



Appendix G Priority Coastal Inundation Locations

June 2022

The Priority Coastal Inundation Locations appendix is adopted from Alameda's 2019 Climate Action and Resiliency Plan.

Priority Coastal Inundation Locations

The vulnerability assessment defined priority coastal inundation locations as those assets or areas exposed to flooding risk soonest and with greatest consequence. Locations with significant flooding at a total water level of 24 or 36 inches (above today's high tide) were identified as at risk of sea level rise flooding "soon." Following climate change projections from the State of California, which the OPC published in 2017 (Griggs et al., 2017), 36 inches of sea level rise can be expected between 2060 and 2070 when considering a high emissions scenario with medium to high risk aversion. A total water level of 36 inches is also equivalent to 50-year storm surge today. Alameda is implementing climate-smart planning, as outlined in AB 2800, the "Climate-Safe Path for All." Therefore, as Alameda demonstrates leadership in GHG emissions reduction, the City should monitor global GHG emissions reduction trajectories and incorporate them into the planning process.

The following criteria¹ were used to identify location-based priority flooding assets:

Exposure assessment: Define the extent to which an asset experiences an impact. This includes considering the percent of an asset impacted as well as the probability of occurrence. The CARP vulnerability assessment was primarily concerned with exposure to flooding due to sea level rise and precipitation. Exposure in this assessment included both magnitude and timing (i.e., how much an asset is exposed to an impact and when exposure begins).

Sensitivity assessment: Determine the degree to which assets are affected by climate change impacts, including non-physical influences like governance. Sensitivity refers specifically to the asset itself, whereas consequence considers impacts to surrounding communities and assets.

Consequence assessment: Determine how impacts to the asset affect the surrounding community and assets, as well as Alameda more generally. Consider impacts to vulnerable communities as defined by a range of social vulnerability indicators.

Adaptive capacity assessment: Define the ability of assets, systems, or people to adjust to an adverse impact. Consider how changes in operations and/or minor physical improvements could increase the resilience of an asset to climate change.

Gap analysis: Consider assets and neighborhoods already addressed in existing City plans and commitments. Identify gaps to determine which assets are most critical to address. Determine the extent to which existing plans and commitments incorporate climate change.

The City has already evaluated sea level rise for select assets and projects. The CARP's vulnerability assessment did not re-examine existing commitments to adaptation, but rather builds on and aligns with those actions underway. **Table G-1** summarizes the key vulnerable assets addressed in existing City plans and/or commitments.

¹ These components are adapted from the ART process, which considers exposure, sensitivity, and adaptive capacity as components of vulnerability. The ART process also defines risk as the combination of likelihood and consequence, with consequence contributing more to overall risk.

Table G-1. Key Vulnerable Assets in Existing City Plans and Commitments

Asset	Plan
Alameda Point Shoreline (including Main Street Ferry Terminal)	Alameda Point Master Infrastructure Plan (MIP) and Alameda Point Town Center and Waterfront Precise Plan
City Hall West	Alameda Point MIP
Northern Waterfront	Northern Waterfront Development Plans
Shoreline Drive	City's 2017–2019 Capital Budget
Veteran's Court Seawall	Storm Drain Master Plan 2008 (focus on capacity upgrades)
Storm Drain Pump Stations	Storm Drain Master Plan 2008
Sewer Pump Stations	Sewer System Management Plan 2017
State Route (SR) 260	Caltrans State Route 260 Transportation Concept Report (signed 2011, reaffirmed 2017)

The 11 priority flooding locations identified through this approach fall within three categories: shoreline, natural, and recreation areas; utilities; and transportation. A detailed map for each location showing 36, 48, and 52 inches of sea level rise, as well as a one-page description of exposure, sensitivity, consequence, and adaptive capacity, are included in Appendix H. These priority flooding locations are described further below.

In addition, this section summarizes the vulnerability assessment results for the climate change vulnerabilities broadly applied by sector in Alameda. Appendices G and H contain detailed vulnerability profiles that align with the planning framework developed by the ART Program. The profiles include vulnerability statements that consider the physical, functional, governance, and informational components of an asset that contribute to sensitivities to climate impacts. Key issues and vulnerabilities for each shoreline segment as well as adaptive capacity and potential consequences are identified.

Shoreline, Natural, and Recreation Areas

The vulnerability assessment identified critical points of overtopping along the shoreline of Alameda that, if addressed, could substantially reduce flooding and inundation threatening residents, businesses, parks, and key assets in Alameda. These segments are discrete locations along the shoreline that overtop at lower sea level rise scenarios (24 or 36 inches) and therefore should be addressed first to help protect other assets and increase the resilience of the shoreline to greater amounts of sea level rise.

Several other segments of the Alameda Point shoreline that are likely to be overtopped at 24 or 36 inches of sea level rise were not defined as high priority because they are already addressed through the approved Alameda Point MIP. The MIP established a framework for sea level rise protection and adaptation at Alameda Point based on the best available science. It also set forth a monitoring and financing program to periodically review the latest science, sea level rise estimates, and guidance from local, state, and federal regulatory agencies. Amendments to the MIP will be adopted as needed to reflect any notable conclusions from the ongoing monitoring. In fact, an MIP amendment will be adopted to consistently reflect the conclusions of the CARP along with the latest OPC sea level rise projections and guidance from 2018.

Transportation

Alameda relies heavily on functional bridges and tunnels to connect to the mainland, and a large population relies on transit systems to commute. The vulnerability assessment focused on those assets that transit-dependent populations most heavily use, such as roadways used by multiple AC Transit bus routes, as well as transportation assets that are essential corridors on and off the island. To help organize and simplify the results of the assessment, several transportation assets were bundled in the summaries presented below.

Note: Transportation assets are also sensitive to the effects of other climate hazards, particularly extreme heat, which can damage road surfaces and pose a hazard to workers. The summaries included here do not discuss heat specifically because Alameda is not expected to experience temperatures that can heavily impact transportation assets. While ferry access is essential on Alameda, the Main Street Ferry Terminal was not identified as a high vulnerability because the City already has plans to adapt the area to address flood risk at ferry access points.

Storm Utilities

Ensuring the long-term viability of utility systems in Alameda is important to maintaining a healthy and vibrant city. In particular, the stormwater system is critical for ensuring proper drainage to prevent roads and neighborhoods from flooding during storm events. The City has identified deficiencies in the stormwater system that need to be funded and addressed to prepare Alameda for the impacts of sea level rise and increased storm intensity and/or frequency. The vulnerability assessment identified additional threats facing the stormwater system that would not be resolved by capacity upgrades to the system.

Threats to the stormwater system include rising ocean levels, rising groundwater levels, and increased storm intensity and/or frequency. Gravity-fed components of the stormwater system are particularly vulnerable to rising ocean levels because outfalls can be blocked. Future pumps may be required in locations currently served by gravity-fed outfalls. Rising groundwater levels associated with sea level rise add more stress to the system overall and could potentially damage or reduce the functionality of subsurface infrastructure. Additional assessment of the risk posed by rising groundwater levels is needed as new information on groundwater, including modeling results, becomes available.

Table G-2 shows the 11 location-based priority flooding assets identified during the vulnerability assessment, two of which include various locations. **Figure G-1** shows their locations spatially on Alameda Island, while **Figure G-2** shows the flooding areas on Bay Farm Island.

Table G-2. Location-Based Priority Flooding Assets

Asset Category	Asset Name	ID for Figures 4-8 and 4-9	Exposure (Sea Level Rise) ^a	Exposure (25-Year Flood) ^b			Sensitivity ^c	Consequence ^d	Adaptive Capacity ^e
Shoreline, Natural, and Recreation Areas	Shoreline Adjacent to Webster and Posey Tubes	1	Moderate (36")	None			Low	High	Moderate
	Veteran's Court Seawall	10	Moderate (36")	None			High	Moderate	Moderate
	Crown Beach and Bird Sanctuary	3	High (12")	None			High	Moderate	Moderate
	Bay Farm Island Bridge Touch Down Area (Alameda Island side)	4	Low (>48")	None			Moderate	Moderate	Moderate
	Eastshore Drive	5	Moderate (36")	None			Moderate	High	High
	Bay Farm Island Lagoon System 1 Outlet Gate and Seawall	9	Moderate (36")	None			Moderate	Moderate	Moderate
Utilities	Storm Drain Pipes and Pump Stations	Citywide	Moderate (36")		Varies		High	Moderate	Moderate
	Bayview Weir and Outfall	7	High (24")	None			High	High	High
Transportation	SR260 and Posey/Webster Tubes	2	Moderate (36")	High (1 ft+ flood)			High	High	Low
	Critical and High-Use Roadways (used by AC Transit)	6	Low (>48")	High (1 ft+ flood)			Moderate	High	Moderate
	SR61/Doolittle Drive	8	Moderate (36")	High (1 ft+ flood)			Low	High	Moderate

^a Exposure (sea level rise): Low= > MHHW+48"; Moderate=MHHW+36"; High=MHHW+12–24"

^b Exposure (25-year precipitation event): Low= <0.5 flood levels (above surface flooding); Moderate= 0.5–1ft flood levels; 1+ft flood levels

^c Sensitivity: Low= flood water recedes without major damage; Moderate= asset will be damaged by flooding (e.g., office), but equipment is not highly sensitive; High= asset is highly sensitive or already failing, and it provides sensitive habitat to protected species

^d Consequence: Low= minor/temporary precipitation-based flooding of residential neighborhood; Moderate= limited access to public services; High= restricted movement of emergency responders

^e Adaptive Capacity: Low= cannot adjust in place, and asset must be relocated or elevated; Moderate= major changes or replacement of existing asset are required; High: asset can adapt to new impacts given changes in operations and/or minor physical improvements

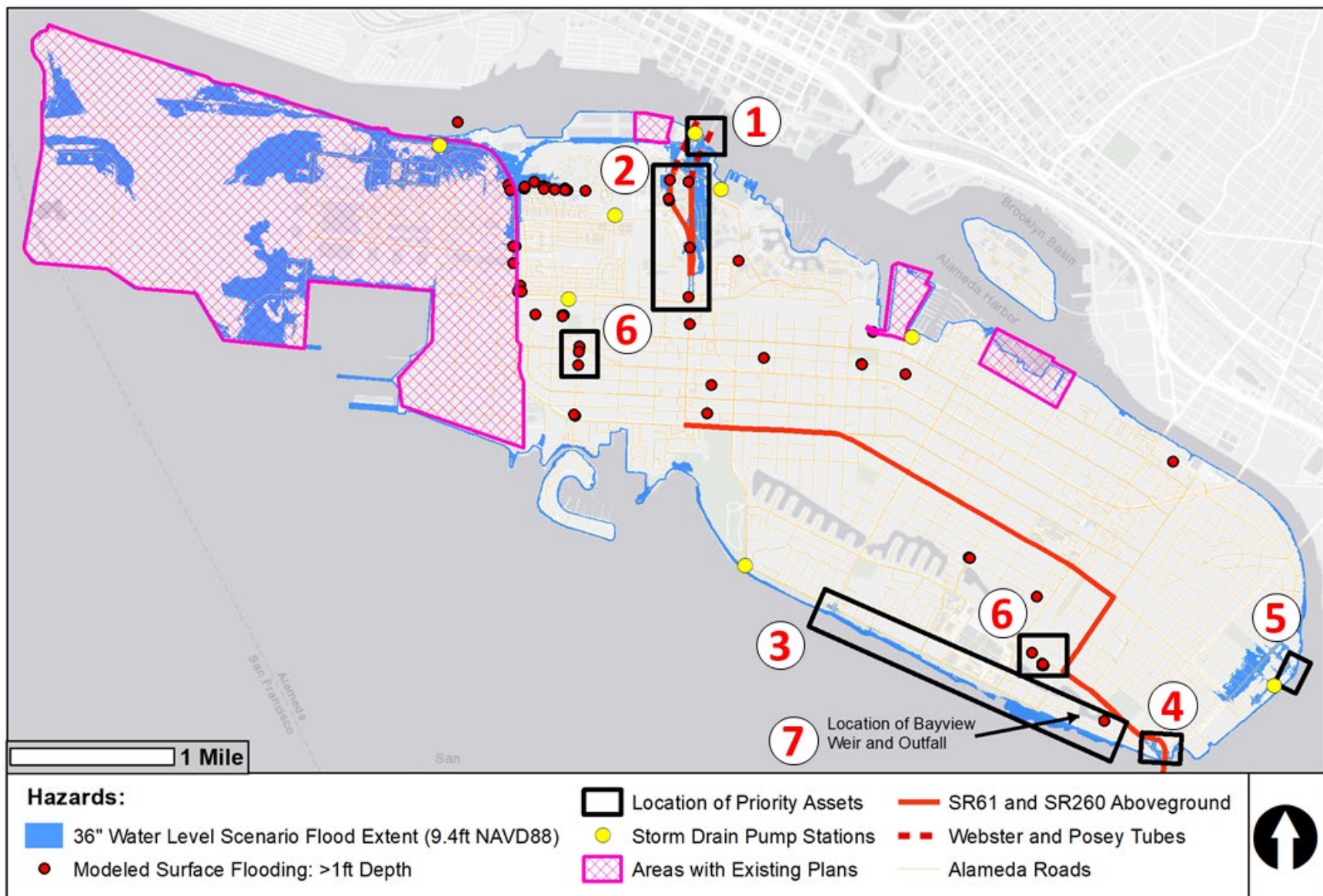


Figure G-1. Map showing the areas of location-based priority flooding on Alameda Island

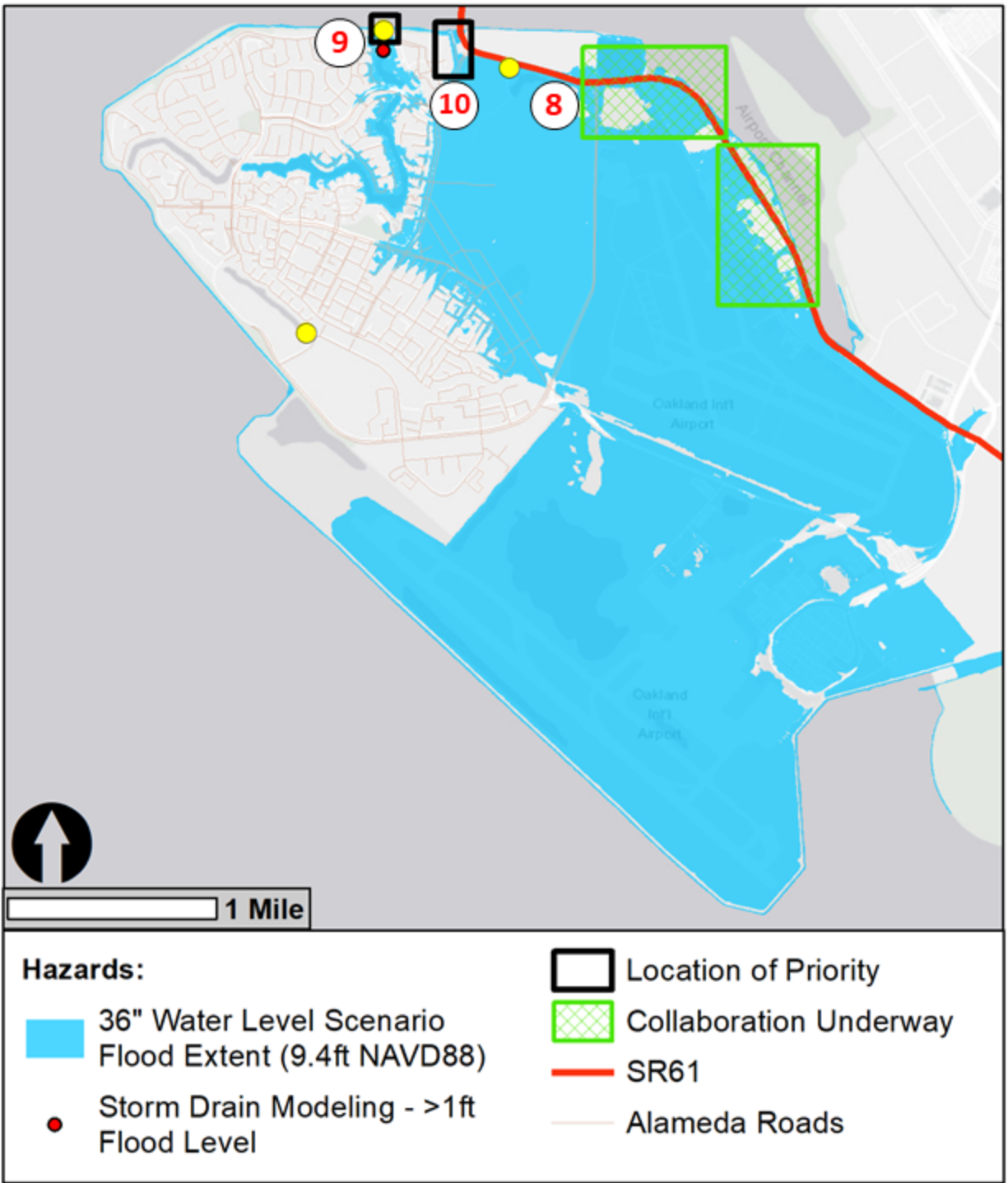


Figure G-2 Map showing the areas of location-based priority flooding on Bay Farm Island

Table G-3. Crown Memorial State Beach Vulnerability Summary

<p>Crown Memorial State Beach is a popular spot for recreation and education in Alameda. It has a pickleweed salt marsh that provides bird habitat in the Elsie Roemer Bird Sanctuary at the east end of the beach, as well as an eelgrass bed just offshore of the beach that provides juvenile fish habitat. Crown Beach and the bird sanctuary make up the majority of the natural shoreline on Alameda Island and are at substantial risk of erosion due to wave action and inundation from sea level rise.</p>	
Key Issue(s)	<ul style="list-style-type: none"> The narrow beach is vulnerable to sea level rise and storm surge flooding, as well as erosion due to wave action. It is backed by a road, housing, and shopping centers, giving it little capacity to migrate inland. Decisions on adaptation will involve the City (owns the land), East Bay Regional Parks District (EBRPD; manages the beach), and the community at large.
Exposure	<ul style="list-style-type: none"> Lower elevation portions of the sandy beach are currently susceptible to flooding at king tides. Large portions of the beach and bird sanctuary are inundated at 36" total water level, at which point small segments of Shoreline Drive also experience flooding originating at this location. At 48" total water level, nearly all of the beach and bird sanctuary are overtopped, leading to flooding of adjacent neighborhoods.
Sensitivity	<p>Governance</p> <ul style="list-style-type: none"> The northern portion of the park is owned by California State Parks; the narrow southern part, including the beach and trail along Shoreline Drive, is owned by the City of Alameda. EBRPD has operating agreements and manages the entire area (bird sanctuary and beach) as one park. <p>Informational</p> <ul style="list-style-type: none"> There is limited information on the efficacy of existing groins to prevent beach erosion. EBRPD is working on a Crown Beach Master Plan update that will consider sea level rise; however, this work is currently on hold and it is unknown when it will proceed. <p>Functional</p> <ul style="list-style-type: none"> The beach and bird sanctuary provide flood protection to important roads (e.g., Shoreline Drive), residential neighborhoods, and commercial areas (e.g., South Shore Shopping Center). <p>Physical</p> <ul style="list-style-type: none"> The beach is not a natural structure and regular nourishment is needed. In 2013, sand was pumped in due to heavy erosion, and groins are used to keep sand in place. Several sensitive resources are present in this area, such as an eelgrass bed and salt marsh that provide nursery habitat and a food source for aquatic birds, including some threatened and endangered species.
Adaptive Capacity	<ul style="list-style-type: none"> The beach is very narrow and backed by a road, so there is limited capacity to migrate inland as the beach erodes and lower-elevation portions become permanently inundated. The sloping character of the beach and tidal flats offshore provide opportunities to adapt the shoreline through living or nature-based features.
Consequences	<ul style="list-style-type: none"> Social: The beach is very popular for recreation and educational programs, and it is one of only a small number of sandy beaches in the East Bay. Economic: Crown Beach is an important tourist destination. Although no fees are collected, tourism brings money to businesses in the area. Environment: Habitat in this area could be lost if the Elsie Roemer Bird Sanctuary is inundated and no adaptation action is taken.

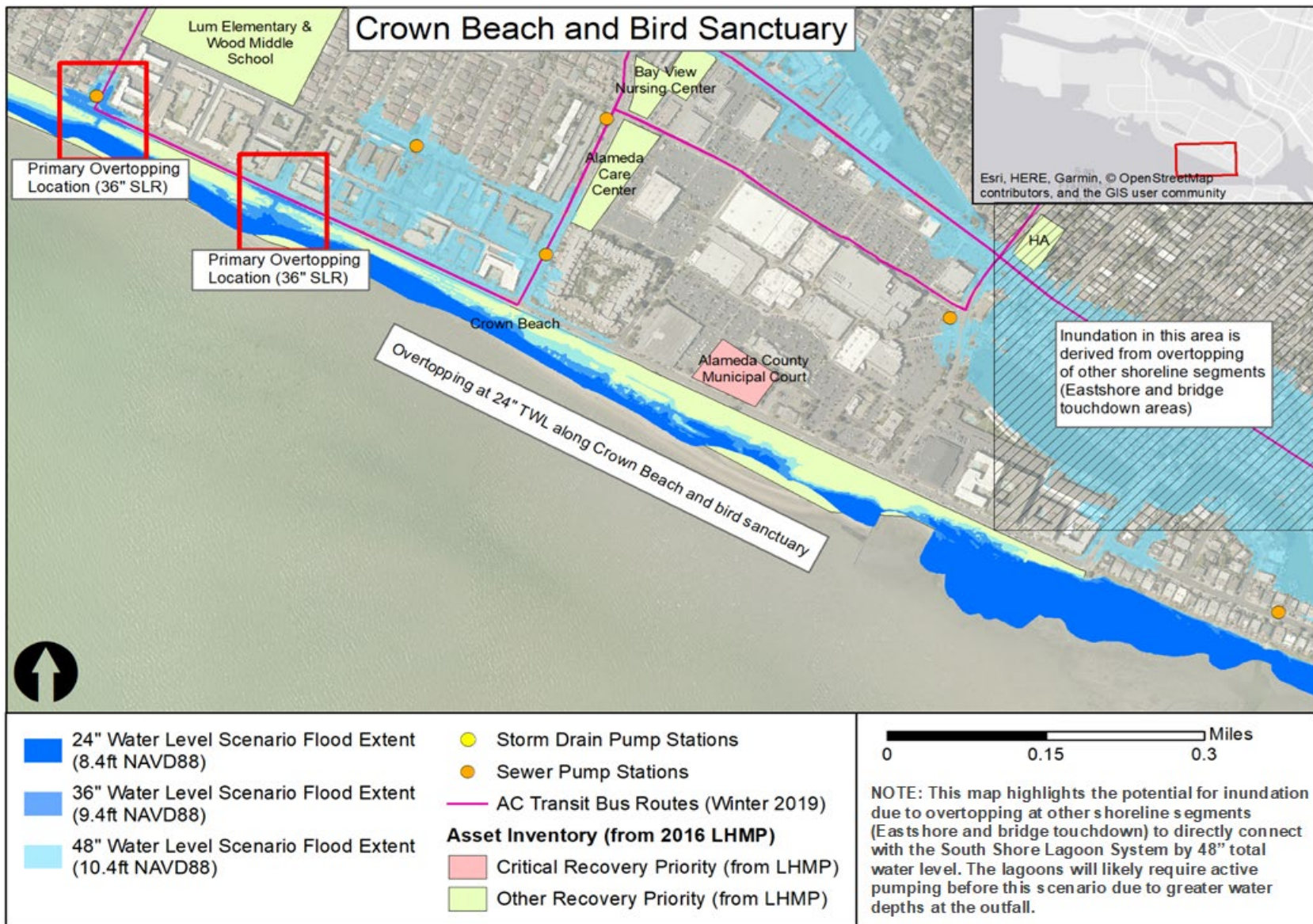


Table G-4. Eastshore Drive (Adjacent Shoreline) Vulnerability Summary

<p>Eastshore Drive is the easternmost, north-south-oriented road on Alameda Island, providing access to the Eastshore and Fernside neighborhoods. These residential neighborhoods have many homes with private docks in San Leandro Bay. Although there are several designated points of public access along Eastshore Drive, there are no extensive public trails or parks along the shoreline. Private homes dominate the eastern waterfront. The Federal Emergency Management Agency (FEMA) recently determined that sections of the Eastshore neighborhood are within the 1 percent annual chance floodplain.</p>	
Key Issue(s)	<ul style="list-style-type: none"> The Eastshore area is a low-lying section of the city with a large residential area vulnerable to flooding from sea level rise and storm events. There is limited space for adaptation because homes are built out very close to the waterfront. A potentially complex collaboration with homeowners and related groups (e.g., homeowners' associations [HOAs]) will be necessary to agree upon shoreline protection measures due to ownership in this area.
Exposure	<ul style="list-style-type: none"> Overtopping of existing shoreline structures in this area begins at 36" total water level, at which point floodwaters extend inland, inundating portions of Fernside Boulevard, the stormwater pump station serving this area, and areas as far inland as the fields near the Harrison Recreation Center. Initial shoreline overtopping is likely restricted to small sections of the shoreline (e.g., at the end of Liberty Drive), but more substantial shoreline overtopping occurs along the east shore at higher water levels, beginning as early as 48" total water level.
Sensitivity	<p>Governance</p> <ul style="list-style-type: none"> Substantial portions of the east shoreline are privately owned. Beginning in 2005, ownership transfers between the U.S. Army Corps of Engineers (USACE) and the City of Alameda, and then between the City and private landowners, resulted in individual property rights over submerged lands along the shore. Property owners will likely need to buy in to potential shoreline protection solutions, although the actual concrete seawall along properties in this area is part of City-owned parcels that are leased to homeowners. <p>Informational</p> <ul style="list-style-type: none"> There is no known inventory of the condition of shoreline protection structures in this area beyond basic shoreline elevation data. <p>Functional</p> <ul style="list-style-type: none"> Shoreline in this area protects residential communities and streets. <p>Physical</p> <ul style="list-style-type: none"> Nearly all of the east shoreline of Alameda Island is heavily armored with engineered flood protection structures like seawalls and levees. The condition and quality of these structures determines their vulnerability to sea level rise and storm surge. Environmental resources like submerged aquatic vegetation (SAV) are present throughout San Leandro Bay, including near the east shoreline of Alameda Island. These resources provide important habitat for aquatic species and some level of wave attenuation.
Adaptive Capacity	<ul style="list-style-type: none"> There is very limited available space for constructing new shoreline structures, especially nature-based shorelines like living levees, which generally require a much larger footprint. Tidal flats along this stretch of shoreline may provide opportunities for some nature-based adaptation strategies. FEMA floodplain designation in this area may open funding opportunities to address shoreline issues.
Consequences	<ul style="list-style-type: none"> Social: Overtopping of this shoreline may lead to flooding of the Eastshore and Fernside neighborhoods, where few homes are flood-proofed. Environmental: Flooding of large residential areas could lead to the release of debris and invasive species into San Leandro Bay, where restoration of sensitive habitats is currently underway.

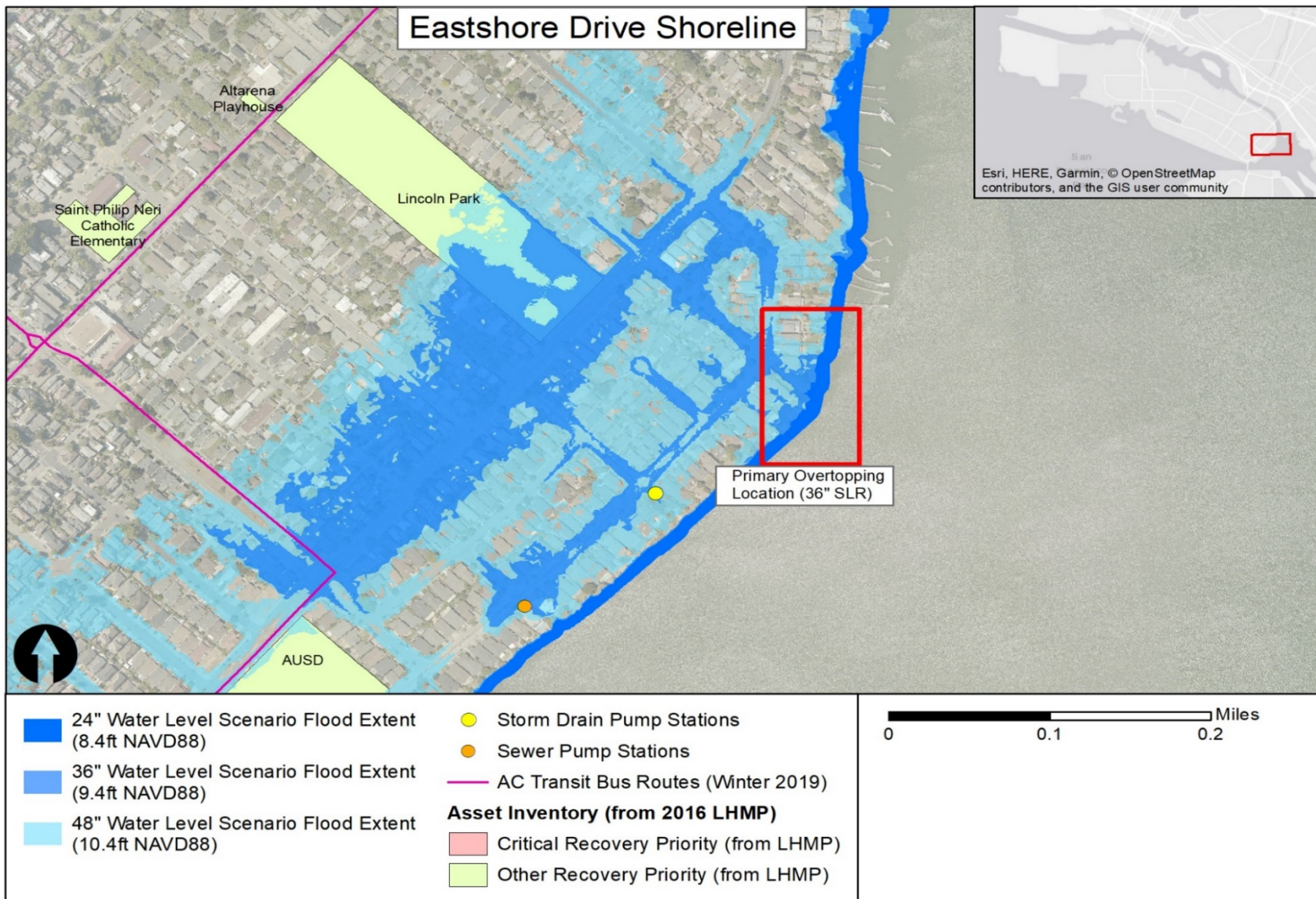


Table G-5. Shoreline Adjacent to Webster and Posey Tubes Vulnerability Summary

<p>The area of concern is the shoreline immediately adjacent to the Webster and Posey Tubes along the northern shore of Alameda Island. Numerous development projects are in the planning stage along the northern waterfront, and any long-term strategy to address flooding along the northern waterfront requires a coordinated approach across all new development projects and areas between. The shoreline in this area is lined with marinas, yacht brokerages, houseboats, and some shoreline public trails, and it is composed of a combination of levees and seawalls.</p>	
Key Issue(s)	<ul style="list-style-type: none"> Overtopping of the shoreline near the tubes leads to inundation of one of the most critical transportation corridors in Alameda, including Webster Street and the tubes themselves. The proximity of businesses along the northern shoreline will pose design challenges for shoreline modifications, which must maintain public access to the waterfront. Numerous sensitive assets in this area would be inundated if the shoreline overtops; many assets were recently added to the FEMA 1 percent annual chance floodplain.
Exposure	<ul style="list-style-type: none"> Shoreline overtopping begins at 36" total water level, at which point several buildings—such as the Oakmont of Mariner Point and Mariner Square Shopping Center—are at risk of inundation, as well as key assets like the Webster and Posey portals. Webster Street initial overtopping is restricted to a small (< 1,000-foot) section of shoreline in the immediate area, but more substantial shoreline overtopping occurs at higher water levels.
Sensitivity	<p>Governance</p> <ul style="list-style-type: none"> The shoreline area is lined with private businesses that should be involved in managing shoreline protection at this site. There is limited City ownership of shoreline except public trails and open space, which are owned and managed by the Alameda Recreation and Parks Department. Any changes to shoreline public access would need to be designed in accordance with Bay Conservation and Development Commission (BCDC) requirements. <p>Informational</p> <ul style="list-style-type: none"> There is no known inventory of the condition of shoreline protection structures in this area beyond basic shoreline elevation data. <p>Functional</p> <ul style="list-style-type: none"> Shoreline protection in this area protects sensitive assets that house vulnerable populations, including several senior care centers and a daycare center. In addition, shoreline protection is needed to keep floodwaters from impacting Bay Ship and Yacht and the Hazardous Materials Transfer Station, which are both locations where hazardous materials could be mobilized. <p>Physical</p> <ul style="list-style-type: none"> Shoreline protection structures in this area suffer from erosion due to deferred maintenance.
Adaptive Capacity	<ul style="list-style-type: none"> There is opportunity to adapt this site by enhancing engineered structures (seawalls and levees) between the public path and the water. It is not clear if engineered structures can be adapted over time to provide sufficient protection for sea level rise beyond mid-century due to the characteristics of this shoreline and the height required to address end-of-century water levels (> 15 feet NAVD88).
Consequences	<ul style="list-style-type: none"> Social: Flooding near the tubes could disproportionately impact vulnerable communities, including many transit-dependent residents that live on and around Webster Street. Many AC Transit bus routes use the roads in this area, placing substantial burden on low-income and other vulnerable populations. Economic: Interruptions to the tubes would severely hamper goods movement from Alameda to the mainland. Environmental: Flooding of the Hazardous Materials Transfer Station and industrial facilities in this area could mobilize harmful substances.

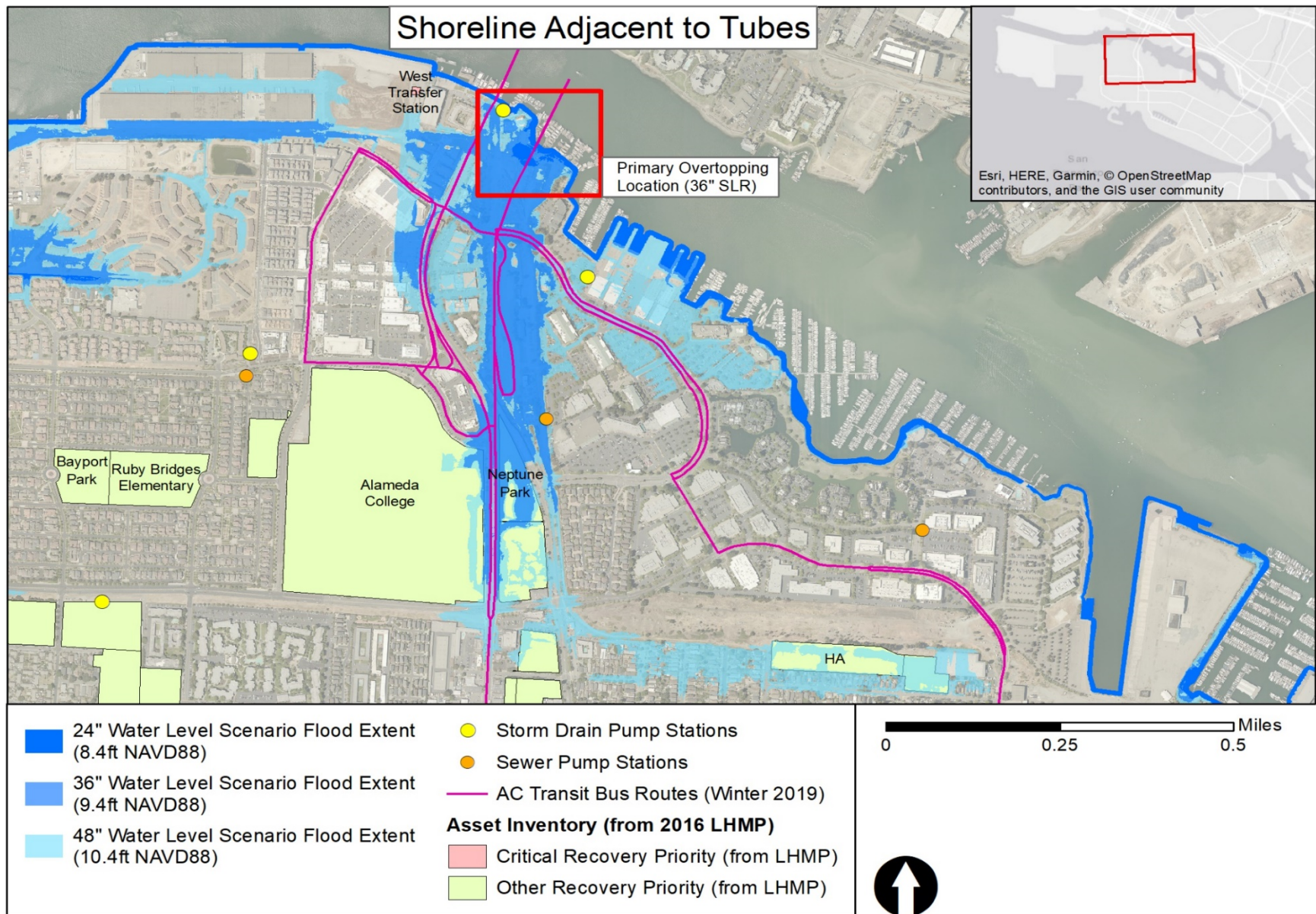


Table G-6. Bay Farm Island Bridge Touchdown and Towata Park Vulnerability Summary

<p>The stretch of shoreline near the Bay Farm Island Bridge touchdown on Alameda Island provides flood protection to the adjacent residential area, Bridgeview Isle, and Krusi Park. Overtopping at this location begins at 24" total water level but does not impact residential areas until 36" total water level. The current shoreline is composed of seawalls and riprap with a mix of City and Raven's Cove HOA ownership. The City owns and maintains Towata Park at this location, which is impacted by flooding at 36" total water level.</p>	
Key Issue(s)	<ul style="list-style-type: none"> Shoreline protection structures in this area currently provide flood protection for surrounding roads, residential neighborhoods, and Krusi and Towata Parks. Floodwater originating in this area may merge with water derived from overtopping in other areas at higher water levels, leading to substantial inundation that is only addressed with shoreline modifications in several locations.
Exposure	<ul style="list-style-type: none"> Minor overtopping of the shoreline directly west of the bridge touchdown on Alameda Island begins at 24" total water level. At 36" total water level, Bridgeview Isle and some nearby houses are impacted. At 48" total water level and higher, the flood area expands significantly with several important streets and other assets impacted. Flooding at higher water levels could connect with the lagoons, leading to more widespread inundation.
Sensitivity	<p>Governance</p> <ul style="list-style-type: none"> Several jurisdictions have oversight of assets near the Bay Farm Island Bridge. The bridge itself is within the Caltrans Right of Way. The shoreline west of Towata Park is owned by the California Department of Parks and Recreation, while Towata Park is owned by the City. Information also suggests that the Raven's Cove HOA may own parts of the shoreline in this area. Coordination among multiple agencies is necessary to address shoreline deficiencies in this area. <p>Informational</p> <ul style="list-style-type: none"> Beyond 48" total water level, multiple areas of shoreline overtopping could lead to flooding of large segments in southeastern Alameda Island, including around the South Shore Lagoons. Because the shoreline overtops at several locations in the same general area, it is not clear where the majority of floodwaters originate, making it challenging to prioritize actions. The lack of clear information on floodwater source suggests an integrated approach is necessary for this entire area. <p>Functional</p> <ul style="list-style-type: none"> Shoreline overtopping in this area leads to flooding along Otis Drive, Fernside Drive, and High Street, which all connect to the Bay Farm Island Bridge and are important connections between Alameda and Bay Farm Island. The bridge is also part of official evacuation routes in Alameda. <p>Physical</p> <ul style="list-style-type: none"> Eelgrass beds are present in the San Leandro Bay Inlet immediately near the Bay Farm Island Bridge. Any adaptation actions in this area need to avoid or mitigate impacts to eelgrass and should seek to enhance eelgrass habitat where possible.
Adaptive Capacity	<ul style="list-style-type: none"> Adaptation in this area will likely require strategies to be integrated and coordinated across multiple landowners and agencies because flooding over the longer term originates from multiple areas of shoreline overtopping.
Consequences	<ul style="list-style-type: none"> Social: Bay Farm Island Bridge is an important corridor for commuters, businesses, and emergency response. It is the only direct connection between the islands and blocked access would greatly disrupt daily life. Economic: Approximately 40,000 vehicles cross the bridge daily and disruptions would greatly impact the movement of goods and services. Environmental: Degradation of the adjacent tidal flat and marsh panne could negatively impact nearby SAV.

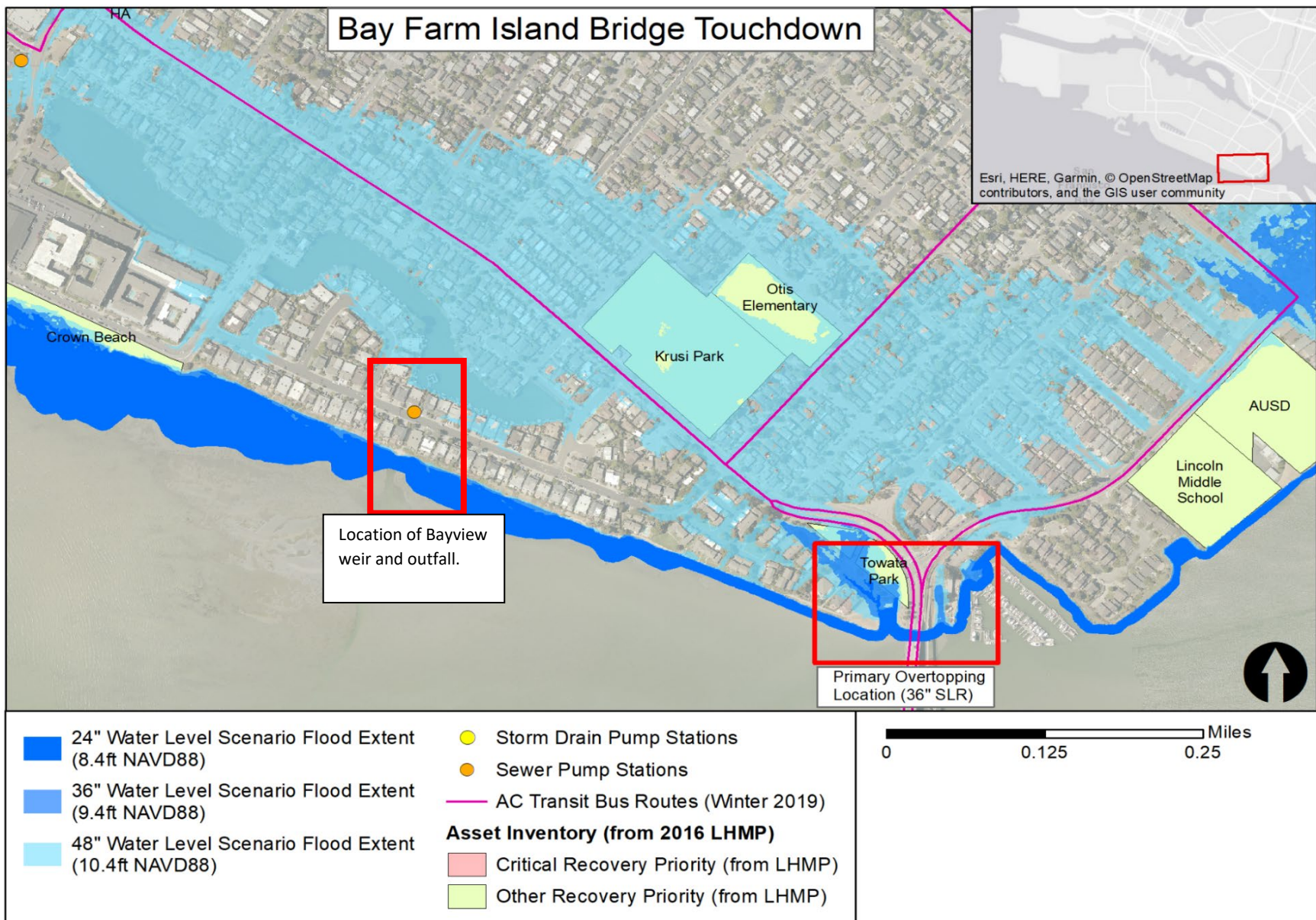


Table G-7. Bay Farm Island Lagoon System 1 North Outlet Gate and Seawall Vulnerability Summary

<p>The Bay Farm Island lagoon system draws water at the southern end and discharges it at the North Outlet Gate, located just west of Bay Farm Island Bridge. The shoreline at the outlet gate is a narrow isthmus of land that provides flood protection but is not a certified seawall or levee. The outlet gate is used to manage water levels in the lagoon through a passive tide gate system (currently inoperable) and an active pump. The shoreline in this area is a critical point of protection for the lagoon system and the homes that surround it.</p>	
Key Issue(s)	<ul style="list-style-type: none"> ■ The lagoon system is at risk of flooding due to issues at the outlet gate, including a slow pump that cannot rapidly lower water levels, an inoperable tide gate, and deficiencies in the seawall at that location. Overtopping of the shoreline in this area could inundate the lagoon system and lead to substantial flooding in surrounding neighborhoods.
Exposure	<ul style="list-style-type: none"> ■ Overtopping at the outlet gate seawall is likely at 36" total water level, potentially leading to overtopping of the banks of the lagoon and flooding of adjacent neighborhoods. Beyond 36" total water level, floodwaters originating at this location merge with floodwaters from elsewhere on Bay Farm Island, leading to substantial inundation across the island.
Sensitivity	<p>Governance</p> <ul style="list-style-type: none"> ■ The City of Alameda assumed maintenance responsibility in 1993 for the dike at the outlet gate, although other entities—including the Harbor Bay Isle Owner's Association—own the lagoon retaining walls and tide gate/pump structure. The City can modify the outlet gate and seawall to protect the lagoon system from flooding. Coordination with relevant Bay Farm Island organizations, including HOAs, is necessary to ensure the lagoon systems are resilient to climate change in the long term. Replacement of the seawall at this location will likely require permits or coordination with BCDC, USACE, and the California Department of Fish and Wildlife. <p>Informational</p> <ul style="list-style-type: none"> ■ There is limited information on the structural condition of the outlet pipe or the dike, including the structural makeup of the dike itself, which is partially built on sunken ships and dredged material. ■ Flooding on Bay Farm Island is connected to several sources of overtopping, making it challenging to identify a primary source. More detailed assessment could help determine the source of flooding, but a coordinated approach to adaptation across Bay Farm Island is warranted. <p>Functional</p> <ul style="list-style-type: none"> ■ Some equipment at the outlet gate and pump is deficient, including the tide gate itself, which is currently inoperable—a pump drains the lagoon. The pump is undersized to drain the lagoons rapidly, which may be necessary if there is a large storm event on top of sea level rise. Compounding this, pressure transducers used to measure water levels in the lagoons are inaccurate and unreliable. <p>Physical</p> <ul style="list-style-type: none"> ■ The structural condition of the dike is unknown, and the seawall built on it may be at risk of failure during a large event like an earthquake. Deficiencies along the interior lagoon retaining walls could also contribute to flooding next to the lagoons.
Adaptive Capacity	<ul style="list-style-type: none"> ■ Operational and physical changes at this site could increase its resilience to sea level rise and storm surge. Relatively minor modifications to the seawall could provide short-term protection from storm events and remove substantial areas from the FEMA 1 percent annual chance floodplain.
Consequences	<ul style="list-style-type: none"> ■ Social: If the seawall breaches or the lagoon system fails to drain during a storm, many homes and businesses could be flooded. ■ Economic: Flooding next to the lagoon system would impact important roads and cut off access to some neighborhoods on the island.

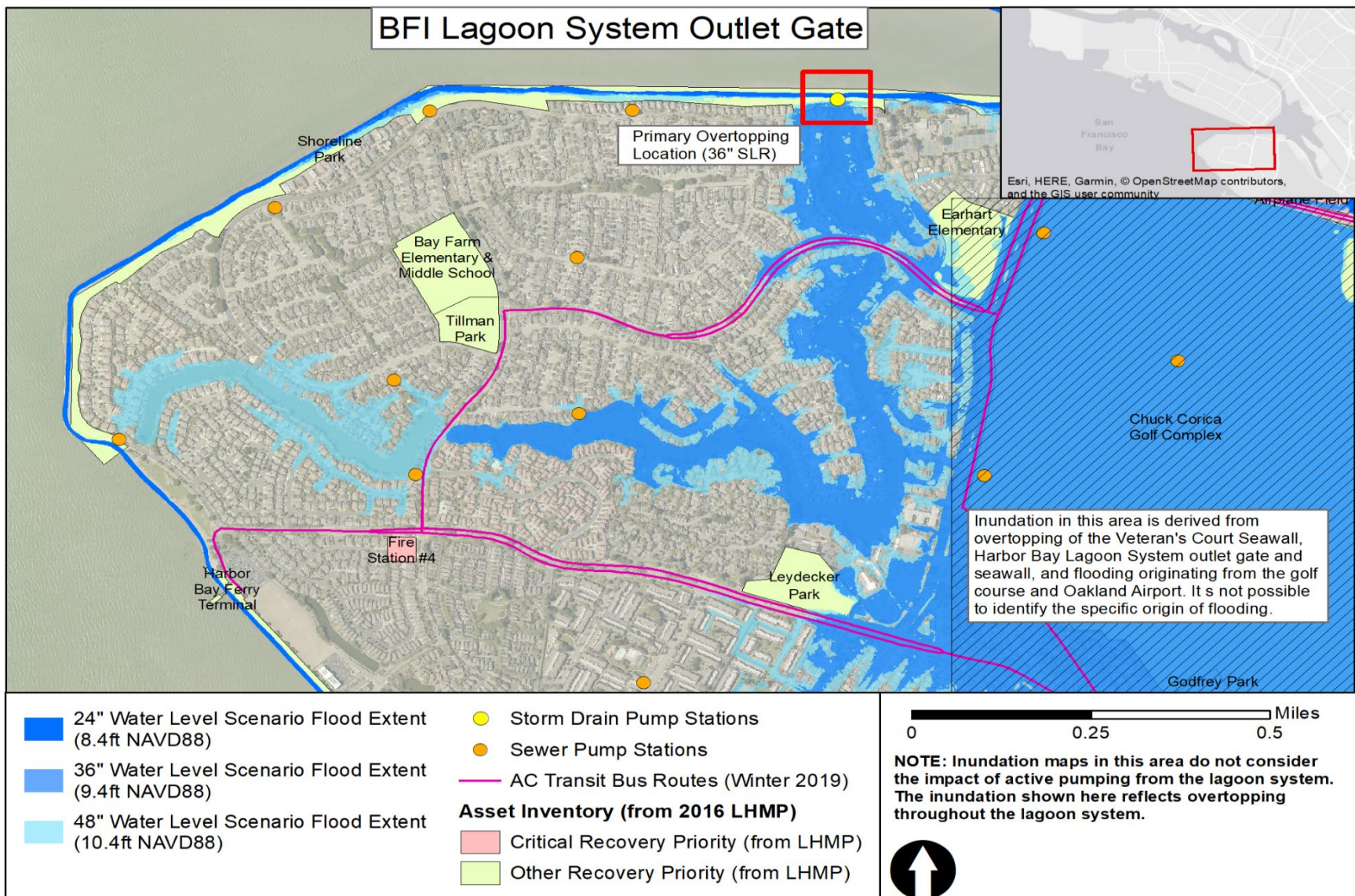


Table G-8. Veteran's Court Seawall Vulnerability Summary

<p>Veteran's Court is a small road near the Bay Farm Island Bridge touchdown on Bay Farm Island. It connects to Island Drive and serves primarily as an access road to the shore for maintenance or recreation. Veteran's Memorial Park is also considered part of this priority shoreline area due to its importance to flood mitigation strategies. Veteran's Court itself serves as a conduit for floodwaters if the seawall in this area is breached, potentially contributing to substantial inundation along Island Drive and adjacent neighborhoods.</p>	
Key Issue(s)	<ul style="list-style-type: none"> ■ The Veteran's Court area is located within the FEMA 1 percent annual chance floodplain. Overtopping of this shoreline results in flooding at a major intersection on Bay Farm Island (Doolittle and Island Drives). While there are options for adapting this specific section of low-elevation shoreline, other shoreline areas across Bay Farm Island also overtop at similar water levels. Beyond 36" total water level, a coordinated response to shoreline overtopping on Bay Farm Island is needed to prevent flooding.
Exposure	<ul style="list-style-type: none"> ■ The Veteran's Court seawall overtops at 36" total water level, below the FEMA base flood elevation (10' NAVD88). At 48" total water level, inundation from Veteran's Court merges with inundation from other overtopped shorelines on Bay Farm Island, making it difficult to determine the exact source of floodwaters. The Veteran's Court area is likely responsible for some component of flooding at the intersection of Island Drive and Doolittle Drive.
Sensitivity	<p>Governance</p> <ul style="list-style-type: none"> ■ The seawall itself is owned by the City but is not accredited by FEMA. Addressing vulnerabilities in this immediate area, especially over the longer term as water levels continue to rise, would likely require coordination with adjacent private landowners, including the Harbor Bay Club and adjacent neighborhoods. ■ Flooding on Bay Farm Island, derived from Veteran's Court and other locations, impacts State Route (SR) 61 (Doolittle Drive), which Caltrans owns. Coordination with Caltrans is important to maintain traffic flow along this critical road, one of the primary evacuation routes from Alameda. <p>Informational</p> <ul style="list-style-type: none"> ■ It is very difficult to determine the exact source of flooding on Bay Farm Island beyond 36" total water level due to overtopping at multiple locations. <p>Functional</p> <ul style="list-style-type: none"> ■ The presence of other vulnerable spots along the shoreline in this immediate area and more broadly across Bay Farm Island means that fixing the Veteran's Court seawall alone will not reduce all local flood vulnerability. <p>Physical</p> <ul style="list-style-type: none"> ■ Alameda's 2008 Storm Drain Master Plan indicates that seepage is observed along the seawall at high tide.
Adaptive Capacity	<ul style="list-style-type: none"> ■ There are multiple options for enhancing flood protection along Veteran's Court, but construction and engineering of some sort is required; however, no immediate or simple modifications to this location could address sea level rise and storm surge.
Consequences	<ul style="list-style-type: none"> ■ Social: Community impacts are likely if major transportation routes on Bay Farm Island are blocked. Flooding is also likely to directly impact residences and businesses. ■ Economic: Substantial disruption to commuter and commercial transit is likely if Island Drive and/or Doolittle Drive flood. ■ Environmental: SAV is present immediately adjacent to Veteran's Court and should be protected.

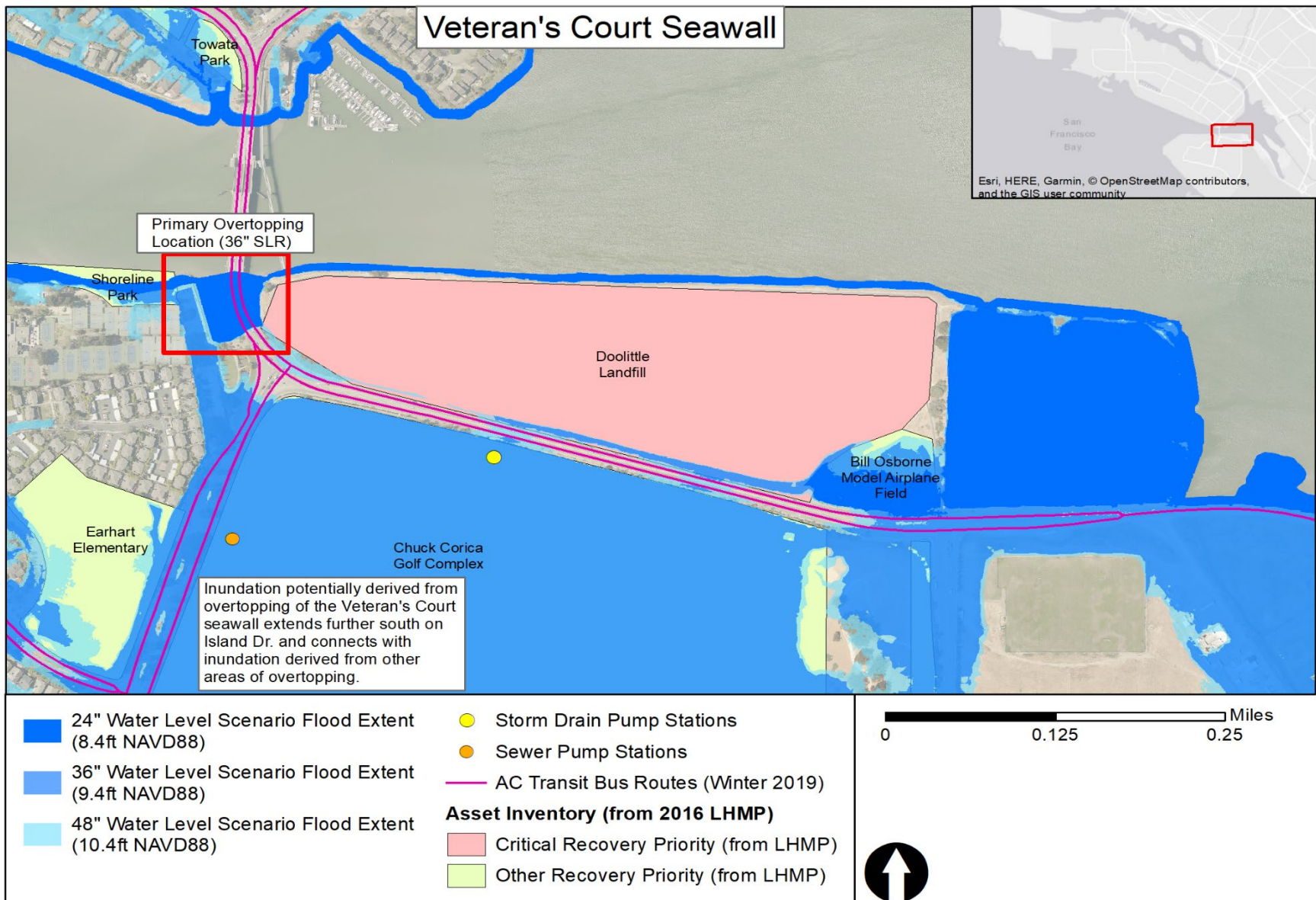


Table G-9. Bay Farm Island Bridge Touchdown and Towata Park Vulnerability Summary

<p>The stretch of shoreline near the Bay Farm Island Bridge touchdown on Alameda Island provides flood protection to the adjacent residential area, Bridgeview Isle, and Krusi Park. Overtopping at this location begins at 24" total water level but does not impact residential areas until a total water level of 36". The current shoreline is composed of seawalls and riprap with a mix of City and Raven's Cove HOA ownership. Towata Park at this location is owned and maintained by the City and is impacted by flooding by 36" total water level.</p>	
Key Issue(s)	<ul style="list-style-type: none"> Shoreline protection structures in this area currently provide flood protection for surrounding roads, residential neighborhoods, and Krusi and Towata Parks. Floodwater originating in this area may merge with water derived from overtopping in other areas at higher water levels, leading to substantial inundation that is only addressed with shoreline modifications in several locations.
Exposure	<ul style="list-style-type: none"> Minor overtopping of the shoreline directly west of the bridge touchdown on Alameda Island begins at 24" total water level. At 36" total water level, Bridgeview Isle and some nearby houses are impacted. At 48" total water level and higher, the flood area expands significantly with several important streets and other assets impacted. Flooding at higher water levels could connect with the lagoons, leading to more widespread inundation.
Sensitivity	<p>Governance</p> <ul style="list-style-type: none"> Several jurisdictions have oversight of assets near the Bay Farm Island Bridge. The bridge itself is within the Caltrans Right of Way. The shoreline west of Towata Park is owned by the California Department of Parks and Recreation, while Towata Park is owned by the City. There is also information suggesting the Raven's Cove HOA may own parts of the shoreline in this area. Coordination among multiple agencies is necessary to address shoreline deficiencies in this area. <p>Informational</p> <ul style="list-style-type: none"> Beyond 48" total water level, multiple areas of shoreline overtopping could lead to flooding of large segments in southeastern Alameda Island, including around the South Shore Lagoons. Because the shoreline overtops at several locations in the same general area, it is not clear where the majority of floodwaters originate, making it challenging to prioritize actions. The lack of clear information on floodwater source suggests an integrated approach is necessary for this entire area. <p>Functional</p> <ul style="list-style-type: none"> Shoreline overtopping in this area leads to flooding along Otis Drive, Fernside Drive, and High Street, which all connect to the Bay Farm Island Bridge and are important connections between Alameda and Bay Farm Island. The bridge is also part of official evacuation routes in Alameda. <p>Physical</p> <ul style="list-style-type: none"> There are eelgrass beds present in the San Leandro Bay Inlet immediately near the Bay Farm Island Bridge. Any adaptation actions in this area need to avoid or mitigate impacts to eelgrass and should seek to enhance eelgrass habitat where possible.
Adaptive Capacity	<ul style="list-style-type: none"> Adaptation in this area will likely require strategies to be integrated and coordinated across multiple landowners and agencies because flooding over the longer term originates from multiple areas of shoreline overtopping.
Consequences	<ul style="list-style-type: none"> Social: Bay Farm Island Bridge is an important corridor for commuters, businesses, and emergency response. It is the only direct connection between the islands and blocked access would greatly disrupt daily life. Economic: Approximately 40,000 vehicles cross the bridge daily and disruptions would greatly impact the movement of goods and services. Environmental: Degradation of the adjacent tidal flat and marsh panne could negatively impact nearby SAV.

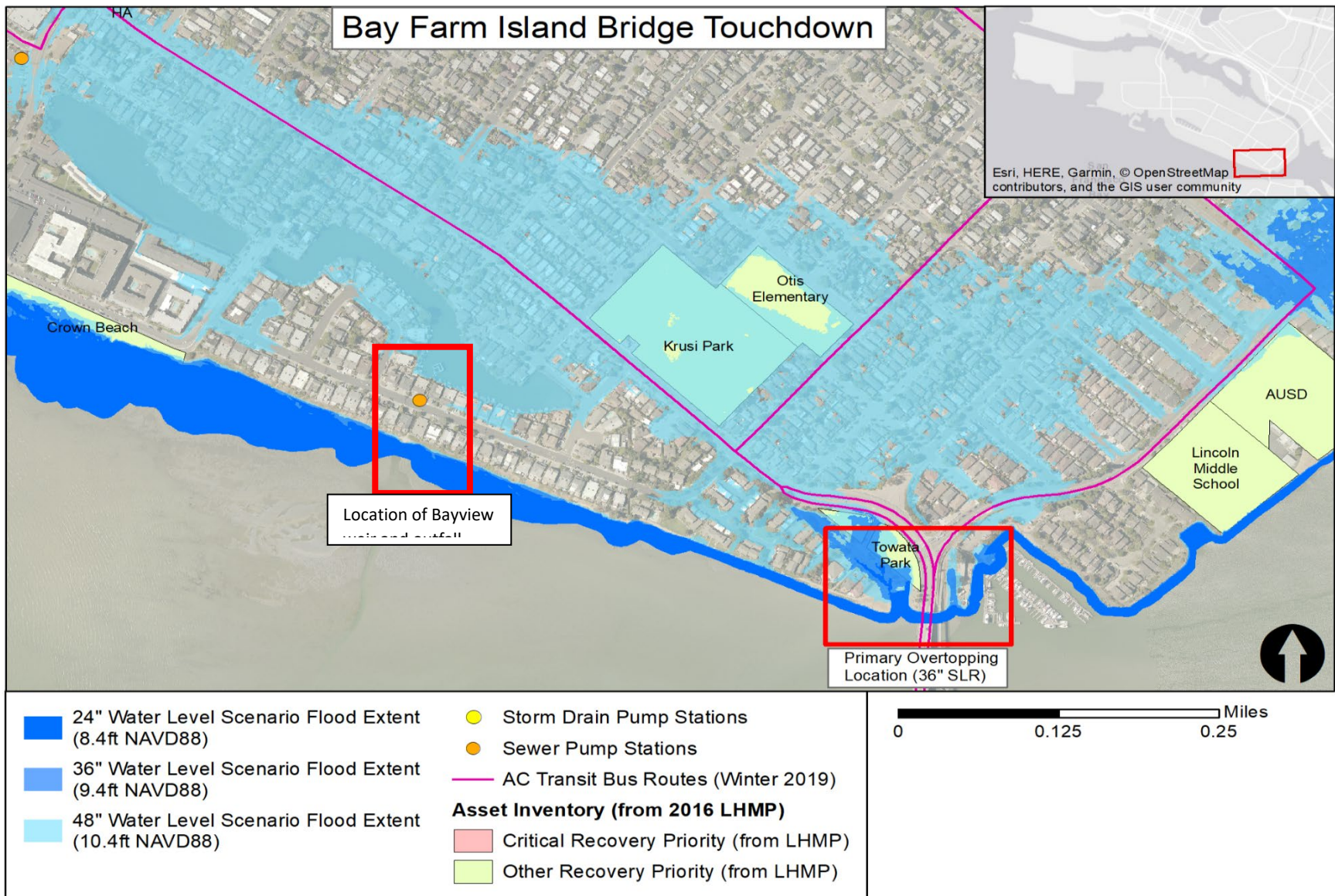


Table G-10. SR260, Including Webster and Posey Tubes, Vulnerability Summary

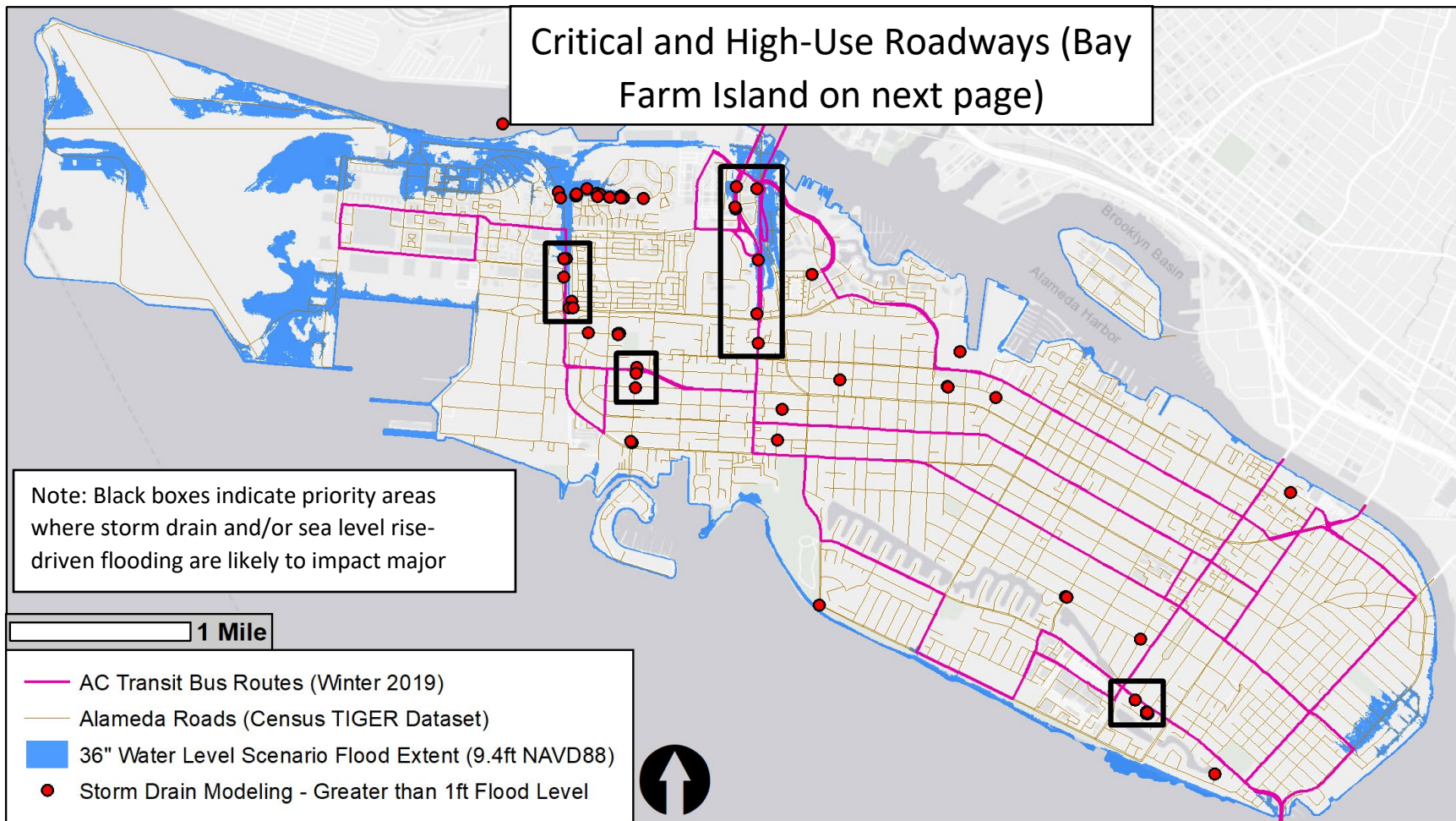
<p>SR260 is a critical transportation corridor connecting Alameda and Oakland—the tubes are one of four ways on or off Alameda Island. The historic average annual daily traffic at the tubes is approximately 31,500, including numerous commercial vehicles, which account for approximately 2.5 percent of daily traffic. The Posey Tube is the second oldest underwater tunnel in the United States (built in 1928) and was added to the National Register of Historic Places in 2000. Although seismic retrofits were completed in 2004, the age of the tube may increase its vulnerability to climate impacts. Webster Tube, built in 1963 to ease traffic volume in Posey Tube, is at lower risk of age-related deterioration.</p>	
Key Issue(s)	<ul style="list-style-type: none"> SR260 is essential to the movement of people, goods, and emergency services. However, the tubes are vulnerable to flooding derived from both shoreline overtopping and precipitation events. Mixed jurisdictional oversight of the asset(s) could also pose a barrier to the implementation of adaptation measures, primarily because Caltrans is not specifically authorized to implement resilience/adaptation projects (but can incorporate adaptation/resilience into larger transportation projects).
Exposure	<ul style="list-style-type: none"> SR260 and the tubes are exposed to sea level rise and storm surge flooding at 36" total water level. Inundation likely originates along the northern shoreline adjacent to the tubes (as described in the summary for that shoreline area). Overtopping near the Main Street Ferry Terminal may also contribute to flooding at the tubes. There is also substantial exposure to storm drain flooding driven by precipitation events near the entrance to the tubes, with storm drain modeling indicating multiple locations of potential flooding greater than 1 foot above street level.
Sensitivity	<p>Governance</p> <ul style="list-style-type: none"> Caltrans owns and maintains SR260 and the tubes. The City of Alameda also has some maintenance responsibility and oversight, particularly along streets that lead to the tubes. <p>Informational</p> <ul style="list-style-type: none"> The extent of age-related deterioration of the Posey Tube and elements within it (electrical/ventilation systems) is not clear. <p>Functional</p> <ul style="list-style-type: none"> SR260 is a very high-use transportation corridor that is highly sensitive to disruptions. Traffic rerouting would be incredibly difficult if the tubes are blocked due to floodwaters, as vehicles would need to be redirected to one of the bridges leading to Alameda. <p>Physical</p> <ul style="list-style-type: none"> Many physical vulnerabilities are associated with the tubes. Notable issues include stormwater pumps that are not corrosion-resistant, and therefore could become inoperable if saltwater enters the tubes. The tubes themselves are also “immersed” and rely on careful waterproofing to maintain their function.
Adaptive Capacity	<ul style="list-style-type: none"> Short-term modifications at the ramps to the tubes could reduce the potential for flooding in the tubes; however, new structures would be required (elevated roadway, floodwalls, etc.). The tubes themselves have very limited adaptive capacity because modifications would be very complicated and require closure during construction.
Consequences	<ul style="list-style-type: none"> Social: SR260 and the tubes are critically important to traffic flow on and off Alameda Island. Multiple AC Transit bus routes use the tubes, and disruptions could disproportionately impact transit-dependent communities that don’t have alternative transportation options. Economic: Major economic impacts are likely if access to the tubes is blocked. Environmental: There are known underground and submerged hazardous waste sites along SR260 and adjacent to the tubes.

Table G-11. SR61 (Doolittle Drive and Other Segments) Vulnerability Summary

<p>SR61 is a state highway owned and maintained by Caltrans. The route runs from the intersection with SR112 near Oakland Airport and terminates on Alameda Island at the intersection of Webster Street and Central Avenue. The road connects Bay Farm Island and Alameda Island across the Bay Farm Island Bridge. Multiple AC Transit bus routes use SR61, including several that serve transit-dependent or disadvantaged communities. The City of Alameda has designated SR61 south of Otis Drive as a primary evacuation route and the segment on Alameda Island as critical access for the evacuation route.</p>	
Key Issue(s)	<ul style="list-style-type: none"> Disruptions to SR61 could have substantial impacts on the flow of commuters and goods within Alameda and to Oakland, including several important bus routes. Existing traffic issues in Alameda would be exacerbated if the City closes SR61 or restricts traffic flow. Overtopping of Doolittle Drive on Bay Farm Island also contributes to broad flooding across the island, with the road serving as a conduit for floodwaters.
Exposure	<ul style="list-style-type: none"> SR61 is exposed to flooding from multiple sources of overtopping, including Veteran's Court seawall, along Doolittle Drive, and at the Bay Farm Island Bridge touchdown on Alameda Island. Shoreline overtopping begins at around 36" total water level. Precipitation-driven storm drain flooding also impacts SR61—the modeled 25-year storm event results in several areas with water levels greater than 0.5 feet above street level.
Sensitivity	<p>Governance</p> <ul style="list-style-type: none"> Caltrans owns and maintains SR61, both in Alameda and Oakland. Flooding along SR61 is also a concern for the City of Oakland and Port of Oakland, and a coordinated approach to address vulnerabilities is warranted. <p>Informational</p> <ul style="list-style-type: none"> It is very difficult to determine the exact source of flooding on Bay Farm Island beyond 36" total water level due to overtopping at multiple locations. <p>Functional</p> <ul style="list-style-type: none"> SR61 has very high average daily traffic, and it is very important for travel between the islands and for emergency services. Several emergency operations staging areas are along SR61. Major congestion issues exist along SR61 during peak hours, primarily at the junction of Webster Street and Central Avenue, and at Doolittle Drive and Island Drive. Traffic flow on SR61 is affected by local Alameda surface streets, traffic from SR112, and traffic diverted from I-880 in Oakland due to construction or accidents. GPS systems like Google Maps and Waze often redirect people onto SR61 if major congestion is on I-880. <p>Physical</p> <ul style="list-style-type: none"> Overtopping in this area could impact Doolittle Landfill, which is protected by a perimeter levee that has known seepage concerns. Groundwater impacts to the landfill are also likely.
Adaptive Capacity	<ul style="list-style-type: none"> There are multiple options for enhancing flood protection along SR61, but construction and engineering of some sort is required. No immediate or simple modifications to this location could address sea level rise and storm surge.
Consequences	<ul style="list-style-type: none"> Social: SR61 is used by several AC Transit bus routes that serve transit-dependent communities, and disruptions could result in major delays to most bus routes in Alameda. SR61 is also a priority evacuation route from Alameda. Economic: Substantial disruption to commuter and commercial transit is likely if SR61 floods. Environmental: Several species of concern are found along SR61. There are also known underground hazardous waste sites along the southern end of SR61 and just north of the route on Alameda Island. Contamination could impact Arrowhead Marsh and other sensitive areas.

Table G-12. Critical and High-Use Roadways (Excluding Caltrans Roads) Vulnerability Summary

<p>Many major and minor roads in Alameda are expected to be impacted by flooding and inundation associated with both sea level rise and storm events. To analyze and present vulnerabilities, key roadways were bundled into a single priority asset group. The common theme for roadways in this asset group is that they are heavily used by multiple AC Transit bus routes, specifically those that serve transit-dependent or socially vulnerable communities and provide critical connections between Alameda and the mainland. Although roadways other than those described here are at risk of damage due to flooding, this assessment prioritized roads that serve as key transit corridors because of their importance to transit-dependent communities.</p>	
Key Issue(s)	<ul style="list-style-type: none"> Entire roads and specific road segments or intersections in Alameda are exposed to flooding from sea level rise, storm surge, and major rainfall events. Given the limited number of connections between Alameda and the mainland, disruptions to key roads like Webster Street can have large impacts on transit-dependent residents and commerce. One key vulnerability is the inability of connecting streets in Alameda to handle additional traffic volume if key roads are closed or restricted and major traffic rerouting is necessary.
Exposure	<ul style="list-style-type: none"> Most of the exposure to key roadway segments is due to precipitation-driven, storm drain flooding—some segments are exposed to sea level rise and storm surge flooding in isolated locations. There is substantial exposure to storm drain flooding as modeled for a 25-year storm event. Flooding greater than 1 foot above street level could occur at multiple locations along key roadways. Heavily impacted roads include Main Street, Webster Street, Stargell Avenue, Atlantic Avenue, Pacific Avenue, and Otis Drive.
Sensitivity	<p>Governance</p> <ul style="list-style-type: none"> The City of Alameda is responsible for maintenance and upgrades of almost all roadways except Caltrans-owned SR260 and SR61. However, the City has very limited control over operational conditions like route alignments for AC Transit. Any route adjustments would be made by AC Transit in collaboration with the City. Alameda is a relatively minor component of the AC Transit system, which also serves Oakland, Berkeley, and other cities in Alameda and Contra Costa counties. AC Transit has four planning districts—Alameda is part of the Northern Alameda County planning area, with a total population of 616,000, potentially resulting in less attention being paid to the transit system within Alameda except where it is part of a major transit route like AC Transit Route 51A. <p>Functional</p> <ul style="list-style-type: none"> AC Transit routes have multiple connections with regional transit services (primarily BART) and are heavily used by commuters. The bus system serves highly transit-dependent and socially vulnerable communities in Alameda Point and adjacent neighborhoods. The entirety of Route 96 runs through census tracts with high social vulnerability, as defined by a composite of several economic and demographic indicators. <p>Physical</p> <ul style="list-style-type: none"> Location-specific issues on roads contribute to overall vulnerability. For example, stormwater catch basin inlets along Mariner Square Drive (used by AC Transit Route 96) are lower in elevation than surrounding road sections, leading to flooding during precipitation events.
Adaptive Capacity	<ul style="list-style-type: none"> Modifications to roadways are often very expensive and require long environmental review and permitting processes. It may be difficult to identify short-term strategies that allow rapid response to threats.
Consequences	<ul style="list-style-type: none"> Social: Multiple AC Transit bus routes serve transit-dependent and disadvantaged communities. Closures or disruptions to roads along these routes would limit the ability of these residents to commute to work and go about daily activities. Economic: Substantial impacts to the transport of goods around Alameda and on/off the islands could occur if key roads are closed/disrupted.



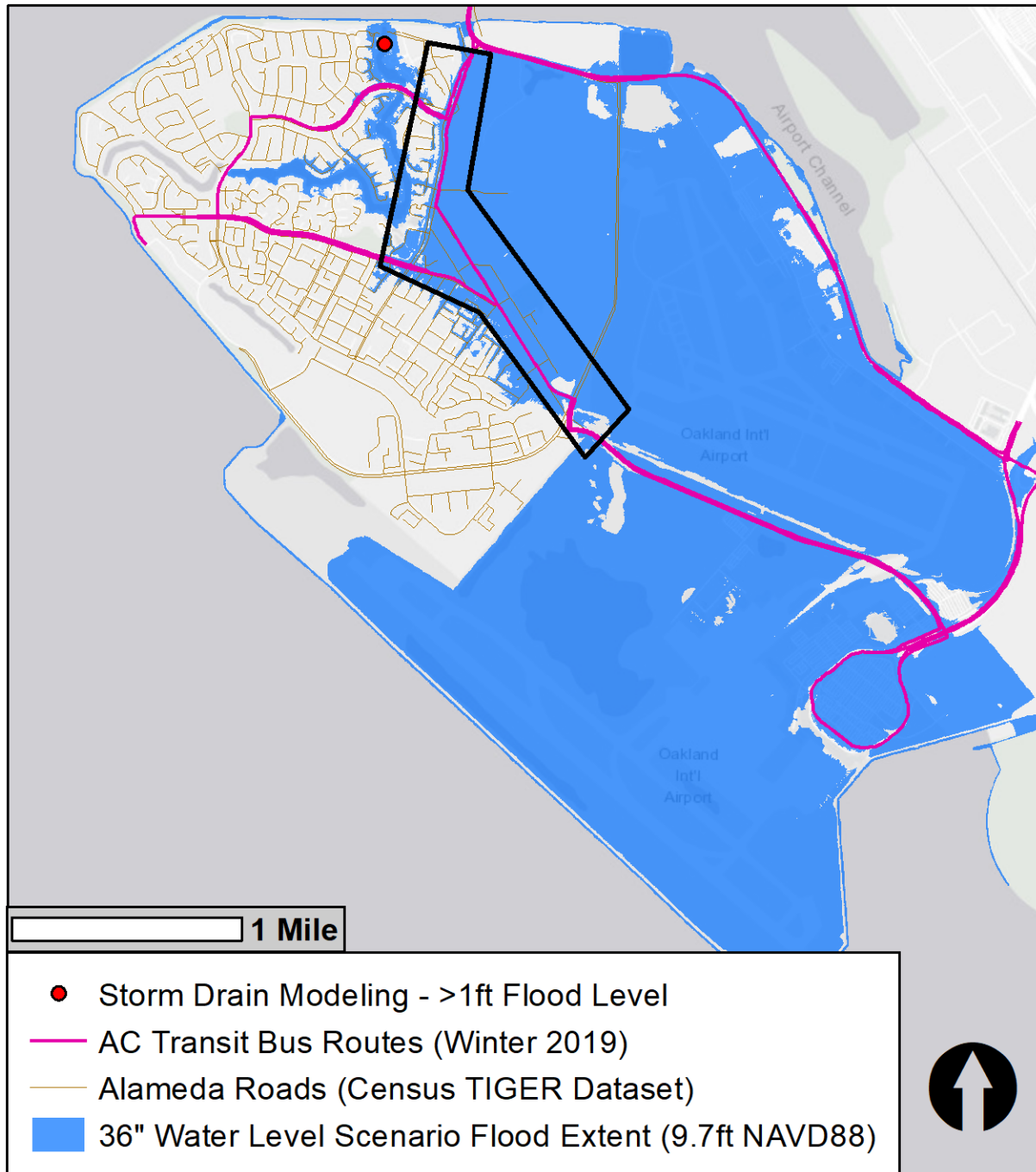


Table G-13. Storm Drain Pipes and Pump Stations Vulnerability Summary

Storm drain pump stations across Alameda are a critical component of the stormwater system and are expected to become even more important as water levels rise. The pump stations operate in areas that cannot drain through a gravity system, although it is likely that most of the gravity-fed components of Alameda's stormwater system will become obsolete as outfalls are submerged and rising groundwater impacts hydraulic conditions.	
Key Issue(s)	<ul style="list-style-type: none"> Alameda's storm drain pump stations are already subject to capacity and operational issues, including flap gate failures, sedimentation, and lack of backup power. While capacity upgrades have already been identified, the City must consider other modifications at the pump stations to increase the resilience of the station infrastructure to floodwater.
Exposure	<ul style="list-style-type: none"> Shoreline overtopping due to sea level rise and storm surge at multiple locations could lead to temporary flooding or permanent inundation at storm drain pump stations. Precipitation-driven storm drain flooding could also impact the pump stations. The degree of flooding varies from station to station. Initial exposure at the storm drain pump stations is primarily related to access; direct impacts to infrastructure are not likely until higher water levels.
Sensitivity	<p>Governance</p> <ul style="list-style-type: none"> The City of Alameda owns and maintains most of the storm drain pump stations. For those that are not owned by the City (Harbor Bay Lagoon System stations and Southshore Lagoon inlet pump), there is a clear division of responsibility for station maintenance. <p>Informational</p> <ul style="list-style-type: none"> None—regular inspections and maintenance result in substantial information related to station condition. <p>Functional</p> <ul style="list-style-type: none"> Operating storm drain pump stations are a vital component of Alameda's stormwater system and their failure would have wide-ranging ripple effects throughout the system. There are known capacity issues with the overall stormwater system (upgrades planned) that result in overland flooding across Alameda during heavy precipitation events. Sea level rise is likely to block some stormwater outfalls, increasing the strain on storm drain pumps or resulting in pump failure. <p>Physical</p> <ul style="list-style-type: none"> Pump stations contain both electrical and mechanical equipment that floodwaters could damage (electric motors drive all pumps). The primary risks are for shorted electrical systems or corroded mechanical equipment. There are known issues with sedimentation at several pump stations and outfalls, further reducing their capacity and functionality. Pump stations were not designed with built-in excess capacity (backup pumps), and several lack backup power systems.
Adaptive Capacity	<ul style="list-style-type: none"> City ownership of most storm drain pump stations increases their adaptive capacity by removing barriers to action. The City can take (and is currently taking) some immediate steps to increase the resilience of the stations, including elevating electrical panels.
Consequences	<ul style="list-style-type: none"> Social: Malfunctioning storm drain pump stations could lead to flooding across Alameda with broad impacts even far from the station itself. Economic: City resources are used to prepare for, handle, and recover from flood events. Flood damage is also a major economic impact. Environmental: The stormwater system conveys water directly to the Bay. Failure of individual pump stations could lead to greater overland flow and mobilization of contaminants from the land surface.

Table G-14. Bayview Weir and Outfall Vulnerability Summary

Water levels in the South Shore Lagoons are maintained by the Bayview weir and outfall, located near the Elsie Roemer Bird Sanctuary. Water is pumped into the lagoon system at the west end at high tide and released from the Bayview outfall at low tide to move water through the lagoon system at a rate that prevents stagnation and water quality issues. The Bayview weir functions as a barrier between lagoon waters and the Bay. The location of the weir and outfall is shown on the map for Crown Beach and the bird sanctuary earlier in this appendix.	
Key Issue(s)	<ul style="list-style-type: none"> ■ The Bayview weir and outfall system is an important component of the South Shore Lagoons. An operational lagoon system is important to maintain water quality and to prevent flooding in communities adjacent to the lagoons. The current weir and outfall are at high risk of sea level rise and storm surge, and they need major repairs and/or replacement. The greatest vulnerability to the weir and outfall system is from sea level rise, which will eventually prevent the gravity-fed system from operating, necessitating an active pump.
Exposure	<ul style="list-style-type: none"> ■ The Bayview weir and outfall are directly exposed to flooding from sea level rise, storm surge, and major rainfall events. Sea level rise compromises the operation of the weir and outfall system due to its current reliance on gravity flow during low tide. Based on engineering drawings, the outfall is roughly equivalent in elevation to mean sea level, or approximately 2 feet above mean low tide. As a result, 24" of sea level rise (not including storm surge) would likely result in the outfall structure being regularly submerged except for a short window around low tide. By 36" total water level, the outfall structure is likely permanently below low tide levels.
Sensitivity	<p>Governance</p> <ul style="list-style-type: none"> ■ The local HOA owns the lagoon system, but the City of Alameda is responsible for maintaining water levels. Residents with homes along the lagoon shoreline have a vested interest in a functioning water level management system. <p>Informational</p> <ul style="list-style-type: none"> ■ Engineering drawings for the outfall structure are old (1959 and 1989) and may not accurately reflect current water levels and mean tide levels. <p>Functional</p> <ul style="list-style-type: none"> ■ The gravity-fed system relies on low tide to drain water from the lagoons. Sea level rise poses a direct and imminent risk to this system as currently designed. Even if the outfall was exposed at low tide in the coming years, rising water levels will reduce the amount of time the City can discharge water from the lagoons, greatly restricting the flood management capacity of this system. ■ The current system design could expose homes surrounding the lagoon system to precipitation-driven overland flooding if water levels at the outfall are too high to allow for discharge. Increased storm intensity in the future could exacerbate the risk of overland flooding. <p>Physical</p> <ul style="list-style-type: none"> ■ BCDC inundation maps indicate the South Shore Lagoon system could eventually be directly connected to the Bay at higher water levels if steps are not taken to protect critical shoreline segments and improve the weir and outfall system. ■ Multiple components of the weir are damaged, including an inoperable flap gate and platform columns.
Adaptive Capacity	<ul style="list-style-type: none"> ■ The existing outfall structure has very limited adaptive capacity because it relies on a gravity flow system. Raising the outfall to accommodate higher water levels would not be feasible. Installation of a pump station at the weir would greatly decrease the vulnerability of the lagoons.
Consequences	<ul style="list-style-type: none"> ■ Social: There is a small chance that the failure of the weir and outfall system could result in flooding adjacent to the lagoons, threatening residential neighborhoods and critical assets, including Alameda Hospital. ■ Environmental: There is known contaminated sediment in the east lagoon (where the weir is located).