180 Grand Avenue
Suite 1050
Oakland, CA 94612
510.839.5066 phone
510.839.5825 fax

esassoc.com

memorandum

date October 8, 2019

to Andrea Pappajohn, Kevin Gardiner (City of Burlingame)

from Dane Behrens, PE; Ari Frink; Matt Brennan, PE; and Jim O'Toole

subject Development and Screening of Burlingame Shoreline Adaptation Strategies

This memorandum outlines priority adaptation strategies to address flood hazards along the shoreline of the City of Burlingame. It follows from the findings of a vulnerability assessment (ESA 2019) that built on the prior countywide study for San Mateo (County of San Mateo et al. 2018). The vulnerability assessments looked in detail at the sources, pathways, and extents of flood forecasts in Burlingame. These forecasts considered flooding from high San Francisco Bay water levels during the existing 100-year recurrence flood event (also referred to herein as the "100-year event" or "base flood event"), and the 100-year flood with several levels of sea-level rise to project future hazards. The findings of the vulnerability assessment were presented to a technical advisory committee and a group of local stakeholders on July 10, 2019.

Additionally, as part of the July technical advisory committee and stakeholder meetings, initial adaptation strategies were presented for five contiguous segments ("reaches") that comprise the Burlingame Shoreline (Figure 1). These range from upgrading or replacing the existing series of unaccredited shoreline berms and protection structures, to more passive strategies such as encouraging sediment delivery to the adjacent Bay mudflats and exploring living shoreline measures. Together, these strategies comprise key components of an overall plan for addressing sea-level rise in Burlingame. In this memorandum, we describe these strategies and suggest several priority strategies for each section of the Burlingame shoreline. This information is intended to provide the City with additional context for screening these strategies for suitability as preferred strategies going forward.

Section 1 below summarizes the main findings of this memorandum. Section 2 discusses the approach taken to identify the adaptation strategies, and Section 3 describes and evaluates each of the strategies in detail. Section 4 gives an overview of the screening process. Sections 5 and 6 discuss next steps and critical information gaps, respectively.

1. Summary of Findings

The main findings of this development and screening of adaptation measures for the Burlingame shoreline include the following:

- In general, the existing shoreline does not include Federal Emergency Management Agency (FEMA)-accredited levees or flood walls, and largely consists of a patchwork of raised pathways and shoreline embankments interspersed with short concrete walls. Shoreline elevations along this network are variable, with shoreline areas west of Broadway at the greatest risk of flooding in the short term. Much of the existing vulnerability to coastal flooding is from overtopping of the levee during coastal storm events that coincide with high tides.
- Raising the shoreline in Reaches 1 and 2 (from Millbrae boundary to Broadway) would have substantial benefits in terms of protecting private and public assets, including Highway 101.
- In the short term, raising the shoreline will likely require a combination of raising or building new levees in some areas while improving existing shoreline protection structures in other areas, given space constraints.
- The aesthetic and recreational impacts of raising the shoreline can be mitigated by integrating the Bay Trail on the improved shoreline.
- Raising the shoreline should be combined with a similar effort raising low-lying portions of the banks of El Portal, Mills, and Easton Creeks, to prevent coastally influenced flooding from these creeks. Improving the banks of El Portal Creek will require coordination with the City of Millbrae and the County of San Mateo.
- Just offshore along parts of Reaches 2, 3, and 5, there are opportunities to create or enhance Bay habitats (e.g., 'living shorelines'), although these should be considered complementary to the flood management approaches, since 'living shorelines' will not on their own prevent flooding. Where feasible, they should be combined with an improved flood barrier system along the shoreline.

2. Adaptation Strategies Development and Screening

Adaptation strategies were developed in response to findings from the prior vulnerability assessment (ESA 2019). In general, this showed:

- The most significant flood hazard was west of Broadway, shown as Reaches 1 and 2 in Figure 1 of the attachment.
- The primary flood pathway is overtopping of the Bay shoreline in Reaches 1 and 2 during the existing 100-year flood event for present day and plus 3.3 feet of sea-level rise (the 'medium' sea-level rise scenario). Higher amounts of sea-level rise further exacerbate flooding by backing up waters in the City's tidal creeks and generating significant flooding both north and south of Highway 101.
- Most of Reaches 1 and 2 are already mapped within the 100-year floodplain, as of the most recent FEMA maps that became effective in April 2019.

The primary approach in developing the series of flood adaptation strategies listed below was to first delineate the City's shoreline into five reaches. Each reach identifies a section of shoreline with similar coastal flood hazard, landward connectivity, existing flood management measures, and linked adaptation strategies. Then, the approach for each reach targeted specific flood pathways and considered viable adaptation strategies. The operational landscape units (SFEI 2019) along each reach were also reviewed for potential complementary habitat enhancement opportunities. For Reaches 1 and 2, this meant developing strategies that address low-lying parts of the shoreline and the creek embankments. For Reaches 3 and 4 (east of Broadway Ave), this meant focusing on low-lying portions of Anza and Burlingame Lagoon shorelines. The strategies include short-and long-term measures. Recommendations for the phasing of these measures will be provided in a subsequent memorandum.

These adaptation strategies have only been developed at a planning level, for purposes of coordinating a City-wide plan to adapt to sea-level rise. Coordination is required, since flooding can enter the developed areas from just one parcel, but then spread to inundate many more parcels. Many of the parcels which would host adaptation measures are privately owned. Permission to implement the measures would be needed for implementation, and the adaptation measures would need to be refined in coordination with each parcel owner's preferences. Refinements at the parcel scale are beyond the scope of this present study.

Adaptation strategies were screened using a series of criteria and considerations developed in collaboration with the City and technical advisor and stakeholder input received during the July 10 meeting. These criteria and considerations include:

Flood Management Criteria:

- Inundation reduction in protected areas
- Engineering competence for erosion, geotechnical, and seismic forces
- Parcel-to-reach scalability
- Adaptive capacity to sea-level rise

Economic Considerations:

- Does strategy reduce asset damages, particularly private property (e.g., buildings)?
- Does strategy provide protection for economically vulnerable groups working or living in the project area?
- Does strategy provide protection for public infrastructure in the project area (e.g., Wastewater mains)?
- Cost

Environmental Considerations:

- Does strategy protect existing habitat? Create new habitat?

Governance Considerations:

- Does this provide benefits beyond the project area?
- Can this strategy be implemented using existing authorities or policies?

General Plan Considerations:

- Protects views to the waterfront (aesthetics)
- Encourages walking and biking (recreation)
- Accommodates water-based recreation and ferry service

The adaptation strategies were screened using the criteria described above. For each reach, each criterion was given a rating of High, Medium, Low, or No Effect where applicable to indicate the effectiveness of the strategy in addressing the criteria. The results of this screening can be viewed for each reach on **Tables 1 through 5** of

Attachment A. The screening is intended to clarify the factors considered and prioritized to arrive at the proposed strategies and options for each reach. The additional strategies also described for each reach were considered, but not recommended as a proposed strategy unless subsequent assessment demonstrates their feasibility as cost-effective and implementable flood protection measures, with optional strategies suggested for each.

3. Adaptation Strategies

This section outlines the proposed strategies for each of the five reaches of Burlingame shown in **Figure 1**. The number of proposed strategies varies by reach, and encompasses both short- and long-term approaches. While the sections below discuss the most pertinent details, Tables 1 through 5 in the attachment provide a more comprehensive look at how the full range of strategies perform relative to the criteria above. Any improvements should be planned in coordination with the County.

3.1 Reach 1

Reach 1 encompasses the Bay shoreline from the mouth of El Portal Creek to Mills Creek (**Figure 2**). Notable features along the shoreline include the Burlingame portion of Bayfront Park, the SFO Airport Marriott, and the Vagabond Inn Executive. Much of the developed area between the shoreline and Highway 101 is at low-lying elevations below both typical high tides and Bay storm surge, and therefore relies on flood barriers at the shoreline to prevent inundation. The shoreline flood barriers currently include sections of raised berms at the shores edge and concrete walls integrated with the Bay Trail. These defenses vary in elevation across the shoreline and are not accredited levees by FEMA. The FEMA base flood elevation (BFE) for this reach is 10 feet NAVD88.

Known Issues

Most of Reach 1 bayward (east) of the Caltrain tracks was mapped within the 100-year floodplain by FEMA (2019). The vulnerability study (ESA 2019) found that the primary pathway for flooding of Reach 1 was from overtopping of low points along the shoreline. This is likely to be the main source of flood waters that could inundate the low-lying area between the shoreline and Highway 101. With increasing amounts of sea-level rise, flooding along the eastern bank of El Portal Creek is projected to become a more important pathway for flooding upstream of Highway 101, leading to flooding on the zone between the highway and Caltrain tracks.

Proposed Strategies

Strategy 1: Raise Low-Lying Parts of Shoreline Embankment and Bay Trail

Of all the reaches and strategies considered, raising the shoreline in Reach 1 is expected to have the largest impact, affecting a large number of private and public low-lying assets, including Highway 101.

The preferred approach for raising the shoreline would target areas where the existing network of shoreline berms and concrete walls could be replaced with FEMA-accredited levees or flood protection structures (**Figure 3**). To be viable from a permitting standpoint, the existing portions of raised shorelines should be replaced and rebuilt where possible, rather than built on top of the existing embankment. This would allow for better control of the composition of the levee, which needs to meet a number of geotechnical requirements to achieve accreditation. This is most likely to be feasible in areas where the existing berms and concrete walls are backed by green space or by parking lots. In these areas, the footprint of a new, higher levee would have less impact on adjacent

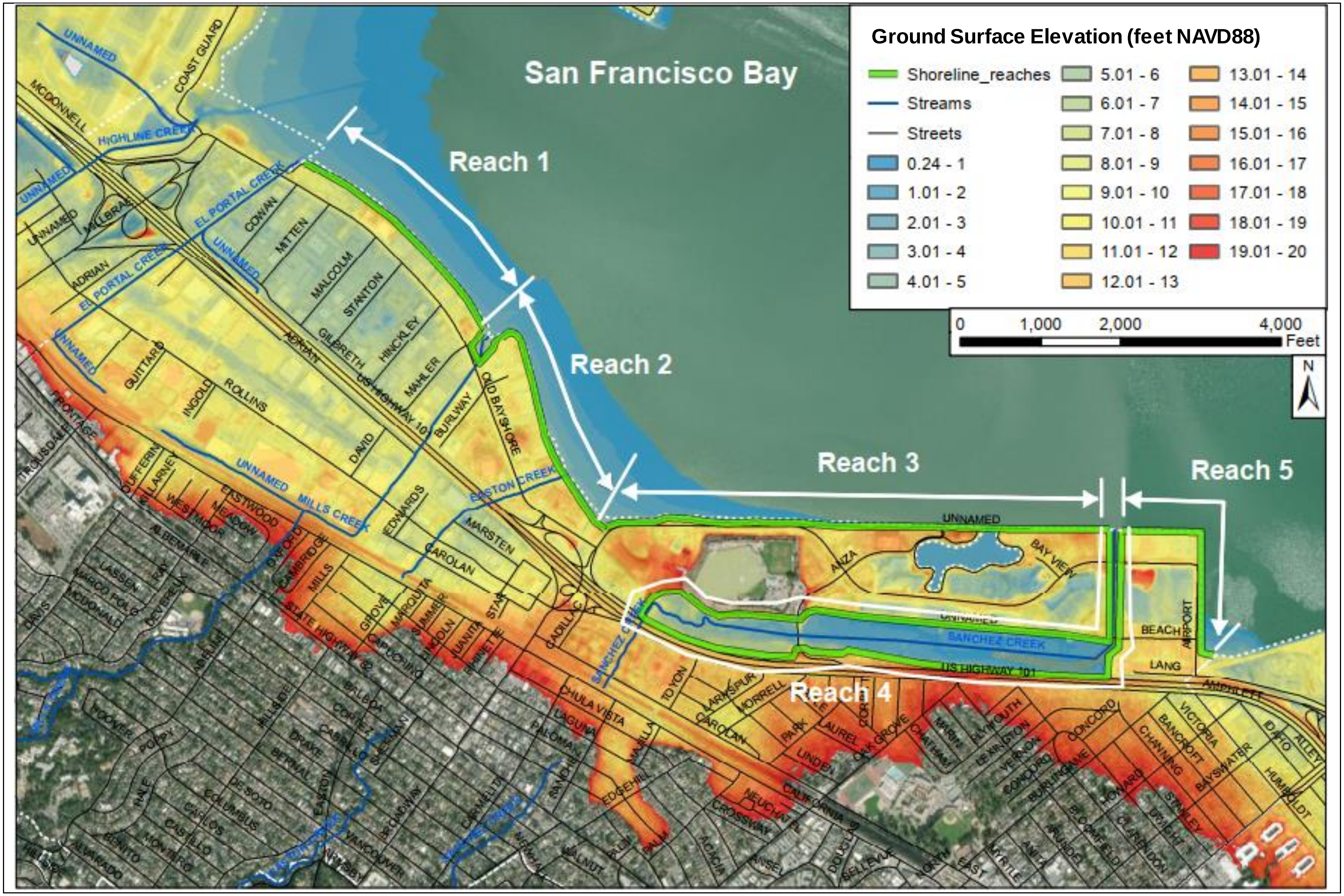

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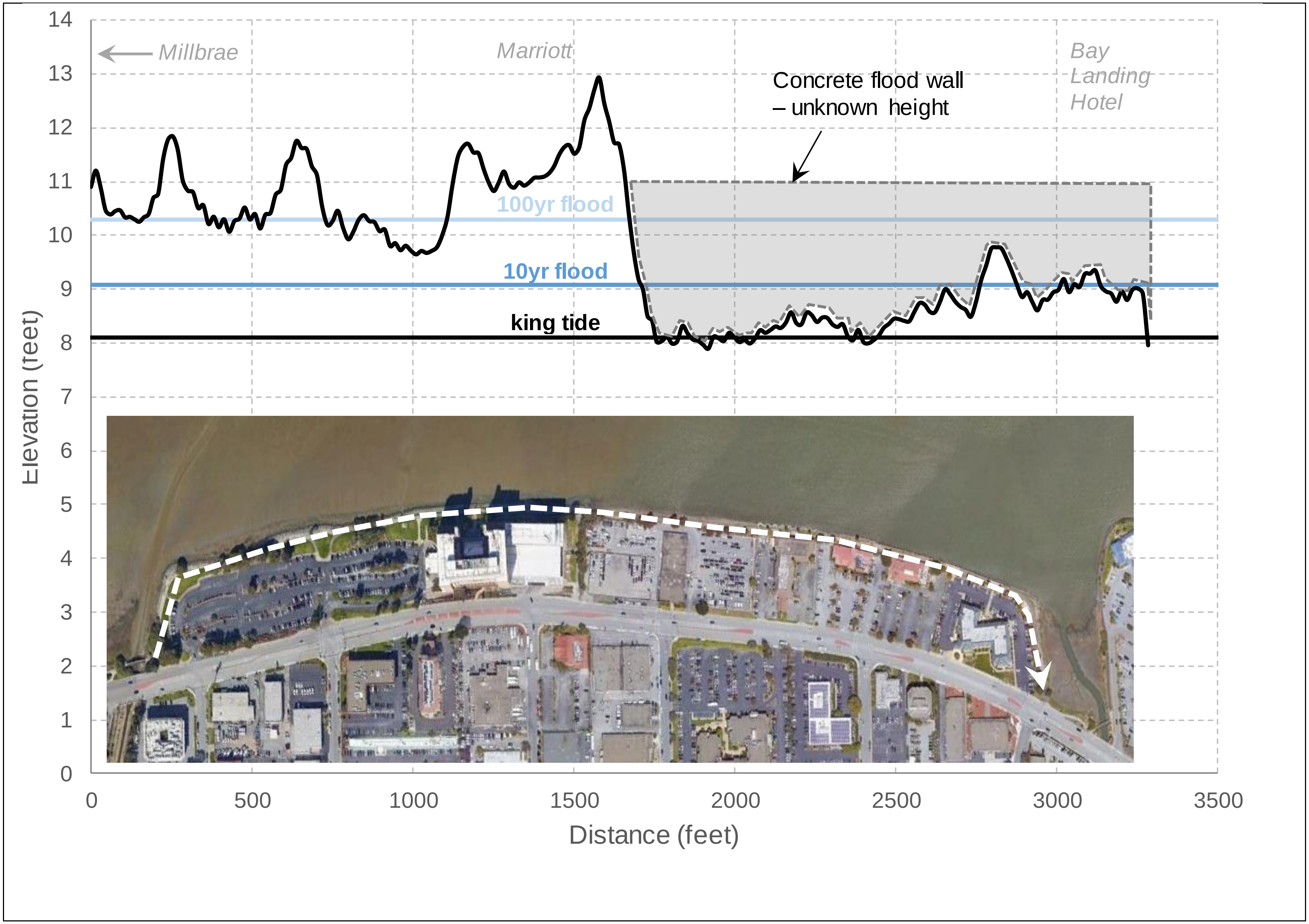
Figure 1
Map of Reaches for City of Burlingame



SOURCE: Shoreline topography based on SCC Coastal LiDAR (2011)

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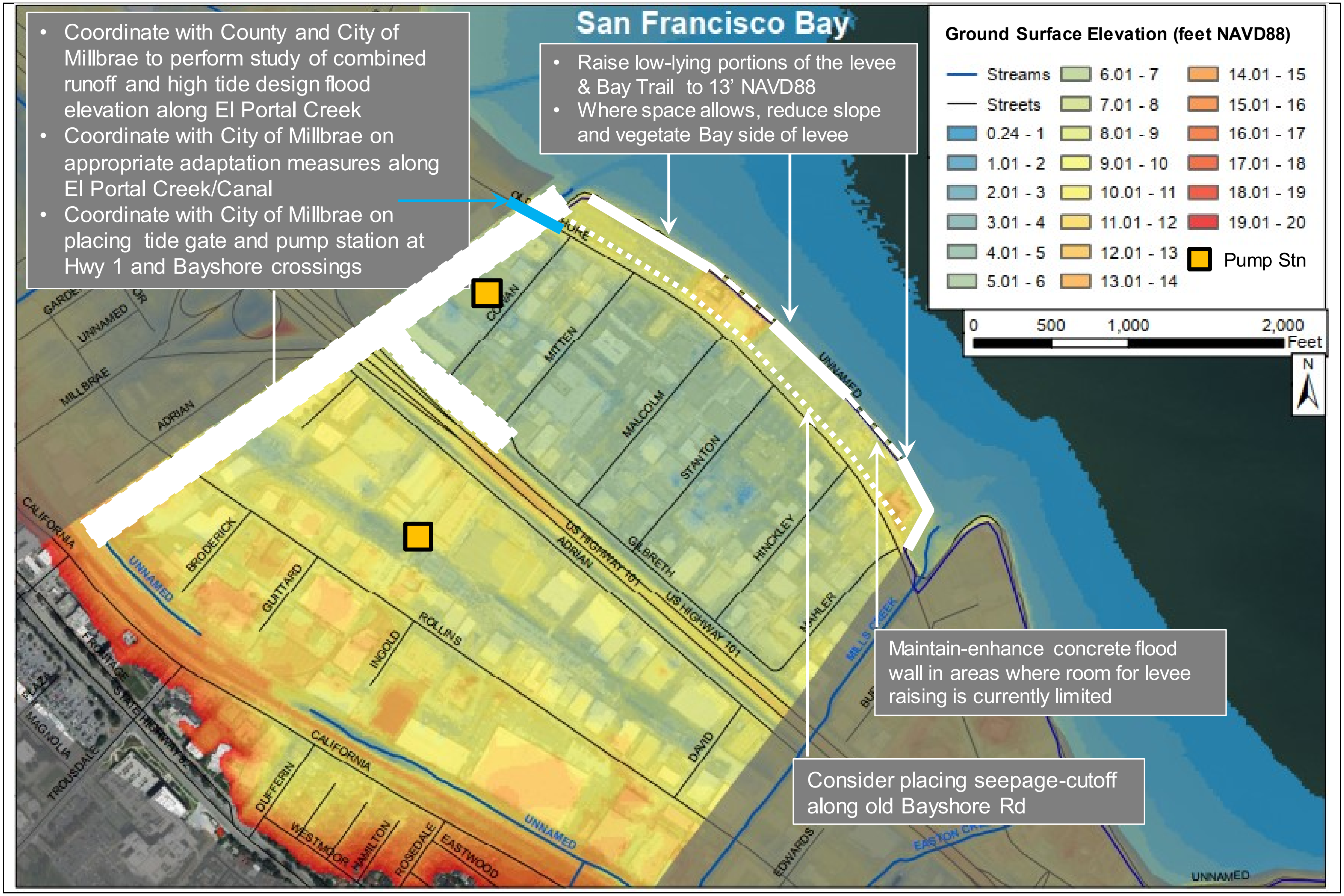
Figure 2

Reach 1 Shoreline



SOURCE: Topography based on NOAA SLR Viewer LiDAR

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Figure 3
Reach 1 Strategies

properties and Bay mudflats. In parts of the Reach 1 shoreline where existing shoreline structures leave too little room for replacing the existing concrete wall with a levee, a short-term option could be to reinforce and heighten the existing wall. Where space allows, replacing the existing segments of concrete wall with a new levee is a preferable strategy because it provides more adaptive capacity for future flood protection: a levee can have a flood wall added in the future to achieve additional protection, whereas the existing walls can only be heightened to a certain point while maintaining FEMA accreditation. As buildings which currently constrain space for a levee are replaced, the option of shifting the building landward should be evaluated. Any redevelopment of existing buildings will require new buildings to be situated further landward to provide additional space for a new levee. Improvements to levees and flood walls in Reach 1 should be planned in concert and with a consistent target elevation. Two options for a target elevation are:

- **Upgrading shoreline protection to shoreline levee/flood wall system at 13 feet NAVD88** would likely prevent flooding of Reach 1 during a present-day 100-year flood event, as well as have capacity for a 100-year event with approximately 3 feet of sea-level rise (projected to occur in between 2070 and 2090). It would also be a sufficient height (10 feet NAVD plus 3 feet of freeboard) to be accredited by FEMA under present-day conditions (so long as other accrediting requirements are also met). For context, the existing shoreline embankment would need to be raised 2–4 feet above the existing grade to create the new FEMA-accredited levee. If the connecting levees and flood walls along the south bank of El Portal Creek and the north bank of Mills Creek were similarly accredited (see below), the City could then ask FEMA for a letter of map revision (LOMR) to remove most of Reach 1 properties from the 100-year flood plain that requires flood insurance. This is the more-costly option, but would be partly balanced by a reduced need for flood insurance within Reach 1. It would require improving approximately 3,500 feet of the shoreline.
- A less costly option, **upgrading shoreline protection to shoreline levee/flood wall system at 11 feet NAVD88** would reduce the flood hazard during a 100-year flood event for up to 1 foot of sea-level rise (c. 2030–2050), but would not be sufficient to achieve FEMA accreditation. However, this would probably require improving only 1,000–2,000 feet of the shoreline. This could be taken as an initial step by the City as it acquires funding for longer-term improvements.

Impacts to aesthetics and recreation resulting from the higher shoreline edge can be mitigated by raising and integrating the Bay Trail with the levee crest, and, in areas of heightened flood wall, by retrofitting existing structures to use lower floors as parking areas. This strategy assumes that the footprint of the new, higher levees would prioritize overlapping on parking areas or green spaces and minimizing placement on the Bay mudflat edge. In more constricted sections a new flood wall would be used, such that long-term impacts to Bay wetlands would be minimal. Neither option provides environmental benefits, but would have a viable regulatory pathway as long as the levee footprint minimally impinges on the existing Bay mudflats. Both options would have benefits for the region outside of Reach 1 by reducing flooding and disruption of service of Highway 101.

Strategy 2: Raise Berms along El Portal Creek

Additional flood protection is needed along El Portal Creek to mitigate the risk of flooding Reach 1 under sea-level rise. Currently, a series of low berms limits waters from overtopping the channel banks. The City of Burlingame would need to coordinate with the City of Millbrae on any improvements, since the creek forms the boundary between the two cities. The creek propagates Bay flooding waters upstream and discharge through the channel can be impaired by elevated Bay water levels, and will be a larger source of flooding with future sea-level rise. Table 1 in the attachment explores two options to address this:

- **Installing a tide gate at the mouth of El Portal Creek**. This would block high Bay tides and storm surge from causing flooding along the banks of the creek, but if these high water levels coincide with high runoff in the channel (which is often the case during storm events), closing a tide gate could trap runoff behind the closed gate, and cause flooding from the runoff. This type of flooding will increase as sea-level rise progresses, since higher Bay levels would mean that the tide gates would need to be closed more often to prevent flooding from Bay waters. To compensate for the tide gate blocking flow to the Bay, a substantial pump station would probably need to be added at the mouth of the channel. Even under Bay water levels favorable for fluvial discharge, the existing embankments may not be sufficient for FEMA accreditation from fluvial events flooding the area behind the coastal barriers.
- **Raising the berms along the creek.** The target elevation for the creek berms should be based on modeling studies of combined runoff and high tides, such as those currently being performed by the County Office of Sustainability. Most of the eastern bank of El Portal Creek is bordered by parking lots, so there are opportunities to raise the berms with limited impact to structures on private property.

Constructing a tide gate at the mouth would disrupt hydrologic continuity and alter tidal hydrology upstream of the gate with increasing frequency as sea-level rises. The potential impacts of these hydrologic changes on biological systems, such as wetlands and fish passage, would need to be considered and may require mitigation. These options are anticipated to have reduced impacts to recreation or aesthetics, and the second option in particular would have the benefit of protecting numerous private and public assets between Highway 101 and the Caltrain tracks.

Additional Strategies

As shown in Table 1, other strategies were considered but not recommended as preferred strategies to pursue, pending some issues discussed below:

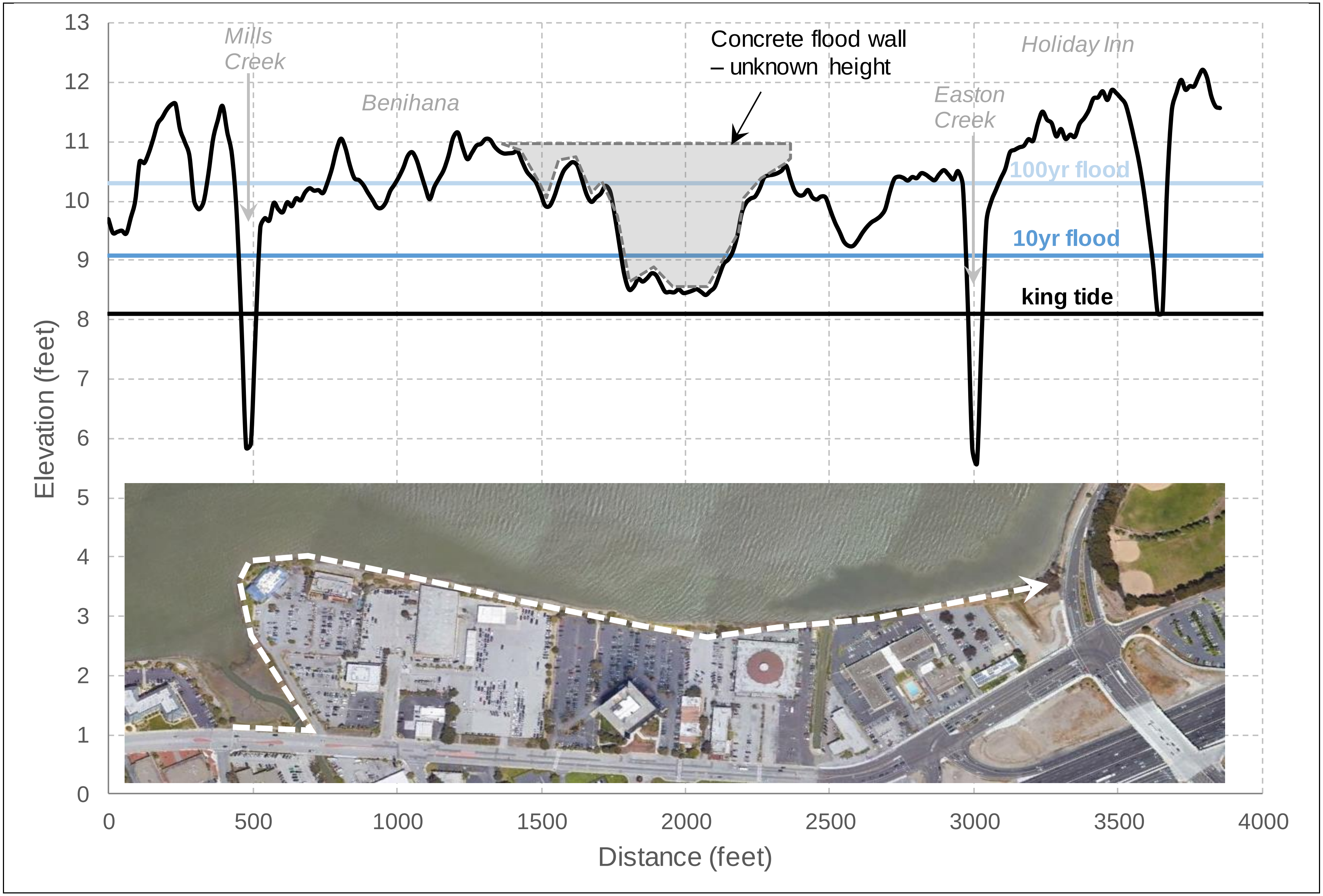
- **Increasing the capacity of the pump stations within Reach 1**. On its own, this strategy would not prevent flooding, but should be explored by the City in concert with the above strategies, to reduce the depth, extent, and duration of flooding.
- **Placing a seepage barrier along the shoreline or Bayshore Road.** This method may be explored by the City as a way of addressing rising groundwater levels, which could cause or exacerbate flooding in the low-lying area between the shoreline and Highway 101. This would require further study by a geotechnical/groundwater firm.

3.2 Reach 2

Reach 2 encompasses the shoreline from Mills Creek to Airport Boulevard (**Figure 4**). Notable features include the City of Burlingame Shorebird Sanctuary around the mouth of Mills Creek, the Benihana Restaurant, and the Bridge Club Bayshore Highway. The FEMA BFE for this reach is 11 feet NAVD88.

Known Issues

Low points along the shoreline below the 100-year flood elevation are located at the Benihana Restaurant and along both Mills and Easton Creeks. The height of the existing shoreline wall is unknown. Most of Reach 2 was mapped within the 100-year recurrence floodplain by FEMA (2019).



SOURCE: Shoreline topography based on SCC Coastal LiDAR (2011)

Figure 4
Reach 2 Shoreline

Proposed Strategies

Strategy 1: Raise Low-Lying Parts of Shoreline

As with Reach 1, raising the shoreline in Reach 2 is expected to provide the most effective way of mitigating flood risk in Reach 2. Unlike Reach 1, the majority of the shoreline of Reach 2 consists of existing shoreline concrete wall and walkway backed by parking areas. Under this strategy, these areas would be altered by constructing a new shoreline levee and reintegrating the pathway (**Figure 5**). The footprint of the higher levee would impact a limited number of parking spaces, and could replace the need for a flood wall. For the remainder of the shoreline, limited space due to existing structures would require enhancing and heightening the existing concrete wall rather than constructing a levee. As these structures reach their life expectancy and are replaced, their location will be required to be shifted landward to provide additional space for a new levee. In the short term, this would mean that the shoreline would still remain a patchwork of flood wall and raised levee, although at higher elevations than at present structures, which are not FEMA-accredited.

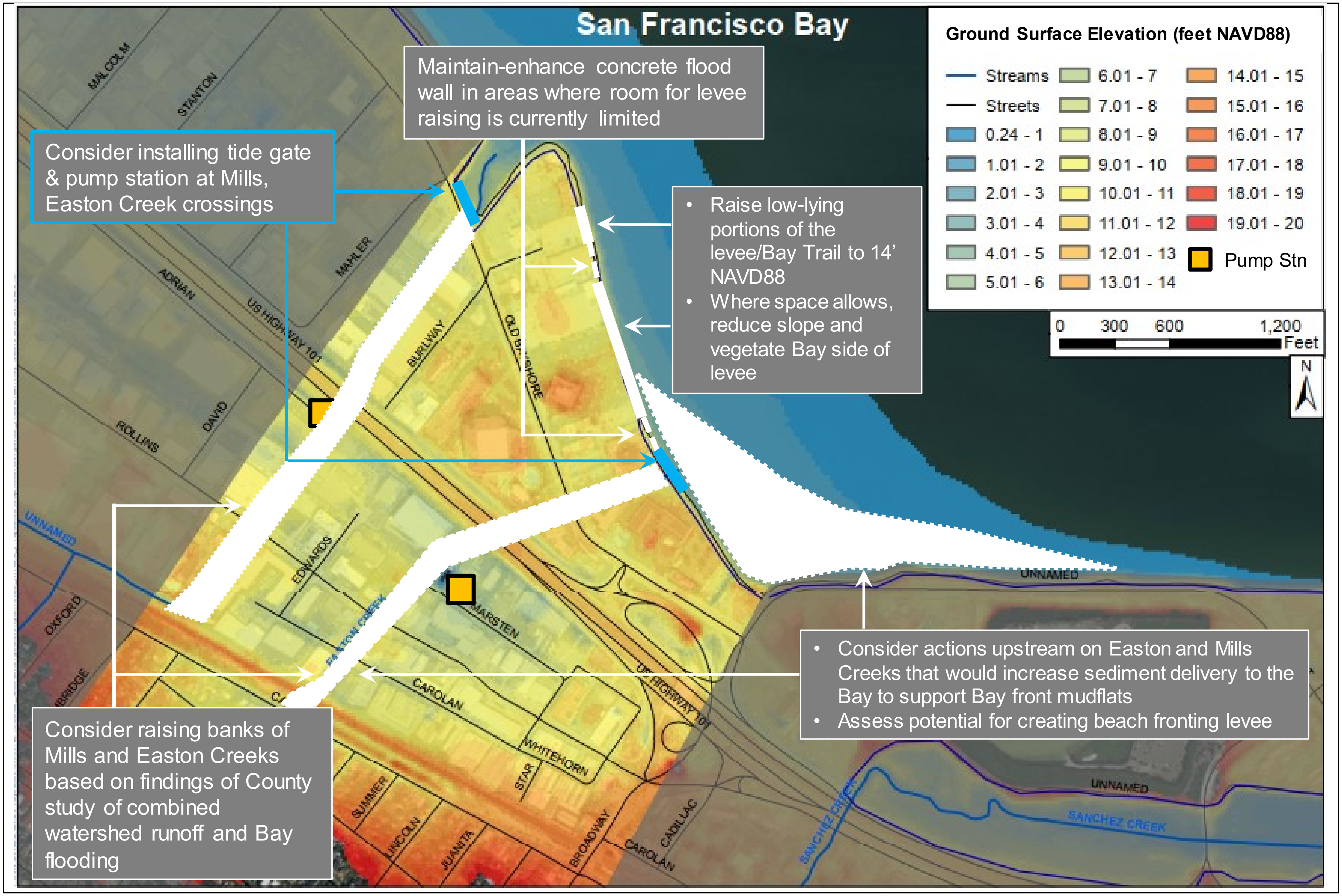
Similar to Reach 1, the new flood wall and levee segments in Reach 2 should be planned in concert, and with the coordination of the County. We considered two options:

- **Upgrading shoreline protection to a shoreline levee/flood wall system at 14 feet NAVD88** would greatly reduce the risk of flooding during the 100-year event under present-day conditions and for up to 3 feet of sea-level rise (c. 2070–2090). This would be the costlier option, requiring improvement to 3,500–4,000 feet of shoreline.
- **Upgrading shoreline protection to a shoreline levee/flood wall system at 12 feet NAVD88** would reduce the risk of flooding during the 100-year event for 0 to 1 foot of sea-level rise (c. 2020–2050). This would require improving roughly 3,500 feet of shoreline, but cost savings would be realized through the lower need for material to build a lower levee/flood wall.

The broader implications of these options are similar to those discussed for the first strategy in Reach 1, and are shown in detail in Table 2 of the attachment.

Strategy 2: Raise Berms Along Mills and Easton Creeks

The available flood models studied in the vulnerability assessment (ESA 2019) suggest that flooding during the 100-year event mostly results from overtopping of the shoreline, rather than overtopping of the banks of Mills and Easton Creeks. However, for both the medium (3.3 feet) and high (6.6 feet) sea-level rise scenarios with the 100-year event, the creek berms become the primary flood pathway upstream of Highway 101. Given the difficulties in managing this flooding with a tide gate at the creek mouths, the most effective strategy would likely involve raising the berms of these creeks. Some of the areas along the margins of the creeks are occupied by parking lots, and could provide room for a levee along the creek banks with only a small impact on adjacent private properties. In some stretches of creek bank with constrained space, as well as the sides of the bridges, a flood wall may be needed.



SOURCE: Topography based on NOAA SLR Viewer LiDAR

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Figure 5
Reach 2 Strategies

Strategy 3: Explore the Possibility of Developing a Bay Beach along the shoreline

As an additional long-term strategy, the City could explore the usefulness of constructing a Bay beach at the junction between Reaches 2 and 3. This area was identified as a possible location for a beach by the recent study by SFEI (2019), which could serve to attenuate wave energy that reaches the shoreline. To be self-sustaining, beaches need to have a supply of sediment or have minimal transport along the shoreline. Locating the beach at the concave junction of Reach 2 and Reach 3 may correspond to convergent sediment transport and reduce the need to re-supply sand. Bay beaches are currently being studied as a complementary method for preventing shoreline erosion and flooding (BCDC and ESA PWA 2013; Leventhal 2010; ESA 2018). Other considerations to address include:

- A beach would need to be combined with a levee along the shoreline to allow for FEMA accreditation. The beach alone will not naturally reach the height needed at this location (14 feet NAVD) to block flood waters and wave runup during the 100-year event, nor be resilient to scour.
- Finding a large source of sand or coarser material is not a certainty, and may be costly to obtain and transport to the site.
- Constructing a beach would require placing fill on existing Bay mudflats. Current regulatory constraints from the Bay Conservation and Development Commission (BCDC) and other regulatory agencies would draw extensive scrutiny for fill to create a beach.

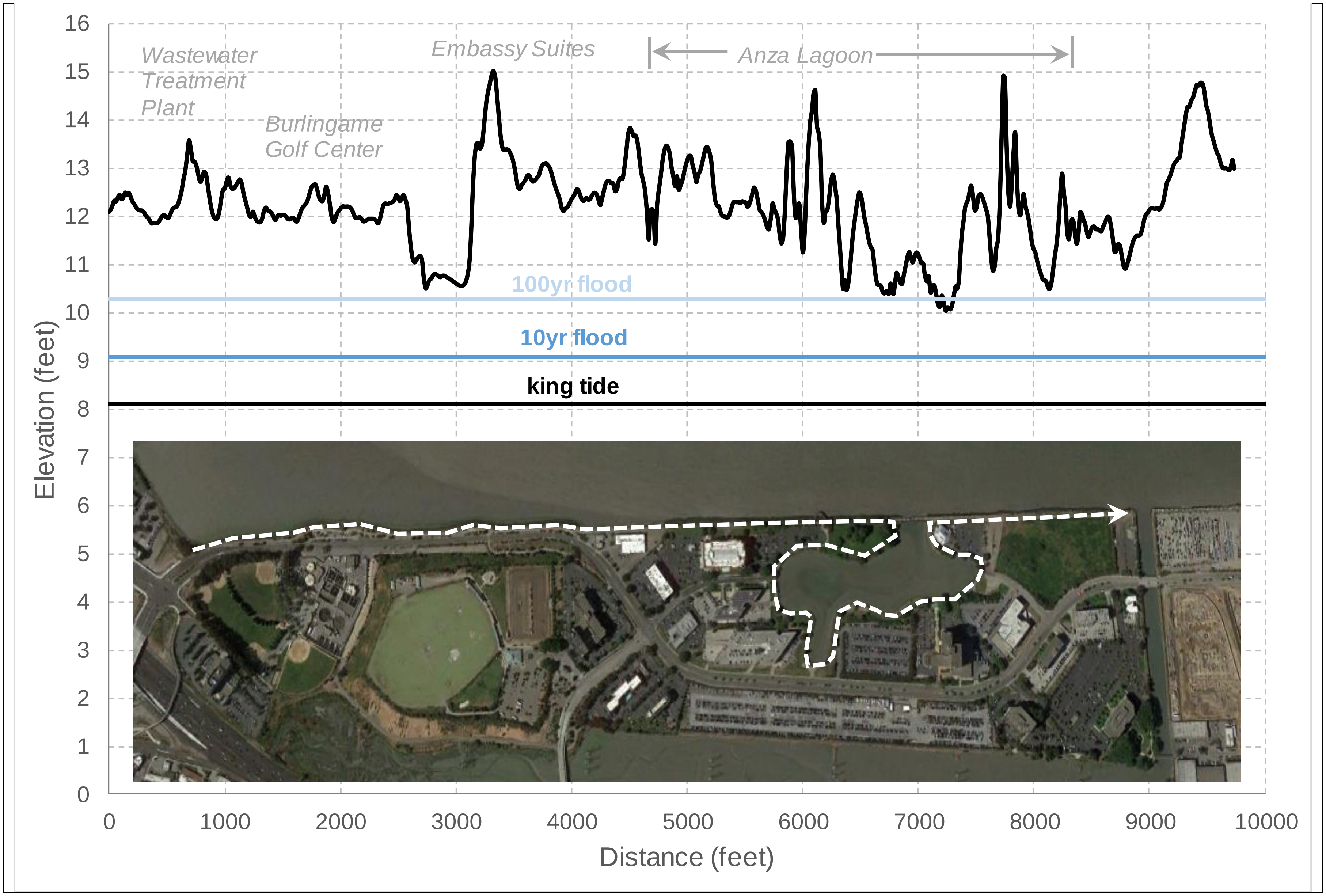
Additional Strategies

As shown in Table 2 of the attachment, other strategies were considered but not recommended as preferred strategies to pursue, pending some issues discussed below:

- Where space allows, **reduce slope and vegetate Bay side of new shoreline levee**. This approach could attenuate waves and wave runup on the levee. However, space is limited and building out into the Bay with added fill would be very challenging from a regulatory standpoint (e.g., BCDC restrictions on placing Bay fill). In addition, vegetation that is regularly inundated, i.e., wetlands, would have to be assessed for the potential for scour.
- **Consider actions upstream on Easton and Mills Creeks that would increase sediment delivery to the Bay.** This option was noted by SFEI (2019), and could have ecological benefits by providing sediment to the adjacent mudflats, which could add resilience of the mudflats in the face of sea-level rise. However, this would not have a significant flooding benefit for the City.
- **Place tide gate at the mouth of Easton and Mills Creeks.** This strategy could be used to limit flooding from high tides for the short-term (0–1 foot of sea-level rise, c. 2020–2050). It would need to be combined with new pump stations located near the mouths of both creeks. Given the relatively low berms along both creeks and their proximity to each other, this could be an effective intermediate strategy while berms are raised in the long term to address combined creek and high tide flooding. In the long term, it would not be a viable strategy, as increasingly high tides would make it necessary to close the tide gates more frequently, increasing the risk of flooding due trapping of rainfall-runoff behind the gates.

3.3 Reach 3

Reach 3 encompasses the shoreline from Airport Boulevard to the edge of the tidal channel connecting the Bay to Burlingame Lagoon (**Figure 6**). Notable features include Veolia Water North America Wastewater Treatment Plant (WWTP), the Burlingame Golf Center, Embassy Suites, Anza Lagoon, and the open parcel at 450 Airport Boulevard. Much of this part of Burlingame is owned by the State Lands Commission.



SOURCE: Shoreline topography based on SCC Coastal LiDAR (2011)

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Figure 6
Reach 3 Shoreline

Known Issues

Most of this area is above the 100-year flood elevation, giving the area more time to adapt to sea-level rise. However, the WWTP is a critical piece of infrastructure that should plan for adaptation as soon as possible. The FEMA (2019) BFE along the Bay shoreline is 11–12 feet NAVD88, and 10 feet NAVD88 inside of Anza Lagoon. A significant portion of the southeast part of Reach 4 is lower than the BFE, so mapped within the most recent FEMA (2019) 100-year floodplain and more vulnerable to flooding.

Proposed Strategies

Strategy 1: Raise Low-Lying Parts of Shoreline within Anza Lagoon

Since most of the Bay shoreline within Reach 3 is not mapped within the 100-year floodplain, adaptation efforts should focus in the short-term on raising portions of the interior shoreline of Anza Lagoon and then, in the longer term, address the Bay shoreline (**Figure 7**). For the Anza Lagoon shoreline, consider:

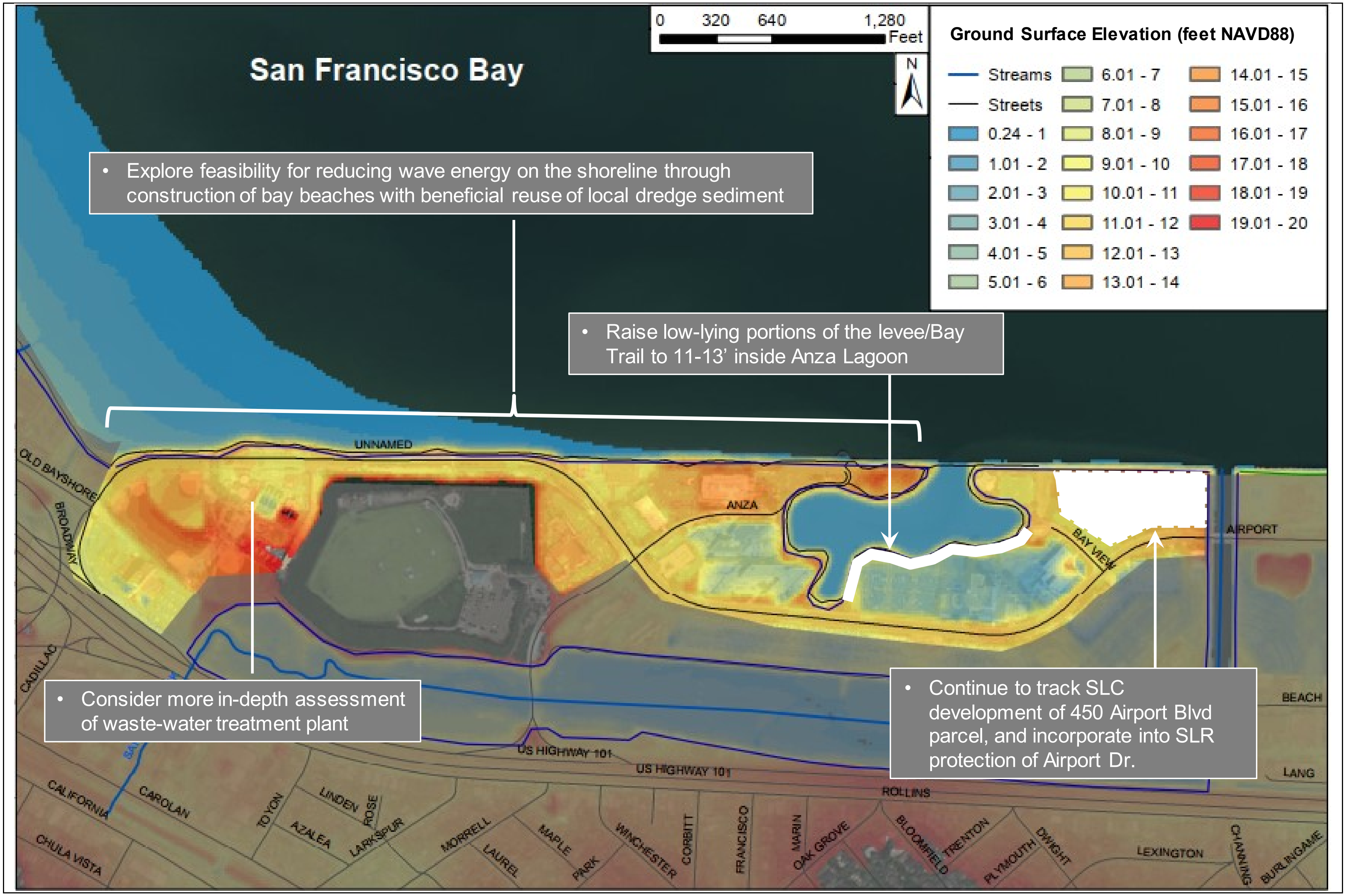
- Raise to a height of 13 feet NAVD, which would require improving roughly 2,000–2,500 feet of shoreline, which could achieve FEMA accreditation if other criteria are also met. This would protect this stretch of shoreline from overtopping from the 100-year event for up to 3 feet of sea-level rise (c. 2070–2090). However, this approach would incur greater cost while protecting a relatively small number of private properties.
- A less costly approach could involve raising the shoreline to 11 feet NAVD88 (roughly 500 feet of shoreline), which would not be sufficient for FEMA accreditation, but would greatly reduce the frequency of flooding compared to the existing shoreline.

The implications of these approaches are indicated in Table 3 of the attachment. Given the smaller number of properties affected by these actions, the relative benefit is smaller than improving the shoreline in Reaches 1 and 2. These approaches would help protect Airport Drive.

Strategy 2: Study the Need for Additional Protection of the WWTP

The WWTP is currently not mapped within the 100-year floodplain (FEMA 2019) due to its elevation, but flooding of the site is predicted for the 100-year event when sea-level rise is between 3.3 and 6.6 feet. These levels are expected to take place somewhere between 2070 and 2200 for San Francisco Bay. However, since wastewater facilities provide critical services to the entire City, beginning long-term adaptation planning now could reduce severe consequences. The most recent guidance from the California Coastal Commission for critical infrastructure is to consider low-likelihood, high-risk scenarios (CCC 2015). Accounting for sea-level rise could involve the following steps:

- **Raising the shoreline embankment along Airport Drive** to a higher elevation, such as a FEMA-accreditable level of 14 feet NAVD88, to reduce flooding of the site for a longer time, allowing more time to adapt the site interior.
- **Conducting a study of WWTP asset locations, elevations, and vulnerabilities**, and determining what flood proofing measures can be applied to the site's interior and facilities.



SOURCE: Topography based on NOAA SLR Viewer LiDAR

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Figure 7

Reach 3 Strategies

Additional Strategies

- **Continue to track development of 450 Airport Blvd (State Lands) parcel development and/or restoration** and coordinate this with City efforts elsewhere along the shoreline in Reach 3.
- **Explore feasibility for reducing wave energy on the shoreline through construction of bay beaches** with beneficial reuse of local dredge sediment. Consider partnership with County of San Mateo Parks on reuse of Marina dredge material. As discussed above, this strategy would provide habitat and aesthetic benefits for the shoreline, but would require finding a sediment source (possibly in perpetuity if alongshore sediment transport is substantial), and would not eliminate the need for a levee along the shoreline.

3.4 Reach 4

Reach 4 includes the shoreline that surrounds the Burlingame Lagoon. This section is not exposed to the open Bay except through a small tidal inlet connecting the lagoon to the Bay (**Figure 8**).

Known Issues

Input from the City and from the stakeholder meeting on July 10, 2019, indicated that flooding is already a concern along the northern shore of the lagoon during moderate storm surge events. FEMA (2019) currently includes most of the office park north of the lagoon within the 100-year floodplain, with the exception of Anza Boulevard (ESA 2019). The FEMA (2019) BFE for the lagoon is 10 feet NAVD88.

Proposed Strategies

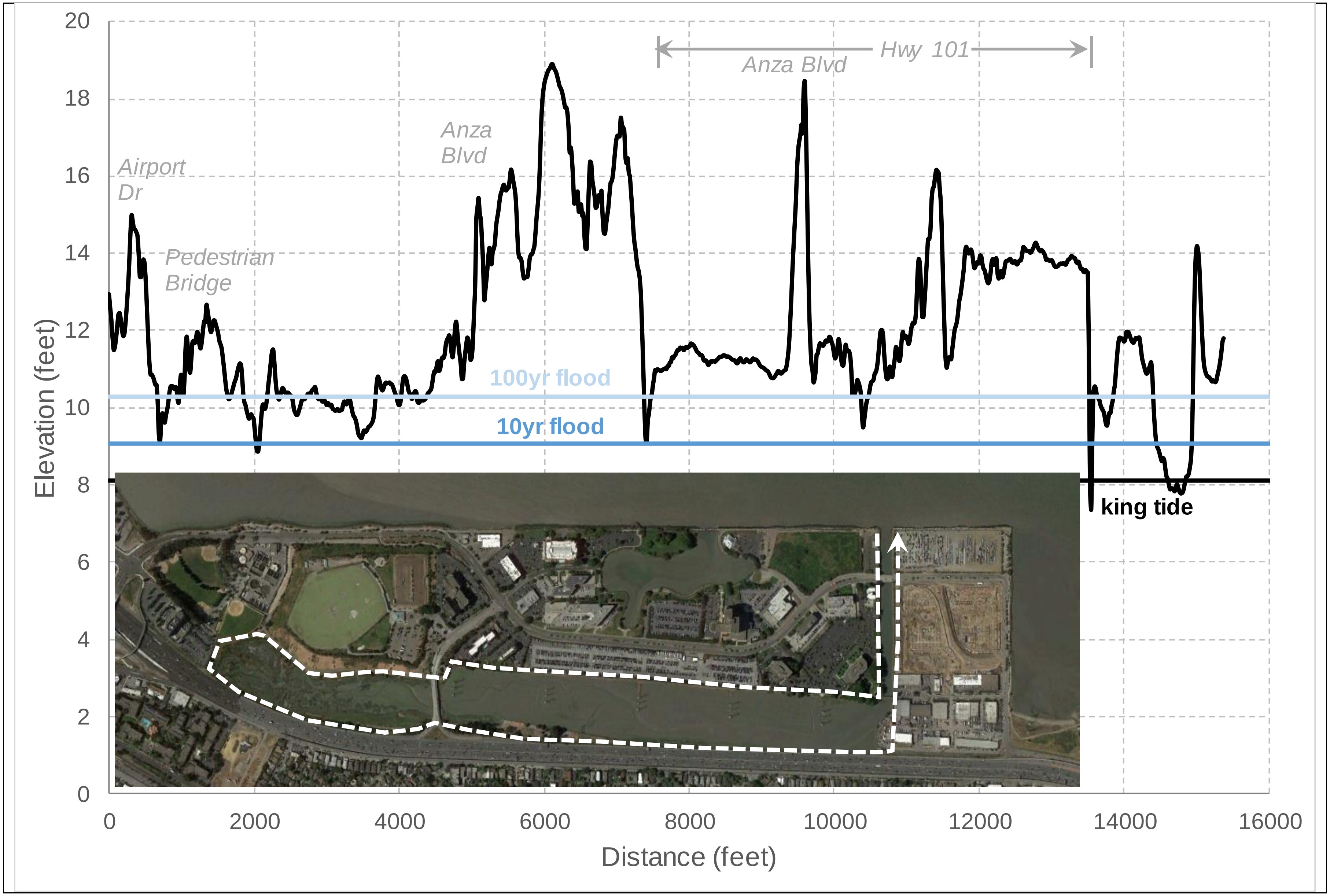
Strategy 1: Raise Northern Shoreline of Burlingame Lagoon

Currently, the available LiDAR topography suggests that most of northern shoreline of the lagoon from Anza Boulevard to the mouth of the tidal channel to the Bay varies from about 9 to 12 feet NAVD88 (Figure 8). Raising this shoreline to meet the required elevation of 13 feet NAVD for FEMA accreditation would require improving roughly 4,500 feet of shoreline. Since the current shoreline consists of a paved pedestrian pathway, this would require either building a shoreline levee with a new elevated pathway, or constructing a sheet-pile wall along the existing pathway. Comparatively, raising the shoreline to a consistent height of 11 feet NAVD would require improving 3,500–4,000 feet of the shoreline, but would only address future 100-year flood levels for up to one foot of sea-level rise (projected to occur 2030–2050). This approach could be taken as a short-term measure as part of an overall strategy to address the most flood-prone locations in the near-term while planning for longer-term actions. Additional considerations are shown in Table 4.

Strategy 2: Consider Living Shorelines Approaches Along Western Shoreline of Burlingame Lagoon

The western shoreline of Burlingame Lagoon includes the mouth of Sanchez Creek, an existing tidal marsh complex, and an embankment protecting Highway 101 (**Figure 9**). While this portion of the highway is not mapped within the 100-year floodplain (FEMA 2019), and is not predicted to flood until sea-level rise is between 3.3 and 6.6 feet (ESA 2019), there is an opportunity to consider approaches that provide wetland and marsh habitat while also protecting the shoreline. SFEI (2019) noted the potential for several living shorelines types:

- An ecotone slope (a vegetated embankment with flatter side slopes than a traditional levee);



SOURCE: Shoreline topography based on SCC Coastal LiDAR (2011)

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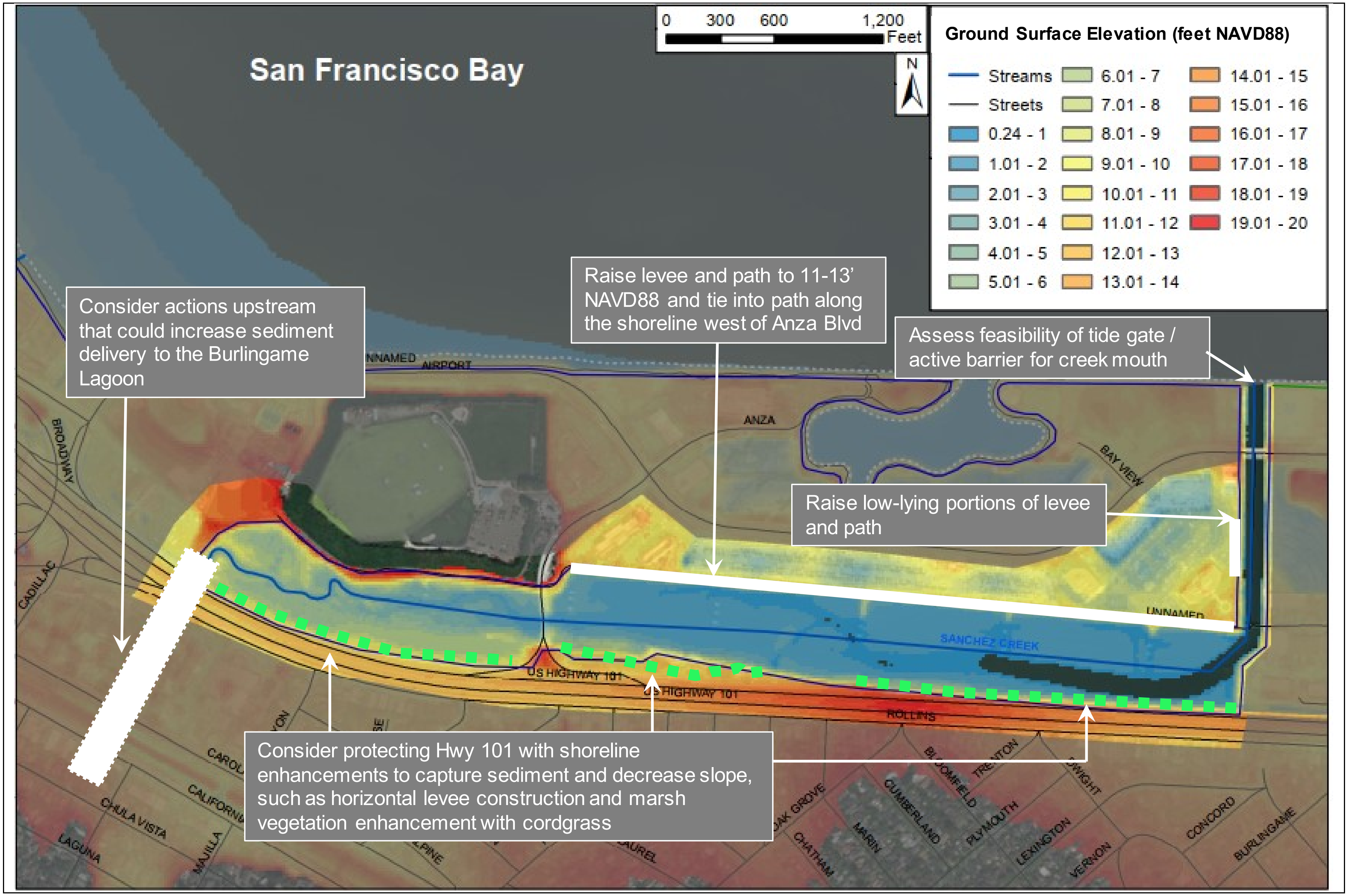
Figure 8
Reach 4 Shoreline



SOURCE: Topography based on NOAA SLR Viewer LiDAR

SeaChange Burlingame . D190002.00

Figure 9

Reach 4 Strategies

- Reconnecting upper portions of Sanchez Creek to allow more sediment to be delivered to the marsh in Burlingame Lagoon; and
- Augmenting tidal vegetation along the shoreline.

While these approaches do not provide flood protection on their own, they could be coupled with construction of engineered barriers (levees, flood walls) to comprise a self-mitigating project.

Additional Strategies

Creation of a tide gate at the mouth of Burlingame Lagoon was raised during the July 10, 2019, technical advisory committee meeting. While this type of approach has the potential for preventing flooding from elevated Bay tides, this strategy faces other complicating factors:

- Regulatory challenges would be significant, since the lagoon provides intertidal and marsh habitat for federally listed threatened aquatic species; this aquatic habitat would be disrupted by the hydraulic closure of the tide gate, with increasing frequency and duration as sea-level rises.
- Freshwater inflow upstream of the tide gate, which is estimated to be 1,100 cfs for the 10-year event (FEMA 2019) could accumulate behind the tide gate and cause flooding from within the lagoon. To offset this flood source would likely require a very large and costly pump station.

A study comparing the tide gate strategy with raising levees and floodwalls along the shoreline could be conducted to further assess the feasibility of these two approaches.

3.5 Reach 5

Reach 5 includes the northern and eastern shoreline of the easternmost portion of the Bay shoreline (**Figure 10**). It is the shortest reach, and includes the Burlingame Point complex that is currently under construction.

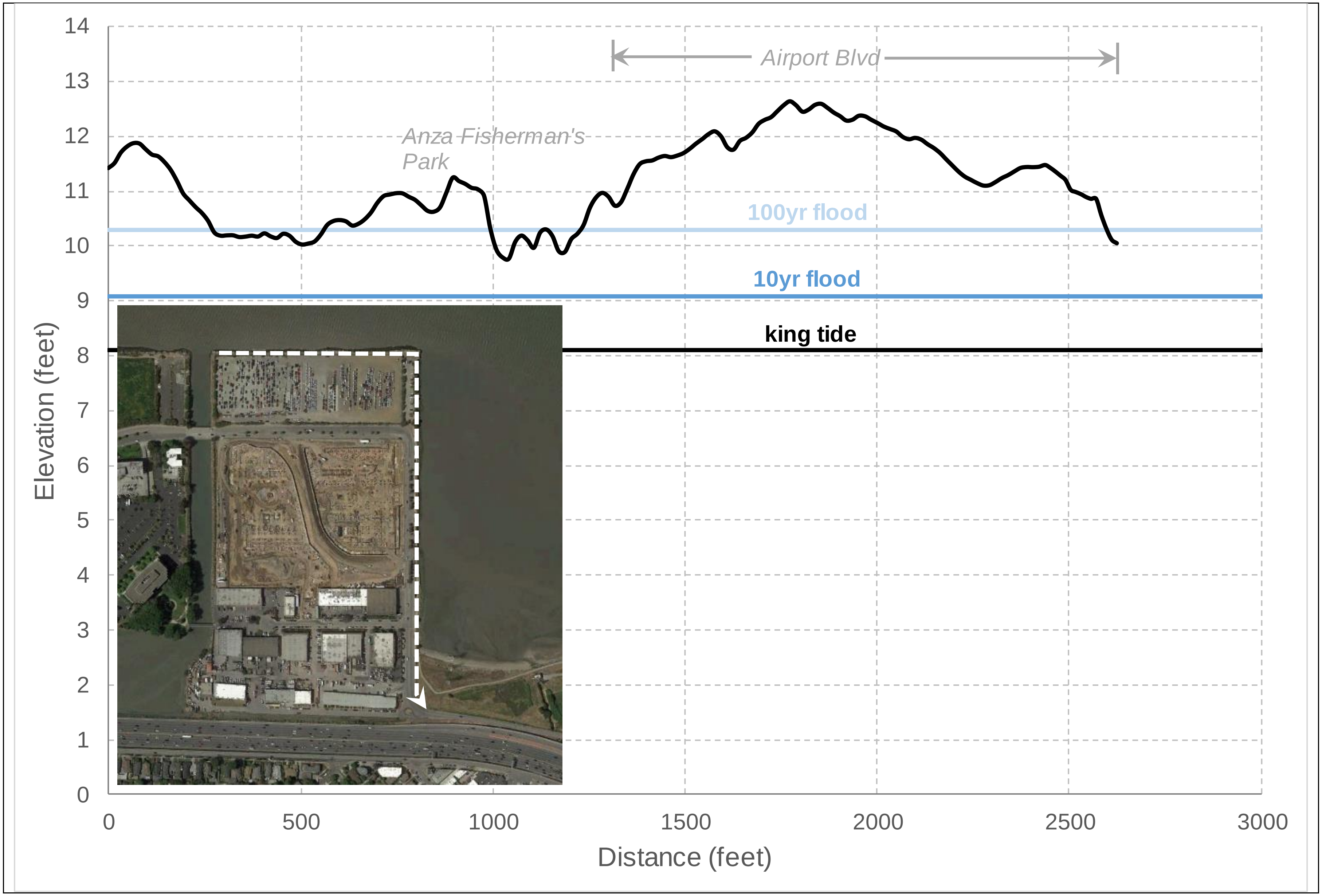
Known Issues

About half of the area is just above the 100-year flood elevation (as per the 2017 LiDAR). These areas would face flood inundation from the 100-year event with 1–2 feet of sea-level rise. A large parcel in the center of the area is currently under construction and that project appears to be raising the ground surface from its prior position below the 100-year flood elevation. The FEMA (2019) BFE for this reach is 12 feet NAVD88.

Proposed Strategies

Strategy 1: Raise Shoreline Along Burlingame Point

Though this section of the shoreline is largely outside of the FEMA 100-year floodplain, extensive flooding is predicted with 3.3 feet of sea-level rise (projected to occur 2070–2090). As part of a long-term strategy, the City may consider raising the existing perimeter embankment to an elevation of 15 feet NAVD (the height required for FEMA accreditation), as a means of protecting the area from future flooding (**Figure 11**). The City should also coordinate with Burlingame Point on the extent and elevations of site grading at the complex. Given the limited number of private or public infrastructure affected by this shoreline improvement, this strategy should have a lower priority than shoreline improvements to Reaches 1–4.



SOURCE: Shoreline topography based on SCC Coastal LiDAR (2011)

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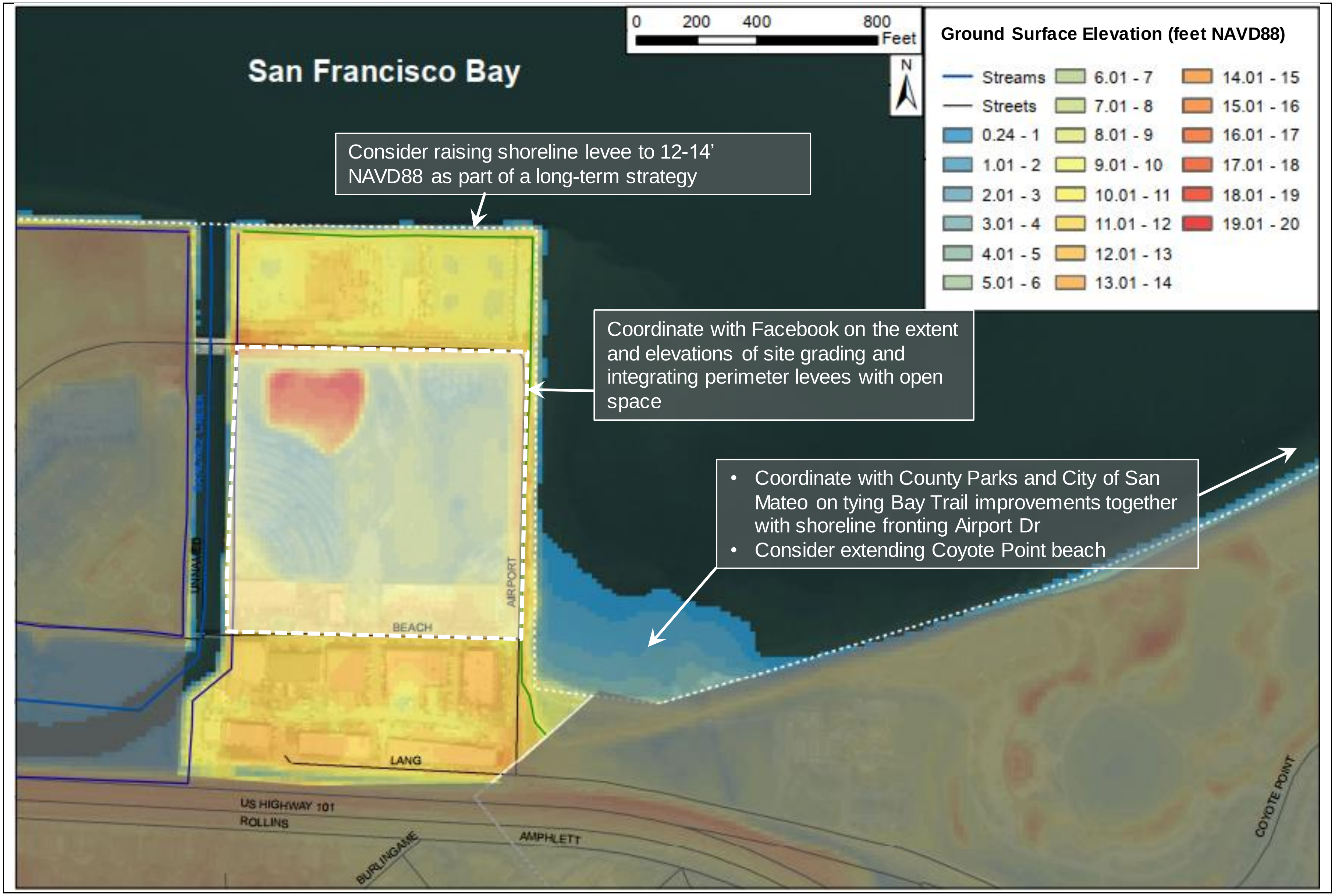
Figure 10

Reach 5 Shoreline



SOURCE: Topography based on NOAA SLR Viewer LiDAR

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Figure 11

Reach 5 Strategies

Strategy 2: Consider Creating Bay Beach that Ties into Coyote Point Beach

As an additional long-term strategy, the City could explore the benefits of expanding or sustaining the Bay beach at the boundary between Reach 5 and the neighboring Coyote Point Beach. The County recently commissioned a study (M&N 2019) to study methods for improving flood protection for the City of San Mateo by upgrading the embankment behind the beach, from the boundary with Burlingame to the Coyote Point Knoll. Plans are underway to construct the upgraded levee by 2021. The City of Burlingame could study constructing a similar beach and levee system at the eastern end of Reach 5, that should tie into the flood protection along the east side of Burlingame Point, and provide protection for Airport Drive in the long term.

4. Information Gaps

- Shoreline elevations (including the existing sections of flood wall protecting Reaches 1 and 2) are uncertain. Elevation surveys are recommended for the Bay shoreline, as well as for the banks of the lower portions of El Portal, Easton, Mills, and Sanchez Creeks.
- The capacity of pump stations within the newly mapped FEMA 100-year floodplain should be studied to assess if retrofitting is needed.
- The likelihood of riverine flooding along the banks of El Portal, Mills, Easton, and Sanchez Creeks may be understated by the available flood maps, which focus on flooding from high Bay water levels (ESA 2019). Combined runoff and high tide flooding along these creeks is currently being studied by the County, and their findings should be integrated into this study. If combined flooding on these creeks is more severe than shown in existing maps, the need for levee improvements along their banks may take a higher priority.

5. Next Steps

- The City and its partners should review the recommendations of this memorandum and choose a level effort to pursue sea-level rise preparedness.
- ESA will incorporate input from the City to advance several preferred strategies and will assist with developing a timeline for future planning that combines these into a planning timeline of overlapping short- and long-term approaches.
- The City should commission a study that surveys the shoreline elevations (with ground-based survey) and elevation of the creek berms. This should be combined with a study of shoreline and creek-bank parcel ownership, to help inform which segments of the shoreline can be improved immediately and which require more planning.
- The City should commission a study of sea-level rise preparedness of the wastewater treatment facility near Airport Boulevard, to assess flood hazards and adaptions measures specific to this facility. In addition to providing a broad assessment of the vulnerability of the facility, the study should look at the vulnerability of individual assets, such as the pipeline that sends secondary treated waste north to the South San Francisco wastewater treatment facility.

6. References

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Attachment A
Screening Criteria Evaluation Tables

TABLE 1: REACH 1 STRATEGIES – CRITERIA SCREENING

Implications of Strategy		Raise Shoreline		Address Flooding on El Portal Canal		Seepage barrier along Bayshore Rd
		Raise to 11 ft NAVD88	Raise to 13 ft NAVD88	Install tide gate	Raise canal levees	
Flood Mgmt	Flood Hazard	-Removes most of Reach 1 from 100-year floodplain -At risk to 100-year flood with 1 ft SLR (c. 2030-2050)	-Removes most of Reach 1 from 100-year floodplain -At risk to 100-year flood with 3 ft SLR (c. 2070-2090)	-Limit flooding upstream of Hwy 101 -Less effective as SLR increases	Limit flooding upstream of Hwy 101	Potential to limit groundwater inundation of low-laying areas with SLR
	Engineering competence for erosion, geotechnical, and seismic	High	High	Med	High	Med
	Parcel-to-reach scalability	High	Med	High	Med	High
	Adaptive capacity to sea-level rise	Med	High	Low	Med	High
Economic	Potential to reduce the risk of asset damages	High	High	Med	High	Low
	Protection for econ. vulnerable groups working or living in the project area	Med	High	Med	Med	Low
	Protection for public infrastructure in the project area (e.g. wastewater mains)	High	High	Med	Med	Med
	Cost	$$$	$$$$	$$$	$$$	$$$
Environmental	Does strategy protect existing habitat?	Yes	Yes	No	Yes	Yes
	Does strategy create new habitat?	No	No	No	No	No
Governance	Does this provide benefits beyond the project area?	Yes	Yes	Yes	Yes	Yes
	Ease of implementation using existing authorities or policies?	Med	Med	Low	Med	High
General Plan Considerations	Aesthetics: protects views to the waterfront	Med	Med	Low	Low	No Effect
	Recreation: encourages walking and biking	High	High	No Effect	Low	No Effect
	Impacts to water recreation and ferry service	Low	Low	No Effect	No Effect	No Effect

TABLE 2: REACH 2 STRATEGIES – CRITERIA SCREENING

Implications of Strategy		Raise Shoreline		Address Flooding on Mills and Easton Creeks		Environmental Approaches	
		Raise to 12 ft NAVD88	Raise to 14 ft NAVD88	Install tide gates	Raise canal levees	Bay Beach fronting levee	Improve Creek Sediment Delivery
Flood Management	Flood Hazard	-Removes most of Reach 2 from 100-year floodplain -At risk to 100-year flood with 1 ft SLR (c. 2030-2050)	-Removes most of Reach 2 from 100-year floodplain -At risk to 100-year flood with 3 ft SLR (c. 2070-2090)	-Limit flooding upstream of Hwy 101 -Less effective as SLR increases	Limit flooding upstream of Hwy 101	Potential to limit wave runup on shoreline levee	Limited impact
	Engineering competence for erosion, geotechnical, and seismic	High	High	Med	High	Low	Low
	Parcel-to-reach scalability	High	Med	High	Med	High	Med
	Adaptive capacity to sea-level rise	Med	High	Low	Med	Med	Med
Economic	Potential to reduce the risk of asset damages	High	High	Med	High	Low	No Effect
	Protection for econ. vulnerable groups working or living in the project area	Med	High	Med	Med	Low	No Effect
	Protection for public infrastructure in the project area (e.g. wastewater mains)	High	High	Med	Med	Low	No Effect
	Cost	$$$	$$$$	$$$$	$$$$	$$$$	$$$
Environmental	Does strategy protect existing habitat?	Yes	Yes	No	Yes	No	Yes
	Does strategy create new habitat?	No	No	No	No	Yes	No
Governance	Does this provide benefits beyond the project area?	Yes	Yes	Yes	Yes	No	No
	Ease of implementation using existing authorities or policies?	Med	Med	Low	Med	Low	Med
General Plan Considerations	Aesthetics: protects views to the waterfront	Med	Med	Low	Low	High	No Effect
	Recreation: encourages walking and biking	High	High	No Effect	Low	High	No Effect
	Impacts to water recreation and ferry service	Low	Low	No Effect	No Effect	Low	Low

TABLE 3: REACH 3 STRATEGIES – CRITERIA SCREENING

Implications of Strategy		Raise Anza Lagoon Shoreline		Environmental Approaches	
		Raise to 11 ft NAVD88	Raise to 13 ft NAVD88	Bay Beach fronting levee	Consider more in-depth assessment of wastewater treatment plant (WWTP)
Flood Management	Flood Hazard	-Removes most of Reach 3 from 100-year floodplain -At risk to 100-year flood with 1 ft SLR (c. 2030-2050)	-Removes most of Reach 3 from 100-year floodplain -At risk to 100-year flood with 3 ft SLR (c. 2070-2090)	Potential to limit wave runup on shoreline levee	Flood protection studies should take place to explore ways of providing add'l protection for WWTP. This should include wastewater mains
	Engineering competence for erosion, geotechnical, and seismic	High	High	Low	--
	Parcel-to-reach scalability	High	Med	High	--
	Adaptive capacity to sea-level rise	Med	High	Med	--
Economic	Potential to reduce the risk of asset damages	High	High	Low	Yes
	Protection for econ. vulnerable groups working or living in the project area	Med	High	Low	--
	Protection for public infrastructure in the project area (e.g. wastewater mains)	High	High	Low	Yes
	Cost	$$	$$$	$$$$	$
Environmental	Does strategy protect existing habitat?	Yes	Yes	No	--
	Does strategy create new habitat?	No	No	Yes	
Governance	Does this provide benefits beyond the project area?	Yes	Yes	No	Yes
	Ease of implementation using existing authorities or policies?	Med	Med	Low	--
General Plan Considerations	Aesthetics: protects views to the waterfront	Med	Med	High	--
	Recreation: encourages walking and biking	High	High	High	--
	Impacts to water recreation and ferry service	Low	Low	Low	--

TABLE 4: REACH 4 STRATEGIES – CRITERIA SCREENING

Implications of Strategy		Raise Shoreline		Environmental Approaches	
		Raise to 11 ft NAVD88	Raise to 13 ft NAVD88	Living Shoreline Enhancements on west shore of Burlingame Lagoon	Improve Sanchez Creek Sediment Delivery
Flood Management	Flood Hazard	-Removes most of Reach 4 from 100-year floodplain -At risk to 100-year flood with 1 ft SLR (c. 2030-2090)	-Removes most of Reach 4 from 100-year floodplain -At risk to 100-year flood with 3 ft SLR (c. 2070-2090)	Potential to limit wave runup on shoreline levee protecting Hwy 101	Limited potential to limit wave runup on shoreline levee protecting Hwy 101
	Engineering competence for erosion, geotechnical, and seismic	High	High	Med	Low
	Parcel-to-reach scalability	High	Med	High	Med
	Adaptive capacity to sea-level rise	Med	High	High	Med
Economic	Potential to reduce the risk of asset damages	High	High	Low/Med	No Effect
	Protection for econ. vulnerable groups working or living in the project area	Med	High	Low	No Effect
	Protection for public infrastructure in the project area (e.g. wastewater mains)	High	High	Low	No Effect
	Cost	$$$	$$$$	$$$	$$$
Environmental	Does strategy protect existing habitat?	Yes	Yes	Yes	Yes
	Does strategy create new habitat?	No	No	Yes	No
Governance	Does this provide benefits beyond the project area?	Yes	Yes	Yes	No
	Ease of implementation using existing authorities or policies?	Med	Med	Med	Med
General Plan Considerations	Aesthetics: protects views to the waterfront	Med	Med	High	No Effect
	Recreation: encourages walking and biking	High	High	High	No Effect
	Impacts to water recreation and ferry service	No Effect	No Effect	No Effect	Low

Table 5: Reach 5 Strategies – Criteria Screening

Implications of Strategy		Raise Shoreline		Environmental Approaches
		Raise to 12 ft NAVD88	**Raise to 14 ft NAVD88**	**Consider Creating Bay Beach that ties into western edge of Coyote Point Beach**
Flood Management	Flood Hazard	-Removes most of Reach 5 from 100-year floodplain -At risk to 100-year flood with 1 ft SLR (c. 2030-2050)	-Removes most of Reach 5 from 100-year floodplain -At risk to 100-year flood with 3 ft SLR (c. 2070-2090)	Potential to limit wave runup on shoreline levee protecting Hwy 101 and Airport Drive
	Engineering competence for erosion, geotechnical, and seismic	High	High	Med
	Parcel-to-reach scalability	High	Med	Med
	Adaptive capacity to sea-level rise	Med	High	Med
Economic	Potential to reduce the risk of asset damages	High	High	No Effect
	Protection for econ. vulnerable groups working or living in the project area	Med	High	No Effect
	Protection for public infrastructure in the project area (e.g. wastewater mains)	High	High	No Effect
	Cost	$$$	$$$$	$$
Environmental	Does strategy protect existing habitat?	Yes	Yes	Yes
	Does strategy create new habitat?	No	No	Yes
Governance	Does this provide benefits beyond the project area?	Yes	Yes	No
	Ease of implementation using existing authorities or policies?	Med	Med	Low
General Plan Considerations	Aesthetics: protects views to the waterfront	Med	Med	High
	Recreation: encourages walking and biking	High	High	High
	Impacts to water recreation and ferry service	Low	Low	Low