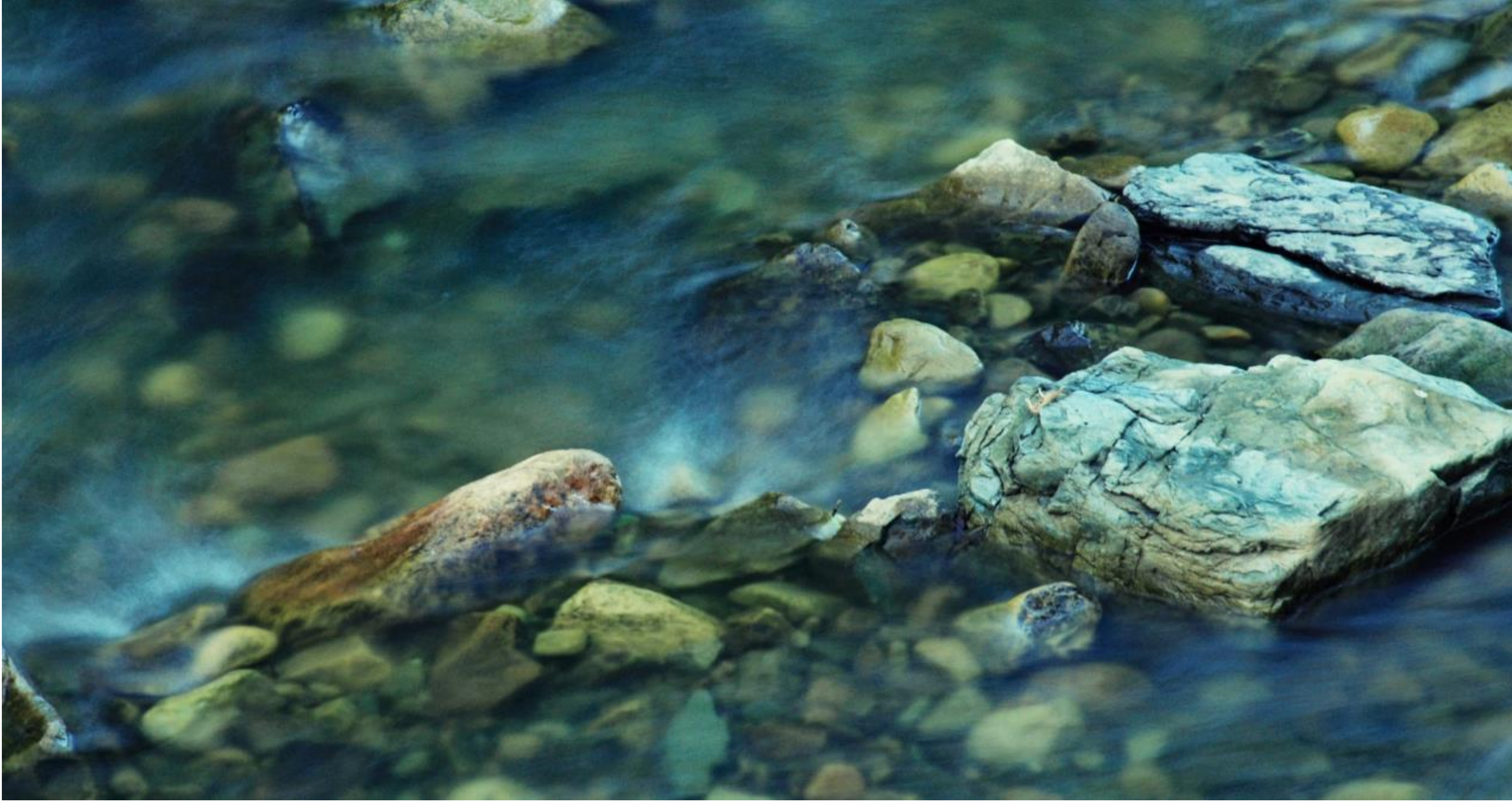

August 2021
Bolsa Chica Lowlands Restoration Project

Sustainable Alternatives Study: Executive Summary

Prepared for Bolsa Chica Land Trust

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Executive Summary

To address issues related to sedimentation, tide range, and water management at the Bolsa Chica wetlands, the Bolsa Chica Steering Committee (BCSC) and Bolsa Chica Land Trust (BCLT) worked together to obtain a Proposition 1 grant to conduct the Bolsa Chica Lowlands Restoration Project (BCLRP) Sustainable Alternatives Study. The objectives of the BCLRP Sustainable Alternatives Study (BCSAS) are listed below with the study summarized in the text that follows.

1. Review project performance since opening of the tidal inlet in August 2006.
2. Identify major performance issues.
3. Develop remediation measures to address major performance issues.
4. Evaluate remediation measures against performance, cost, and environmental impacts.
5. Formulate a short-term program to address immediate performance issues.
6. Formulate a long-term program to address future performance issues with sea level rise (SLR).

To provide mitigation for impacts to deep, open water habitat associated with port landfill projects, the BCLRP was constructed in Huntington Beach, California between 2004 and 2006 with a portion of the restored wetlands (Full Tidal Basin [FTB]) opened to tidal exchange in August 2006. The FTB design consisted primarily of open water shallow subtidal habitat. Within this basin, extensive eelgrass beds were subsequently established by separate restoration actions after the BCLRP site had been restored and mitigation credits allocated. Presently, eelgrass dominates a large part of the FTB providing enhanced habitat for marine fish and marine birds. Based primarily on the establishment of this high-quality habitat, the BCLRP has met the required mitigation goals for the port landfill projects. On the other hand, the BCLRP was not successful at restoring the low coastal salt marsh habitat within the FTB or enhancing the mid to high coastal salt marsh habitats within the Muted Tidal Basin (MTB). In large part, this is because the original design did not consider the impact of inlet morphology on tide range and the corresponding impact on habitat distributions within the FTB and MTB. In addition, sustaining the high-quality marine fish and bird habitats requires an extensive operations and maintenance (O&M) program to achieve three primary objectives: (i) maintain tide range within the FTB and manage water levels in the MTB and broader wetland complex (Future Full Tidal Basin and Seasonal Ponds), (ii) protect eelgrass habitat from declines due to reduced tidal exchange and continuous sedimentation from the ocean inlet (i.e., burial by sand), and (iii) eliminate erosion to downcoast beaches.

The success of the BCLRP at providing coastal salt marsh habitat is linked primarily to the ability to manage surface water levels both now and in the future with SLR. As designed, the major performance problems are associated with the following:

- The open inlet requires continual maintenance to remove accumulated sand.
- Successful water level management within the MTB is linked to successful water level management within the FTB, which is linked to successful functioning of the ocean inlet.
- Average ground elevations are substantially below normal coastal salt marsh elevations due to subsidence from historical oil extraction.
- Current oil operations require flood protection for existing infrastructure and surrounding neighborhoods rely on groundwater drainage through the BCLRP.
- In the long-term with SLR, coastal salt marsh will not be sustainable in the FTB or MTB without intervention.

Sustaining an open ocean inlet, now and in the future with SLR, requires continued management of the sand that accumulates in the wetlands (flood bar shoal), which needs to be continually removed and placed on the downcoast beach. Natural tidal, wave, and littoral sand processes result in a dynamic equilibrium between the ocean inlet and flood bar shoal size. These natural processes favor a relatively smaller inlet and larger flood bar shoal because Bolsa Chica lacks a river or adequate stormwater flows to naturally flush sand from the system like many other coastal wetlands. Regardless, maintaining the open ocean inlet requires mechanical intervention, which has been managed by the maintenance dredging program. The continuous need for maintenance dredging over the years has depleted the maintenance fund account and threatens the financial sustainability of future maintenance dredging activities. To improve performance and lower costs, the maintenance dredging used varying techniques with lessons learned from prior efforts applied to future efforts. This led to the development of a small-scale maintenance dredging program, which has managed to nearly stabilize the tide range in the FTB, and limit impacts to eelgrass; however, since all the sand is not removed during each small-scale dredging event, sand continues to accumulate within the wetlands, thus more extensive work is needed to address this continued "net" accumulation of sediment.

In both the FTB and MTB, the average water levels have been too high relative to ground elevations to properly maintain the habitats with the result being mudflat and open water habitats in areas that were targeted for coastal salt marsh habitats. In the FTB, the reason for this habitat inundation is that the intended Pacific cordgrass shelf was not designed at a high enough elevation relative to the targeted water level (tide) range; therefore, the only coastal salt marsh habitat is found in the FTB around Rabbit Island. In the MTB, operational problems with the water control structures associated with tidal muting in the FTB have made it difficult to drain water from large portions of the MTB, thereby inundating the habitats.

The O&M program includes water level management within the MTB and broader wetland complex using water control structures, groundwater pumps, and pump stations to drain water from the MTB to the FTB. The ongoing oil operations require water management to prevent flooding of oil infrastructure. Over the years since project construction was completed, numerous changes were made to the operation of the water control structures and new pumps were installed to more effectively operate the system given infrastructure limits and budget constraints. However, continued tidal muting in the FTB limits the effectiveness of the water control structures to achieve desirable water levels within the MTB, so more work is needed to improve water management within the MTB, as well as tidal exchange between the MTB and FTB. With the occurrence of a major storm, flooding of the existing oil infrastructure in the MTB is already a concern under existing conditions and this infrastructure poses a constraint to making tidal connection improvements because it limits the maximum allowable water levels within the MTB to prevent flooding of the infrastructure.

In a very real sense, the current inundation of coastal salt marsh habitats within the BCLRP provides insights into the anticipated impacts of SLR on coastal wetlands throughout California, since one of the primary causes of the low ground elevations at Bolsa Chica is land subsidence associated with historical oil extraction in the area. In addition, groundwater levels within the wetlands and adjacent properties would likely increase with increasing sea levels and these higher groundwater levels would likely have impacts to the low-lying residential neighborhood to the east of the MTB, where ground elevations are already below present day mean sea level. Higher mean water levels within the FTB and MTB coupled with higher groundwater levels throughout the area would likely make it increasingly difficult to address stormwater runoff from the surrounding neighborhood. This problem is not unique to Bolsa Chica as most low-lying areas across the state would likely have to address similar SLR impacts. Over the next few decades, present SLR projections suggest that the FTB will become completely inundated and not able to support coastal salt marsh anywhere. By the turn of the century, the entire BCLRP site and surrounding residential neighborhood will likely become inundated without some type of intervention.

A three-day workshop was convened at the start of the BCSAS to obtain input from experts with relevant expertise from outside the current BCLRP team. Several of these experts had prior experience with or knowledge of the BCLRP. To facilitate creativity, the experts were provided minimal guidance in terms of constraints, so they were given “free range” to develop potential solutions. Ultimately the group identified 10 potential solutions for consideration during the Study. During the Study, six additional solutions, now termed “remediation measures”, were identified for evaluation. These 16 remediation measures were grouped into categories based on four intended objectives as presented in Table ES-1. The remediation measures ranged from operational and construction equipment changes to construction of new structures and renovation/modification of existing structures, as illustrated in Figure ES-1. The complete cessation of maintenance dredging, as well as abandonment of the existing ocean inlet, were identified as potential remediation measures. With input from the BCLT and BCSC, an initial screening assessment was conducted on the 16 remediation measures and two remediation measures (2B and 2C) were eliminated from further consideration, leaving 14 remediation measures carried forward for evaluation. A potential long-term sustainability alternative, as shown in Figure ES-2, illustrates the various components of the long-term vision for the BCLRP that was developed during the workshop.

Table ES-1
Remediation Measures

Intended Objective	Remediation Measures
Optimize sediment management efficiency to reduce maintenance dredging costs	1A: Large-Scale Dredging – Conduct maintenance dredging every 2 years by removing all sediment accumulation in the wetlands to reverse tidal muting in the FTB. This was conducted previously in 2009 and 2011 and was deemed unsuccessful at maintaining water levels in the FTB.
	1B: Different Dredging Method – Ongoing adaptative dredging management using different dredging equipment to improve dredging efficiency.
	1C: Install Permanent Infrastructure – Installation of permanent infrastructure to reduce dredging costs.
	1D: Optimize Dredging Operations – Adaptative management to optimize dredging operations through contracting, bidding process, or dredging work sequencing.
	1E: Eliminate Maintenance Dredging – Stop maintenance dredging and allow sedimentation to progress naturally, thereby reducing maintenance dredging costs, burying eelgrass habitat, and increasing the risk of inlet closure. This was previously done from 2011-2014 and it resulted in a reported imminent inlet closure.
Reduce the amount of sediment deposition within the wetlands	2A: Enhanced Ebb Flush – Innovative method to remove sedimentation from the wetlands as an alternative to mechanical dredging. Conceptually, fluidizers (pipes that expel water) would be used to resuspend sediment during ebb tides allowing the ebb tidal currents to flush the sand to the ocean.
	2B: Bedload Barrier – Innovative method to block sediment from depositing inside the FTB during flood tides. Conceptually, pipes would be lowered during flood tides to keep sediment between the inlet jetties and then the pipes would be raised during ebb tides to allow flushing of sediment out of the inlet.
	2C: Increase Tidal Prism – Increase the ebb tidal prism by creating a hydraulic connection between Huntington Harbor and the FTB via Inner Bolsa Bay and Outer Bolsa Bay. A larger ebb tidal prism could potentially increase the flushing of sediment from the wetlands.
	2D: Extend Jetties – Lengthen the existing jetties farther out into the ocean to increase littoral transport blockage near the inlet, thereby potentially reducing the volume of sand that enters the wetlands.
	2E: Narrow Inlet – Narrow the inlet channel by installing a sheet pile wall to deepen the inlet channel to relocate the flood and ebb sand bars to potentially reduce the volume of sand that enters the wetlands.
	2F: Offshore Breakwater – Construct an offshore breakwater parallel to shore to reduce wave-induced suspension of sand at the inlet entrance to potentially reduce the volume of sand that enters the wetlands.
Restore MTB wetland vegetation	3A: MTB Single-Site Pumping – Enhance the gravity drainage through the MTB towards the Freeman Creek Pump Station for discharge into the FTB.
	3B: MTB Multi-Site Pumping – Add pumping stations at the three MTB water control structures to drain water from the MTB into the FTB and provide greater flexibility in managing the MTB water levels.

Intended Objective	Remediation Measures
	3C: Seepage Terrace – Close the MTB tidal connection to restore non-tidal vegetation and regrade the MTB to create a seepage channel that would utilize groundwater to support a variety of non-tidal wetland habitats.
Provide long-term sustainability	4A: Tidal Inlet Abandonment – Provide the primary FTB tidal exchange through Inner Bolsa Bay and regulate or eliminate tidal exchange through the tidal inlet. Modify existing hydraulic connections through Huntington Harbour, Outer Bolsa Bay, and Inner Bolsa Bay to provide tidal exchange to the FTB.
	4B: Ecotone Levee – Place fill in the MTB to create a "horizontal" levee focused on establishing transitional wetland habitat and create new tidal connections between the FTB and MTB.

The remediation measures were evaluated based on of the following seven metrics:

- FTB habitat stability – Changes in water levels and habitats from the Baseline Condition
- MTB habitat stability – Changes in water levels and habitats from the Baseline Condition
- Implementation Cost – Estimated implementation cost
- O&M Cost – Estimated annual O&M cost
- Environmental Impacts – Potential environmental impacts
- SLR Resiliency – Assess SLR resiliency
- Sustainability- Assess carbon sequestration and greenhouse gas emissions

Each of the 14 remediation measures was evaluated based on the seven metrics with a separate evaluation matrix produced for each remediation measure. The goal of this task was to identify a set of remediation measures that could be combined to form one or more alternatives that would provide the basis for a short-term (Year 2020-2030), midterm (Year 2030-2060), and long-term (Year 2060-2100) management program with the timeframes associated with various SLR projections.

The results of the evaluation revealed that in the short term (2020-2030) to midterm (2030-2060) there are no remediation measures that would address all the problems and maintain the ecological value of all the habitats. Given the various constraints, the ocean inlet cannot be modified to be self-sustaining, and so human intervention (e.g., maintenance dredging) is required to provide adequate hydrology to the system. There are conventional remediation measures (e.g., eliminate maintenance dredging) that could be implemented to reduce maintenance costs; however, implementation of those measures would cause sedimentation and reduced water quality impacts to existing eelgrass beds and broader marine community resources and increase the risk of inlet closure, thereby resulting in significant loss of habitat function. There are innovative measures (e.g., enhanced ebb flush) that have the potential to cost-effectively reduce/eliminate maintenance dredging over the long-term; however, implementation of those measures would require substantial, upfront investments to prove the technology and obtain environmental clearances/permits with no guarantee of successful performance. Structural changes to the inlet (e.g., extend the jetties or narrow the ocean inlet) would not substantially reduce maintenance dredging requirements nor address future issues related to SLR. The only remediation measures to substantially reduce maintenance dredging requirements would involve drastic changes to the system hydrology at the cost of impacting existing habitats. Remediation measures to change the hydrology of the system include abandoning the ocean inlet with tidal exchange provided via Huntington Harbour or potentially increasing storm pulsed sediment flushing by connecting the FTB to the East Garden Grove Wintersburg Flood Control Channel.

It is expected that SLR will outpace efforts to control water levels or address flood bar sedimentation. The existing ground elevations are too low to provide coastal wetlands habitats in the future, resulting in mostly subtidal habitat within the FTB and open water habitat within the MTB, thereby reducing habitat for target special status bird species in the MTB. The placement of fill appears to be the only option available to provide coastal salt marsh habitat under projected SLR. A strategic SLR adaptation plan that provides a long-term vision for the BCLRP is needed to prioritize the implementation of remediation measures. This would serve as a starting point for coordinating efforts to address SLR between the BCLRP, oil operator, City of Huntington Beach, and other stakeholders since some of the proposed remediation measures are dependent on other activities such as oil operations. A long-term SLR adaptation plan would facilitate consistency among the short-, mid-, and long-term remediation measures. For example, selecting remediation measures to increase low salt marsh habitat in the FTB may not be prudent if it cannot be supported with SLR. A general framework of an SLR adaption plan is provided below.

Conclusions

In the short term (2020 to 2030), the best option is to continue the adaptive O&M program that has been utilized over the past 15 years with the maintenance dredging in the FTB and water management plan in the MTB. Maintenance dredging to remove sedimentation in the wetlands is the only practical method that can be implemented in the short-term to provide adequate hydrology for supporting the habitats in the FTB. Likewise, water management in the MTB via pumping is the best method for controlling water levels to minimize loss of vegetated marsh, remove stormwater to protect oil infrastructure and adjacent residential areas, and maximize bird habitat.

Opportunities identified from this study should be explored as part of the continuing adaptive management strategy. The following short-term (2020-2030) remediation measures were found to potentially provide some benefit in improving the efficiency of maintenance activities for the BCLRP:

- Continue optimizing maintenance dredging methods and operations based on the small-scale dredging approach.
- Modify water management in the MTB to restore wetland vegetation.

In the midterm (2030 to 2060), increasing sea levels would likely affect the dynamic equilibrium between the ocean inlet and flood bar shoal. Depending on the degree of change to this dynamic equilibrium, the remediation measures listed below could be considered in the midterm to improve the efficiency of maintenance activities for the BCLRP and/or improve the effectiveness of various components of the BCLRP:

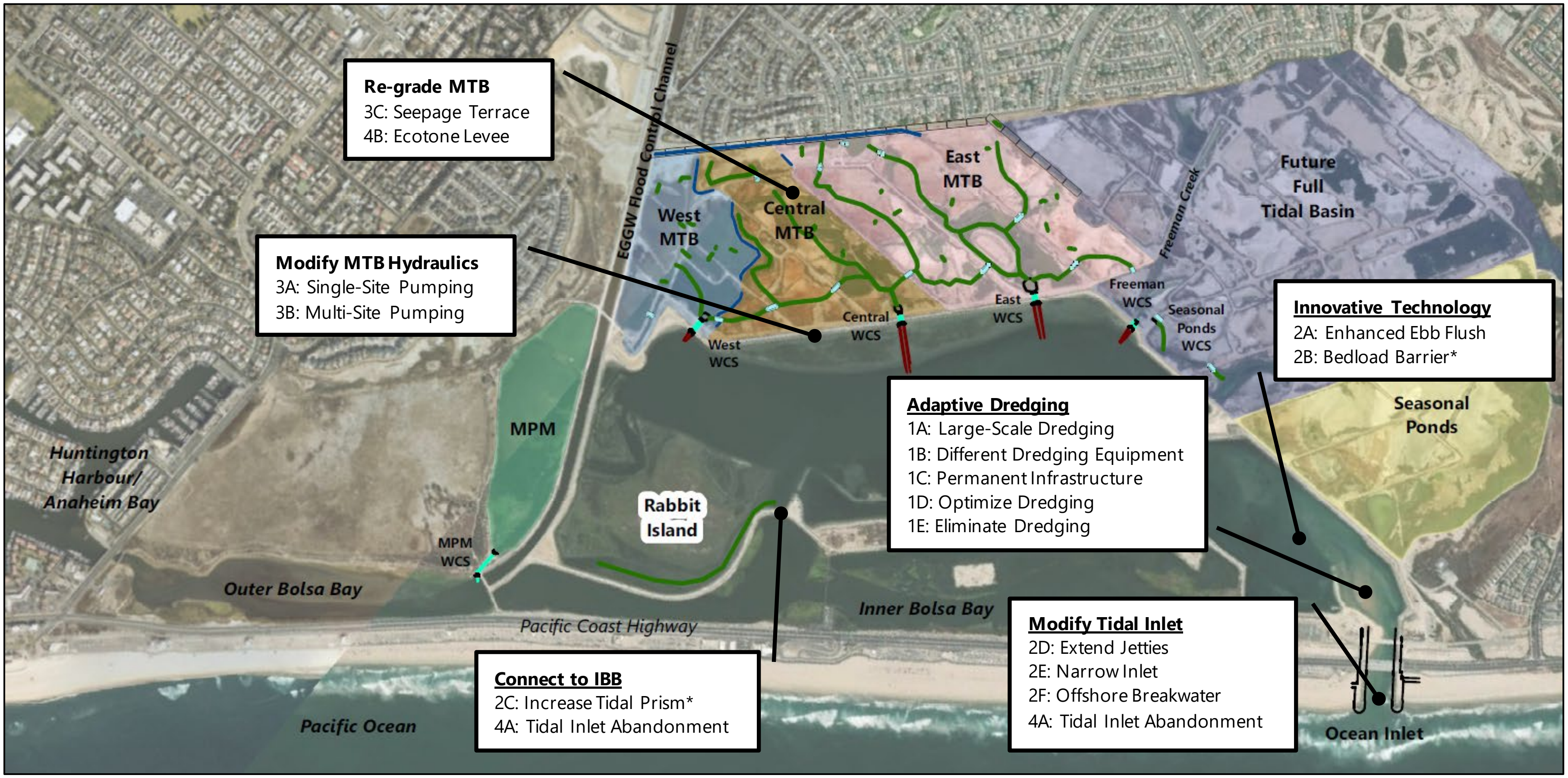
- Increase ebb tidal prism between Huntington Harbour and the FTB via Inner Bolsa Bay and Outer Bolsa Bay.
- Seepage terrace pilot project for SLR adaptation.
- Ecotone levee pilot project for SLR adaptation.

Potential pilot projects for SLR adaptation involving the seepage terrace or ecotone levee remediation measures in the MTB could be implemented in phases. This would provide a unique opportunity to develop and implement SLR adaptation measures that could be monitored and modified to improve effectiveness and efficiency for larger-scale projects.

In the long term (2060 to 2100), placement or redistribution of sediment appears to be the only remediation measure available to provide coastal salt marsh habitat under projected increases in sea levels. In addition, placing fill within the MTB could address the impacts of SLR on groundwater and stormwater management. Raising ground elevations within the MTB would provide a buffer to address high surface water levels and reduce the volume of water available to increase groundwater seepage flows from the wetlands into the surrounding neighborhood. If coastal salt marsh habitats are desirable within the FTB in the long-term, then fill placement would likely yield the only method for establishing and maintaining such habitats.

Given that SLR will continue to negatively affect Bolsa Chica at a rate greater than most other coastal wetlands due to low ground elevations caused by oil extraction-induced subsidence, it is prudent to pursue large-scale SLR adaptations as soon as possible since these adaptations would likely take time to implement. In addition, much of this work would be implemented as pilot projects and time would be needed to verify the benefits of these remediation measures. The planning and design of SLR adaptation measures at Bolsa Chica should consider multi-species ecological benefits, carbon sequestration capacity, capital costs, and O&M costs, as well as the ability of the system to buffer the SLR impacts to areas adjacent to Bolsa Chica. The SLR adaptation efforts at Bolsa Chica have broad ramifications in that the site provides early insight into issues that other coastal wetland systems will face in coming decades.

Figures



Notes: *Excluded from detailed analysis; FTB: Full Tidal Basin; IBB: Inner Bolsa Bay; MTB: Muted Tidal Basin; OBB: Outer Bolsa Bay; WAB: Warner Avenue Bridge; WCS: water control structure

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Figure ES-1
Remediation Measures

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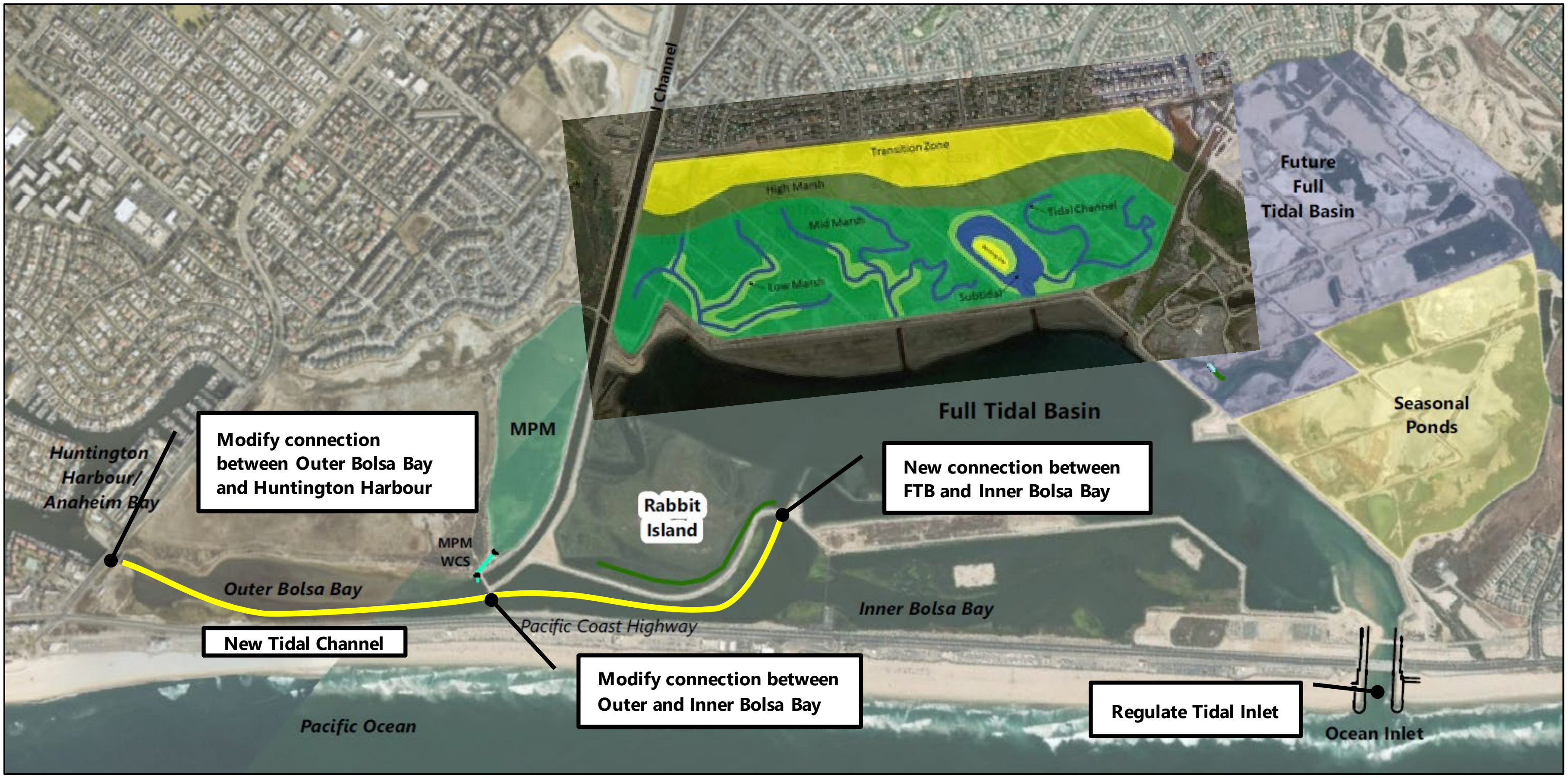

Notes: FTB: Full Tidal Basin; IBB: Inner Bolsa Bay; MTB: Muted Tidal Basin; OBB: Outer Bolsa Bay; WAB: Warner Avenue Bridge; WCS: water control structure

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Figure ES-2
Long-Term Sustainability

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