Hayward Shoreline Resilience Study

MARCH 2015

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1. Introduction

The San Francisco Bay Conservation and Development Commission (BCDC) conducted the Adapting to Rising Tides (ART) Pilot Project in partnership with the National Oceanic and Atmospheric Administration Coastal Services Center (NOAA CSC) and with assistance from ICLEI Local Governments for Sustainability, the Metropolitan Transportation Commission, and California Department of Transportation (Caltrans). The ART Pilot Project was a multi-sector, collaborative planning effort that addressed two questions:

- How will climate change impacts of sea level rise and storm events affect the future of Bay Area communities, infrastructure, ecosystems and economy?
- What strategies can we pursue, both locally and regionally, to reduce and manage these risks?

The project area was a portion of the Alameda County shoreline from Emeryville to Union City. This subregion was selected based on local community and stakeholder interest and capacity for participation, its diverse shoreline features, and the presence of regionally significant transportation infrastructure. Upon completion of the ART Pilot Project in 2013, several geographic areas and issues were identified that needed further assessment due to their early exposure and significant vulnerabilities. These geographic areas included the Hayward shoreline (see Figure 1.1) and an area of Oakland including the Oakland Coliseum and Oakland International Airport and the portion of the City of Alameda that includes Bay Farm Island. The issues that were identified for further examination included housing and community members, transportation assets, regional passenger rail and shoreline parks in Alameda County. These projects and others have become the ART program, a permanent and Bay-wide sea level rise adaptation planning program. ART program findings, projects and outcomes, and adaptation-planning tools, are available at www.adaptingtorisingtides.org.

The Hayward Shoreline Resilience Study area was selected for several reasons, including its low elevation, the presence of previous studies of the area and the presence of significant regional and local assets. These assets include regional wastewater infrastructure, the eastern approach to the San Mateo-Hayward Bridge (State Route 92, SR-92), important regional recreation assets, including the Bay Trail and the Hayward Shoreline Interpretive Center and tidal marshes and managed ponds that support Bay species and provide other ecosystem services along the shoreline. While there is no residential development in the study area, the City of Hayward is a community of approximately 150,000 people, who rely on the assets within the study area for the services described above.

The study area is approximately two miles long and one mile wide: from Hayward’s Landing at Alameda County Flood Control and Water Conservation District Zone 4 Line A in the north to Mt. Eden Creek in the Eden Landing Ecological Reserve, part of the South Bay Salt Pond Restoration Project, in the south. The inland extent of the project area runs from San Francisco Bay through the Hayward Regional Shoreline into an area of commercial and industrial development, including the EBDA Pipeline, City of Hayward’s Water Pollution Control Facility (HWPCF), and Calpine Russell Energy Center (Figure 1.1). The City of Hayward has carefully planned and restricted development along the shoreline to preserve habitat and open space since 1970 through the Hayward Area Shoreline Planning Agency (HASPA), a Joint Powers Authority between the City, EBRPD, and HARD. HASPA began studying the effects of sea level rise in 2010 and these earlier efforts informed the Hayward Resilience Study (PWA 2010).

The Hayward Resilience Study was conducted over a nine month period in partnership with a working group made up of representatives from local and regional agencies, including Alameda County Flood Control

Control and Water Conservation District (Alameda County Flood Control), the California Coastal Conservancy, Caltrans, the City of Hayward planning and environmental services departments, East Bay Dischargers Authority, East Bay Regional Park District, Hayward Area Recreation and Park District, San Francisco Bay Trail, and Union Sanitary District. Additional participants included Caltrans and the Metropolitan Transportation Commission, who were part of a staff team that worked on the assessment of the San Mateo-Hayward Bridge (State Route 92) and contributed to the adaptation responses for that asset. Outcomes included site-specific vulnerability and risk assessments, adaptation responses for individual assets and agencies as well as the entire study area.

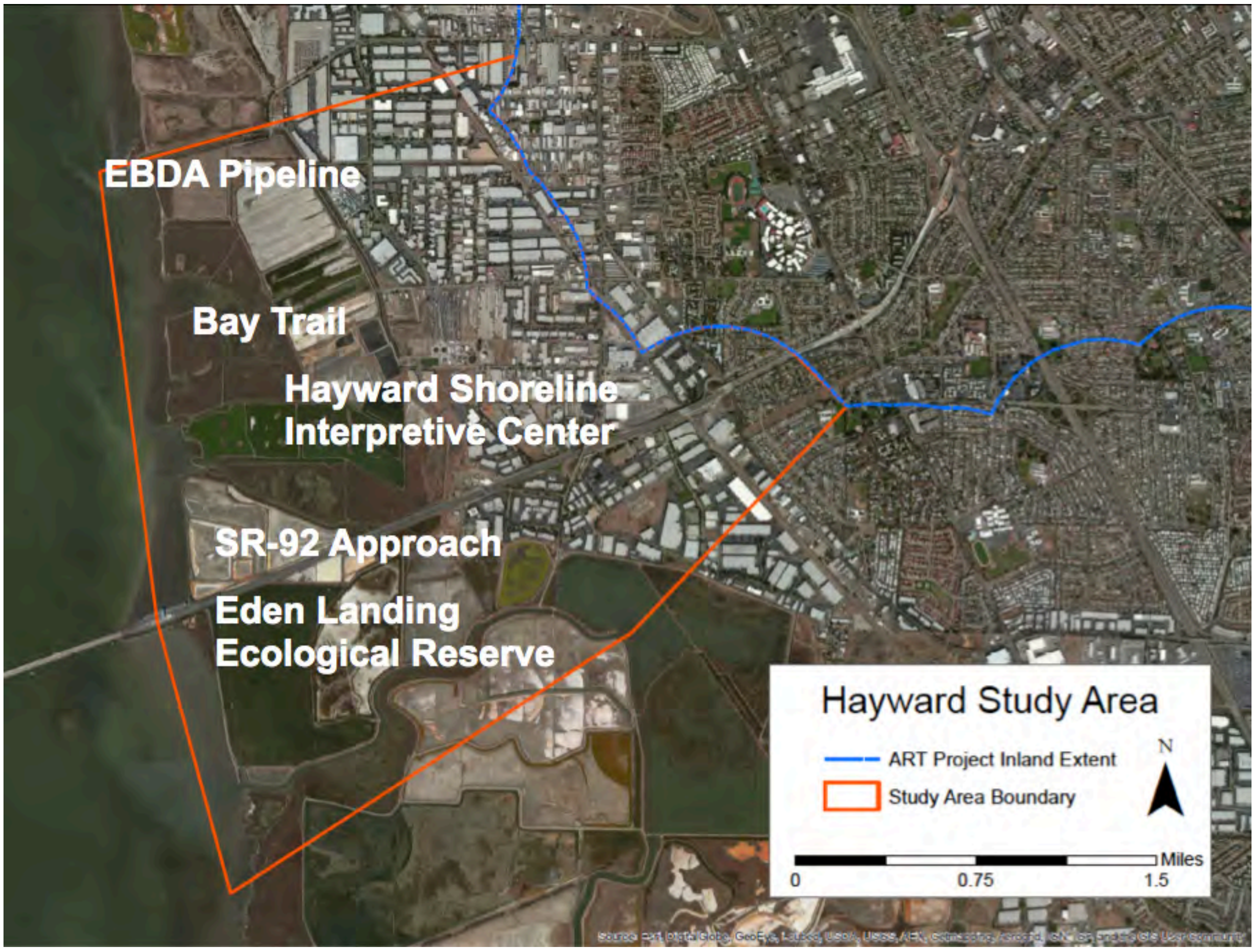

Figure 1.1. Map showing study area boundaries and assets.

Hayward Resilience Study Planning Process

Figure 1.2. ART planning process used in the Hayward Resilience Study.

The study followed the adaptation planning process and tools developed by the ART Program (Figure 1.2). In the beginning of the study, ART program staff and the working group developed four resilience goals to guide the study. These goals were intended to reflect the values of working group members and to identify the current and future assets along the Hayward shoreline that the group wanted to preserve. These goals guided the study from the assessment of vulnerability to the development of adaptation responses. For example, adaptation responses were evaluated by how well they met the resilience goals. In addition to guiding the study, the resilience goals also served to communicate both internally and externally what was important to the project working group, could the goal be modified during the project if necessary and assist in the prioritization of assets and vulnerabilities and in the development of adaptation strategies. The resilience goals for the study were broad, but conveyed that the working group felt that balancing objectives was critical:

Resilience Goals

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1. Protect the health, safety, and welfare of those who live, work, and recreate in the Hayward Shoreline area.
2. Prevent the disruption of key community services by protecting critical infrastructure.
3. Protect the environmental value of the Hayward Shoreline area by preserving habitat, water quality, and endangered species.
4. Build organizational and community capacity so stakeholders can work collaboratively to address future conditions.

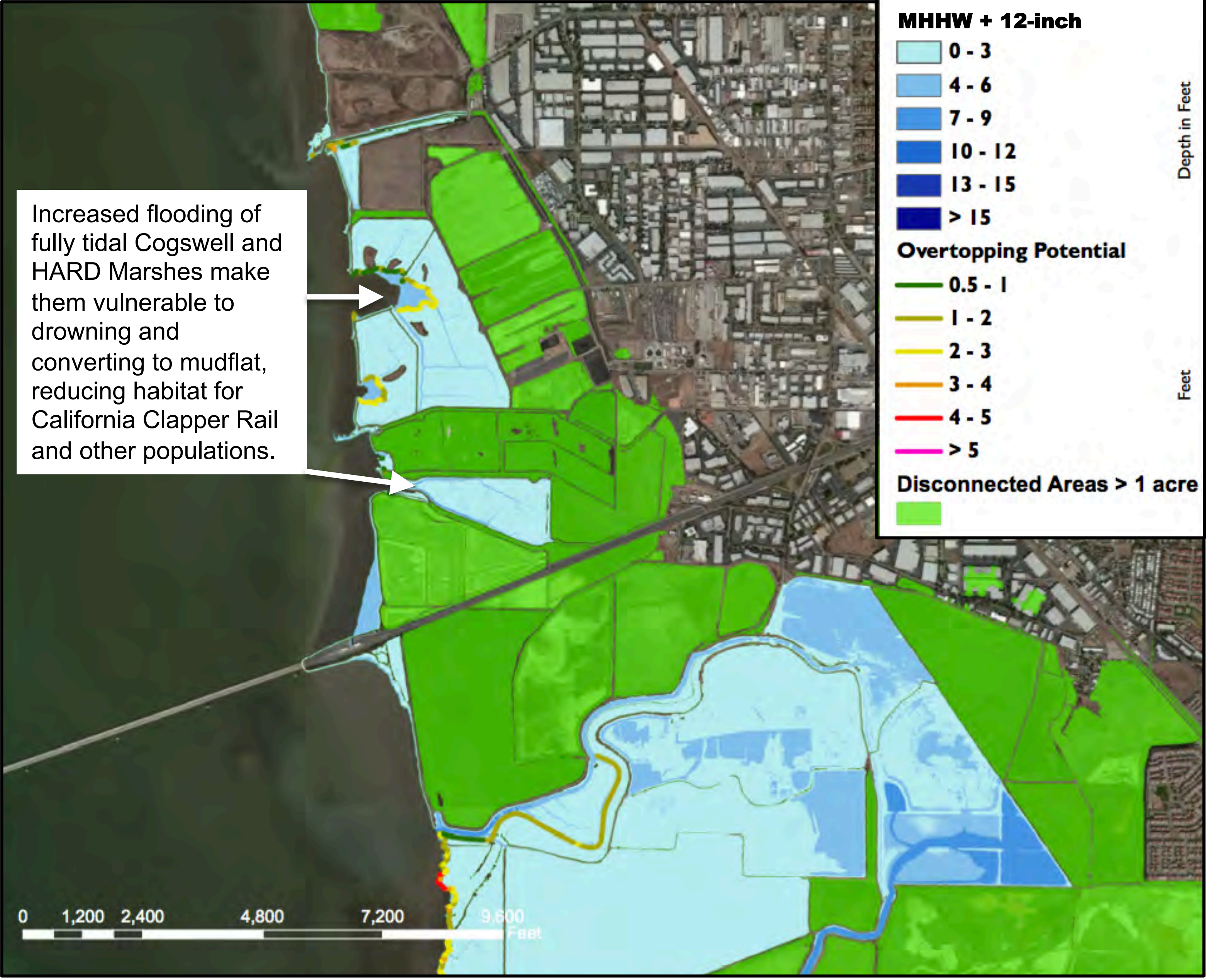
2. Vulnerability assessment and adaptation responses

ART staff evaluated the assets in the study area to determine which ones might be affected by sea level rise and storm surge extreme tide impacts using six maps: 12, 24, 36, 48, 72 and 96 inches above the daily high tide (mean higher high water, MHHW). Each of these maps represents a number of combinations of sea level rise and extreme tide conditions along the Hayward shoreline. For example, 36" above MHHW can represent the 100-year extreme tide (1% annual chance) today (with no sea level rise) or it can represent the daily high tide with 36 inches of sea level rise, which is the most likely 2100 sea level rise projection at this time according to the National Research Council 2012 guidance. The 12-, 24-, 36-, 48-inch water levels are within the range of sea level rise projections for the period until 2100; however, the 72- and 96-inch water levels are outside this range and therefore do not correspond with permanent inundation scenarios that are likely to occur before 2100. These water levels were included to evaluate extreme tides in combination with lesser amounts of sea level rise. It is important to note that these maps are planning-level tools. They do not account for waves and other natural and other processes that may affect topography, water levels, and potential flooding along the Hayward shoreline, such as sediment movement, marsh accretion, and drainage capacity. While they are appropriate for the purpose and scale of the planning conducted along the Hayward shoreline and for developing alternatives, more detailed engineering and modeling will be necessary to determine feasibility and project design. The South Bay Salt Pond Restoration Project, which is included, in part, in the southern portion of the study area, demonstrates the level of detailed analyses necessary for implementation. See Appendix A for full mapping methodology and complete inundation and shoreline elevation maps.

ART staff and asset managers considered how assets would be affected differently by temporary flooding due to extreme tides and by permanent inundation due to sea level rise. As sea level rise worsens over time, assets that are currently not subject to flooding due to berms and other shoreline features, or only vulnerable to infrequent flood events, will be flooded more often and more severely. ART staff conducted desktop analysis and expert interviews to answer key questions about asset sensitivity to sea level rise and extreme tide impacts. Vulnerabilities were defined based on the physical and functional characteristics of individual assets and agencies. A critical component of the study included the evaluation of study area vulnerabilities, or the vulnerabilities that cut across management boundaries and involve multiple assets and thus cannot be adequately addressed by a single asset manager or agency. The working group reviewed and modified both the individual asset vulnerabilities and the study area vulnerabilities. Individual asset vulnerabilities are characterized and summarized in profile sheets, which also include possible actions to address the vulnerabilities (Appendix B). Profile sheets are designed to be a quick snapshot of both types of vulnerabilities. Using the study area maps described above, the discussion below highlights some of the more critical asset vulnerabilities identified during the study and developed with the working group.

Select Asset Vulnerabilities and Study Area Exposure

The figures below include some of the assets evaluated in the study and the six water levels used for the assessment, with each map showing when a particular asset becomes vulnerable to flooding and inundation. Assets are vulnerable to intermittent flooding and/or permanent inundation depending on their construction and function. For example, marshes are resilient to short term flooding but plants will die and habitat will be lost if the marsh is permanently inundated. Conversely, Hayward Shoreline Interpretive Center is vulnerable to even short-duration flooding because the facility would be damaged by floodwater and would have to close during repairs. Natural areas such as Cogswell Marsh are among the first assets vulnerable to sea level rise and extreme tide impacts and therefore are presented in the 12-inch map. In contrast, wastewater infrastructure is vulnerable at higher water levels, as shown on the 36-inch map. Together, the maps illustrate the range of assets that are vulnerable at the various water levels, from tidal marshes and managed ponds to the Bay Trail and Hayward Shoreline Interpretive Center (HSIC) to wastewater discharge systems and SR-92 to flood control channels and commercial and industrial land use. The green areas are disconnected low-lying areas that are protected by some natural or man-made feature from flooding and inundation.



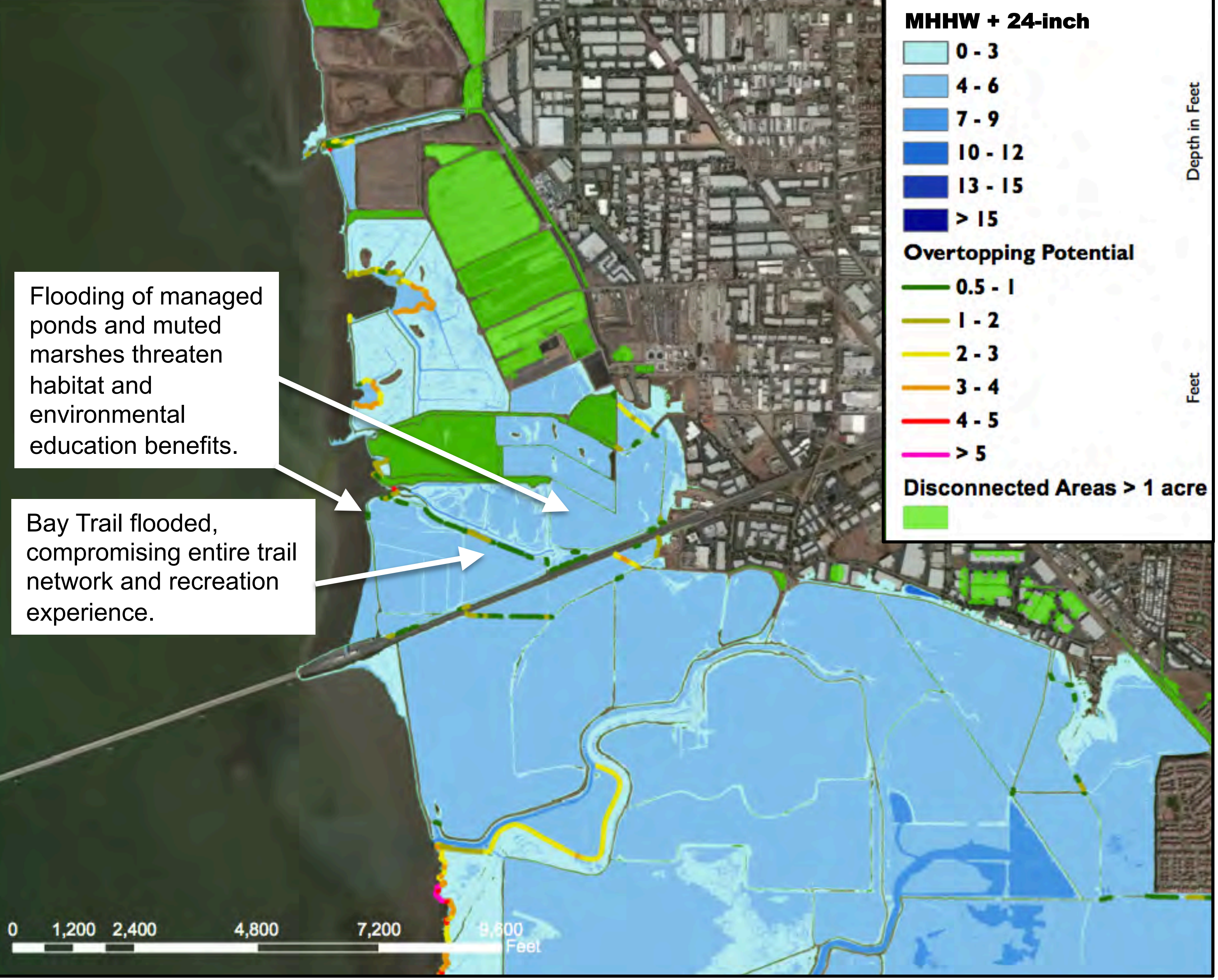
Water level combinations

Permanent inundation
12" Sea level rise + MHHW
(most likely 2050)

Temporary flooding

0" Sea level rise +
1-yr extreme tide
(today)

Figure 2.1 Sea level rise map showing inundation areas, that is, where water surface elevation exceeds topographic elevation (darker blue = greater depth). The map also shows overtopping potential along shoreline assets such as tidal marshes, levees, and roadways (different colors for different depths; no color for depths less than 0.5 feet). Disconnected areas are protected by some topographic feature from being inundated, but highlighted in green because they are determined solely by how well the elevation data captures the area's hydraulics. For reference, MHHW is approx. 7.0 feet NAVD88 and King Tides are approx. 12 inches above MHHW. Most likely sea level rise projections are based on NRC (2012).



Water level combinations

<u>Permanent inundation</u>

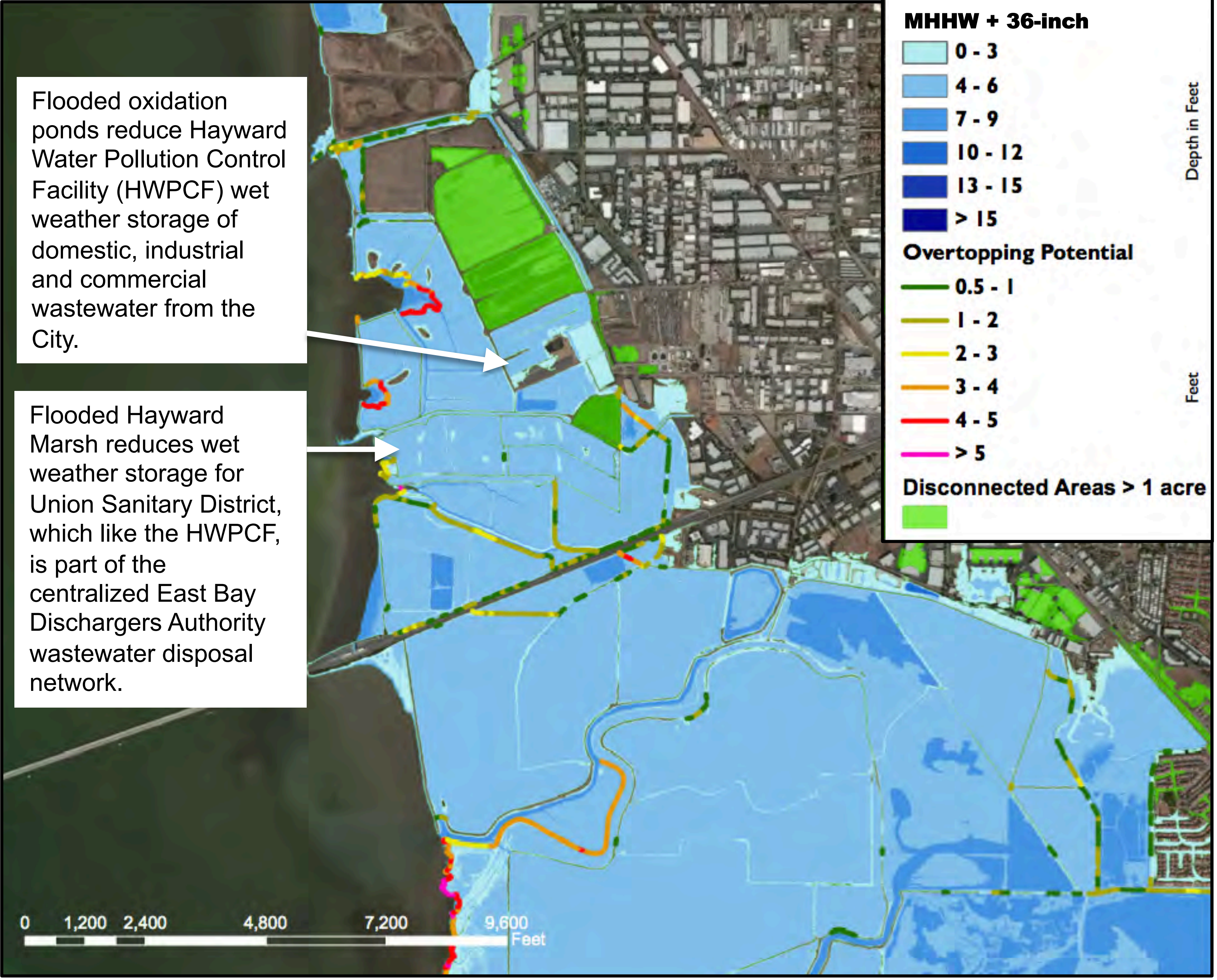
24” Sea level rise + MHHW

<u>Temporary flooding</u>

0” Sea level rise + 5-yr extreme tide (today)

12” Sea level rise + 1-yr extreme tide (most likely 2050)

Figure 2.2 Sea level rise map showing inundation areas, that is, where water surface elevation exceeds topographic elevation (darker blue = greater depth). The map also shows overtopping potential along shoreline assets such as tidal marshes, levees, and roadways (different colors for different depths; no color for depths less than 0.5 feet). Disconnected areas are protected by some topographic feature from being inundated, but highlighted in green because they are determined solely by how well the elevation data captures the area's hydraulics. For reference, MHHW is approx. 7.0 feet NAVD88 and King Tides are approx. 12 inches above MHHW. Most likely sea level rise projections are based on NRC (2012).



Water level combinations

Permanent inundation
36" Sea level rise + MHHW
(most likely 2100)

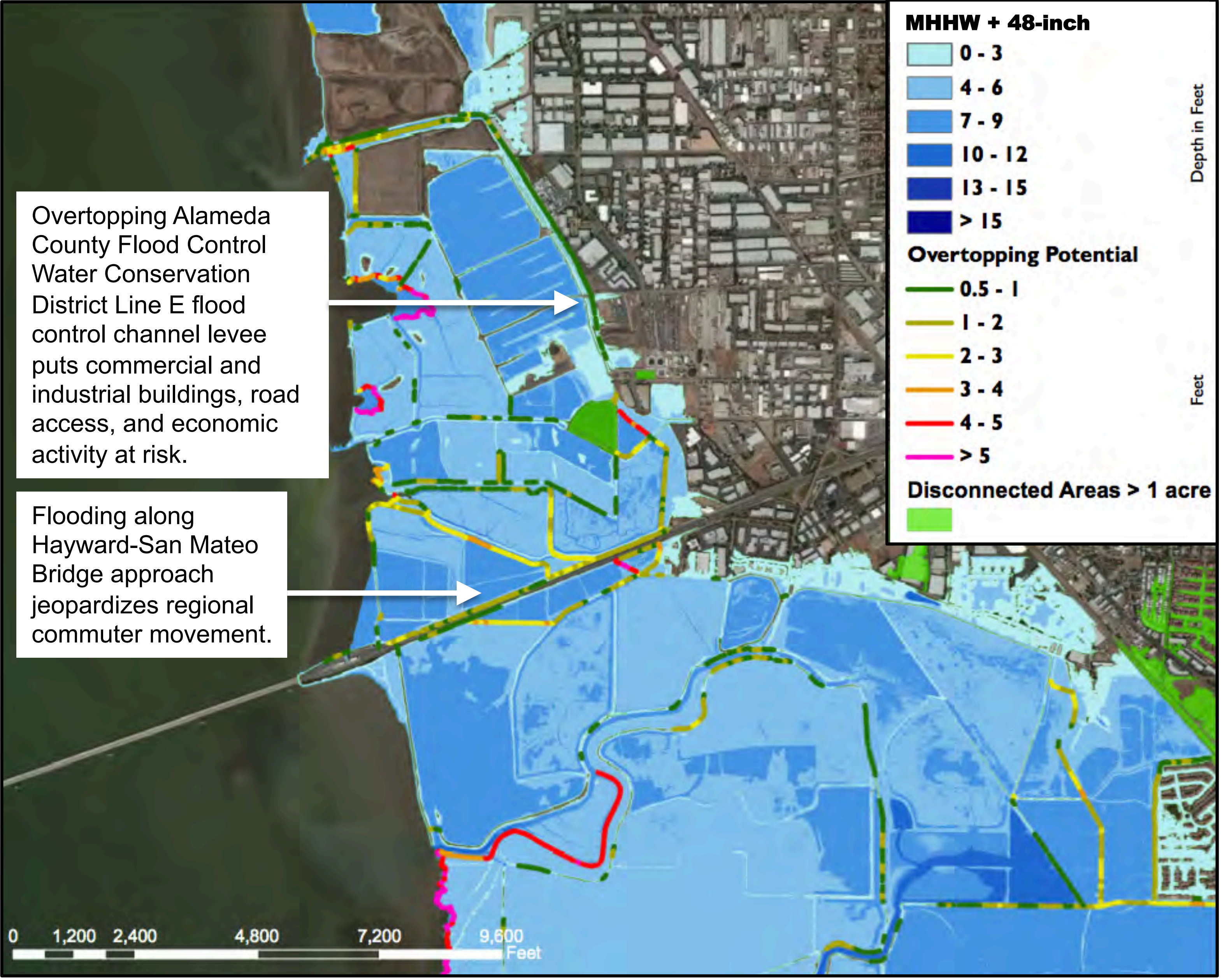
Temporary flooding

0" Sea level rise +
50-yr extreme tide
(today)

12" Sea level rise +
5-yr extreme tide
(most likely 2050)

24" Sea level rise +
1-yr extreme tide

Figure 2.3 Sea level rise map showing inundation areas, that is, where water surface elevation exceeds topographic elevation (darker blue = greater depth). The map also shows overtopping potential along shoreline assets such as tidal marshes, levees, and roadways (different colors for different depths; no color for depths less than 0.5 feet). Disconnected areas are protected by some topographic feature from being inundated, but highlighted in green because they are determined solely by how well the elevation data captures the area's hydraulics. For reference, MHHW is approx. 7.0 feet NAVD88 and King Tides are approx. 12 inches above MHHW. Most likely sea level rise projections are based on NRC (2012).



Water level combinations

Permanent inundation
48" Sea level rise + MHHW

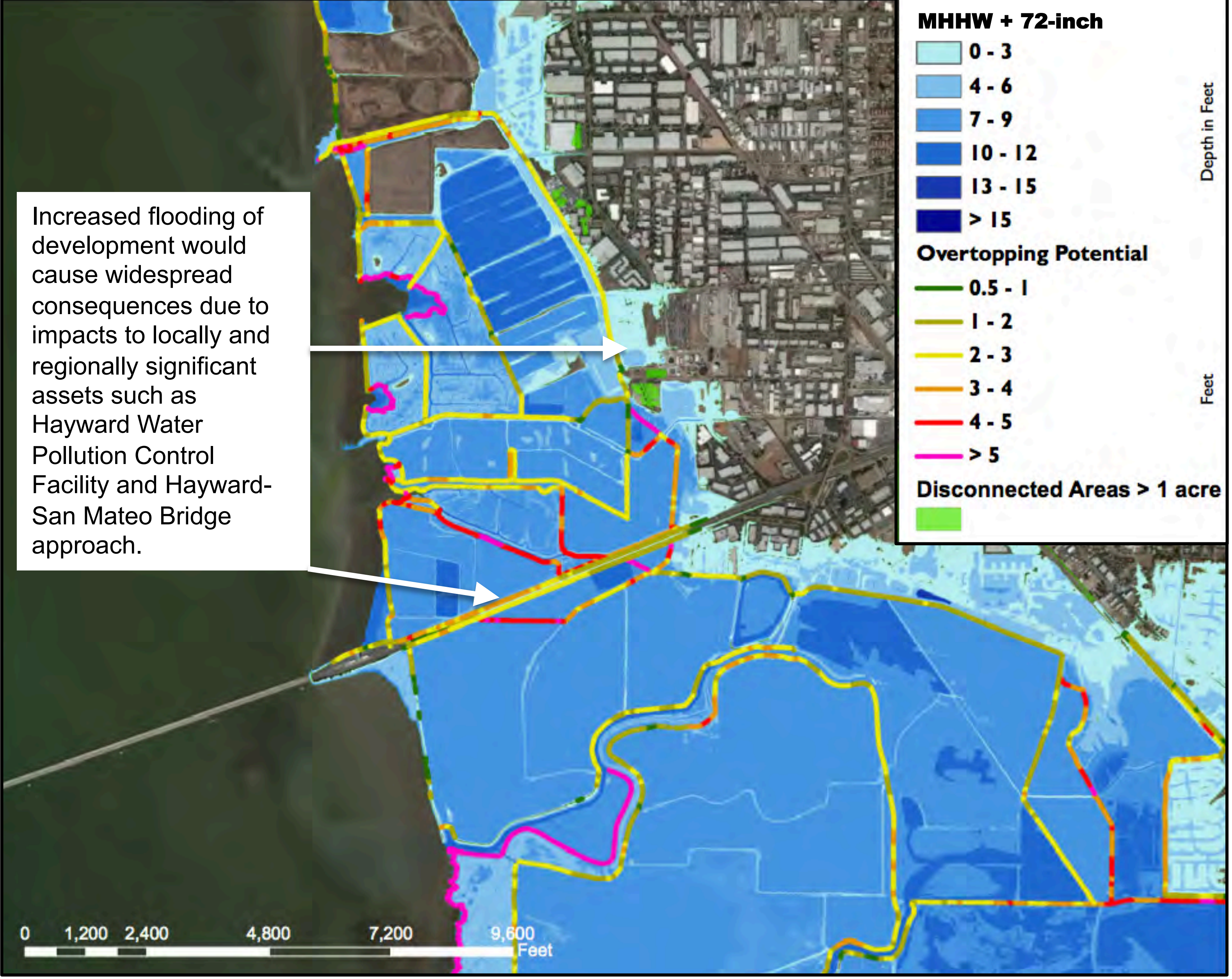
Temporary flooding

12" Sea level rise + 50-yr extreme tide (most likely 2050)

24" Sea level rise + 5-yr extreme tide

36" Sea level rise + 1-yr extreme tide (most likely 2100)

Figure 2.4 Sea level rise map showing inundation areas, that is, where water surface elevation exceeds topographic elevation (darker blue = greater depth). The map also shows overtopping potential along shoreline assets such as tidal marshes, levees, and roadways (different colors for different depths; no color for depths less than 0.5 feet). Disconnected areas are protected by some topographic feature from being inundated, but highlighted in green because they are determined solely by how well the elevation data captures the area's hydraulics. For reference, MHHW is approx. 7.0 feet NAVD88 and King Tides are approx. 12 inches above MHHW. Most likely sea level rise projections are based on NRC (2012).



Water level combinations

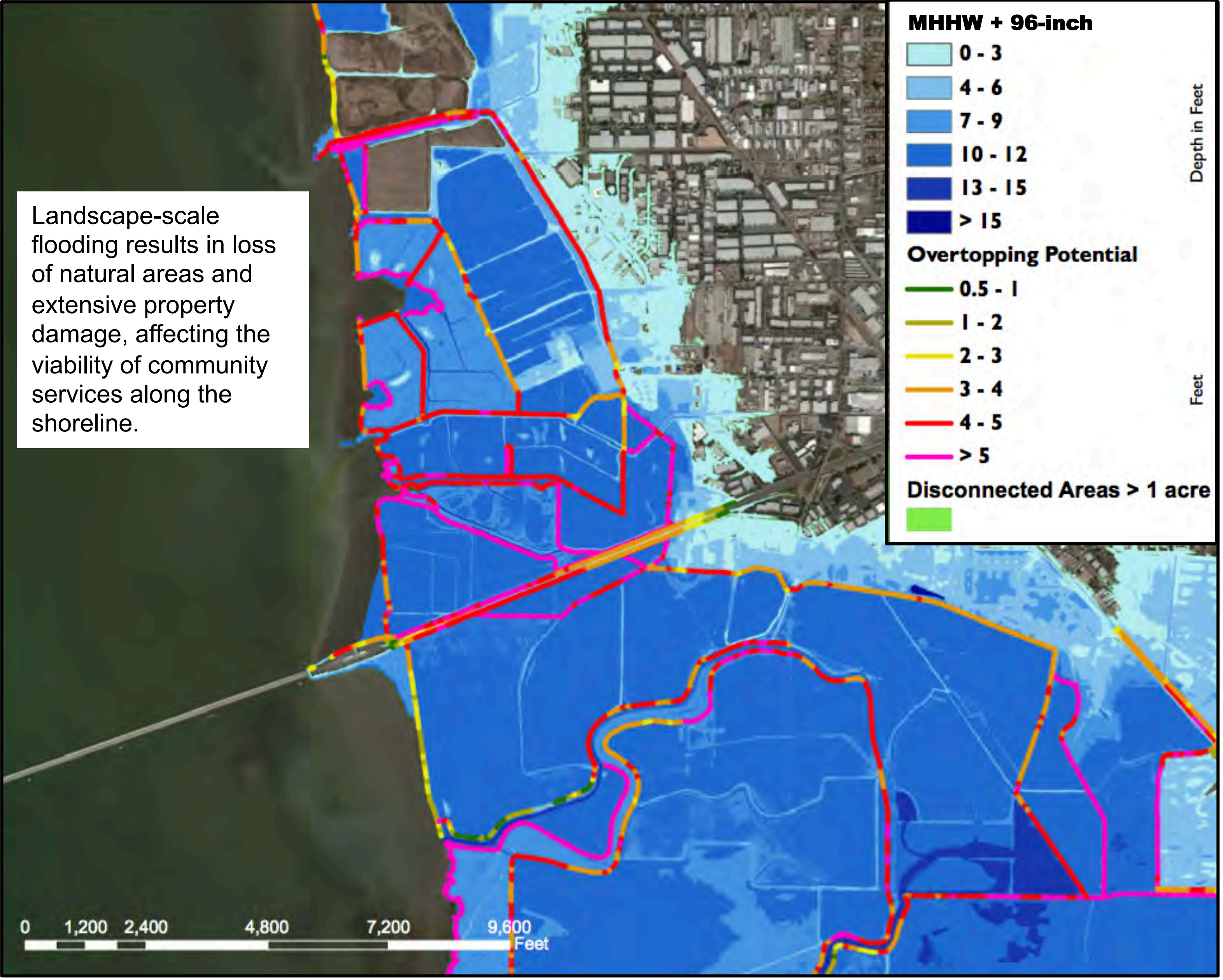
Temporary flooding

36" Sea level rise +
50-yr extreme tide
(most likely 2100)

48" Sea level rise +
5-yr extreme tide

60" Sea level rise +
1-yr extreme tide

Figure 2.5 Sea level rise map showing inundation areas, that is, where water surface elevation exceeds topographic elevation (darker blue = greater depth). The map also shows overtopping potential along shoreline assets such as tidal marshes, levees, and roadways (different colors for different depths; no color for depths less than 0.5 feet). Disconnected areas are protected by some topographic feature from being inundated, but highlighted in green because they are determined solely by how well the elevation data captures the area's hydraulics. For reference, MHHW is approx. 7.0 feet NAVD88 and King Tides are approx. 12 inches above MHHW. Most likely sea level rise projections are based on NRC (2012).



Water level combinations

Temporary flooding

60” Sea level rise + 50-yr extreme tide

Figure 2.6 Sea level rise map showing inundation areas, that is, where water surface elevation exceeds topographic elevation (darker blue = greater depth). The map also shows overtopping potential along shoreline assets such as tidal marshes, levees, and roadways (different colors for different depths; no color for depths less than 0.5 feet). Disconnected areas are protected by some topographic feature from being inundated, but highlighted in green because they are determined solely by how well the elevation data captures the area's hydraulics. For reference, MHHW is approx. 7.0 feet NAVD88 and King Tides are approx. 12 inches above MHHW. Most likely sea level rise projections are based on NRC (2012).

Adaptation Responses

An adaptation response is a set of actions that, together, address one or more climate change vulnerability. Types of actions considered in the ART subregional project include policy development; changes in organizational programs and operations; data collection and assessment efforts; design changes and physical improvements to infrastructure; and education and outreach to increase the resilience of neighborhoods and communities. An adaptation response also includes implementation information including which agencies could implement the actions, how the actions could be funded, and how actions could be streamlined into existing agency processes, including maintenance and operations, funding cycles and policy and planning.

Study Area Vulnerabilities and Adaptation Responses

After developing and reviewing the asset-specific vulnerabilities for the study area, ART staff worked with the working group to identify those vulnerabilities that cut across management, jurisdictional and ownership boundaries and identify the what individual assets rely upon, known as functional vulnerabilities in the ART process, to develop the study area vulnerabilities. The study area vulnerabilities are particularly important along the Hayward shoreline, which is uniformly low, protected by ad hoc shoreline structures such as berms that were not designed for flood protection and, due to funding and permitting challenges, not on a regular maintenance schedule. Since the entire study area is overtopped at about the same water level, rather than there being one or two low spots or gaps, at some point it will be necessary to address this problem at the study area scale. The study area assessment led to five key study area vulnerabilities. These vulnerabilities are key because they involve multiple assets and/or reflect dependencies, or relationships, between assets. In many cases, addressing the study area vulnerabilities will address multiple asset-specific vulnerabilities at once. The study also developed possible adaptation responses to address study area vulnerabilities based on literature review, best professional judgment, and input from the working group.

The summary that follows describes the study area vulnerabilities and actions that can be taken to address them, highlighting how coordinated action will be necessary for multiple assets and jurisdictions to preserve local and regional assets from temporary flooding and permanent inundation.

1. Study area is low-lying and protected by ad hoc shoreline protection, requiring near-term maintenance and improvements and long-term planning to improve shoreline resilience.

The patchwork of bayfront non-engineered berms backed by restored tidal and muted marshes and managed ponds in the study area form the first line of defense against coastal flooding. However, this landscape was not developed with the purpose of flood protection. In the 1850s, the area was used for commercial salt production, which continued until the 1940s. Wetlands were restored to tidal action beginning in 1980s. In most cases, the bayfront berms and tidal and muted marshes and managed ponds function under current Bay water levels. However, sea level rise will progressively flood these features and affect their ability to provide wave attenuation, recreation, and wildlife benefits to surrounding utilities, businesses, and communities.

In the Hayward Regional Shoreline north of SR-92, the bayfront berms overtop between 36 and 48 inches above MHHW. Some berms have been strengthened over time with riprap revetments, but lack of funding and permit requirements have made it difficult to keep up with maintenance. The berms in front of Hayward Marsh are especially in need of repair. The fact that it took six years and FEMA funding to repair the berms in front of the Oliver Salt Ponds after they were overtopped and damaged by the winter storms in 2005 and 2006 demonstrates the challenge of maintaining shoreline protection given existing conditions and that is without the addition of future sea level rise.

Alameda County Flood Control's Line E flood control channel, which extends parallel to the shoreline behind the tidal and muted marshes and managed ponds, does not provide any additional protection because, like most flood infrastructure, it was designed for the current one percent chance annual water level (100-year flood event) and did not anticipate higher water levels associated with a rising Bay. In addition, decreased federal funding and public opposition to additional property-based assessments constrains Alameda County Flood Control's ability to maintain and improve flood management projects. Like many flood management agencies, Alameda County Flood Control has to compete for limited grant funding to plan, permit, and implement critical flood infrastructure projects just to protect against the current one percent chance water level. Furthermore, incentives for flood emergency preparedness and land use strategies to improve flood protection are not particularly strong, e.g., hazard mitigation plans are rarely incorporated into general plans, which affects how landscape-scale adaptation planning is mainstreamed into existing processes.

As sea level rises, tidal marshes are predicted to convert to mudflat, while muted marshes and managed ponds will be inundated with more water and more often. There are two critical components that allow marshes to persist as water levels rise. The first is access to sediment and tidal marshes in many parts of the Bay do not currently have access to the sediment needed to naturally build them up higher. This lack of sediment is a result of diminishing hydraulic mining impacts and changes in watershed processes. The second component needed is undeveloped, high ground behind them that would allow them to naturally migrate landward as sea level rises. Due to the heavily urbanized nature of much of the Bay shoreline, undeveloped, high ground is not often available in the width and height necessary to allow the natural process of marsh migration to occur. Drainage will also become worse in muted marshes and managed ponds, negatively impacting plants and animals that require specific water levels to thrive.

A good example of how the unknowns and challenges surrounding how marshes and wetlands will respond to higher water levels is the South Bay Salt Pond Restoration Project. This project, located south of SR-92, includes bayfront berms, tidal marshes, and managed ponds, and has a 50-year planning horizon that factors in sea level rise and relies heavily on adaptive management to determine the ultimate mix of bayland habitats. The project has focused on this planning horizon and setting adaptive management principles because of the novel challenge of restoring thousands of acres of habitat in a changing intertidal zone. They cannot predict exactly how natural areas will adapt to changing water levels but have set flexible goals for the project with a focus on creating a mosaic of habitat types to accommodate as many climate futures and species as possible.

Shoreline managers including regional park districts, Alameda County Flood Control, and California Department of Fish and Wildlife will need to simultaneously maintain current structural shorelines, improve the resilience of existing natural areas, and plan for long-term, landscape-scale solutions to improve flood protection in the study area, all the while maintaining habitat and recreation. In an effort to begin to move forward on some of this, East Bay Regional Park District is currently pursuing a Hayward Regional Shoreline Programmatic Environmental Impact Report for routine levee maintenance to expedite repairs and maintenance and reduce the burden of permit applications and reporting requirements on park district staff. This effort factors in short-term sea level rise and extreme tides, but staff acknowledge that there are limits to raising the bayfront berms because, in many cases, they are built on poorly compacted Bay Mud, which will be unable to support the additional weight of material required for raising the crest. Furthermore, unlike much of the South Bay where salt ponds are being restored to tidal marsh, the study area already has tidal marsh and building large bayfront levees may affect water circulation and sediment transport processes sustaining this existing marsh habitat.

As improvements are made to the bayfront levees to address current and near term flood risk, the regional and local park districts should engage resource agencies, such as California Department of Fish and Wildlife and U.S. Fish and Wildlife Service, to develop an adaptation response for addressing sea level rise and extreme tide impacts on tidal and muted marshes and managed ponds in the study area (BCDC 2013). This strategy would include shared goals, decision-making, and funding responsibilities to maintain existing natural areas and improve their resilience and role in flood protection. Managers need to make a long-term commitment to assessing progress and responding to changing conditions, which will also involve forming partnerships to monitor and identify when tidal and muted marshes and managed ponds are approaching thresholds for possible interventions.

In addition, hydrologic, geomorphic, and ecological analyses to determine the feasibility of possible interventions, e.g., coarse beaches to decrease marsh edge erosion and beneficial reuse of dredged sediment to increase sedimentation on the marsh plain, would need to be conducted to inform the adaptation strategy. Park districts can learn lessons on technical considerations and regulatory mechanisms for sea level rise planning and adaptation implementation from the South Bay Salt Pond Restoration Project. Ultimately, an adaptation strategy can support park district strategic planning by prioritizing natural areas for restoration and enhancement for mid-century sea level rise, as well as improving flood protection for the other assets in the study area. In recognition of this relationship, regional park districts will need to build partnerships with the City of Hayward, Alameda County Flood Control, and East Bay Dischargers Authority to investigate opportunities for landscape-scale, multi-benefit shoreline protection solutions for end of century sea level rise (further described in item 5 below).

Figure 2.7. Hayward Resilience Study area looking south from Old West Winton Landfill.

2. Sea level rise and extreme tides may impact regionally significant infrastructure and lead to widespread consequences for transportation and wastewater treatment and conveyance. Asset managers need to work within their agencies and with partners now to understand and prepare for these impacts.

The study area contains significant regional transportation and wastewater assets: SR-92, the East Bay Dischargers Authority treated wastewater pipeline, and the Hayward Water Pollution Control Facility. These vulnerabilities and responses are generally the responsibility of the agencies that own and manage them, but due to their importance to the region for transportation and wastewater services and the possible impacts that their failure could have on system users and site neighbors, these assets will require coordination with neighbors, partners, and regulatory agencies.

Wastewater infrastructure in the study area serves approximately 900,000 people in Hayward, Castro Valley, Union City, San Leandro, Oro Loma, and the Livermore-Amador Valley. This large service area means disruptions in wastewater treatment and conveyance may lead to widespread consequences, but it also introduces broader opportunities for adaptation. Since 1978, East Bay Discharge Authority has been operating a joint wastewater discharge system with a combined transport and outfall pipe, discharging dechlorinated treated wastewater effluent to the Bay. The joint Bay outfall has performed very well, but it will need to be replaced and/or substantially upgraded in the next few decades. The wastewater utility may need to commit staff resources and funds to planning for its replacement in-kind or with another discharge system and is currently examining concept alternatives for decentralizing discharge facilities, many of which are vulnerable to sea level rise. Throughout their work on this project, East Bay Discharge Authority is working with its member agencies, neighboring landowners like EBRPD, and regulatory agencies. The findings from this project, due to finish in 2015, will identify how future system improvements can respond to sea level rise adaptation along the Hayward shoreline. Some specific actions include:

- Completing a system-wide assessment on infrastructure condition.
- An articulation of shared objectives, decision-making, and funding responsibilities for individual treatment plants to address sea level rise and storm surge impacts on system performance, especially related to how to handle wet weather flows, e.g., Hayward Water Pollution Control Facility oxidation ponds.
- A study on decentralized alternatives to existing wastewater treatment and discharge practices

incorporating stakeholder and expert input and technical review.

- Based on study results, East Bay Discharge Authority may conduct further feasibility analysis on select concepts and strategies.
- Based on feasibility analysis, East Bay Discharge Authority should partner with regional park districts, Alameda County Flood Control, the City of Hayward, and South Bay Salt Ponds Restoration Project to investigate opportunities for long-term, coordinated, multi-benefit shoreline protection approaches that integrate the future wastewater system.

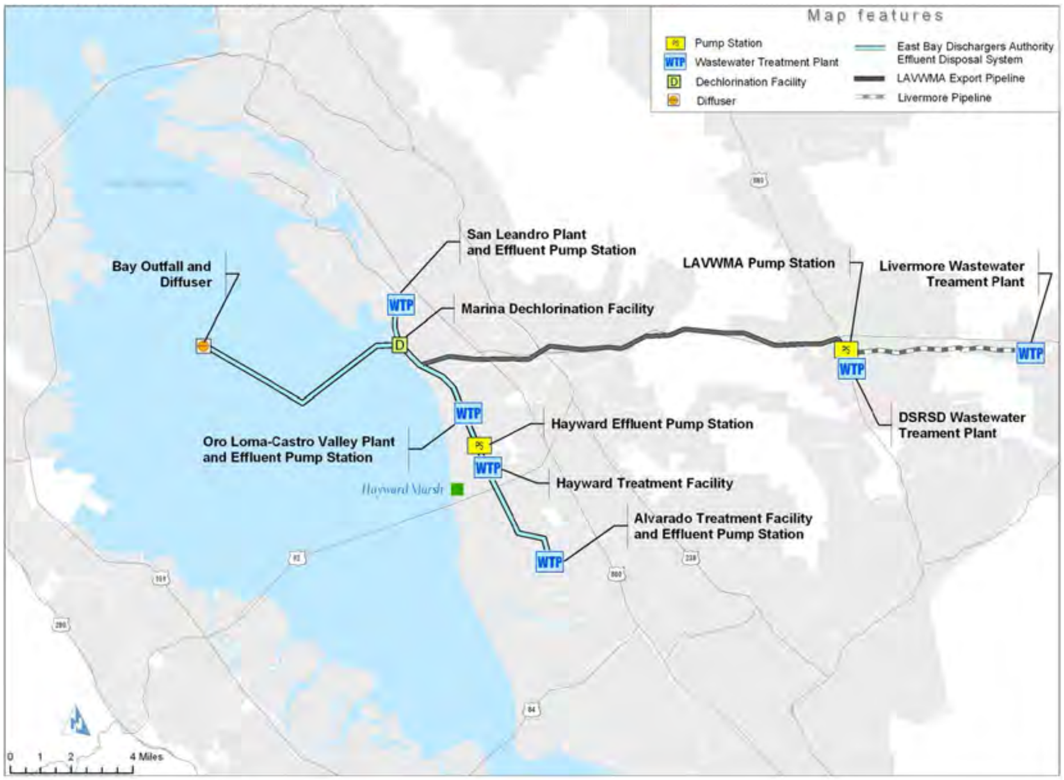


Figure 2.8. Map of East Bay Dischargers Authority facilities (RWQCB 2012).

Another critical regional asset with both local and regional implications, is the SR-92 approach to the San Mateo-Hayward Bridge, which carries 81,000 vehicles each day, mainly commuter traffic with some cargo and transit. There is not sufficient capacity on other bridges to absorb disruptions to the San Mateo-Hayward Bridge without resulting in significant delays to other bridges, which are equally vulnerable to sea level rise and storm surge events. The SR-92 approach is vulnerable currently due to poor drainage and eventually to overtopping from temporary flooding and permanent inundation. SR-92's drainage issues may impact City property, and any changes to the approach will require cooperation with neighboring landowners as well Bay Area Toll Authority and the Metropolitan Transportation Commission. (AECOM 2014). The work identified by the study that needs to be conducted to improve the resilience of the SR-92 approach includes:

- A drainage study of the approach and toll plaza should be conducted in conjunction with the City of Hayward, Alameda County Flood Control, regional park districts and California Department of Fish and Wildlife to determine if the existing system has adequate capacity to continue functioning as sea level rises.

- Caltrans should increase inspection and maintenance of SR-92 water or salt sensitive components in areas at risk of flooding or where increases in groundwater levels are anticipated.
- Caltrans should prepare for flood events by stockpiling materials, establishing turnkey agreements for equipment rental, and pre-positioning emergency power generation capacity, portable pumps, and debris removal equipment and installing manual, remote control, or automatic temporary barriers or waterproof closures to protect sensitive components, e.g., toll plaza.
- Depending on the results of the drainage study, Caltrans could install drainage improvements, e.g., boat section for the road, new shoreline protection, and extensive pump systems, to improve the capacity of the existing drainage infrastructure to continue function as sea level rises.
- Caltrans should expand or form multi-agency partnerships to facilitate the planning and funding of multi-objective improvements to SR-92 that would help to reduce or avoid the flooding and inundation on inland development and adjacent natural areas, e.g., select adaptation responses ranging from eliminating or relocating the toll plaza to protecting SR-92 toll plaza and highway in-place by widening the right-of-way and building levees or seawalls along both sides on the road or by re-engineering SR-92 to become an elevated causeway.
- As evidenced by these two examples, regionally significant assets will have local and regional implications and will require a significant amount of coordination and partnership among responsible and affected parties to find mutually beneficial adaptation responses that will include cost sharing and address permitting, ownership, management and financing challenges.

3. Unique shoreline recreation and education is at risk; preserving these functions will require local and regional collaboration.

The Hayward Shoreline Interpretive Center, owned and operated by the Hayward Area Regional Park District, provides environmental education for over 9,000 students each year, as well as serving as a community resource for education, meetings and gatherings related to connecting the people in the region to the Bay and its resources. The center is one of the only environmental education facilities along the shoreline in the East Bay and connects children and adults to shoreline habitat and the Bay through art, field trips, and education programs. This important and unique service is provided to the region through the center, which is vulnerable to low levels of sea level rise and is already affected by extreme tides. Due to the location of the center and the construction of the building, modest water levels could have significant impacts on the center and ultimately result in the loss of the facility. Additionally, the educational programs developed and implemented by the center rely on the marshes, managed ponds, and trails, which are also vulnerable to modest levels of sea level rise and extreme tide impacts. Even if the center could be rebuilt, marshes in this area will not persist without intervention, as described above in the first study area vulnerability. In addition, the majority of Bay Trail access to and through these natural areas is located on top of the levees and berms that are themselves currently vulnerable to storm events and increasingly so due to a rising Bay.

The center and its symbiotic relationship to the adjacent recreational and natural assets demonstrates that the only possible solution for this vulnerability is one that would address multiple assets, services and involve a number of agencies and organizations working together to address the widespread flooding of the low-lying areas. The park district does not have an alternative shoreline park where environmental education could occur at a new interpretive center, nor does it have the funding to move the current center or significantly reconstruct it to ensure that it persists as sea levels rise. While the park district manages the center, they do not manage most of the natural areas or trails and do not have the institutional capacity to protect and enhance them. Some specific actions developed by the study to protect and preserve shoreline interpretation for the region's children and adults include:

- The interpretive center will continue to interpret sea level rise impacts for community members and participate in regional discussions about the role of parks and environmental education in sea level rise adaptation.
- Hayward Area Recreation and Park District will continue to participate in the Climate Literacy Collaborative, a regional environmental education initiative other regional park districts, state and national parks, wildlife refuges, and others, in order to develop and implement appropriate climate education in their education and recreation programs.
- The park district should consider updating the Hayward Shoreline Interpretive Center Master Plan to include the need for retrofitting and possible relocation due to sea level rise and extreme tide impacts.
- The park district should work with the Bay Trail, East Bay Regional Park District, and regional partners like the Coastal Conservancy to plan for and fund a resilient shoreline education center.

Figure 2.9. Photo of Hayward Shoreline Interpretive Center during a King Tide that was 8.8ft NAVD88. Courtesy of Ronald Horii.

4. Asset managers, regulatory agencies, and funding entities will need to adopt new decision-making frameworks to successfully address sea level rise and extreme tide impacts.

Most agencies were designed to address the conditions and issues that existed when they were created, with some amendments and updates along the way that allow them to address current issues with static solutions, e.g., build a levee to protect against current flood events or restore a marsh and perform compliance monitoring and move on to other needs rather than develop and implement a long-term adaptive management plan for that new levee or marsh. For example, completed Bay Trail segments may need to be reconstructed at higher elevations or realigned to protected locations. This will require changes to the Bay Trail's planning and funding mechanisms, which are currently focused on securing miles of new trail and filling gaps between existing trail, not building resilience into existing trail networks. Sea level rise will require asset managers to fund, plan, and implement more iterative projects and ask regulatory agencies to acknowledge shifting baselines for habitat and other resources. Regional research initiatives such as the Bayland Ecosystem Habitat Goals Update may also help guide regional decisions about shoreline habitat restoration given sea level rise and storm impacts and provide the scientific basis for updating regulations to accommodate adaptive management. As regional, state, and federal regulatory agencies grapple with climate change impacts and their agency mandates, land managers like park districts will need to coordinate with these regulatory agencies and neighboring land owners and jurisdictions to propose projects and work together to define what responsible, adaptive, shoreline management looks like. Securing funding for these projects may also require new collaboration between recreation, restoration, and infrastructure funding sources to implement multi-objective projects.

Figure 2.10 Hayward Shoreline Resilience Study working group members on a field trip to the shoreline.

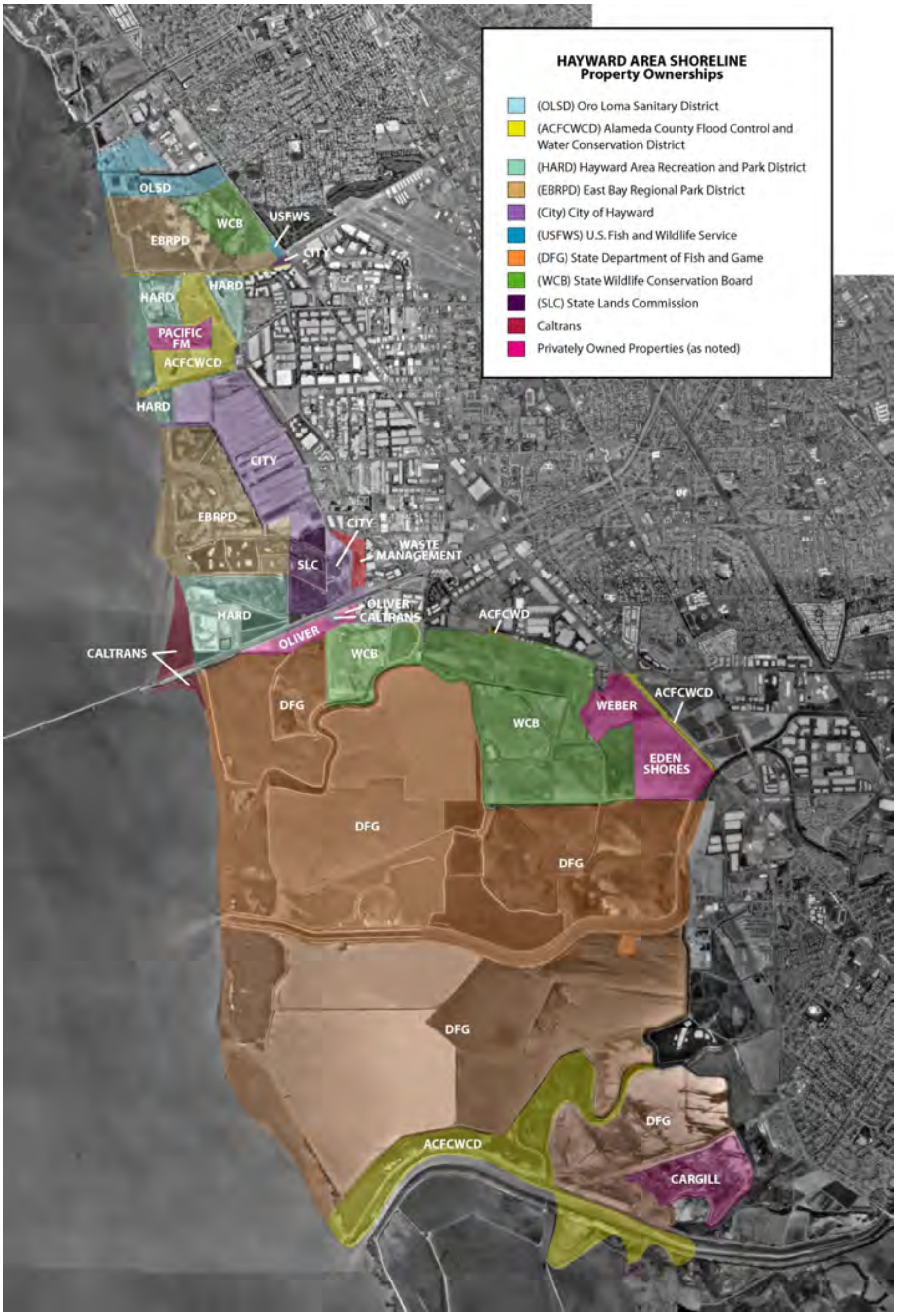
As part of this process, regulatory agencies will need to adapt their practices and policies in light of climate change. Interventions can look more harmful when compared to a past state that is no longer possible. For example, most marshes around the Bay shoreline won't persist "as is" and will drown as sea level rises. The current regulatory regime is set up to consider the impacts of interventions, such as short-term impacts of fill in existing marshes. This approach does not adequately address current and future impacts to the marsh habitat. It can also be difficult to get permits for multi-benefit, multi-jurisdictional, green infrastructure projects due to limited pilot projects, the lack of precedence, the challenge of coordinating different regulatory requirements, and difficulty in establishing conditions that promote flexibility while ensuring adequate monitoring and adaptive management is in place to promote a high likelihood of project success. For example, BCDC's current regulations, which were designed to reduce filling of the Bay in the late 1960s, requires that project proponents make the case that their proposals include the minimum amount of fill necessary to achieve the purpose of the project. This raises the question of how to evaluate transition zone slopes and other soft shoreline approaches to flood protection, which may require more fill than traditional levees, but also provide wave attenuation, recreation, and wildlife benefits. Addressing this issue may require different or expanded relationships with permitting agencies to effectively balance short- and long-term impacts to habitat, water quality, flood protection, and recreation. The solution to this vulnerability cannot come from Hayward alone, but proactive asset managers that participate in regional conversations are needed for changes in shoreline governance.

5. Temporary flooding and permanent inundation beyond mid-century will affect the entire study area and a long-term, multi-objective, landscape-scale solution with new governance structures is needed to achieve resilience goals.

In order to address future flood risk while maintaining the environmental, social, and economic functions identified in the study's resilience goals, asset managers will have to engage in detailed, ongoing, collaborative planning. In the near-term, there are actions that individual asset managers and agencies can take to improve their own resilience, such as levee maintenance, drainage improvements, and emergency planning (Appendix B). However, water levels higher than 48 inches above MHHW flood the SR-92 approach and extensive portions of the commercial and industrial areas, including the Hayward Water Pollution Control Facility, resulting in significant property damage and human and environmental health impacts. In the long-term, future shoreline protection will require adjacent asset owners, managers and jurisdictions to work together. These agencies and organizations will have to work together to plan, permit, and fund projects. The Hayward Resilience Study developed some conceptual long-term visions for this area, but moving from vulnerability assessment into detailed feasibility analysis, engineering design and eventual implementation will require more information and organizational support from working group members and stakeholders.

Figure 2.11 demonstrates the number of stakeholders that need to be involved in adaptation planning for the Hayward Study Area. In recognition of the challenge that this patchwork of ownership and management pattern creates, the City of Hayward and the two park districts created the Hayward Area Shoreline Planning Agency (HASPA), a Joint Powers Authority (JPA) in 1970 to preserve shoreline open space. While HASPA's original goal of preserving open space has largely been met, there has been recognition that sea level rise, a lack of maintenance and funding and storm events threaten the open space, habitat, recreation areas and interpretative services that the JPA has successfully preserved. HASPA has investigated sea level rise impacts, but has limited staff time, funding, and political power to address the issue. In order to be effective in addressing new challenges associated with sea level rise, HASPA would need to add new members, including private landowners and other agencies, and would also need to add staff and funding. The working group recognized the lack of current capacity to address this vulnerability so the study developed conceptual visions for the shoreline, including discussion of which landowners and agencies would need to be involved in any of the possible visions.

Figure 2.11 Hayward Area Shoreline Property Ownerships. Courtesy of HASPA.



Three Conceptual Landscape Visions

In the near-term, agencies will continue to implement those actions that are within their current purview and for which funding can be found and permits can be obtained. However, without a landscape vision to sea level rise and extreme tide impacts, agencies will spend time and money on short-term, patchwork solutions and not be able to effectively address long-term impacts to their assets. Because of this need for a coordinated and multi-objective adaptation strategy for the shoreline, working group members helped develop three conceptual futures for the study area. The descriptions below represent different balances of grey and green infrastructure given the physical setting of the study area and surrounding land uses. Two of the futures demonstrate 'holding the line' at current development, while the third demonstrates moving out of the hazard zone. These visions reflect findings from the vulnerability assessment and are specific to the study area.

TRADITIONAL LEVEE

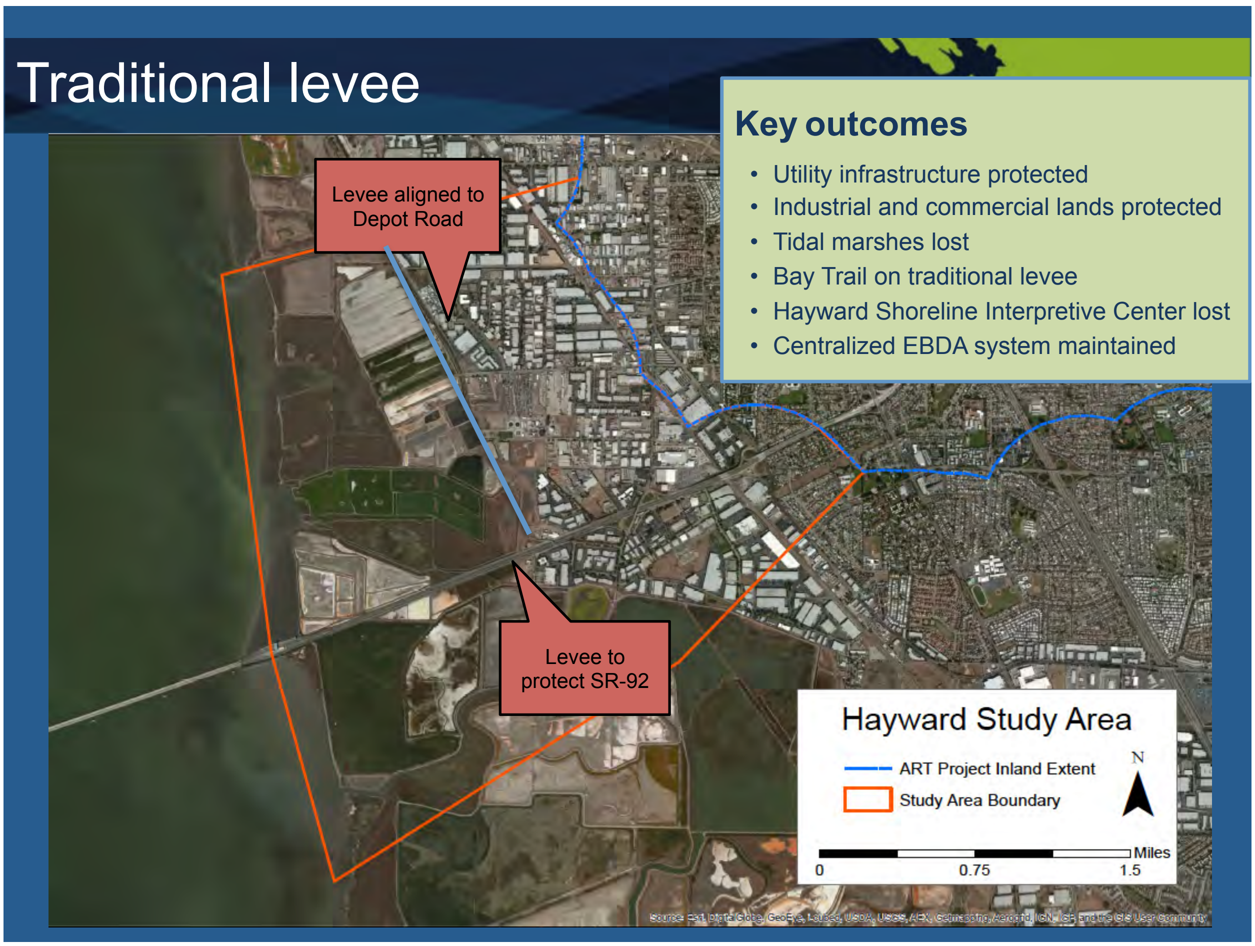


Figure 2.12 Traditional levee conceptual landscape solution.

The traditional levee alternative reflects current approaches and understanding of shoreline protection and infrastructure and so includes a centralized wastewater system reliant on deep-water discharge. A conventional 3:1 levee would replace the existing outboard levees and move the line of protection inland to Depot Road. This vision would require Hayward, Alameda County Flood Control, East Bay Dischargers Authority, and Caltrans to work together to plan and build compatible levee alignments to protect their assets and services. A traditional levee in this location would protect the existing Hayward Water Pollution Control Facility and commercial/industrial land uses, while utility alignments would remain in service in their current locations until water levels exceeded the height of the levee. However, the oxidation ponds used by the wastewater treatment plant would be lost, forcing the City of Hayward to invest in alternative wet weather storage facilities. The solar panels located in decommissioned ponds would also need to be relocated. While there are fewer feasibility questions associated with this strategy because the engineering standards are well developed and widely used, this strategy does not provide sufficient transition zone habitat to preserve the marshes and ponds north of SR-92, significantly reducing habitat for important Bay species and eliminating the public's wildlife viewing experience and shoreline interpretation opportunities. Future recreation would be limited to a trail on top of or behind a high levee.

HORIZONTAL LEVEE

In the Horizontal Levee alternative, the study area would use a green infrastructure approach, which combines flood protection, habitat, wastewater discharge, and recreation into a joint solution to address current and future needs. Wetlands and freshwater inputs would be used to construct a horizontal levee through the oxidation ponds to protect commercial/industrial land uses and maintain utility alignments in their current location. East Bay Dischargers Authority, Hayward, the regional park districts, and Alameda County Flood Control would need to work together to plan this levee. East Bay Dischargers Authority and Hayward would need to implement wastewater system changes to use the horizontal levee for decentralized discharge. The park districts would need to factor the horizontal levee into a sea level rise adaptation strategy to preserve tidal marshes and managed ponds, but such a strategy should make that goal much easier and possible. Similarly, Alameda County Flood Control would need to consider the possibility of overflow from the flood control channel Line E onto the horizontal levee in future flood risk planning. Prior to construction of this nature-based flood protection, the oxidation ponds would need to be decommissioned and the solar panels would need to be relocated.

The Bay Trail could be sited on top of the horizontal levee crest and the interpretive center could be moved to a location along Depot Road to preserve recreation and shoreline interpretation opportunities. Elevating SR-92 and constructing a horizontal levee in coordination with the South Bay Salt Pond Restoration Project in Eden Landing would further maximize habitat connectivity. While this vision has the potential to provide multiple benefits and cost-sharing opportunities, one significant constraint is the ability to acquire sediment for construction. The proposed levee would require at least 750,000 cubic yards of material, which is the average annual total for Bay beneficial reuse of dredge material. The horizontal levee would also cross multiple property boundaries and eventually host co-located functions, so agreeing on funding for construction, maintenance, and repairs will require cooperation from at least four agencies.

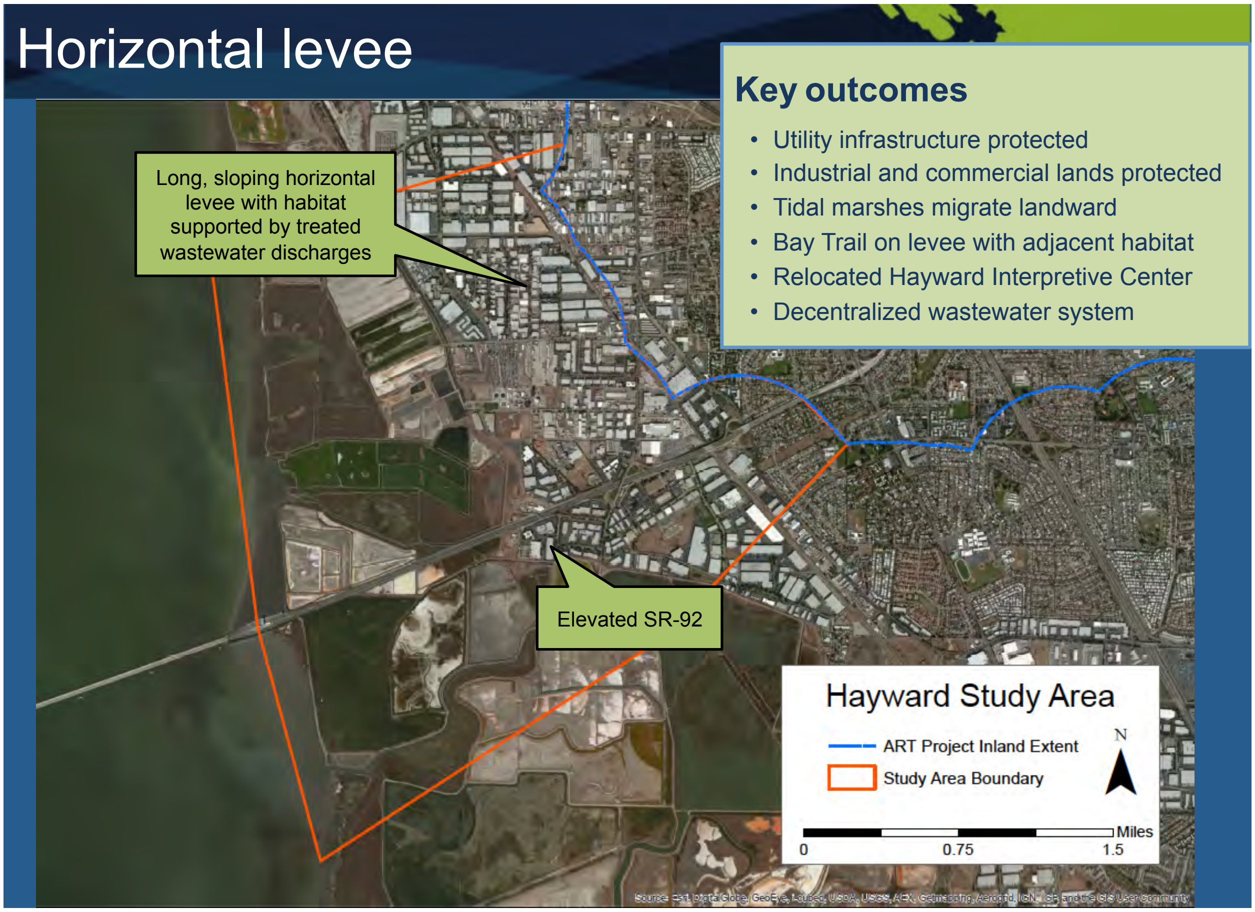


Figure 2.13 Horizontal levee conceptual landscape vision.

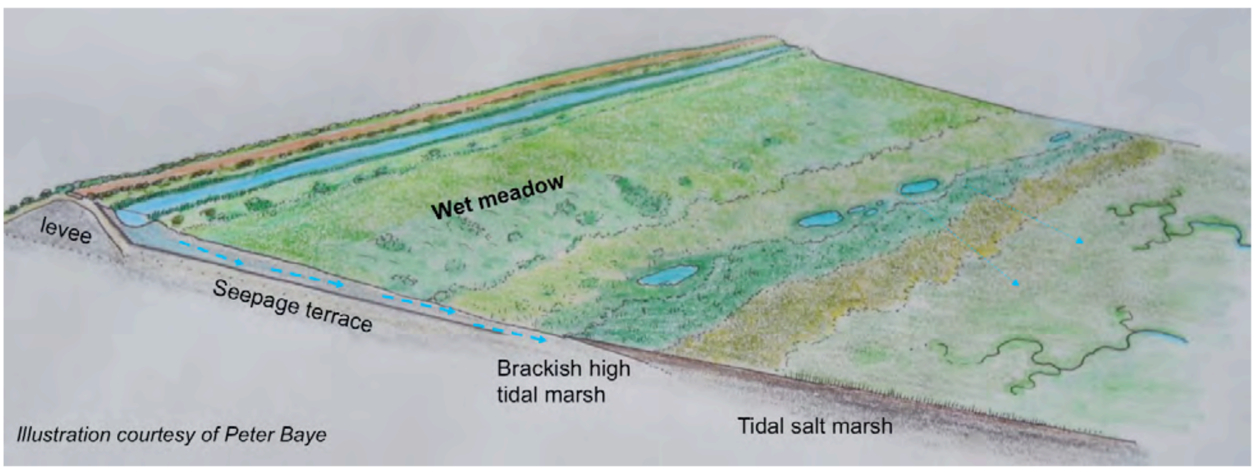


Figure 2.14 Illustration of horizontal levee. Courtesy of Peter Baye.

ROOM FOR THE BAY

In the managed realignment future, the City of Hayward and other land owners and jurisdictions will gradually and deliberately relocate utilities and commercial/industrial land uses to higher ground and convert the future floodplain to recreation and possible natural areas. A crucial first step would include forming a working group of stakeholders, including agencies that participated in the Hayward Resilience Study and members of the public, such as landowners and tenants in the commercial/industrial park. Various voluntary mechanisms for relocation could be implemented, e.g., transfer of development rights programs, rezoning, and land acquisition through willing buyer/willing seller transactions. Hayward would work with East Bay Dischargers Authority to establish a decentralized wastewater system. A new wastewater treatment plant (or plants) would need to be constructed and on-line before Hayward could decommission the existing plant. The City must coordinate with Alameda County Flood Control to determine the future flood risk associated with eliminating the maintenance of existing shoreline protection and relying on higher elevations to protect against flooding and to understand the options for converting the former industrial park into floodable space, e.g., a park. Hayward Area Recreation and Park District will play role in this conversion because the existing interpretative center will need to be closed and replaced with an environmental education center in the newly created park. It is unclear whether the area is suitable for wetland restoration and able to provide future habitat value. Depending on the success and implementation of a marsh adaptation strategy, there may no longer be marshes to interpret so the center may need to be reprogrammed to fit the changing environment. However, the park would provide community open space and recreation that can also withstand temporary flooding. The Bay Trail will need to be relocated to an appropriate location given the final restoration and recreation development of the area and constructed out of floodable materials.

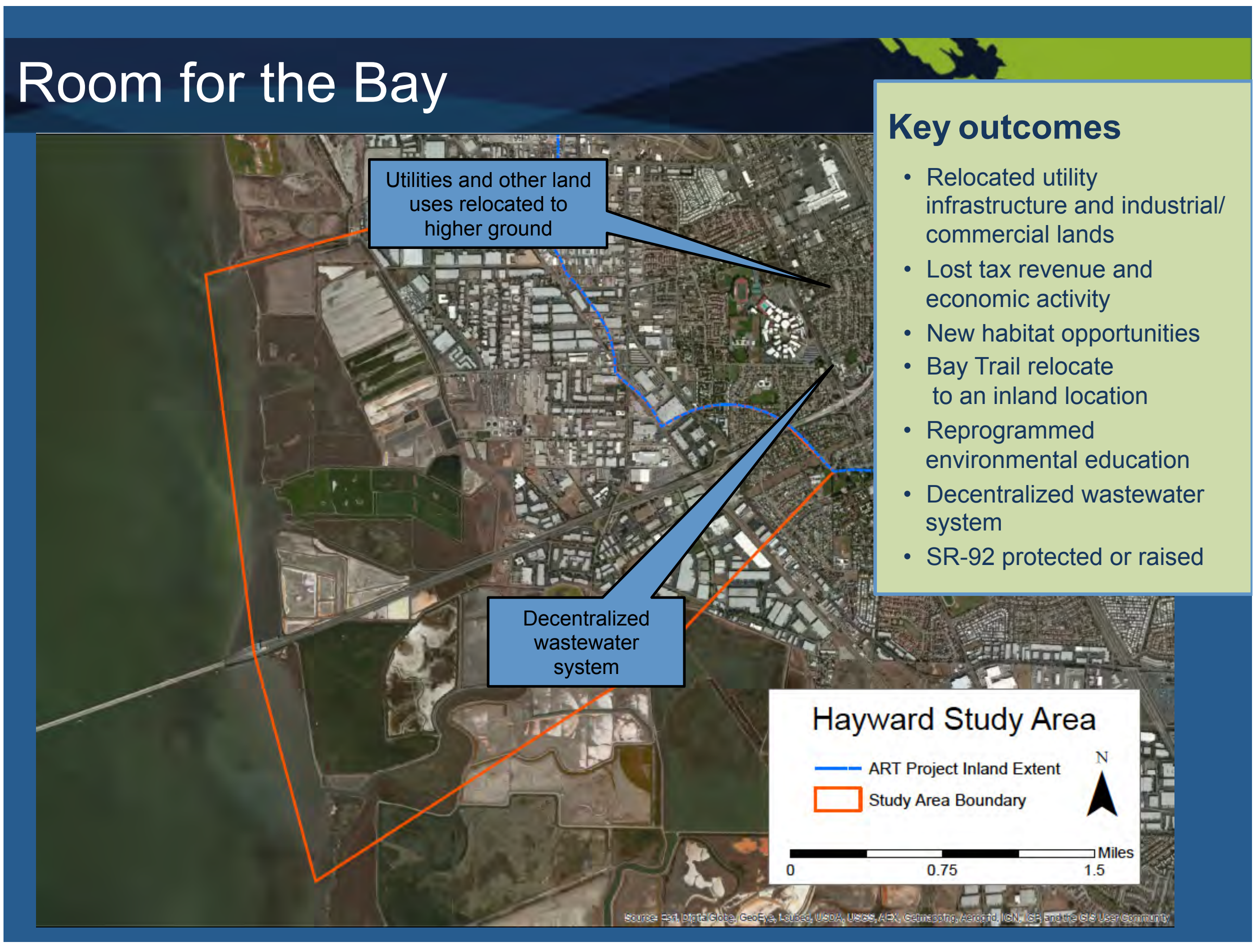


Figure 2.15 Room for the Bay conceptual landscape vision.

Evaluation of Adaptation Responses

Working group members and ART staff used qualitative evaluation criteria, combined with research and working group expertise, to investigate the consequences of each of the conceptual landscape visions. The criteria identified how well each option met the study's resilience goals to:

- 1. Protect the health, safety, and welfare of those who live, work, and recreate in the Hayward Shoreline area.
- 2. Prevent the disruption of key community services by protecting critical infrastructure.
- 3. Protect the environmental value of the Hayward Shoreline area by preserving habitat, water quality, and endangered species.
- 4. Build organizational and community capacity so stakeholders can work collaboratively to address future conditions.

The criteria also asked about the technical and organizational feasibility of each option and the sustainability of the visions. Working group members rated each option as having positive, negative, or neutral effects on the criteria. The working group compared their ratings and discussed disagreements about impacts. Having this structure to evaluate consequences helped explore and weigh tradeoffs between the visions in an organized and more objective way. Working group members had many questions about feasibility of both near-term and long-term adaptation responses that would require more detailed technical analysis to answer. For example, the study did not include the geotechnical analysis that would be necessary for the traditional levee or horizontal levee, which is a logical next step for this effort. Also, some responses are outside the control of working group members and the Hayward Resilience Study such as regulatory changes by the Regional Water Quality Control Board or other parties. These unanswered questions are being investigated through ongoing work in the Hayward study area by East Bay Dischargers Authority, Hayward Area Recreation and Park District, and the ART Program.

The working group did not endorse a final proposed vision, but did explore the implications of each vision on the environment, the economy, social equity, and governance and found that some of the visions did better than others on meeting the objectives of the resilience goals. The working group agreed that individual agency actions, while necessary for the near term, were insufficient and would result in wasted effort and poor outcomes due in part to a lack of coordination between agencies. No one was ready to choose Room for the Bay, both because it scored poorly for impacts to the economy and society and equity and because it may be a strategy for even higher water levels past 2100 but not for current planning horizons. The most interest and discussion revolved around possible alignments and outcomes for the horizontal and traditional levees. The working group rated the horizontal levee more positively than the traditional levee for environmental and societal impacts but acknowledged the uncertainty around using this new type of shoreline protection.

Adaptation Models Around San Francisco Bay

Adaptation work for single sectors like transportation and within single jurisdictions like the City and County of San Francisco are critical steps forward and easier to achieve in the near term than multi-sector, multi-objective planning. For examples of single-sector or single-jurisdiction adaptation see ART program work with:

- Capitol Corridor
- East Bay Regional Park District
- Metropolitan Transportation Commission
- Caltrans
- BART
- San Francisco Public Utilities Commission

3. Next steps for Hayward and ART

Through the Hayward Resilience Study process, ART program staff and the working group were able to assess the local vulnerabilities and understand how they fit together and interact on the landscape. This understanding helped the working group develop relevant adaptation responses for the area and begin to wrestle with the implementation challenges inherent in the multi-objective, cross jurisdictional planning that will be required to address the vulnerabilities in the study area. The actions proposed in this study reflect place-based opportunities and constraints. The Hayward Shoreline is very low-lying, there is little high ground to retreat to, but the shoreline also has more open space and wetland than many parts of the region.

The Hayward Resilience Study is a significant step for adaptation along the Hayward shoreline. By identifying the vulnerabilities to the specific assets within the study area and assessing the relationships among the assets, the study defined the problems that need to be solved and the unique local characteristics that will contribute to the opportunities and constraints for adaptation responses. In order to prepare for temporary flooding and permanent inundation, working group members and other asset managers will need to carry this information forward in their own agencies when conducting maintenance and improvements. Understanding what thresholds trigger consequences will inform planning and help to make efficient use of limited resources.

However, in addition to individual agencies taking up adaptation in their own decision making process and on their own property in the near-term, there is a clear need for working group members and other managers to expand their collaboration with neighbors, regulators, and state and regional funding sources to pursue long-term multi-objective planning along the shoreline. As previously described, East Bay Dischargers Authority is conducting a project to convene technical and regulatory advisory committees to investigate and begin planning infrastructure improvements for wastewater discharge that incorporate habitat and flood protection in a way that anticipates sea level rise. They are using a small amount of money ($200,000) to integrate adaptation into major investments in the wastewater discharge system. The South Bay Salt Pond Restoration Project has used its significant financial resources to advance adaptive management as a field and work with stakeholders and regulators on a consistent basis for years. Due to these resources, they have been able to support research and decision-making tools beyond the ability of most projects, but lessons learned in the South Bay Salt Ponds will inform marsh and managed pond restoration around the Bay and serve as a model for long-term planning for natural areas in the face of sea level rise.

Landscape-scale visions will not be required for all vulnerabilities along the Bay shoreline. However, where there are required, such as along the Hayward study area, they will require asset managers and agencies to work or stretch beyond their current scope and mandate and collaborate with new partners in new ways. The few existing mechanisms for interagency coordination such as JPAs, Memorandums of Understanding, and Shoreline Master Plans, may be inadequate to address sea level rise and extreme tide impacts and have not been applied to this issue to date. Even in places like the Hayward shoreline with a JPA, a shoreline plan, and public agencies that are engaged with one another, there are so many challenges to implementing landscape-scale shoreline projects or conduct planning for the distant future that agencies and organizations do not know how to take the first step. Most asset managers find it challenging to address current issues such as erosion, aged equipment, and deferred maintenance in their current governance arrangements, much less plan for long term adaptation. There is also no clear convener in Hayward to do this sort of planning and cooperative implementation. Adaptation planning is more complicated than willingness; local partners and the ART program have begun the conversation in Hayward and local agencies are aware of their shared problems and it is necessary to identify the appropriate agencies and organizations to take the lead on the long term process of developing and implementing shoreline solutions.

Through the ART Pilot project in Alameda County and subsequent ART program projects, working group members, stakeholders and others have identified actions and adaptation responses that must be taken up at the regional level by regional, state and federal agencies. There is a clear role for regional government in sea level rise adaptation and collaborative shoreline management, particularly related to regional, state, and federal assets and services. These include cross-jurisdictional vulnerabilities, governance challenges, information and data gaps, and barriers to sharing information. In Hayward, regional, state or federal agencies should work to improve the resilience of the San Mateo-Hayward Bridge, the regional wastewater infrastructure, and the natural area and recreation complex that includes the wetlands, the Bay Trail, the shoreline interpretive center, habitat, and flood control. ABAG, MTC, and BCDC are developing programs, such as the ART program, to assist local governments with data, findings, processes, tools and approaches to hazard mitigation, resilience and climate adaptation. These efforts are a good start and will provide a foundation for a more robust regional approach to assisting, participating and, at times, leading, this work. Regional agencies understand the need for large scale adaptation planning and the need to work with local, state and federal jurisdictions and agencies to support and build a more resilient region at all scales.

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