion of the bulk fill monitoring program. The plans will consider not only any needs for modifying the soft fill contours but will also consider the desirability for modifying the entrances to the MHEA by extending containment or adjusting sill elevations (Conditions D-3, P-1, P-5, P-8, P-10).
2.5.5 Light, Sediment, and Water Quality within the MHEA

Objectives:
- Identify the effects of modified bathymetry and flow on light attenuation, sediment deposition and scour, and water quality (Conditions C-1, D-3);
- Conduct post-placement habitat suitability assessments of the habitat conditions developed throughout the MHEA to verify predictions made during design (Conditions D-3, P-1, P-5, P-8, P-10);
- Develop recommendations for any design modifications required for final fill placement and surface sculpting (Conditions D-3, P-1, P-5, P-8, P-10).

Duration:
- Total duration will be approximately 1 year;
- Beginning within two months after bulk fill placement;
- Ending prior to final fill placement.

Frequency:
- Establish 38 monitoring stations corresponding to future pilot planting areas;
- Sediment erosion and accretion investigations are to be initiated within 2 months of completion of bulk fill placement and shall include four bimonthly sampling intervals (4, 6, 8, and 10 months following fill placement);
- Conduct tended light, temperature, and turbidity monitoring using towed sampling arrays during high and low tides during spring and neap tide series 6 and 10 months following bulk fill placement;
- Establish untended monitoring stations in conjunction with current meters to measure DO, temperature, turbidity, PAR, salinity, and depth. Work will occur approximately 6 months after fill placement. Deployment periods will be for a minimum of a two week period and data will be collected at 20 minute intervals.

Data to be collected:
- From the established monitoring stations, data collected shall include the amount of erosion and deposition over interval time to determine rates of change;
- Towed instrument arrays shall provide spatial distribution and quantitative data on light, temperature and turbidity within the MHEA at high and low tidal stages;
- Station monitoring of DO, temperature, turbidity, PAR, salinity, and depth shall provide information on daily, as well as tidally influenced cycles in these parameters.

Analyses and reporting to be completed:
- The fixed monitoring stations shall be used to develop a coarse erosion and accretion map of the MHEA and to evaluate rates of elevational changes in potential eelgrass restoration areas;
- Data will be analyzed with hydrodynamic flow conditions and predictions and used to further assess sediment transport and deposition within the system;
- Towed instrument data shall be used to develop high and low-tide condition contour maps of light attenuation, and, when merged with bathymetric data, available bottom PAR.
Additionally, data will be used to develop contour maps of surface water temperature and turbidity at high and low tides;

- Fixed monitoring data will be used to determine normal cycles in measured parameters. Data will be used to investigate the effects on light, turbidity, temperature, and dissolved oxygen of tidal circulation relative to daily insolation and geographic position within the system.

**Actions to be taken based on monitoring:**

- A final technical memorandum will be prepared and integrated with the memorandum on hydrodynamic data to summarize information collected, explain the data in the context of its meaning to long-term development of eelgrass and other habitats, and to discuss the findings in the context of any necessary design changes prior to placement of the final fills. In addition, the data shall be used to further refine predictions regarding maintenance needs and site performance for various habitats (Conditions D-3, P-1, P-5, P-8, P-10);

- Final fill and surface sculpting plans shall be reviewed in conjunction with the hydrodynamic model results and any recommendations for modifications needed shall be completed within 60 days of completion of the bulk fill monitoring program (Conditions D-3, P-1, P-5, P-8, P-10).
2.6 HABITAT SUITABILITY EVAL./WARRANTY PERIOD (0-1.5 YR. POST-CONSTRUCTION)

2.6.1 Consolidation/Settlement Assessment

Objectives:

- Determine sediment consolidation and settlement of the final fill condition of the MHEA (Conditions C-1, D-3);
- Determine the settlement of habitat structures including bird islands and fish enhancement structures (C-1, D-3, D-5, D-10, D-11, D-12);
- Determine the settlement and deformation of the MHEA containment structures and marsh containment berm (C-1, D-3, D-11);
- Develop recommendations for any necessary modifications to fill contours or structures to achieve desired habitat objectives (D-2, D-3, and D-12).

Duration:

- Total duration shall be approximately 1.5 years;
- Beginning after final fill placement and surface sculpting.

Frequency:

- Bathymetric surveys shall be completed once at the beginning of the final fill consolidation period and once at the end of the period;
- Consolidation and settlement of the final MHEA fill shall be further assessed using the four consolidation monitoring platforms; monitoring shall occur once at the completion of the final fill and semi-annually for 1.5 years following the final fill placement.
- Surveys of bird roosting islands and the marsh containment berm will be completed three times, at six-month intervals (i.e. spanning an 18-month period).

Data to be collected:

- Bathymetric surveys of the entire MHEA;
- Consolidation curves for sediments generated at four monitoring stations;
- Surveys of structural habitat and marsh containment berm.

Analyses and reporting to be completed:

- Bathymetric and survey data shall be presented in chronological layers in a GIS database;
- Analyses of net change will be completed between data sets in order to document consolidation, erosion, and accretion changes within the system;
- Consolidation curves from the settlement station data shall be used to generate predictions on long-term consolidation over the entire site.

Actions to be taken based on monitoring:

- A technical memorandum will be prepared that presents data on site bathymetric change, structure settlement, and predicts long-term changes in the MHEA based on observed settlement, scour and accretion patterns (C-1, D-3, D-5, D-11, D-12, D-13);
- The technical memorandum will include any recommendations for implementation of corrective measures where deemed essential to meet the long-term goals of the MHEA;
If work would require more than minor repairs or modifications, a corrective measures plan will be prepared by the Corps/Port and reviewed by the TAC prior to implementation (Condition C-5). However, all work associated with restoring project contours, adjusting hydraulic features, adding or relocating fish structures, and tuning elevations or circulation patterns are considered to be minor modifications in the design. Work that would be subject to further TAC review would be any action that resulted in an inability or diminished capacity to achieve project performance goals.
## 2.6.2 Surface Sediment Stability and Topographic Suitability for Eelgrass/Marsh Restoration

**Objectives:**
- Determine when surface stability, sediment characteristics, and topography are adequate to support transplantation of eelgrass and marsh plants without high incidence of failure (Condition C-1, D-8, D-9);
- Establish a baseline condition against which future monitoring results may be compared (Condition P-1, P-5);
- Identify any required modifications to proposed Phase 1 pilot restoration sites (Condition D-9);
- Assess the area of the site that is potentially suited to the restoration of eelgrass habitat.

**Duration:**
- Total duration shall be approximately 4 to 12 months depending upon rate of surface stabilization;
- Beginning after final fill sculpting and placement;
- Ending upon initiation of eelgrass planting.

**Frequency:**
- Establish 38 monitoring stations corresponding to proposed pilot planting areas;
- Sediment erosion and accretion investigations are to be initiated within 2 months of completion of final fill sculpting and will include monthly sampling for a period of 6 months;
- Site stability is to be investigated monthly until conditions are appropriate to transplant eelgrass.
- Sediment samples are to be collected at each of the 38 monitoring stations during months 0, 3, 6, 12, and 18 following completion of final fill sculpting.

**Data to be collected:**
- From the established monitoring stations, data collected shall include determining the amount of erosion and deposition over interval time to determine rates of change, as well as evaluating bottom stability relative to the ability to receive transplanted eelgrass planting units;
- Sediment samples are to be analyzed for particle size using standard ASTM D-1140 methods.

**Analyses and reporting to be completed:**
- The fixed monitoring stations shall be used to develop a coarse erosion and accretion map of the MHEA and to evaluate rates of elevational changes in potential eelgrass restoration areas;
- Data will be analyzed with hydrodynamic flow conditions and predictions and used to further assess sediment transport and deposition within the system;
- Sediment particle size data will be used to assess deposition and scour across the pilot planting areas and evaluate changes in sediment grain size relative to the suitability for target biological community development.

**Actions to be taken based on monitoring:**
- Monthly progress reports will be prepared identifying the area of the site that is suitable for planting based on acceptable sediment stability, sediment particle size, adequate diffuse attenuation coefficients (DAC), and calculated canopy level PAR daily dosages in various portions of the MHEA for eelgrass, and acceptable sediment stability.
- The reports will make recommendations as to when to initiate planting, based on the availability of suitable planting areas and source materials, efficiencies of scale in planting operations, and seasonality of the vegetation being planted. (Condition D-3)
2.6.3 MHEA Water Column Environmental Conditions

Objectives:
- Identify the water column conditions following the final fill and sculpting of the MHEA;
- Establish a baseline against which future water quality conditions may be assessed to aid in evaluation of site performance and need for maintenance (Condition C-1);
- Verify water residence time predictions and locate any areas of concern relative to poor circulation and water quality;
- Determine the suitability of various areas of the MHEA to support desired habitats and provide for early detection of potential problems to be addressed by site management;
- Verify adequacy of conditions to proceed with scheduled 1st phase eelgrass planting in plots selected, or provide recommendations for revision to plans prior to proceeding (Condition D-2, D-3);
- Provide an early predictor as to probable development of eelgrass habitat through the phase two transplant and natural recruitment from planted stock (Condition C-1).

Duration:
- Total duration shall be approximately 18 months;
- Beginning after final fill sculpting and placement.

Frequency:
- Conduct tended light, temperature, and turbidity monitoring using towed sampling arrays during high and low tides during spring and neap tide series 6, 12, and 18 months following final fill sculpting;
- Establish untended monitoring stations at 6, 12, and 18 months at selected stations and outside reference area beds at Crown Beach and Bayfarm Island to examine DO, temperature, turbidity, PAR, salinity, and depth. Deployment periods will be over a minimum of a two week period at each station. Rotations will occur between stations while maintaining continual monitoring at the control site. Data will be collected at 20 minute intervals;
- Conduct a short-term florescent dye dispersion study to examine residence time, circulation patterns, and stagnant pool distribution patterns. Studies are to include the use of towed florometers to plot tracer concentrations and evaluate concentration distributions through multiple tidal cycles. Using concentration degradation curves, water turnover will be calculated for the MHEA.

Data to be collected:
- Towed instrument arrays shall provide spatial distribution and quantitative data on light, temperature and turbidity in the MHEA at high and low tidal stages;
- Station monitoring of DO, temperature, turbidity, PAR, salinity, and depth will provide information on daily as well as tidally influenced cycles in these parameters;
- Dye dispersion studies will generate time dependent maps of dye concentration through a number of tidal cycles;
• Any areas identified with high water mass residence time will be further investigated using deployed instruments to measure dissolved oxygen conditions as a means of evaluating potential water quality concerns.

Analyses and reporting to be completed:
• Towed instrument data will be used to develop high and low-tide condition contour maps of light attenuation, and, when merged with bathymetric data, available bottom PAR. Additionally, data will be used to develop contour maps of surface water temperature and turbidity at high and low tides;
• Towed instrument data for dye dispersion studies will similarly be managed and data will be plotted in GIS for visual display and change analyses will be completed using numeric and spatial modeling tools;
• Fixed monitoring data will be used to determine normal cycles in measured parameters. Data will be used to investigate the effects on light, turbidity, temperature, and dissolved oxygen of tidal circulation relative to daily insolation and geographic position within the system.
• A technical memorandum will be prepared which discusses the findings of the monitoring and provides an estimation of the areas and amount of habitat likely to be developed over the course of the subsequent performance evaluation period. The memorandum shall also identify any significant concerns and issues over the subsequent 10 year period. (Condition D-9, P-5, P-8).
2.7 PERFORMANCE EVALUATION PERIOD (0-10 YEAR POST-EELGRASS PLANTING)

2.7.1 Physical Site Conditions Development

**Bathymetry and Avian Island Surveys**

Objectives:
- Evaluate long-term bathymetric changes within the MHEA and develop a plan of action if any deficient settlement, erosion, or deposition conditions are observed that would be detrimental to the long-term success of the habitat (Condition P-8, P-10, P-11);
- Evaluate change in sediment particle size as a means of examining erosion/accretion and habitat suitability changes within the MHEA
- Evaluate changes in avian island elevations and form;
- Assist in refining maintenance dredging trigger monitoring schedules based on long-term rates of site change (Condition P-8, M-1);
- Assist in refining maintenance dredging cost estimates based on observed rates of sediment deposition (Condition M-1).

**Frequency:**
- Bathymetric surveys shall be completed once each year in years 1, 2, 3, 5, and 10.
- Sediment grain size analysis shall be completed once each year in years 1, 2, 3, 5, and 10.

**Data to be collected:**
- Bathymetric surveys of the entire MHEA;
- Sediment grain size distribution for surface sediments at 20 monitoring stations corresponding to benthic infauna sampling locations;
- Physical surveys of avian islands.

**Analyses and reporting to be completed:**
- Bathymetric surveys will be presented in a GIS database as separate layers for each survey year;
- Elevation/area graphs for each survey year shall be prepared;
- Grain size distribution curves shall be prepared for each monitoring station with cumulative curves for successive years being presented together;
- An analysis of sediment particle size change will be developed, mapped, and analyzed relative to benthic community data;
- Analyses of net change in bathymetry and islands shall be completed between data sets in order to document settlement, consolidation, erosion, and accretion changes within the system.

**Actions to be taken based on monitoring:**
- Monitoring reports will include a section on site bathymetry that will include presentation of data as bathymetric charts and contour change analyses. Data shall also be presented as a volumetric summary of erosion and accretion. Data shall be used to monitor long-
term changes in the MHEA and predict the costs, anticipated frequency, and need for periodic maintenance dredging (Condition M-1, M-6, M-8, M-9).

- Sediment particle size shift will be used to further support conclusions regarding erosion and accretion patterns, rates, and equilibrium conditions.
- Sediment particle size changes will be used to assist in the interpretation of biological data including eelgrass and benthic community development.
2.7.2 Biological Resources Development

*Eelgrass*

Objectives:
- Track the development of eelgrass habitat within the MHEA (Condition P-1, P-2, P-3, P-5, P-7, P-8, P-10, M-8);
- Evaluate eelgrass donor bed impacts one year following harvest to determine if residual impacts occurred (Condition P-9);
- Determine whether eelgrass meets the project requirements for eelgrass habitat creation and at what level (Conditions P-1, P-8, P-11).

Duration:
- Total duration 10 years;
- Beginning at the termination of the 2nd phase eelgrass planting.

Frequency:
- Eelgrass surveys shall be completed once each year in years 1, 2, 3, 5, 7, and 10. Surveys will be conducted in June-July of each year.

Data to be collected:
- Eelgrass surveys will be completed using a combination of side-scan sonar and bathymetry with diver ground-truthing to resolve any identification uncertainties and complete shoot density assessments. Data collected will include both electronic digital and paper chart records for side-scan as well as paper chart records for bathymetry data and diver ground-truthing.

Analyses and reporting to be completed:
- Survey results will be presented as eelgrass bed density maps using separate data layers for each survey year in a GIS database;
- Analyses of net change will be completed between yearly data sets in order to document expansions and contractions in eelgrass beds.
- Monitoring reports will include a section on eelgrass habitat development that will include presentation of data as cumulative distribution maps, as well as summary tables and charts expressing trends in the eelgrass bed cover by density class and cumulative total area over the course of the monitoring period. The reports will also include an assessment of the status of the MHEA relative to meeting identified eelgrass restoration goals. (Conditions P-1, P-8, P-11)

Actions to be taken based on monitoring:
- Phase 1 monitoring will be used to identify conditions suitable to support eelgrass within the MHEA and will guide further planting during Phase 2 transplants.
- Phase 1 monitoring of the donor eelgrass beds will provide information to determine if prolonged detectable impacts to donor beds occur. If this monitoring indicates that a
Phase 2 harvesting is not prudent, then a second phase of transplants will either not occur or will be accomplished by dividing Phase 1 transplant units within the MHEA.

- If eelgrass performance is not met, additional site evaluations will be undertaken to determine the probable limiting factors and to identify possible methods to correct these. Consideration will be given to modifying the MHEA to expand eelgrass habitats.
**Salt Marsh**

Objectives:
- Track the development of salt marsh habitat within the MHEA (Condition D-2, D-8, P-3, P-4, P-7).
- Identify maintenance requirements.

Duration:
- Total duration 10 years;
- Beginning at the termination of the planting (within 0.5 years of completion of final fill sculpting and end of contractor warranty period).

Frequency:
- Salt marsh surveys will be completed once each year in years 1, 2, 3, 5, and 10. Surveys will be conducted in June-July of each year.

**Data to be collected:**
- Marsh surveys shall be completed using a combination of low elevation aerial photography to establish vegetative cover, stratified random quadrat surveys to document vegetation composition and canopy height, and general field surveys to document floral species occurrence and species recruitment events, including colonization by invasive species.

**Analyses and reporting to be completed:**
- Aerial survey results shall be presented as marsh vegetation maps (including high, mid, and low marsh vegetation classes) using separate data layers for each survey year in a GIS database;
- Quadrat survey data shall be used to determine and present temporal patterns of change in marsh vegetation cover and composition. Aerial coverage data shall be analyzed to determine and present larger-scale vegetation coverage information;
- Analyses of net change shall be completed between yearly data sets in order to document expansions, contractions, and conversions between marsh habitat types;
- Monitoring reports shall include a section on marsh habitat development that includes presentation of data as habitat distribution maps as well as summary tables and charts expressing trends in the marsh cover by vegetation type. (Condition P-3, P-4, P-7)

**Actions to be taken based on monitoring:**
- Triggered maintenance actions to remove exotic species.
**Benthic Communities**

Objectives:
- Track the development of the benthic community within the (Condition P-2, P-3, P-10).

Duration:
- Total duration 10 years;
- Begins at the termination of the contractor’s warranty period.

Frequency:
- Benthic infaunal surveys will be completed once each year in years 1, 2, 3, 5, 7, and 10. Surveys will be conducted in April of each year coincident with collection of sediment grain size samples;
- Benthic epifaunal surveys are to be completed as an element of fish community surveys and shall be conducted in April of years 1 through 10.

Data to be collected:
- Benthic infaunal surveys will include the collection and identification of density, biomass, and composition of invertebrates by major taxonomic groups;
- Epibenthic surveys will include the collection of information on epibenthic invertebrate fauna including density, biomass, and composition by species.

Analyses and reporting to be completed:
- Data on benthic fauna will be summarized in tabular and chart formats;
- Analyses will include assessment of changes in biomass and density with respect to time, habitat, tidal elevation, sediment particle sizes, and total organic carbon.
- Monitoring reports will include a section on benthic community development which will include presentation of data as summary tables and charts and provide an analysis of changes relative to the time since project construction and any habitat changes (Condition P-2, P-3, P-4, P-7, P-10).
Fish and Epibenthic Communities

Objectives:
- Track the development of the fish community within the MHEA including sampling of shallow unvegetated subtidal areas, shallow channels, eelgrass habitat, and eelgrass reference areas (Condition P-2, P-3, P-4, P-7, P-10);
- Determine if least tern foraging habitat has been improved with respect to the expansion of occurrence and availability of post-larval forage fish of the size and species consumed by least terns. (Condition P-4, P-6, P-10)
- Compare abundance of fish during the 10 year monitoring program to baseline conditions. (P-11)
- Use the "by-catch" of the fish sampling methods to monitor abundance and diversity of epibenthic fauna, particularly the crabs and shrimps.

Duration:
- Total duration 10 years;
- Begins at the termination of the construction warranty period.

Frequency:
- Fish community surveys will be conducted annually each year in years 1 through 10. Surveys will be conducted in April and July of each year.

Data to be collected:
- Fish community surveys will include sampling and identification of density, biomass, and composition of fishes using multiple gear types (Gear types to be reviewed based upon effectiveness of gear in created habitats);
- April surveys will include the use of beach seines, round haul nets, otter trawl, long line, and perhaps other gear as necessary to document biodiversity;
- Summer surveys will include the use of beach seines and round haul nets and are to target small schooling fish that may serve as prey for least terns;
- Crabs and shrimps will be identified and enumerated from all fishing gear types.

Analyses and reporting to be completed:
- Data of fish communities will be summarized in tabular and chart formats;
- Community composition changes, and size class distributions for dominant species will be developed;
- Focused assessments will be made of the smaller schooling fish as a food resource to terns, and analyses of this group by species, size class, and abundance will be conducted during the tern season;
- Compare the abundance of fish to baseline conditions prior to completion of the MHEA.
- Compare the abundance of shrimps and crabs to baseline conditions prior to completion of the MHEA.
- Monitoring reports will include a section on fish community development that will include presentation of data in summary tables and charts and provide an analysis of
changes relative to time and habitat changes and importance to the overall system, and
comparison to baseline conditions (Condition P-2, P-3, P-4, P-7, and P-10).

- The monitoring report will specifically assess the fish community structure relative to
  resources available as a contributor to the forage base for least terns and determine if the
  MHEA is more productive as a foraging area or forage fish producer than was the un-
  modified deepwater Middle Harbor. (Condition P-4, P-6, P-10).
Avian Communities

Objectives:
- Assess the utility of various habitats created for different bird guilds (Condition D-8, D-11, P-2, P-3, P-4, P-6, P-7, P-10, M-8) including brown pelican and California least tern;
- Examine species diversity and abundance patterns as well as habitat use patterns relative to natural variability observed in other estuarine, marsh, and marine habitats existing within the immediate vicinity, specifically the Martin Luther King shoreline and Arrowhead Marsh.

Duration:
- Total duration 10 years;
- Beginning at the termination of the contractor’s warranty period.

Frequency:
- General avian surveys will be conducted 2 times/year in years 1, 2, 3, 5, 7, and 10. Two surveys each will be conducted in December and June of each year. To the extent possible, surveys will be conducted during two consecutive weeks by boat and on foot and will be conducted during low-tide and high-tide on each of the two survey dates during the sampling period;
- Comparable surveys will be conducted within MLK/Arrowhead Marsh reference areas.

Data to be collected:
- Avian community surveys will identify the species composition, abundance, and activities of birds present. In addition, surveys will identify the bird distribution by habitat and survey zone within the MHEA and reference areas. As a part of the bird surveys, human abundance and activities will be recorded.

Analyses and reporting to be completed:
- Data for avian communities will be summarized in tabular, chart, and map formats;
- Bird species will be grouped based on guilds of shared characteristics and analyzed by these groupings, with particular emphasis on brown pelicans and least terns;
- Community composition and distribution of bird guilds will be analyzed both on the basis of season and period since project completion;
- Analyses will include assessment of changes in bird density, activity patterns, and distribution patterns relative to tides, season, survey year, and human activities;
- Comparisons of density and diversity relative to the pre-project baseline data;
- Comparisons of avian diversity and density to reference areas will also be made for purposes of considering normal seasonal and interannual variability within the regions avian communities but not for purposes of comparisons to evaluate performance of the site.
- Monitoring reports will include a section on avian communities which will include presentation of data as summary maps, tables and charts and providing an analysis of site uses relative to time, season, tides, habitats (Condition P-2, P-3, P-4, P-6, P-7, P-10, M-8).
2.7.3 Human Use and Public Access

**Human Use and Public Access**

Objectives:
- Track the activities and intensity of public use within the MHEA over the course of the monitoring period (Conditions D-4, R-1, R-2, R-3);
- Determine the extent of public compliance with applicable MHEA regulations (Condition M-3, M-4);
- Identify any conflicts between public access and habitat development conflicts and identify potential mechanisms for conflict resolution (Condition R-2).
- Identify any persistent violations of public access restrictions such as the presence of domestic animals within the MHEA, access into closed areas, or operation of motorized vessels beyond research, patrol, and emergency vessels.

Duration:
- Total duration 10 years;
- Beginning at the termination of the contractor’s warranty period.

Frequency:
- Public access and use surveys will be conducted concurrent with avian surveys and will be conducted in December and June of each year in years 1, 2, 3, 5, 7, and 10. To the extent possible, surveys will be conducted on two consecutive weeks by boat and on foot and shall be conducted during low-tide and high-tide on each of the two survey dates during the quarter.

**Data to be collected:**
Public access and use will include information on abundance (group size), and activities (kayaking, sail boating, wading, swimming, etc.). In addition, surveys will identify human use by habitat and survey zone within the MHEA. The manager will coordinate surveys with the manager of the MHSP.

**Analyses and reporting to be completed:**
- Human access and usage will be presented by MHEA regions;
- Distribution of public uses will be analyzed both on the basis of season and period since project completion;
- Analyses shall include assessment of frequency and type of MHEA access rule violations and any changes in bird density, activity patterns, and distribution patterns relative to human activities;
- Monitoring reports will include a section on human use and public access including identification of persistent conflicts.

**Actions to be taken based on monitoring:**
- Make recommendations to remedy public access conflicts in cooperation with the MHSP manager to resolve conflicts through education, signage, physical access restriction, or docent programs, etc.
2.8 LONG-TERM SITE MANAGEMENT PERIOD (10+ YEARS POST-EELGRASS PLANTING)

2.8.1 Physical Site Changes and Maintenance Needs Identification

**Bathymetry**

Objectives:
- Monitor long-term bathymetric changes within the MHEA relative to maintenance dredging needs and hydrologic or elevational impairment triggers for required action (Condition M-6, M-9);
- Assist in continually refining maintenance dredging schedules and cost estimates based on long-term monitoring of observed rates of sediment deposition and natural geomorphic developments (Condition D-3, M-1, M-6, M-9).

Duration:
- In perpetuity;
- Beginning 10 years post-planting of eelgrass in MHEA.

Frequency:
- Surveys are to be conducted once every three years (subject to modification based on observed bathymetry);

Data to be collected:
- Comprehensive site bathymetry.

Analyses to be completed:
- Data will be analyzed and used to construct bathymetric contour maps that will be saved as GIS data layers;
- Time series bed form analyses will be completed;
- Conditions will be compared to maintenance threshold triggers identified during the habitat establishment monitoring period;

Actions to be taken based on monitoring:
- Management reports will be prepared for each active monitoring year, documenting work completed during the year and summarizing maintenance actions required or anticipated in the subsequent year. These management reports will include a section on maintenance dredging which shall include maps and textual and chart summaries of the most recent bathymetric surveys, rates of sediment deposition, and status of the site bathymetry relative to maintenance dredging triggers (Condition M-1, M-6, M-9).
**Avian Islands**

Objectives:
- Monitor avian island settlement and bird usage to identify any maintenance reconstruction or vegetation control needs (Condition M-6, M-9).

  Duration:
  - In perpetuity;
  - Beginning 10 years post-planting of eelgrass in MHEA.

  Frequency:
  - Annual island bird use surveys will be performed during high and low tides during the winter (December) and summer (June).
  - Island profile surveys will be conducted every three years (subject to modification based on history of rates of change);
  - Surveys will also be completed following major seismic events, if observations of change (such as deformation or changing high tide lines) are noted.

Data to be collected:
- Bird usage surveys will document the number, species, and activities of birds using each island. These surveys may be coordinated with efforts of local citizen groups (e.g. Audubon bird counts)
- Island sections running due north-south and east-west will be surveyed across a monumented apex of each island.

Analyses to be completed:
- Bird usage survey data will be summarized by island and will report bird use in tabular and chart formats;
- Physical survey data will be presented as a time series of island cross-sections allowing for the assessment of island shape and elevation change over time.

Actions to be taken based on monitoring:
- Management reports will include a section on avian roosting islands which will include maps, tables, charts, profiles, and summaries of the status of each island (Condition M-6, M-9);
- Maintain an island, in the form of vegetation control, rock supplement or other forms of reconstruction will be based on a combination of island deterioration and diminishing values to avifauna (Condition M-6, M-9).
2.8.2 Habitat Concerns Relative to Maintenance Needs

Habitat and Public Access Interface

Objectives:
- Monitor long-term conditions of the marsh access areas to determine if excessive damage is occurring and adjust access areas or limit access, if warranted (Condition M-6, M-9);
- Monitor public access within restricted access areas and determine if additional access controls are necessary to adequately protect sensitive resources along the UP Mole area (Condition M-6, M-9);
- Monitor boating access to determine the level of compliance with restrictions on motorized crafts and fixed keel vessels and determine if additional access controls or modification of regulations is needed (Condition M-9).

Duration:
- In perpetuity;
- Beginning 10 years post-planting of eelgrass in MHEA.

Frequency:
- At least monthly.

Data to be collected:
- Conditions of site and levels of degradation.

Analyses to be completed:
- Evaluation of degree of impact or access regulation violation on a qualitative basis.

Actions to be taken based on monitoring:
- Management reports will be prepared each year documenting identified habitat degradation issues arising during the year and actions taken to resolve problems during the course of the year. Reports will also identify the level of observed success of impact reduction following implementation of additional measures. (Condition M-1, M-6, M-9).
3.0 MAINTENANCE AND MANAGEMENT PROGRAM

The MHEA has been designed to require minimal on-going maintenance. However, to ensure the long-term health and viability of the area, some level of on-going management and maintenance will be required. The Corps/Port will provide the necessary legal instruments and financial commitments to ensure permanent preservation and management of MHEA as a wildlife habitat. Further, the CD requires that the management entity agree to manage MHEA for wildlife habitat values. In accordance with the USFWS BO, documentation that the MHEA will be maintained and managed in perpetuity must be provided and approved prior to initiation of dredging.

While the MHEA management is principally focused on the habitat and fish and wildlife benefits, the area also must support various joint uses of public access for education and recreation. This burden is not exclusively one of the MHEA, but rather is shared by the adjacent Middle Harbor Shoreline Park. The Port of Oakland’s MHSP (not addressed in this management plan) has a reciprocal obligation to focus on public access for education and recreation while maintaining and protecting habitat, fish and wildlife benefits developed around the MHEA. The Middle Harbor Shoreline Park will include necessary management of surrounding uplands. Park management activities will extend down to the high-tide line except at the public beach area between the training walls where park maintenance shall extend down to the 0 foot MLLW elevation (Figure 1-2). The MHSP will provide for public access and viewing opportunities as well as opportunities for environmental education. The management plans for both the MHEA and the MHSP will provide for resolution of any conflict that might emerge between the public access and MHEA habitat. This does not mean that the MHSP must necessarily bear the full burden of any actions necessary to resolve conflict, however, it must provide the mechanisms for implementing such resolutions.

The MHEA has an obligation to maintain opportunities for public access coincident with the shoreline facilities developed within the MHSP. It also has an obligation to accommodate public access for educational and recreational purposes to the extent that these uses are limited in their adverse impact to managed ecological resources. This maintenance and management section is designed to identify the long-term work efforts anticipated to be required to fulfill the MHEA obligations consistent with the habitat and public access goals established for the area.

3.1 SITE MANAGER REQUIREMENTS

It is intended that a resource management entity be selected and adequately funded to take on responsibility for perpetual management of the MHEA. The TAC Agreement and first phase CD require that an appropriate non-Port entity, with wildlife area management expertise, be charged with the management responsibility for the MHEA. However, the Port has also indicated a desire to maintain some level of involvement in the MHEA.

The site manager must possess the following technical and business management capabilities:

- An established history of managing parks or natural resource areas that demonstrates both an understanding of natural systems and an effective use of resources;
- Demonstrated staff and equipment resources or ability to contract for required services;
- Experience working within coastal wetland and marine environments;
- A solid understanding of coastal resource ecology and estuarine physical processes.
Further, the entity must commit to managing the MHEA by providing a selected site manager through staff resources, contractual means, or other dependable methods. This demonstrated ability to meet the long-term commitment would be necessary to effectively manage the MHEA. The manager must be willing to work cooperatively with the manager(s) of the MHSP to efficiently and effectively integrate resource conservation and public access. It is further anticipated that the site manager will coordinate with interested members of resource and regulatory agencies and the TAC as appropriate.

3.2 LONG-TERM MAINTENANCE REQUIREMENTS

Long-term management of the MHEA includes regular inspections and routine maintenance. Less frequent major maintenance is also anticipated but cannot be fully determined at the present time. The required maintenance outlined in this section is considered to be an essential element of the MHEA work.

3.2.1 Site Reviews and Patrols

While a full-time on-site manager is not anticipated, it is contemplated that regular site inspections will be made by the site manager to assess maintenance needs and to evaluate the effectiveness of public access controls.

Site Reviews
Site reviews are expected to be made regularly by the management entity. During each review, the staff will be present on-site for at least two hours and will inspect and assess the following:

- Review the shoreline and identify debris accumulation in public access and habitat areas, shoreline erosion/accretion, vegetation establishment on islands;
- Assess the need for debris removal in public access and shoreline habitat areas;
- Review the condition of signage and buoy markers and assess maintenance needs;
- Note the level and type of public use and whether restricted access areas are violated and where violations occur;
- Determine the need, if any, for active enforcement, additional passive enforcement, or modification of restricted areas;
- Evaluate marsh damage from authorized access and determine the need, if any, for modification of access areas or modification of access intensity;
- Note the degree to which birds are using various areas of the marsh, shoreline, and roosting islands.

Patrol and Enforcement
The MHEA management criteria call for specific restrictions on access and allowable uses within the MHEA. Restrictions require that:

- No encroachment of swimming, boating, hiking, and other human disturbance may occur within 200 ft. of designated least tern or brown pelican roosting areas;
- Only non-motorized vessels without fixed keels shall be authorized within the MHEA except for vessels required for scientific sampling and maintenance activities;
- The motors on scientific and maintenance vessels must be kept well maintained to minimize contamination of the MHEA;
- No access to the containment jetty and bulkhead is authorized;
All restricted access areas shall be adhered to as posted.

Because the use regulations were contemplated as a part of the MHEA requirements within the USFWS BO, once adopted, regulations shall not be modified without the review and approval of the USFWS.

The site manager shall conduct regular reviews and patrols of the site to determine if site regulations are being followed. In the event that chronic violations are noted and adaptive control measures are unsuccessful, the site manager shall take action to enforce measures through one or more options including:

- Issue advisory warning letters by mail or in person to violators. This may be done either by direct contact, or through tracing of vehicle or vessel registration numbers;
- Enlist the assistance of local law enforcement including, but not limited to, Oakland Police Department and California Department of Fish and Game, to issue citations;
- Issue citations directly (assuming the site manager selected has police enforcement powers).

**3.2.2 Minor Maintenance**

**Debris/Trash Removal**

Debris removal will be required along MHEA shorelines in order to maintain a healthy and aesthetically appealing resource. While the degree to which debris accumulates will fluctuate over time, the locations where material will aggregate are fairly predictable.

The site manager will remove material as it accumulates to the north of Point Arnold and in areas located to the south of the MHSP beach (The MHSP manager will be responsible for removal of trash and debris on the MHSP beach). Management agreements between the MHEA and MHSP are encouraged. In areas located to the south of the MHSP beach, accumulated natural kelp and eelgrass wrack will be left in place while non-natural debris will be removed. The natural kelp and eelgrass wrack provides an important detrital forage-base for maintenance of invertebrates, such as kelp flies and amphipods, that are prey to shorebirds and small fish. For this reason, these resources are not to be removed from the coves or restricted access area along the UP Mole.

Trash and debris removal is anticipated to be completed as needed with an estimated monthly frequency. More frequent removal may be required during certain times of the year.

**Signage/Buoy Maintenance**

The MHEA includes a number of buoys and signs used to mark navigational and restricted access areas. These markers require maintenance to replace worn or damaged units, remove excessive marine growth, and replace worn anchor chains and shackles. In addition, it may be appropriate to relocate or add additional markers based on human use monitoring. This work will be competed as a part of the signage/buoy maintenance program.

Annual maintenance of signage/buoys will be required. Replacement of buoys is anticipated to be required on an approximately three year cycle, while signage replacement will depend upon the degree of vandalism experienced.
Vegetation Control
The MHEA could experience two forms of vegetation growth impacts. The first is the establishment of native or non-native vegetation on avian islands which would adversely impact avian uses. The second impact is the establishment of exotic vegetation within the MHEA and the subsequent degradation of habitat. Specifically, the establishment of smooth cordgrass (Spartina alterniflora) is a primary concern.

Avian Island Vegetation
Significant establishment of vegetation on the avian islands is not anticipated to occur since the islands are to be constructed of rock and would initially lack finer sediments. As the system matures, fine sediment will accrete around some of the islands. Accretion will generally occur below mean sea level (a tidal range below the elevation at which vascular vegetation will generally grow). Over time, an accumulation of both silt and bird droppings will result in enough fine sediment for some vegetation to become established in low energy areas. However, in areas exposed to regular wave energy, it is not anticipated that significant vegetation will ever become established. For this reason, vegetation control on islands is not expected to be a significant concern.

If, however, vegetation does begin to dominate portions of various islands, then the site manager will remove it. If there is a conflict between bird use and vegetation, it may also be appropriate to reduce the accumulation of sediment by spraying the islands with a fire hose.

Exotic Species Establishment
Control of exotic species may be more difficult than island vegetation control and ultimately may be found to be impractical. However, it is highly desirable to maintain the MHEA free of invasive exotic plant species for as long as possible. To minimize the establishment of exotic species, most particularly, smooth cordgrass, annual survey and eradication efforts if needed shall be undertaken in middle summer. This period is preferred for control since it will be after seedlings become established but prior to extensive growth and sub-surface rhizome expansion. Plants will be removed by hand or herbicide treated with a direct wick-type application of Monsanto’s Rodeo® or similar EPA wetland application certified product. In the event that significant numbers of undesirable plants are found, a second effort, in the late summer shall be undertaken.

3.2.3. Major Maintenance
Major maintenance is characterized as maintenance requiring extensive directed activities to correct a degrading condition within the MHEA. Such maintenance activity is anticipated to be infrequent and may require specialized expertise and equipment. Most major maintenance is anticipated to be contracted out by the site manager. Specific major maintenance which may be required within the MHEA includes maintenance dredging and avian island reconstruction.

Maintenance Dredging
Maintenance dredging is anticipated to be required principally within the deep basin at the west end of the site, but may also occur elsewhere. Maintenance dredging requirements within the habitat areas are not anticipated to be the principal means of addressing natural changes. To the extent that natural system development is not at odds with designated habitat goals, no modifications are proposed. If sedimentation is identified as a chronic problem, opportunities will be sought to tune the system by adjusting the entrance apertures or modifying the forms of islands and shoals. If specific areas of sedimentation are neither acceptable in the context of natural system development nor resolvable by tuning the system, then dredging shall be contemplated as an ongoing maintenance
element. Accretion may occur in the various channel systems and most particularly in the upper ends of the side channels extending away from the main channel.

Maintenance dredging should not be triggered by the normal site evolution so long as that condition is not detrimental to the overall habitat goals. The as-built conditions achieved within the MHEA will be a result of best professional judgement, predictive modeling, constructability analyses and practical engineering, material and placement properties, as well as contractor capabilities. The final stable conditions achieved will be the result of natural weathering of the as-built conditions combined with depositional processes. These processes are expected to change the MHEA from the as-built condition to a more natural form. This process may occur over several years and even decades. To conduct maintenance in an attempt to prevent this process would result in impacts and be of little benefit.

The determination as to whether or not maintenance dredging is required should be made based on a multiple step assessment of physical sediment accumulation and adverse site response to the accumulation. Specifically, maintenance dredging should only be conducted when the following findings are made:

1) Sediment has accumulated within the MHEA and has not simply been reconfigured within the site;
2) Sediment accumulation is occurring in a manner that is adverse to the natural habitat development and persistence within the site as determined by changes in circulation, physical water quality parameters, or habitat distribution and abundance;
3) It is not anticipated that an alternative stable site condition with comparable and similar habitat values will result in absence of intervention;
4) Modifications to structural components of the site (jetty openings, wave attenuation or circulation structures) would not correct the situation observed, and;
5) Maintenance dredging would not result in impacts that are greater than not taking any action when considering the logical progression of the site in absence of the dredging.

When it is determined that maintenance dredging is required, actions should be targeted at achieving specific objectives as follows:

- Removal of accumulated imported sediments at a rate that is roughly comparable to the rate of sediment input to the system allowing for some sediment loss beyond maintenance areas;
- Removal of sediment from areas which exhibit rapid and substantial accretion and which, if left unmaintained, would result in deleterious effects to the system through adverse alteration of the hydrodynamics, degradation of water quality, or unwanted modifications to elevations;
- Maintain or improve the overall habitat values of the system, while recognizing that some localized resource impacts may be necessary to achieve a greater area-wide benefit.

As an initial maintenance trigger, sediment removal from the western sedimentation basin shall be considered when the volume of the basin is reduced to less than 50% of its initial capacity. If monitoring of the sedimentation rate and/or site hydrodynamics indicate that different percentages of volume removal are appropriate, then volumes will be modified upward or downward.

Specific assessments of the maintenance triggers will be made during the Performance Evaluation Period after the second, third, fifth, and tenth years following final construction. Adjustment of the
maintenance triggers during the Performance Evaluation Period will be made through the revisions to this plan and shall be incorporated into RWQCB and BCDC permits administratively by adoption of the revised plan. During this period, the Middle Harbor Habitat TAC will serve in an advisory role to the permitting agencies.

Adjustments to the maintenance dredging triggers following the end of the Performance Evaluation Period will be made by the concurrence of the habitat management entity with the resource and regulatory agencies. The forum for these modifications will be the Dredged Material Management Office (DMMO) which will evaluate compliance with the maintenance plan or proposed modifications to the maintenance triggers.

The need to perform maintenance dredging has been contemplated as a part of the MHEA management process and it may be essential to the long-term viability of the area. For this reason, future maintenance dredging in conformance with the maintenance objectives for the MHEA is considered to be a part of the work authorized by initial project approvals. Maintenance dredging may have some adverse impacts to MHEA resources such as localized loss of eelgrass habitat, however, such impacts are anticipated and adequately compensated for by the benefits maintenance provides to the overall system.

Maintenance dredging will be subject to the same impact minimization requirements required of the initial dredging and material placement efforts used to create the MHEA.

**Avian Island Reconstruction**

Avian islands within the MHEA will be constructed on liquifiable sediment bases and may be subject to some level of natural subsidence and further deformation during seismic events. The anticipated subsidence has been accounted for in the design, however, seismic deformation can only be addressed as a maintenance element.

In the event that avian islands are degraded by seismic activities, it is appropriate to evaluate the degree to which islands have been affected, the impacts the deformation has had on bird utility, and whether island reconstruction is warranted based on the level of impact the change in island conditions has had on avian usage within the MHEA.

If it is determined that island reconstruction is necessary, repair plans shall be prepared and used to guide maintenance work. The repair plans shall include an access and construction control plan to minimize any adverse impacts to other portions of the MHEA from the restoration work. Additional quarry rock and bedding gravel shall be brought into the MHEA by barge at high tide. Material shall be placed using a crane-mounted clamshell to reconstruct the damaged islands in accordance with initial project design standards. In the event that substantive changes are proposed to occur to improve the islands values, these would be subject to further review and approval by permitting agencies.

For purposes of planning, it has been assumed that some level of island reconstruction may be required approximately once every 15 years.
APPENDIX 1: DESIGN REQUIREMENTS AND COMMITMENTS, PERFORMANCE STANDARDS AND GOALS, AND PROJECT CONDITIONS FOR THE MHEA

Various design requirements, performance standards, and project conditions form the basis for the Middle Harbor Enhancement Plan. This appendix summarizes these guiding elements to the MHEA design. Standards, goals, and project conditions are identified and numbered for reference. Sources and citations to the specific obligations are also provided. The referenced elements are separated into five broad categories, as discussed below which underpin the monitoring, adaptive management, and maintenance programs discussed in this document.

Design Standards – These are design-related standards and objectives that are to be met through agency and TAC coordination or which are to be reflected in the development of various plans, specifications, or other technical analyses completed for the project. In some instances, the achievement of design objectives is dependent upon the quality of predictions made based on field data, performance of similar projects, or numerical models.

Construction Period – Construction period compliance monitoring will be conducted to ensure that standards or permit requirements are adhered to and, if necessary, that measures are taken to bring the project work into compliance with protective measures. In general, construction measures apply to all elements of the 50’ deepening project and will be addressed in the overall project plans and specifications. However, where measures include specific consideration of Middle Harbor, these have been noted within this document.

Performance Goals – Performance goals include qualitative and quantitative measures against which success of the MHEA project shall be evaluated. These goals have resulted in development of the success evaluation monitoring and reporting element. In some instances, specific criteria, (e.g. the minimum area of eelgrass to be created) vary between the governing documents. In such cases, all obligations are identified in order to allow evaluation of the relevant levels of success through successive milestones.

Management Requirements – Management requirements include specific provisions directed at ensuring that long-term management actions are adequately defined, authorized, and financed. Site management also includes provisions relating to managing habitats and public access within the MHEA.

Non-project Activities Commitments – These commitments include those made under the auspices of non-MHEA projects that have direct relationship to the MHEA management needs. Specifically, these commitments relate most closely to the MHSP development, an element of the Port of Oakland’s Berths 55-58 project. Because the MHSP includes the shoreline/upland interface with the MHEA, the Port must integrate both educational and habitat enhancement elements across the projects’ interface shoreline boundary and provide a mechanism for conflict resolution between public access and MHEA habitat.
### CONSTRUCTION PERIOD

<table>
<thead>
<tr>
<th>No</th>
<th>Design Standards / Performance Goals / and Project Conditions</th>
<th>Source</th>
<th>Citation</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-1</td>
<td>Monitor during construction: confirmation of the hydrodynamic modeling, tracking consolidation and subsidence to predict final site elevations, water quality, bathymetry, current velocities, tidal range, and biological colonization.</td>
<td>TAC Agreement</td>
<td>Pg. 3</td>
</tr>
<tr>
<td>C-2</td>
<td>Deploy silt curtains if the TSS concentration within 100 feet of the site (i.e. within 100 feet bayward of the MHEA containment dike) exceeds 1,500 mg/L more than 10 percent of the time as measured with continuous monitoring equipment.</td>
<td>FEIR Addendum</td>
<td></td>
</tr>
<tr>
<td>C-3</td>
<td>MHEA: A silt curtain shall be used if TSS levels outside the dike and sill exceed 1,500 mg/L on a continuous basis</td>
<td>USFWS BO</td>
<td>Pg. 5.2-15, Pg. 19</td>
</tr>
<tr>
<td>C-4</td>
<td>Monitoring of herring spawning areas between 12/01 and 03/01. Stop dredging for 2 weeks when herring spawning is observed within 200 meters of dredging. (Monitoring is principally associated with 50’ foot deepening project)</td>
<td>FEIR/S</td>
<td>Pg. 5.4-9</td>
</tr>
<tr>
<td>C-5</td>
<td>Study and report the effects of dredging activities on least tern foraging. Observations should be gathered at least weekly from paired sites, which strongly show and do not show turbidity, as induced by dredging as well as dredged sediment deposition in MHEA. (Monitoring is principally associated with 50’ foot deepening project)</td>
<td>USFWS BO</td>
<td>Pg. 19</td>
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### DESIGN STANDARDS

<table>
<thead>
<tr>
<th>No</th>
<th>Design Standards</th>
<th>Source</th>
<th>Citation</th>
</tr>
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<tbody>
<tr>
<td>D-1</td>
<td>No NUAD material to be used in MHEA fill</td>
<td>ROD/Rev. FEIR/IR</td>
<td>Pg. 3</td>
</tr>
<tr>
<td>D-2</td>
<td>Provide mosaic of habitats: shallow water, eelgrass beds/shallow flats, deep channels/basins, sand beach, hard bottom, coastal salt marsh, covered water area, avian high tide refugia, and buffers between public access and habitats.</td>
<td>TAC Agreement</td>
<td>Pg. 2</td>
</tr>
<tr>
<td>D-3</td>
<td>Design habitat to be self-sustaining to the degree possible.</td>
<td>TAC Agreement</td>
<td>Pg. 2</td>
</tr>
<tr>
<td>D-4</td>
<td>Provide marsh and beach habitat, recognizing that some habitat values may be limited by managed public access and education/interpretive activities.</td>
<td>TAC Agreement</td>
<td>Pg. 2</td>
</tr>
<tr>
<td>D-5</td>
<td>Provide protected shorebird roosting sites that are largely unvegetated or that support low-lying vegetation consistent with shorebird use (both on the shoreline and on islands).</td>
<td>TAC &amp;FEIR</td>
<td>Pg. 2 &amp;FEIR Pg. 5.4-12</td>
</tr>
<tr>
<td>D-6</td>
<td>Provide jetty flat surface crest below Mean High Tide elevation with discontinuous large boulders along jetty crest to provide storm refuge for birds.</td>
<td>FEIR/S</td>
<td>Pg. 5.4-13</td>
</tr>
<tr>
<td>D-7</td>
<td>Prior to Final Design, fund study to determine optimum depth for eelgrass in SF Bay. Select 2 reference areas, conduct small pilot transplant, conduct pre-project survey.</td>
<td>USFWS BO</td>
<td>Pg. 17</td>
</tr>
<tr>
<td>D-8</td>
<td>Develop 3-5 acre marsh area to provide bird foraging opportunities.</td>
<td>FEIR/S</td>
<td>Pg. 5.4-13</td>
</tr>
<tr>
<td>D-9</td>
<td>Create minimum of 55-acre habitat suitable for eelgrass, 110 acres of other shallow water, investigate benefits of phased sediment disposal in MHEA and implement disposal and habitat enhancement if appropriate, design to maximize early creation of shallow water habitat suitable for least tern prey and foraging.</td>
<td>USFWS BO Pg. 17</td>
<td></td>
</tr>
<tr>
<td>D-10</td>
<td>Provide new beach area that will also provide storm refuge to birds.</td>
<td>FEIR/S Pg. 5.4-13</td>
<td></td>
</tr>
<tr>
<td>D-11</td>
<td>Provide improved bird habitat, with reduced predators and human disturbance through construction of four avian islands, each being a maximum size 5,000 sq. ft. and by providing a protected area along the shoreline of the UP Mole.</td>
<td>FEIR/S Pg. 5.4-12</td>
<td></td>
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<tr>
<td>D-12</td>
<td>Provide 4-8 total acres of hard bottom habitat (including existing 3 acres).</td>
<td>FEIR/S Pg. 5.4-12</td>
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<tr>
<td>D-13</td>
<td>Provide approx. 180 acres of shallow water habitat.</td>
<td>FEIR Addendum Corps Addenda to CD Pg. 3</td>
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<tr>
<td>D-14</td>
<td>Any fill needed for habitat purposes shall be the minimum necessary to achieve the purposes of the project.</td>
<td>Port/BCDC letter 10/5/98&quot; Pg. 8</td>
<td></td>
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<tr>
<td>D-15</td>
<td>Assess the effects of seismic event on the MHEA through informal review with the Engineering Criteria Review Board of BCDC.</td>
<td>USFWS BO Pg. 18</td>
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<tr>
<td>D-16</td>
<td>Develop performance criteria and a contingency plan to be implemented in the event that habitat objectives are not achieved.</td>
<td>Corps Addenda to CD Pg. 2</td>
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**PERFORMANCE GOALS**

| P-1  | Provide a habitat enhancement project that will maximize the opportunity for enhancement of eelgrass beds by creating an area that is expected to generate approximately 13 acres of vegetated eelgrass or a smaller project only to mitigate for loss of eelgrass. (Note that a higher obligation of 15 acres exists in the BO) | NFMS BO Pg. 1 |
| P-2  | Create productive shallow water habitat in MHEA. | BCDC 1st phase, COE Addenda to CD Pg. 17, Pg. 2 |
| P-3  | Provide an estuarine community within MHEA that is of higher productivity and greater diversity than the existing community. | BCDC 1st phase, Corps Addenda to CD Pg. 17, Pg. 2 |
| P-4  | Increase habitat benefits for aquatic birds and most particularly the least tern colony, by increasing habitat and the productivity of fisheries. | FEIR/S Pg. 5.4-14 |
| P-5  | Establish and implement long-term monitoring of an eelgrass bed with equal or greater spatial extent and density as existing bed. | FEIR/S Pg. 5.4-13 |
| P-6  | Enhance least tern prey species, which may improve foraging opportunities. | FEIR/S Pg. 5.4-13 |
| P-7  | Create habitat that is more highly productive than existing habitats. Cause a net increase in habitat value. | USFWS BO Pg. 18 |
| P-8  | Create a minimum of 15 acres of eelgrass habitat within 10 years after initiation (start of dredging) of project, not including habitat planted in the previous 3 years. Contingency plan must identify additional enhancements should the performance criterion not be met after ten years. | USFWS BO Pg. 18 |
| P-9  | Select at least 2 eelgrass donor areas whose total area is at least 2x size of transplant area, no more than 5% plants to be removed. Survey donor plots 1 yr. following thinning. | USFWS BO Pg. 18 |
| **P-10** | Provide a greater number of fish than existing conditions. | FEIR/S | Pg. 5.4-12 |
| **P-11** | Create eelgrass beds in the MHEA to mitigate for loss of eelgrass beds removed during channel widening in the Inner Harbor. | ROD & Chief's Rpt. | Pg. 3, Pg. 2 |
| **P-12** | Attract new fish to MHEA with scattered fish enhancement structures. | FEIR/S | Pg. 5.4-12 |
| **P-13** | Perform corrective actions as needed, unless agencies conclude that benefits are comparable to achieving goals, and corrective measures may diminish values. | TAC Agreement | Pg. 3 |

**MANAGEMENT & MONITORING COMMITMENTS**

| **M-1** | Provide necessary legal instruments and financial commitments to ensure permanent preservation and management of MHEA as a wildlife habitat. | BCDC & TAC, COE Addenda to CD | Pg. 9, TAC pg.2&3, Pg. 2 |
| **M-2** | Site management to be delegated to another agency or organization with wildlife area expertise, with appropriate funding. CD requires that an appropriate agency agrees to manage MHEA for wildlife. | TAC & BCDC, COE Addenda to CD | Pg. 3 BCDC-23, Pg. 3 |
| **M-3** | Only non-motorized vessels without fixed keels shall be authorized within the MHEA except for vessels required for scientific sampling and maintenance activities. The motors on scientific and maintenance vessels must be well-maintained to minimize contamination of the MHEA. | USFWS BO | Pg. 18 |
| **M-4** | Prohibit and control swimming, boating, hiking, and human disturbance within 200 ft. of designated least tern or brown pelican roosting areas. Ensure that these regulations cannot be changed without the approval of the USFWS. | USFWS BO | Pg. 18 |
| **M-5** | Before dredging is initiated, provide documentation to USFWS that the MHEA shall be maintained and managed in perpetuity. USFWS approval required. | USFWS BO | Pg. 19 |
| **M-6** | Adopt a monitoring plan, evaluate: area and density of eelgrass, abundance and "relative" diversity of sediment infauna, aquatic epifauna, abundance of fish from 10-30mm in length (including postlarval size classes), use by least terns and other diving birds, sediment dynamics (any change in bottom elevations, accretion/erosion and surface sediment texture/grain size). Sampling shall include shallow unvegetated subtidal areas, shallow channels, eelgrass habitat, and eelgrass reference areas. MHEA shall be monitored at least annually for at least 10 years including interim preparation of annual reports. | USFWS BO | Pg. 18 |
| **M-7** | Provide funding consistent with implementation of the project goals, including site management and maintenance, and separate contingency funding for corrective actions. | TAC Agreement | Pg. 2&3 |
| **M-8** | Monitored MHEA for not less than 10 years during years 1,2,3,5, and 10 following construction and interim reports shall be submitted during monitoring years. Plan to be approved by USFWS. | BCDC 1st phase | Pg. 20 |
| **M-9** | Conduct required monitoring and reporting necessary to direct maintenance and ensure on-going habitat viability through adaptive management. Include management/maintenance activities as necessary for maintenance dredging, beach grooming, cleaning, and grading, buffer maintenance, and vegetation control measures at loafing islands, and exotic vegetation and predator control. MHSP development will include necessary management of surrounding uplands. | TAC Agreement | Pg. 3-4 |

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## NON-PROJECT ACTIVITIES COMMITMENTS

<table>
<thead>
<tr>
<th>R-1</th>
<th>Provide for public access and viewing opportunities (through the MHSP)</th>
<th>TAC Agreement</th>
<th>Pg. 2</th>
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<tbody>
<tr>
<td>R-2</td>
<td>Port application to BCDC for port facilities and public access improvements (MHSP) shall provide for resolution of any conflict that might emerge between the public access and MHEA habitat components.</td>
<td>COE Addenda to CD</td>
<td>Pg. 2</td>
</tr>
<tr>
<td>R-3</td>
<td>Provide opportunities for environmental education (education projects to be developed as part of MHSP).</td>
<td>TAC Agreement</td>
<td>Pg. 2</td>
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