Palo Alto Baylands

Climate Change and Sea Level Rise at the Baylands

Prepared for:

City of Palo Alto

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CITY OF PALO ALTO

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Acronyms and Other Abbreviations

AR5	Fifth Assessment Report on Climate Change
ART	Adapting to Rising Tides
Bay	San Francisco Bay
Bay Area	San Francisco Bay Area
Baylands	Palo Alto Baylands Nature Preserve
BCDC	San Francisco Bay Conservation and Devlopment Commision
City	City of Palo Alto
FEMA	Federal Emergency Management Agency
Flood Control Basin	Palo Alto Flood Control Basin
Future Tidal Marshes Tool	Future San Francisco Bay Tidal Marshes planning tool
IPCC	Intergovernmental Panel on Climate Change
MHHW	mean higher high water
OPC	California Ocean Protection Council
Point Blue	Point Blue Conservation Science
RWQCP	Regional Water Quality Control Plant
SAFER Bay	Strategy to Advance Flood Protection, Ecosystems and Recreation along the Bay
SCVWD	Santa Clara Valley Water District
SFCJPA	San Francisquito Creek Join Powers Authority
Silicon Valley 2.0	*Silicon Valley 2.0 Climate Adaptation Guidebook*
Tidal Marsh Recovery Plan	*Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California*
USFWS	U.S. Fish and Wildlife Service

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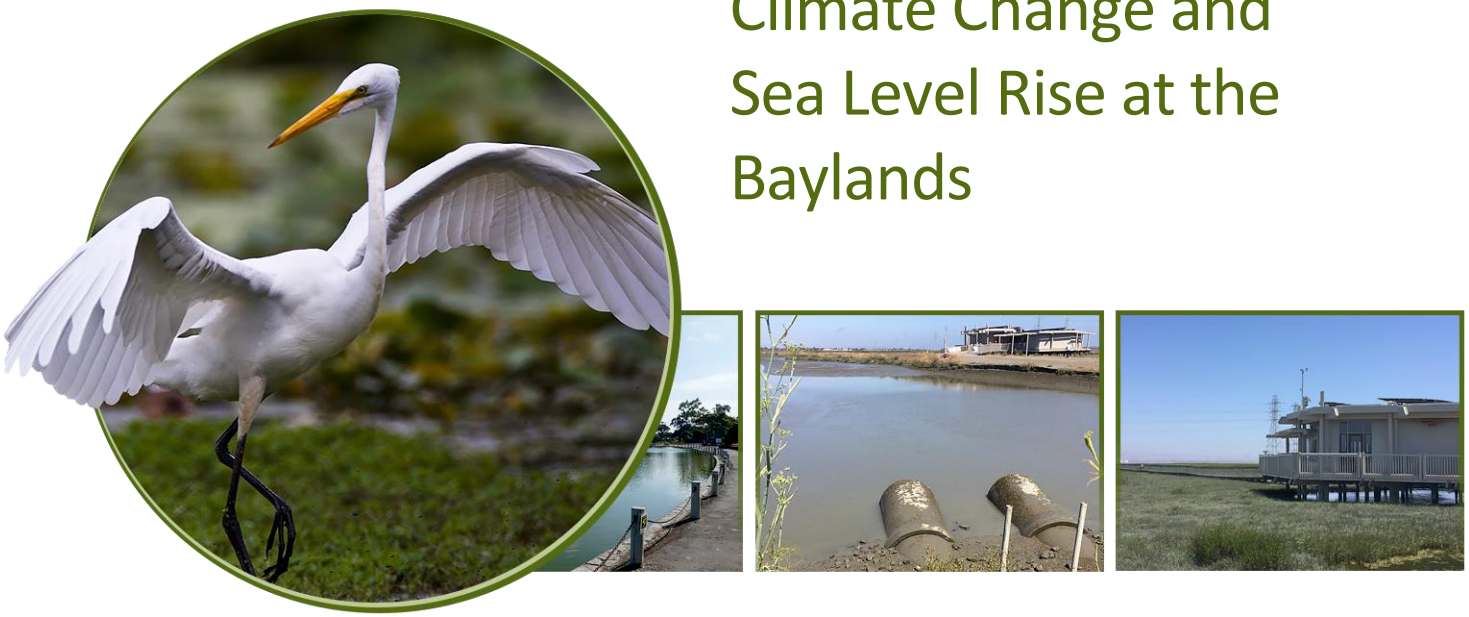


1 Executive Summary

Sea levels in the San Francisco Bay Area (Bay Area) have increased by 8 inches since recordkeeping began in the mid-1850s (NOAA 2018), and there has been significant acceleration of sea levels since 2011 (Ackerly et al. 2018). As water levels rise in San Francisco Bay (Bay), the frequency and areal extent of flooding will increase. Areas once considered to be outside the floodplain will begin to experience periodic coastal flooding or permanent inundation. The Palo Alto Baylands Nature Preserve (Baylands), located along the Bay, is vulnerable to future flooding.

The goal of this document is to describe the potential impacts of sea level rise on physical assets and habitats in the Baylands and to describe high-level measures that the City of Palo Alto (City) can take to adapt to climate change and sea level rise. This document should be used as a starting point for planning efforts to address potential future impacts caused by sea level rise and climate change. The document includes descriptions of existing nearby planning efforts and aims to expand upon those efforts to focus on the Palo Alto Baylands.

The effort to map the Baylands' coastal flood exposure leveraged existing sea level rise layers prepared as a part of the San Francisco Bay Conservation and Development Commission (BCDC) program "Adapting to Rising Tides" (ART). The sea level rise exposure assessment for the Baylands involved completing a spatial analysis using a geographic information system to estimate the timing and extent of permanent inundation for the site's features and assets: flood control structures, access, and nonrecreational features and facilities. The habitat assessment mapping effort used elevation-based habitat maps produced by the Future San Francisco Bay Tidal Marshes planning tool (Future Tidal Marshes Tool) to understand changes to potential future habitat types in the Baylands.

The results of the exposure assessment show that many areas within the Baylands would experience a tipping point for coastal inundation, with 36 inches of sea level rise where portions of many flood control levees and berms may be overtopped, causing

widespread inundation throughout the Baylands. Other areas of the Baylands, including the unprotected Harriet Mundy Marsh and Faber-Laumeister tract, may be exposed to flooding with 12 inches of sea level rise. Byxbee Park, the City of Palo Alto's capped former landfill, will not be affected under any of the sea level rise scenarios assessed in this document because of its higher elevation.

The results of the habitat assessment show that under a no-management scenario—a scenario in which the landscape is not managed through levees, pumps, routine maintenance, or other management actions—deposition of sediment and organic material at the Baylands will likely keep pace with sea level rise through the late 21st century. However, the rate at which this accretion will occur depends on the amount of available sediment and organic material. The results show that by 2050, the unprotected Harriet Mundy Marsh and Faber-Laumeister tract would maintain a mid marsh habitat, but that much of the other Baylands habitat types would convert to higher elevation habitat types (e.g., mudflat to mid marsh).

Beyond sea level rise, changes in climatic conditions such as temperature and precipitation could alter future growing seasons, along with the amount of freshwater soil moisture available. These changes could ultimately lead to a change in the composition of plants and the wildlife that depend on them. Species with broader temperature and precipitation tolerance are likely to persist better than highly specialized species.

Potential high-level adaptation measures may include physical, governance, and initiative strategies that may be used to better prepare the Baylands for future environmental conditions resulting from sea level rise and climate change.

Physical adaptation measures may include the following:

- Raising and improving flood control structures such as levees and berms
- Increasing the capacity of the Palo Alto Flood Control Basin
- Elevating critical roadways, trails, and structures to minimize flood damage
- Installing climate-smart restoration plantings to enhance the ecological function of degraded or destroyed areas to prepare them for the consequences of climate change (Point Blue 2018)
- Constructing tidal marsh transition zones

Governance measures may include the following:

- Coordinating with neighboring stakeholders and regional and local planning efforts
- Incorporating sea level rise language into guidance documents (e.g., Baylands Master Plan, the Palo Alto Comprehensive Plan, and the City of Palo Alto Design Standards, City of Palo Alto Storm Drain Master Plan) and emergency plans to provide a means for guiding future decision making

The following informational initiatives could be taken:

- Monitoring changing conditions in the short term to inform the timing for implementing adaptation measures
- Identifying and addressing data gaps by conducting studies to better understand flood risk at the Baylands

- Identifying co-benefits, which have the potential to reduce impacts on human and ecological health at the same time
- Securing funding for proposed adaption actions

2 Predictions of Climate Change and Sea Level Rise

The global climate continues to exhibit rapid changes compared to the pace of natural variations observed throughout Earth's history. Widespread evidence exists to show climate trend deviations. Scientists have documented increases in atmospheric and oceanic temperatures, melting of glaciers, reduction of ice sheets and snowpack, shifting rainfall patterns, intensification of storm events, and rising sea levels. Increasing atmospheric temperatures influence global sea levels: as average air temperatures rise, thermal expansion of warming ocean water occurs and land ice melts.

2.1 Latest Climate Science

In 2017, the California Ocean Protection Council (OPC) Science Advisory Team Working Group compiled, reviewed, and summarized the latest research on sea level rise (Griggs et al. 2017). The study's findings were incorporated into an updated sea level rise guidance document for the State of California, which OPC adopted in 2018 (OPC 2018). The update presents the latest peer-reviewed projections of sea level rise; describes an extreme scenario for sea level rise caused by rapid ice sheet loss from the West Antarctica ice sheet, and scenario selections using risk-based (probabilistic) planning capabilities. The 2018 update also lays out preferred approaches for planning for vulnerable assets, natural habitats, and public access.

2.2 Trends in Sea Level Rise and Future Projections for San Francisco Bay

Since the installation of the San Francisco tide station in the mid-1850s, local water levels have increased by 8 inches (NOAA Sea Level Rise Trends 2018). Rising sea levels represent new challenges for San Francisco Bay. As Bay water levels rise, the frequency and areal extent of flooding will increase. Areas once considered to be outside of the floodplain will begin to experience periodic coastal flooding or permanent inundation.

Table 1 shows sea level rise projections for the Bay. Based on the latest climate science, sea levels in the Bay Area are likely (67% probability) to rise between 7.2 and 13.2 inches by the middle of the 21st century and between 12 and 40.8 inches by the end of the century. OPC recommends using the upper limit of the likely range for projects with a high tolerance to flooding (e.g., park trails).

Because there is uncertainty regarding future greenhouse gas emissions, sea level rise projections with a lower probability of occurring are also considered. In the Bay Area, there is a 0.5% probability (1-in-200 chance) that sea level rise will reach or exceed 22.8 inches by the middle of the 21st century and 82.8 inches by the end of the century (OPC 2018). OPC recommends using the lower probability projections (particularly the 0.5% probability projections) when planning for assets with a lower tolerance to flooding, such as water treatment facilities.

Table 1. Sea Level Rise Projections for San Francisco Bay

Year	Median (50% probability of exceedance [inches])	Likely Range (67% probability of exceedance [inches])	1-in-20 chance (5% probability of exceedance [inches])	1-in-200 chance (0.5% probability of exceedance [inches])	H++ (extreme risk aversion [inches])
2030	4.8	3.6 to 7.2	7.2	9.6	12
2050	10.8	7.2 to 13.2	16.8	22.8	32.4
2100	19.2 to 30	12 to 40.8	38.4 to 52.8	68.4 to 82.8	122.4

Notes:

- Projections represent a sea level rise increase above the 1991–2009 mean sea level.
- 2100 projection ranges depend on the future condition scenario, as described in the International Panel on Climate Change *Fifth Assessment Report (AR5)* (IPCC 2013).

The latest sea level rise guidance also includes an extreme scenario that extends to 122.4 inches by 2100. OPC recommends using this scenario when planning for projects with an extremely low flood tolerance, such as nuclear power plants.

3 Analysis Methodology

The following sections present the methodology for assessing the impacts of sea level rise on the Baylands. Methods used included conducting a literature review of local studies of sea level rise and flood protection, assessing sea level rise exposure to determine the potential timing and extent of impacts on Baylands assets, and habitat modeling was conducted to estimate the evolution of marshes as they are exposed to rising Bay levels.

3.1 Literature Review

Previous studies of sea level rise and climate change have been conducted at or near the Baylands. These studies are summarized below.

3.1.1 Strategy to Advance Flood Protection, Ecosystems and Recreation along the Bay—Draft Feasibility Reports

The San Francisquito Creek Joint Powers Authority (SFCJPA) was founded by the Cities of East Palo Alto, Menlo Park, and Palo Alto, San Mateo County Flood Control District, and Santa Clara Valley Water District (SCVWD) in 1999, the year after a major flood occurred (SFCJPA 2016). SFCJPA and its member agencies seek to protect people, property, and public infrastructure in East Palo Alto, Menlo Park, and Palo Alto from Bay coastal flooding; restore habitat in the Bay's tidal marsh ecosystem; and enhance recreation opportunities along the Bay shoreline (SFCJPA 2016).

SFCJPA and its member agencies are planning the Strategy to Advance Flood Protection, Ecosystems and Recreation along the Bay (SAFER Bay) Project to protect its communities located within the Federal Emergency Management Agency (FEMA) 1% (100-year) flood zone from Bay coastal flooding (SFCJPA 2015, 2016). The goal of SFCJPA is to implement the SAFER Bay Project and thereby remove these communities from FEMA's coastal floodplain, while enabling adaptation to climate change by using tidal marsh areas for flood protection in a way that sustains marsh habitat and facilitates marsh restoration (SFCJPA 2015). SAFER Bay aims to align with regional efforts that promote adaptation to sea level rise in the context of developed shoreline areas, including the South Bay Salt Ponds Restoration Project and other restoration efforts. It is designed to support the objectives of the San Francisco Estuary Partnership's 2016 *Comprehensive Conservation and Management Plan* (SFCJPA 2016).

SAFER Bay is divided into two project areas: SAFER Bay North, from the Redwood City/Menlo Park border south to San Francisquito Creek; and SAFER Bay South, from San Francisquito Creek south to the Palo Alto/Mountain View border. SAFER Bay is divided into 11 reaches. Restoration options have been proposed for each reach: modifying existing levees, establishing new levees, establishing ecological transition zones, and constructing floodwalls at Matadero Creek to the 100-year water surface elevation (Figure 1). Reaches 1–9 are located in SAFER Bay North and associated with East Palo Alto and Menlo Park. Reaches 10 and 11 are located in SAFER Bay South and extend from San Francisquito Creek to the Palo Alto/Mountain View border. Reaches 8–11 overlap the Baylands.

Figure 1. Project Reaches and Restoration Options in the Strategy to Advance Flood Protection, Ecosystems and Recreation along the Bay

Source: SFCJPA 2015

3.1.1.1 SAFER Bay North 2016 East Palo Alto and Menlo Park Feasibility Report

The SAFER Bay North feasibility report recommends installing transition zone habitat in the Baylands adjacent to existing tidal marshes at Faber and Laumeister marshes (Reaches 8 and 9) because these marshes support special-status species, including Ridgway's rail (formerly known as California clapper rail; *Rallus longirostris obsoletus*) and salt marsh harvest mouse (*Reithrodontomys raviventris*) (SFCJPA 2015).

Reach 8—Laumeister Marsh

Reach 8 extends from Bay Road to Runnymede Street in East Palo Alto (Figure 1). The SAFER Bay North feasibility report recommends restoring Reach 8 by building a new levee on the Bay side of the existing levee, with a restored transition zone habitat. Transition zone habitat would increase the quantity and quality of habitat for rails and harvest mice and would provide a greater opportunity for creating high-tide refugia and improved marsh resiliency to sea level rise.

Reach 9—Faber Tract Marsh

Reach 9 extends from Runnymede Street in East Palo Alto to the O'Connor Pump Station in Palo Alto (Figure 1), which is the terminus of SFCJPA's San Francisco Bay to Highway 101 Project for flood projection, ecosystem restoration, and recreation. The SAFER Bay North feasibility report recommends coordinating with partners for restoration actions, which consist of constructing a new levee with restored transition zone habitat along Faber Tract from the Runnymede Street Outfall to the O'Connor Pump Station at the Friendship Bridge, avoiding the East Palo Alto Sanitary District sewer line (SFCJPA 2015). Restoration of such a transition zone adjacent to Faber Tract Marsh would significantly enhance marsh habitat that supports Ridgway's rail and salt marsh harvest mouse. It also would increase the resiliency of the tidal marsh to sea level rise and help to meet the objectives of the U.S. Fish and Wildlife Service's (USFWS's) *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California* (Tidal Marsh Recovery Plan) by creating high-tide refugia (SFCJPA 2015).

3.1.1.2 SAFER Bay 2015 South Baylands Draft Feasibility Report

In SFCJPA's SAFER Bay South project area, the project aims to protect the cities of Palo Alto and Mountain View from flooding. SAFER Bay South consists of Reaches 10 and 11, which traverse the Baylands from San Francisquito Creek to the Palo Alto/Mountain View border (Figure 1). The project objectives include reducing the risk of flooding; incorporating features that facilitate climate change adaptation by using tidal marshes for their ecological function; expanding opportunities for recreation and connectivity; minimizing future maintenance; and creating partnership opportunities.

Figure 1 shows the restoration options for Reaches 10 and 11. No recommendations were made for a preferred option for each reach.

Reach 10—Palo Alto Airport

Reach 10 begins at the San Francisquito Creek levee at the Friendship Bridge in Palo Alto, wraps around the Palo Alto Airport along the landward side of the Baylands tidal marsh wetlands, and ties into higher ground at Byxbee Park. The 2015 SAFER Bay South Draft Feasibility Report considered three options for flood control through levee creation and associated restoration along Reach 10, as described below.

Reach 10, Option 1 (shown in red in Figure 1) consists of installing a levee that would tie into the San Francisquito Creek Project, running along the Bay side of the Palo Alto Airport and continuing southeast before terminating in Byxbee Park. This option presents the opportunity

to restore transition zone habitat on the outboard side of the levee east of Embarcadero Road. Option 1 would require installing floodgates at the runways or elevating the runways.

Reach 10, Option 2 (shown in light pink in Figure 1) is similar to Option 1. Under this option, the levee adjacent to the airport would be closer to the runway, allowing more space for restoration of a transition zone at a gentle slope. Option 2, however, would result in the loss of seasonal wetlands (diked former tidal marsh) because the habitat would be converted to high marsh and transitional habitat. Thus, this option represents an ecologically beneficial trade-off between seasonal wetlands and tidal marsh/transitional habitat (SFCJPA 2015).

Under **Reach 10, Option 3** (shown in bright pink in Figure 1), the levee would wrap around the Bay side of the Duck Pond and Baylands Ranger Station rather than being located adjacent to the airport. This option would require installation of a pipe connecting the Duck Pond to the Bay to control flows into the leveed basin (SFCJPA 2015). Option 3 would have greater impacts on tidal marsh habitat than the other two options; however, transition zone habitat could be added on the outward (Bay) side of the levee (SFCJPA 2015).

Reach 11—Palo Alto Flood Control Basin

Reach 11 extends from Byxbee Park to a tie-in point at the City of Mountain View border near Coast Casey Forebay. The SAFER Bay 2015 South Baylands Draft Feasibility Report considered three options for flood control through levee creation and associated restoration along Reach 11, as described below (SFCJPA 2015).

Reach 11, Option 1 (shown in bright green in Figure 1) consists of enhancing the existing levee where it begins at the north end of Byxbee Park, wraps around the outside of the perimeter levee for the Flood Control Basin, and ties in at the City of Mountain View border near Coast Casey Forebay. The option does not allow for significant restoration of transition zone habitat because space is not available. Option 1 would fill and otherwise affect diked salt marsh habitat in the basin along roughly 2 miles of levee improvements (SFCJPA 2015).

Reach 11, Option 2 (shown in bright blue in Figure 1) consists of installation/enhancement of three levees. The first levee extends from the south end of Byxbee Park and runs southwest along the Emily Renzel Wetlands, then along the north side of Matadero Creek to East Bayshore Road. The second levee extends from East Bayshore Road along the south side of Matadero Creek and around the southern end of the Baylands along East Bayshore Road to Adobe Creek. A third, proposed levee would continue along the Adobe Creek Loop Trail on the south side of Adobe Creek, from East Bayshore Road to a tie-in at the City of Mountain View border near Coast Casey Forebay (SFCJPA 2015). This option would require raising floodways along Matadero, Barron, and Adobe creeks.

According to the SAFER Bay 2015 South Baylands Draft Feasibility Report, Reach 11, Option 2 provides a significant opportunity to restore tidal marsh and transition zone habitat on a large scale along the Bay side edge of the Baylands, and to further the objectives of USFWS's Tidal Marsh Recovery Plan. This restoration could also include reconnecting the Flood Control Basin to tidal exchange; restoring the basin to marsh; and removing the existing levee between the Flood Control Basin and Charleston Slough to create a large, contiguous marsh with freshwater input from Adobe Creek.

Reach 11, Option 3 (shown in yellow in Figure 1) consists of two levees. The first levee extends from the southern edge of Byxbee Park, through the Flood Control Basin, and along the north side of Adobe Creek to East Bayshore Road. The second levee would run along Adobe Creek

to the City of Mountain View, the same as in Option 2. Under this option, the northern portion of the Flood Control Basin could be restored to tidal marsh habitat and Adobe Creek would be directly connected to the Bay. As with Option 2, floodwalls would be required along Adobe and Matadero creeks, and opportunities for a tidal marsh transition zone would be created along the Bay side.

3.1.2 Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California

The Tidal Marsh Recovery Plan, proposed by USFWS, is the largest ever tidal marsh recovery effort on the West Coast. The goal of this effort is the comprehensive restoration and management of tidal marsh ecosystems (USFWS 2013). The Tidal Marsh Recovery Plan aims to restore the habitats of five species that are federally listed as endangered: two endangered animals, the Ridgway's rail and salt marsh harvest mouse, and three endangered plants, Suisun thistle (*Cirsium hydrophilum* var. *hydrophilum*), soft bird's-beak (*Chloropyron molle* ssp. *molle*), and California sea-blite (*Suaeda californica*).

The Baylands are located within the Tidal Marsh Recovery Plan's Central/South Bay recovery unit, which identifies three species for recovery: California sea-blite, Ridgway's rail, and salt marsh harvest mouse. Ridgway's rail and salt marsh harvest mouse are known to occur in the Baylands, particularly in outer Bayside marshes. According to the Tidal Marsh Recovery Plan, "[c]overed species in this recovery unit face unique management issues that vary substantially from other recovery units (e.g., invasive *Spartina* control, the current planning and implementation of extensive tidal marsh restoration, and high human density and recreational pressure)" (USFWS 2013:152).

Restoration and sea level rise adaptation efforts should be planned to align with the Tidal Marsh Recovery Plan to ensure the success of these federally listed endangered tidal marsh species and their unique habitats.

3.1.3 Shoreline Regional Park Community Sea Level Rise Study Feasibility Report and Capital Improvement Program

The City of Mountain View led the *Shoreline Regional Park Community Sea Level Rise Study Feasibility Report* and Capital Improvement Program in 2012 to address long-term flood protection from sea level rise for Mountain View's Shoreline Regional Park Community (City of Mountain View 2012). The Shoreline Regional Park Community is located adjacent to the Baylands, just south of the Flood Control Basin, and is susceptible to overflow flooding from the Flood Control Basin. The study recommends the following adaptation projects in the vicinity of the Baylands:

A. **Charleston Slough and Palo Alto Flood Control Basin Levee Improvement**: As a shared effort by the Cities of Palo Alto and Mountain View, improve a 6,600-foot section of the levee that separates Charleston Slough and the Flood Control Basin by raising the elevation of the levee crest and providing erosion protection.

B. **Coast Casey North Levee Improvement:** Construct a coastal levee to help protect property in Mountain View's northwest corner from flooding caused by the Bay. The levee would extend 1,300 feet from the high ground of Mountain View's Shoreline Park landfill to the boundary with Palo Alto.

C. **Coast Casey Pump Station Improvement:** Improve pump station capacity at the Coast Casey Stormwater Pump Station to counter sea level rise impacts on the pump station's hydraulics. If flood protection improvements are implemented for the Flood Control Basin, as described in A, then the Coast Casey Pump Station Improvement Project may not be necessary.

3.1.4 Palo Alto Flood Control Basin Hydrology July 2016 Update

In 2016, SCVWD published a study that examined the hydraulic performance of the Flood Control Basin during a variety of tidal and watershed conditions. The study focused on exploring ways to improve the tidal barrier system during large flood events and potential future sea level rise of up to 66 inches.

The study found that the Flood Control Basin has sufficient volume to store storm runoff generated during high-flow events under existing conditions. However, as tides start to rise beyond the elevation originally accounted for in the structure's design, the basin may become too small to effectively control backwater flooding conditions. As sea level rises, the time period when stored floodwater can be released to the Bay will be compressed, thereby limiting the duration of discharge into the Bay. In addition, the gravity-driven tide gate will be less efficient at quickly draining stored floodwater because the pressure differential between water levels in the basin and in the Bay will be lower. As the duration and rate of discharge to the Bay is affected, the water level in the Flood Control Basin may exceed its design. An impact scenario not explored by the 2016 study is the potential for Bay water levels to exceed the elevation of the Flood Control Basin's levee.

3.1.5 Adapting to Rising Tides (San Francisco Bay Conservation and Development Commission)

ART is a regional collaborative interagency program supported by BCDC, the California Department of Transportation, the Bay Area Toll Authority, the Metropolitan Transportation Commission, and the Bay Area Regional Collaborative. ART projects address climate change vulnerability and adaptation projects (BCDC 2018a, 2018b). As part of the ART program, the Bay Shoreline Flood Explorer tool (https://explorer.adaptingtorisingtides.org/home) was developed to help Bay Area communities prepare for the impacts of current and future flooding caused by sea level rise and storm surges. ART Bay Area, a project in the ART program, involves conducting a regional vulnerability assessment of the Bay Area's transportation infrastructure, Priority Development Areas and Priority Conservation Areas as identified in *Plan Bay Area*, and vulnerable and disadvantaged communities (BCDC 2018c).

3.1.6 Future San Francisco Bay Tidal Marshes Planning Tool (Point Blue Conservation Science)

The Future San Francisco Bay Tidal Marshes planning tool (Future Tidal Marshes Tool; http://data.prbo.org/apps/sfbslr/) used by Point Blue Conservation Science (Point Blue) projects future habitat evolution in response to different scenarios for sea level rise and sedimentation (Veloz et al. 2014). The models that generate the maps provide a range of projections to address the uncertainty in future rates of sea level rise and availability of suspended sediment. The models identify the areas of the landscape that are vulnerable or resilient to sea level rise, enabling planners to make informed decisions about sea level rise adaptation and restoration potential (Veloz et al. 2014).

The Future Tidal Marshes Tool assesses marsh accretion as modeled by ESA PWA using the Marsh-98 model. The model assumes that the rate at which the elevation of the marsh plain changes depends on the availability of suspended sediment and organic material, the water's depth, and the duration of inundation periods. If enough suspended sediment is available, then the tidal marsh's elevation can accrete to keep pace with increased inundation from sea level rise (SFCJPA 2016; Orr et al. 2003). Outputs from the model show the projected future composition of marsh habitat (e.g., percent subtidal, mudflat, low marsh) based on the elevation. Point Blue's Future Tidal Marshes Tool can be used to assess future elevation-based habitat types, allowing the user to toggle between differing degrees of sea level rise, sedimentation, and organic materials over time (Veloz et al. 2014). This tool was used for this analysis, as described in Section 3.2.2, "Habitat Models/Mapping."

3.1.7 Silicon Valley 2.0 Climate Adaptation Guidebook (County of Santa Clara)

The *Silicon Valley 2.0 Climate Adaptation Guidebook* (Silicon Valley 2.0) is a Santa Clara County–wide effort to understand and minimize the anticipated impacts of climate change and to prepare the County of Santa Clara to collaborate across agencies and municipalities for adaptation (County of Santa Clara 2015). The project developed the geo-economic Silicon Valley 2.0 Climate Change Preparedness Decision Support Tool (http://www.siliconvalleytwopointzero.org/) to evaluate the vulnerability of key assets to potential climate change scenarios and the consequences of such scenarios on those assets. The assessment of climate vulnerability evaluated sea level rise, riverine flooding, wildfire, extreme heat, drought, and air quality deterioration. Various elements of shoreline flood protection were assessed, including engineered flood protection (dikes and levees), nonengineered berms, and wetlands. Natural landscapes such as the Baylands were assessed qualitatively at a high-level habitat scale. Habitats related to the Baylands that were assessed included coastal wetland, riparian and riverine, and grassland habitats. Water and wastewater, including water treatment plants, were also assessed.

Silicon Valley 2.0 recommends the following climate adaptation strategies for shoreline flood protection related to the Baylands:

- Conduct an overtopping analysis of existing shoreline flood protection assets.
- Use the updated FEMA Flood Insurance Rate Maps to identify the source of flooding (e.g., riverine versus coastal) associated with 100-year flood events.
- Increase pump station capacity and provide protection for pump stations.
- Enhance monitoring and/or maintenance programs for levees and floodwalls.
- Increase the design criteria for current and future flood protection projects from 100-year flood events to higher impact flood events.
- Model projected change in the frequency and magnitude of riverine flooding caused by precipitation in the County.

Silicon Valley 2.0 recommends the following climate adaptation strategies for ecosystems related to the Baylands:

- Develop climate-smart planting palettes and education campaigns to support restoration of plants that are projected to better survive under changing climate conditions. Climate-smart restoration and land conservation is the process of enhancing the ecological function of degraded or destroyed areas in a manner that prepares them for the consequences of climate change (Point Blue 2018).
- Maximize the retention of local water supply and quality through climate-smart land conservation and stewardship.
- Protect biodiversity through multi-agency and multi-county conservation of climate-smart wildlife corridors.
- Implement a fine-scale habitat assessment utilizing climate water deficit data as a proxy for future vegetation health and persistence under changing climate regimes.
- Prioritize cold water habitat conservation and restoration through amendments to habitat conservation plans and in-creek projects.
- Develop best practice standards for water retention design for habitat restoration and habitat creation projects on natural lands.

- Increase climate messages in ongoing water conservation public awareness campaigns.
- Understand vector-based impacts of climate and address invasive species through the pursuit of stronger state laws and programs.

3.2 Data Analysis

Sea level rise mapping models were used to assess the exposure of Baylands features and habitat evolution caused by changing water levels. All data layers were leveraged from readily available sources and no additional modeling was completed for this effort.

3.2.1 Flood Models/Mapping

Inundation maps are a valuable tool for evaluating the potential exposure of habitats, infrastructure, and other assets to future water level conditions. The maps are a useful means to evaluate the timing and extent of flooding that may be experienced based on projections of sea level rise. Inundation maps also help planners to identify critical flooding thresholds where an entire area may be compromised.

The effort to map the Baylands' coastal flood exposure used existing sea level rise layers prepared as a part of BCDC's ART program (AECOM 2016; BCDC 2018b). The ART mapping provides the geographical extent and depth of inundation for the Bay Area's nine counties using a combination of 10 sea level rise scenarios, tidal datums, and extreme tides modeled to represent local conditions along the shoreline. In addition to areas directly exposed to flooding and inundation, the model identifies low-lying, hydraulically disconnected areas that may experience drainage issues caused by backflow through the stormwater collection system during high tides; elevated groundwater levels; or ponding during times of heavy rain. Also included in the ART mapping dataset are maps for all 10 scenarios that depict where the Bay may overtop the shoreline. The inundation maps do not account for wave height, rainfall, or other potential variations in conditions that could affect the depth of inundation at any given location.

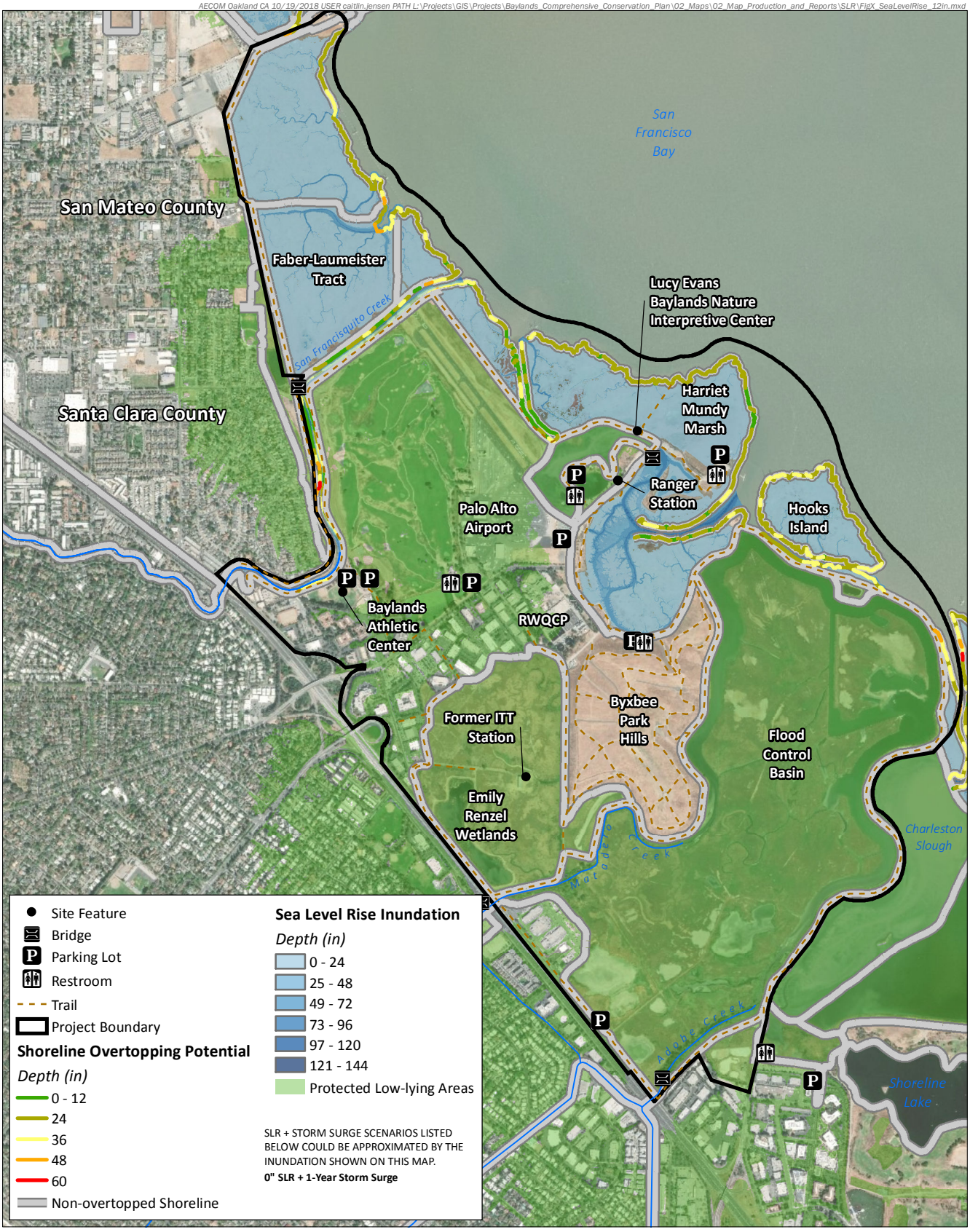
Four sea level rise amounts—12, 24, 36, and 66 inches—were selected for flood exposure (Figures 2–5). The scenarios represent mid-range to high-end projections for the years 2050 and 2100 based on the state's latest sea level rise guidance (OPC 2018). To evaluate future daily exposure to inundation, projections of future sea level rise were added to the average high-tide elevation, represented by mean higher high water (MHHW). The MHHW + 66-inch scenario is equivalent to the extent of flooding that could occur during a 100-year coastal storm event with 24 inches of sea level rise (the high-range projection for 2050).

The assessment of the Baylands' exposure to sea level rise involved conducting a spatial analysis in a geographic information system to estimate the timing and extent of permanent inundation of flood control structures, access, and nonrecreational facilities. Sea level rise layers were overlaid on the locations of site features to estimate exposure to future water level conditions.

3.2.2 Habitat Models/Mapping

Understanding the vulnerabilities of Baylands habitat to sea level rise is important for future land management and species conservation. The marshes at the Baylands provide valuable ecosystem services and habitat for a diversity of plant and animal species. Habitat modeling is a valuable means of predicting future changes to tidal marsh habitats that will result from sea level rise and climate change, to enable better understanding and preparation for how these systems may change. The Future Tidal Marshes Tool was used to project the evolution of habitat in the Baylands in response to different sea level rise and sedimentation scenarios.

For this effort, projected habitat change was assessed using the elevation parameter, which shows marsh elevation and habitat type in meters relative to MHHW. A time horizon of 2050 and a sea level rise rate of approximately 65 inches per century were selected (e.g., 65 inches by 2110). According to the model, sea levels are projected to rise by approximately 24 inches by 2050. Future Baylands habitats were assessed under two scenarios: a low-sedimentation, low-organic-materials scenario, and a high-sedimentation, high-organic-materials scenario. These scenarios were selected to explore the range of possible future conditions. A baseline map from 2010 was used to compare the projected results to near-present-day habitat conditions. All future habitat scenarios assume full tidal action and do not take into account land management of elevation, including levees, even if a levee is present.



N

0 0.5
Miles

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FIGURE 2

MHHW + 12" Sea Level Rise

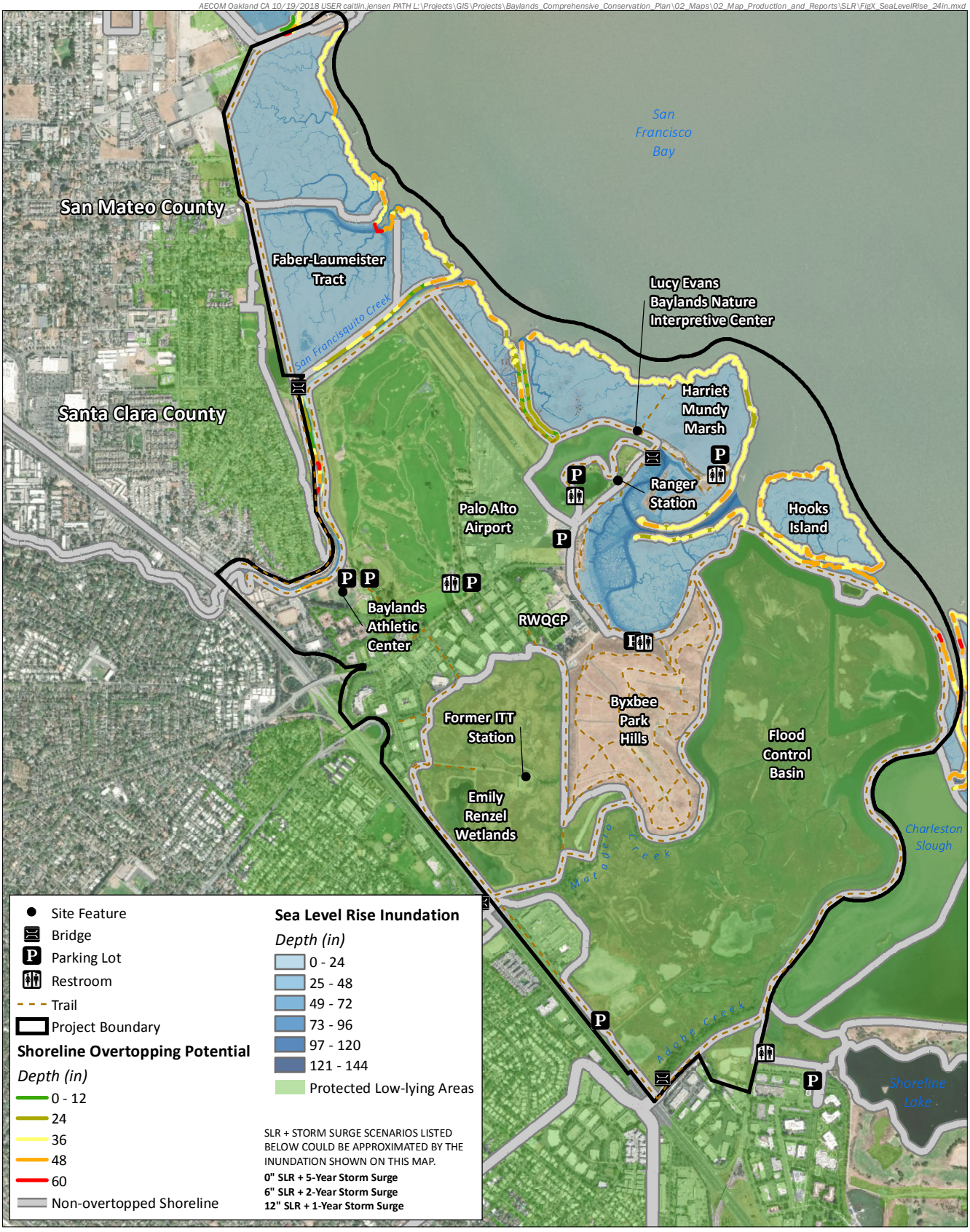

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FIGURE 3

MHHW + 24" Sea Level Rise

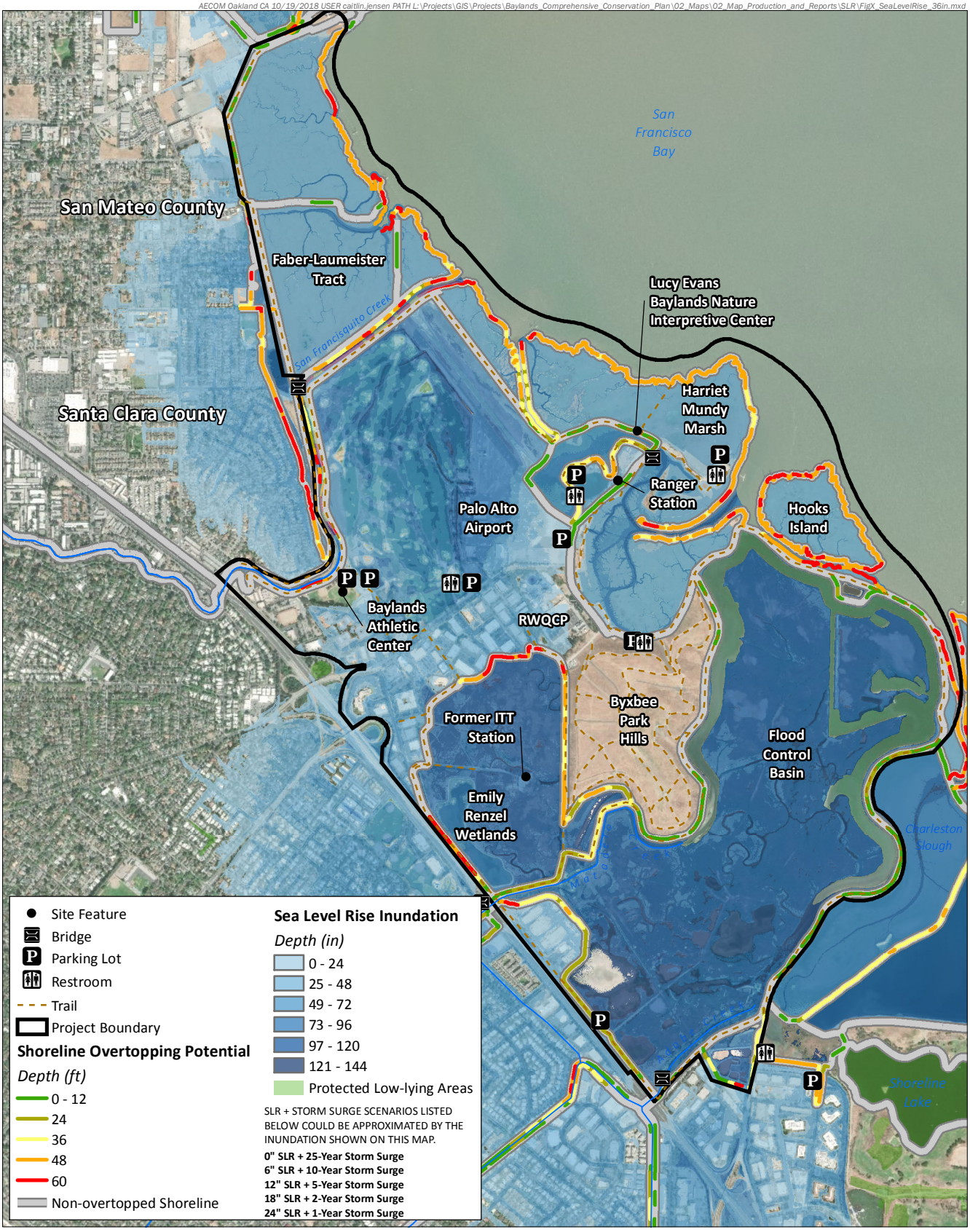

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FIGURE 4

MHHW + 36" Sea Level Rise

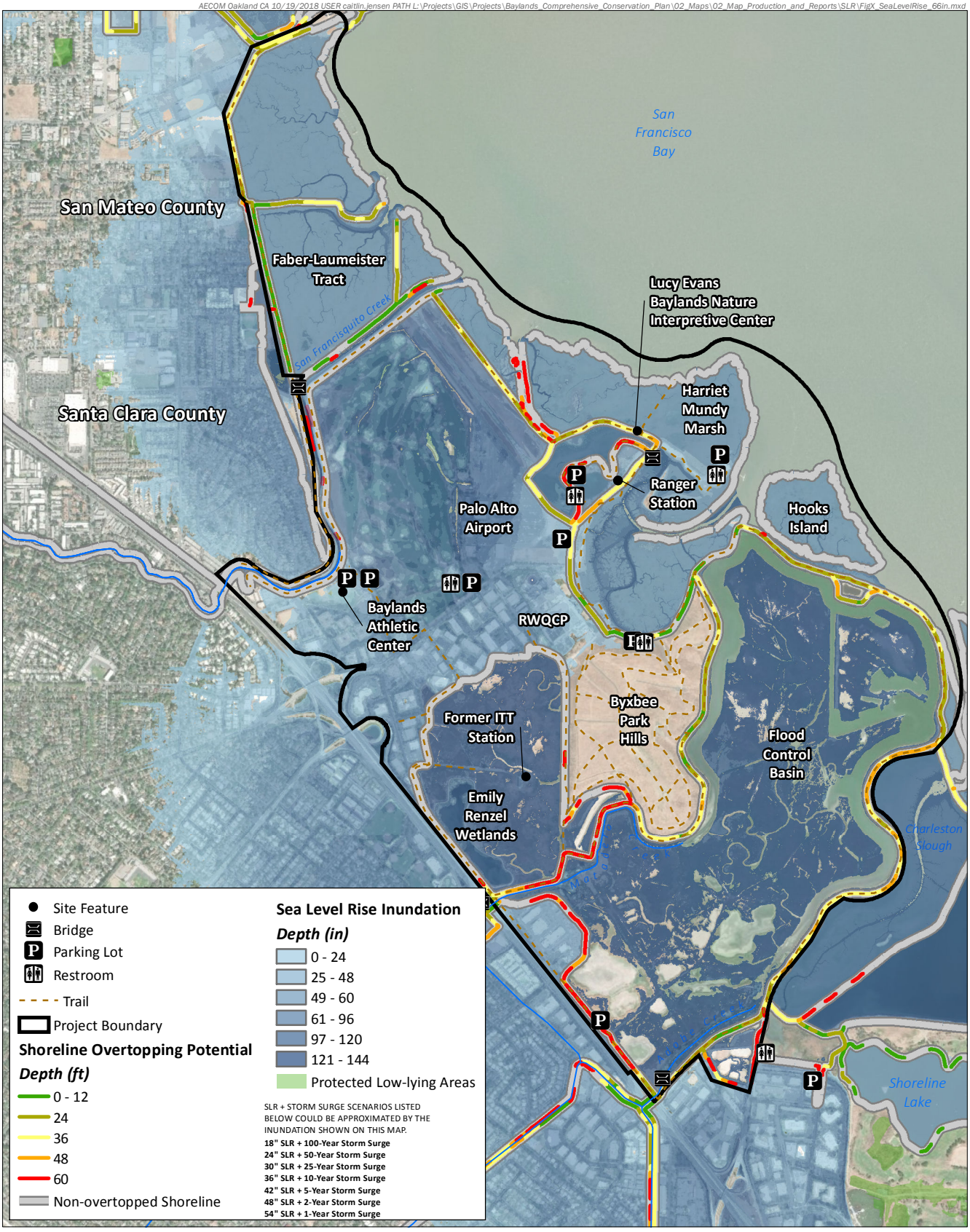

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FIGURE 5

MHHW + 66" Sea Level Rise

4 Impacts

An initial assessment of the Baylands' exposure to sea level rise was performed, using inundation maps to evaluate the potential vulnerability of Baylands features and assets to permanent inundation. A "no action" scenario was assumed to examine the effect of not implementing strategies to protect existing assets.

Some sections of the Baylands, such as the unprotected Harriet Mundy Marsh and Faber-Laumeister Tract, are already exposed to the MHHW + 12-inch scenario during the exceptionally high tides known colloquially as "King Tides." However, the Baylands do not experience a tipping point for coastal inundation until the MHHW + 36-inch scenario occurs. During that scenario, portions of many protective levees and dikes would be overtopped, causing widespread inundation throughout the Baylands. Because the MHHW + 36-inch scenario is equivalent to a 50-year coastal storm event under existing conditions, portions of the Baylands could experience temporary flooding during a storm today. Also, nearly all of the Baylands (except for Byxbee Park) are located in low-lying protected areas, making these areas susceptible to flooding during heavy rain, which may cause local ponding.

Table 2 summarizes the analysis of inundation exposure by geographic location. The table lists the asset category (flood control, access and recreation, or nonrecreational features) that corresponds to each feature in parentheses after the asset name. Sections 4.1 through 4.3 provide additional details regarding inundation pathways and potential consequences for the specific assets in each category.

Table 2. Summary of Sea Level Rise Exposure for Baylands Assets

Baylands Assets	Sea Level Rise and Equivalent Storm Surge Scenario			
	MHHW + 12-Inch (King Tide)	MHHW + 24-Inch (5-year storm)	MHHW + 36-Inch (50-year storm)	MHHW + 66-Inch (100-year storm + 24-inch sea level rise)
Major Roadways				
Embarcadero Road (access and recreation)			✓	✓
East Bayshore Road (access and recreation)			✓	✓
Byxbee Park				
Trails (access and recreation)				
Interpretive signs (access and recreation)				
Byxbee parking lot (access and recreation)				✓
Restroom (access and recreation)				
Regional Water Quality Control Plant				
Regional Water Quality Control Plant (nonrecreational features)			✓	✓
"You Are Here" sign (access and recreation)			✓	✓
Permanently installed art ["Riding the Currents"] (access and recreation)			✓	✓

Baylands Assets	Sea Level Rise and Equivalent Storm Surge Scenario			
	MHHW + 12-Inch (King Tide)	MHHW + 24-Inch (5-year storm)	MHHW + 36-Inch (50-year storm)	MHHW + 66-Inch (100-year storm + 24-inch sea level rise)
Palo Alto Municipal Golf Course				
Golf course (access and recreation)			✓	✓
"You Are Here" sign (access and recreation)				✓
Permanently installed art ["Birdie"/Kaikoo V"] (access and recreation)			✓	✓
Golf course parking lot (access and recreation)			✓	✓
Restroom (access and recreation)			✓	✓
Palo Alto Airport				
Runway (nonrecreational features)			✓	✓
Airport terminal (nonrecreational features)			✓	✓
Emily Renzel Wetlands				
Former ITT property and access road (nonrecreational features)			✓	✓
Matadero Creek bridge (access and recreation)				✓
Interpretive signs (access and recreation)			✓	✓
"You Are Here" sign (access and recreation)				✓
Wildlife viewing platform (access and recreation)			✓	✓
Renzel Trail and Faber Bike Path (access and recreation)			✓	✓
Harriet Mundy Marsh and San Francisquito Trail				
Sailing station parking lot (access and recreation)				✓
Sailing station (access and recreation)	✓	✓	✓	✓
EcoCenter (nonrecreational features)	✓	✓	✓	✓
Interpretive signs (access and recreation)	✓	✓	✓	✓
"You Are Here" sign (access and recreation)			✓	✓
Lucy Evans Baylands Nature Center (access and recreation)			✓	✓
Nature center boardwalk (access and recreation)	✓	✓	✓	✓
Wildlife viewing platform (access and recreation)	✓	✓	✓	✓
Restroom (access and recreation)				✓
Trails (access and recreation)	✓	✓	✓	✓
Flood Control Basin				
Tide gate (flood control)			✓	✓
Flood Control Basin parking lot (access and recreation)			✓	✓
Animal services center (nonrecreational features)			✓	✓
"You Are Here" sign (access and recreation)			✓	✓
Adobe Creek Loop Trail (access and recreation)			✓	✓

Baylands Assets	Sea Level Rise and Equivalent Storm Surge Scenario			
	MHHW + 12-Inch (King Tide)	MHHW + 24-Inch (5-year storm)	MHHW + 36-Inch (50-year storm)	MHHW + 66-Inch (100-year storm + 24-inch sea level rise)
Faber-Laumeister Tract				
East Palo Alto Marsh Trail (access and recreation)			✓	✓
Friendship Bridge (access and recreation)				
Duck Pond				
Baylands Ranger Station (nonrecreational features)			✓	✓
"You Are Here" sign (access and recreation)			✓	✓
Duck pond parking lot (access and recreation)			✓	✓
Restroom (access and recreation)			✓	✓
Save the Bay nursery (nonrecreational features)			✓	✓
Baylands Athletic Center and Central Business Plaza				
San Francisquito Creek stormwater pump station (nonrecreational features)		✓	✓	✓
"You Are Here" signs (access and recreation)			✓	✓
Permanently installed art ["Streaming"] (access and recreation)				
Athletic center and ballpark parking lots (access and recreation)			✓	✓
Baylands Athletic Center (access and recreation)				✓
Former Los Altos Treatment Plant Site				
Adobe Creek Bridge (access and recreation)				✓
Restroom (access and recreation)			✓	✓
Terminal Boulevard parking lot (access and recreation)			✓	✓

Notes:
Flood Control Basin = Palo Alto Flood Control Basin; MHHW = mean higher high water

4.1 Flood Control

The Palo Alto Flood Control Basin is a 585-acre floodwater retention basin that receives inflow from Matadero, Adobe, and Barron creeks and the Coast Casey Stormwater Pump Station. Incoming floodwaters are stored in the basin and released to the Bay through a gravity-driven tide gate structure when water levels in the Flood Control Basin exceed the Bay's tidal elevation. As the Bay's tides rise, the tide gate closes to prevent Bay water from entering the basin. The City of Palo Alto opens the tide gate in the summer to allow water to circulate in the basin.

During the MHHW + 36-inch scenario, the tide gate and levee barriers would become vulnerable to overtopping by elevated Bay tides. The depth of flooding caused by such overtopping ranges from 12 to 24 inches along the basin's north and east sides and from 24 to 60 inches on the south and southwest sides of the basin levee (Figure 4). When Bay waters would enter the basin, the capacity and efficiency of the flood control structure may be reduced further. Coastal floodwaters may spill into neighboring basins and wetlands, and may back up the lower reaches of nearby creeks. The potential also exists for scouring of the levee walls, and for levee failure during overtopping events.

Depending on its size, extent, and location, levee failure could lead to widespread flooding of adjacent development and loss of the Flood Control Basin.

4.2 Access

The Baylands accommodate a wide range of public and recreational activities such as running, cycling, water sports, golfing, picnicking, and wildlife viewing. Flood exposure to roads, trails, and other public access areas was evaluated to assess the impacts of human use of the Baylands.

4.2.1 Access to and within the Baylands

Embarcadero Road and East Bayshore Road are the primary access routes into the Baylands and connect the area's major assets. During the MHHW + 36-inch scenario, floodwater would overtop protective levees and dikes, and both roads would be exposed to permanent inundation. Once these primary routes are inundated, overland access to Baylands assets would be extremely limited.

The Adobe Creek and Matadero Creek bridges were identified as vulnerable to future flooding conditions. Although much of the area surrounding the bridges would be inundated under the MHHW + 36-inch scenario, the bridge approaches would not be exposed to coastal flooding until the MHHW + 66-inch scenario occurs. Loss of bridge crossings would access to and within the Baylands. Depending on bridge design and flood velocity, the bridges may also sustain long-term structural damage.

4.2.2 Trails

The Baylands have a network of public, multiuse trails extending through the region for more than 18 miles. Trails located along the Bay in the unprotected Harriet Mundy Marsh, including approximately 1 mile of the San Francisquito Creek Trail, are first exposed to inundation during the MHHW + 12-inch scenario (King Tides).

The MHHW + 36-inch scenario represents a tipping point when portions of nearly all of the area's trails are exposed to permanent inundation. Byxbee Park is the only area of the Baylands not anticipated to be permanently inundated under the sea level rise scenarios evaluated. However, as sea levels rise, the former landfill at Byxbee Park should be protected to prevent the release of contaminants.

Permanent inundation would affect much of the access to the Baylands' trail system. Flooding would inhibit regional connectivity, as the San Francisquito Creek Trail also provides a link to the San Francisco Bay Trail, the City of East Palo Alto, and points beyond. Similarly, flooding of the Renzel Trail would eliminate a pedestrian link to other sites outside of the Baylands, including the City of Mountain View.

The many location maps and interpretive signs located along the trails are vulnerable to future inundation. However, signage has a high capacity for adaptation and can be relocated relatively easily.

4.2.3 Other Public Access Areas

The Baylands provide access to numerous public access and recreation opportunities, educational facilities, and wildlife access areas. Assets such as the sailing station, sailing station parking lot, Lucy Evans Nature Center Boardwalk, and wildlife viewing platform, located in the unprotected Harriet Mundy Marsh, are the first to be exposed to permanent inundation during the MHHW + 12-inch scenario.

Overtopping of the protective levees and dikes during the MHHW + 36-inch scenario would expose most public access areas and facilities. Permanent inundation of public facilities would result in a loss of recreational options in the area and will require removal or relocation of buildings.

Many permanent art installations are located throughout the Baylands and may be exposed to coastal inundation, especially during the MHHW + 36-inch scenario. Depending on their construction material, many of the pieces may be sensitive to water, but can be relocated.

4.3 Nonrecreational Features and Facilities

In addition to public recreation, the Baylands has several nonrecreational features and facilities, including several critical assets such as the Palo Alto Airport and the Regional Water Quality Control Plant (RWQCP). An inundation exposure analysis was completed to evaluate how future water levels may affect these assets in the absence of additional flood protection.

4.3.1 Palo Alto Airport

The Palo Alto Airport terminal and runway are located close to the Bay and largely protected by a Bayfront levee that is not accredited under FEMA's flood protection standards. Both the runway and the terminal would be first exposed to coastal inundation during the MHHW + 36-inch scenario. Inundation would cut off access to the airport, which may also limit emergency response capabilities.

4.3.2 Regional Water Quality Control Plant

The RWQCP would be exposed to permanent inundation under the MHHW + 36-inch scenario. Many of the plant's features are highly sensitive to water, which could lead to large amounts of damage if they are exposed, even temporarily. Pollutants may be introduced to the Bay if plant operations cease.

4.3.3 Former ITT Property

The buildings at the former ITT property and access road would be vulnerable to coastal inundation during the MHHW + 36-inch scenario. Even temporary flooding could damage the buildings.

4.3.4 Other Nonrecreational Facilities

The EcoCenter, located in the unprotected Harriet Mundy Marsh, would be subject to coastal inundation during the MHHW + 12-inch scenario. By the MHHW + 36-inch scenario, facilities such as the Baylands Ranger Station and the Save the Bay plant nursery would be exposed to inundation. Permanent inundation would result in a loss of use for the area, cessation of ranger station operations, and a loss of growing space for many plants used in local restoration projects.

The San Francisquito Creek Stormwater Pump Station, located along East Bayshore Road near San Francisquito Creek, may be exposed to inundation during the MHHW + 24-inch scenario. Pump stations contain electrical and mechanical components highly sensitive to flood exposure. Rising sea levels may also overwhelm the capacity of the pump station and cause localized flood conditions in the southwest portion of the Baylands, which is served by the pump.

4.4 Habitats

Elevation-based habitat maps were produced by Point Blue's Future Tidal Marshes Tool for the present day (baseline year set to 2010) and 2050. Figure 6 displays the baseline (2010) map, showing the present-day elevation and associated general habitat types, according to the Future Tidal Marshes Tool. The results are driven by elevation compared to MHHW; therefore, the habitat types shown serve as a general proxy for their associated elevations. The map can be interpreted as the expected default habitat type by elevation under a no-management scenario (e.g., levees, pumping).

As shown in Figure 6, the elevation-based estimates of the Baylands' present-day habitat types include higher elevation mid marsh (depicted as dark green) along the Bayside marshes including Faber Marsh, Laumeister Marsh, and tidal marshes on the Bay side of the Baylands levees, and in the Palo Alto Harbor and Hooks Island areas. Because of their higher elevation, Byxbee Park and the area between the Palo Alto Golf Course and the harbor are shown as upland habitat (depicted as light green), which accurately represents the present-day habitat type. The golf course, based on its low-lying elevation alone, is represented as mudflat in the model (depicted as brown), although it is actually managed as an upland golf course system. The remaining Baylands areas are shown mostly as being at subtidal and mudflat elevations, which is consistent with the Flood Control Basin's role as a flooding catchment basin. Low marsh (depicted as bright green) is shown scattered throughout the mid marsh and mudflat habitats. Subtidal areas (depicted as light blue) are areas of elevation below the tidal inundation line and are generally consistent with the present-day locations of standing water.

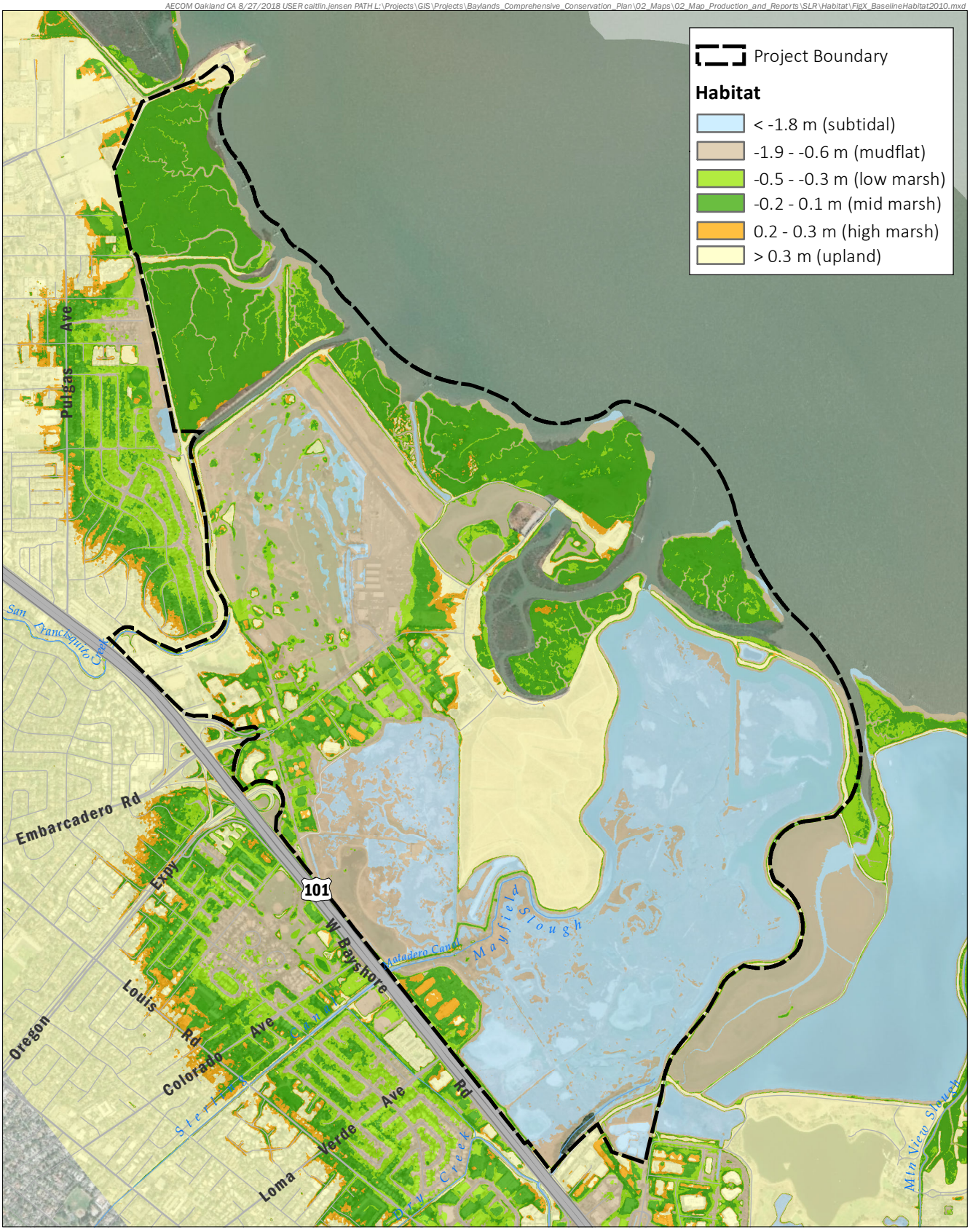
Figure 7 shows the Baylands' elevation-based habitat types for the year 2050 under a low-sedimentation, low-organic-materials scenario. This scenario represents one end of the range of potential future habitat scenarios. Figure 8, which shows the elevation-based habitat types for the year 2050 under a high-sedimentation, high-organic-materials scenario represents the opposite end of the range.

Both scenarios show sediment accretion and an overall rise in the elevation of the Baylands preserve. The low-sedimentation, low-organic-materials scenario depicts mild accretion of marsh habitats and overall elevation, while the high-sedimentation, high-organic-materials scenario depicts conversion of nearly the entire Baylands area beyond Byxbee Park and Mayfield Slough to mid marsh.

Under the potential low-sedimentation, low-organic-materials scenario, the landscape is expected to remain at a lower elevation, close to baseline conditions. Deposition of organic materials and sedimentation would lead to marsh accretion, shown as a transition from the lower lying subtidal areas to higher elevation mudflats. Under this scenario, the Bayside's present-day mid marsh wetlands would remain mid marsh wetlands. The Palo Alto Golf Course, if unmanaged, would accrete sediment and rise in elevation, transitioning to low marsh. Byxbee Park is expected to remain upland; however, the sliver of upland between the golf course and the park would be reduced in scale and an increase in wetland area may occur along the edges.

According to the model mapping results, under the potential high-sedimentation, high-organic-materials scenario, the landscape would accrete sediment, raising the overall elevation to potentially support mid marsh wetlands throughout the entire Baylands (Figure 8). Under this scenario, the Bayside wetlands are expected to remain at a mid marsh elevation and Byxbee Park would remain at an upland elevation. The open water of Matadero Slough in the Flood Control Basin would remain as subtidal open water in this scenario.

It is important to remember that the models predict changes to the landscape's elevation under a no-management scenario and do not predict changes incorporating land management, such as dredging and other elevation-controlling activities. Furthermore, the model does not consider existing levees. Therefore, the selected scenarios should be interpreted as showing how the landscape could change if the levees no longer functioned. Raising the existing levees and implementing further flood protection solutions, assuming that water management of the marshes and Flood Control Basin would remain as is, would allow habitats landward of the levees to remain more similar to existing conditions. Management of the Baylands landscape and elevations will be essential to determining the future conditions suitable for maintaining marshland habitats.



Point Blue Conservation Science, 2018;
Esri Imagery, 2016

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Palo Alto Baylands Comprehensive Conservation Plan

FIGURE 6

Year 2010: Elevation-based Habitat Baseline

AECOM Oakland CA 8/27/2018 USER caitlin.jensen PATH L:\Projects\GIS\Projects\Baylands_Comprehensive_Conservation_Plan\02_Maps\02_Map_Production_and_Reports\SLR\Habitat\FigX_2050_LowSed_LowOrg.mxd

Point Blue Conservation Science, 2018;
Esri Imagery, 2016

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FIGURE 7

Year 2050: Elevation-based Habitat Low Sediment/Low Organic Materials

AECOM Oakland CA 8/24/2018 USER caitlin.jensen PATH L:\Projects\GIS\Projects\Baylands_Comprehensive_Conservation_Plan\02_Maps\02_Map_Production_and_Reports\SLR\Habitat\FigX_2050_HighSed_HighOrg.mxd

Point Blue Conservation Science, 2018; Esri Imagery, 2016

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FIGURE 8

Year 2050: Elevation-based Habitat High Sediment/High Organic Materials

Table 3 shows a summary of sea level rise exposure and projected habitat type conversion for Baylands habitat assets, based on Point Blue's Future Tidal Marshes Tool.

Table 3. Summary of Sea Level Rise Exposure and Projected Habitat Type Conversion

Present-Day Location	Sea Level Rise Scenario[1]	Projected Future Habitat Type[2]	
		2050 Low-Sediment, Low-Organic-Materials Scenario[3]	2050 High-Sediment, High-Organic-Materials Scenario[3]
Duck Pond Tidal lagoon	MHHW + 36-inch	Conversion to low marsh Maintenance as lagoon	Mid marsh
Tidal/salt marsh: Harriet Mundy Marsh Faber-Laumeister Tract	MHHW + 12-inch	Mid marsh (through 2100)	Mid marsh (through 2100)
Diked/muted salt marsh: Flood Control Basin (present-day subtidal and mudflat habitats)	MHHW + 36-inch	Mudflat	Mid marsh
Emily Renzel Wetland (marsh) Pond Former ITT property	MHHW + 36-inch	Mudflat Open water Mid marsh	Mid marsh Mid marsh Pond
Riparian corridors: Matadero Creek Mayfield Slough Adobe Creek San Francisquito Creek	MHHW + 12-inch	Riparian corridor conversion to brackish marsh streambank	Riparian corridor conversion to brackish marsh streambank
Uplands habitat: Byxbee Park	N/A	Upland	Upland

Notes:
Flood Control Basin = Palo Alto Flood Control Basin; MHHW = mean higher high water; N/A = not applicable
1 The sea level rise scenario that was mapped at which the habitat type is first projected to be affected.
2 Data from Point Blue Conservation Science's Future San Francisco Bay Tidal Marshes planning tool.
3 Projected habitat type changed based on a no-management scenario.

4.4.1 Duck Pond and Tidal Lagoon

The Duck Pond and tidal lagoon are low-lying areas of the Baylands that are currently protected by a series of levees and dikes for up to MHHW + 36 inches of sea level rise. Once sea levels rise above this level, the area would be exposed to permanent inundation, resulting in a transition of habitats.

Based on existing conditions, the habitats in this area consist of open water and fringing tidal brackish marsh because freshwater inflow mixes with the saltier Bay water. Under the low-sedimentation, low-organic-materials scenario, the landscape would likely remain similar to present-day conditions up to MHHW + 36 inches of sea level rise. The Future Tidal Marshes Tool predicts that beyond MHHW + 36 inches of sea level rise, the brackish water lagoon (fed by a pipe connected to the Bay) would remain open water and the Duck Pond may accumulate sediment and organic material and fill in to transition into a low marsh habitat. A grove of palm trees northwest of the Duck Pond is protected by fencing and designated as a bird sanctuary for herons and egrets, which used this area as a rookery

during breeding season in 2005–2010. Rising sea levels may cause this palm tree grove to become exposed to brackish water. Although palm trees support a higher level of salinity than other tree species, significant increases in salinity through intrusion of brackish water could reduce the viability of these trees. In addition, the areas fringing the lagoon could begin to fill in and covert to low marsh.

The Future Tidal Marshes Tool predicts that under the high-sedimentation, high-organic-materials scenario, marsh habitats would accrete and the Duck Pond and lagoon could become mid marsh habitat if sea levels exceed MHHW + 36 inches and the surrounding levees no longer protect the area.

4.4.2 Tidal Marsh/Salt Marsh

Tidal marsh in the Baylands is subject to tidal action and tidal brackish marsh occurs in areas of the Baylands where freshwater locally reduces salinity. For the tidal marsh and salt marsh habitats, the Future Tidal Marshes Tool was used to assess the effects of sea level rise on the composition of marsh habitat. As shown in Table 3, the Harriet Mundy Marsh and Faber-Laumeister Tract are would be exposed to sea level rise at MHHW + 12 inches and MHHW + 36 inches, respectively.

The Future Tidal Marshes Tool predicts that under the low-sedimentation, low-organic-materials scenario, the habitats at Faber-Laumeister Tract, Harbor Point and the inner harbor channel, Harriet Mundy Marsh, Hooks Island, and Sandpoint would remain as mid marsh habitat into 2100. Habitat types are projected to maintain accretion rates comparable to future sea levels. Lower lying areas that currently consist of mudflat and higher areas of high marsh are projected to become more equilibrated in elevation and to convert to mid marsh habitat. The high-sedimentation, high-organic-materials scenario is also projected to maintain accretion rates comparable to future sea levels, with little to no expected change in marsh habitats.

According to the Future Tidal Marshes Tool, the only scenario in which elevation-based marsh habitat is projected to change type is a scenario of high sea level rise and low sedimentation. In this scenario, the rising sea levels would slowly outpace the sediment accretion rate, and the mid marsh and high marsh habitats could transition to low marsh and mudflat habitats.

4.4.3 Diked/Muted Salt Marsh

4.4.3.1 Flood Control Basin

The Flood Control Basin, the Emily Renzel Wetlands, the site of the former Los Altos Treatment Plant, and the newly acquired former ITT property would protected by levees tying into Byxbee Park for up to MHHW + 36 inches of sea level rise. Existing habitat types consist of managed diked or muted salt marsh. Beyond MHHW + 36 inches, the Flood Control Basin would be overtopped, exposing the habitats landward of the levees to sea level rise.

The existing tide gate system controls the Flood Control Basin's tidal action and freshwater outflows, causing the basin to have muted tidal flows. As a result, the northern area of the Flood Control Basin, the area closest to the tide gate, experiences more saline conditions than the southern area. The southern portion of the basin is mostly dry, with marsh panne formations present throughout, indicating seasonal ponding. A large open area in the northeastern corner of the basin is denuded of vegetation and supports roosting by numerous seabirds throughout the day.

According to the Future Tidal Marshes Tool, under the potential low-sedimentation, low-organic-materials scenario, these areas would accumulate sediment and convert from present-day subtidal and mudflat elevations to a homogenous mudflat elevation. The model

infers that the elevation of these areas would increase slightly as a result of the increase, albeit low, in sediment and organic materials, thus allowing more marsh habitat to accumulate as the overall elevation rises.

Under the potential high-sedimentation, high-organic-materials scenario, these areas are expected to accumulate sediment and organic materials at a greater rate than under the low-sedimentation, low-organic-materials scenario. The elevation increase could lead to a conversion to a mid marsh elevation habitat complex, with the channel areas remaining open water.

4.4.3.2 Emily Renzel Wetlands and former ITT Property

The present-day Emily Renzel Wetlands and the former ITT property comprise muted tidal wetland habitat, with a portion of the site consisting of a restored freshwater pond fed by tertiary-treated wastewater from the RWQCP. If sea level rise causes salt water to intrude into the pond, the present habitat type would likely transition to a brackish marsh habitat and the plant community would likely change accordingly. Existing freshwater wetland plants would likely decline and new brackish water–tolerant plant species would establish. Cattail could remain present depending on the amount of salinity, but other more saline-tolerant species could also establish.

The sea level rise scenarios for MHHW + 36 inches and MHHW + 66 inches show that these areas, under a no-management scenario, will likely be inundated under several feet of water as Bay water overtops the levee structures, fills in the Flood Control Basin, and flows into the Emily Renzel Wetlands. According to the Future Tidal Marshes Tool, under the low-sedimentation, low-organic-materials scenario at 2050, the Emily Renzel Wetlands would convert to mudflat, the former ITT property (at a higher elevation) would convert to mid marsh, and the pond would remain open water. Under the high-sedimentation, high-organic-materials scenario at 2050, the Emily Renzel Wetlands and former ITT property would accrete and convert to mid marsh habitat and the pond would remain open water.

If these areas were to become completely inundated, the marsh habitats would likely become open water rather than marsh, as the marsh would not be able to keep pace with several feet of sea level rise. The amount of inundation and management actions would ultimately determine the ground elevation and water levels, thereby defining the resulting habitat types in these areas.

4.4.4 Riparian Corridors

The habitats and riparian corridors of Matadero Creek and Mayfield Slough, Adobe Creek, and San Francisquito Creek will be largely affected by the increased salt water inflow up the creek corridors as sea level rises. As sea level rises, the tideline location where freshwater and salt water converge will move upstream, causing the amount of salt water to increase throughout the Baylands' riparian corridors.

The Matadero Creek and Adobe Creek riparian corridors currently consist of a mix of native and nonnative riparian species that largely depend on fresh groundwater, acquiring water for survival through their root systems. The habitat composition of the riparian corridors could be affected as the creeks become more saline. The riparian tree species that presently grow alongside the creeks depend on fresh groundwater and have little salinity tolerance. If saline water intrudes into the local groundwater sources, the health of the established tree populations may decline, thereby reducing the amount of riparian tree habitat. Saline-tolerant species such as pickleweed may replace the trees along the creeks, shifting the creeks' estuarine habitats farther inland and pushing the freshwater-dominant riparian corridors farther upstream. This transition will have secondary impacts by reducing the number of

freshwater-dependent shade tree canopies in the Baylands.

4.4.5 Upland

The upland habitat of Byxbee Park comprises annual nonnative Euro-Asian grassland species that have become naturalized to the region. This habitat is not expected to be substantially affected by sea level rise under any condition, as it is located at a higher elevation than any of the evaluated sea level rise scenarios. Although most of Byxbee Park would remain unchanged under the modeling scenarios, the bayside of the landfill levee road may evolve and become more marsh-like if the surrounding habitats are converted to brackish marshland or brackish open water. Other climate stressors, such as temperature and precipitation, could alter future growing seasons and the amount of freshwater soil moisture available. Changes in growing seasons and soil moisture content may cause changes in the composition of plants and the wildlife that depend on existing conditions. Species with broader temperature and precipitation tolerances are likely to persist better than highly specialized species.

4.5 Wildlife

Impacts on wildlife will be driven primarily by habitat transitions. Based on the MHHW + 36-inch sea level rise scenario, the Duck Pond and tidal lagoon would accrete and to fill in with marsh vegetation. Under this scenario, the grove of palm trees currently located northwest of the Duck Pond could decline, eliminating suitable nesting habitat for herons and egrets.

The tidal lagoon currently serves as important foraging and nesting habitat for overwintering shorebirds and waterfowl that migrate seasonally along the Pacific Flyway. As the existing habitat changes from mudflats to mid marsh, the invertebrate community and migratory birds dependent on mudflats may be affected.

The present-day outer tidal mid marsh habitats are projected to be unaffected by rising sea levels through the late-century projections. The stable mid marsh habitat will continue to provide habitat for mid marsh–dependent wildlife, including the federally listed endangered salt marsh harvest mouse and Ridgway's rail, which are found only in this habitat type. Other more common species occurring in mid marsh that will continue to be supported include black rail (*Laterallus jamaicensis*), Virginia rail (*Rallus limicola*), and sora (*Porzana carolina*).

If Bay levels exceed the Flood Control Basin's walls, as expected during the MHHW + 36-inch sea level rise scenario, much of the Baylands will be inundated with brackish water. Increased saline water creates an opportunity for expansion of tidal marsh species, including rail species and the salt marsh harvest mouse. Seabird roosting habitat may transition as large open areas become inundated or filled in with dense marsh vegetation.

A freshwater pond is located in the muted tidal Emily Renzel Wetlands. Wildlife species associated with freshwater ponds include sora, rails, herons, egrets, and passerine species, as well as amphibian and turtle species. If sea levels exceed levee elevations and inundate the Emily Renzel Wetlands, the berm surrounding the freshwater pond could become overtopped and infiltrated with brackish water, affecting the freshwater plant communities and wildlife associated with the pond.

Along riparian corridors, an increase in brackish water and saline conditions may cause the riparian tree canopy to decrease. A loss of riparian habitat will result in a loss of nesting areas for many canopy-dependent wildlife, including songbird and raptor species.

The upland nonnative grassland habitat at Byxbee Park is expected to remain largely unchanged by sea level rise, given its higher relative elevation. Therefore, it is assumed that the wildlife species found in Byxbee Park will remain consistent. However, the loss of surrounding marsh habitat will cause upland habitat to become isolated and less connected to surrounding upland habitats, potentially reducing overall habitat quality.

Beyond sea level rise, changes in climatic conditions such as temperature and precipitation could alter future growing seasons, along with the amount of freshwater soil moisture available. These changes could ultimately lead to a change in the composition of plants and the wildlife that depend on them. Species with broader temperature and precipitation tolerance are likely to persist better than highly specialized species.

5 Management Adaptations to Sea Level Rise

The following discussion presents a range of high-level risk reduction solutions for habitats, wildlife, flood control, access and recreation, and nonrecreational features and facilities, to be evaluated for implementation within the planning time frame of the Baylands Comprehensive Conservation Plan. Adaptation strategies may include physical, governance, and informational strategies that may be used to better prepare the Baylands for future environmental conditions as a result of sea level rise.

5.1 Flood Control

The flood control basin tide gate and levees are overtopped during the MHHW + 36-inch scenario, which may reduce the ability of the structures to provide flood protection. Potential adaptation strategies are discussed below.

Physical

- Expand the flood retention capacity area by connecting with other basins (SCVWD 2016).
- Introduce pumps to efficiently discharge stored floodwaters (SCVWD 2016).
- Modify the elevation of the levee walls and tide gate (SCVWD 2016).
- Replace the tide gate structure to improve the functionality of the flood barrier system (SCVWD 2018). (Project completion is scheduled for mid-2022.)
- Construct horizontal/living levees (such as an expanded version of the Oro Loma Sanitary District's experimental levee) and tidal marshes to provide large-scale flood protection for a greater geographic area, and to create the potential for increased tidal action (SFCJPA 2015).

Governance

- Incorporating sea level rise language into guidance documents (e.g., Baylands Master Plan, the Palo Alto Comprehensive Plan, and the City of Palo Alto Design Standards, City of Palo Alto Storm Drain Master Plan) and emergency plans to provide a means for guiding future decision making
- Use comparable sea level rise scenarios across City departments and external agencies, and in compliance with various local legislative requirements, to provide a consistent level of protection for the region.

Informational

- Develop monitoring programs to evaluate the impacts of sea level rise on Baylands operations and physical damage caused by ongoing flooding events.
- Identify and address data gaps by conducting studies to better understand the flood risks to the Baylands' critical infrastructure.

5.2 Access

To maintain uninterrupted Baylands access, the following strategies are considered for roadways and trails.

5.2.1 Access to and within the Baylands

Critical roadways are exposed during the MHHW + 36-inch scenario, which will limit access to Baylands assets and could inhibit emergency access. Potential adaptation strategies are discussed below.

Physical

- Elevate critical roadways to maintain public and staff access to and within the Baylands.
- Add alternative transportation routes within the Baylands area to increase the redundancy of roadway access.
- Upgrade current pedestrian paths to be used as alternative emergency evacuation routes during flood events.

Governance

- Incorporate coastal flooding scenarios into emergency planning and decision-making processes that involve evacuations to avoid flood damage and ensure public safety in the Baylands.

5.2.2 Trails

Nearly all multiuse trails, interpretive signs, and public art are exposed to flooding during the MHHW + 36-inch scenario, thus limiting recreational use of the Baylands and diminishing regional trail connectivity. Potential adaptation strategies are discussed below.

Physical

- Reroute pedestrian trails to increase redundancy for visitor and staff access.
- Elevate low-lying trails or incorporate a boardwalk into trail design to maintain access during high-water events.
- Abandon or relocate low-lying trails that experience frequent flooding to allocate resources to protecting other Baylands assets.
- Relocate, elevate, or adapt interpretive signage and public art, as necessary, to maintain their function.

Governance

- Incorporating sea level rise language into guidance documents (e.g., Baylands Master Plan, the Palo Alto Comprehensive Plan, and the City of Palo Alto Design Standards, City of Palo Alto Storm Drain Master Plan) and emergency plans to provide a means for guiding future decision making
- Incorporate language about sea level rise and flood protection measures into trail plans and maintenance plans to provide a mechanism for adapting future trail placement and/or preserving trails.

Informational

- Install signage along trails regarding flood protection and future flood challenges to update visitors about ongoing climate adaptation programs and opportunities.
- Establish an ongoing monitoring program to track instances of trail flooding, and thus to provide a means to quickly identify trails, or trail sections, that experience repeat flooding conditions. This information can also inform the process of adapting vulnerable trails (e.g., boardwalk installations) or relocating trails for which maintenance is not cost effective.

5.3 Nonrecreational Features and Facilities

The Palo Alto Airport, the RWQCP, and the former ITT property are exposed to sea level rise during the MHHW + 36-inch scenario, which may cause flood damage to sensitive assets and cut off access to critical facilities. Potential adaptation strategies are discussed below.

Physical

- Flood-proof facilities where possible to prevent damage from temporary flooding conditions. Flood-proofing techniques include:
  - elevating structures to allow floodwaters to pass through quickly, thereby minimizing flood damage;
  - making buildings watertight up to expected flood heights; and
  - flood-proofing electrical equipment.
- Add backup power at on-site facilities, with sufficient fuel for several days, to minimize interruptions to critical assets.

Governance

- Incorporate sea level rise into Baylands and Palo Alto design standards for new infrastructure and improvements to protect critical elements of facility design.
- Collaborate with adjacent landowners, agencies, and organizations to find a shared, multi-objective, regional solution that can be planned and implemented through a joint effort.

Informational

- Conduct a study regarding the influence of sea level rise on groundwater levels and the associated impact of increased liquefaction potential during earthquakes to inform future site and emergency planning for critical facilities.
- Establish a flood emergency management plan for vulnerable facilities to limit on-site employees' injuries and potential loss of life.
- To inform long-term planning and priority setting, develop and maintain an asset management plan that includes asset-specific information such as location, age, elevation, condition, and replacement cost.
- Perform an economic analysis of critical assets to evaluate the cost of protecting the assets versus retreating or relocating the assets to sites less vulnerable to coastal flooding.

5.4 Habitats and Wildlife

If future sea levels overtop the levees during the MHHW + 36-inch scenario, nearly all Baylands habitat will transition to marshlands. Potential adaptation strategies are discussed below.

Physical

- Construct tidal marsh transition zones consistent with USFWS's Tidal Marsh Recovery Plan to enhance the habitat of threatened species that are vulnerable to sea level rise.
- Create strategic openings in the levees to connect interior habitats to the Bay and allow the growth of tidal marsh habitat to preserve vulnerable habitat areas.
- Implement climate-smart restoration plantings, consistent with the Silicon Valley 2.0 adaptation strategy, to promote vegetation with a wider climate tolerance zone.
- Create new tree roosting habitat for birds in areas with a freshwater source suitable of supporting riparian species to expand vulnerable habitats.

Governance

- Consider the ecological impacts of water modifications on the landscape by collaborating with the Baylands Group, Point Blue, USFWS, and others during planning efforts.
- Take a community approach to habitat and wildlife restoration and persistence at the Baylands.

- Collaborate directly with regional and local planning efforts and surrounding partners, including SAFER Bay, Silicon Valley 2.0, and the neighboring Cities of Mountain View and East Palo Alto.

Informational

- Form a stakeholder working group and technical advisory committee to aid in development, management, funding, and implementation of actions to protect the Baylands.
- Implement climate-smart restoration plantings to increase the likelihood of long-term establishment.
- Implement water conservation and management initiatives for future-focused management of wetlands habitats.
- Install public signage to inform the public of sea level rise and landscape connectivity.

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