PROJECT REPORT

WETLAND POLICY CLIMATE CHANGE UPDATE PROJECT

Wetland Fill Policy Challenges and Future Regulatory Options:

Findings and Recommendations

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CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD

SAN FRANCISCO BAY REGION

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Executive Summary

The San Francisco Bay Regional Water Quality Control Board (Regional Water Board) proposes to develop an amendment to the Water Quality Control Plan for the San Francisco Bay Basin (Basin Plan) to address the threats posed by climate change to water quality and beneficial uses. The Regional Water Board is proposing to amend the Basin Plan because it is critical that our policies and decisions influence climate change adaptation projects to improve beneficial uses of the San Francisco Bay (Bay). The proposed Basin Plan Amendment (BPA) will use the latest science to maximize the use of nature-based solutions (often called “green infrastructure”) to protect vulnerable shorelines from sea level rise.

Motivation

Increasing concentrations of greenhouse gases and resultant climate changes are driving rising sea levels within the San Francisco Bay region. The region will likely experience an acceleration in the rate of relative sea level rise (SLR); increases in the frequency, intensity, and duration of storms; shifts in the seasonal timing and volume of rainfall; changes in Delta outflows; and impacts to the physical and ecological conditions and processes that support the diversity and resilience of shoreline habitats.

The Bay’s tidal marshes and flats (mudflats), which are critical to water quality and the health of the Bay, are especially threatened by SLR and decreases in suspended sediment entering the Bay from creeks, streams, and rivers, which drain to the Bay. Modeling demonstrates that these factors could drown most of the Bay’s tidal marshes by 2100, convert vast areas of mudflats to open water, and make it more challenging, if not impossible, to achieve habitat restoration goals. Furthermore, these large-scale changes will permanently impact beneficial uses of the Bay, such as wildlife habitat, preservation of rare and endangered species, fish migration and spawning, recreation, and commercial fishing.

Climate change and SLR threaten critical shoreline infrastructure and low-lying communities through increased risk of flooding and erosion. Where development has encroached upon natural shorelines, traditional solutions employed to control erosion and flooding have relied on levees, seawalls, and rock revetments (often called “grey infrastructure”). Grey infrastructure solutions provide minimal benefits to water quality and beneficial uses and often negatively impact natural Bay features, such as mudflats, wetlands, and beaches. In contrast, green infrastructure solutions rely on mudflats, wetlands, and beaches to reduce erosion and flooding risks by working with nature.

Our Role

The Regional Water Board is charged with protecting, enhancing, and restoring the beneficial uses in the Bay, its tributaries, and its nearshore environments. Our regulatory authority is derived from provisions of the federal Clean Water Act, the state Porter-Cologne Water Quality Control Act, and policies in the Basin Plan. Our authority extends to regulation of activities that might affect wetlands, such as wetland fill, dredging of navigation and flood control channels, and the beneficial reuse of dredged sediment by issuing permits for such activities. While our permitting decisions incorporate the California Wetlands Conservation Policy (commonly known as “No Net Loss”), our Basin Plan currently does not consider the threats to the Bay’s wetlands and nearshore habitats by climate change and SLR. Additionally, the Basin Plan does not address how planning and permitting decisions can address these threats and support water quality and beneficial uses of the Bay in the long-term and at a regional scale.

The Basin Plan Amendment

A BPA to incorporate these recommendations and address climate change and wetland fill will likely include both non-regulatory and regulatory elements:

Non-Regulatory Elements

Non-regulatory elements of the proposed BPA will include:

- A narrative explaining the impacts to water quality and beneficial uses of the Bay associated with a changing climate and SLR.
- References to the 2015 Goals Report, the U.S. Fish and Wildlife Service’s *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California* (USFWS 2013), *Rising Seas in California* (OPC 2017), and the *State of California Sea Level Rise Guidance* (OPC 2018).
- An updated list of tidal wetland restoration sites that are currently being restored, as well as those currently planned for restoration (e.g. South Bay and Napa-Sonoma salt ponds, Hamilton, Sears Point, etc.).
- Support for a regional approach to tidal wetland monitoring, such as the Wetland Regional Monitoring Program currently being developed by the Regional Water Board and its partners.

Regulatory Elements

Regulatory elements of the proposed BPA will include:

- Documentation of the threats that climate change poses to the Bay’s tidal wetlands and adjacent habitats, and their beneficial uses, including but not limited to threats from SLR, changes in freshwater inputs, and changes in regional sediment supplies.

- Identification of preferred strategies for climate change adaptation, emphasizing the roles that natural and nature-based processes can play while integrating feasible solutions that maximize Bay-wide water quality and related habitat benefits.
- Clarification of the regulatory framework to be considered for project that convert waters of the State from one type to another (e.g., seasonal wetland to tidal wetland).
- Clarification of how the “No Net Loss” policy will be applied to Bay margin wetland restoration projects, especially in consideration of losses in acreage, functions and values associated with SLR projections.
- Identification of instances where fill in waters of the State may be considered beneficial, or otherwise may not trigger a requirement for compensatory mitigation. Restoration elements to be considered could include:
    - Horizontal/ecotone levees;
    - New/enhanced estuarine-terrestrial transition zones in baylands in places where they are currently absent or impacted by shoreline hardening, current or historic land uses, or other anthropogenic impacts;
    - Living shorelines, beaches, and hybrid coastal infrastructure; and
    - Strategic sediment placement to raise elevations in restoring and subsided bayland.
- Clarification that avoidance and minimization in the context of Bay fill includes evaluating opportunities for incorporating the upland/landward edge of the Bay in any alternatives analysis completed consistent with Clean Water Act Section 404(b)(1) guidelines, and identification of approaches for how projects should consider facilitating the upslope transgression of tidal wetlands as sea levels rise.
- Identification of the benefits of “complete” tidal wetland systems consistent with the definition in the 2015 Baylands Goals update.
- A framework for how the Regional Water Board will consider temporal tradeoffs and uncertainties in wetland restoration to avoid and minimize fill impacts in waters/wetlands.
- A framework for evaluating mitigation on a regional, sub-regional (Suisun, North Bay, Central Bay, South Bay, Lower South Bay), or operational landscape unite (OLU) basis, rather than project-by-project, and clarifying expectations for the role mitigation banks may play.

- Emphasis on the expectation that projects consider and appropriately address project-related indirect and cumulative impacts to waters.
- References to existing technical guidance on natural and nature-based features, including “living shorelines,” and emphasis on the role that nature-based infrastructure can play in avoiding and reducing impacts.

Collaborative Approach

The Regional Water Board will develop the BPA through a collaborative public process and in coordination with our partner resource and regulatory agencies, many of which are implementing their own climate change-focused policy updates.

One venue for collaborating on policy development is the Bay Restoration Regional Integration Team (BRRIT). The BRRIT is a newly formed regulatory team that brings together staff from the Regional Water Board, U.S. Army Corps of Engineers, Bay Conservation and Development Commission (BCDC), National Marine Fisheries Service, U.S. Fish and Wildlife Service, and the California Department of Fish and Wildlife to streamline permitting for projects funded through the San Francisco Bay Restoration Authority. Regional Water Board staff will also continue to collaborate with BCDC staff on related initiatives including but not limited to BCDC’s new Bay Plan Amendment for Fill for Habitat Projects, which was approved by BCDC on October 3, 2019. Lastly, Regional Water Board staff will hold a series of public meetings to solicit input from interested parties.

Table of Contents

1 Introduction

Human activities since the Industrial Revolution are changing the earth's climate, driving rising sea levels across the globe and in the San Francisco Bay (Bay) region. As the earth's climate continues to change, the region will likely experience further acceleration in the rate of local sea level rise (SLR), warmer temperatures, more extreme weather (including changes in the frequency, intensity, and duration of droughts and floods, see Swain et al. 2018), and changes in the seasonal patterns of rainfall and snowmelt runoff (Delta outflow). Addressing the water quality threats posed by climate change is a high priority for the San Francisco Bay Regional Water Quality Control Board (Regional Water Board) and this regulatory review project was identified by the Regional Water Board as a high priority in its 2015 and 2018 Triennial Reviews of the Basin Plan.

Recognizing the threat that climate change and SLR pose to the Bay's built and natural communities, multiple regional, local, and inter-agency efforts are underway to assess the vulnerability of the Bay's shoreline assets and develop plans to improve their long-term resilience. The Regional Water Board is an active participant in many of these efforts, due to its broad regulatory authority that addresses how dredging and filling of wetlands and waters, flood management, beneficial reuse, shoreline development, and related activities can impact water quality and the beneficial uses of the Bay and its tributaries. Specifically, the Regional Water Board plays a key role in facilitating projects that restore tidal wetlands and improve the adaptive capacity of the Bay's shoreline to rising sea levels. To support these activities, the Regional Water Board helped lead the 2015 update of the Baylands Ecosystem Habitat Goals (Goals Project 2015), which calls for the accelerated restoration of 100,000 acres of tidal wetland habitats by 2030. More recently, the Regional Water Board funded the development of the San Francisco Estuary Institute's Adaptation Atlas (SFEI and SPUR 2019), which proposes a science-based framework for identifying opportunities to deploy nature-based infrastructure along the Bay's shoreline. A second phase of project work to support a more detailed Adaptation Atlas is currently underway. Regional Water Board staff are also playing a lead role in the development of a proposed Wetland Regional Monitoring Program (WRMP) that, if implemented, will assess where and how tidal wetlands throughout the Bay (including restoration projects) are responding to climate change and SLR.

In 2016, Bay Area voters approved Measure AA, which will provide $500 million over 20 years to fund tidal wetland restoration and related activities in the Bay through the newly formed San Francisco Bay Restoration Authority (SFBRA). In anticipation of the need to efficiently permit SFBRA projects, state and federal regulatory agencies[1] are initiating a new collaborative effort called the Bay Restoration Regional Integration Team, or BRRIT. The BRRIT will coordinate permitting efforts between regulatory agencies and consult on relevant policy and procedural changes to facilitate restoration project planning and implementation. The coordination and funding provided by the SFBRA, BRRIT, and their partners is expected to increase the number of tidal wetland restoration and SLR adaptation projects in the region, and the pace at which they move through planning, design, and permitting. To help facilitate the permitting and implementation of projects that will improve long-term beneficial uses, and to help prevent projects that will have long-term and/or cumulative negative impacts to the Bay, it's critical that the Regional Water Board's plans and policies consider how our regulations can uniquely influence climate change adaptation.

To update these plans and policies, Regional Water Board staff are proposing an amendment to Water Quality Control Plan for the San Francisco Bay Basin (Basin Plan Amendment or BPA) to address a suite of regulatory opportunities and challenges that have been identified by staff and stakeholders. The purpose of this Report is to provide background information on these challenges and opportunities and inform the development of a related Basin Plan Amendment. Chapter 2 summarizes the unique threats that climate change and rising sea levels pose to the Bay's estuarine habitats and shoreline communities. Chapter 3 summarizes the recommendations from the Baylands Ecosystem Habitat Goals Update (2015 Goals Report) and San Francisco Bay Shoreline Adaptation Atlas (2019 Adaptation Atlas) that are relevant to the Regional Water Board's regulatory authorities. Chapter 4 describes the Regional Water Board's permitting policies and procedures, and Chapter 5 presents case studies of projects where the absence of clear regulatory guidance for climate change and tidal wetland restoration projects contributed to permitting complications. Finally, Chapter 6 presents the suite of challenges and opportunities that could be addressed in a Basin Plan Amendment, which include updating wetland fill policies for habitat restoration and shoreline adaptation projects, addressing spatial and temporal mismatches between project impacts and benefits, facilitating the development of tidal marshes with connectivity to terrestrial and subtidal habitats, and addressing strategic sediment placement to enhance tidal marsh resilience and diversity. The appendices include a summary of climate change science and the State's implementation guidance to support SLR adaptation (Appendix A), a discussion of the potential impacts of sea level rise on the Bay's tidal wetlands (Appendix B), a review of current SLR viewers for the Bay

[1] BRRIT participants include the Water Board, U.S. Army Corps of Engineers, Bay Conservation and Development Commission, National Marine Fisheries Service, U.S. Fish and Wildlife Service, and the California Department of Fish and Wildlife.

(Appendix C), a listing of the beneficial uses currently assigned in the Basin Plan to certain tidal wetlands (Appendix D), and a copy of the Basin Plan’s Fill Policy and the California Wetlands Conservation Policy (Appendix E).

2 Climate Change, Sea Level Rise, and the Bay's Tidal Wetlands

The continuing increase in atmospheric greenhouse gases (GHG) due to human activities is driving significant changes in Earth's climate, oceans, and landscapes. Globally and throughout California, sea level rise is among the most readily apparent of these impacts (Griggs et al. 2017). Climate change contributes to global (eustatic) sea level rise and relative sea levels[2] through a variety of global, regional, and/or episodic mechanisms. Global contributions to sea level rise include long-term changes in geophysical, atmospheric, and hydrologic conditions and processes across the globe such as the thermal expansion of warming oceans and the melting of land-based ice in glaciers, ice caps, and ice sheets. Regional contributions to relative sea levels include vertical land motion due to plate tectonics, subsidence and compaction, the effects of melting ice on Earth's rotation and gravitational fields, and changes in Pacific Ocean winds, circulation, and temperatures such as the El Niño - Southern Oscillation (ENSO) and Pacific Decadal Oscillation (PDO). Episodic contributions to Bay relative sea levels include short-term impacts on local sea levels from storms, waves, king tides, and Delta outflow. These drivers, which are discussed in detail in Appendix A, have already increased the mean relative sea level at the Golden Gate by 7 inches since 1900 (OEHHA 2018, see Figure 1 below from NOAA CO-OPS 2018a); this rate is expected to increase in the future.

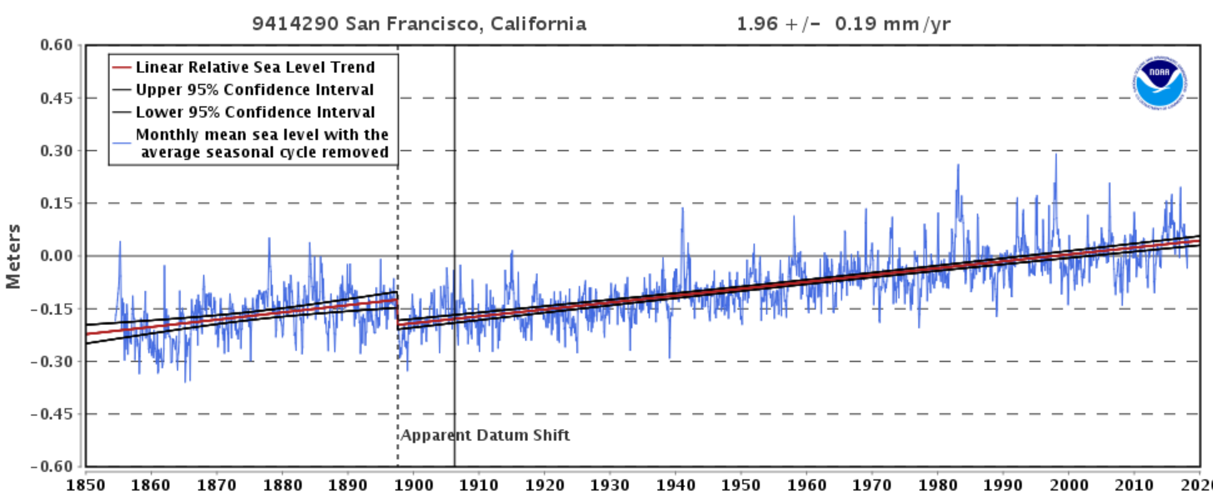

Figure 1. Sea level rise at the Golden Gate has risen over 7 inches in the past 100 years. (Image: NOAA CO-OPS)

[2] Global or eustatic sea level rise is the worldwide average rise in mean sea level. Relative sea level is the elevation of the sea relative to a reference land elevation at a given location. In some areas where land is rising faster than the pace of SLR due to tectonic action (for example, much of the southern coast of Alaska), relative mean sea levels are *falling* even though global mean sea levels are *rising*. See Appendix A and https://tidesandcurrents.noaa.gov/sltrends/ for more information.

2.1 Sea Level Rise Projections

Currently the most up-to-date information describing potential future SLR scenarios in California is the April 2017 report *Rising Seas in California: An Update on Sea Level Rise Science* (Griggs et al. 2017), published by the California Ocean Protection Council Science Advisory Team (OPC-SAT). This report incorporates the findings of a broad range of climate change research, particularly advances in ice loss science which indicate that the rate of ice loss from the Greenland and West Antarctic ice sheets is increasing, and that this loss will soon become the largest component of sea level rise globally and in California. To help planners and decision-makers contextualize the risk associated with planning for different levels of SLR, the *Rising Seas* report assigns statistical probabilities to a range of potential SLR scenarios based on low and high emissions[3] scenarios (see Figure 2 below). For example, the report estimates that under a low emissions scenario, there is a 66 percent probability that by 2100, sea levels at the Golden Gate will have risen by 1.0 to 2.4 ft, and a 0.5 percent probability that SLR will meet 5.7 ft. Under a high emissions scenario, there is a 66 percent probability of 1.6 to 3.4 ft of SLR by 2100, and an 0.5 percent probability of 6.9 ft of SLR. It's important to note that since the probabilities presented in the *Rising Seas* report are based on two precise emissions scenarios, they may not reflect the actual emissions of the future, and therefore do not represent the actual probability that a given amount of SLR will occur.

The *Rising Seas* report also describes an extreme long-term SLR scenario, called H++, which was previously defined in the *Fourth National Climate Assessment* (USGCRP 2017) and supporting scientific literature. This scenario accounts for potentially catastrophic West Antarctic ice sheet loss, but due to the level of scientific uncertainty associated with its occurrence, the *Rising Seas* report does not assign it a probability.

[3] GHG emissions govern global rates of SLR. In the *Rising Seas* report and the *State of California Sea-Level Rise Guidance*, "low emissions" refers to Representative Concentration Pathway (RCP) 2.6, which requires substantial reductions in global GHG reductions. "High emissions" refers to RCP 8.5, a "business as usual" scenario that assumes that global GHG emissions will continue to increase over time. Modeling indicates that the differences in SLR and other climate change impacts between these two scenarios will be especially stark in the latter half of this century. A reader-friendly guide to the RCPs and their utilization in global climate modeling is available at https://skepticalscience.com/rcp.php.

		Probabilistic Projections (in feet) (based on Kopp et al. 2014)					H++ scenario (Sweet et al. 2017) *Single scenario
		MEDIAN	LIKELY RANGE		1-IN-20 CHANCE	1-IN-200 CHANCE	
		50% probability sea-level rise meets or exceeds...	66% probability sea-level rise is between...		5% probability sea-level rise meets or exceeds...	0.5% probability sea-level rise meets or exceeds...	
				Low Risk Aversion		Medium - High Risk Aversion	Extreme Risk Aversion
High emissions	2030	0.4	0.3 -	0.5	0.6	0.8	1.0
	2040	0.6	0.5 -	0.8	1.0	1.3	1.8
	2050	0.9	0.6 -	1.1	1.4	1.9	2.7
Low emissions	2060	1.0	0.6 -	1.3	1.6	2.4	
High emissions	2060	1.1	0.8 -	1.5	1.8	2.6	3.9
Low emissions	2070	1.1	0.8 -	1.5	1.9	3.1	
High emissions	2070	1.4	1.0 -	1.9	2.4	3.5	5.2
Low emissions	2080	1.3	0.9 -	1.8	2.3	3.9	
High emissions	2080	1.7	1.2 -	2.4	3.0	4.5	6.6
Low emissions	2090	1.4	1.0 -	2.1	2.8	4.7	
High emissions	2090	2.1	1.4 -	2.9	3.6	5.6	8.3
Low emissions	2100	1.6	1.0 -	2.4	3.2	5.7	
High emissions	2100	2.5	1.6 -	3.4	4.4	6.9	10.2
Low emissions	2110*	1.7	1.2 -	2.5	3.4	6.3	
High emissions	2110*	2.6	1.9 -	3.5	4.5	7.3	11.9
Low emissions	2120	1.9	1.2 -	2.8	3.9	7.4	
High emissions	2120	3	2.2 -	4.1	5.2	8.6	14.2
Low emissions	2130	2.1	1.3 -	3.1	4.4	8.5	
High emissions	2130	3.3	2.4 -	4.6	6.0	10.0	16.6
Low emissions	2140	2.2	1.3 -	3.4	4.9	9.7	
High emissions	2140	3.7	2.6 -	5.2	6.8	11.4	19.1
Low emissions	2150	2.4	1.3 -	3.8	5.5	11.0	
High emissions	2150	4.1	2.8 -	5.8	5.7	13.0	21.9

Figure 2. Probabilistic sea level rise projections from the 2018 California Sea-Level Rise Guidance. *(Image: OPC)*

The 2017 Rising Seas report formed the technical basis for the Ocean Protection Council's *State of California Sea-Level Rise Guidance* (OPC 2018), which at the time of publication is the state's official SLR guidance for state and local governments. This document (summarized in Appendix A) proposes a methodology for decision-makers to analyze and assess the risks posed by sea level rise based on the best available science (Griggs et al. 2017), a framework for incorporating SLR into planning, permitting, and investing decisions, and descriptions of preferred multi-benefit coastal adaptation approaches and strategies.

2.2 Tidal Wetlands and Sea Level Rise Adaptation

Prior to European colonization, the San Francisco Bay region (including San Francisco Bay, San Pablo Bay, and Suisun Marsh) supported roughly 190,000 acres of tidal wetlands along the Bay margins and the tidally influenced portions of the Bay's tributaries. These formerly extensive tidal wetlands formed roughly 2,000 to 5,000 years ago, as SLR due to the melting of Ice Age glaciers and ice caps leveled off, allowing tidal flows to deposit broad plains of sediment in the baylands (Atwater et al. 1979). It took less than 200 years of post-colonial activity in the Bay, including the large-scale diking, draining, and filling of wetlands in the late 19th through mid-20th centuries, to reduce the area of tidal wetlands to roughly 40,000 acres by the 1990s (see Goals Project 1999 and Figure 3 below). It's important to note that this 40,000 acres includes roughly 24,000 acres of tidal wetlands that formed *after* much of the baylands were diked, drained, and/or filled, due to the shoaling of tidal channels and the tidal deposition of post-Gold Rush sediment washed out of the Sierra Nevada (ibid).

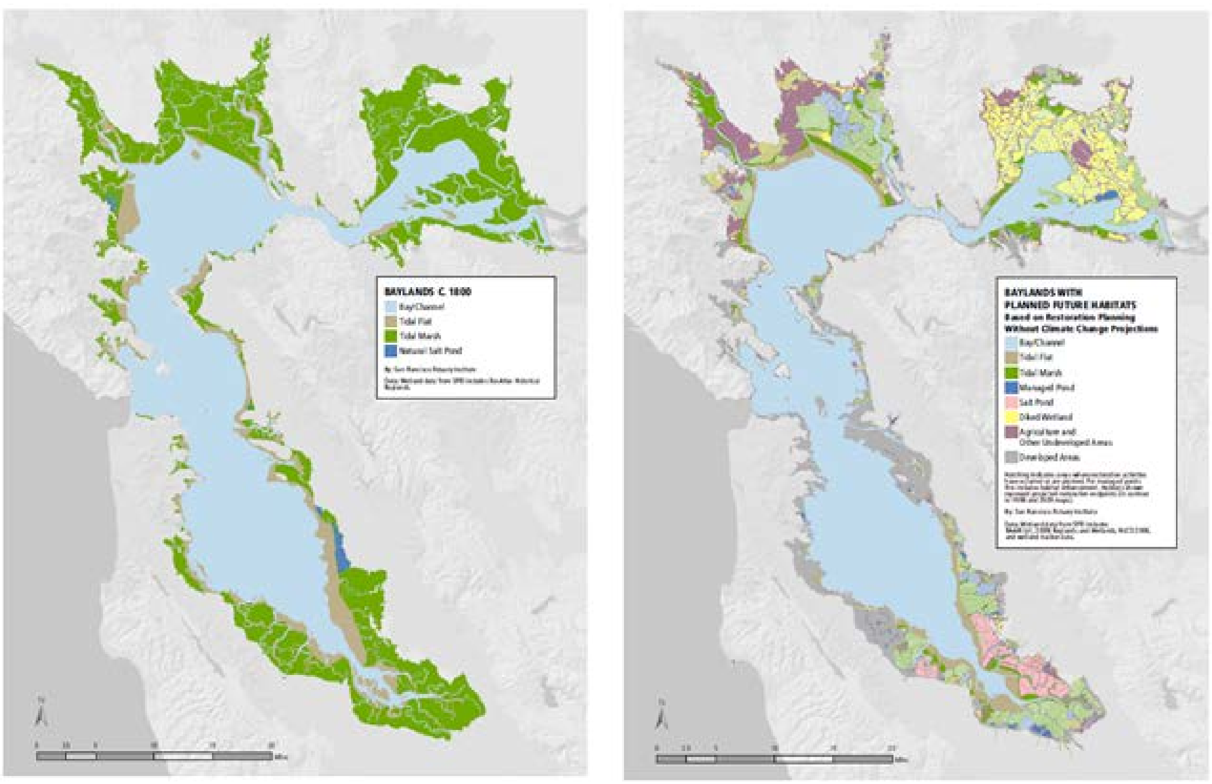

Figure 3. In the SF Bay region, the landscape-scale impacts of wetland loss have been deeply felt. By the mid-20th century, over 90% of the Bay's fringing marshes had been diked and drained for urban development, agriculture, and salt production. (Image: Goals Project 2015)

The significant physical and ecological impacts of large-scale tidal wetland loss in the Bay have been well documented in many reports, including the 1999 and 2015 Baylands Ecosystem Habitat Goals Reports, the U.S. Fish and Wildlife Service's Recovery Plan for Tidal Marsh Ecosystems of Central and Northern California (2013), and elsewhere. These impacts include (1) the loss of crucial foraging, breeding, and rearing habitat for a broad range of resident and migratory fish and wildlife, including many rare and endangered aquatic and terrestrial species that are directly and/or indirectly dependent on wetland food webs; (2) a reduction in the ability of the Bay's tidal wetlands to transform, assimilate, or eliminate pollution from Bay and tributary waters, resulting in a decrease in water quality, and (3) a decrease in the ability of bayland habitats to sequester carbon from the atmosphere, which could otherwise be a powerful tool for fighting climate change.

In many segments of the Bay, tidal wetland loss has also significantly increased the vulnerability of shorelines to erosion and inundation from waves, storms, and tides. Tidal wetlands reduce the impacts of storms and storm surges along the Bay shoreline by attenuating waves and spreading out and slowing down high water (Goals Project 2015). A large body of literature (including Lacy and Hoover 2011, ESA PWA 2012, and AECOM 2016a and 2016b) and multiple local/regional climate change adaptation planning and policy efforts (including the Adaptation Atlas, the Bay Conservation and Development Commission's Adapting to Rising Tides Program[4] and proposed Bay Plan Amendment for Fill for Habitat Projects[5], Marin County's Bay Waterfront Adaptation Vulnerability Evaluation (BayWAVE)[6] and Collaboration: Sea-level Marin Adaptation Response Team (C-SMART)[7] Projects, San Mateo County's Sea Change Initiative[8], the Bay Area Resilient By Design Challenge[9], and many others) therefore point to the conservation and restoration of tidal wetlands as a critical strategy to help protect the Bay's natural and built communities from the impacts of storm waves, surges, and other high-water events, which are likely to become more frequent with climate change (see Appendix A).

Unfortunately, the 40,000 acres of Bay tidal wetlands that persisted into the 21st century and the approximately 30,000 acres of tidal marshes and flats that have subsequently been restored (Goals Project 2015) are now at risk from the combined effects of sea level rise, decreasing amounts of suspended sediment, lateral edge erosion, and lack of upland migration space in the Bay (see Figure 4 and Appendix A). There is significant concern among scientists that by 2100, SLR will result in the widespread drowning of the Bay's tidal marshes, converting them to low marsh habitats and/or unvegetated mudflats. The loss of these wetlands would have tremendous negative consequences for the region's ecosystems, communities, and people.

[4] BCDC Adapting to Rising Tides: https://www.adaptingtorisingtides.org/
[5] BCDC Fill for Habitat Bay Plan Amendment: https://bcdc.ca.gov/BPAFHR/FillHabitat.html
[6] Marin BayWAVE: https://www.marincounty.org/main/marin-sea-level-rise/baywave
[7] Marin C-SMART: https://www.marincounty.org/depts/cd/divisions/planning/csmart-sea-level-rise
[8] San Mateo Sea Change: https://seachangesmc.org/
[9] Bay Area Resilient By Design: http://www.resilientbayarea.org/

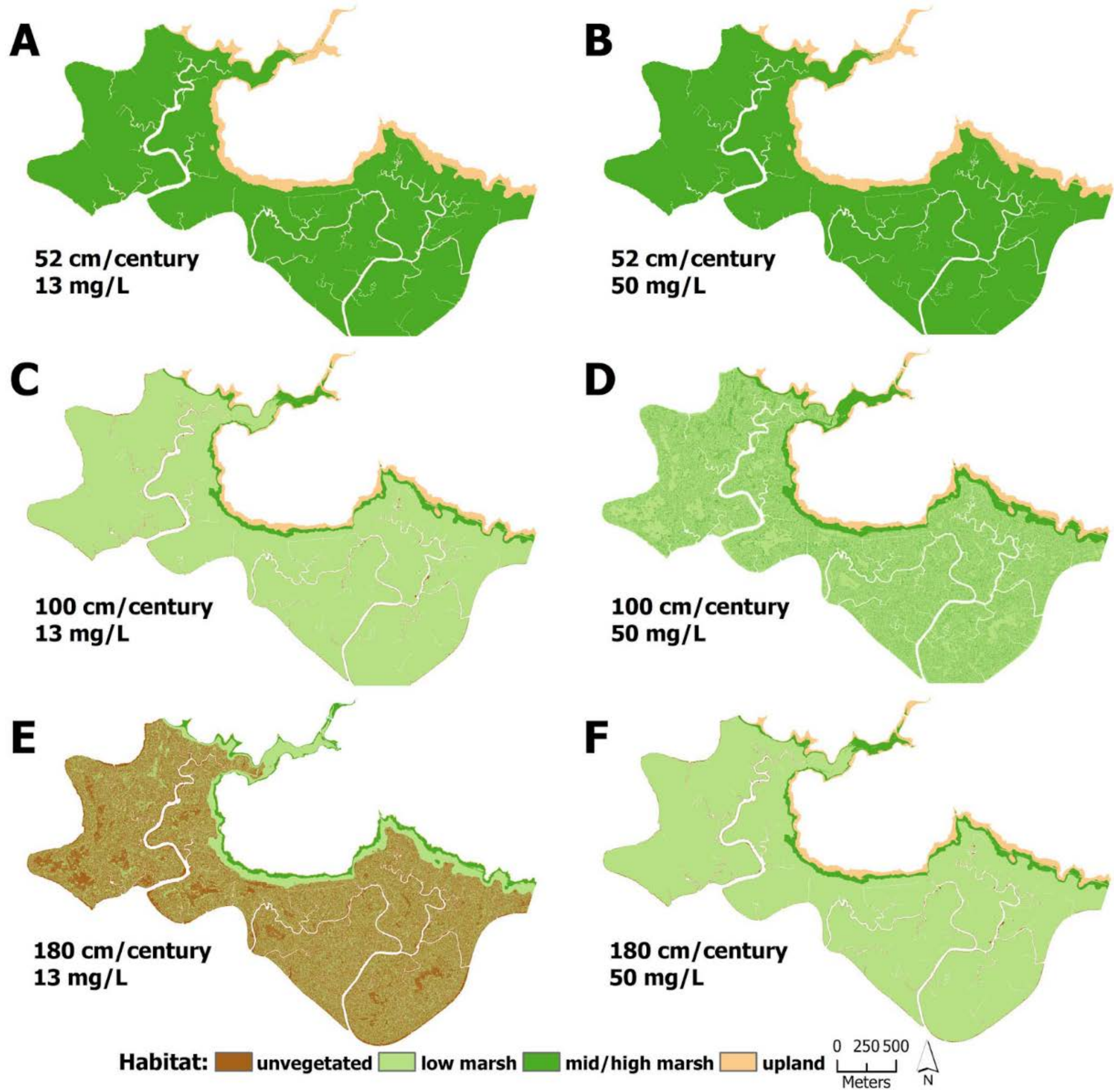

Figure 4. High rates of sea level rise (in cm/century) can combine with low concentrations of suspended sediment (in mg/L) to drive wetland drowning, as shown in modeling of Rush Ranch, a tidal brackish marsh in Suisun. (Image: Schile et al. 2014)

To help prevent this loss, the Regional Water Board has engaged in multiple inter-agency tidal wetland conservation and recovery efforts, including the 1999 and 2015 Baylands Goals Reports, and the 2019 Adaptation Atlas. These reports inform Regional Water Board plans, policies, and procedures related to wetland conservation, fill, restoration, and resilience. Chapter 3 below summarizes the recommendations of these reports, with a focus on describing how climate change threatens the health and resilience of bayland habitats, and strategies that would enhance their long-term persistence.

It's important to emphasize that with the exception of mudflats, post-colonial human activities in the Bay have resulted in the loss of not only most of the region's tidal wetlands, but almost all of its beaches, oyster reefs, and eelgrass beds. These losses are detailed in the 1999 and 2015 Baylands Goals reports as well as the 2010 Subtidal Habitat Goals Report (SCC et al. 2010). The loss of these habitats has resulted in tremendous damage to the Bay's ecological diversity and integrity, which has resulted in cascading impacts to public health through decreased water and sediment quality, contamination of the Bay food web (including sportfish, shellfish, and other organisms consumed by people), increasing harmful algal blooms (HABs), and other mechanisms. Increasing the acreage and resilience of these habitats will therefore not only create a Bay shoreline that provides more effective protection from climate change but generate regional improvements in environmental health that will benefit both people and nature.

3 Recommendations from the Baylands Goals Reports and the Adaptation Atlas

The 1999 and 2015 Baylands Ecosystem Habitat Goals Reports were significant, regional, interdisciplinary efforts that synthesized the best available science on Bay estuarine hydrology, geomorphology, and ecology to propose strategies for the long-term conservation and restoration of bayland habitats, including tidal wetlands and flats. Both reports were developed by teams of scientists and engineers from public agencies, including the Regional Water Board, as well as non-governmental organizations, academia, and private industry. Scientists from the San Francisco Estuary Institute (SFEI) made major contributions to both Goals Reports and were lead authors of the Regional Water Board-funded 2019 Adaptation Atlas. The Adaptation Atlas built upon the science of the Goals Reports and related regional efforts to develop a framework for sea level rise adaptation along the San Francisco Bay shoreline. This framework utilizes the science of Operational Landscape Units or "nature's jurisdictions" to illustrate where certain types of natural and nature-based features (NNBF) (e.g. wetland restoration, beach enhancement, ecotone levees, etc.) would be most effective at protecting the shoreline as well as providing benefits to Bay habitats and water quality. This chapter summarizes the recommendations of those reports as they relate to Regional Water Board plans, policies, and procedures governing the conservation and restoration of tidal wetlands.

3.1 Evolution of the Baylands Goals Reports and the Adaptation Atlas

In 1999, the first Baylands Goals Report catalogued the ecological resources and habitat restoration opportunities within the San Francisco baylands. It classified the baylands into 20 geographic segments, and recommended the types, amounts, and distribution of wetlands and related habitats for restoration to support target special-status species and ecological services. The 1999 report documented the historical extent of the baylands circa 1800, and the subsequent loss of diverse bayland habitats including tidal wetlands, tidal flats, tidal lagoons, coarse beaches, salt pannes, and shallow Bay waters. It then established a target of protecting and restoring 100,000 acres of tidal wetlands within the Bay, well above the roughly 40,000 acres of marsh that remained when the report was developed (Figure 3). Since then, over 30,000 acres of tidal wetlands are have been restored in the Bay, with roughly 30,000 acres in the planning and design pipeline (Goals Project 2015, Figure 3).

When the first Baylands Goals report was released, most of the Bay's tidal wetland restoration projects focused primarily on restoring intertidal habitat features that could support special-status species such as Ridgway's (formerly California clapper) rail and salt marsh harvest mouse (SMHM), such as mature high marsh plains and dendritic tidal channel networks. With the exception of high tide refugia along channels and the landward edges of marshes, habitats outside the tidal frame, such as subtidal open waters and estuarine-terrestrial transition zones, were less emphasized in project design and performance assessments. As the practice and science of tidal wetland restoration matured in the Bay Area, projects increasingly began to reflect the importance of establishing robust connections between supratidal, intertidal, and subtidal habitats, from shallow subtidal open waters to estuarine-terrestrial transition zones (often called *ecotones*).

In the years after the release of the first Baylands Goals report, scientific consensus began to coalesce around the risk that a finite sediment supply, climate change, and sea level rise posed to the Bay's tidal habitats. In 2011, Dave Schoellhamer at the U.S. Geological Survey demonstrated a post-1994 step decrease in sediment delivery to the Bay, indicating a potentially reduced supply of sediment available to support accretion in the Bay's tidal wetlands (Schoellhamer 2011). In following years, multiple teams of researchers applied different modeling methods to demonstrate how accelerating rates of SLR could drown the Bay's tidal wetlands, especially if suspended sediment concentrations throughout the Bay decreased (see Figure 4, Appendix A, Stralberg et. al 2011, Swanson et al. 2013, Schile et al. 2014).

In response to this evolving understanding of estuarine dynamics, the stakeholders who produced the original 1999 Baylands Goals report developed *The Baylands and Climate Change - What We Can Do* (also referred to as the 2015 Baylands Goals report). The 2015 report synthesized the post-1999 science describing the ecological functions and benefits of "complete" tidal wetlands (those with connected habitats that span supra-, inter-, and sub-tidal elevations), as well as the science detailing how climate change and SLR could lead to the loss of tidal wetlands through drowning, erosion, and "coastal squeeze" (where tidal marshes are caught between rising sea levels and hardened shoreline infrastructure). The 2015 report continued the geographic classification of the baylands developed for the 1999 report and proposed a suite of targeted strategies to accelerate the pace of tidal wetland restoration and increase the resilience of existing and restoring tidal wetlands to climate change.

Around the same time that the 2015 Baylands Goals report was developed, natural and nature-based features such as beaches, horizontal levees, and related features began to be tested throughout the Bay not just for their ecosystem benefits, but for their ability to reduce the impacts of sea level rise and extreme weather events on the shoreline. A number of pilot projects have been constructed and monitored to learn how such features may be deployed on a large scale. A collaboration led by the Oro Loma Sanitary District (OLSD) developed a pilot project for a horizontal levee (subsurface seepage levee fed by treated wastewater) at the OLSD wastewater treatment plant in San Lorenzo, a design concept aimed at creating estuarine-terrestrial transition zones, attenuating wave energy along the shoreline, restoring freshwater-brackish-salt marsh gradients, and reducing nutrient concentrations in the Bay.[10] The Coastal Conservancy's innovative Aramburu Island Beach Enhancement Project in Mill Valley used tree logs as "groins" to control beach movement, and placed sand, shell, and gravel to naturally buffer and protect a retreating shoreline and improve nesting, foraging, and roosting habitat for resident and migratory shorebirds[11]. Through the San Francisco Bay Living Shorelines Project, research teams from San Francisco State University led oyster and eelgrass bed restoration experiments off the San Rafael and Richmond shorelines, testing approaches to re-establishing these critical subtidal habitats (and wave attenuation features) at appropriate locations in the Bay.[12]

Despite the success of these projects, the Bay has lacked a coordinated, science-based blueprint for determining which nature-based approaches would be most appropriate in different portions of the Bay's diverse 400-mile-long shoreline. This created challenges for planners, designers, and other leaders charged with preparing their communities for sea level rise, as well as for regulatory staff who had to assess the tradeoffs between potential impacts and benefits of proposed projects on natural resources in both the near- and long-term. Meanwhile, some communities proposed traditional shoreline armoring such as rip-rap revetments and seawalls as adaptation approaches, increasing the risk of cumulative armoring throughout the Bay, which could drive sea levels in the Bay even higher by minimizing or eliminating space for flooding along the Bay margins (Wang et al. 2018). Seeing the value of a science-based framework to help decision-makers select appropriate multi-benefit, nature-based SLR adaptation strategies for their communities, the Regional Water Board funded SFEI to develop the San Francisco Shoreline Adaptation Atlas (SFEI and SPUR 2019).

The Adaptation Atlas uses a rigorous approach rooted in physical processes and geospatial analysis to classify the Bay shoreline into 30 cross-jurisdictional Operational Landscape Units (OLUs), or "nature's jurisdictions" (like a watershed, but for the shoreline).[13] Each OLU has shared geographic, geophysical, and ecological characteristics that make it an effective unit for planning for sea level rise. The Atlas describes the environmental setting of each OLU, including elements of the built

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[10] Oro Loma Horizontal Levee: https://oroloma.org/horizontal-levee-project/

[11] Aramburu Island Enhancement Project: https://www.marincountyparks.org/projectsplans/land-and-habitat-restoration/island-enhancement-aramburu

[12] San Francisco Bay Living Shorelines Project: http://www.sfbaylivingshorelines.org/sf_shorelines_about.html

[13] The OLUs in the Adaptation Atlas reflect current conditions in the Bay and opportunities for future adaptation, while the segments in the Baylands Goals reports are based on historic ecology. Therefore, the boundaries of the 30 OLUs in the Atlas do not match those of the 20 geographic units in the Baylands Goals reports.

landscape (e.g. zoning, housing density, job density, etc.) that influence land use planning. It then pairs each OLU with a suite of technically feasible nature-based SLR adaptation approaches that could be combined with more traditional measures such as levees and tidegates, and maps where within each OLU these approaches may be most appropriate. The Atlas also describes general considerations for each nature-based approach, including their potential environmental impacts and benefits, as well as their adaptability to increasing amounts of SLR over time. Released in May 2019, the Adaptation Atlas is already being utilized by partner agencies including the Bay Conservation and Development Commission, Metropolitan Transportation Commission, Marin and San Mateo counties, and multiple local cities and districts.

There are numerous major recommendations from the 1999 and 2015 Baylands Goals reports and the Adaptation Atlas that inform the policy and procedural updates being considered by the Regional Water Board. These recommendations include:

- Where technically feasible and appropriate, natural and nature-based SLR adaptation approaches are preferable to traditional shoreline armoring, to support beneficial uses of the Bay including improved water quality.
- Consider opportunities to combine nature-based SLR adaptation approaches, such as beaches with wetlands, as well as opportunities to combine traditional and nature-based measures in hybrid approaches.
- When making decisions about the potential near-term and long-term benefits and impacts from projects, consider how SLR, climate change, watershed freshwater/sediment inputs, and other drivers will influence landscape evolution and functions, and the regional distribution and connectivity of tidal wetland and other habitats.
- Restore “complete” tidal marshes with connected sub-, inter-, and supra-tidal habitats, including subtidal flats and channels, intertidal channels and marsh plains, internal[14] high tide refugia, and estuarine-terrestrial transition zones (often referred to as T-zones or ecotones). This includes:
    - Conserve and create space for tidal wetlands to move inland with rising sea levels, and transgress over adjacent upland and floodplain habitats.
    - Where technically feasible, increase opportunities for Bay- and watershed-derived sediment to reach existing and restoring tidal wetlands by connecting tidal wetlands to nearby or adjacent riverine and

[14] “Internal” hide tide refugia refers to refugia in the marsh interior, such as along channels, as opposed to refugia in the estuarine-terrestrial transition zone or along exterior levees. See Toms and Baye 2016.

floodplain/riparian habitats. Where this is not possible, consider strategic sediment placement to help maintain marsh elevations with respect to sea level.

In almost all cases, implementing these recommendations would require a permit from the Regional Water Board to place fill in wetlands and waters, convert one type of wetland or water to another, or a related action. These recommendations are discussed in greater detail in the following sections; their potential regulatory implications are discussed in Chapter 4.

3.2 Comparative Advantages of Nature-based Sea Level Rise Adaptation Approaches

The Adaptation Atlas discusses in-depth how nature-based approaches to SLR adaptation, when located and designed appropriately, can provide benefits beyond those provided by traditional shoreline armoring. For example, alone, or more likely in combination:

- Tidal wetlands, especially “complete” systems, can attenuate wave energy, provide temporary storage for floodwaters, support local groundwater recharge, transform and/or sequester pollutants in the water column, sequester carbon in the long-term, provide habitat for a broad range of plants, fish, and wildlife, and support recreational and educational opportunities.
- Beaches can attenuate wave energy, respond dynamically to changing wave conditions, provide nesting, foraging, and roosting habitat for resident and migratory shorebirds, and support coastal access and recreation.
- Horizontal seepage levees (a subset of ecotone levees) can create estuarine-terrestrial transition zones, attenuate wave energy, remove nutrients, contaminants of emerging concern, and other pollutants from treated wastewater, and restore freshwater-brackish-saline wetland gradients that have largely been lost throughout the estuary.
- Nearshore reefs (oyster reefs and eelgrass beds) and mudflats can attenuate wave energy, provide foraging and nursery habitat for aquatic organisms and shorebirds, and support pelagic food webs.

The Atlas also describes numerous approaches to restore and sustain nature-based shoreline infrastructure, such as polder[15] management (managing subsided diked baylands to maximize sediment accretion so they can one day be restored to intertidal

[15] The term “polder”, commonly used in Europe, refers to a portion of low-lying land diked and drained from the sea. Without dikes, a polder would be flooded on every tide.

wetlands), mudflat augmentation (adding sediment to mudflats so they can in turn supply sediment to tidal marshes), creek-to-baylands reconnection (connecting creeks directly to tidal marshes and mudflats to provide sediment and freshwater), and migration space preparation (moving infrastructure and other obstacles to sea level rise and tidal wetland transgression[16]). These approaches are meant to work with, not against, natural estuarine processes to accelerate the evolution and maintenance of wetland, mudflat, and beach ecosystems and support their related beneficial uses.

3.3 Combining Nature-based and Traditional Shoreline Protection Approaches

The Adaptation Atlas describes how different nature-based adaptation approaches can be combined to provide enhanced shoreline protection and ecosystem benefits. For example, beaches can be designed and constructed such that they help reduce wave impacts on wetlands landward of the beach. In this approach, the beach provides the primary protection against waves and reducing wetland erosion, while the wetland provides further wave attenuation and temporary storage of floodwaters. Multiple examples of this type of combined system occur naturally throughout the Bay, at locations such as Point Pinole Regional Shoreline (Figure 5), the Outer Bair Island unit of the San Francisco Bay National Wildlife Refuge, and Brooks Island. These beach-wetland ecosystems are especially valuable to wildlife, as the high beach crests and dependent vegetation communities provide abundant refuge from high water events.

Figure 5. Point Pinole Regional Shoreline supports one of the few remaining “complete” tidal marshes in the Bay, with a broad marsh plain dissected by tidal channels, ponds/pannes, an estuarine-upland transition zone, a barrier beach, and mudflats along the Bay shore.

[16] The term “transgression” in this context refers to the gradual movement upslope of estuarine habitats such as tidal wetlands, whereby upland habitats are converted to estuarine ones.

In addition to being combined together, nature-based approaches can be combined with traditional shoreline armoring to develop "hybrid" systems that include both natural and grey/armored components. For example, traditional rock revetments can be used as artificial headlands to contain "pocket beaches", which are common throughout portions of the Bay shoreline with steeper nearshore topography (e.g. places such as the Marin Headlands, Points San Pablo and San Pedro, and the Contra Costa shoreline from eastern San Pablo Bay through the Carquinez Strait). In some portions of the shoreline that have been heavily armored, such as the southern Richmond-El Cerrito shoreline, pocket beaches have formed between revetments built in the early to mid- 20th century. Wind and wave action have in some locations even formed small dune fields (e.g. east of Marina Bay).

The Adaptation Atlas also describes how different nature-based and hybrid sea level rise adaptation approaches can be combined over time as part of a *phased adaptation pathway*. Many sea level rise adaptation measures require long lead times to accommodate planning, design, permitting, and implementation. Phased adaptation pathways provide a framework for identifying appropriate suites of action at different SLR thresholds and create a mechanism for addressing uncertainty and allowing for flexibility over time. When utilized as part of a comprehensive, long-term climate resilience strategy, phased, place-based adaptation pathways can identify opportunities for the long-term landward transgression of defenses from tidal flooding (managed retreat), which can over time create space for the restoration of complete tidal wetland systems and other nature-based adaptation measures. The Adaptation Atlas features a hypothetical adaptation pathway derived from the 2015 Baylands Goals report (Figure 6, below) illustrating how decisions are triggered at certain SLR thresholds (e.g., deciding to acquire, prepare, and restore migration space once sea levels have risen 0.5 ft to create space for tidal wetland restoration before sea level rise exceeds 2 ft).

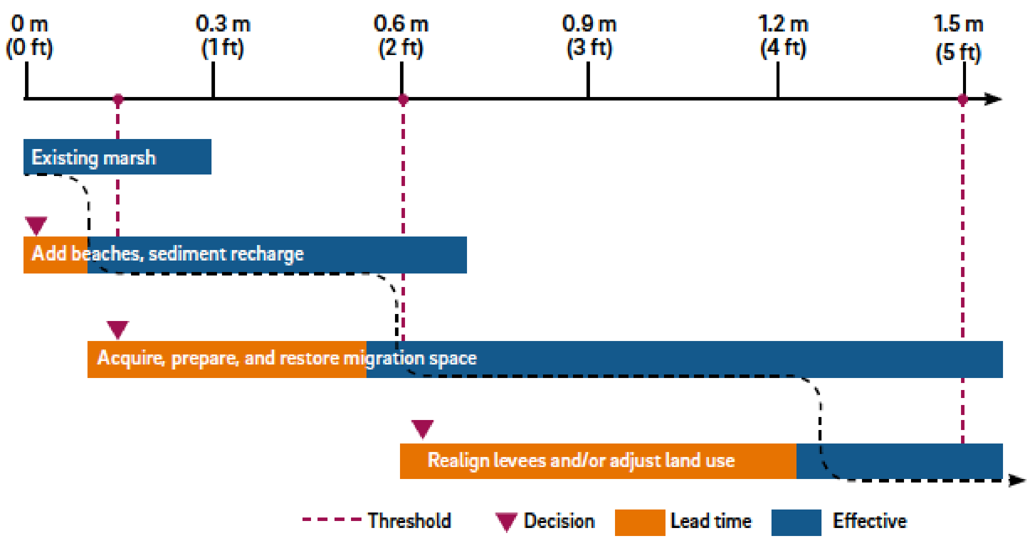

Figure 6. A conceptual phased adaptation pathway for nature-based measures triggered by different amounts of sea level rise (from the Adaptation Atlas, adapted from the 2015 Baylands Goals report).

It's important to note that even where natural and nature-based features are deployed along the shoreline, some areas may still require elements of traditional grey infrastructure to maintain appropriate levels of flood protection. For example, many developed areas of the Bay are located in subsided, diked baylands (polders) that, if not for levees, would be flooded by high tides. Many of these areas will therefore continue to require flood risk management levees between developed areas and the Bay. Creating, restoring, or enhancing nature-based features such as marshes and beaches in front of (bayward) of these levees can help minimize wave runup and overtopping, protecting levees from wave damage and potentially reducing the need for levees to be overbuilt to account for these processes.

3.4 Using Environmental Drivers of Landscape Evolution to Identify and Apply Appropriate Adaptation Measures

The resilience of the Bay's tidal wetlands is governed by complex interactions between multiple physical (e.g. tidal inundation, sedimentation/erosion) and ecological (e.g. vegetation productivity) processes that are described at length in the 2015 Baylands Goals report. Scientists have developed a suite of conceptual models that describe these interactions in detail (WRMP in-progress). The conditions that generally exert the most significant influence on the vertical and lateral extents of tidal marshes are topography/morphology, hydrology, sediment supply, and vegetation; these factors are described in further detail in Appendix B. Essentially, landscape evolution in the Bay's tidal wetlands is governed by the balance between the accretion of sediment (both mineral fine sands, silts, and clays as well as organic detritus from wetland plants), tidal inundation regimes (the frequency, depth, and duration of inundation from tides), and wave-driven erosion or accretion along the shoreline. The 2015 Baylands Goals report distills the interactions between environmental drivers into the following processes (Figure 7):

- **Migration (Transgression)** is the movement of baylands upslope into their watersheds. Migration is governed by sea level, hydrology, sediment supply, plants, topography, subsidence, and the availability of adjacent migration space. Migration of tidal wetlands into the estuarine-terrestrial transition zone is primarily driven by rising sea levels. The estuarine-terrestrial transition zone has been an attractive area for development due to its proximity to the Bay and elevations above typical tides and storm surges. This area will therefore be highly contested as urban development and climate change continue.

- **Erosion** is the vertical or lateral loss of tidal baylands due to the loss of sediment from their surfaces or edges. Most lateral erosion occurs at the bayward edge of wetlands due to wave action. Rising sea levels can increase erosion by allowing larger waves to act upon wetland edges and shorelines.

- **Progradation** is the extension of tidal wetlands and flats into the bay by the natural deposition of sediment when subtidal areas are converted to intertidal elevations. Progradation is governed by sediment supply, intertidal plant and animal populations, and the nature of erosive forces along the boundary between tidal and subtidal areas. Progradation can be especially strong near the mouths of creeks and rivers, where watershed-derived sediment deposits along the Bay's shoreline.

- **Drowning** is the conversion of baylands to habitats lower in the tidal frame (e.g., intertidal vegetated marsh converting to intertidal non-vegetated mudflat, or intertidal non-vegetated mudflat converting to subtidal open water). Sea level rise can drive drowning by increasing the frequency, depth and duration of tidal inundation within baylands.

- **Accretion** is the vertical buildup of marshes with inorganic sediment and organic matter (mainly peat). Accretion can prevent drowning and can convert lower tidal baylands to higher tidal baylands. For example, accretion can convert subtidal open water to tidal mudflats, and tidal mudflats to tidal marsh. Most tidal wetland restoration sites in SF Bay are designed to maximize accretion and accelerate the development of mature tidal marsh.

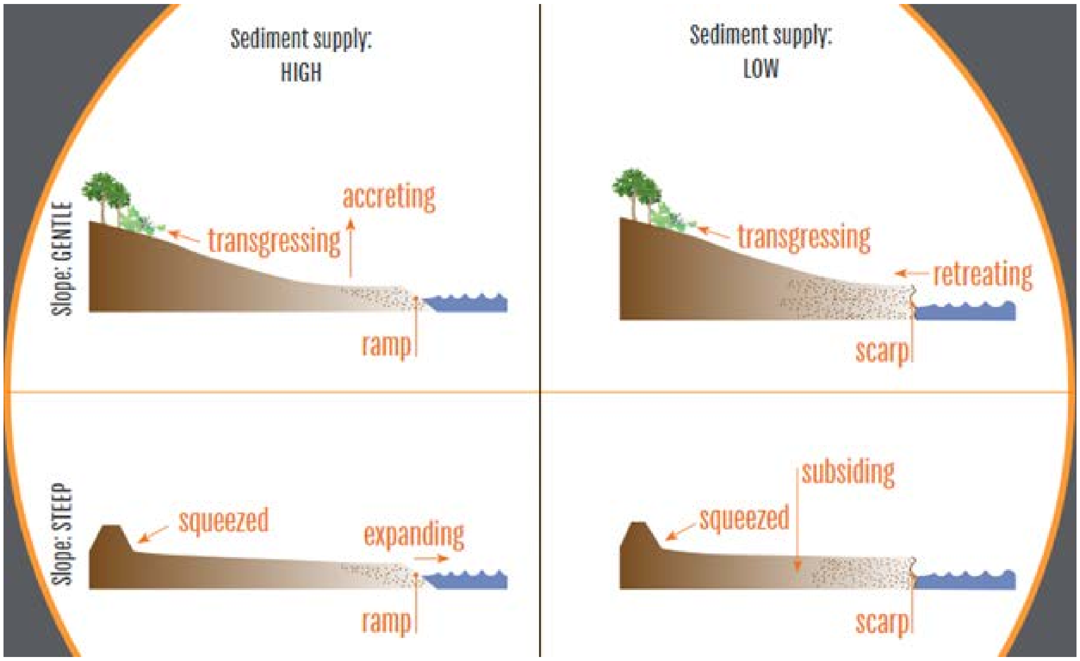

Figure 7. Marshes can shift vertically and/or horizontally in response to drivers that include antecedent topography, sediment supply, and sea levels. (Image: Beagle et al. 2015)

Decisions about shoreline adaptation in the near-term and long-term must consider the potential interactions between these processes, how they may change in the near- and long-term, and how the resulting landscape will evolve (not just at a given location, but within the entire OLU). The balance, diversity, and distribution of habitats that currently exist within San Francisco Bay will naturally shift in the future, and projects should be planned to maximize collective ecological functions in the long-term across different habitats on a landscape scale. Prioritizing one type of habitat at every location at the expense of other habitats will result in a Bay that is neither healthy nor resilient.

3.5 Conserving and Restoring "Complete" Tidal Wetland Systems With Connections to Uplands and Watersheds

The 1999 and 2015 Goals Reports and 2019 Adaptation Atlas emphasize how the most healthy, diverse, and resilient tidal wetland habitats are those that have robust physical and ecological connections to subtidal channels and embayments as well as estuarine-terrestrial transition zones. This continuum of habitats is called a "complete" tidal wetland system, and it supports different physical processes and ecological functions along its gradients. For example, subtidal connections allow sediment transported by the tides to move into tidal marshes and support accretion, while also allowing productivity from the marshes to be exported into open water ecosystems, supporting the pelagic food web. Intertidal channels weaving throughout marsh plains provide for the movement of water, sediment, and wildlife through the wetland. Supratidal areas within the interior of marsh plains (and near intertidal channels) provides high tide refugia for marsh wildlife when tides and storms inundate the marsh plain.

The 2015 Baylands Goals Report places special emphasis on the importance of the estuarine-terrestrial transition zone. The report defines this zone as:

> *"...the area of existing and predicted future interactions among tidal and terrestrial or fluvial processes that result in mosaics of habitat types, assemblages of plant and animal species, and sets of ecosystem services that are distinct from those of adjoining estuarine, riverine, or terrestrial ecosystems."*

More than just an area of transition between estuarine and terrestrial vegetation, the transition zone is where physical and ecological processes such as sediment delivery and wildlife movement connect the baylands with contributing upland watersheds and vice versa. The extent of the transition zone is therefore spatially and temporally variable and depends on the ecosystem services being considered (Figure 8). The 2015 Baylands Goals report includes an extensive list of the major ecosystem services provided by this transition zone, all of which directly or indirectly support the beneficial uses of the Bay and its tributaries.

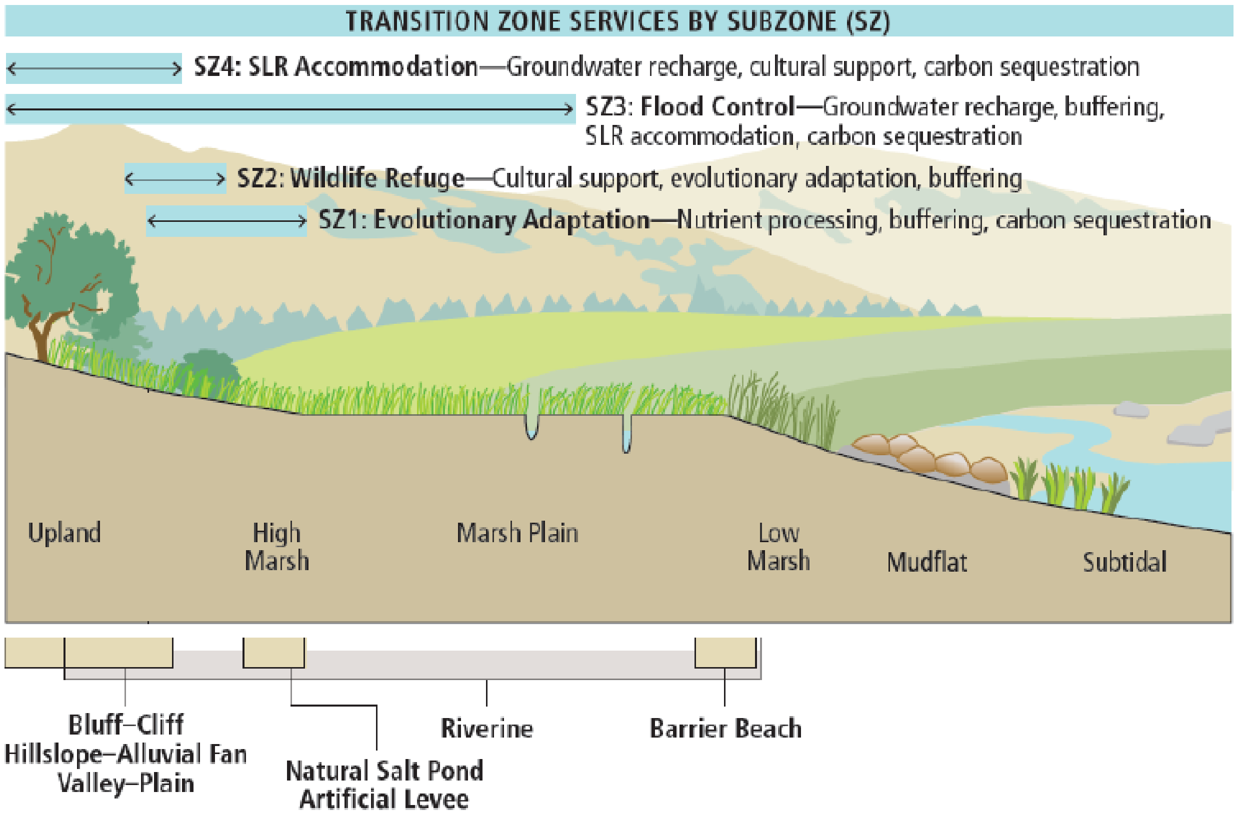

Figure 8. A conceptual diagram of a "complete" tidal wetland system, showing how different portions of the estuarine-terrestrial transition zone provide different ecosystem services. (Image: 2015 Baylands Goals report)

Prior to reclamation and urbanization of the Bay, many of its tidal wetlands had extensive transition zones situated along broad, gently sloped floodplains, alluvial fans, and hillslopes. In the present day, this is rarely the case. The landward edges of modern Bay tidal marshes are instead dominated by steep, often armored berms and levees that surround residential neighborhoods, industrial and/or commercial development such as salt ponds and office parks, or infrastructure such as highways, railroads, and ports (Figure 9). The limited extent of transition zones (particularly in the Central and South Bay Segments) reduces ecological functions and ecosystem services in these tidal marshes under current conditions and leaves practically no room for the future SLR-driven transgression of estuarine habitats upslope.

Figure 9. Tidal marshes within Faber Tract (left, Santa Clara County) and Point Edith (right, Contra Costa County) lack functional estuarine-terrestrial transition zones due to their proximity to developed baylands and uplands. (Images: Google Earth)

Research indicates that the transgression of tidal wetlands over adjacent upland habitats will be one of the primary mechanisms through which the Bay maintains intertidal habitat (see Appendix B). Therefore, one of the core recommendations from the 2015 Baylands Goals report and the Adaptation Atlas is to protect and conserve transition zones where they already exist within the landscape, and to design extensive transition zones into tidal wetland restoration projects where possible.

The 2015 Baylands Goals report and the Adaptation Atlas also emphasize the importance of connecting tidal wetlands and adjacent habitats such as beaches with watershed sources of freshwater and sediment. Tidal wetlands require periodic inputs of freshwater and coarse sediment to maintain healthy, diverse vegetation communities, and watershed sediment delivery is a primary mechanism by which sediment to support accretion is transported to tidal wetland and nearshore habitats (Figure 10). In San Francisco Bay, heavy urbanization of much of the shoreline, leveeing of stormwater and flood control channels, and diking of salt ponds has resulted in the near-complete disconnection of many rivers, creeks, and streams from their former baylands. The effects of this disconnection are documented in the 2015 Baylands Goals report and the Adaptation Atlas, as well as companion work done by SFEI as part of its Flood Control 2.0 initiative (e.g. SFEI 2017). Absent robust connections between watershed flows and bayland habitats, tidal marshes tend to become less ecologically diverse, and have lower rates of mineral sediment accretion thereby putting them at risk of drowning and conversion to mudflats (downshifting) due to sea level rise. Restoring these connections will therefore improve watershed flood control and estuarine resilience, and support sea level rise adaptation (ibid).

There are many locations throughout the Bay where it may not be technically feasible or cost-effective to reconnect watersheds to baylands. For example, some of the Bay's tidal marshes are far from even engineered flood control channels, or nearby tributaries drain small areas without much flow or sediment supply. In these circumstances, strategic sediment placement may provide an artificial analogue to natural sediment delivery. Strategic sediment placement encompasses a spectrum of relatively more and less engineered techniques to place sediment either directly onto tidal wetlands, or in areas where sediment can be moved via watershed flows or tides into wetlands (Stantec and SFEI 2017). For example, thin-layer placement is an approach whereby hydraulically dredged sediment from one location (e.g., a flood control channel or marina) is pumped and applied as a slurry in thin layers (~ less than 18 inches) to an existing tidal marsh. This approach approximates the pulse delivery of sediment from storms that the Bay's tidal wetlands evolved with for thousands of years (most dominant Bay wetland plant species are perennials that tolerate and, in many cases, maintain dominance through periodic burial). Thin-layer placement has been used to improve tidal wetland resilience at Seal Beach National Wildlife Refuge (USFWS 2018) and to improve estuarine wetland hydrology in Butano Marsh (cbec et al. 2018); the approach is currently being studied in San Francisco Bay through a collaborative research project with the San Francisco Bay National Estuarine Research Reserve (Raposa et al. 2017). Another approach to strategic sediment placement is "seeding" tidal mudflats or subtidal channels with slurry, so that incoming tides can transport the sediment and deposit it on the marsh plain (Figure 11). These approaches to enhance tidal wetland resilience may be especially valuable in systems that are isolated from watershed sources of sediment and support regionally critical populations of special-status plants and wildlife.

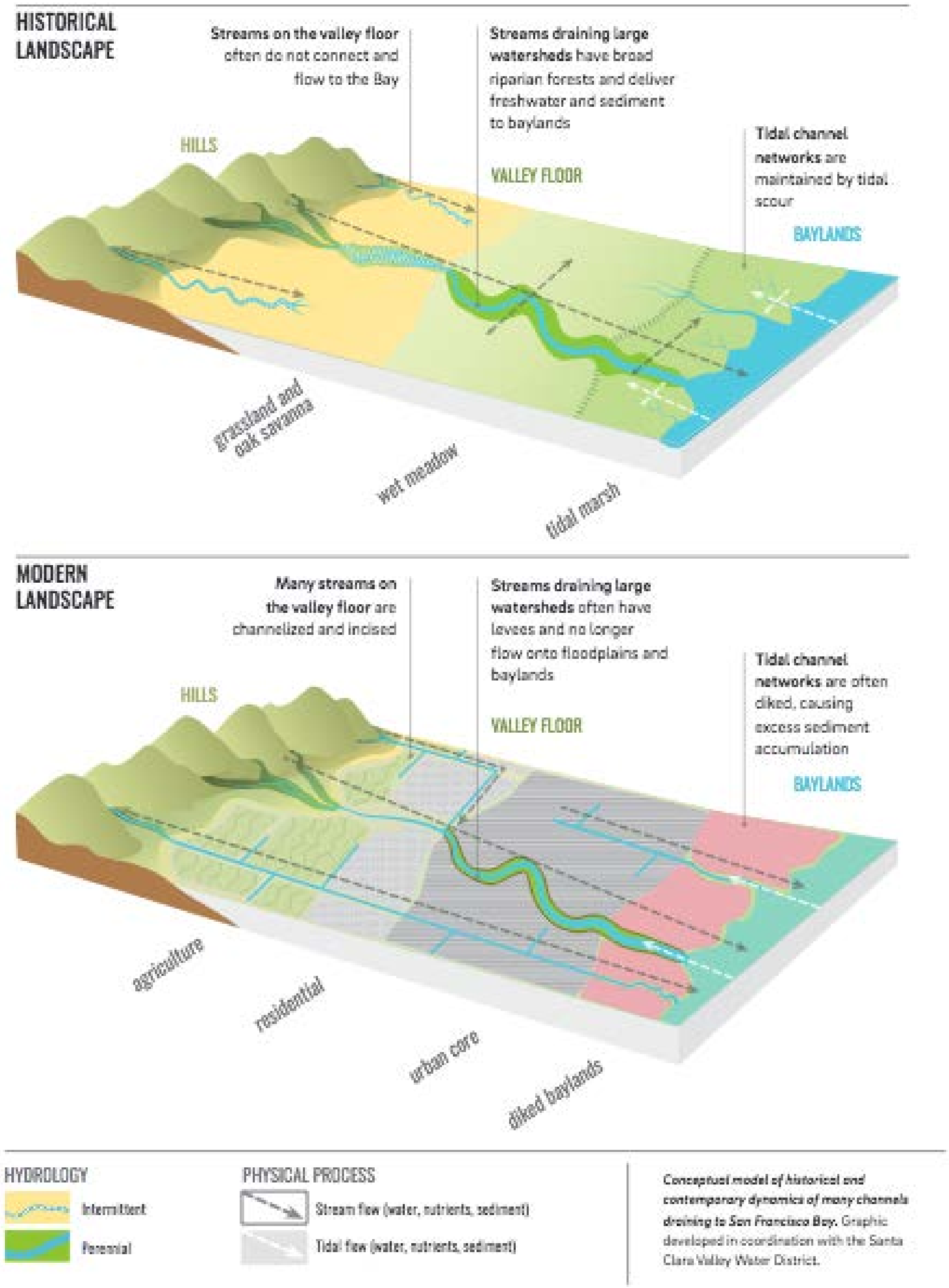

Figure 10. Post-European contact loss of watershed-bayland connectivity has negatively impacted many of the physical processes that support resilient bayland habitats. (Image: SFEI 2017)

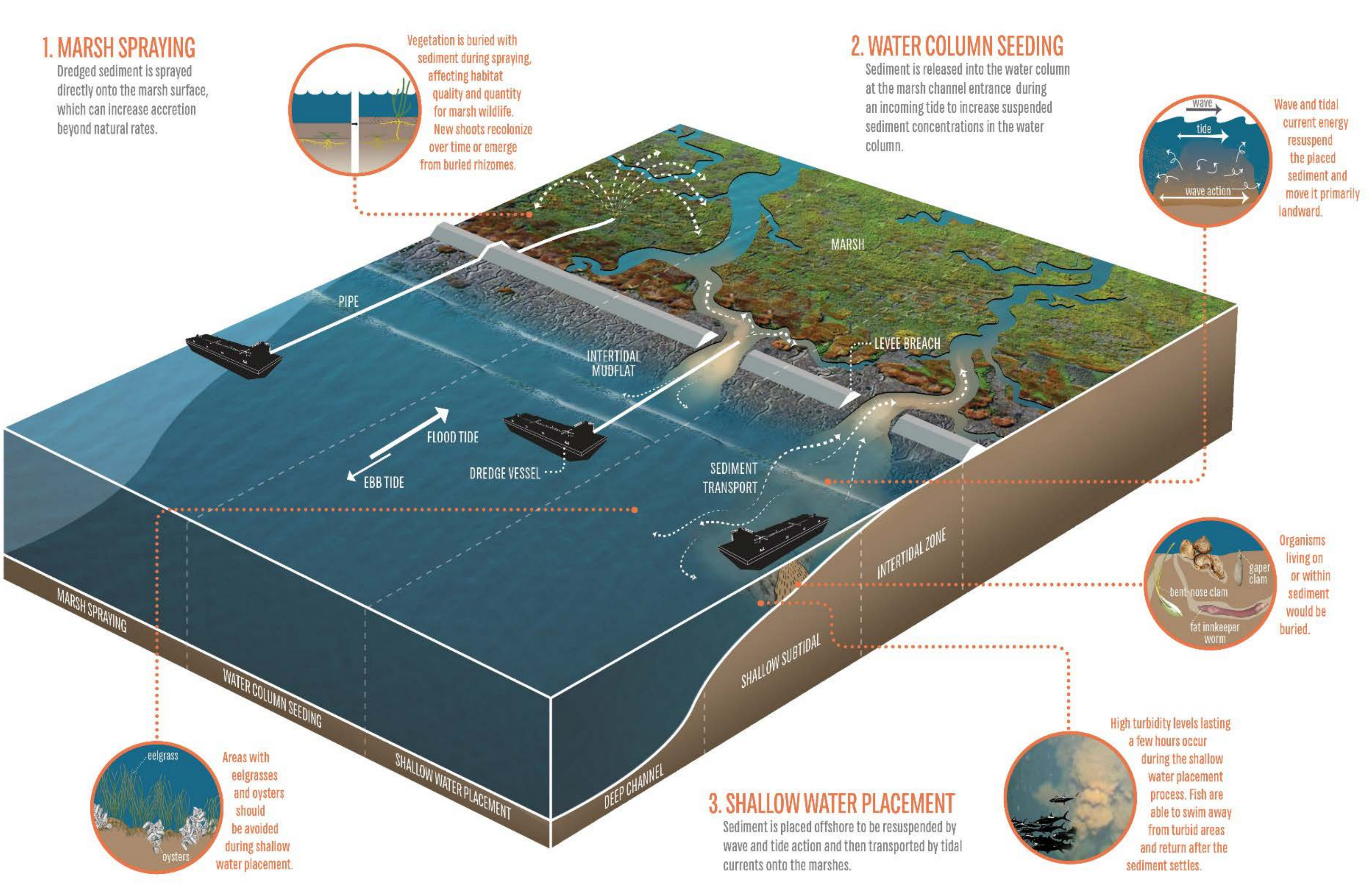

Figure 11. Marsh spraying, water column seeding, and shallow-water placement are all techniques to enhance the delivery of clean dredged sediment to tidal wetlands. (Image: Stantec and SFEI 2017)

4 San Francisco Bay Wetland Regulations and Policies

The strategies and interventions to improve tidal wetland habitats and shoreline resilience discussed in Section 3 will likely result in direct, indirect, and in some cases cumulative impacts to wetlands and waters that will require regulatory approval (permits) from the Regional Water Board and other environmental resource and regulatory agencies. The Regional Water Board derives its jurisdictional authority over wetlands and waters from the Clean Water Act, the Porter-Cologne- Water Quality Control Act (Porter-Cologne Act), Basin Plan policies, and the State's antidegradation policy. Many of these regulations and policies were initially developed in the mid- to late-1900s, when the large-scale reclamation, filling, and re-engineering of wetlands and shorelines drove widespread habitat loss and water quality degradation in San Francisco Bay, its tributaries, and other waters throughout California. Since these regulations and policies drive Regional Water Board permitting decisions, applying them to modern climate change adaptation scenarios can create a suite of regulatory opportunities and challenges. This section summarizes how the Regional Water Board has historically interpreted and applied these regulations and presents an overview of some of the regulatory opportunities and challenges a Basin Plant amendment could potentially address.

4.1 Clean Water Act Sections 404 and 401

The Clean Water Act (CWA) is the primary federal law that regulates discharges to waters of the United States (WOTUS), or federal waters. Under the CWA, in order to discharge dredged or fill material into federal waters, applicants must obtain a CWA section 404 permit from the U.S. Army Corps of Engineers (Corps) and a section 401 water quality certification (401 certification) from the Regional Water Board verifying that the project will comply with state water quality standards, which include but are not limited to Basin Plan water quality objectives and beneficial uses (see Section 4.3) and the state Anti-Degradation Policy.[17]

The Corps grants two types of permits under CWA section 404: individual permits, and general permits. Individual permits are project-specific permits that can address any type of dredging or filling activity in federal waters. General permits address specific classes of dredged or fill discharge activities that are similar in nature and/or involve the same or similar types of potential/minimal adverse environmental effects. The Corps issues a variety of general permits, including:

[17] The State of California Anti-Degradation Policy (Resolution 68-16) was adopted by the State Water Board in 1968 to require (1) that existing beneficial uses of water bodies are to be maintained and protected, and (2) best practicable treatment or control (BPTC) of discharges to high-quality waters to assure that pollution will not occur.

- *Regional general permits*, which cover a specific geographic area. Examples of regional general permits in the San Francisco Bay region include permits for levee maintenance and water management in Suisun Marsh managed wetlands/duck clubs, maritime facilities maintenance at the Ports of Oakland and San Francisco, and marina maintenance in San Mateo.
- *Programmatic general permits* (for existing local, State or other federal programs) that protect waters of the United States to the standards of the CWA section 404 program. Examples of programmatic general permits in the San Francisco Bay region include permits for mosquito abatement activities, National Marine Fisheries Service eelgrass restoration projects, and CDFW salmonid habitat restoration projects.
- *Nationwide general permits* (NWP) cover activities such as bank stabilization (NWP 13), aquatic habitat restoration/establishment/enhancement (NWP 27), and the development of living shorelines (NWP 54). Some tidal wetland restoration projects in the Bay are permitted by the Corps under NWP 27, but many larger, more complex projects (especially ones with major flood control elements) are often permitted under individual permits. NWP 54 is a relatively newer nationwide permit and has yet to be widely utilized in the Bay.

Both individual and general CWA section 404 permits require 401 certifications from either the State Water Resources Control Board (State Water Board) or the Regional Water Board. The State Water Board has issued statewide 401 certifications for some general permits, such as regional general permits for emergency projects and some classes of nationwide permits that are exempt for review under California's Environmental Quality Act (CEQA).[18] Projects implemented under NWP 27 are not exempt from CEQA, and therefore require individual 401 certification from the Regional Water Board. For example, construction of the Aramburu Island Shoreline Protection and Ecological Enhancement Project was permitted by the Corps under NWP 27, but required an individual 401 certification from the Regional Water Board. Projects implemented under NWP 54 are exempt from CEQA (and are therefore covered by a statewide 401 certification for CEQA-exempt projects, see Section 4.2 below) only if they fall within the limits established by the CEQA exemptions for minor alterations to land (CEQA §15304) or small habitat restoration projects (CEQA §15333). However, because its environmental limitations were developed with primarily East and Gulf

[18] The 2017 NWPs that are covered under this statewide 401 certification are listed at https://www.waterboards.ca.gov/water_issues/programs/cwa401/docs/generalorders/nwp_go.pdf

Coast systems in mind, NWP 54 is poorly suited to San Francisco Bay[19] and will likely not be applied locally unless the San Francisco Corps office develops its own statutory guidance for the permit (Marilyn Latta, pers. comm.). For example, a recent living shorelines and tidal wetland enhancement project at Giant Marsh in Richmond required both an individual CWA section 404 permit from the Corps as well as a 401 certification from the Regional Water Board.

4.2 Porter-Cologne Water Quality Control Act

The primary framework for protecting water quality at the state level is the Porter-Cologne Water Quality Control Act (Water Code §13000 et seq.), which requires the development of Waste Discharge Requirements (WDRs) for any discharge of waste that could affect the quality of waters of the state, including waters that are not under federal jurisdiction. Projects receive WDRs (and are therefore certified under Porter-Cologne) through a variety of mechanisms. Most projects that are issued 401 certifications by the State and Regional Water Boards are automatically enrolled for coverage under the Statewide General WDRs for Dredged or Fill Discharges (Order 2003-0017-DWQ), which simply state that 401 certifications are enforceable by the State and Regional Water Boards under Porter-Cologne. However, there are major exceptions to this rule:

- Large, complex projects that include innovative components or are subject to intense public interest are brought before the Regional Water Board to be approved through an Order issuing individual WDRs. Examples of tidal wetland restoration/shoreline adaptation projects that have their own WDRs issued through the Regional Water Board include Phase 1 of the Bel Marin Keys Unit V Tidal Wetland Restoration Project and the South Bay Shoreline Protection Project (see Section 5.1 below). The process to develop individual WDRs and an Order for Board approval generally takes longer than the process to develop a 401 certification. Individual WDRs include 401 certification.
- Relatively small, simple wetland and shoreline habitat restoration projects that fall under the CEQA exemption for small (less than 5 acre) habitat restoration projects (CEQA §15333). These projects are permitted through a statewide general order prescribing WDRs that also provides 401 certification (File

[19] For example, NWP 54 prohibits living shoreline placement more than 30 linear feet bayward of the Mean Higher High Water (MHHW) line. In East and Gulf coast systems where native oysters grow high into the intertidal (to or near MHHW), this is an appropriate limit. In West Coast systems such as San Francisco Bay where native oysters only grow low in the intertidal or in subtidal areas (below MLLW) along broad mudflats, this effectively prohibits the application of NWP 54. Language elsewhere in NWP generally is inconsistent with the typical tide ranges and shallow bathymetry of much of San Francisco Bay.

#SB12006GN). Due to the complexity of most estuarine/shoreline projects, this general order is rarely used in the San Francisco baylands.

Projects that result in a dredged or fill discharge to state waters outside federal jurisdiction (and therefore aren't subject to 401 certification) are prescribed WDRs through statewide general order WQO 2004-0004. This order was developed by the State Water Board to address changes in how the Clean Water Act was interpreted and enforced by federal courts following the Supreme Court's 2001 decision in *Solid Waste Agency of Northern Cook County v. U.S. Army Corps of Engineers*, 531 U.S. 159 ("SWANCC"). However, like the general order for small habitat restoration projects, this order is rarely if ever applied in San Francisco Bay.

4.3 Basin Plan Policies

The Water Quality Control Plan for San Francisco Bay Basin (Basin Plan, SFBRWQB 2017) is the Regional Water Board's master water quality control planning document. It designates beneficial uses and water quality objectives for waters of the State, including surface waters and groundwater, and describes implementation programs to achieve those objectives. The Basin Plan is adopted and approved by the State Regional Water Board, USEPA, and the Office of Administrative Law where required.

Multiple sections of the Basin Plan emphasize the importance of the Bay's intertidal, subtidal, and shoreline habitats to the health and resilience of the entire estuary. For example, Chapter 2.2.3 of the Basin Plan highlights the ecological values of mudflats and tidal wetlands:

> *"Mudflats make up one of the largest and most important habitat types in the Estuary. Snails, clams, worms, and other animals convert the rich organic matter in the mud bottom to food for fish, crabs, and birds.*
>
> *Mudflats generally support a variety of edible shellfish, and many species of fish rely heavily on the mudflats during at least a part of their life cycle. Additionally, San Francisco Bay mudflats are one of the most important habitats on the coast of California for millions of migrating shorebirds.*
>
> *Another important characteristic of the Estuary is the fresh, brackish, and salt water marshes around the Bay's margins. These highly complex communities are recognized as vital components of the Bay system's ecology. Most marshes around the Bay have been destroyed through filling and development. The protection, preservation, and restoration of the remaining marsh communities are essential for maintaining the ecological integrity of the Estuary."*

Chapter 2 of the Basin Plan describes the existing and potential beneficial uses that are associated with different wetland types, and also designates beneficial uses for 34 significant wetland areas within the region (most of which are tidal brackish or salt marshes; see Appendix D). In general, beneficial uses for tidal wetlands include but are not limited to: EST – Estuarine Habitat, RARE – Preservation of Rare and Endangered Species, REC1 – Water Contact Recreation, REC2 – Noncontact Water Recreation, SPWN – Fish Spawning, and WILD – Wildlife Habitat.[20] Chapter 3 of the Basin Plan describes narrative and numeric water quality objectives that are considered necessary to protect these existing and potential beneficial uses. These objectives include standards for fundamental water quality characteristics such as temperature, dissolved oxygen, salinity, pH, and suspended sediment as well as more complex attributes such as toxicity, biostimulatory substances, and specific chemical constituents.

Chapter 4 of the Basin Plan describes implementation plans for meeting water quality objectives and protecting beneficial uses. Chapter 4.23, Wetland Protection and Management, focuses on strategies meant to conserve, enhance, and restore wetlands throughout the estuary, including tidal wetlands. It references the 1999 Baylands Goals Report and accompanying Baylands Ecosystem Species and Community Profiles as "*a starting point for coordinating and integrating wetland planning and regulatory activities around the Estuary*", and also refers to the 1994 version of the San Francisco Estuary Partnership's (SFEP) Comprehensive Conservation and Management Plan (CCMP) for "*recommendations on how to effectively participate in a Region-wide, multiple-agency wetlands management program.*" The Basin Plan has not yet been updated to reference the science or recommendations in the 2015 Baylands Goals Report, the 2019 Adaptation Atlas, or the 2016 CCMP.

4.3.1 California Wetlands Conservation Policy and the Basin Plan Fill Policy

Section 4.23 of the Basin Plan refers to numerous other state policies that guide the Regional Water Board's wetland-related planning and regulatory actions. One of the most crucial of these policies is the California Wetlands Conservation Policy (Executive Order W-59-93, Appendix E), commonly referred to as the "No Net Loss" policy. California Governor Pete Wilson signed the California Wetlands Conservation Policy in 1993 to address the growing need to incentivize, coordinate, and implement wetland restoration across the state, especially in the San Francisco Bay region and in coastal Southern California. The policy has three primary objectives:

[20] It's important to note that the list in Appendix D and in the Basin Plan is not comprehensive; due to the large number of small and non-contiguous wetlands, it is not practical to delineate and specify beneficial uses of every wetland area.

1. *To ensure no overall net loss and a long-term net gain in the quantity, quality, and permanence of wetlands acreage and values in California in a manner that fosters creativity, stewardship, and respect for private property.*
2. *To reduce procedural complexity in the administration of State and federal wetlands conservation programs.*
3. *To encourage partnerships to make restoration, landowner incentive programs, and cooperative planning efforts the primary focus of wetlands conservation.*

No Net Loss directs the state and its agencies (including but not limited to the Regional Water Board) to implement a range of measures aimed at growing wetland acreage, functions, and values statewide, including developing policies to incentivize multi-benefit wetland conservation projects that also benefit flood control, groundwater recharge, recreation, and other needs. The policy is clear that its objectives are not meant to be achieved on a permit-by-permit basis; rather, implementation should be guided by regional wetland conservation strategies (it was in this spirit that the 1999 Baylands Goals Report was conceived). The policy doesn't differentiate between the functions and values of different kinds of wetlands (e.g., seasonal freshwater marsh vs. tidal salt marsh vs. open water vs. mudflat) and calls for development of a consistent definition of wetlands for regulatory purposes.

To help achieve the objectives of No Net Loss, Chapter 4.23.4 of the Basin Plan prescribes how the Regional Water Board must regulate projects that would result in wetland diking, dredging, or filling. This policy (Fill Policy) incorporates the USEPA's CWA Section 404(b)(1) guidelines for determining the circumstances under which dredging or filling of wetlands, streams, or other waters of the state may be authorized. Under these regulations, a project applicant must demonstrate that the following three sequential steps have been taken to reduce direct, indirect (secondary), and cumulative[21] impacts to wetlands and waters: 1) all practicable measures to avoid impacts must be exhausted; 2) minimization measures must be incorporated into the project design to further reduce any remaining impacts; and 3) if after all practicable avoidance and minimization measures have been applied, the applicant must provide compensatory mitigation for any unavoidable impacts. This tiered strategy for addressing potential wetland impacts is often summarized by the phrase *"first avoid, then minimize, then mitigate."* As a part of this assessment, an applicant must also provide an alternative analysis which demonstrates that the proposed project is the least environmentally damaging practicable alternative (LEDPA). The No Net Loss Policy further instructs the Regional Water Board to evaluate projects together with their proposed mitigation to ensure no net loss of wetland acreage and functions.

Section 4.4 below describes how No Net Loss and the Fill Policy are typically applied within the Regional Water Board's 401 certification and WDR permitting processes.

4.4 Current Application of the California Wetland Conservation Policy and the Basin Plan Fill Policy Within the 401/WDR Process

In order to determine the precise footprints of impacts to wetlands from diking, dredging, and filling activities, permit applicants must first establish the spatial boundaries of wetlands. Section 404 of the Clean Water Act defines WOTUS in tidal waters as all areas below the High Tide Line (HTL) and defines the HTL as "the line of intersection of the land with the water's surface at the maximum height reached by a rising tide." In the absence of tidal data, the HTL may be determined by field indicators such as a line of oil or scum along shore objects, shoreline deposits of fine shell or debris, breaks in vegetation types, or other physical or biological signs. HTL includes spring high tides and other regularly occurring high tides, but not storm surges driven by waves and/or low-pressure weather systems. The Porter-Cologne Water Quality Control Act defines waters of the State more broadly to include any surface or groundwater within California

[21] *Direct impacts* to wetlands generally include instances in which a wetland is impacted by an activity at the same time and location as the activity, whereas *indirect* or *secondary impacts* are instances where a wetland is impacted on a different spatial and/or temporal scale as the activity. For example, building a levee around a tidal wetland not only results in direct impacts to the wetland underneath the footprint of levee fill; it also results in indirect/secondary impacts to the non-filled wetland inside the levee by isolating it from the tidal processes (tidal flows, sediment deposition, etc.) that sustain the wetland. *Cumulative impacts* are the incremental (direct and/or indirect) impacts of an activity considered together with the impacts of other past, present, and reasonably foreseeable future activities implemented by a discharger and other entities. Cumulative impacts can result from individually minor but collectively significant activities that take place over a period of time. For example, the impact from a small shoreline hardening project may be minor, but the cumulative impacts of multiple shoreline hardening projects within a region over time are likely to be significant. The Water Board regulates direct, indirect, and cumulative impacts to wetlands and waters.

and grants Regional Water Board staff extensive discretion to determine the limits of State jurisdiction. However, to minimize confusion between state and federal jurisdiction, the Regional Water Board generally considers the upper limit of its jurisdiction in tidal areas to be the HTL, unless federally jurisdictional wetlands are present above HTL.

When applying for a 401 certification or WDR, the applicant must provide adequate information for Regional Water Board staff to quantify and understand the project's temporary and permanent impacts to wetlands and other waters, and how those impacts would be avoided, minimized, and/or mitigated to achieve "No Net Loss." The Regional Water Board has discretion when determining appropriate compensatory mitigation ratios (compensatory acres and/or length: impacted acres and/or length) for projects. In general, when compensatory mitigation is necessary for the project to comply with the Basin Plan, Regional Water Board policy prioritizes the creation/restoration of a similar habitat type at a location near the impact site (e.g., if impacts result in a net loss of seasonal wetlands, then mitigation would ideally create new seasonal wetland near the impacted habitats). Projects that compensate for impacts in this way typically have lower mitigation ratios than projects that compensate through out-of-type projects farther from the impact site. The Regional Water Board considers numerous additional factors when identifying appropriate mitigation ratios and strategies, including existing habitat quality, current and potential future land use practices, the likelihood of a mitigation site developing quality compensatory habitats and/or supporting special-status species, the local/regional abundance of impacted/compensatory habitats, and much more. The Regional Water Board accepts enhancement projects (which improve wetland functions without increasing wetland acreage) as mitigation for the temporary impacts to wetlands, and on rare occasions has accepted enhancement projects as mitigation for permanent impacts, especially when the permanent impacts are small.

This interpretive flexibility is fundamental to the California Wetlands Conservation Policy, which emphasizes that the Regional Water Board shall achieve the long-term net gain of wetland <u>functions</u> and <u>values</u> as well as wetland <u>acreage</u>, shall do so *"in a manner that fosters creativity, stewardship, and respect for private property"*, and shall not achieve this goal *"on a permit-by-permit basis."* Further, the policy promotes *"development of means to provide flexibility in the regulatory process for the accidental or unintentional creation of wetlands, and for allowing public agencies, water districts, and landowners to establish wetlands on their property consistent with the primary purpose of the property."* This emphasis on flexibility and creativity reflects the varied natural and political environments across California, as well as the varied governance of local and regional coalitions that were forming in the late 1980s and early 1990s to respond to the challenge of wetland conservation.

4.5 Permitting Challenges: Multi-Benefit Projects and Climate Change Resilience

As described in Section 3, climate change and sea level rise will fundamentally alter many of the physical and ecological processes that maintain estuarine habitats, including wetlands, around the Bay's margins. Accelerating rates of sea level rise will make it more difficult for existing tidal wetlands to maintain elevations relative to the tides, especially if sediment availability in the Bay decreases further. Even if Bay sediment supplies remain constant, SLR will increase the amount of time for most wetland restoration projects to achieve elevations suitable to support marsh vegetation. And regardless of the Bay's sediment supply, sea level rise will raise the elevation of the HTL over time, gradually changing the vertical and lateral extents of jurisdictional Waters of the State, including tidal wetlands, and increasing the risk of shoreline flooding and erosion.

In response to changing conditions in the Bay, many habitat restoration and climate change adaptation initiatives along its shoreline are proposed as "multi-benefit" projects that address sea level rise, "complete" tidal wetland habitats, coastal flood risk, and sediment management. For example, projects such as the South Bay Shoreline Project (see Section 5.1 below) and Phase II of the South Bay Salt Pond Restoration Project propose to construct large levees along the shoreline that will protect developed baylands from rising sea levels while allowing inactive salt ponds bayward of the levees to be restored to tidal action. Other projects, such as Corps' Strategic Placement Pilot Project (Stantec and SFEI 2017), propose to strategically place clean sediment from navigational dredging projects to help existing tidal marshes maintain elevation capital, improve topographic diversity, and increase high tide refugia within marsh interiors.

Despite the advantages of multi-benefit approaches to tidal wetland restoration, these projects generally require filling WOTUS and/or waters of the State, which can conflict with the Clean Water Act, Porter-Cologne, and the Regional Water Board's wetland protection policies. A common challenge is the requirement that applicants first demonstrate that they have attempted to *avoid* and *minimize* impacts to wetlands and waters before proposing compensatory *mitigation*. Applicants are often unaware of this requirement or are limited in their ability to avoid fill due to existing development, property boundaries, adjacent land uses, or other factors.

Another common challenge is that new or upgraded flood control levees typically have to be built bayward of existing shoreline infrastructure, which means that their construction often requires a significant amount of fill in tidal wetlands and/or other waters. This is especially true if the bayward portion of the levee is built with gradual side slopes to create a functional estuarine-terrestrial transition zone/ecotone: the more gradual the slope, the farther it will extend out into waters, resulting in a larger area and volume of fill. Since these levees are typically designed to protect against future as well as existing sea levels (and provide lateral and vertical space for estuarine habitats to transgress farther upslope), much of their fill creates land above the existing HTL, therefore converting waters to non-jurisdictional areas. If the area being restored to tidal action is already a waters of the state (e.g., open Bay waters, salt ponds, or seasonal wetlands), Regional Water Board staff have historically considered these restorations to be a *type conversion*, which converts one aquatic habitat type to another aquatic habitat type but does not result in a net increase in aquatic habitat. Therefore, large, multi-benefit tidal wetland restoration projects that construct new or upgraded levees often struggle to comply with No Net Loss and the Basin Plan Fill Policy, because the footprint of levee fill that creates land above HTL is not offset by new aquatic habitat elsewhere.

Another challenge to permitting large, multi-benefit tidal wetland restoration projects is that there is frequently a large time lag between the temporary and permanent impacts of construction and the evolution of mature tidal marsh habitats. Depending on multiple factors, including initial site elevations, tidal exchange, and sediment supplies, large restoration sites can take years or (usually) decades to develop the intertidal elevations, channel networks, and native vegetation communities that support the wetland functions and values cited in the Basin Plan and No Net Loss. This time lag can introduce considerable uncertainty about long-term project benefits that contrast with certainties about near-term impacts. While interim states of tidal wetland evolution such as open tidal water and mudflats also support beneficial uses (particularly as habitat for estuarine fish, waterfowl, and shorebirds), they provide related but different functions and values than those of mature tidal wetlands.

Finally, the typical Regional Water Board practice of establishing the HTL as the upper boundary of waters of the State in tidal areas can make it difficult to incorporate the concept of the “complete” tidal wetlands system (Section 3) into permitting decisions. In some instances, staff have considered fill placed along the landward edges of existing marshes (to create or expand an estuarine-terrestrial transition zone) that converts an area below HTL to an area above HTL to be a conversion of wetlands to uplands, even though the fill creates a transition zone that enhances the functions and values of the remaining wetlands below HTL. This can create special challenges for wetland restoration/enhancement projects that back up to hardened, urbanized edges that do not provide healthy ecotones for adjacent tidal wetlands and waters.

The cumulative impact of these challenges is that the Regional Water Board’s permitting process tends to focus on carefully accounting for and balancing the site-scale footprints (acreage and/or length) of project impacts and compensatory mitigation, with relatively less consideration for how projects will ultimately function on a landscape-scale. This is especially true with regards to the temporal and spatial uncertainties wrought by climate change. Without appropriate guidance in the Basin Plan or other regulatory documents to help staff assess the potential long-term evolution of a project, its position within the landscape, and the physical and ecological processes that govern its functions, staff are left to focus on acreage as the primary way to account for No Net Loss of wetlands. Large, publicly funded, multi-benefit tidal wetland restoration projects typically do not have the resources to mitigate for impacts off-site, so they often attempt to offset fill impacts by grading down exterior or interior perimeter levees or other landscape features above HTL to below HTL. This practice converts uplands into tidal wetlands while also providing a source of material with which to build new/upgraded levees or other project features. However, many projects do not have this option, or the footprint of areas to below HTL is still far smaller than the footprint of areas filled to above HTL.

Section 5 below describes case studies of large, multi-benefit projects that have addressed these regulatory challenges, and highlighted potential policy changes that would streamline the permitting of similar projects in the future.

5 Restoration and Permitting Case Studies

Prior to the release of the 1999 Goals Project report, tidal wetland restoration projects in San Francisco Bay typically relied on simple engineering designs that often included little more than levee breaches to restore tidal action, encourage sediment deposition and the establishment of tidal marsh plants, and develop habitats suitable for marsh wildlife. Since then, over 12,000 acres of tidal restoration projects have been put in the ground, and nearly 30,000 acres more are in the planning stages (not counting projects supported by the newly funded San Francisco Bay Restoration Authority). While this is great news for the Bay and its habitats, it means that almost all of the “low-hanging fruit” has been picked, and that future wetland restoration and shoreline adaptation projects will generally require more complex designs to address infrastructure, flood protection, sea level rise, and other elements. Permitting these more complex projects can pose challenges for local regulatory agencies, including the Regional Water Board.

This section describes three recent case studies that illustrate these challenges and describes the permit-by-permit basis by which the projects were approved by the Regional Water Board. The South San Francisco Bay Shoreline Protection Project (Section 5.1) and Novato Creek Dredging and Beneficial Reuse Project (Section 5.2) are multi-benefit projects aimed at restoring tidal wetland habitats while reducing flood risk in adjacent communities. The Foster City Levee Improvement Project (Section 5.3) is focused primarily on flood protection.

5.1 South San Francisco Bay Shoreline Protection Project

The South San Francisco Bay Shoreline Protection Project (Shoreline Project) is a long-term partnership between the Corps and the Shoreline Project’s local sponsors, the California State Coastal Conservancy and Santa Clara Valley Water District. The goal of the multi-phase, multi-purpose project is to improve coastal flood protection for portions of the Lower South Bay while restoring thousands of acres of former salt ponds owned by the U.S. Fish and Wildlife Service (USFWS) and the City of San Jose. The Regional Water Board adopted Waste Discharge Requirements (including a section 401 certification) for the project in November 2017. The Project focuses on protecting the low-lying, flood-prone community of Alviso and the adjacent San Jose-Santa Clara Regional Wastewater Facility (RWF), a 110 million-gallon-per-day (MGD) facility that is the largest advanced treatment plant in the western United States.

The Shoreline Project will construct a new Flood Risk Management (FRM) levee that will start at the small town of Alviso, head north and east along the bayward boundaries of New Chicago Marsh, cross Artesian Slough (and the discharge point for the RWF), and skirt the bayward edge of existing mitigation wetlands and the RWF before terminating at the Coyote Creek flood bypass. This new engineered levee will largely follow the alignments of existing unengineered levees along the Alviso bayfront, most of which were originally constructed during marsh reclamation activities in the early to mid-1900s. The portions of the new levee that border salt ponds proposed for tidal restoration (Ponds A12, A13, and A18) include a bayward ecotone with gently sloping sides of 30:1 (H:V) (Figure 12). This ecotone will provide extensive estuarine-transitional habitat in the tidal portions of the Project, as well as space for the SLR-driven transgression of tidal marsh habitats over adjacent uplands on the levee slope.

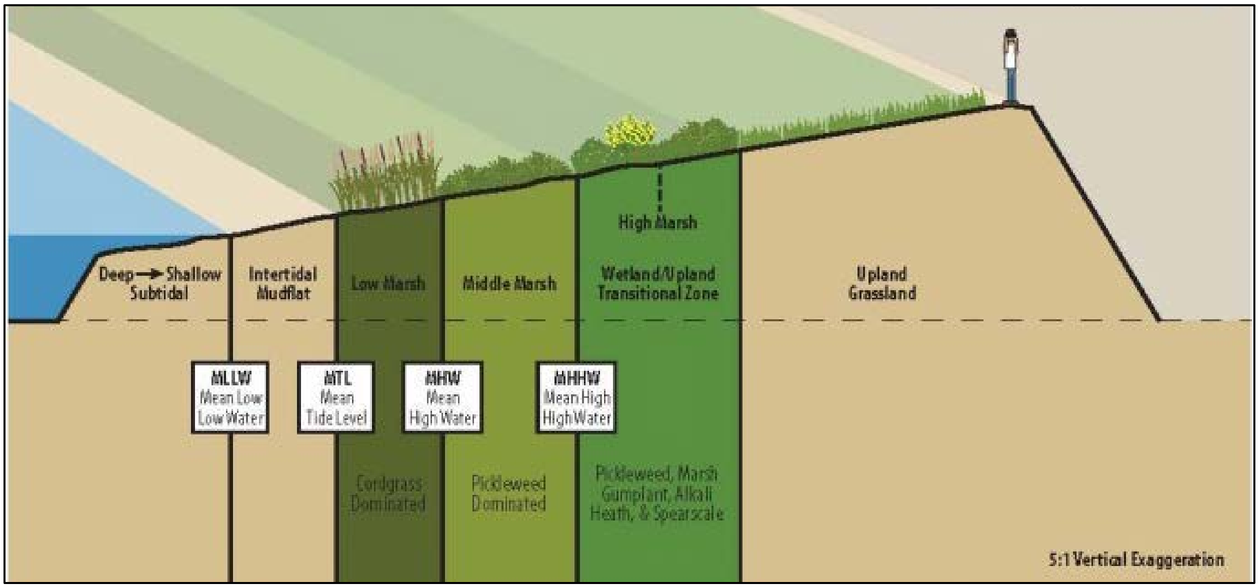

Figure 12. A conceptual cross-section of the ecotone levee proposed for tidal portions of the South Bay Shoreline Protection Project. (Image: USACE)

The Corps broke the Shoreline Project down into five reaches that will be designed and constructed over 14 years (Figure 13). Construction of the levee and ecotone began in 2018 and is expected to be complete by 2021, after which the Corps expects to sequentially breach salt ponds to tidal action. The project's adaptive management process spaces pond breaching events 5 years apart, so that lessons learned from prior breach phases can be applied to future ones. As a result, the Corps expects to breach ponds A12 and A18 in 2022 (Phase I), ponds A9, A10, and A11 in 2027 (Phase II), and ponds A13, A14, and A15 in 2032 (Phase III).

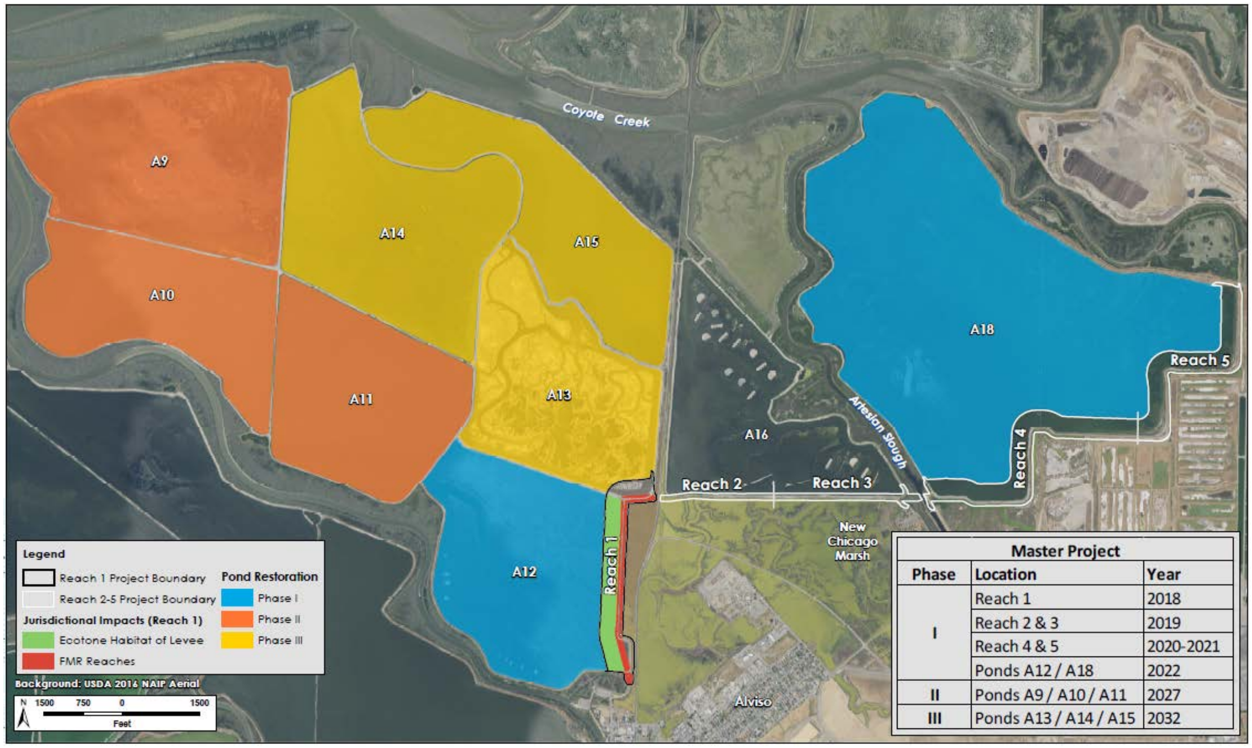

Figure 13. The proposed phasing of the South San Francisco Bay Shoreline Protection Project. (Image: USACE)

5.1.1 Regulatory Considerations and Policy Challenges

Multiple elements of the Shoreline Project posed challenges for staff charged with assessing its compliance with regulations and policies such as Porter-Cologne and No Net Loss. First, due to the levee and ecotone's alignment along the edge of existing flood management infrastructure, the vast majority of fill placed to construct the overall Project would be placed in wetlands and jurisdictional waters. Much of this fill would result in ground elevations above the HTL, resulting in a net loss of wetlands and other waters. Staff calculated that construction of the levee and ecotone would result in a post-construction net loss of over 131 acres of wetlands and other waters. Additionally, though the overall Project proposes to restore thousands of acres of salt ponds to tidal action (with a goal that those salt ponds would evolve into tidal wetlands), the timing and outcomes of restoration remained uncertain. Since ponds A12 and A18 aren't proposed to be breached to tidal action until all reaches of the FRM levee and ecotone are complete, the elapsed time between impacts and mitigation would likely be on the order of years. Further, it is difficult to predict the rate at which ponds A12 and A18 would develop mature tidal wetland habitat (due to uncertainties about substrate elevations, accretion rates, and rates of vegetation establishment). Finally, the Shoreline Project's adaptive management framework meant that future breaching of the remaining ponds was not guaranteed.

Regional Water Board staff were especially concerned that the proposed alignment for Reaches 4 and 5 will cause cumulative direct and indirect impacts to local wetlands beyond those caused by levee/ecotone fill. For example, the proposed alignment would isolate two existing, subsided mitigation wetlands landward of the levee, making it less likely that the wetlands would be able to tidally fill and drain in the future (particularly with SLR). Further, the proposed alignment would place the ecotone immediately adjacent to subtidal waters, with no outboard intertidal marsh to buffer wave energy and reduce the risk of wave-driven erosion of the ecotone's slope. For these and other reasons, staff requested a feasibility analysis of an alternate alignment for Reaches 4 and 5 that moved the levee and ecotone farther inland, taking advantage of existing high ground along the berms that surround the RWF's inactive biosolid ponds. This landward alignment would minimize the short-term net loss of wetlands and waters by restoring additional acres of vegetated marsh bayward of the levee within the footprint of the inactive ponds and improve tidal exchange within the mitigation wetlands. This alignment would also potentially free up thousands of cubic yards of clean fill that could be used to construct the levee and ecotone, reducing the need for the Shoreline Project to import fill from off-site. Regional Water Board staff estimated that the net gain of wetlands under this landward alignment would be roughly 61 acres.

5.1.2 Permitting Solution to Policy Challenges

Though the Corps expressed interest in the landward alignment, they could not commit to it as it was different than the project authorized in federal funding legislation. The Corps and Regional Water Board staff subsequently negotiated an alternate strategy for permitting the Shoreline Project that considered the following design elements as compensatory mitigation for impacts to wetlands and waters from fill activities:

1. 19 acres of restored tidal wetlands provided by the Phase I excavation of breaches in ponds A12 and A18, and the lowering of levees around these ponds;[22]
2. 36 acres of restored tidal wetlands provided by the Phase I development of tidal wetlands along the ecotone levee below the high tide line;
3. 20 acres of restored tidal wetlands provided by the Phase II excavation of breaches in ponds A9 through A11, and the lowering of berms around these ponds (20 acres of enhanced wetlands);

[22] The relatively rapid (within 3-5 years) establishment of vegetated high marsh on lowered levee berms has been well-established in past SF Bay restoration projects. Since these areas are not dependent on accretion to achieve suitable intertidal elevations, they can support intertidal vegetation soon after construction.

4. 20 acres of restored tidal wetlands provided by the Phase III excavation of breaches in ponds A9 through A11, and the lowering of berms around these ponds; and
5. 28.2 acres of restored tidal wetlands provided by the long-term, SLR-driven development of new estuarine wetland habitats along the levee/ecotone face.

This accounting lowered the calculated net loss from over 131 acres to a little under 9 acres. Though there would still be a considerable temporal lag between impacts and mitigation, Regional Water Board staff considered the short-term development of high marsh on lowered berms and the long-term, SLR-driven transgression of wetlands along the ecotone slope to both be more certain than the eventual development of vegetated tidal marsh within the salt pond interiors. It's important to note, however, that without the construction of Phases II and II, (i.e., breaching of salt ponds) net loss would be closer to 49 acres. The order approved in December 2017 permits the entire project (Phases I through III) by requiring supporting documentation for future phases (e.g. design reports) to be submitted to the Regional Water Board for review and approval prior to construction. The Regional Water Board did this to acknowledge its comfort with the alignment along Reaches 1 through 3, and signal that the Corps must consider their plans for future reach alignments.

In August 2019, the Corps indicated that it was moving forward with geotechnical investigations necessary to plan and implement a portion of the landward alignment through Reaches 4 and 5 of the Shoreline Project. This alignment would result in the cleanup and conversion of roughly 35 acres of inactive sludge drying ponds at the RWF to tidal wetlands and result in no net loss (and in fact a net gain) of wetlands at the site. As of September 2019, Regional Water Board staff have continued to engage with the Corps and its local partners to support the implementation of the landward alignment.

5.2 Novato Creek Dredging and Beneficial Reuse Project

Prior to their reclamation in the late 1800s and early 1900s, the baylands surrounding the lower reaches of Novato Creek supported a broad mosaic of tidal wetlands, channels, ponds/pannes, and associated habitats. Rapid development of the valley floor and foothills in the 20th century converted broad swaths of floodplain, grassland, and oak woodland habitats to low-density residential, commercial, and industrial development. Reclamation shrunk the tidal prism of Novato Creek, while upland development increased rates of sediment delivery to the baylands, leading to high rates of sedimentation in the lower reaches of the creek. The resulting channel is too small to pass floods larger than 10-20 year events (KHE 2016), and requires regular dredging to increase the creek's capacity and reduce the risk of flooding along developed portions of the creek's former floodplain (Figure 14). The Marin County Flood Control and Water

Conservation District (MCFCWCD) dredges roughly 8,000 linear feet of the lower creek and its tributaries every four years, generating roughly 30,000 cubic yards of gravels, sand, and silt with each dredge round. Historically, the County trucked this material to the Gnoss Field airport to dry, and then used it to reinforce the unengineered levees that hold back the tides from the Novato baylands.

In the early 2010s, MCFCWCD initiated a multi-benefit flood protection program for the watershed, the goals of which include reducing flood risk and improving ecosystem services in both the upstream fluvial and downstream estuarine reaches of Novato Creek. Engineering analysis indicated that one of the most effective ways to increase the flow capacity of lower Novato Creek was to restore portions of its baylands to tidal action, increasing the creek's tidal prism, so it could scour deeper and wider in response to the larger tidal flows. One of the diked bayland areas proposed for restoration is Deer Island Basin, an undeveloped 300+ acre basin along the creek's northern side managed primarily for stormwater detention (Figure 15). The basin is surrounded by a mix of residential development, open space, and critical local infrastructure including the Novato Sanitary District wastewater treatment plant and the Sonoma Marin Area Rail Transit (SMART) line. To facilitate tidal restoration and protect these areas from rising sea levels, the County will have to build a new flood control levee landward of the existing outboard levee. In 2016, the County proposed the Novato Creek 2016 Dredge and Ecotone-Thin Layer Lift Pilot Study (Project) to beneficially reuse dredged sediment from Novato Creek to construct a portion of this new flood control levee, with the understanding that it would take multiple dredge rounds to complete construction.

Figure 14. Novato Creek prior to the 2016 dredge round. (Image: Wikimedia Commons)

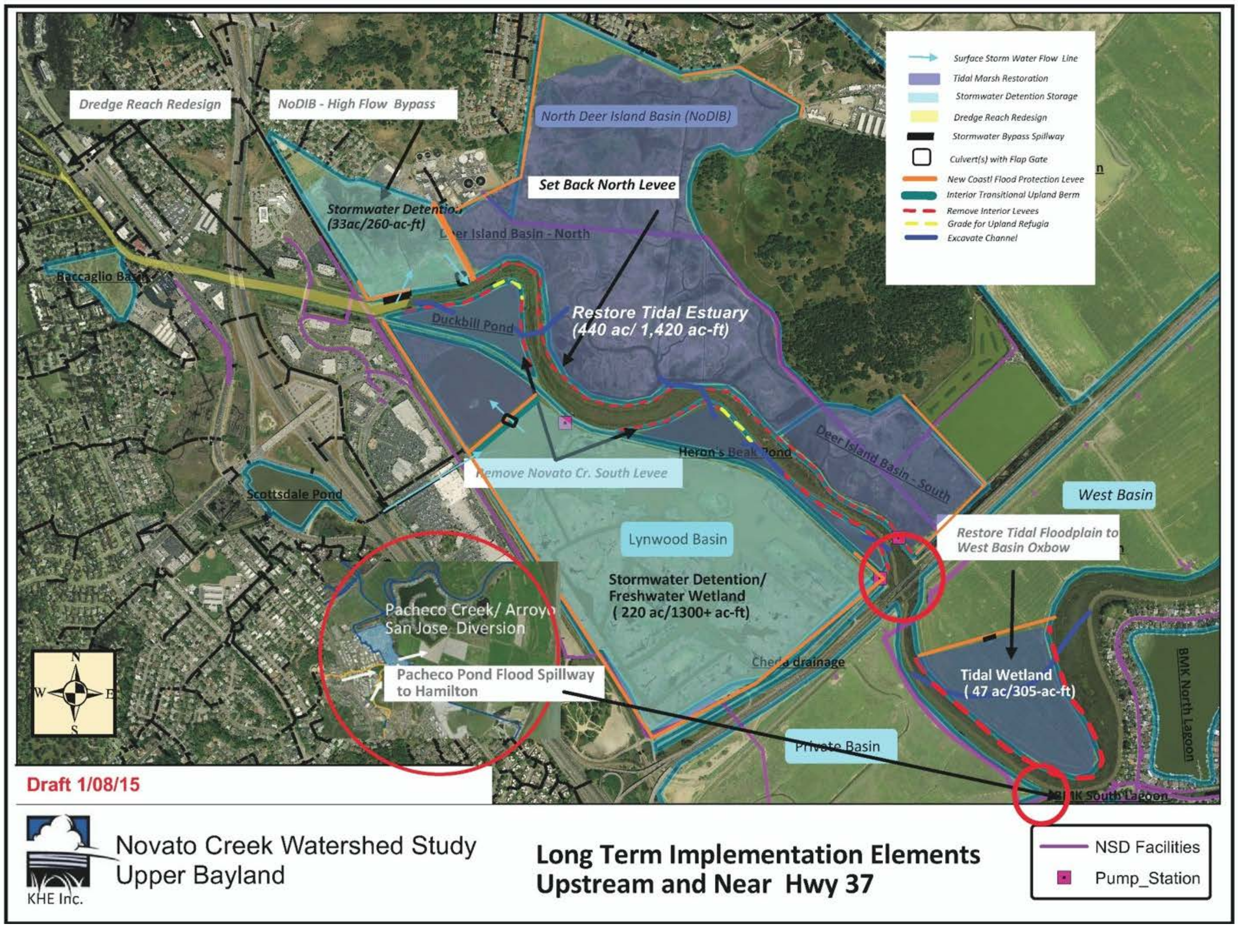

Figure 15. Marin County's proposed long-term flood management vision for the Novato Baylands, splitting east and west Deer Island Basin into tidal restoration and stormwater detention components, respectively. (Image: KHE)

Since the 2016 dredge round would only generate enough sediment to construct a portion of the levee, the County proposed to build the foundation of the portion that would separate west Deer Island Basin (proposed for seasonal stormwater detention) from east Deer Island Basin (proposed for tidal wetland restoration) (Figure 15). The County's permit application proposed to construct a 2,500-foot-long, 50-foot-wide engineered levee core with over 9,000 cubic yards of drier, "seasoned" sediment from previous dredge rounds stored at Gnoss Field. This core would have a maximum height of 4 feet, and a footprint of a little under 3 acres. A 950-foot-long portion of the levee adjacent to east Deer Island Basin would have an unengineered ecotone, constructed out of over 5,000 cubic yards of fresh material from dredging in 2016. The County proposed to test numerous methods of hydraulic "thin lift" application to place this sediment, so while it couldn't guarantee the precise dimensions of the resulting fill, it would have a maximum width of 132 feet (a footprint also under 3 acres), and a maximum depth of 2 feet. Finally, the County proposed to store additional stockpiles of freshly dredged sediment on top of the levee core, as storage for future levee-raising activities. The footprints of the proposed levee are shown in Figure 16, while the proposed cross-section is shown in Figure 17.

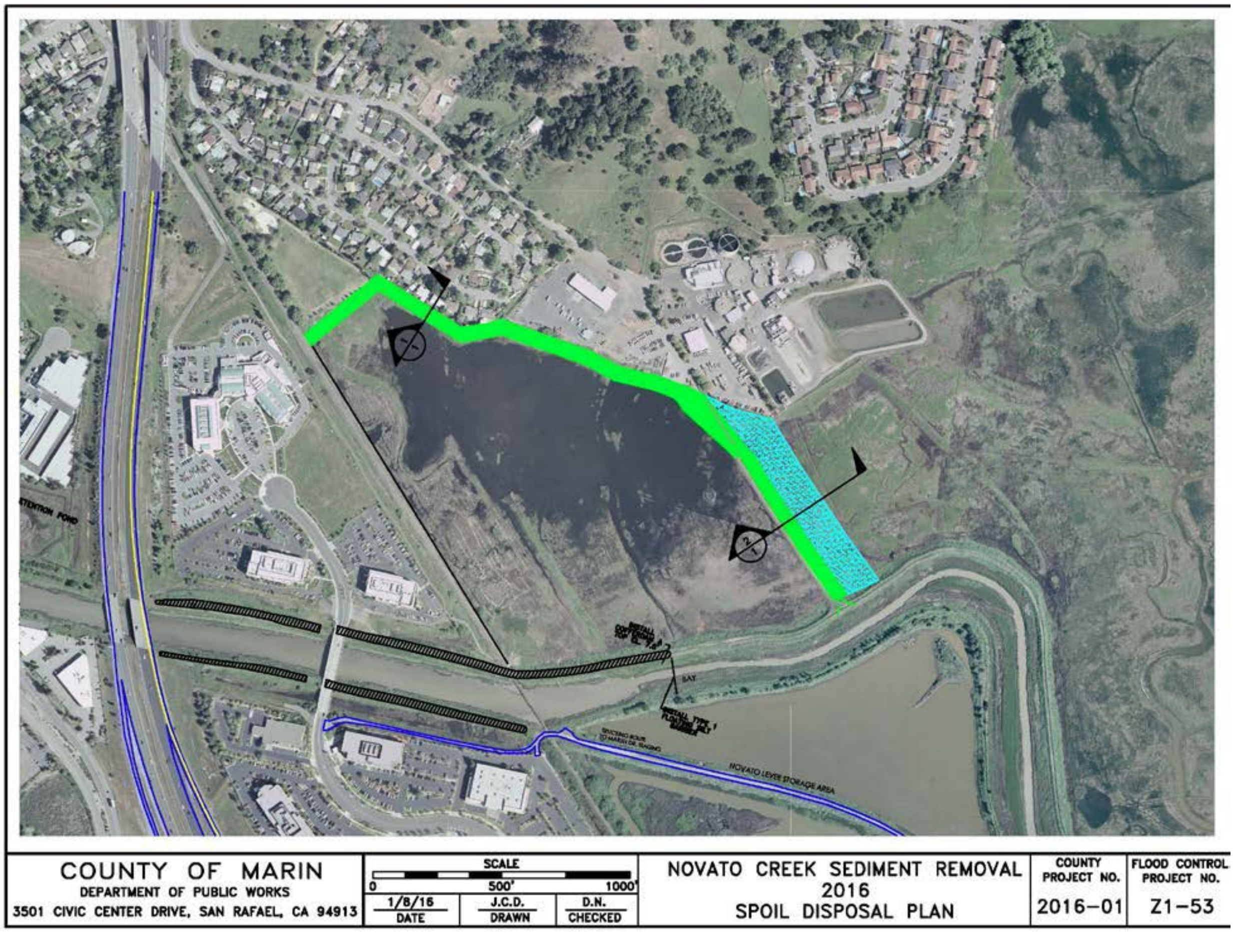

Figure 16. The footprint of the engineered levee core is shown in green, while the ecotone is shown in blue. (Image: Marin County)

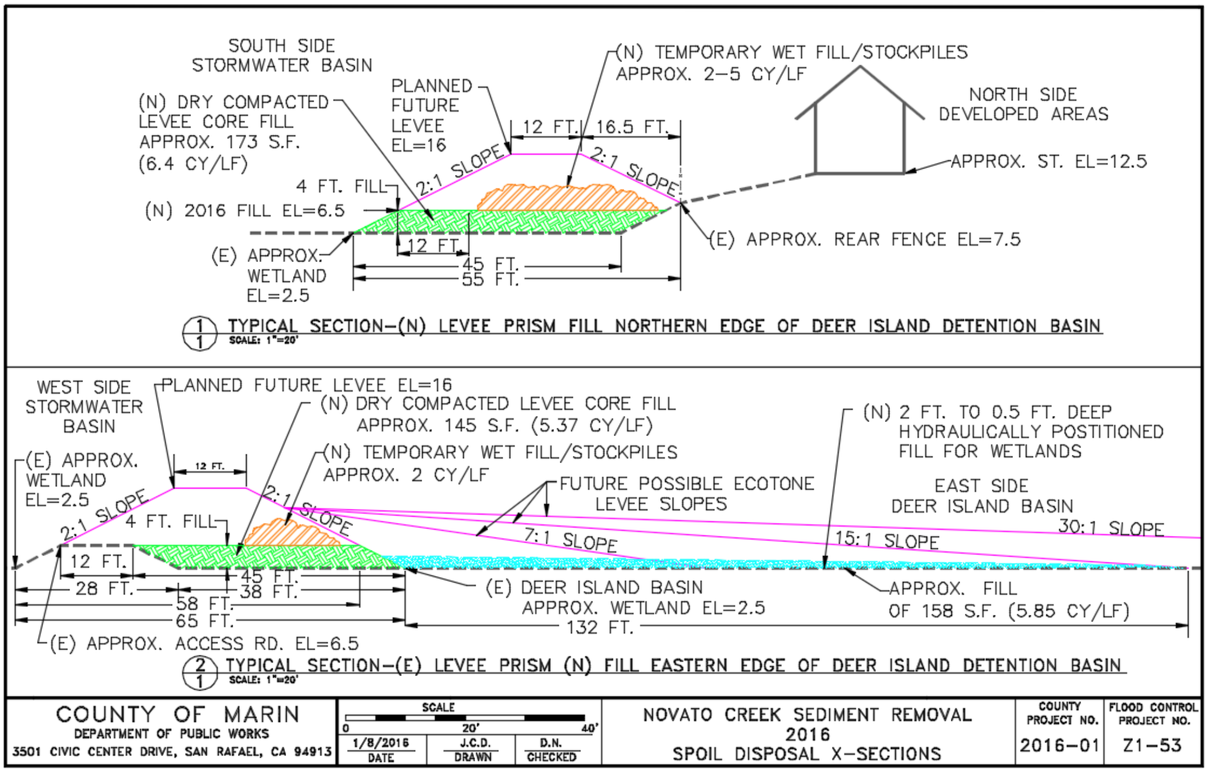

Figure 17. The cross-section of the proposed beneficial reuse, with the engineered core shown in green, and the ecotone in blue. (Image: MCWCFCD)

5.2.1 Regulatory Considerations and Policy Challenges

Though Regional Water Board staff generally supported the beneficial reuse and wetland restoration elements of the proposed Project, the potential for fill in and conversion of wetlands created challenges for the permitting process. In their permit application, MCFCWCD proposed that the project would be self-mitigating, because (1) all fill areas would be revegetated with appropriate native species, (2) staff anticipated that native clonal wetland species would grow rapidly into the hydraulically placed ecotone sediments, and (3) construction of the levee would help hasten the eventual tidal restoration of over 300 acres of diked baylands within Deer Island Basin. However, the timing of this broader restoration is unclear, and is ultimately dependent on multiple dredge rounds (to generate enough sediment to construct the levee) as well as acquiring sufficient grant funding to support design, permitting, and construction.[23] Regional Water Board staff considered the proposed fill for the levee core to be a permanent loss of wetlands, since the placement of up to four feet of fill (in addition to stockpiles) would convert seasonal wetlands within the levee core footprint into upland to be temporary and a net benefit not requiring compensatory mitigation). Since the

[23] A proposed property tax measure to support flood control activities in the Novato Creek watershed, including tidal restoration of Deer Island Basin, was rejected by Flood Zone 1 voters in November 2017.

timing of Deer Island Basin tidal restoration was uncertain, staff couldn't accept the project as mitigation for the certain, permanent loss of wetlands within the levee core footprint.

At first, MCFCWCD considered mitigating for this permanent loss off-site, by proposing to restore tidal action to nearby managed ponds south of Highway 37 (Duck's Bill and Heron's Beak ponds). The levees surrounding these ponds support upland/ruderal habitats, and MCFCWCD proposed to lower them to intertidal elevations, resulting in a compensatory net gain of wetlands. However, the timing of this project was also uncertain, as MCFCWCD had not yet allocated funds for pond restoration.

5.2.2 Permitting Solution to Policy Challenges

To comply with No Net Loss and the Basin Plan fill policies, MCFCWCD revised the Project description to limit fill for the levee core to a maximum depth of two feet (consistent with the ecotone slope) and eliminate stockpiling of sediment. These changes made the fill for the levee core a temporary impact that would not require compensatory mitigation. The dredging and levee construction were completed in the fall of 2016 (Figure 18), in time to handle large storm flows in Novato Creek in the winter of 2016-2017. For the 2020 dredge round, MCFCWCD is proposing to take a similar approach to beneficial reuse that will place another lift of dredged sediment from the creek onto the Deer Island Basin levee core and ecotone. As of September 2019, Regional Water Board staff had not yet issued a permit for this work.

Figure 18. The new levee core and ecotone in Deer Island Basin shortly after construction in the fall of 2016. (Image: MCFCWCD)

5.3 Foster City Levee Improvement Project

In the 1960s, Bay Area real estate magnate T. Jack Foster converted almost four-square miles of previously reclaimed tidal wetlands near San Mateo into a planned community of residential and commercial development that would eventually become Foster City. Construction of the community required an extensive 8-mile-long system of levees and water control structures to keep the tides from flooding the City's low-lying diked baylands (Figure 17). In 2016, the Federal Emergency Management Agency (FEMA) determined that the levees that surround Foster City did not meet FEMA standards, and did not protect the city from the 1-percent annual chance (base) flood. This "de-certification" of the levees meant that if the levees were not improved within roughly two years, Foster City residents and businesses with federally backed loans would have to purchase costly flood insurance. City officials therefore initiated the Foster City Levee Protection Planning and Improvement Project (Project) to develop plans for levee improvement, and to build public support for funding construction.

5.3.1 Regulatory Considerations and Policy Challenges

As the first major levee improvement project proposed by a Bay Area municipality aimed to address FEMA accreditation as well as climate change, the Foster City project posed a novel suite of regulatory challenges to the Regional Water Board and partner regulatory agencies. The draft EIR for the Project assessed additional alternatives, one of which proposed a horizontal levee bayward of Segment 2, an almost mile-long portion of the northern Foster City shoreline. The 30:1 (H:V) side slopes of this feature would extend over 400 feet into the open waters of San Francisco Bay, and require almost 1 million cubic yards of fill placed over 100 acres (Figure 19). While this alternative fulfilled the Regional Water Board and other agencies' request that the City consider a nature-based infrastructure solution, it was poorly suited for the broader geomorphic setting of the Foster City shoreline.[24] In addition, the scale of required fill made compliance with BCDC's bay fill policies and the Regional Water Board's No Net Loss and Basin Plan fill policies highly unlikely, and the logistical and constructability challenges of importing and placing the large volume of required fill were insurmountable. The preferred project (both the 2050 and 2100 design scenarios) had a much smaller footprint, primarily due to the reliance on sheet pile and conventional floodwalls to provide the majority of flood protection improvements. The relatively small footprints of the proposed floodwalls minimized direct impacts to wetlands and waters within the alignment of proposed work, leading the City's project team to conclude that this approach was the most likely to be permitted by regulatory and resource agencies.

[24] Later analysis performed in the 2019 Adaptation Atlas indicated that most of the highly exposed (primarily northern and eastern) segments of the Foster City shoreline were poorly suited for horizontal levees, due to the depths of offshore mudflats and high wave energy in this region.

Figure 19. The levee system surrounding Foster City. Note the extensive shell hash beach outboard of the levees in Segments 3 and 4, and the tidal mudflats & wetlands outboard of the levees in Segments 1, 5, 6, and 7. (Image: Foster City)

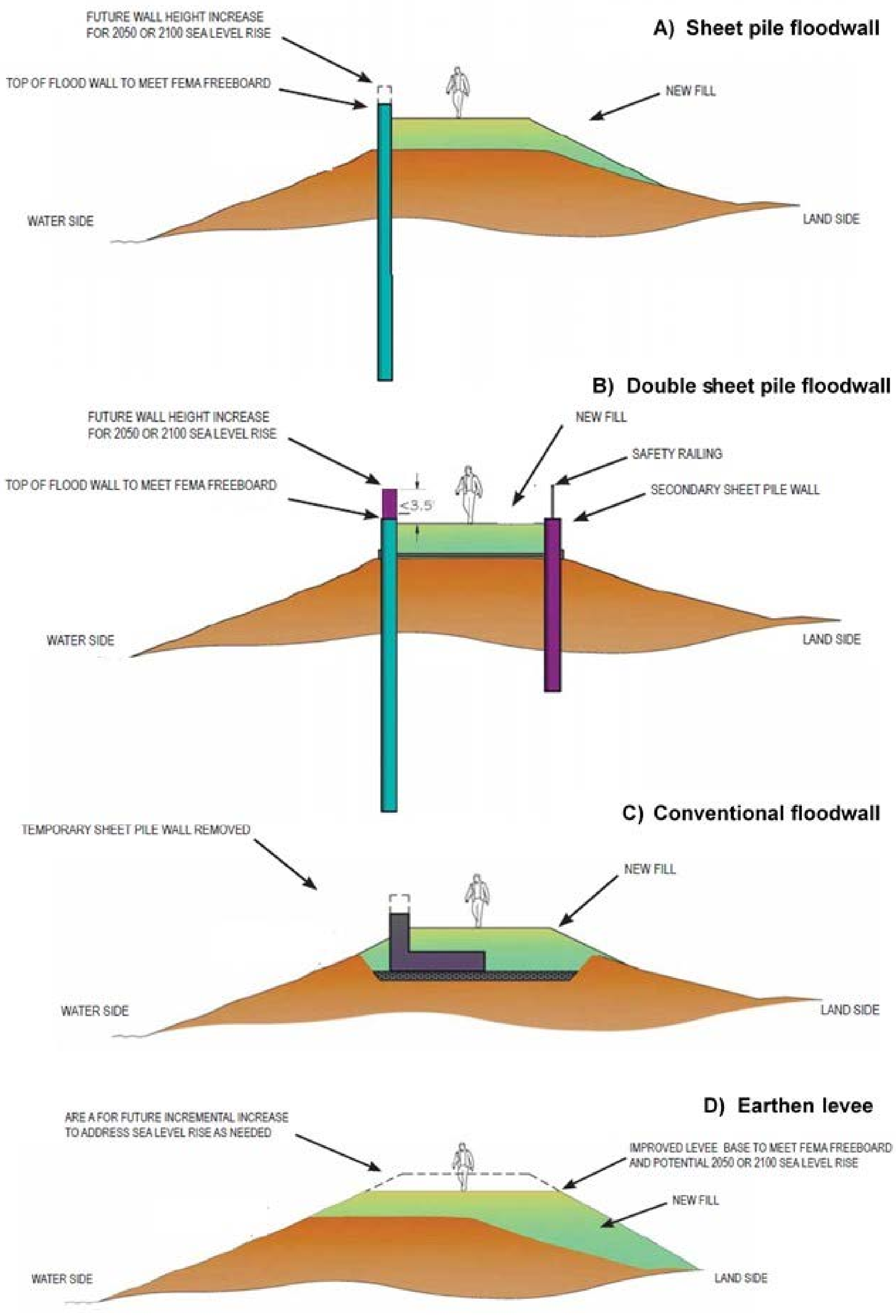

Figure 20. The design scenarios (FEMA freeboard + SLR for 2050 and 2100) in the City's preferred project proposed different combinations of sheet pile flood walls (A and B), conventional floodwalls (C), and earthen levees (D). (Image: Foster City)

Regional Water Board staff commented on the Draft EIR In January 2017, focusing on three main points:

1. The proposed project's reliance on floodwalls increased the risk of squeezing coastal habitats bayward of the levee (such as wetlands and beaches) between rising sea levels and a hardened shoreline.
2. Inconsistent with CEQA statute and guidance, the draft EIR did not describe any reasonable alternatives to shoreline hardening, such as coarse shoreforms (e.g., gravel/shell hash beaches, which dominate the Segment 4 shoreline at the aptly named Shell Beach) that might achieve similar wave attenuation, aesthetic, recreational, and ecological benefits as a horizontal levee but are much more reasonable and feasible to construct and permit in this geographic setting.[25]
3. The Regional Water Board's approach to determining appropriate mitigation ratios for impacts to wetlands/waters depends on numerous factors. There is no predetermined set of ratios used to determine appropriate mitigation acreage.

The City responded to these comments in March 2017 and maintained that the floodwall-focused preferred project was the least environmentally damaging practicable alternative due to its limited physical footprint. In its response, the City continued to emphasize the relatively minimal *direct* impacts associated with the footprints of the proposed floodwalls, without assessing the indirect and cumulative impacts of floodwalls on the physical and ecological processes that support beneficial uses of the nearshore habitats along the Foster City Shoreline. This emphasis reflects a common misperception among permit applicants that the Regional Water Board's policies rely strictly on quantitative assessments of project footprints that do not include qualitative assessments of project impacts.

Ultimately, further analysis by the City's design team throughout 2017 revealed that the proposed sheet pile wall height/burial depth for the FEMA freeboard + SLR for 2100 preferred project scenario were not geotechnically feasible. In September 2017, the design team told Regional Water Board staff that they were interested in pursuing a pilot project to explore a future adaptation strategy that incorporated coarse shoreforms and similar living shorelines. The team expressed a hope that by including coarse shoreforms in the FEMA freeboard +SLR for 2050 scenario, the resulting design would attenuate enough wave energy to provide flood protection equivalent to the FEMA freeboard + SLR for 2100 scenario.

[25] The 2019 Adaptation Atlas recommended beaches as a potentially suitable strategy to protect the Foster City shoreline from rising sea levels. Consistent with Water Board comments to the City, the Atlas highlights Shell Beach as one of the Bay's finer examples of coarse wave-built shorelines.

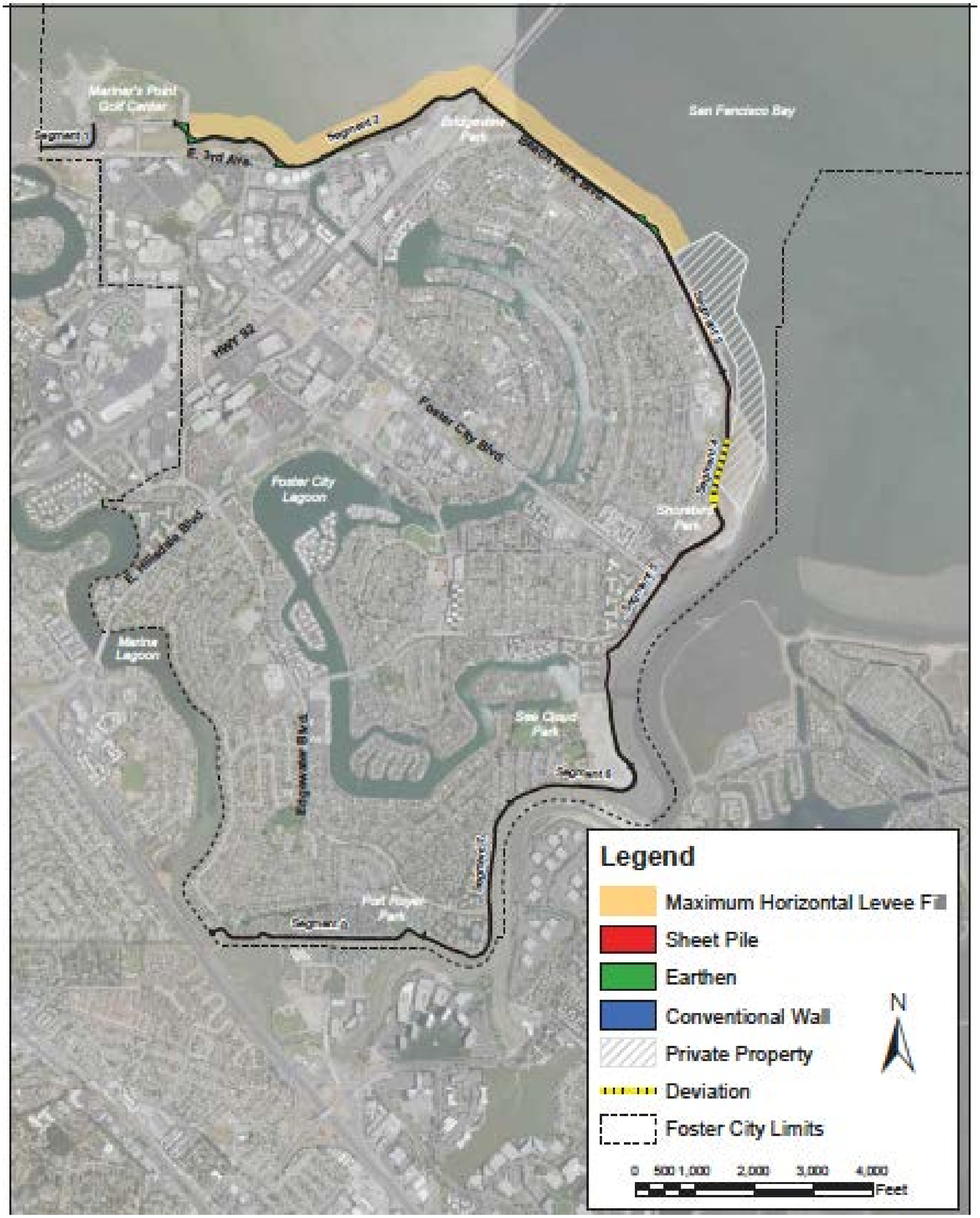

Figure 21. The proposed horizontal levee alternative along Segment 2 of the Foster City levees. (Image: Foster City)

5.3.2 Permitting Solution to Policy Challenges

In late 2018, the Regional Water Board received a permit application from Foster City for the Project. In early 2019, Regional Water Board staff responded to the City's application with a letter notifying the City that their application was incomplete and would require supplemental materials to be submitted before staff could issue a 401 certification. Among the materials staff requested were an alternatives analysis that includes an assessment of how Project alternatives could be integrated with nature-based SLR adaptation measures in the future. In the letter, staff also notified the City that the eventual 401 certification for the Project would require the post-certification submittal of an SLR Adaptation Plan that includes the following:

1. A summary of technical studies and other information needed to develop phased SLR adaptation pathways through at least 2100.
2. Consideration of the City's location in the Bay, site-specific shoreline conditions and processes, and cumulative impacts of various regional and local SLR adaptation plans and projects.
3. An evaluation of the feasibility of utilizing nature-based infrastructure (including coarse shoreforms) as a significant component of adaptation strategies, including as pilot projects.
4. A timeline for implementation of the Plan based on clearly identified thresholds and triggers for planning and implementation.
5. A description of potential adaptation funding mechanisms, including but not limited to financial assurances that planning and development of the post-2050 project will be funded by the Applicant and with grants.
6. A mechanism to allow for the Plan to be improved and updated as SLR science and adaptation planning improve over time.

As of September 2019, these materials had not yet been submitted by the City to the Regional Water Board, but discussion between the two parties on these topics was ongoing.

6 Developing a Basin Plan Amendment to Address Climate Change and Fill in Wetlands and Waters

Substantial work is under way around the Bay to address the anticipated impacts of climate change and SLR on the natural and built communities along the Bay's shoreline. Among decision makers and the general public, there is increasing awareness of the importance of developing multi-benefit projects that address flood risk reduction, infrastructure reliability, social and economic resilience, environmental justice, water quality improvement, habitat conservation and restoration, and shoreline access. Projected sea level rise, and the associated expected increase in the number and pace of shoreline adaptation projects, including Bay margin tidal wetland restoration, underscore the need for the Regional Water Board to review and consider updates to its policies to ensure they appropriately support adaptation projects consistent with the Board's mission to protect water quality and beneficial uses.

Through internal discussions, coordination with partner regulatory agencies, and the development of this report, Regional Water Board staff have determined that the most effective and comprehensive way to review and update our policies is through the Basin Plan Amendment (BPA) process. The BPA process is a formal process through which amendments to the Basin Plan are developed, reviewed, and refined by Regional Water Board staff as well as through an extensive public review process and scientific peer review. At a public hearing, the Regional Water Board may then adopt the BPA. Adopted BPAs must be approved by the State Water Board as well as the Office of Administrative Law and the USEPA.

A Basin Plan Amendment to address climate change and wetland fill will likely include both non-regulatory and regulatory elements. These elements are described in greater detail below.

6.1 Non-Regulatory Elements

At a minimum, a Basin Plan Amendment will likely include adding the following non-regulatory language to the Basin Plan:

- A narrative explaining the impacts to water quality and beneficial uses of the Bay associated with a changing climate and sea level rise
- References to the 2015 Baylands Goals Report, the U.S. Fish and Wildlife Service's *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California* (USFWS 2013), *Rising Seas in California* (OPC 2017), and the *State of California Sea Level Rise Guidance* (OPC 2018)

- An updated list of tidal wetland restoration sites that are currently being restored, as well as those currently planned for restoration (e.g. South Bay and Napa-Sonoma salt ponds, Hamilton, Sears Point, etc.).[26]
- Support for a regional approach to tidal wetland monitoring, such as the Wetland Regional Monitoring Program currently being developed by the Regional Water Board and its partners

6.2 Regulatory Elements

A Basin Plan Amendment could include some or all of the following regulatory elements:

1. Documentation of the threats that climate change poses to the Bay's tidal wetlands and adjacent habitats, and their beneficial uses, including but not limited to threats from sea level rise, changes in freshwater inputs, and changes in regional sediment supplies.
2. Identification of preferred strategies for climate change adaptation, emphasizing that the most feasible solution that maximizes landscape-scale beneficial uses must be implemented, and noting the roles that natural and nature-based features can play. More specifically, the BPA could identify that hardening of the shoreline will be considered acceptable by the Regional Water Board only after nature-based and/or hybrid solutions (such as those described in the Adaptation Atlas and the Baylands Goals Update) have been considered and demonstrated to be impracticable.
3. Clarification of the regulatory framework for proposals to convert waters of the State from one type to another (e.g., seasonal wetland to tidal wetland).
4. Clarification of how the "No Net Loss" policy will be applied to Bay margin wetland restoration projects, especially in consideration of losses in acreage, functions and values associated with SRL projections.
5. Identification of instances where fill in waters of the State may be considered beneficial, or otherwise may not trigger a requirement for compensatory mitigation. This is intended to support the design and implementation of restoration projects with an appropriate and resilient site- and landscape-scale mosaic of habitats. Relevant restoration elements to be considered could include:

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[26] Partner agencies, such as the Coastal Conservancy, Metropolitan Transportation Commission, SF Bay Joint Venture, SF Bay Regional Coastal Hazards Resiliency Group, and Bay Area Clean Water Agencies, are developing similar lists for wetland restoration, shoreline/flood protection, and sea level rise adaptation projects. The development of these lists should be coordinated between agencies, so stakeholders are working from a common understanding of what types of projects are being developed in which locations along the SF Bay shoreline.

a. Horizontal/ecotone levees;

b. New/enhanced estuarine-terrestrial transition zones in baylands where they may currently be absent or impacted by shoreline hardening, current or historic land uses, or other anthropogenic impacts;

c. Living shorelines, beaches, and hybrid coastal infrastructure; and

d. Strategic sediment placement to raise elevations in restoring and subsided baylands.

6. Clarification that avoidance and minimization in the context of Bay fill includes evaluating opportunities for incorporating the upland/landward edge of the Bay in any alternatives analysis completed consistent with Clean Water Act Section 404(b)(1) guidelines, and identification of approaches for how projects should consider facilitating the upslope transgression of tidal wetlands as sea levels rise.

7. Identification of the benefits of "complete" tidal wetland systems consistent with the definition in the 2015 Baylands Goals update (e.g., from supratidal to subtidal elements). This element could include clarifying the higher value of tidal wetland and shallow water habitat compared to deep open water habitat within the context of historic tidal wetland losses in the Bay and regional restoration goals (not as a function of the inherent value of one type of habitat over another).

8. A framework for how the Regional Water Board will consider temporal tradeoffs and uncertainties in wetland restoration, particularly with respect to climate change, SLR, sediment supply, and the projected lifespans of adaptation features (utilizing adaptation pathways). This element is expected to include a proposal for how SLR can be taken into consideration to avoid and minimize fill impacts in waters/wetlands.

9. A framework for evaluating mitigation on a regional (SF Bay), sub-regional (Suisun, North Bay, Central Bay, South Bay, Lower South Bay), or OLU basis, rather than project-by-project, and clarifying expectations for the role mitigation banks may play.

10. Emphasis on the expectation that projects consider and appropriately address project-related indirect and cumulative impacts to waters, such as the impacts of isolating existing wetlands landward of flood risk management or related infrastructure and impacts of regional shoreline hardening on Bay hydro- and morphodynamics.

11. References to existing technical guidance on natural and nature-based features, including "living shorelines," and emphasis on the role that nature-based infrastructure can play in avoiding and reducing impacts. This element could also include support for increased monitoring of natural and nature-based features to

develop a regional understanding of how they work and how and where they might be most effectively deployed.

6.3 Agency Coordination

No regulatory agency in the Bay is singularly responsible for planning and regulating actions to adapt to climate change and sea level rise. Rather, each agency has its own unique legislative mandate and regulatory focus. While this distributed model of regulatory governance has many benefits (for example, avoiding the political capture that may be a risk if only one entity were in charge of regional climate change adaptation), if agencies do not closely coordinate with one another, they can run the risk of promulgating policies and regulations that may conflict with one another. To avoid such an outcome for the BPA, Regional Water Board staff have been regularly coordinating BPA planning efforts with partner regulatory agencies through many of the programs and projects listed in Section 2.2 as well as more targeted efforts. For example, the Bay Conservation and Development Commission recently approved a Bay Plan Amendment for Fill for Habitat that tackles many of the same challenges as the Regional Water Board's proposed BPA for climate change and wetland fill. Regional Water Board staff are meeting regularly with BCDC staff to ensure that the two processes are aligned, and in June 2019 issued official comments to BCDC on the proposed language in the Bay Plan Amendment.

The BRRIT will be another venue that can help support inter-agency policy coordination. The structure of the BRRIT includes a Project Management Team (PMT) composed of senior agency officials tasked with, among other things, coordinating the development and implementation of policies related to tidal wetland restoration and multi-benefit projects. Senior staff from the Regional Water Board sit on the PMT and expect to discuss the proposed BPA with the PMT during the BPA development process.

7 Conclusions

Climate change will have profound, lasting effects on the physical and ecological processes that support tidal wetlands and adjacent ecosystems in San Francisco Bay, driving cascading impacts to the Bay's water quality as well as the beneficial uses supported by these unique habitats. Rising sea levels, limited sediment supplies, and continued urbanization and armoring of the Bay's shoreline threaten to drown, isolate, and degrade nearshore landscapes that provide critical habitats for native and special-status species, protect low-lying areas from flooding, and filter pollution from the Bay. As a State agency responsible for protecting and improving the beneficial uses of Bay Area wetlands and waters, it's imperative that the Regional Water Board's policies and regulations reflect the most recent scientific guidance on how to safeguard the landscape-scale, long-term resilience of these habitats.

The proposed Basin Plan Amendment will incorporate the most recent guidance from the 2015 Baylands Ecosystem Habitat Goals Report, 2019 San Francisco Bay Shoreline Adaptation Atlas, and related scientific literature to address key regulatory challenges and opportunities related to beneficial fill in wetlands, natural and nature-based sea level rise adaptation approaches, shoreline armoring, protection of estuarine-terrestrial transition zones, and associated issues. The Basin Plan Amendment will support informed decision-making by Regional Water Board staff as well as planners, permit applicants, and partner regulatory agencies. Critically, the process to develop the Amendment will provide the Regional Water Board with an opportunity to collaborate with stakeholders, articulate a collective vision for the long-term protection of beneficial uses associated with tidal wetlands and associated nearshore habitats, and drive actions in support of that vision.

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Appendix A Sea Level Rise Drivers and Projections

As previously discussed in Section 2, climate change contributes to global (eustatic) sea level rise and relative sea levels through a variety of global, regional, and/or episodic mechanisms. This appendix summarizes these contributions and presents sea level rise projections from the 2017 California Ocean Protection Council - Science Advisory Team (OPC-SAT) publication *Rising Seas in California: An Update on Sea Level Rise Science* (Griggs et al. 2017).

Contributions to Global (Eustatic) Sea Level Rise

Global contributions to sea level rise include thermal expansion of the oceans, and the addition of meltwater from glaciers, ice caps, and ice sheets.

Thermal expansion: The oceans cover roughly 70% of the Earth's surface, and as Earth's atmosphere has warmed, oceans have absorbed more than 90% of its excess heat (Dahlman 2015). The resulting thermal expansion of the oceans accounts for approximately half of the observed signal in sea level rise (Griggs et al. 2017). Figure A-1 from the New York Times (Wallace 2016) displays how this absorbed heat has impacted surface water temperatures in the planet's oceans. It's important to note that there is a time lag between warming of the atmosphere and warming/expansion of the oceans, a phenomenon called "thermal intertia" that has already built the potential for considerable warming and SLR into Earth's climate systems (Ehlert and Zickfield 2018).

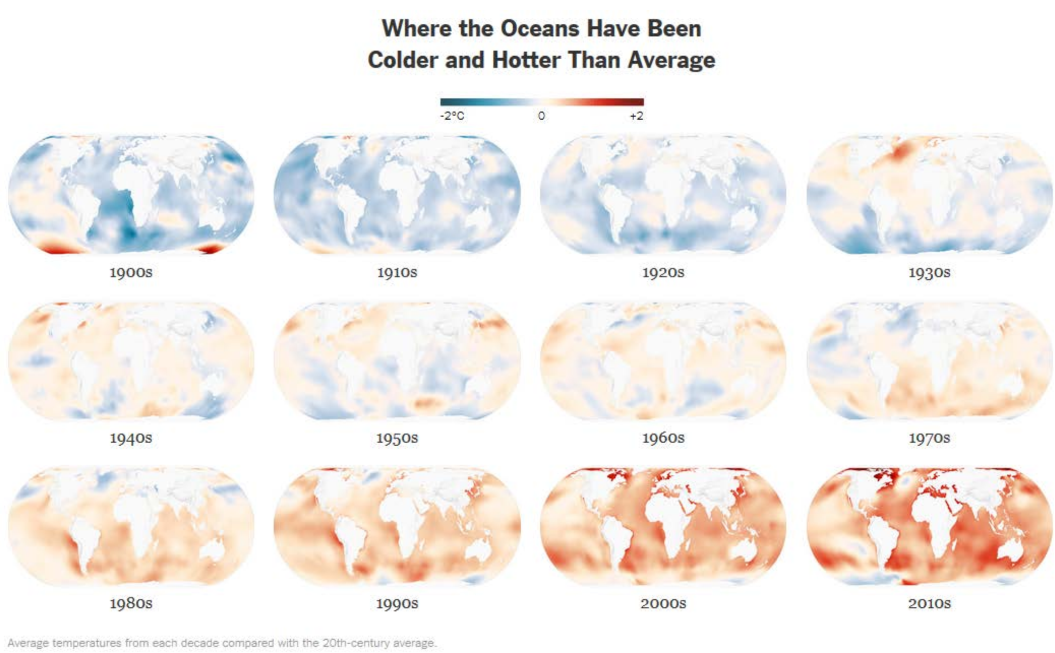

Figure A- 1. Warming of the oceans (and resulting thermal expansion) is a global phenomenon. (Image: Wallace 2016)

Meltwater from glaciers, ice caps, and ice sheets: The remaining half of the observed signal of sea level rise is due to the melting of glaciers and polar ice features including ice caps and ice sheets. The distinctions between these sources of ices are primarily based on size and whether or not the ice is located over land or water (NSIDC 2019a). If ice over land melts or enters the ocean as icebergs or ice floes, it can contribute to SLR; sea ice that is already floating does not contribute to SLR. However, the melting and loss of sea ice affects other critical climate factors such as albedo (reflectance), atmospheric and oceanic circulation, and heat exchange (NSIDC 2019b).

Appendix 2 in the *Rising Seas* report (Griggs et al. 2017) contains an extensive discussion of ice loss mechanisms and their impact on global SLR as well as relative SLR off the California coast; the following is a brief summary. The Greenland and Antarctic ice sheets contain about 99% of the planet's freshwater ice, enough to raise global sea levels by 24 (Gregory et al. 2004) and 187 feet (Lythe et al. 2001), respectively. The Greenland ice sheet (GIS) is primarily supported by bedrock, so it mostly loses mass through surface melt and iceberg calving (Smith et al. 2017). In contrast, the vast Antarctic ice sheets extend from bedrock out into the sea, and melt primarily via subglacial melting and iceberg calving. Subglacial melting "lubricates" the movement of ice downhill from land into the ocean, where warmer water temperatures accelerate melting and the calving of icebergs and ice floes into nearshore waters. This movement can be slowed down by the presence of nearshore ice shelves (portions of ice sheets that spread out over water) as well as bedrock promontories that impede downhill movement. However, locations where portions of ice shelves crack off and float away from shore or where bedrock promontories don't exist can experience the rapid calving of land ice into the ocean. These factors are why the rates at which glaciers and ice sheets move are critical to understanding global SLR. Though the mechanisms and rates of polar ice loss are in the early phases of intensive study and modeling by scientists, recent research aided by remote sensing indicates that the West Antarctic ice sheet (WAIS) has become particularly unstable. Once these processes initiate, they accelerate in a non-linear fashion, and would be almost impossible to reverse without substantial cooling of the oceans (which would take millennia due to the oceans' thermal capacity, and require massive reductions in GHG emissions). Loss of the West Antarctic ice sheet poses a particularly grave threat to California due to its sheer size as well as the Earth's gravitational and rotational forces. The stability of the Antarctic ice sheets (particularly WAIS) and the implications of ice sheet loss on sea levels are both highly active fields of research and are therefore not fully accounted for in most SLR projections. The *Rising Seas* report includes one scenario, H++, that accounts for full WAIS collapse; however, the report does not assign a probability to this scenario.

Regional Contributions to Relative Sea Level Rise

Regional contributions to relative sea level rise in coastal California include gravitational and rotational effects, vertical land motion due to plate tectonics, and land subsidence.

Gravitational and rotational "fingerprints": The retreat of large polar ice sheets in Greenland and Antarctica affects their gravitational pull on the ocean, and alters the Earth's pole and rate of rotation. These ice sheets are massive enough to "pull" ocean water towards them, away from places further away; the amount of water that they pull from a given location depends on the distance between the ice sheet and the location in question. As these ice sheets melt, their mass decreases, their gravitational attraction decreases, and water flows back to the locations from where it was previously "pulled". The volume of water and the rate at which this water returns depends on the rate at which the different ice sheets melt. The complex spatial distribution of these impacts on sea level rise are referred to as sea level "fingerprints", and they are particularly relevant to the effects of the melting WAIS on the California coast. Due to these effects, for every 1 foot of meltwater contributed to the seas by melting of the WAIS, the California coast experiences 1.25 feet of SLR (see Figure A-2 below from Griggs et al. 2017, also Mitrovica et al. 2011). When coupled with the volume of vulnerable ice contained in the WAIS, this phenomenon further underscores the importance of its long-term stability (or lack thereof) to SLR in California.

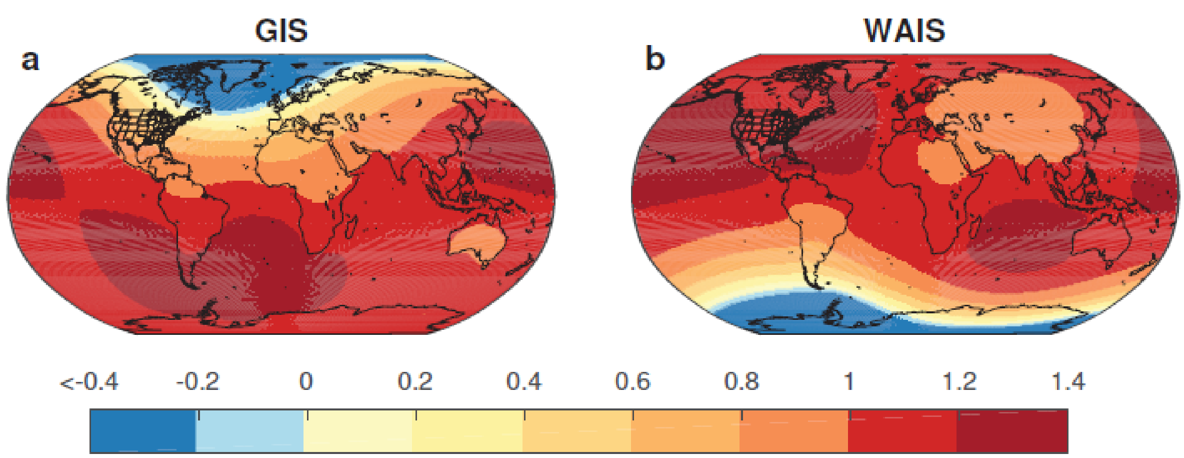

Figure 1. Sea-level 'fingerprints' resulting from the distribution of ice and water around the Earth and ensuing gravitational and rotational effects.

The maps depict the relative response of sea-level to the loss of ice mass from (a) Greenland Ice Sheet (GIS) and (b) West Antarctic Ice Sheet (WAIS). The color bar represents the fractional departure of relative sea level rise from that expected given the ice contribution to global mean sea level. For example, when ice is lost from the Greenland Ice Sheet the relative effect on the US West Coast is 75% of the sea-level rise expected from the water volume added to the ocean. By comparison, when ice is lost from the West Antarctic Ice Sheet the US West Coast experiences 125% of sea-level rise from that expected from the water volume added.

Figure A- 2. Sea level "fingerprints" resulting from the distribution of ice and water around the Earth and ensuing gravitational and rotational effects. (Image: Griggs et al. 2017)

Vertical land motion: California sits at the junction of multiple tectonic plates whose movement within the Earth's crust causes localized uplift (increase in relative ground elevations) or deep subsidence (decrease in relative ground elevations). Off Cape Mendocino, the Gorda, Pacific, and North American tectonic plates meet in an area called the Mendocino Triple Junction, which links the convergence of the Cascadia subduction zone (to the north) with the translation of the strike-slip San Andreas fault zone (to the south). In the San Francisco Bay area south of Cape Mendocino, the coastline is experiencing rates of relative sea level rise of between roughly 1 to 2 mm/yr (Griggs et al. 2017, see Figure A-3 below from NOAA CO-OPS 2018a).

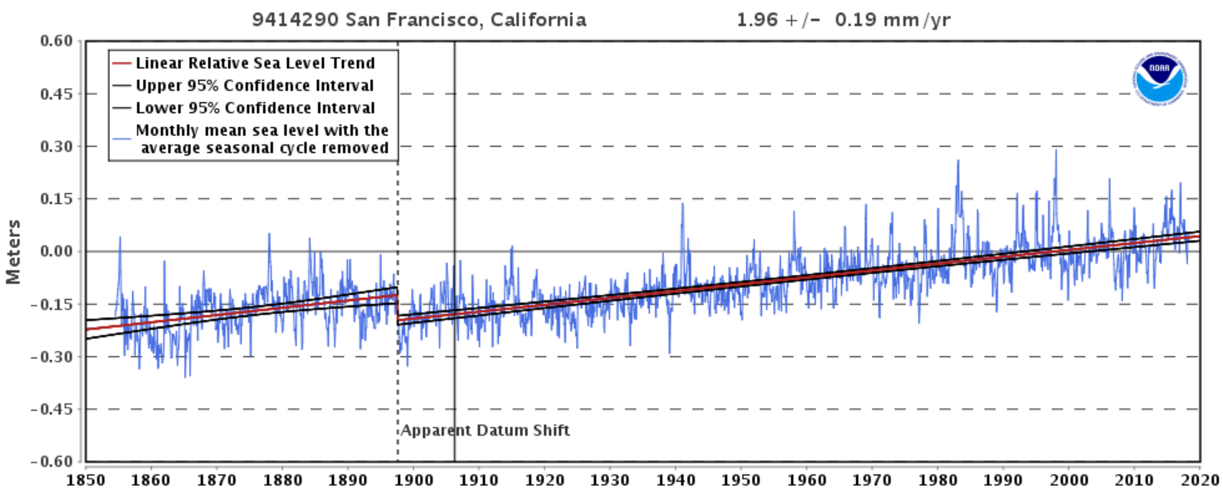

Figure A- 3. Observed relative sea level rise at the Golden Gate tide gauge. (Image: NOAA CO-OPS 2018)

Groundwater extraction, fill compaction, and local land subsidence: Groundwater extraction in alluvial basins surrounding San Francisco Bay has been known to lead to significant ground subsidence. In fact, the Santa Clara Valley was the first place in the nation where land subsidence was recognized by experts to be driven by groundwater withdrawal (Tolman and Poland 1940). Groundwater extraction to support orchards and then urban uses in the Santa Clara Valley led San Jose and its surrounding communities to sink by 2 to 8 feet by 1969 (ibid, Figure A- 4); total subsidence was as much as 13 feet in some locations before regional groundwater recharge efforts began to take effect (SCVWD 2018). This subsidence has dramatically impacted shoreline communities such as Alviso that are now much more vulnerable to tidal flooding and inundation from rising sea levels. Although subsidence due to groundwater extraction in the Bay Area has largely been arrested, the compaction and consolidation of artificial fill on compressible Bay Muds along the Bay's historic margins continues to drive localized subsidence. Recent research indicates that while much of the SF Bay shoreline experiences local subsidence of less than 2 mm/yr, areas of artificial fill on top of Holocene Bay Mud deposits (e.g. portions of San Francisco, San Francisco International Airport, Treasure Island, and Foster City) are subsiding at rates of over 10 mm/yr (Figure A- 5). This local subsidence accelerates localized rates of SLR and increases the footprint of areas that are vulnerable to flooding due to SLR (Shirzaei and Bürgmann 2018).

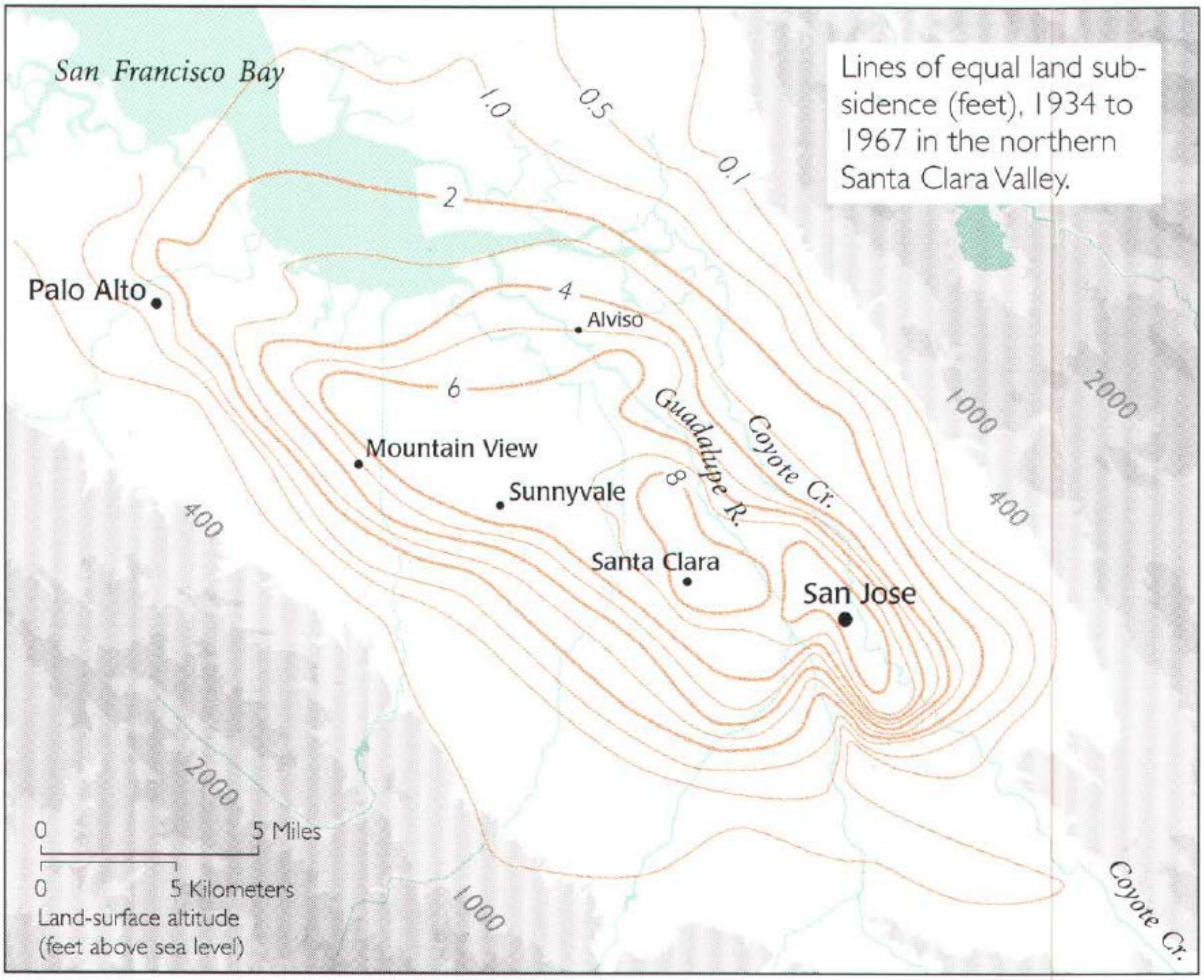

Figure A- 4. Subsidence due to groundwater extraction in Santa Clara Valley between 1934 and 1967. (Image: Ingebritsen and Jones 2005)

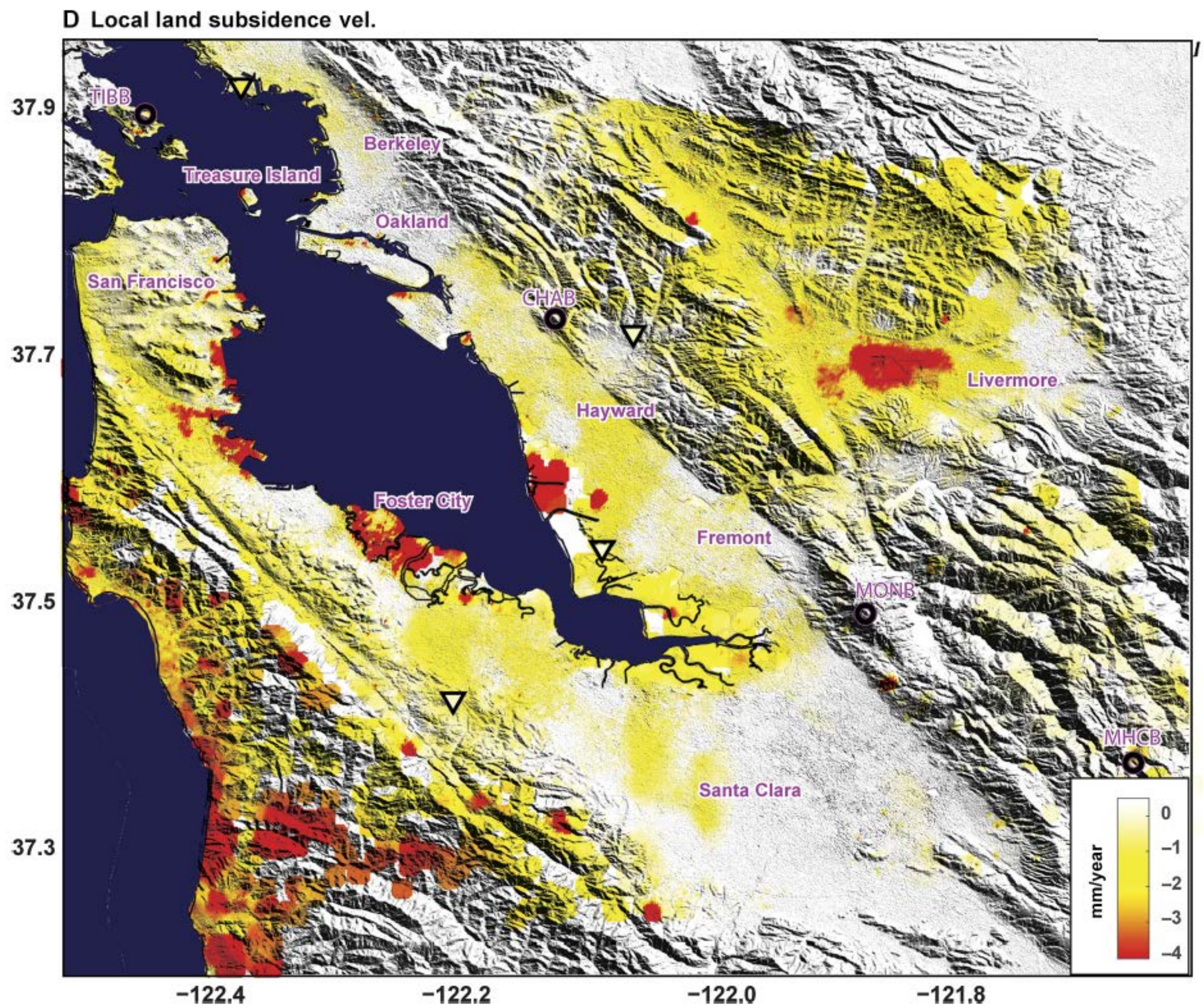

Figure A- 5. Compaction and consolidation of artificial fill on Bay Muds also contributes to local subsidence. (Image: Shirzaei and Burgmann 2018)

Episodic Contributions to Elevated Water Levels

Water surface elevations in the Bay are highly variable due to multiple factors, and can mask longer-term trends in sea levels. Episodic contributions to elevated water levels in the Bay include short- to moderate-term events such as El Nino-Southern Oscillation (ENSO)/Pacific Decadal Oscillation (PDO) events, storms, king tides, and periods of high Delta outflows. These factors contribute to total water levels, which establish base flood elevations throughout the Bay.

El Nino-Southern Oscillation (ENSO)/Pacific Decadal Oscillation (PDO): ENSO and PDO refer to large-scale coupled oceanographic-atmospheric processes that can lead to elevated water temperatures (and therefore thermal expansion) in the eastern Pacific and along the California coast. Research indicates that oscillations in the ENSO and PDO cycles can drive significant (average of 6 inches) changes in Pacific sea levels, that ENSO and PDO cycles can either reinforce or dampen each other's effects on water surface elevations, and that the combination of El Nino plus positive PDO correlates with especially high sea levels in the Americas. El Nino conditions throughout 2014-2016 and an especially warm "blob" of water in the eastern Pacific in the summer of 2015 contributed to higher-than-typical water surface elevations throughout much of the San Francisco Estuary that summer, reflected in high tides running roughly half a foot higher than predicted, and low tides up to a foot higher than predicted (Figure A-6).

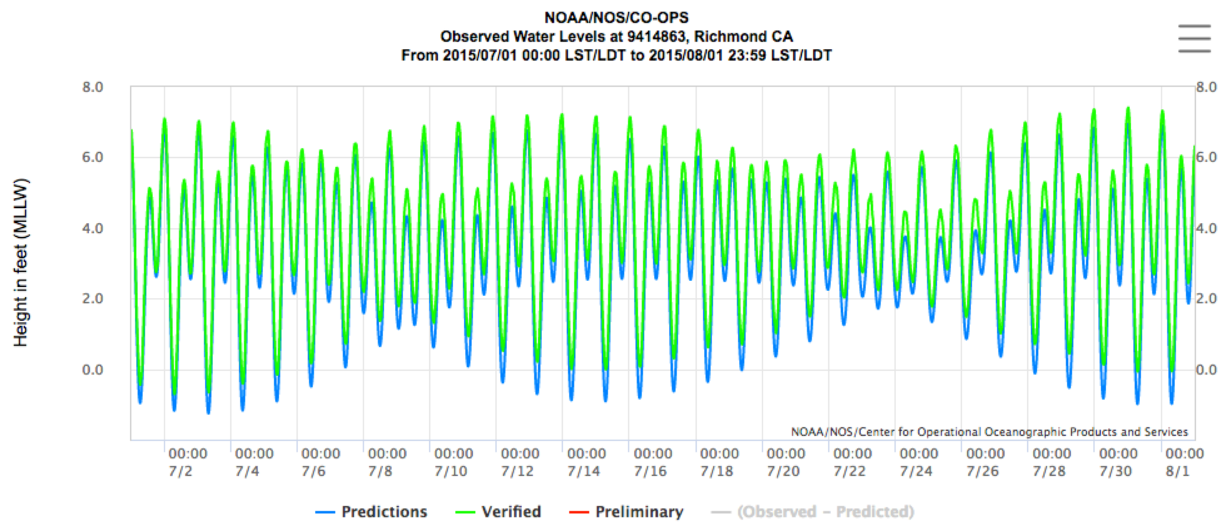

Figure A- 6. The "blob" of warm water off the Northern California coast in the summer of 2015 contributed to higher-than-normal tidal elevations. (Image: NOAA CO-OPS)

There is a growing body of evidence that sea levels in the eastern portions of the North Pacific are linked to PDO and related North Pacific wind patterns, and that these patterns may have suppressed SLR along the U.S. Pacific coast from roughly 1980 through the late 2000s, causing SLR in California to lag behind global (eustatic) SLR and well behind SLR in the western North Pacific (Bromirski et al. 2011). Research since then indicates that this pattern is potentially reversing, and that sea level rise along the U.S. West Coast could be shifting into a mode of rapid acceleration that will allow it to "catch up" with global SLR (ibid, Hamlington et. al 2016).

Storms: Storm contributions are important because shoreline ecosystems and infrastructure are typically flooded by short-term, extreme events long before they are flooded by long-term increases in base sea levels. Winter storms elevate water levels through storm surge (increase in ocean surface elevations driven by periods of low atmospheric pressure and wind effects, see Bromirski et al. 2017) and by generating wind-waves that can overtop shoreline barriers to flooding such as levees and seawalls. Storm surge in the Bay can exceed 2 to 3 feet on top of antecedent tide levels (AECOM 2016a). Wind-waves are limited by fetch (the maximum distance upon which winds can move across a basin) as well as shoreline bathymetry; though they can grow to 4 to 5 feet in the Bay interior, the Bay's extensive mudflats tend to limit wind-waves to a maximum height of 3 ft along the shoreline (ibid). In 2016, AECOM produced two reports for the Federal Emergency Management Agency (FEMA) describing extreme tidal elevations in the Bay driven by storms and other factors (AECOM 2016a), as well as an analysis of the history and potential future of extreme storms in the Bay (AECOM 2016b).

King tides: The phrase "king tides" refers to high tides that are higher than usual, often on the order of a foot or more above Mean Higher High Water (MHHW, the average elevation of a location's daily higher high tide). They are the highest astronomical tides (HAT) and are very predictable. Usually, these tides can be more precisely described as "perigean spring tides", which occur when a new or full moon is in alignment with the sun, and is closest to Earth (Figure A-7). In the SF Bay Area, the highest king tides typically occur during the winter months, when perigean spring tides coincide with storms and storm runoff that result in elevated local tidal elevations. Initiatives such as the California King Tides Project[27] demonstrates how sea level rise will impact local shorelines.

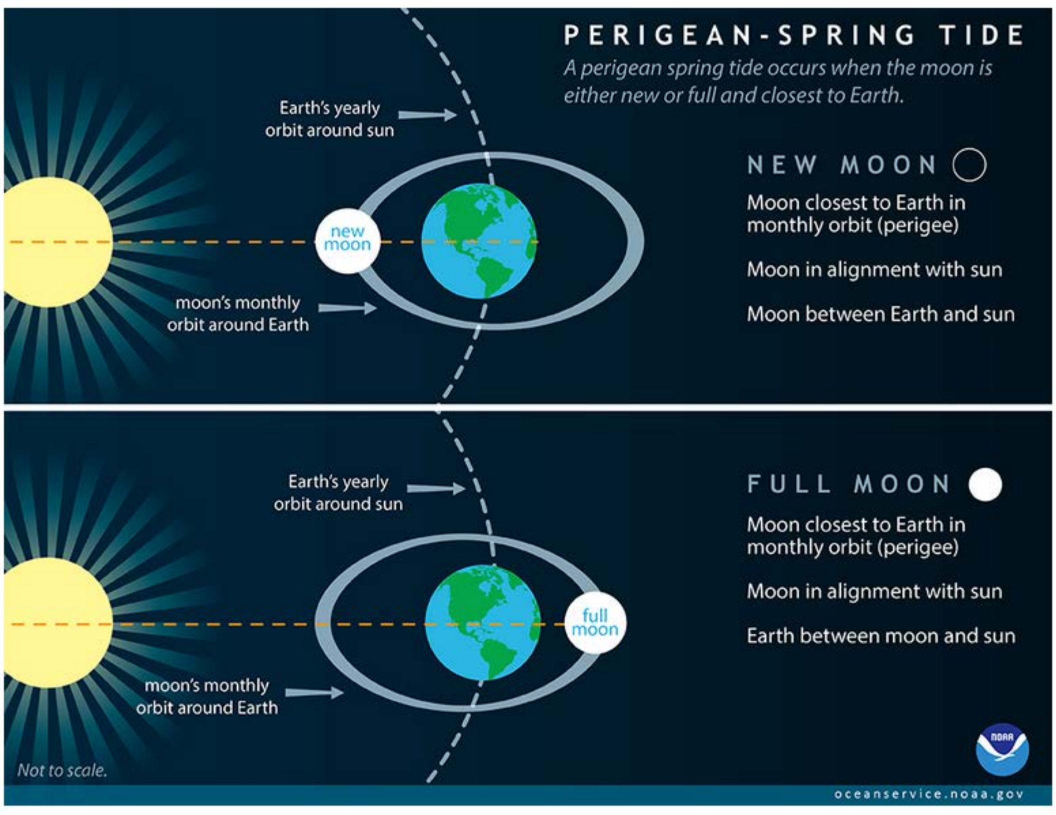

Figure A- 7. Perigean spring tides or "king tides" contribute to higher-than-normal high tides. (Image: NOAA NOS 2018)

[27] California King Tides Project: https://www.coastal.ca.gov/kingtides/

High Delta and tributary outflows. San Francisco Bay is the outlet through which the Sacramento-San Joaquin Delta drains to the Pacific Ocean. The Delta drains roughly 40% of the state of California, and receives approximately 50% of the state's streamflow (USGS 2000). During particularly wet years, sustained high Delta outflow limits the degree to which low tides can drain out of San Francisco Bay, limiting local drainage. This effect was observed during the record winter of 2016-2017, when especially high Delta outflows contributed to elevated water levels in Suisun and San Pablo Bays, hindering local drainage and leading to the sustained flooding of a low-lying portion of Highway 37 near Novato Creek which was subsequently repaired by Caltrans this past year. Figure A- 8 displays a graph of water levels at the Richmond gage during this period - note the especially high tides and truncated lows from February 16th through the 21st, during what otherwise would have been a typical neap tide cycle.

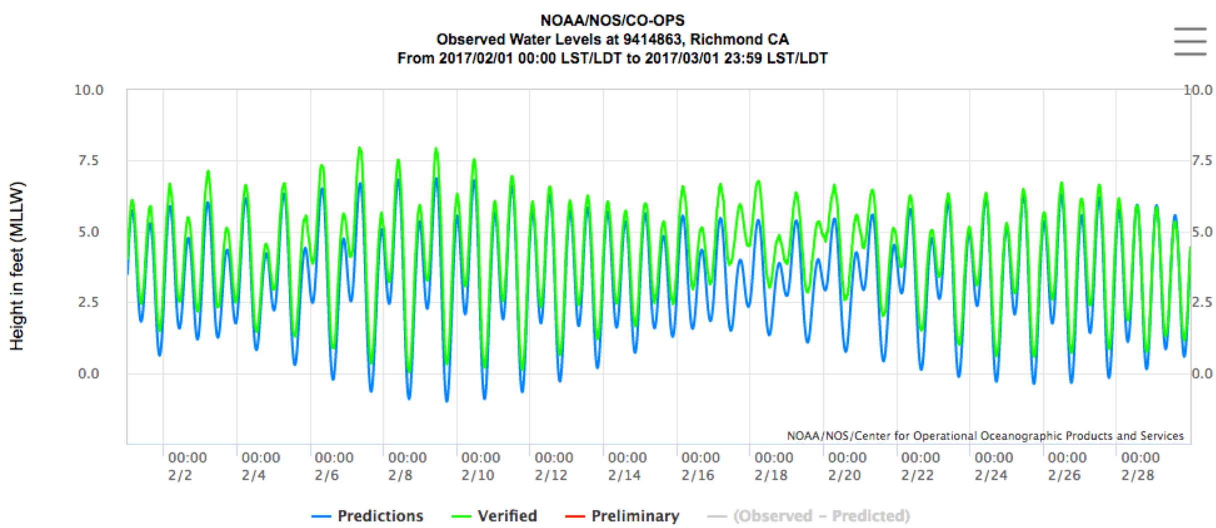

Figure A- 8. Record rainfall and high Delta outflows raised high and low tides to higher-than-normal elevations in February 2018, especially the week of 2/14 (Image: NOAA CO-OPS)

Sea Level Rise Projections

The section summarizes the sea level rise projections from the 2017 OPC-SAT report (Griggs et al. 2018), which lay the scientific foundation for the state of California's official sea level rise guidance (OPC 2018).

Rising Seas in California: 2017 Update on Sea Level Rise Science

In 2005, Governor Arnold Schwarzenegger signed Executive Order S-03-05, which established greenhouse gas reduction targets for the state, created the Climate Action Team, and directed state agencies to work together to achieve these targets and develop appropriate mitigation and adaptation strategies. As part of these efforts, the state must periodically assess the potential impacts of climate change in California and develop a suite of regionally-specific adaptation responses. So far, the state has produced three such Climate Assessments in 2006, 2009, and 2012, and is currently developing the fourth.

California's Fourth Climate Assessment includes a broad portfolio of projects aimed at addressing information gaps about climate vulnerabilities as well as the scope, timing, cost and feasibility of adaptation strategies. One critical component of the Assessment is updating sea level rise projections for California. In April 2017, the California Ocean Protection Council Science Advisory Team (OPC-SAT) published *Rising Seas in California: An Update on Sea Level Rise Science* (Griggs et al. 2017). As previously discussed in Section 2, this update assigns statistical probabilities to SLR scenarios associated with two potential emission pathways to help planners and decision-makers contextualize the risk associated with planning for particular levels of SLR. Again, it's important to note that since the probabilities presented in the *Rising Seas* report are based on two precise emissions scenarios, they may not reflect the actual emissions of the future, and therefore do not represent the actual probability that a given amount of SLR will occur.

The update incorporates the findings of a broad range of recent climate change research, particularly advances in ice loss science which indicate that the rate of ice loss from the Greenland and West Antarctic ice sheets is increasing, and that this loss will soon become the largest component of global sea level rise. In order to account for potentially catastrophic WAIS loss in a high- emissions future, the 2017 Rising Seas report describes an extreme long-term SLR scenario, called **H++**, which was first defined in the Fourth National Climate Assessment (USGCRP 2017).

The 2017 Rising Seas report formed the technical basis for the Ocean Protection Council's 2018 sea level rise guidance (OPC 2018), discussed below.

State of California Sea Level Rise Guidance: 2018 Update

In 2018, the California Ocean Protection Council (OPC) published updated sea level rise guidance for state and local governments (OPC 2018). This guidance proposes a methodology for decision-makers to analyze and assess the risks posed by sea level rise based on the best available science (e.g. Griggs et al. 2017), a framework for incorporating SLR into planning, permitting, and investing decisions, and descriptions of preferred multi-benefit coastal adaptation approaches and strategies. OPC developed the guidance through a multi-year process that included extended consultation with municipal leaders, partner stakeholders, state coastal management agencies, and the Coastal and Ocean Working Group of California's Climate Action Team (CO-CAT).

Probabilistic Sea Level Rise Projections

Figure 2 in this report (repeated as Figure A-9 below) displays the OPC's probabilistic projections of SLR for San Francisco with respect to a 1991-2009 baseline. Since the extreme H++ is a single scenario based on estimates of the maximum rate of physical collapse of the ice sheets (and not multiple model runs), it does not have a probability associated with it. The table highlights the recommended projections for use in low, medium-high, and extreme risk aversion decisions in blue boxes. This risk aversion framework is described in greater detail below.

		Probabilistic Projections (in feet) (based on Kopp et al. 2014)						H++ scenario (Sweet et al. 2017) *Single scenario
		MEDIAN	LIKELY RANGE			1-IN-20 CHANCE	1-IN-200 CHANCE	
		50% probability sea-level rise meets or exceeds…	66% probability sea-level rise is between…			5% probability sea-level rise meets or exceeds…	0.5% probability sea-level rise meets or exceeds…	
					Low Risk Aversion		Medium - High Risk Aversion	Extreme Risk Aversion
High emissions	2030	0.4	0.3	-	0.5	0.6	0.8	1.0
	2040	0.6	0.5	-	0.8	1.0	1.3	1.8
	2050	0.9	0.6	-	1.1	1.4	1.9	2.7
Low emissions	2060	1.0	0.6	-	1.3	1.6	2.4	
High emissions	2060	1.1	0.8	-	1.5	1.8	2.6	3.9
Low emissions	2070	1.1	0.8	-	1.5	1.9	3.1	
High emissions	2070	1.4	1.0	-	1.9	2.4	3.5	5.2
Low emissions	2080	1.3	0.9	-	1.8	2.3	3.9	
High emissions	2080	1.7	1.2	-	2.4	3.0	4.5	6.6
Low emissions	2090	1.4	1.0	-	2.1	2.8	4.7	
High emissions	2090	2.1	1.4	-	2.9	3.6	5.6	8.3
Low emissions	2100	1.6	1.0	-	2.4	3.2	5.7	
High emissions	2100	2.5	1.6	-	3.4	4.4	6.9	10.2
Low emissions	2110*	1.7	1.2	-	2.5	3.4	6.3	
High emissions	2110*	2.6	1.9	-	3.5	4.5	7.3	11.9
Low emissions	2120	1.9	1.2	-	2.8	3.9	7.4	
High emissions	2120	3	2.2	-	4.1	5.2	8.6	14.2
Low emissions	2130	2.1	1.3	-	3.1	4.4	8.5	
High emissions	2130	3.3	2.4	-	4.6	6.0	10.0	16.6
Low emissions	2140	2.2	1.3	-	3.4	4.9	9.7	
High emissions	2140	3.7	2.6	-	5.2	6.8	11.4	19.1
Low emissions	2150	2.4	1.3	-	3.8	5.5	11.0	
High emissions	2150	4.1	2.8	-	5.8	5.7	13.0	21.9

Figure A-9. Probabilistic sea level rise projections for the San Francisco Bay region from the State of California Sea-Level Rise Guidance (OPC 2018).

Risk Aversion Framework

The risk aversion framework described in the OPC's guidance provides a step-wise approach to help decision makers assess risk by evaluating the impacts and adaptive capacity of the project across a range of SLR projections. The approach has the following steps:

1. ***Identify the nearest tide gauge to the proposed project.*** As previously discussed, relative rates of sea level rise vary along the California coast due to variations in plate tectonics and subsidence. Planners therefore need to select the appropriate SLR projections for their geography which, in the SF Bay Area, is the table presented above.

2. ***Evaluate the proposed project's lifespan.*** Planners should consider a project's anticipated lifespan when deciding whether to consider SLR projections for low or high-emission scenarios. The longevity of most greenhouse gases means that their impacts on the environment are felt and experienced long after being emitted. Before 2050, differences in sea level rise projections under different emissions scenarios are small because near-term SLR is largely "locked in" by past greenhouse gas emissions and the slow response times of the ocean and land ice to warming. As a result, prior to 2050, the guidance only considers SLR projections based on the RCP 8.5 ("business as usual") emission scenario. After 2050, SLR projections increasingly depend on the pathway of future greenhouse gas emissions. Between 2050 and 2150, the guidance therefore includes SLR projections for both the RCP 2.6 ("low-emissions") and RCP 8.5 scenarios. The guidance also includes the H++ scenario (which isn't tied to a specific emissions trajectory) for consideration in projects with a lifespan beyond 2050 with extreme risk aversion (see Step 3 below).

3. ***For the nearest tide gauge and the anticipated project lifespan, identify a range of sea level rise projections.*** The guidance recommends that decision makers evaluate a range of SLR projections based on three different levels of risk aversion in order to develop adaptation pathways and contingency plans with precautionary enough consideration of SLR to safeguard people and resources (Figure A-9). The three levels of risk aversion are:

    - *Low risk aversion* for adaptive, risk tolerant, lower-consequence projects, such as an unpaved coastal trail. The OPC estimates that projects designed to account for these amounts of SLR will have a roughly 17% chance of being overtopped in their lifetime.

    - *Medium-high risk aversion* for less adaptive, more vulnerable projects or populations that will experience medium to high consequences as a result of underestimating SLR (e.g. coastal housing development).

- *Extreme risk aversion* (H++) for high consequence projects with a design life beyond 2050 that have little to no adaptive capacity, would be irreversibly destroyed or significantly costly to relocate/repair, or would have considerable public health, public safety, or environmental impacts should this level of SLR occur. The H++ estimates should be included in planning and adaptation strategies as a “worst case” scenario.

It’s important to note that the low risk and medium-high risk aversion scenarios may underestimate the likelihood for extreme sea level rise.

4. ***Evaluate the potential impacts of sea level rise on the project and its adaptive capacity across a range of sea level rise projections and emissions scenarios.*** For each identified SLR projection, the guidance recommends that decision makers conduct a vulnerability assessment to determine:

- The consequences of potential impacts: How could potential SLR impacts to a project, its environment, and its community affect equity, environment, economy, and governance, and would these impacts would be minimal, moderate, or catastrophic?
- What is at stake: Would vulnerable communities, coastal habitats, and/or critical infrastructure would be significantly impacted?
- Adaptive capacity: Can people, natural systems, and infrastructure readily respond or adapt to rising sea levels?
- Economic impacts: Will failure to adequately plan for sea-level rise create significant economic burdens now or in the future?

Evaluating these factors will help decision makers understand the vulnerabilities of people, assets and the natural environment under a range of SLR possibilities and determine their tolerance for the risks associated with the consequences of over- or underestimating SLR. This approach aligns with ongoing efforts throughout the state to complete vulnerability assessments, including efforts helmed by the California Coastal Commission and the Governor’s Office of Planning and Research. The guidance acknowledges that that the social, economic and environmental impacts of different levels of exposure to SLR may be difficult to quantify and qualify, and that decisions will ultimately require balancing tradeoffs and priorities that may not be consistent across communities or jurisdictions.

5. ***Select sea level rise projections based on risk tolerance and, if necessary, develop adaptation pathways that increase resiliency to sea level rise and include contingency plans if projections are exceeded.*** Appendix 4 of the OPC guidance presents a framework for assisting decision-makers in evaluating tradeoffs and determining the appropriate SLR projections based on the condition and characteristics of the shoreline being evaluated, risk tolerance/aversion, consequences, adaptive capacity, and economic considerations. It also recommends that coastal communities consider developing adaptation pathways that account for the uncertainties associated with the severity and timing of sea level rise, particularly after mid-century. Such adaptation pathways can provide a structure for sequencing adaptation measures using the time horizon of projected hazards from a changing climate. These plans should identify threshold events/impacts (e.g. flooding extents, frequency of damage, or extents of coastal development) that would trigger subsequent SLR adaptation planning and/or implementation, and ensure that low-regret, near-term actions don't preclude future options for addressing long-term SLR (including extreme scenarios).

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Appendix B Impacts of Sea Level Rise on Tidal Wetlands

Environmental Drivers of Landscape Evolution

The following material is summarized from the in-progress compendium of SF Bay tidal wetland conceptual models being compiled by the Wetland Regional Monitoring Pilot Program (WRMP in-progress).

- **Topography/Morphology:** The shape, form, and elevation of the baylands are a fundamental control on wetland characteristics, especially if they were influenced by processes such as diking and draining which can lead to large-scale subsidence (oxidation and settlement of wetland soils). Mature tidal wetlands in the SF Estuary have elevations near or above MHHW, while deeply subsided diked baylands can have elevations at or below Mean Lower Low Water (MLLW). Tidal wetlands can slope gradually into subtidal mudflats (ramp), or have a sudden topographic break along the shoreline (scarp) depending on mudflat and bay wave conditions. Similarly, estuarine-terrestrial transition zones can be gently or steeply sloped depending on the underlying geology.
- **Hydrology:** Bayland habitats are strongly influenced by the inundation regime (the frequency, depth and duration of inundation from tidal and fluvial flows). Tidally influenced baylands at lower elevations will be flooded more frequently, at deeper depths, and for longer periods of time than areas high in the tidal frame. Over the past century, the historic NOAA tide gage near the Golden Gate Bridge has measured roughly seven inches of sea level rise, equivalent to a rate of approximately 2 mm/year. As described in Appendix A, this rate is expected to accelerate sharply - perhaps exponentially - in the future.
- **Mineral sediment supply:** The supply of inorganic (mineral) sediment available to deposit on tidal wetlands helps govern their ability to keep pace (maintain elevations) with rising sea levels. Most tidal wetlands in the Bay primarily receive fine-grained sediment from tidal deposition; the relatively few that are hydraulically connected to creeks can also receive episodic flood pulses of coarser watershed-derived sediment. Both types of sediment (fines - clays and silts; and coarse - sand) are important for the development of diverse, resilient baylands. In the 1990s, scientists observed a step decrease in the suspended sediment in the Bay, thought to be due to depletion of the pool of sediment washed into the Bay from hydraulic mining in the 1800s (Schoellhamer 2011). Additional detail describing sediment supply and demand in the Bay is included below.
- **Vegetation:** Tidal baylands in SF Bay generally can only support tidal marsh vegetation if their elevations are at or above roughly Mean Tide Level (MTL). Below MTL, tidal inundation occurs too frequently, at deeper depths, for too long

to support emergent wetland plants such as native cordgrass (Spartina foliosa). Wetland vegetation creates surface roughness that increases the sediment “trapping” capacity of the wetland, and as a result, vegetated wetlands tend to be more resilient than unvegetated tidal mudflats. In salt marsh communities within the Central and South Bay Segments, accretion (see below) tends to be dominated by mineral sediment, but in fresh and brackish marsh communities in the North Bay and Suisun, accretion tends to be dominated by organic matter (peat) accumulation. As sea levels continue to rise, scientists expect that saline water will penetrate further upstream into San Francisco Bay, up the Carquinez Straits, into Suisun Marsh, and into the Sacramento-San Joaquin Delta.

Mechanisms of Tidal Wetland Loss in San Francisco Bay

Aside from direct dredging and filling from human activities, there are two primary mechanisms of marsh loss in San Francisco Bay: (1) vertical downshifting and drowning (loss of elevation resulting in a conversion from vegetated marsh to unvegetated mudflat and eventually open water), and (2) lateral erosion (marsh retreat from the bayward edge). These mechanisms are described below.

Marsh Drowning, Coastal Squeeze, and the Loss of High Tide Refugia

Multiple teams of researchers have taken different approaches to modeling the long-term resiliency of tidal wetlands in SF Bay. Despite the differences in modeling approaches, **the overwhelming consensus of these studies is that sea level rise will result in the widespread increases in the depth, duration, and frequency of tidal inundation in the Bay’s tidal marshes, converting them to low marsh (*Spartina*) and/or unvegetated mudflats.** Generally speaking, modeled scenarios with relatively higher rates of SLR and lower suspended sediment concentrations (SSC) demonstrate faster and more widespread marsh drowning than scenarios with lower rates of SLR and higher SSC (Stralberg et al. 2011, Swanson et al. 2013, Schile et al. 2014, Thorne et al. 2015). Accordingly, the risk of marsh drowning is greatest in salt marshes that are mostly dependent on the accretion of mineral sediment to keep pace with SLR (Figure B- 1). Current supplies of suspended sediment in the South Bay appear to be adequate to support rapid rates of marsh accretion in salt marshes there (Downing-Kunz et al. 2017), but it’s unclear how sediment supply and accretion rates may change as large acreages of subsided baylands are restored to tidal action. These areas will require significant volumes of sediment - first, to achieve marsh plain elevations suitable to support intertidal vegetation, and then further sediment to keep pace with rising sea levels. Freshwater and brackish marshes in the North Bay and Suisun demonstrate improved modeled SLR resilience thanks to their production of abundant organic peat, but remain vulnerable to mudflat conversion in high-SLR, low-SSC scenarios (Stralberg et al. 2011 and Schile et al. 2014). The modeling demonstrates that restoring tidal wetland sites throughout the estuary may struggle to keep pace with sea level rise, especially in scenarios with high rates of SLR.

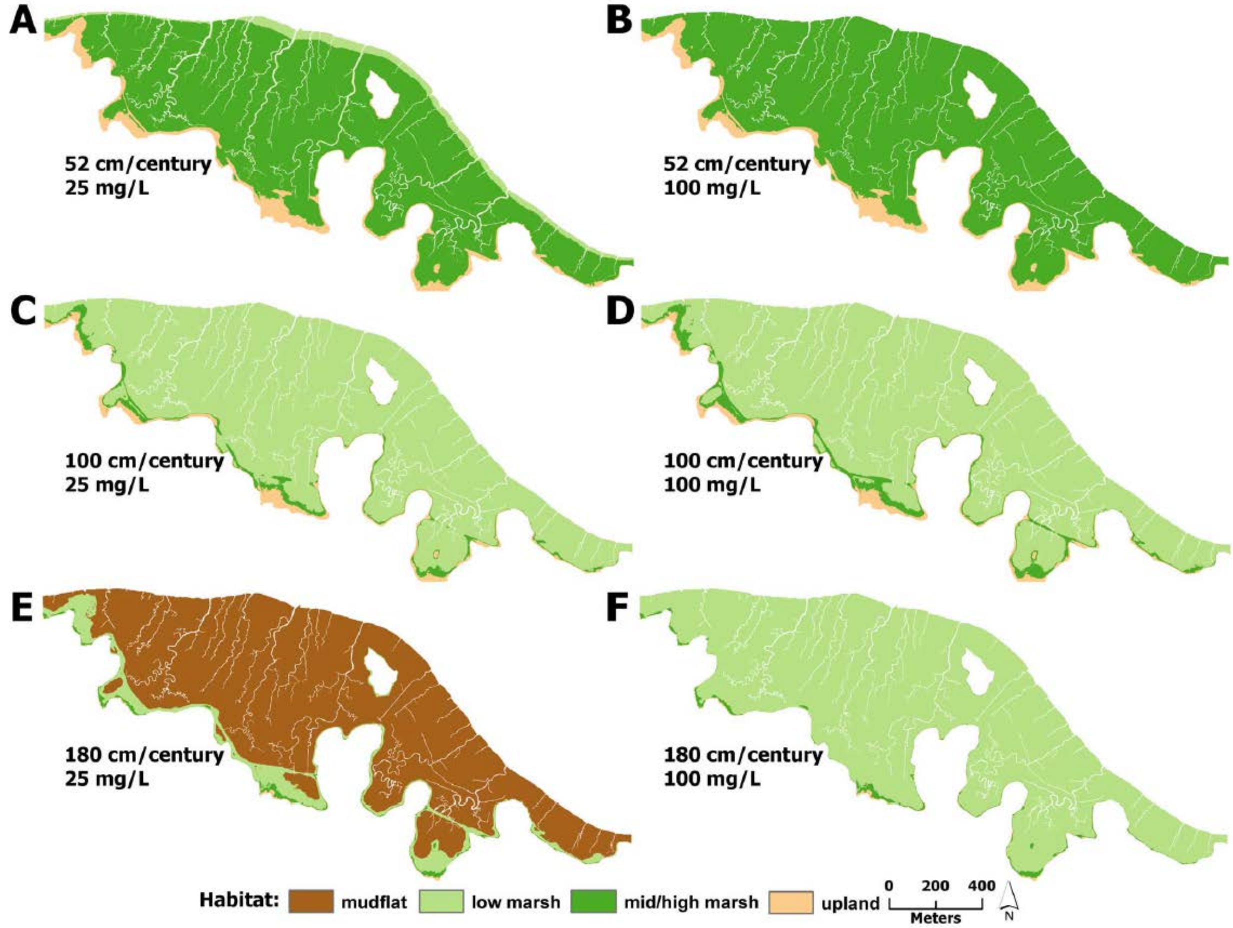


Figure B- 1. Modeled habitat distributions in 2110 at China Camp under different sea level rise scenarios and suspended sediment concentrations. (Image: Schile et al. 2014)

In many modeled scenarios, particularly ones with higher rates of SLR and lower concentrations of suspended sediment, the only locations that are likely to maintain high (mature) tidal marsh habitats are places where tidal wetlands can migrate/transgress over the estuarine-terrestrial transition zone (see scenarios C through F in Figure B- 1). In this way, the morphology of the T-zone (especially its steepness) largely determines the limits of high marsh habitats. In locations where tidal marshes abut steep headlands or (more commonly) steep levees, the narrow bands of high marsh that persist in these modeled circumstances are a far cry both morphologically and ecologically from the broad dendritic high marsh plains that drowned due to rising seas. In locations with no functional T-zone, high marsh disappears completely, as it has nowhere to migrate to. This phenomenon, called “coastal squeeze”, is a particular risk for drowning marshes with highly urbanized inland edges. As discussed in Section 3.1, these marshes are often pinned against infrastructure such as highway or railroad embankments, or separated by levees from residential, commercial, and/or industrial development. The narrow, steeply sloped, linear nature of the landward edges of these marshes prevents the establishment of a functional T-zone, and increases the risk that high marsh habitats will eventually be “squeezed” and lost between urban development and rising tides.

The modeling also demonstrates that before marshes downshift to mudflat, they will first cause internal high tide refugia with restricted elevations to downshift. These features include locations such as natural tidal creek levees (Figure B- 2), T-zones, flood deposits, and other topographic high points within and along marshes that support taller, shrubby vegetation such as gumplant (*Grindelia stricta*), coyote bush (*Baccharis glutinosa*), and in limited locations California sea blite (*Suaeda californica*). This vegetation provides shelter for marsh wildlife from high tides, king tides, and other high-water events. Since these species are sensitive to prolonged inundation (which is why they colonize high points), they are highly vulnerable to drowning and becoming replaced by more inundation- tolerant species such as pickleweed. These high marsh species don’t grow as high as the shrubbier vegetation they replace, and therefore provide relatively less protection from high water events. The loss of high tide refugia within the marsh plain puts marsh wildlife such as Ridgway’s rail and salt marsh harvest mouse at an increased risk of drowning and predation.

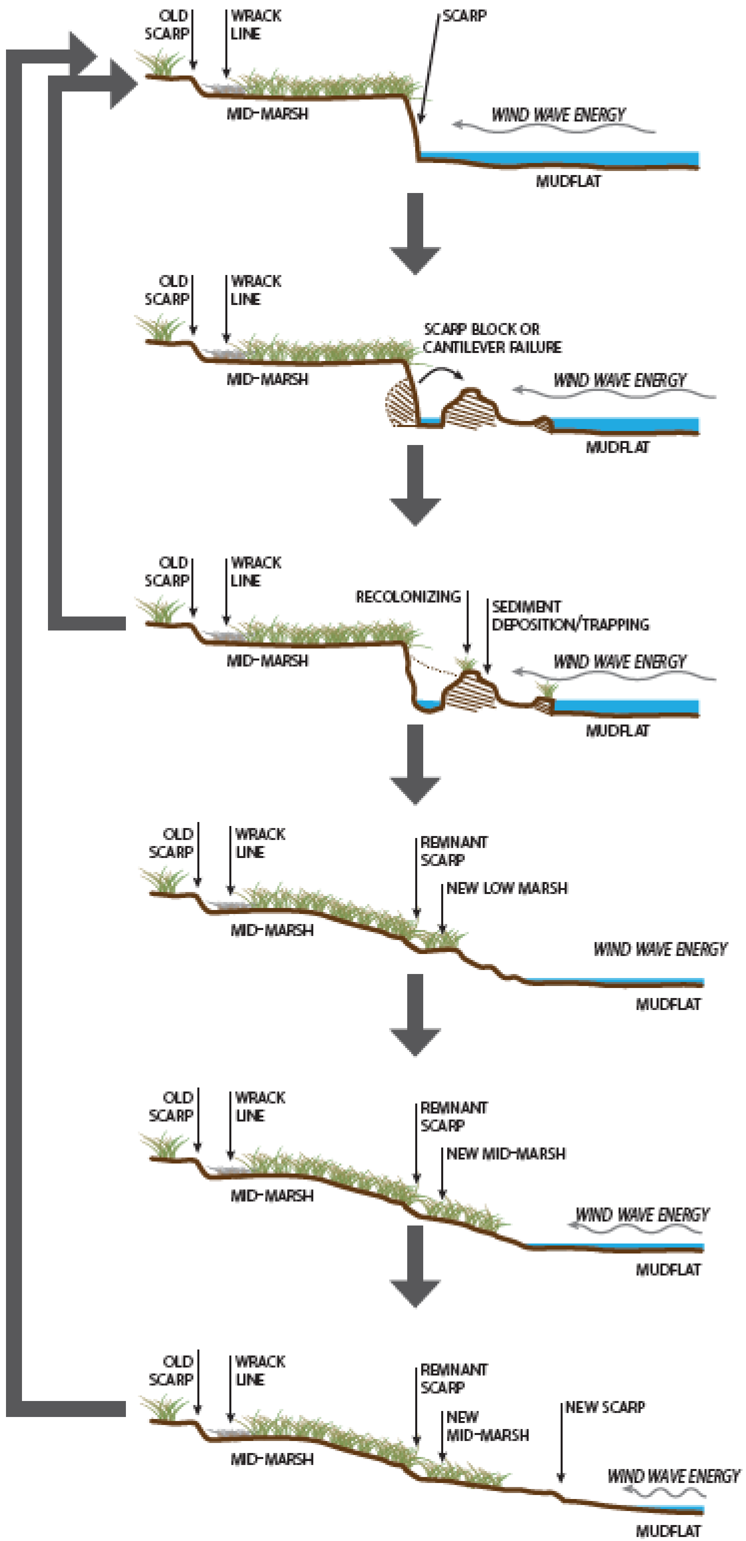
Figure B- 2. The canopy of tall vegetation along naturally deposited tidal creek levees provides shelter for marsh wildlife from king tides at China Camp State Park. (Image: Peter Baye)

Lateral Movement of the Marsh Edge

The interface where intertidal wetlands transition to mudflats is a highly dynamic region that is subject to change on multiple spatial and temporal scales. Changes in vertical elevations in this region help govern the lateral position of the marsh edge (Willemsen et al. 2018). In San Francisco Bay, the relatively unconsolidated nature of newer Bay Muds, the Bay's tidal regime, and the difficult-to-access nature of the Bayshore make this region particularly difficult to study. One of the most detailed assessments of natural shoreline typology and lateral change in the Bay is Beagle et al.'s (2015) *Shifting Shores* report, which focused on marsh retreat and expansion in San Pablo Bay (SPB). SPB is a unique sub-basin within greater San Francisco Bay due to the presence of large expanses of mudflats and shallow open water (facilitating the settlement, re-suspension, and tidal transport of suspended sediment) as well as large tributaries that contribute a significant proportion of the Bay's overall bedload and suspended sediment loads (Dusterhoff et al. 2017). Beagle et al. classified SPB's edge into five distinct morphologies, mapped their distribution, assessed post-1855 rates of marsh edge retreat and expansion within SPB, and proposed a conceptual model of marsh edge evolution based on a suite of physical drivers including wind and wave energy and direction, shoreline orientation, topography/bathymetry, sediment supply and type, vegetation, and relative SLR (Figure B-3). The study had several key findings:

1. Much of SPB's marsh edge is expanding baywards, and has been for 150 years, especially around the mouths of large creeks,
2. Recent (1993-2010) retreat of the marsh edge is occurring at limited locations, mainly in areas that stick out into the Bay (i.e. Hamilton Field, where SPB marshes experienced significant expansion between 1855 and 1993 due to the deposition of Gold Rush sediments), and
3. Parts of the shoreline may look like they are retreating (i.e. some marsh scarps), but they are in fact expanding rapidly.

The finding re: marsh expansion at creek mouth deltas underscores the importance of watershed sediment supply (not just estuarine sediment supply) and watershed-bayland connections as likely crucial factors controlling the growth and, ultimately, resilience of the Bay's tidal wetlands. This is especially true in the Bay's more urbanized areas, where engineered flood control channels limit the movement of sediment from watersheds and fluvial systems into the nearshore environment, reducing the sediment available for marsh accretion and driving expensive dredging activities to achieve flood control objectives (Dusterhoff et al. 2017). The impacts of bayland sediment starvation may be magnified in watersheds with abundant bedload (coarser sands, gravels, and cobbles) that, prior to modern re-engineering, helped nourish and maintain coarse beaches and related nearshore features in the Bay. For example, Beagle et al. found that tidal wetlands near Point Pinole that were and continue to be armored by beaches had experienced significant retreat between 1855 and 2010. Follow-up work by Dusterhoff et al. suggests that many of the creeks in the region (e.g., Pinole Creek, San Pablo Creek, and Wildcat Creek) retain a significant amount of watershed-derived sediment (including bedload) in their engineered flood control channels, likely limiting the supply of coarse sediment that could nourish beaches in the baylands. Management actions that therefore (a) improve the delivery of both suspended sediment and bedload from watersheds into the baylands and (b) support the restoration and maintenance of coarse beach features in front of marshes will be important tools for decision-makers looking to support the long-term resilience of tidal wetlands in the Bay.



Scarp without bayward vegetation (SN)

Fails under pressure from wind wave energy or wave run-up, and undercut blocks fall or cantilever, depositing sediment (with or without vegetation) in front of the scarp.

Scarp without bayward vegetation (SN)

The failed block dissipates wave energy until this deposit is scoured away and redistributed on the mudflat or marsh plain, thus creating an erosional environment as the wave energy is then directed back to the scarp.

Scarp with bayward vegetation (SV)

If the failure is large enough to redirect wave energy for longer periods of time, the failed blocks may create an environment for sediment deposition and trapping between the old scarp and the failed block.

Ramp with inflection point (RI)

A ramped profile begins to form as sediment fills in behind the failed block, building elevation, creating new low marsh and leaving behind a remnant scarp.

Ramp without inflection point (RNI)

As the ramping continues, wave energy is dissipated such that the low marsh vegetation traps sediment, building up to mid-marsh habitat.

Ramp with new bluff forming (RI)

When the new mid-marsh levels, the ramped profile steepens and wind wave energy begins to erode the new mid-marsh, creating a new scarp. And the cycle continues...

Figure B-3. The proposed conceptual model of Bay edge evolution from Beagle et al. (2015), showing how different marsh edge morphologies may represent different phases of evolution and marsh retreat/expansion.

Wetland Loss and Shoreline Flood Risk

The potential SLR-driven loss of tidal wetlands not only threatens the integrity of bayland ecosystems but increases the risk of flooding and erosion along the San Francisco Bay shoreline. The wave-attenuating properties of the Bay's tidal marshes and tidal flats are well known and have been documented in detail by researchers. A 2011 study by the US Geological Survey in Corte Madera Marsh found that wave height decreased by as much as 80 percent across Corte Madera Bay's shallows and tidal flats; what wave height remained at the shoreline was rapidly attenuated within the marsh (Lacy and Hoover 2011). Subsequent modeling of the mechanisms of wave attenuation in the same marshes (ESA PWA 2012) indicated that they were particularly effective at reducing the impact of waves at lower water levels (see Figure B-4 and Figure B-5 below). The wave attenuation properties of Bay wetlands likely vary with elevation, vegetation, exposure/geography, and other elements, but with adequate width their presence can significantly reduce the risk of wave-driven overtopping of shorelines.

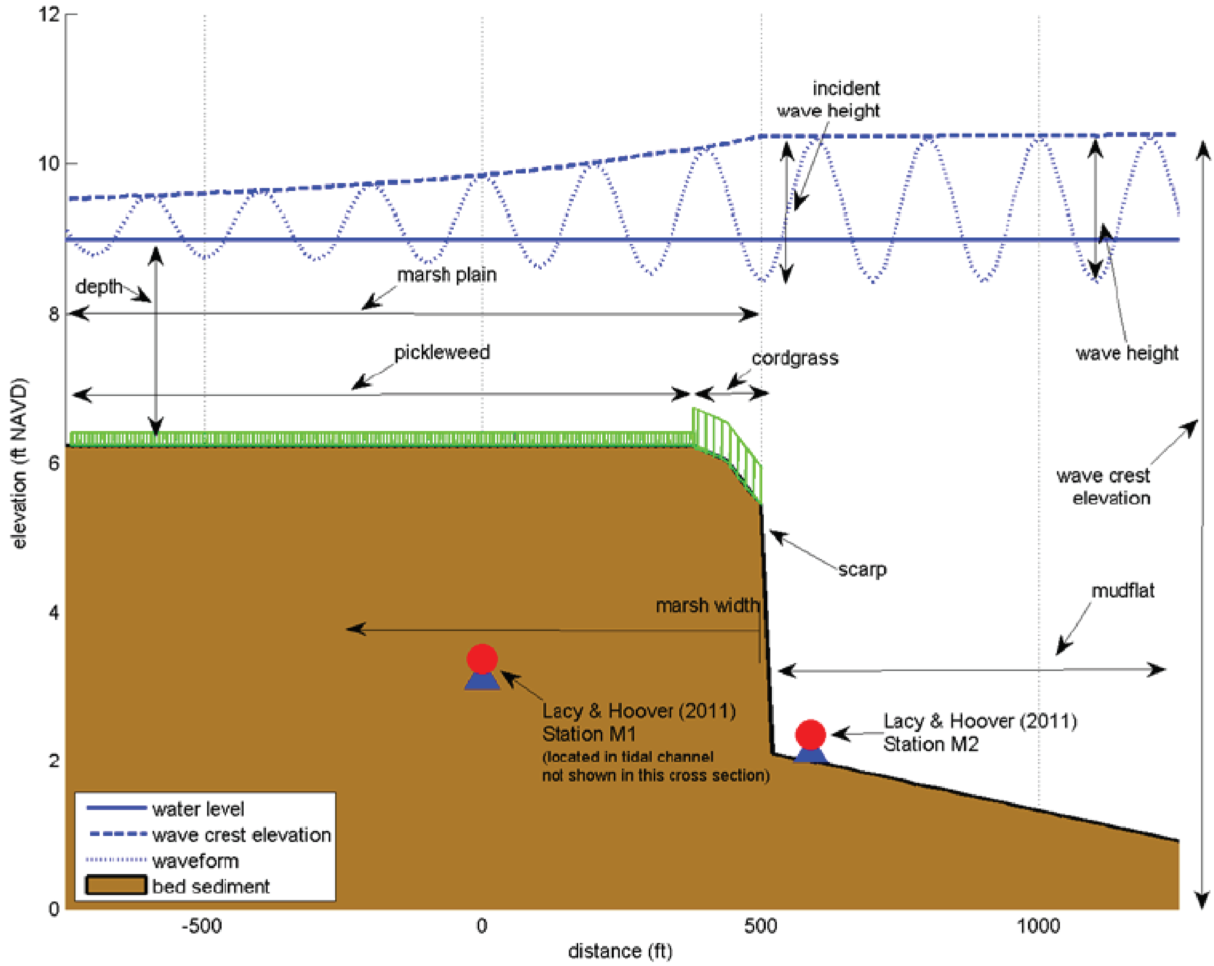


Figure B- 4. Offshore waves decrease in height when they encounter a vegetated marsh plain. (Image: ESA PWA 2012)

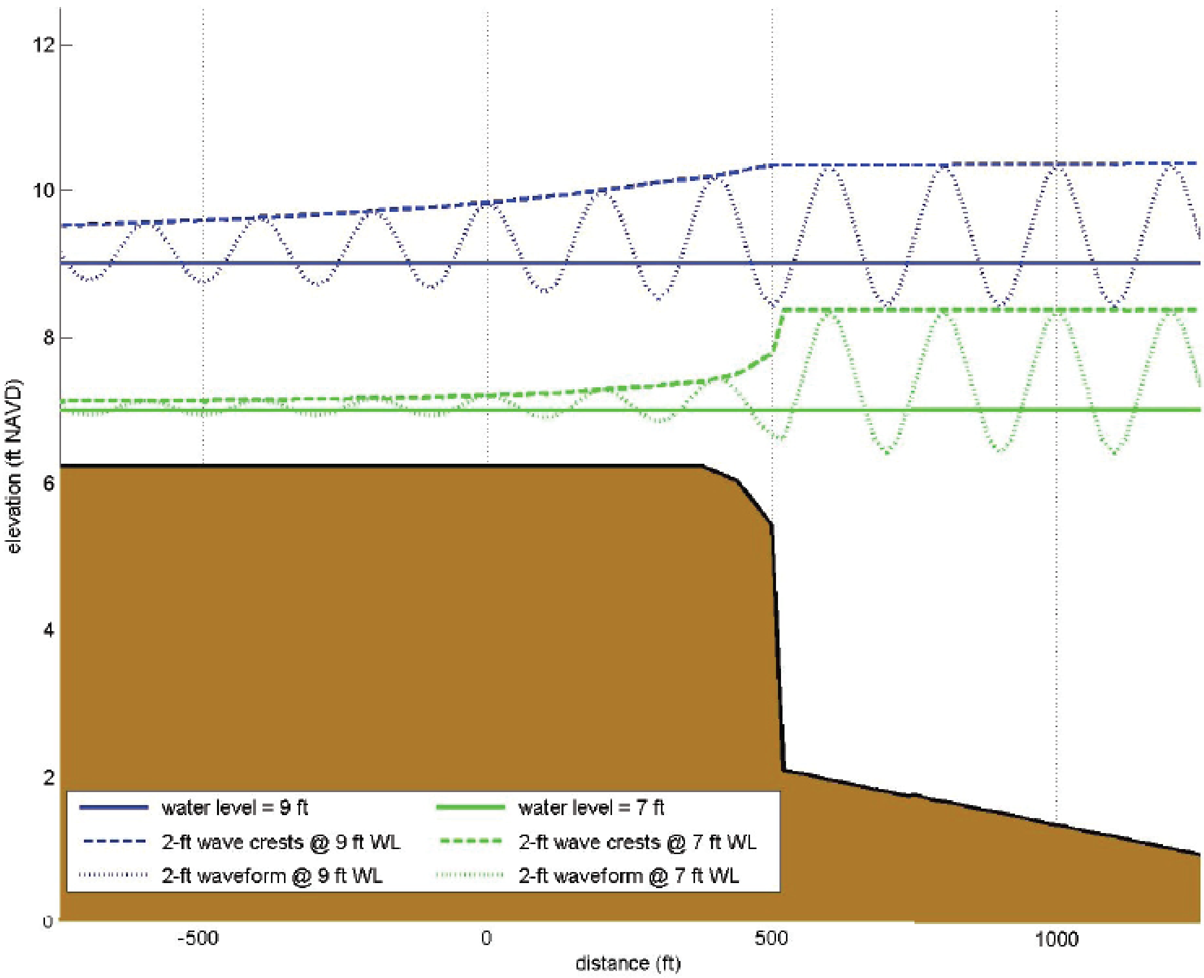


Figure B-5. Higher water levels experience relatively less attenuation over marshes. (Image: ESA PWA 2012)

This is important because along the San Francisco Bay shoreline, episodic flooding from waves generated by wind and storms will occur much sooner than permanent flooding from tidal inundation. This is demonstrated in the CoSMoS modeling described in Appendix C as well as the data and map products developed by BCDC's Adapting to Rising Tides program, which are based on modeling done by FEMA for the California Coastal Analysis and Mapping Project (CCAMP). It's important to note that unlike CoSMoS, CCAMP/ART modeling assumes that marshes are static, and do not change vertically or horizontally with sea level rise. Since that assumption will likely prove false (see marsh drowning discussion above), these models likely underestimate flooding from future (with sea level rise) scenarios, because lower, smaller marshes will have a decreased ability to attenuate wave energy. Critically, no models of SF Bay SLR and/or flood risk incorporate the probability of levee failure, which is likely high given the relatively un-engineered nature of many of the Bay's levees.

Estuarine Sediment Supply and Demand

The above material underscores that not only will existing marshes throughout San Francisco Bay require additional sediment to keep pace with rising sea levels, but that existing and planned restoration sites will need even more sediment if they are ever to support intertidal marsh in the near- and long-terms. Determining the Bay's projected future sediment budget is therefore an active field of research. A recent synthesis report developed by USGS and SFEI, funded jointly by the Bay Regional Monitoring Program and the USGS, calculated the net sediment supply from terrestrial sources to the Bay under "average" climate conditions to be 2.0 +/-0.8 million metric tonnes (1 billion kilograms) per year (Schoellhamer et al. 2018). Approximately 70% of this sediment enters the Bay from local tributaries, with the remainder entering from the Sacramento-San Joaquin Delta (ibid). Table B-1 breaks down these loads into bedload (relatively coarser and heavier sediment that tends to deposit in channels) and suspended sediment (relatively finer and lighter sediment that tends to deposit in the Bay. This table makes clear that after accounting for the removal and storage of bedload in flood control channels, the fraction of bedload that contributes to net sediment supply in SF Bay is minimal. In other words, the vast majority of the sediment that is available to accrete on existing and restoring marsh plains is suspended sediment, most of which comes from local Bay Area watersheds. The SFEI report states that *"The result of all the anthropogenic, geologic, and climatic differences* [between the Central Valley and Bay Area watersheds] *is that, although small* [Bay Area] *tributaries together comprise just 5% of the total watershed area and, for this 22-year period, 6.6% of the annual freshwater discharge, small tributaries now dominate the sediment supply."* Unlike suspended sediment from the Central Valley/Delta, which can get washed through the North Bay and out the Golden Gate during large storm events, suspended sediment from local tributaries tends to get trapped in engineered flood control channels or deposited on Bay mudflats. Large flood events can flush some sediment from flood control channels into open Bay waters (Livsey et al. 2019), where it can then be tidally transported and deposited elsewhere. Bay mudflats tend to act as local reservoirs for suspended sediment, where wave action can re-work deposited sediments into a suspended form that then becomes available for tidal transport and deposition in marshes (Lacy et al. 2015, MacVean and Lacy 2014).

It's important to note that though bedload may be a small component of the Bay's net sediment supply, it's an ecologically critical one. Coarse sediment such as sands and gravels form beaches and related features that naturally protect tidal marshes and flats from erosion (and are important habitats in their own right). In addition, marshes need coarse sediment in order to develop and sustain the microtopography and substrate that supports diverse tidal marsh plant communities, including habitat for rare plants (Baye et al. 2000) and high tide refugia along the bayward edges of tidal marshes (Baye

2010). Much of the Bay's coarse bedload is sourced from specific watersheds and trapped in engineered flood control channels, where natural transport processes are unlikely to move it into Bay nearshore and wetland habitats. This suggests that coarse material will need to be actively removed from flood control channels and placed in and along the Bay in order to support beaches and related nature-based features (Dusterhoff et al. 2017, Baye 2010).

Table B-1. Table 4.2 from Schoellhamer et al. 2018, which summarizes the mass of estimated net mean annual suspended and bedload in the Bay under present sediment erosion and transport conditions.

	Suspended load (Mt/yr)	Bedload (Mt/yr)	Total load (Mt/yr)
Sacramento-San Joaquin Delta	0.58 (0.39 to 0.77)	0.025 (-0.07 to 0.12)	0.61 (0.32 to 0.89)
Bay Area Watersheds*	1.38 (0.91 to 1.85)	0.013 (-0.056 to 0.082)	1.39 (0.85 to 1.93)
Total net terrestrial supply	1.96 (1.30 to 2.62)	0.038 (-0.12 to 0.20)	2.0 (1.2 to 2.8)

*Assumes that the estimates of storage and removal by dredging practices in flood control channels remain valid and that all storage and removal is bedload.

Using relationships described in the 2018 USGS/SFEI sediment synthesis report, the *mass* of sediment supply in Table B-1 can be very roughly translated into the *volumes* described in Table B-2:

Table B-2. Summary of the volumes of estimated net mean annual suspended and bedload in the Bay under present sediment erosion and transport conditions.

	Suspended load (Mm^3/yr)	Bedload (Mm^3/yr)	Total load (Mm^3/yr)
Sacramento-San Joaquin Delta	0.68 (0.46 to 0.90)	0.015 (-0.042 to 0.072)	0.69 (0.42 to 0.97)
Bay Area Watersheds*	1.61 (1.06 to 2.16)	0.008 (-0.034 to 0.049)	1.62 (1.03 to 2.21)
Total net terrestrial supply	2.29 (1.52 to 3.06)	0.023 (-0.072 to 0.120)	2.31 (1.45 to 3.18)

*Assumes that the estimates of storage and removal by dredging practices in flood control channels remain valid and that all storage and removal is bedload.

In 2011, Bruce Jaffe and colleagues from the USGS developed a preliminary estimate of the amount of mineral sediment that would be necessary to sustain the South Bay's existing tidal wetlands and anticipated restoration sites, assuming approximately 14 in of SLR by 2050 and 48 in of SLR by 2100. The researchers found that maintenance of existing wetlands through 2100 would likely require under 1 million cubic meters of sediment per year, but that inclusion of the Bay's tidal wetland restoration sites (including the entire South Bay Salt Ponds complex) would increase that number to be between 1 and 2 million cubic meters of sediment per year (Jaffe et al. 2011, Figure B-6) . This is a rough estimate that does not account for the contributions of organic sediment accretion, which are minimal in tidal salt marshes but play a more significant role in maintaining tidal freshwater and brackish marshes.

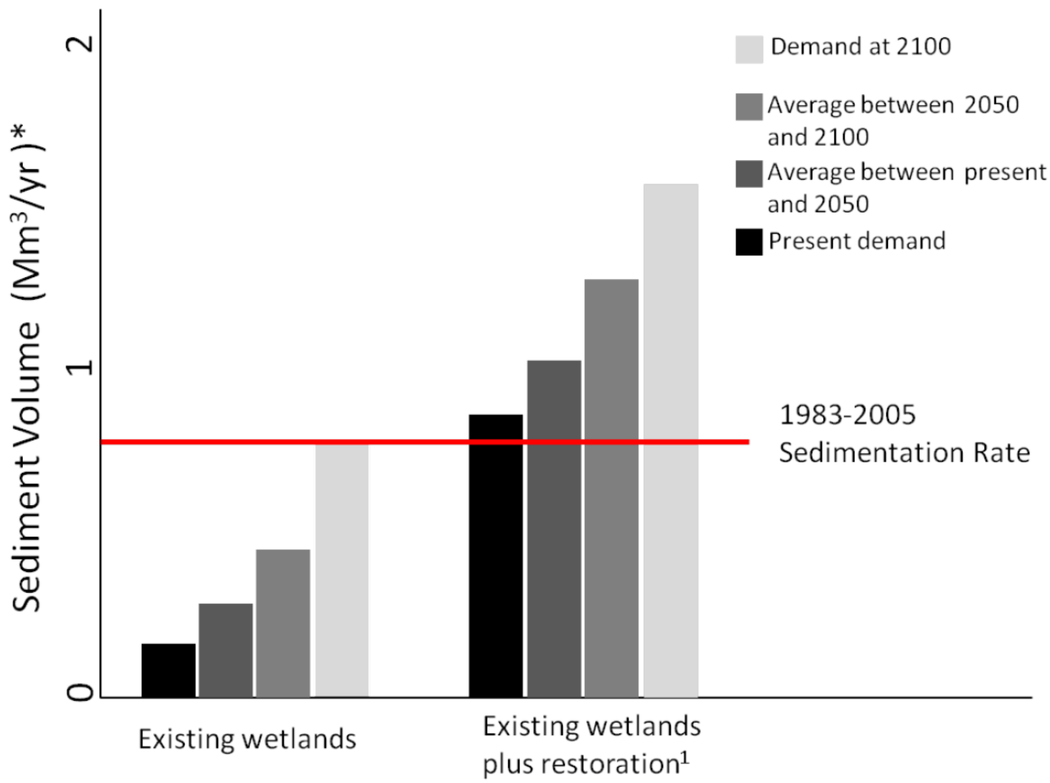


Figure B- 3. An estimate of the potential sediment needed for the long-term restoration and resilience of marshes in the Lower South Bay. (Image: Goals Project 2015, modified from Jaffe et al. 2011)

So far, there is no estimate for the amount of sediment that would be necessary to maintain existing and restoring tidal wetlands throughout the entire Bay, only in the South Bay. Even if that were the case, comparing the volume of sediment required to maintain and restore the Bay's tidal wetlands to the Bay's net sediment *supply* described in Table B-2 is difficult due to the variable density and related characteristics of the suspended and bedload transported to the Bay. Figure B- 7 (Dusterhoff et al. 2017) below displays the spatial variability in estimated sediment loads from many of the Bay's major tributaries. Just four of these tributaries - Sonoma Creek, Walnut Creek, the Napa River, and Alameda Creek - provide roughly 20% of the total net sediment supply to the Bay (Figure B- 8, from Schoellhamer et al. 2018). Since the sediment supply from these tributaries is largely dependent upon discharge, interannual variability in the frequency, intensity, and duration of precipitation can lead to significant interannual variability in sediment delivery. Figure B- 9 (Dusterhoff et al. 2017) displays the annual sediment load estimates for the Napa River in between 1957 and 2013; very wet years (e.g. 1986) generate larger sediment loads. It's therefore likely that future sediment delivery to the Bay will be strongly dependent on (1) how climate changes impacts the frequency, intensity, and duration of rainfall and runoff across the Bay Area's watersheds, and (2) future changes in land use patterns and characteristics within these watersheds (e.g. impermeable surface coverage, use of LID/green infrastructure, fire intensity), which impact watershed sediment yields.

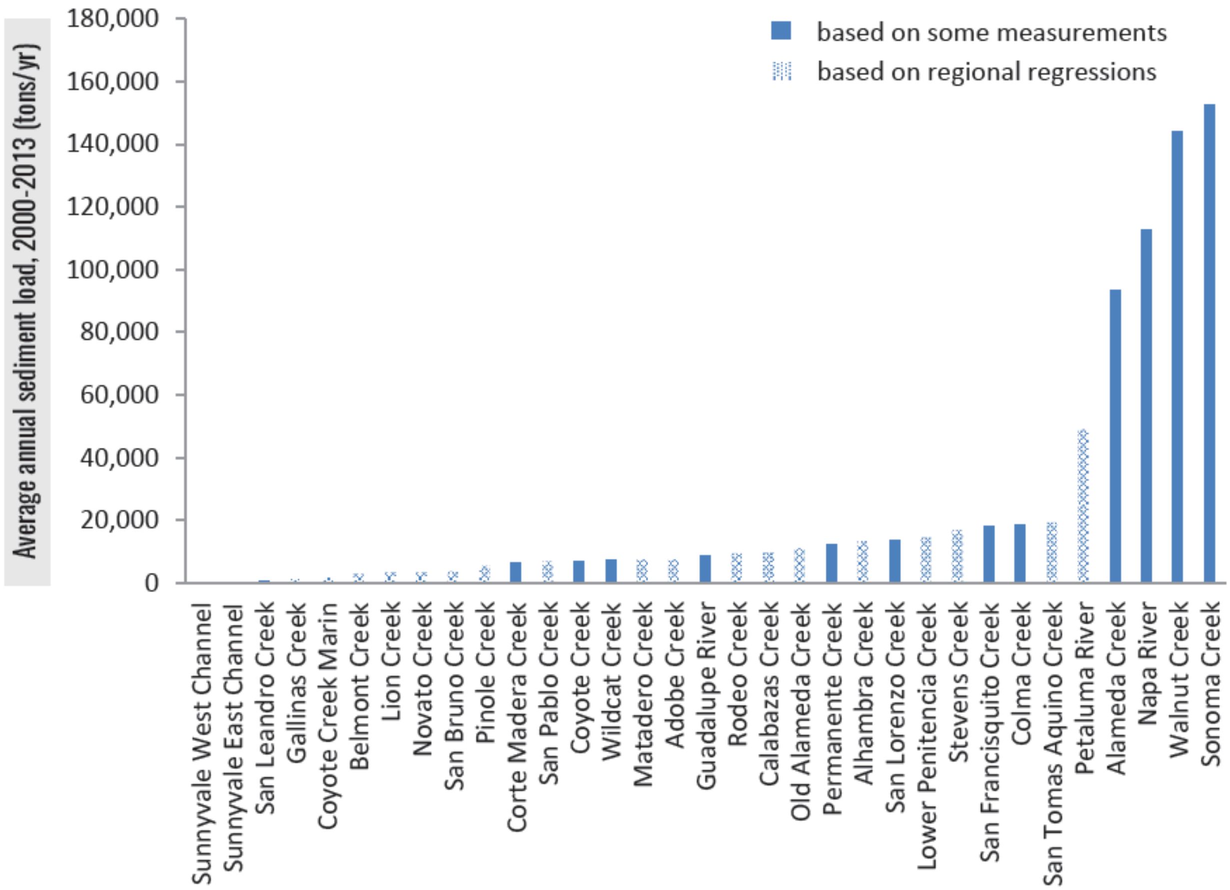


Figure B- 4. Average annual sediment loads among Bay tributaries. (Image: Dusterhoff et al. 2017)

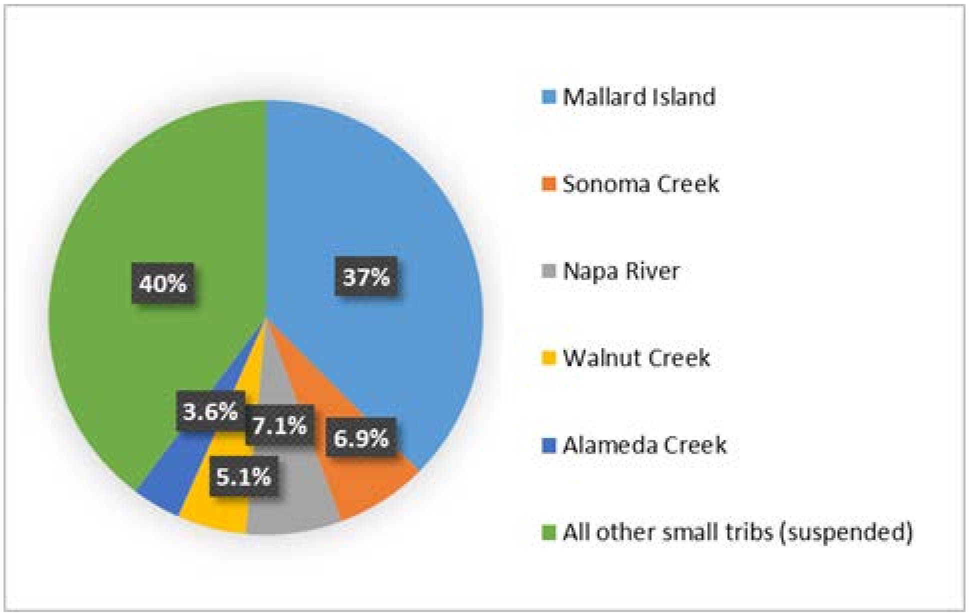


Figure B- 5. Napa River, Sonoma Creek, Walnut Creek, and Alameda Creek account for roughly one fifth of the sediment loading to the Bay. (Image: Schoellhamer et al. 2018)

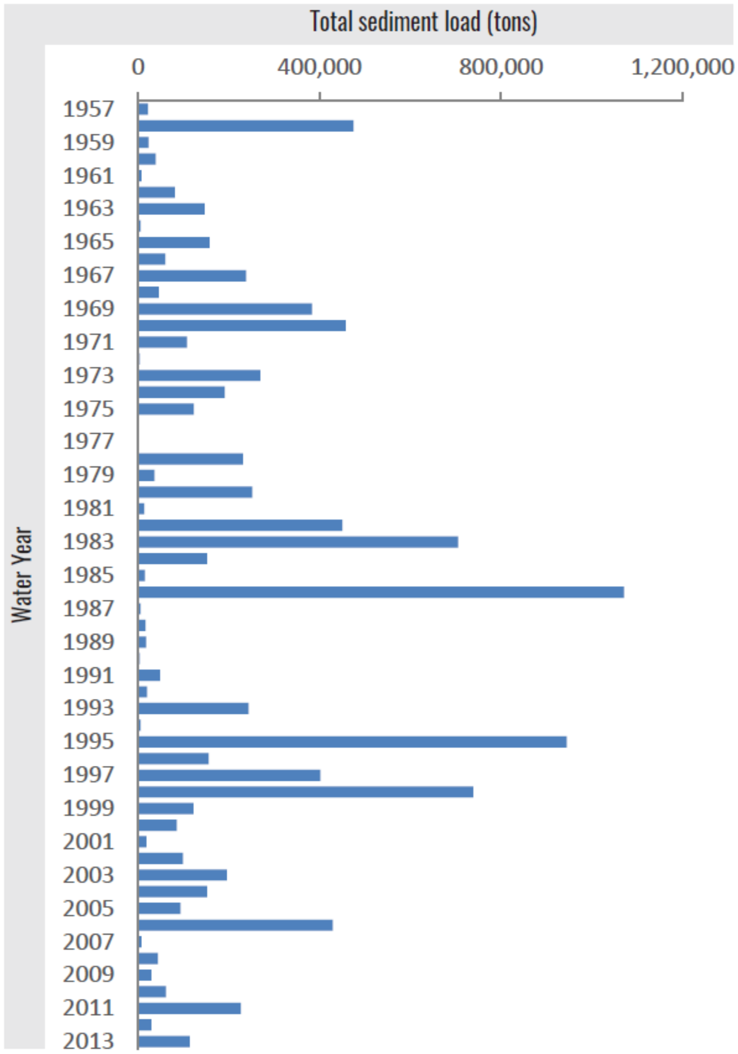


Figure B- 6. Estimated total sediment loads from the Napa River vary with precipitation. Wet years produce more runoff and higher sediment loads. (Image: Dusterhoff et al. 2017)

Further, the mechanisms by which sediment from the Delta and local tributaries can be transported to existing and restoring tidal marshes throughout the Bay are also highly variable. For example, existing and restored tidal marshes within the Napa River baylands have abundant channels connecting them with the river mainstem (Figure B-10), such that suspended sediment can be transported with relative efficiency between the river mainstem and the baylands. Whether this connectivity drives net *accretion in* or *export from* marshes is driven by spatial and temporal variations in tides, wind, fluvial discharge, morphology, and other factors which are discussed at length in multiple other reports and journal articles. Within the restoring salt ponds in the Napa baylands, this connectivity has led to a spatially variable environment in which some portions of the ponds are accretionary, while others are erosional (Brand et al. 2012, Wilson 2016).

Figure B- 7. The complex morphology and hydrology of the Napa-Sonoma marshes leads to complicated patterns of sediment erosion, transport, and deposition. (Image: Google Earth)

In contrast to Napa and like most of the Bay's tributaries, Alameda Creek is largely disconnected from its baylands, having been confined to an engineered flood control channel (Figure B- 11). As a result, the majority of its sediment load either deposits within the fluvial and/or tidal portions of the channel (necessitating flood control dredging) or gets flushed to the mudflats south of the San Mateo Bridge. Sediment that accretes on mudflats must then be re-suspended into the water column by waves in order to be carried and deposited by tides into nearby mature marshes or restoring salt ponds at CDFW's Eden Landing Ecological Reserve. This relatively less efficient mechanism of sediment delivery to the baylands increases the risk of tidal advection of sediment outside the Golden Gate, and likely decreases the rate at which sediment can accrete on local existing tidal marshes and restoration sites.

Figure B- 8. Alameda Creek drains directly into San Francisco Bay, disconnected from its baylands. (Image: Google Earth)

This spatial and temporal variability in the volume and mechanics of sediment delivery to the baylands has accordingly led to spatial and temporal variation in the observed rates of sediment accretion within the Bay's restoring and mature tidal marshes. Figure B- 12 below (Downing-Kunz et al. 2017) displays observed accretion rates at Ponds A6 and A21 of the South Bay Salt Ponds complex (restored to tidal action in the last decade), and compares them to observed rates of accretion at Lower Muzzi Marsh (restored to tidal action in 1976) and in low, mid, and high portions of a mature marsh. In this figure, the data describing accretion rates in a mature marsh summarize the findings of Callaway et al. (2012) in Heerdt (Corte Madera) Marsh. Subsided sites with elevations lower in the tidal frame, such as Ponds A6 and A21, generally have much faster accretion rates than marshes higher in the tidal frame (e.g. Muzzi Marsh and Heerdt Marsh), due to the increased frequency, duration, and depth of inundation (and therefore opportunities for the deposition of suspended sediment).

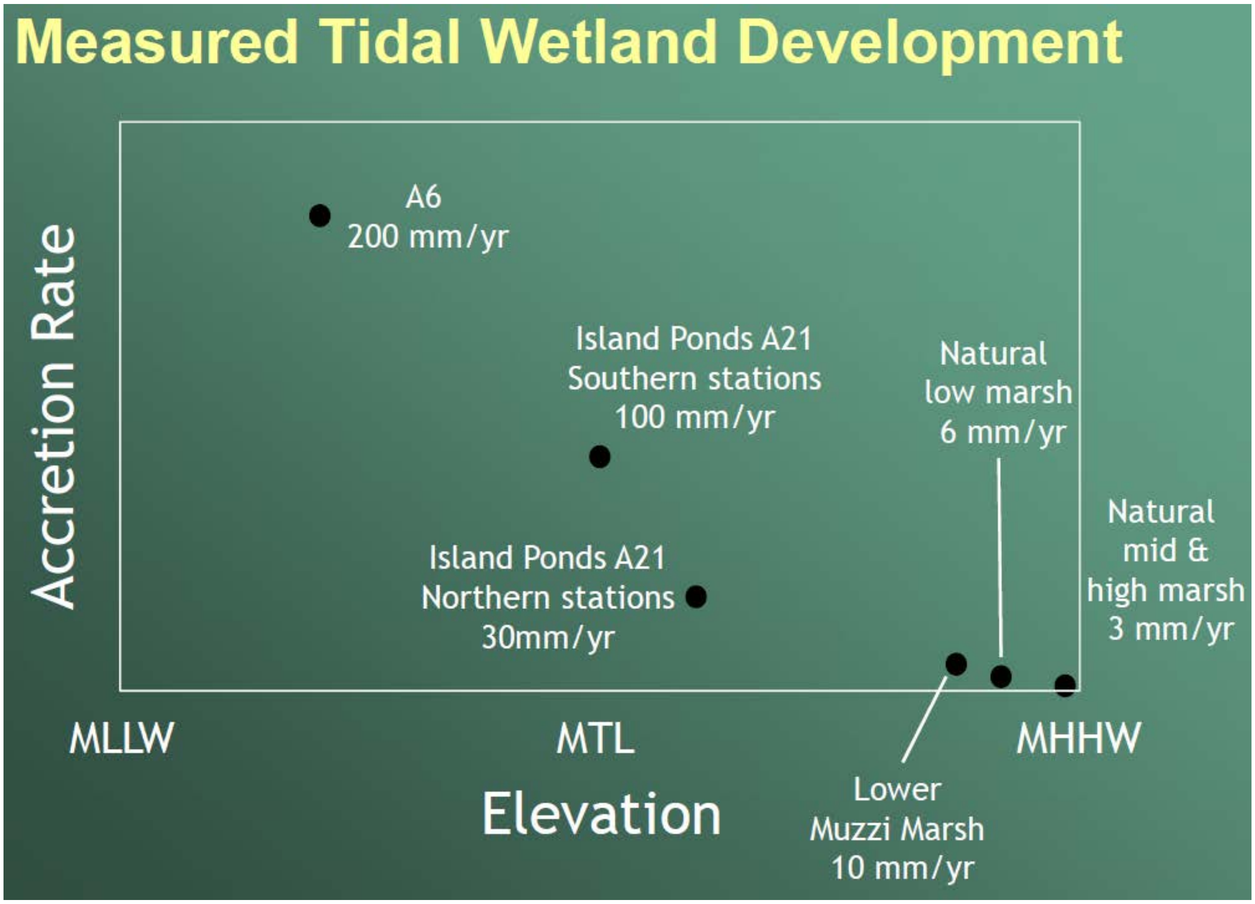


Figure B- 9. Observed rates of accretion vary throughout the Bay due to changes in local and regional physical drivers. (Image: Downing-Kunz et al. 2017)

The importance of watershed-bayland connectivity to Bay tidal wetland resilience is discussed in the 2015 Goals Report and at length in a follow-up report entitled Changing Channels: Regional Information for Developing Multi-Benefit Flood Control Channels at the Bay Interface (Dusterhoff et al. 2017). This report analyzes watershed-bayland connectivity, channel morphology, and sediment dynamics in major creeks throughout the nine county Bay Area, and proposes sediment management approaches that would decrease in-channel deposition (and therefore expensive dredging) in flood control channels, and increase accretion in subsided baylands and restoring tidal marshes.

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Appendix C Sea Level Rise Viewers

Multiple agencies and entities have developed a variety of regional sea level rise models (with accompanying visualizations/viewers) in order to estimate how SLR will impact shoreline communities and ecosystems and communicate this information to a range of audiences. Many of these models have different end users in mind, and utilize different technical inputs, assumptions and analysis methods; as a result, they can describe different impacts for the same geographic location. It's therefore critical that Regional Water Board staff identify the right model/viewer to address their particular question about sea level rise. **In general, the models/viewers presented here are regional in scale and scope**, and are not appropriate to determine the detailed risk of inundation/flooding at a specific location; for example, they should not be used to determine for regulatory purposes the flood risk due to SLR of a shoreline landfill. When working with these models and viewers, Regional Water Board staff should engage colleagues with appropriate technical backgrounds to support their analysis and decision-making. It is also critical to emphasize that **no models of SF Bay SLR and/or flood risk incorporate the probability of levee failure**, which is likely high given the relatively un-engineered nature of many of the Bay's levees.

Sea Level Rise Models: A Brief Primer

At their most basic level, sea level rise models attempt to overlay future sea levels on top of adjacent shoreline topography, and project the extent and depth of inundation that could be triggered by SLR. As mentioned earlier, inundation has both spatial and temporal components: areas that are high enough not to be inundated by a particular baseline level of SLR may still be inundated by episodic high water (e.g. king tides, storm surge, waves, etc.) on top of that baseline. There are therefore two basic types of SLR models: so-called "bathtub" models, which apply static water surface elevations across a landscape, and "dynamic" models, which take into account variable forces such as wind, waves, storm surge, and even (in some more advanced versions) watershed inputs.[28] In general, dynamic models are preferable to bathtub models, because they better reflect the environmental variance that can lead to flooding. However, all models are only as good as their inputs; the models below should be used as guides only, and not as precise representations of future site-specific conditions. When using any SLR model or viewer, Regional Water Board staff should consider the following questions:

[28] To visually compare a dynamic SLR model with a bathtub SLR model, visit the sea level rise viewer on cal-adapt.org, which compares the dynamic CoSMoS model with a bathtub model.

- ***What is the topographic resolution of the model?*** A model utilizing topo data on a 10m x 10m grid will likely have very different outputs from a model with 1m x 1m resolution.
- ***How does the model treat shoreline and stormwater infrastructure?*** Some models utilize idealized shorelines that don't reflect gaps, low points, or flooding conduits such as flood control channels, stormwater drains and culverts, tidegates, and other infrastructure. This can lead to errors in the model outputs.
- ***Which SLR, tide, and storm scenarios does the model consider?*** Are the scenarios consistent with those described in the literature discussed in Section 2 above? Are the inputs adjustable, to give users a sense of which conditions may create thresholds/tipping points?
- ***For long-term SLR scenarios, does the model maintain the zero-date shoreline configuration?*** Some models (usually customized, site-specific models, not the regional models described below) can incorporate mechanisms of geomorphic change along shorelines, such as wetlands eroding and retreating and/or beaches growing vertically with rising sea levels.

Coastal Storm Modeling System (CoSMoS) and Our Coast, Our Future

http://data.pointblue.org/apps/ocof/cms/

Our Coast, Our Future (OCOF) is a collaborative effort between 16 federal agencies, California state and local agencies, and non-profits to *"provide coastal decision-makers* [in California] *with locally relevant, online maps and tools to help understand, visualize, and anticipate vulnerabilities to sea level rise and storms."* OCOF is continually updated to reflect the most recent science. OCOF is based on the USGS's Coastal Storm Modeling System (CoSMoS), a dynamic model that takes into account 40 different SLR and storm scenarios to model total water levels (water levels that include the effects of wave run-up, wave set-up, storm surge, seasonal effects, tides, and SLR) while accounting for vertical land motion, levees, major river discharge, and wind waves. The primary OCOF product is an interactive flood map that displays flood extent, depth, duration, wave heights, current velocity, and minimum/maximum flood potential; it also has the ability to compare different scenarios.

The OCOF interface is shown below in Figure C- 1. Users can select a display output (flooding, waves, current, duration, and flood potential), and then choose from a variety of inputs (SLR amount, storm scenario frequency, and king tide scenario). For example, the graphic below shows estimated flooding (inundation from SLR, waves, and storm surge) in the Richardson Bay area of Marin County due to a 20-year storm on top of 1.6 ft of SLR. OCOF also gives users the ability to export graphics, reports, GIS files, and related data, using the tools in the upper-right-hand corner of the viewer. The OCOF model for Southern California currently includes modules for shoreline geomorphic change; these options are not yet available for the SF Bay Area but hopefully will be made available in the future.

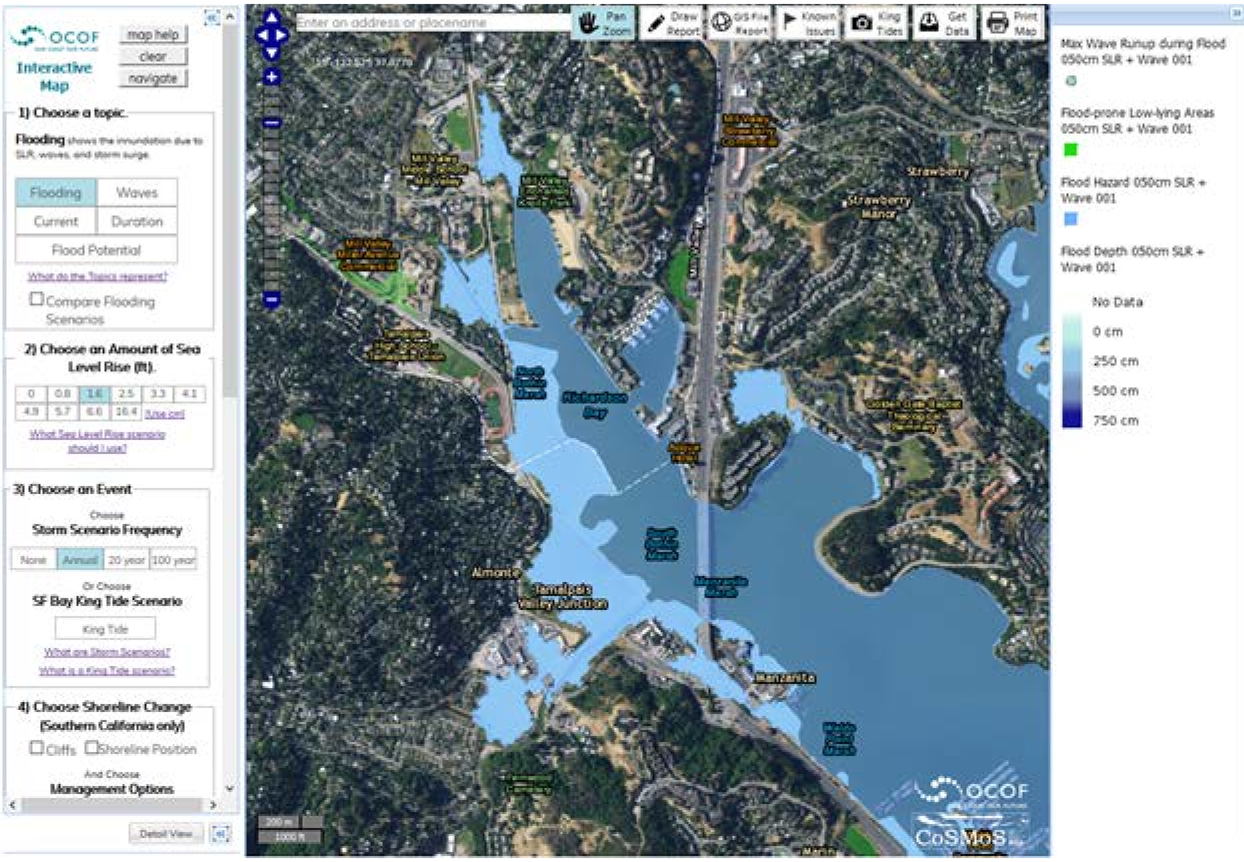

Figure C- 1. The graphical interface of the CoSMoS sea level rise viewer at the Our Coast, Our Future website. (Image: OCOF)

FEMA California Coastal Analysis and Mapping Project (CCAMP)

Region 9 of the Federal Emergency Management Agency (FEMA) is in the process of updating federal Flood Insurance Rate Maps (FIRMs) for the San Francisco Bay Area so that they reflect updated coastal flood hazard analyses, the latest topographic data collected through the California Coastal Mapping Project, and a range of associated new technologies and data. This effort, called the California Coastal Analysis and Mapping Project (CCAMP), is divided into two components: within San Francisco Bay (San Francisco Bay Area Coastal Study), and along the Bay Area's outer Pacific Coast (Open Pacific Coast Study). As of September 2019, the Project has released updated effective FIRMs for Alameda, Marin, Sonoma, Napa, Solano, San Mateo, and Contra Costa counties, and preliminary FIRMs for Santa Clara and San Francisco counties. In addition to these regulatory maps, CCAMP has also developed a series of non-regulatory Increased Flooding Scenario Maps for all nine Bay Area counties. These maps, which are based on the most recent coastal floodplain mapping and analyses, describe how the 1% annual (or 100-year) coastal floodplain may change with 1, 2, and 3 feet of sea level rise. For example, the graphic below displays the Increased Flooding Scenario Map for a portion of the Redwood City shoreline:

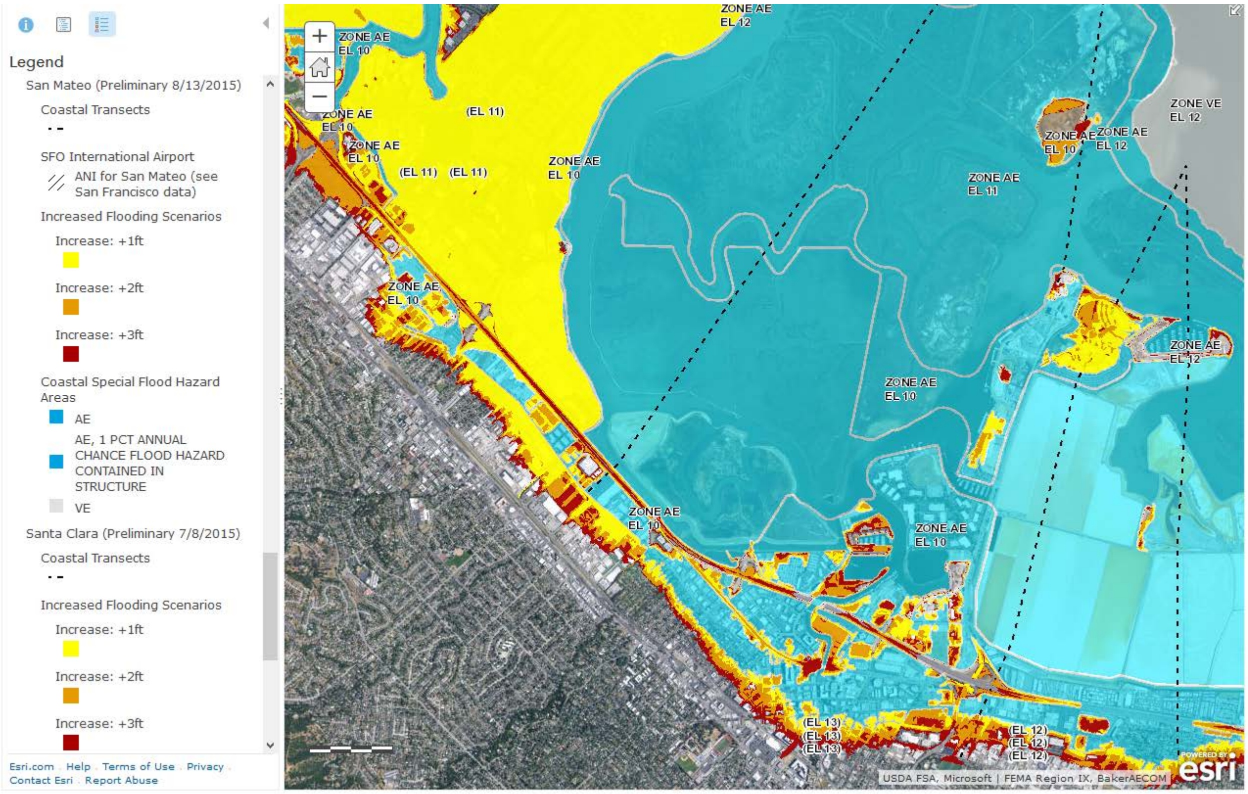

Figure C- 2. Non-regulatory Increased Flooding Scenario Map for the Redwood City shoreline. (Image: FEMA)

It's important to note that the flood extents for 1, 2, and 3 ft of SLR are based on a *bathtub* topographic analysis added on top of BFEs generated from a *dynamic* model. FEMA utilizes a dynamic model to generate what it calls stillwater Base Flood Elevations (BFEs); a somewhat confusing term that includes wave set-up but not wave run-up in areas with steep slopes and coastal structures. In other words, the FEMA maps do not account for how wave/storm dynamics may change with greater depths (1, 2, or 3 ft) of flooding above BFEs, and therefore may underestimate actual SLR impacts under these conditions.

Updated FIRM maps are available at https://msc.fema.gov/portal/home. As of October 2019, the Increased Flooding Scenario Maps were offline due to federal contracting challenges (K. Schaefer, personal comm.).

BCDC Adapting to Rising Tides (ART) Maps and Data Products and the Bay Shoreline Flood Explorer

https://www.adaptingtorisingtides.org and https://explorer.adaptingtorisingtides.org/home

BCDC's Adapting to Rising Tides (ART) program partnered with the Metropolitan Transportation Commission and the San Francisco Estuary Institute to develop a comprehensive suite of sea level rise vulnerability mapping and analysis products for all nine Bay Area counties. These products are based on the 2010-2011 Bay Area topography and bathymetry updates from the USGS and NOAA, the flood modeling work done by FEMA for CCAMP, and a detailed shapefile of SF Bay shoreline typography developed by SFEI. The ART mapping products include: (1) county-specific SLR and extreme tide matrices that depict water levels relevant to vulnerability and adaptation planning efforts, (2) inundation maps for 10 scenarios that capture over 90 combinations of future sea levels and extreme tide conditions, (3) maps of overtopping potential for all 10 scenarios that depict where the Bay may overtop the shoreline, and (4) an online geodatabase of all overtopping and flooding scenarios. Coupled with the inundation maps, the overtopping potential maps help identify the shoreline locations and flowpaths that could lead to inland flooding.

The ART products utilize a "one map, many futures" approach to demonstrate how shoreline overtopping and inundation from storm events can occur long before long-term inundation from sea level rise. For example, the map below shows the Oakland International Airport portion of the Alameda County shoreline with 36 in of SLR, which elevation-wise equates to a 50-yr storm surge added to existing conditions, a 25-yr storm surge on top of 6 in of SLR, a 5-yr storm surge on top of 12 in of SLR, a 2-yr storm surge on top of 18 in of SLR, and a 1-yr storm surge on top of 24 in of SLR. However, it's important to emphasize that the map products do not differentiate between the *severity* of different flooding scenarios based on the amount of time that a given location would be inundated, as flooding due to SLR will persist for longer than flooding due to storm surges.

Figure C- 3. An example Adapting to Rising Tides map for the Oakland International Airport region. (Image: BCDC)

Geodatabases containing the data are available to download, and all data can be viewed online through the BCDC Bay Shoreline Flood Explorer. Documentation from BCDC, USGS, and the consultant AECOM (May et al. 2017) describes the differences in the modeling approaches used by ART and OCOF.

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Appendix D Beneficial Uses of Select San Francisco Bay Area Tidal Wetlands

Table 2-4 Beneficial Uses of Wetland Areas[a]

Basin/Marsh Area	*Wetland Types*			*Beneficial Uses*								
	Fresh	Brackish	Salt	EST	MAR	MIGR	COMM	RARE	REC1	REC2	SPWN	WILD
Alameda County												
Arrowhead			•	•				•	•	•	•	•
Coyote Hills			•	•				•	•	•	•	•
Emeryville Crescent			•	•				•	•	•	•	•
Hayward (e.g., Cogswell, Hayward Area Recreation District, Oro Loma, & Triangle marshes)			•	•					•	•	•	•
Hayward Marsh		•		•				•		•	•	•
Contra Costa County												
North Contra Costa		•	•	•				•	•	•	•	•
Point Edith		•		•				•		•	•	•
San Pablo Creek			•	•				•	•	•	•	•
Wildcat Creek				•				•	•	•	•	•
Marin County												
Abbotts Lagoon			•		•				•	•		•
Bolinas Lagoon			•		•				•	•		•
Corte Madera			•	•				•	•	•	•	•
Drakes Estero			•						•	•	•	•
Gallinas Creek		•	•	•				•	•	•	•	•
Limantour Estero			•		•				•	•		•
Corte Madera Ecological Reserve			•	•					•	•		•
Novato Creek		•	•	•		•		•	•	•	•	
Richardson Bay			•	•				•	•	•	•	•
Rodeo Lagoon			•		•				•	•		•
San Pedro		•	•	•			•	•		•	•	•
San Rafael Creek		•	•	•				•	•	•		•
Tomales Bay			•		•	•			•	•	•	•
Napa County												
Mare Island			•	•						•		•
Napa		•		•		•	•	•	•	•	•	
San Pablo Bay			•	•		•	•	•	•	•	•	•
San Mateo County												
Bair Island			•	•				•	•	•		•
Belmont Slough			•	•				•	•	•	•	•
Pescadero	•		•		•	•		•	•	•	•	•
Princeton		•	•						•	•		•
Redwood City Area				•				•	•	•		•
Santa Clara County												
South San Francisco Bay			•	•		•	•	•	•	•	•	•
Solano County												
Southhampton Bay			•	•				•	•	•	•	•
Suisun	•	•		•		•		•	•	•	•	•
White Slough			•	•		•		•	•	•	•	•
Sonoma County												
Petaluma		•		•		•	•	•	•	•	•	•

Appendix E Basin Plan Wetland Fill Policy and California Wetlands Conservation Policy

Basin Plan Wetland Fill Policy

4.23 Wetland Protection and Management

Wetlands and related habitats comprise some of the Region's most valuable natural resources. Wetlands provide critical habitats for hundreds of species of fish, birds, and other wildlife; offer open space; and provide many recreational opportunities. Wetlands also serve to enhance water quality, through such natural functions as flood control and erosion control, stream bank stabilization, and filtration and purification of surface water.

The Water Board will refer to the following for guidance when permitting or otherwise acting on wetland issues:

- Governor's Executive Order W-59-93 (signed August 23, 1993; also known as the California Wetlands Conservation Policy, or the "No Net Loss" policy);
- Senate Concurrent Resolution No. 28; and
- Water Code Section 13142.5 (applies to coastal marine wetlands).

The goals of the California Wetlands Conservation Policy include ensuring "no overall net loss," achieve a "long-term net gain in the quantity, quality, and permanence of wetlands acreage and values ...", and reducing "procedural complexity in the administration of state and federal wetlands conservation programs."

Senate Concurrent Resolution No. 28 states, "It is the intent of the legislature to preserve, protect, restore, and enhance California's wetlands and the multiple resources which depend on them for the benefit of the people of the state."

Water Code Section 13142.5 states, "Highest priority shall be given to improving or eliminating discharges that adversely affect ... wetlands, estuaries, and other biologically sensitive sites."

The Water Board may also refer to the Estuary Project's Comprehensive Conservation and Management Plan (June, 1994) for recommendations on how to effectively participate in a Region-wide, multiple-agency wetlands management program.

4.23.1 Baylands Ecosystem Habitat Goals

Consistent with the California Wetlands Conservation Policy, the Water Board participated in the preparation of two planning documents for wetland restoration around the Estuary: Baylands Ecosystem Habitat Goals (1999) and Baylands Ecosystem

Species and Community Profiles (2000), together known as the Habitat Goals reports. The Habitat Goals reports provide a starting point for coordinating and integrating wetland planning and regulatory activities around the Estuary. The Habitat Goals reports identify and specify the beneficial uses and/or functions of existing wetlands and suggest wetland habitat goals for the baylands,defined in the Habitat Goals reports as shallow water habitats around the San Francisco Bay between maximum and minimum elevations of the tides. The baylands ecosystem includes the baylands, adjacent habitats, and their associated plants and animals. The boundaries of the ecosystem vary with the bayward and landward movements of fish and wildlife that depend upon the baylands for survival. The Habitat Goals reports were the non-regulatory component of a conceptual regional wetlands management plan from the mid-1990's.

4.23.2 Determination of Applicable Beneficial Uses for Wetlands

Beneficial uses of water are defined in Chapter 2 Beneficial Uses and are applicable throughout the Region. Chapter 2 also identifies and specifies the beneficial uses of 34 significant marshes within the Region (Table 2-3). Chapter 2 indicates that the listing is not comprehensive and that beneficial uses may be determined site-specifically. In making those site-specific determinations, the Water Board will consider the Habitat Goals reports, which provide a technical assessment of wetlands in the Region and their existing and potential beneficial uses. In addition to the wetland areas identified in Chapter 2, the Habitat Goals reports identified additional wetlands in the Region as having important habitat functions. Because of the large number of small and non-contiguous wetlands within the Region, it is not practical to specify beneficial uses for every wetland area. Therefore, beneficial uses will frequently be specified as needed for a particular site. This section provides guidance on how beneficial uses will be determined for wetlands within the Region.

Information contained in the Habitat Goals reports, the National Wetlands Inventory (NWI) prepared by the U.S. Fish and Wildlife Service (USFWS), and in the scientific literature regarding the location and areal extent of different wetland types will be used as initial references for any necessary beneficial use designation. The NWI is the updated version of the USFWS's Classification of Wetlands and Deepwater Habitats of the United States (Cowardin, et al. 1979), which is incorporated by reference into this plan, and was previously used by the Water Board to identify specific wetland systems and their locations. The updated NWI or other appropriate methods will continue to be used to locate and identify wetlands in the Region. A matrix of the potential beneficial uses that may be supported by each USFWS wetland system type is presented in Table 2-4.

It should be noted that, while the Habitat Goals reports and USFWS's NWI wetlands classification system are useful tools for helping to establish beneficial uses for a wetland site, it is not suggested that these tools be used to formally delineate wetlands.

4.23.3 Hydrology

Hydrology is a major factor affecting the beneficial uses of wetlands. To protect the beneficial uses and water quality of wetlands from impacts due to hydrologic modifications, the Water Board will carefully review proposed water diversions and transfers (including groundwater pumping proposals) and require or recommend control measures and/or mitigation as necessary and applicable.

4.23.4 Wetland Fill

The beneficial uses of wetlands are frequently affected by diking and filling. Pursuant to Section 404 of the Clean Water Act, discharge of fill material to waters of the United States must be performed in conformance with a permit obtained from the U.S. Army Corps of Engineers (Corps) prior to commencement of the fill activity. Under Section 401 of the Clean Water Act, the state must certify that any permit issued by the Corps pursuant to Section 404 will comply with water quality standards established by the state (e.g., Basin Plans or statewide plans), or can deny such certification, with or without prejudice. In California, the State and Regional Water Boards are charged with implementing Section 401. California's Section 401 regulations are at Title 23, CCR, Division 3, Chap 28, Sections 3830-3869. Pursuant to these regulations, the Water Board and/or the Water Board's Executive Officer have the authority to issue or deny Section 401 water quality certification. The certification may be issued with or without conditions to protect water quality.

The Water Board has independent authority under the Water Code to regulate discharges of waste to wetlands (waters of the state) that would adversely affect the beneficial uses of those wetlands through waste discharge requirements or other orders. The Water Board may choose to exercise its independent authority under the Water Code in situations where there is a conflict between the state and the Corps, such as over a jurisdictional determination or in instances where the Corps may not have jurisdiction. In situations where there is a conflict between the state and the Corps, such as over a jurisdictional determination or in instances where the Corps may not have jurisdiction, the Water Board may choose to exercise its independent authority under the Water Code.

The regulation of "isolated" waters determined not to be waters of the U.S. is one such instance where the Corps does not have jurisdiction. The U. S. Supreme Court, in its 2001 decision in Solid Waste Agency of Northern Cook County v. U. S. Army Corps of

Engineers (the “SWANCC decision”) determined that certain isolated, non-navigable waters are not waters of the U.S., but are the province of the states to regulate. The Water Code provides the State and Regional Water Boards clear authority to regulate such isolated, non-navigable waters of the state, including wetlands. To address the impacts of the SWANCC decision on the waters of the state, the State Water Board issued Order No. 2004-0004-DWQ in 2004, General WDRs for dredged or fill discharges to waters deemed by the Corps to be outside of federal jurisdiction. It is the intent of these General WDRs to regulate a subset of the discharges that have been determined not to fall within federal jurisdiction, particularly those projects involving impacts to small acreage or linear feet and those involving a small volume of dredged material.

Order No. 2004-004-DWQ does not address all instances where the Water Board may need to exercise its independent authority under the Water Code. In such instances, dischargers and/or affected parties will be notified with 60 days of the Water Board's determination and be required to file a report of waste discharge.

For proposed fill activities deemed to require mitigation, the Water Board will require the applicant to locate the mitigation project within the same section of the Region, wherever feasible. The Water Board will evaluate both the project and the proposed mitigation together to ensure that there will be no net loss of wetland acreage and no net loss of wetland functions. The Water Board may consider such sources as the Habitat Goals reports, the Estuary Project's Comprehensive Conservation and Management Plan, or other approved watershed management plans when determining appropriate "out-of-kind" mitigation.

The Water Board uses the U.S. EPA's Section 404(b)(1), "Guidelines for Specification of Disposal Sites for Dredge or Fill Material," dated December 24, 1980, which is incorporated by reference into this plan, in determining the circumstances under which wetlands filling may be permitted.

In general, it is preferable to avoid wetland disturbance. When this is not possible, disturbance should be minimized. Mitigation for lost wetland acreage and functions through restoration or creation should only be considered after disturbance has been minimized.

Complete mitigation projects should be assessed using established wetland compliance and ecological assessment methods, such as the Wetland Ecological Assessment (WEA) and the California Rapid Assessment Method (CRAM).

California Wetlands Conservation Policy (Executive Order W-59-93, August 23, 1993)

WHEREAS, wetlands act as primary producers in the flood chain, help retain floods, recharge and discharge groundwater, act as water quality filters, provide recreational and scenic values, and harbor a significant number of California's threatened and endangered plant and animal species; and

WHEREAS, in the nineteenth century and early decades of the twentieth century as much as ninety percent of California's historical wetlands base has been converted to other uses, with a consequent reduction in the functions and values wetlands provide; and

WHEREAS, wetlands in California continue to be converted to other uses and degraded by sedimentation, loss of associated upland habitat, and other factors; and

WHEREAS, past conservation efforts have resulted in the long-term protection of approximately two-thirds of California's remaining wetland acreage; and

WHEREAS, the administration of wetlands programs is often time consuming, duplicative, inconsistent, and therefore costly to landowners and public agencies; and

WHEREAS, it is the policy of the State of California to streamline regulatory permitting processes;

NOW, THEREFORE, I, PETE WILSON, Governor of the State of California, by virtue of the power and authority vested in me by the Constitution and statutes of the State of California, do hereby issue this order to become effective immediately:

I. It is hereby declared to be the policy of the State of California that all State government programs and policies that affect the wetlands of California be coordinated as described herein.

II. It is hereby declared to be the policy of the State of California that its Comprehensive Wetlands Policy rests on three primary objectives:

a) To ensure no overall net loss and long-term net gain in the quantity, quality, and permanence of wetlands acreage and values in California in a manner that fosters creativity, stewardship, and respect for private property.

b) To reduce procedural complexity in the administration of State and Federal wetlands conservation programs.

c) To encourage partnerships to make restoration, landowner incentive programs, and cooperative planning efforts the primary focus of wetlands conservation.

All agencies of the State shall conduct their activities, consistent with their existing authorities, in accordance with these three objectives.

III. The California Wetlands Conservation Policy addresses wetlands inventory, planning, wetlands, regulation, landowner incentives, wetlands mitigation banking, and other wetlands conservation approaches (e.g., acquisition, restoration, management, and education). The goal of the California Wetlands Conservation Policy is to achieve a long term increase of wetlands acreage, functions, and values in California. Steps taken to achieve this goal shall emphasize maintaining economic uses (e.g., agriculture) of restored and enhanced lands and be achieved through the voluntary participation of landowners. This goal is not meant to be achieved on a permit-by-permit basis. The Task Force or specific agencies as identified in the "California Wetlands Conservation Policy," will develop and implement the following:

a) a Statewide wetlands inventory and wetlands accounting system;

b) identification and implementation of regional and Statewide wetlands restoration goals;

c) State agency assistance and support for local and regional wetlands planning efforts;

d) promotion of landowner incentive programs to preserve, restore, and enhance wetlands, including the provision of adequate funding from State and Federal sources;

e) delegation of the permitting authority for the Federal Clean Water Act Section 404 program from the U.S. Army Corps of Engineers to the San Francisco Regional Water Quality Control Board and, for a limited set of activities, the San Francisco Bay Conservation and Development Commission as part of a longer term effort to explore feasibility of Statewide delegation, with adequate Federal funding, of the program;

f) development of a consistent regulatory wetlands definition for State agencies that improves the overall efficiency of the Federal-State permitting process;

g) development of a balanced Statewide policy concerning Army Corps of Engineers nationwide permits;

h) development of consistent standards and guidelines concerning mitigation and monitoring of mitigation and restoration efforts;

i) actions that promote efficiency of wetlands-related permitting processes of various State agencies, including but not limited to creation of consistent deadlines, establishment of concurrent permit review procedures, and sponsorship of pre-application consultations between permittees and permitting agencies;

j) development of means to provide flexibility in the regulatory process for the accidental or unintentional creation of wetlands, and for allowing public agencies, water districts, and landowners to establish wetlands on their property consistent with the primary purpose of the property;

k) development of Statewide wetland mitigation banking guidelines and the development of demonstration wetland mitigation banks in the Central Valley;

l) enhanced coordination of State, Federal, and private acquisition, restoration, and incentive programs, including the establishment of a demonstration program in Southern California;

m) ongoing management of wetlands which maintains or enhances wetlands values and recognizes the responsibility to minimize impacts to surrounding landowners;

n) the development of internal policies within State agencies that encourage wetland conservation activities which are compatible with programmatic goals such as flood control, groundwater recharge, water management, water pollution control, recreation, and other purposes;

o) such other matters as are deemed necessary to carry out the purposes of this Executive Order.

IV. It is hereby declared to be the policy of the State of California that the California Wetlands Policy and Plan will initially emphasize Regional Strategies in the Central Valley, the San Francisco Bay Area, and in Southern California. They will be designed to test how wetlands programs can be implemented, refined, and combined in unique ways to achieve the goals and objectives of this California Wetlands Conservation Policy.

V. An Interagency Task Force on Wetlands will be established by the Secretary of Resources and Secretary for Cal/EPA to provide coordination and information exchange among agencies, boards, commissions, and departments as necessary to ensure continued coordinated development and implementation of the California Wetlands Conservation Policy. The Task Force shall invite the participation as necessary of other boards and commissions, and local, Federal, and private agencies which have jurisdiction, expertise, and resources which may contribute to the continued development and implementation of the California Wetlands Conservation Policy. The Secretary of the Resources Agency and the Secretary for Cal/EPA shall serve as co-chairmen.

IN WITNESS WHEREOF I have hereunto set my hand and caused the Great Seal of the State of California to be affixed this 23rd day of August 1993.

Pete Wilson
Governor of California

ATTEST:
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Secretary of State