

FLOOD CONTROL

ALHAMBRA CREEK

(Tidal reach from the mouth to Green St.)

Key Issue Statement

Given the past and current flood risk in Martinez, it is critical that planners work with flood managers to better understand the vulnerability of homes, businesses, utilities, and community facilities to combined tidal-riverine flooding. With this information, the Martinez can engage stakeholders in long-range planning and develop funding strategies to implement projects that improve resilience to sea level rise and provide multiple benefits.



Asset Description

Alhambra Creek drains approximately 17 square miles of mostly open space and agricultural lands in the upper watershed and flows through the City of Martinez, underneath the Union Pacific Railroad (UPRR), and through the Martinez Regional Shoreline before entering the Bay. Martinez was built in the floodplain of Alhambra Creek and is responsible for managing this natural channel. In response to nearly annual flooding, citizens taxed themselves in the late 1990s to help fund a multi-million dollar flood protection and habitat restoration project. In 2001, improvements to the channel from the mouth to Marina Vista Avenue were made as part of the City's Intermodal Transportation Project: the channel was widened and restored, two new, wider railroad bridge spans were constructed to remove the historic bottleneck of flood flows backing up into downtown, and the railroad

tracks were raised. As a result of these improvements, the area downstream of Marina Vista Avenue is no longer in the 100-year floodplain. The area upstream of Marina Vista Avenue is still in the 100-year floodplain and flooding occurs during 10-year and larger riverine flows.

As a result of the 2001 flood improvements, current flooding in Martinez is primarily due to riverine flows. Flooding begins well upstream of current tidal influence, near Highway 4 at the confluence of Alhambra and Franklin Creeks, and adjacent land uses such as homes and community service facilities are in the 100-year floodplain. The city designates locations where community members can get sand and sand bags to prepare for large riverine flows. The New Year's storms in 2006 resulted in flooding upstream of Marina Vista Avenue, and public officials reported that the damage would have been even worse had the 2001 flood improvements not been completed.

Exposure to Flooding

Storms that coincide with high tides result in the most extensive flooding, and sea level rise will exacerbate riverine flooding. Tidal influence currently extends to Green Street (upstream of the 2001 flood improvements), and higher downstream tides will cause the tides to extend further ('migrate') upstream and raise water levels in the creek. While the relatively steep slope of the creek will constrain this migration distance, sea level rise will progressively reduce the capacity of the creek to discharge flood flows, such that smaller, more frequent storms will cause overbank flooding and stormwater backups. This will be particularly an issue in low-lying areas that will no longer be able to effectively gravity drain against the higher downstream tidal condition. In addition, even before overbank flooding occurs, sea level rise will reduce available freeboard and levees may lose their FEMA accreditation. This results in the surrounding areas being designated as flood prone and would require residents and property owners now in the 100-year floodplain to purchase flood insurance. At this time, there are no capital improvement plans for Alhambra Creek to address the current riverine flooding or factor in sea level rise.

While overlaying FEMA Flood Insurance Rate Maps (FIRMs) and sea level rise inundation maps suggests the risk of joint coastal-riverine flooding, watershed-scale hydraulic modeling is needed to quantify the combinations of Bay water levels, sea level rise, and riverine flows that cause flooding. Without this joint coastal-riverine flood modeling, the potential for an increase in flood risk in the current 100-year floodplain due to sea level rises may be underestimated. Furthermore, this modeling may reveal new areas at risk that were not exposed by simply overlaying FEMA FIRMs and sea level rise inundation maps.

Vulnerabilities

INFO: FEMA FIRMs do not factor in sea level rise, which make it difficult for flood managers and communities to prepare for future flooding. The City of Martinez does not have a watershed-scale hydraulic model such as HEC-RAS to evaluate the combinations of Bay water levels, sea level rise, and riverine flows that cause flooding. FEMA FIRMs show the overlay of the 100-year riverine and coastal floodplains, whereby the 100-year riverine flow sets the upstream and the 100-year tidal condition sets the downstream flood extent. The joint probability of riverine and coastal events likely increases the elevation and extent of the 100-year floodplain, but FEMA FIRMs depict riverine and coastal flooding as independent events and use the higher of



the two flood elevations where riverine and coastal floodplains overlap.

GOV1: The City of Martinez has only three engineers tasked with managing transportation projects, the Clean Water (NPDES) Program, and flood protection. In the past, ballot measures and grants have been used to raise funds to hire consultants to address Alhambra Creek flooding. The city has no dedicated funds for capital improvements and long-range flood management planning to address the impacts of sea level rise, e.g., purchase properties in the floodplain as they become available.

GOV2: Because the hydraulic dimensions of the railroad bridges will affect future flooding, any projects to address the impacts of sea level rise on Alhambra Creek will require coordination with UPRR.

PHYS: Downtown Martinez is currently in the 100-year FEMA floodplain and the current flood protection strategy of using sand bags will not be a viable as sea level rises because increased tidal action will reduce the capacity of Alhambra Creek to convey and discharge flood flows, particularly when rainfall events coincide with high tide.

Consequences

Society and Equity: If Alhambra Creek flooding becomes more frequent and extreme, community members could lose Martinez Waterfront Park recreation opportunities and Intermodal Transportation Project options as well as suffer damage to homes and businesses located downtown.

Environment: Since sea level rise will increase the frequency and intensity of flooding over time and the 2001 improvements included a secondary outlet from Alhambra Creek to the Martinez Regional Shoreline Salt Marsh to help convey large flows, this outlet will be used progressively more often and could lead to increased ponding and poor drainage, affecting salt marsh endangered and threatened species such as the Ridgway Rail and Salt Marsh Harvest Mouse.

Economy: If Alhambra Creek cannot provide adequate flood protection, damage to homes and businesses could affect the local economy and disruptions to UPRR service could affect the regional economy.

WATER MANAGEMENT

Contra Costa Water District

Key Issue Statement

CCWD and has built redundancy in its distribution and treatment infrastructure and has emergency storage to ensure customers will continue to be served in the event of a hazard event such as an earthquake or extreme coastal storm. The greatest potential impact of sea level rise on CCWD water service will not be vulnerable infrastructure assets in the ART project area; rather it is the impact of salinity on Delta water quality.



Asset Description

Contra Costa Water District (CCWD) provides water service to approximately 500,000 customers in central and northeastern Contra Costa County. CCWD delivers approximately 121,170 acre-feet annually of treated and untreated water to its customers, which include retail and wholesale customers, municipalities, agricultural users and industrial customers. CCWD anticipates a 22 percent increase in population by 2035, and based on CCWD's latest demand and supply projections there will be a water supply shortfall under multiple-drought year conditions starting in the 2035 timeframe. During multiple-year drought conditions, CCWD can implement short-term demand management measures to meet a portion of its demand.

All of CCWD's water supplies are diverted from the Sacramento-San Joaquin Delta. CCWD operates four water intakes in the Delta: Mallard Slough, Rock Slough, Old River and Middle River. In addition to these water intakes, CCWD owns and operates the Los Vaqueros Reservoir located near the City of Brentwood. This is an offstream reservoir that has 160 thousand acre-feet capacity and is primarily used to improve the water quality of water served to CCWD customers and secondarily provides dedicated storage for emergency supplies. CCWD's main conveyance facility is the 48-mile Contra Costa Canal, which conveys untreated water from Rock Slough, passing through many cities and communities, before terminating at the Martinez Reservoir located in the City of Martinez. The Canal also conveys water to an untreated water pipeline called the Shortcut Pipeline, which provides water service to several small industrial customers, and delivers water to Martinez Reservoir and Mallard Reservoir. Martinez Reservoir serves as a water supply source for the City of Martinez Water Treatment Plant (WTP) and Shell Martinez Oil Refinery. Mallard Reservoir serves as a water storage forebay for CCWD's Bollman Water Treatment Plant.

CCWD has several untreated and treated water interties with neighboring agencies that can be used in the event of emergency to provide mutual aid. CCWD also has standard operating criteria by which all of its facilities are designed and constructed, to provide adequate water supply and storage in case of an emergency. CCWD has a 22-mile transmission pipeline called the Multi-Purpose Pipeline (MPP) that primarily conveys treated water west from the Randall-Bold Treatment Plant in Oakley to the central county Treated Water Service Area and also provides wholesale treated water to municipalities along the way. During an

emergency, such as mudslides or seismic activity, that disrupt Canal operations the MPP can transport treated water in reverse to eastern Contra Costa County or convey untreated water if needed.

Exposure to Flooding

Assets on the Bay shoreline and along major creeks and channels in the project area were analyzed to determine if they were exposed to either current or future flooding. Current flood risk was determined using the most current FEMA Flood Insurance Rate Maps (FIRMs) available when the analysis was conducted. Some assets that are within the FEMA-designated 100-year floodplain are also at risk of more frequent or extensive flooding in the future due to sea level rise. The potential for increased flood risks as sea level rises within the current 100-year floodplain may be underestimated as the increase in riverine flooding due to elevated Bay water levels has not been fully resolved. Lastly, there are assets that are not currently within the FEMA-designated 100-year floodplain but will potentially be exposed to flooding in the future due to sea level rises. Some of these assets may currently be protected from the 100-year flood by the existing shoreline while others may be at a distance from either the Bay shoreline or creek and channel banks and therefore beyond the extent of current flooding.

Only a portion of the CCWD service area and infrastructure are within the Contra Costa ART project area (the shoreline from Richmond to Bay Point). In the ART project area, CCWD water supply assets that could be impacted by flooding are the Mallard Reservoir and the Shortcut Pipeline, both of which are within the FEMA designated 100-year floodplain and could be impacted by sea level rise. It is important to note, however, that the greatest potential risk posed by sea level rise to CCWD service will not be direct impacts on water supply infrastructure, rather impacts to water quality in the Delta. As sea level rises the Delta will get increasingly saline, which will limit fresh water supplies.

Vulnerabilities

INFO: CCWD has studied and prepared for extended dry condition and seismic related emergencies, however CCWD has not performed an assessment to determine potential the storm events or sea level rise impacts on Mallard Reservoir because the redundancy in distribution and treatment infrastructure combined with emergency supplies ensures that customers can continue to be served in the event of an emergency such as a major storm event that could interrupt service at Mallard Reservoir and the Bollman Treatment Plant.

PHYS1: The Shortcut Pipeline may be located on predominantly low soil strength bay muds and be subject to a high groundwater table because of its proximity to San Francisco Bay. Rising groundwater will increase the potential that pipelines will float, making them susceptible to damage that will increase the need for maintenance, repair, and replacement. The Shortcut Pipeline is however redundant with the Contra Costa Canal.

FUNC1: CCWD has built some redundancy in the system to address seismic hazard vulnerabilities, which could also help avoid service disruption during a flood event. CCWD owns and operates two water treatment plants, multiple intakes and dedicated emergency storage in Los Vaqueros Reservoir to supply customers in times of emergency. Depending on the water year type, Los Vaqueros Reservoir dedicates between 77,000 and 44,000 acre-feet of storage for emergency supplies.

FUNC2: CCWD treats raw water for drinking water purposes; it relies on chemicals for treatment, power to run the facilities, and road access to maintain its assets and ensure workers can reach its facilities. If flooding impacts power supplies or the roads and highway system that provide access to and from CCDW facilities (e.g., the I-680 approach or Waterfront Road), the ability to provide water to its customers may be constrained.

GOV: CCWD's 2016-2025 Capital Improvement Plan (CIP) includes \$329 million in funded Priority Level 1 and 2 expenditures. This includes a \$13.5 million project to refurbish the Shortcut Pipeline, of which about \$4.5 million has been completed. There is also Priority Level 2 and 3 funding for the Canal Modernization project, which will upgrade the Contra Costa Canal to ensure that the Canal continues to meet long-term safety, reliability, and operations requirements. CCWD identifies necessary capital improvement projects through a robust asset management program that includes renewal and replacement studies and master planning studies based on condition assessments, risk management evaluations, useful life, and other factors to identify projects that are included in the CIP. No specific project was identified for Mallard Reservoir, but due to the redundancy and reliability built into CCWD's systems, as discussed previously, if Mallard Reservoir is inundated by a large storm event or other emergency, there are alternatives for CCWD to divert, convey, treat, and ultimately deliver water to its customers.

Consequences

Society and Equity: Water is critical for emergency response, especially for hospitals, and fire protection, and is required for recovery after a disaster such as an earthquake or widespread flooding. Any unforeseen, long-term disruption of water supply in the CCWD service area would impact all customers, and in particular members of the community such as the elderly or young children who are particularly in need of safe drinking water.

Environment: No direct environmental impacts.

Economy: CCWD provides water to 50 agricultural users, 2,735 commercial customers and nearly one-third of CCWD's deliveries are to industrial customers. These businesses provide jobs and revenue to Contra Costa County, and are dependent on CCWD to remain open. If the ability to provide water is disrupted and emergency supplies are exhausted, the economic disruption would be significant throughout central and northeastern Contra Costa County.

STORMWATER

City of Richmond Stormwater

Key Issue Statement

City stormwater assets that are directly exposed to flooding, or have their lowest elevation below future high tides, are vulnerable to sea level rise. Assets that are not directly exposed but rely on gravity drainage or have insufficient capacity to store and convey both stormwater and Bay water are also vulnerable. Because of their inherent function and location, large pipes, culverts, outfalls, storm gates, weirs, pump stations and force mains are especially at risk. For example, pipes and culverts are larger and carry more flow the closer they are to the receiving waters, and pump station and their attached force mains are typically located in low-lying areas, for example at road underpasses or roads that are below grade. The City has very limited resources to conduct studies to better understand the current condition of the stormwater system that are needed to under its future vulnerability to sea level rise.

Asset Description

The City of Richmond has approximately 94 miles of separate storm sewer pipes plus numerous gutters, manholes, outfalls, storm gates, pump stations and other drainage infrastructure that helps manage rainfall runoff and prevent flooding.¹ The city's stormwater program is responsible for implementing the Regional Water Quality Control Board's Municipal Regional Stormwater National Pollution Discharge Elimination System Permit, which requires the city to have a detailed industrial and commercial inspection plan and site controls (CAS612008 Portion C.4.b). There is one staff person in Public Works dedicated to the stormwater program and they are responsible for issuing and enforcing permits to industrial and commercial sites to ensure implementation of best management practices to protect water quality. The city hired a private firm, Veolia, to manage city-owned stormwater infrastructure, including inspection, repairs, and maintenance of stormwater infrastructure. Veolia also manages the city bond-funded capital improvements program that consists of primarily small curb-gutter engineering projects to address nuisance flooding. Veolia also manages the city-owned wastewater system, which demands more immediate attention than the stormwater system due to the age of the collection system and significant issues with inflow and infiltration.

Exposure to Flooding

The City of Richmond conducted an assessment to determine which components of the storm system assets are at risk from 6 feet of sea level rise plus mean higher high water (MHHW) or have their lowest point (invert elevations) below 6 feet of sea level rise. The table and map that follows are courtesy of Patrick Phelan, City of Richmond Engineering Services Department.

¹ Stormwater infrastructure does not affect management of the lower reaches of Wildcat and San Pablo Creeks, which have been assessed separately with the help of the Contra Costa County Flood Control and Water Conservation District that manages these flood control channels.

Collection Device	Total City-wide Number	Total with invert below 6 feet SLR Number	% at risk
Collection Device (storm drains, catch basins, etc.)	5270	396	8%
Manhole	1846	349	19%
Weir (engineered sanitary sewer overflow)	2	2	100%
Outfall	136	79	58%
Storm Gate (not including sluice gates)	16	9	56%
Pump Station	12	7	58%
	Miles	Miles	
Force Main	0.22	0.19	86%
Pipe	151.9	25.5	17%
Pipe with diameter of 36 inches or greater	36.1	8.6	24%
CMP (corrugated metal pipe)	4.8	0.4	9%
Culvert (large, often square conveyances)	6.1	2.4	39%
Concrete Ditch	13.5	0.4	3%

Table 1. Stormwater assets in the City of Richmond potentially affected by, or with an invert elevation below, 6 feet of sea level rise plus MHHW (NAVD88).

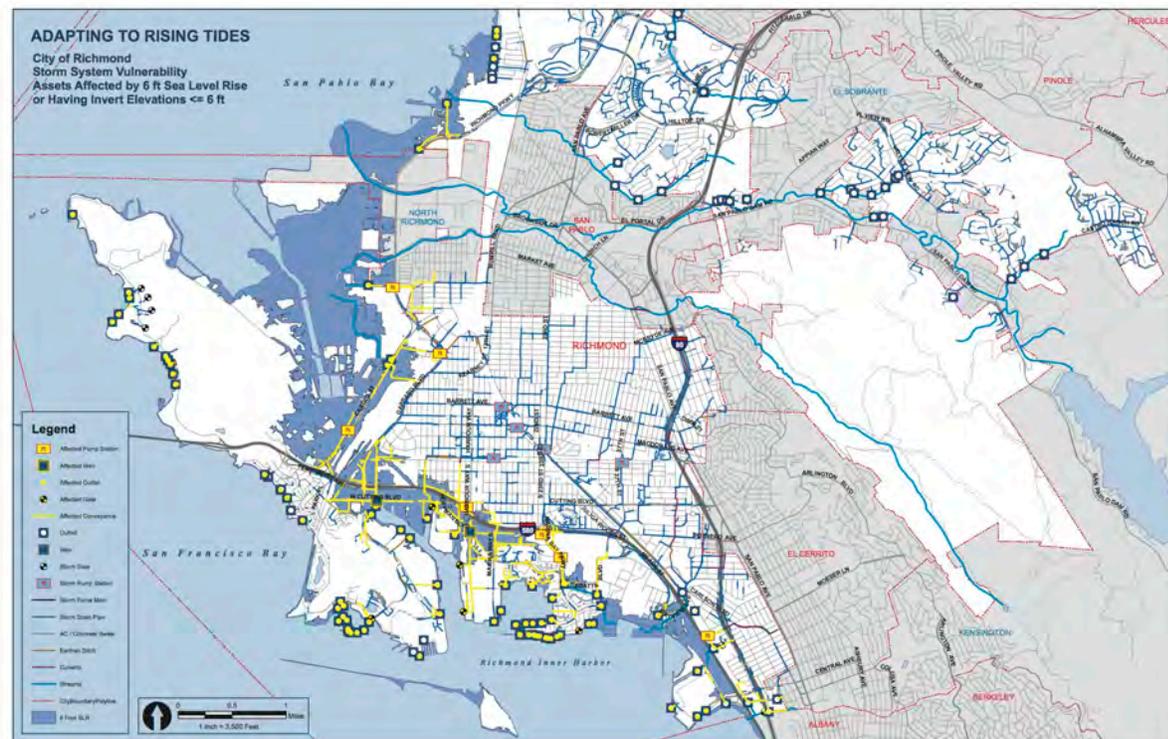


Figure 1. Map of city stormwater assets potentially affected by, or with an invert elevation below, six feet of sea level rise plus MHHW (NAVD88).

Outfalls are the first line of defense against sea level rise in the city's stormwater system. An exposure analysis conducted by the city indicates that 79 outfalls would be inundated at high tide with 6 feet of sea level rise. As these outfalls do not have storm gates to prevent Bay water from entering the stormwater system, where upstream pipe capacity is insufficient to store both stormwater and Bay water, there could be street and basement flooding during extreme tides or even the daily high tide. This is already a problem in many low-lying areas along the Richmond shoreline where historic marshes were filled for development. For example, the Richmond Annex neighborhood already experiences "sunny day flooding" when stormwater does not drain during high tide and backs up into people's homes. Higher water tables associated with sea level rise could also infiltrate the stormwater system and further reduce pipe capacity, and pipes and other infrastructure that was not constructed for saline conditions may be vulnerable to corrosion. Although some of the city outfalls have storm gates, these are often inaccessible to city staff and there is no plan in place to repair and maintain over time.

In addition to sea level rise affecting gravity fed stormwater drainage, sea level rise will also affect force main pipes because pump stations are vulnerable to flooding. Pump stations require uninterrupted power and access, meaning back-up power or fuel supplies will be needed to maintain operation during long duration disruptions. This can be problematic during storms where road access is disrupted. Furthermore, pump stations are built with the ability to lift water to a certain elevation at a certain rate, which may be exceeded with sea level rise. Operating pump stations more frequently or adding pumps will increase maintenance costs, energy use and GHG emissions. For these reasons, adding pump stations to improve gravity fed stormwater drainage may be difficult.

Vulnerabilities

INFO: The city has not conducted a drainage study to analyze the capacity of the stormwater system to store and drain various combinations of Bay water levels, sea level rise, and flood flows. This coastal-riverine flood analysis would inform capital improvement projects and would be especially useful for weighing the costs and benefits of building extra capacity now or waiting until later to act, e.g., putting in slightly larger pipes than are necessary now may be more expensive in the short term, but is likely to be far less costly than replacing them again when sea level rises.

GOV: The city has only one staff person dedicated to their stormwater program and this time is spent implementing the NPDES Permit. Consultants are used to inspect and maintain stormwater infrastructure as well as manage the city bond-funded capital improvements program. There are no resources allocated specifically to support long-range stormwater management planning to address the impacts of sea level rise.

FUNC1: Pump stations rely on uninterrupted power to operate. Although some of the pump stations have backup generators and fuel onsite that will help avoid service disruption, access to these facilities to resupply fuel and allow for maintenance may be limited by flooding of the transportation system.

FUNC2: Assets that rely on gravity drainage are often at the lowest elevation in the system and therefore are often in low-lying areas that could be exposed to flooding. For example, the city's two engineered sanitary sewer overflow weirs could be flooded potentially causing a sanitary sewer overflow into the storm system, or the conveyance of floodwaters into the sanitary system and an overloading the wastewater treatment plant with high salinity and lower strength (organic matter content) flows than the system is used to.

PHYS1: As sea level rises, the capacity of stormwater pipes to discharge flood flows will diminish over time. Further analysis is needed to understand the most sensitive pipes and thresholds for stormwater backups.

PHYS2: As sea level rises, stormwater infrastructure such as pipes and pump stations that were not constructed for saline water conditions will suffer from corrosion if they are not improved replaced.

PHYS3: Corrugated metal pipes do not have as long of a lifespan as other material types, and exposure to flooding or seawater could cause them to fail earlier than expected.

Consequences

Society and Equity: Reduced discharge capacity of the stormwater system and failures of pump stations could cause flooding of streets and roads, neighborhoods, job centers, and parks, disproportionately affecting residents with limited resources to respond or recover.

Environment: Damage, disruption or failure of the stormwater system could cause flooding in post-industrial areas such as the South Richmond shoreline, which may mobilize contaminants and impact wetland habitat and Bay water quality. Overflowing of sanitary sewer overflow weirs could cause the release of untreated, or partially treated, wastewater, which could have public or health environmental impacts.

Economy: Flooding of streets and roads due to diminished function of the stormwater system could disrupt access to local goods, jobs and services and affect operations at the Port of Richmond. In addition, regional passenger and freight rail service could be affected, which would impact the regional economy. Flooding of homes and businesses in neighborhoods could impact the local economy if residents and employees need to seek other places to live or work, especially if the disruption is long enough or the damage is severe.

WASTEWATER SERVICES SECTOR

North Richmond Water Reclamation Plant and Richmond Advanced Recycling Expansion

Key Issue Statement

The North Richmond Water Reclamation Plant (NRWP) and Richmond Advanced Recycling Expansion (RARE) facilities may not be accessible to workers, supplies and equipment if the roadways that provide access are flooded. Additional problems may arise if power supplies are compromised and workers cannot access the facility with additional fuel needed to ensure there is back up power to maintain plant operations.



Asset Description

EBMUD was established in 1923 and provides wastewater, recycled water, and drinking water service throughout the East Bay, including Contra Costa County. The EBMUD North Richmond Water Reclamation Plant (NRWRP) and the Richmond Advanced Recycling Expansion (RARE) receive secondary treated wastewater from West County Wastewater District (WCWD) and treat it for reuse by industrial, public and private customers. The RARE delivers purified water to Chevron's Richmond Refinery, which is used to generate steam, and the NRWRP provides tertiary treated water to meet Chevron's tower cooling needs. The expected operating life of these EBMUD assets is to around mid-century.

Exposure to Flooding

The RARE could be impacted by 5 feet of sea level rise or more, while the NRWRP is not directly at risk from current or future flooding.

Vulnerabilities

INFO: There is limited information on contractual agreements between EBMUD and Chevron's Richmond Refinery, and it is unclear if the emergency response or operational plans for these particular facilities and for Chevron operations include contingencies to manage flood emergencies.

GOV: EBMUD owns the North Richmond Water Reclamation Plant (NRWRP) and the Richmond Advanced Recycling Expansion (RARE) but depends on West County Wastewater District (WCWD) for wastewater and on Chevron to use the treated recycled water. The process and relationships may not be in place to support the coordination and collaboration that will be needed to address shared vulnerabilities to sea level rise and storm event flooding.

PHYS: The NRWRP is located in a zone of very high liquefaction susceptibility and the RARE is in a zone of high liquefaction susceptibility. A rising groundwater table may increase liquefaction potential, and may cause damage to the either one of the facilities during a seismic event.

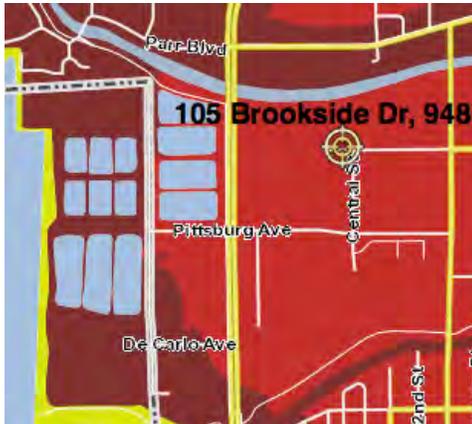


Figure 2: Liquefaction Susceptibility
(<http://gis.abag.ca.gov>)

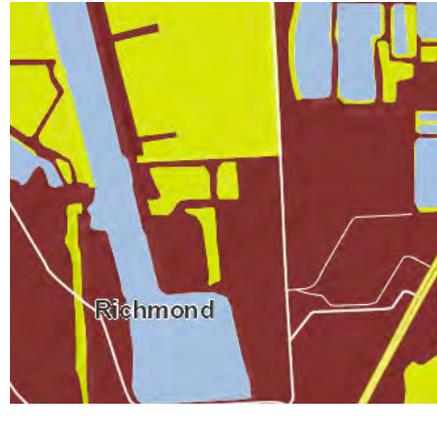


Figure 1: NRWRP Liquefaction Susceptibility

FUNC1: Wastewater treatment systems are large, expensive, and complex, and there is little redundancy within each system. This includes the RARE and NRWRP, which are the only facilities of their type in the system, meaning their function would not be easily replaced if they were damaged or disrupted due to sea level rise or storm event flooding.

FUNC2: Wastewater facilities rely on roads and highways to bring employees, fuel and other supplies, materials and equipment to the site. If roads used to access these facilities experience extensive flooding they may not be able to continue operations. For example, the RARE may be inaccessible if Castro Street, Petrolite Street, or Xylene Street is flooded. Similarly, if Richmond Parkway, Parr Boulevard, Pittsburg Avenue, Central Avenue, Brookside Dr. or Fred Jackson Way are flooded then the NRWRP would not be accessible.

Consequences

Environment: The RARE and NRWRP facilities together provide Chevron with approximately 7.5 MGD. If these facilities stop functioning, treated and recycled water would be replaced with potable water. The environmental impact of this would depend on water supply conditions at the time.

Economy: EBMUD does not anticipate an economic impact if the RARE or NRWRP operations cease during a flooding event and treated and recycled water to support Chevron operations were replaced by potable water.

FLOOD CONTROL

Pinole Creek

(Tidal reach from Bay to Pavon/BNSF Railroad)

Key Issue Statement

Lower Pinole Creek provides flood protection for approximately a 25-year storm and bridge constrictions, ongoing channel sedimentation, and sea level rise will further reduce flood capacity. CCCFC&WCD does not have a funding mechanism to address regulatory challenges and meet the requirements of the USACE O&M Manual to improve channel capacity for current and future flooding. It is critical that planners work with flood managers to better understand the vulnerability of the wastewater treatment plant as well as adjacent communities and businesses to combined tidal-riverine flooding using watershed-scale hydraulic models. With this information, CCCFC&WCD and the City can engage stakeholders in long-range planning and develop funding strategies to implement projects that improve resilience to sea level rise and provide multiple benefits.

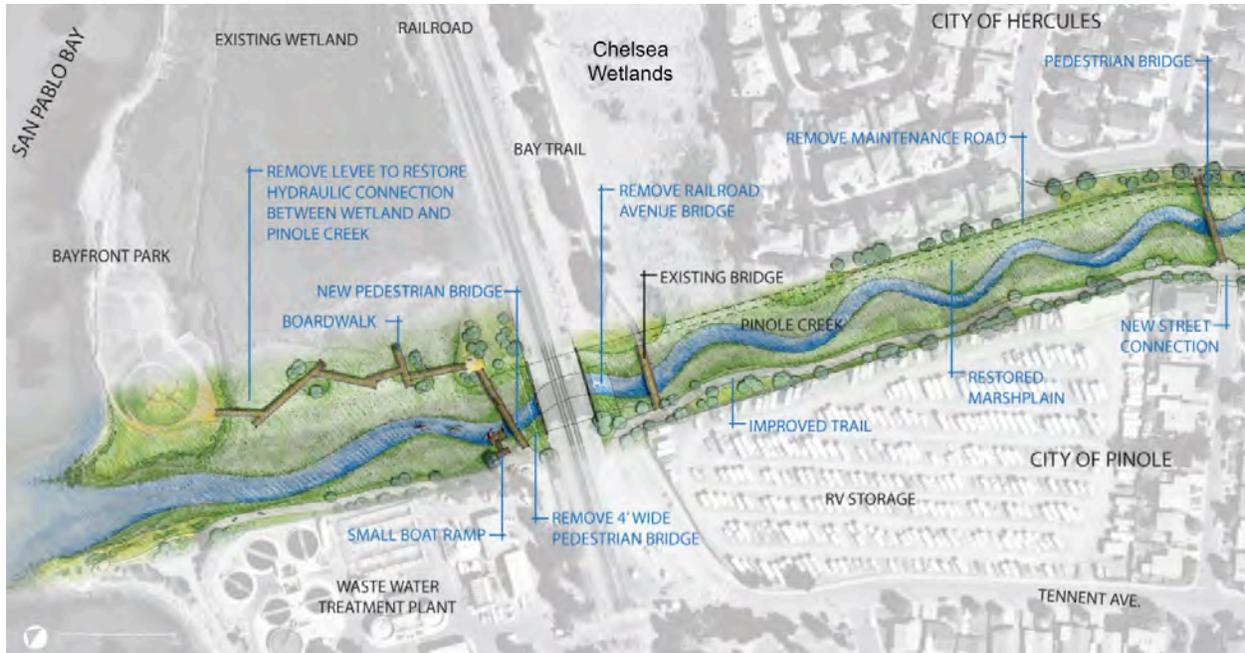
Asset Description

Pinole Creek drains approximately 15 square miles of mostly open space and agricultural lands in the upper watershed and flows through a mixture of residential, commercial, and industrial uses in the City of Pinole before entering the Bay. In 1965, the U.S. Army Corps of Engineers (USACE) constructed a 1.5-mile earthen trapezoidal channel from the mouth to I-80 to prevent flooding in downtown Pinole. USACE designed the channel for the 50-year riverine flow (2600 cubic feet per second, cfs) at mean higher high water (5.76 feet NAVD88).¹ As the local sponsor, the Contra Costa County Flood Control and Water Conservation District (CCCFC&WCD) now owns and maintains the channel as part of Flood Control Zone 9.

In 2008, CCCFC&WCD, City of Pinole, and the State partnered on a Demonstration Project to restore capacity for the design flowrate² and ultimately inspire residents to vote to raise local funds for improved maintenance. Sediment accumulates in the tidal reach of Pinole Creek because of conditions created by the original USACE design. Although the channel is inspected annually, this sediment had not been removed because CCCFC&WCD receives zero dollars to maintain Pinole Creek due to funding restrictions associated with Propositions 13 and 218. This sedimentation in combination with increased runoff associated with post-1965 development have reduced flood capacity. The channel now only conveys approximately the 25-year riverine flow. During high creek stages, interior drainage backs up into the neighborhood around Orleans Drive on the south side of the creek, and the 2005/2006 New Year's Eve storm events almost caused overbank flooding. The 2008 demonstration project restored the design flow capacity, but due to development in the watershed, flood risk remains.

¹ It was estimated that the 100-year riverine flow was 3,000 cfs and the 100-year tide was 9.08 feet NAVD88.

² After discussion with USACE staff, it was agreed that water surfaces used in 1962, without predicted sea level rise, be used for risk and uncertainty analysis. The goal was to analyze levee elevations that provide protection from the old flow rate used in the original 1960's project (not future flooding).



Vision of the Pinole Creek Demonstration Project (2007 Redevelopment Agency). While the creek was widened and improved, many elements of the project were not completed such as removal of the Railroad Ave. bridge.

CCCFC&WCD have been very proactive along with the City in acknowledging that the Federal Emergency Management Agency Flood Insurance Rate Maps (FIRMs) significantly underestimate the community's flood risk. Phase I of the Demonstration Project was completed in 2011 and included widening and enhancing the channel 1900 feet upstream of the Union Pacific Railroad (UPRR) bridge. Phase II would have included removal of the Railroad Avenue bridge, the most significant constriction of the four bridges³ that cross the 0.5-mile tidal reach, and improving the hydraulic connection between Pinole Creek and the adjacent wetland at the mouth of the creek. However, the City of Pinole no longer plans to pursue Phase II and gave back the remaining grant funds because of issues associated with the Railroad Avenue bridge, namely that it was constructed on property owned by UPRR, that it provides important utility crossing (i.e., untreated and treated wastewater, petroleum transport, and PG&E) requiring the construction of four separate replacement utility crossings, and that it provides an emergency evacuation route for residents living near Tennent Avenue.

Exposure to Flooding

Sea level rise will exacerbate riverine flooding. Tidal influence currently extends approximately 0.5 miles from the mouth to a few hundred feet downstream of BNSF (adjacent to the Rosti cul-de-sac) and sea level rise will cause the tides to extend further ('migrate') upstream and raise water levels in the creek. This will progressively reduce the capacity of the creek to discharge flood flows, such that smaller, more frequent storms will cause overbank flooding and stormwater backups, particularly in low-lying areas that will no longer be able to effectively gravity drain against the higher downstream tidal condition. However, even before flooding, sea level rise will reduce available freeboard and levees may lose their FEMA accreditation, which would require residents and property owners in the floodplain to purchase flood insurance.

³ Bridges in order from downstream to upstream are pedestrian bridge, UPRR, Railroad Avenue Bridge, and another pedestrian bridge (Bay Trail).



While overlaying FEMA FIRMs and sea level rise inundation maps suggests the risk of joint coastal-riverine flooding, watershed-scale hydraulic modeling is needed to quantify the combinations of Bay water levels, sea level rise, and riverine flows that cause flooding. Without this joint coastal-riverine flood modeling, the potential for an increase in flood risk in the current 100-year floodplain due to sea level rises may be underestimated. Furthermore, this modeling may reveal new areas at risk that were not exposed by simply overlaying FEMA FIRMs and sea level rise inundation maps.

Vulnerabilities

INFO: FEMA FIRMs do not factor in sea level rise, which make it difficult for flood managers and communities to prepare for future flooding. Furthermore, FEMA FIRMs show the overlay of the 100-year riverine and coastal floodplains, whereby the 100-year riverine flow sets the upstream and the 100-year tidal condition sets the downstream flood extent. The joint probability of riverine and coastal events likely increases the elevation and extent of the 100-year floodplain, but FEMA FIRMs depict riverine and coastal flooding as independent events and use the higher of the two flood elevations where riverine and coastal floodplains overlap.

GOV1: CCCFC&WCD does not have adequate maintenance funding to preserve what limited flood capacity exists and has to coordinate with the City of Pinole, which has limited staff resources to commit to flood protection, to develop a funding strategy for both maintenance, capital improvements, and long-range flood management planning.

GOV2: While the Railroad Avenue bridge is the most significant hydraulic constriction, the dimensions of the UPRR bridge also affect future flooding. UPRR has not been an active stakeholder in flood management planning.

GOV3: Since Pinole Creek is a federal facility, improvements must be consistent with USACE policy to remain eligible for federal disaster relief. The existing O&M Manual that guides work in the creek does not reflect the existing channel sediment accumulations (aggraded channel) and does not allow for restoration

measures to help relieve these issues, for example by improving the capacity of the channel to naturally flush by connecting it to the Chelsea Wetland Restoration Project.

PHYS: Pinole Creek provides less than 100-year flood protection and increased tidal action due to sea level rise will further diminish its capacity to discharge flood flows, particularly when rainfall events coincide with high tide.

Consequences

Society and Equity: Residents and business owners could lose their homes and livelihoods if downtown flooding becomes more frequent and extreme. Furthermore, if storm events and sea level rise shut down the wastewater treatment plant, even temporarily, at the mouth of Pinole Creek, untreated wastewater could back up into homes, businesses, and neighborhoods and spread disease.

Environment: Since there is minimal marsh habitat adjacent to Pinole Creek, there are minimal flooding consequences to species.

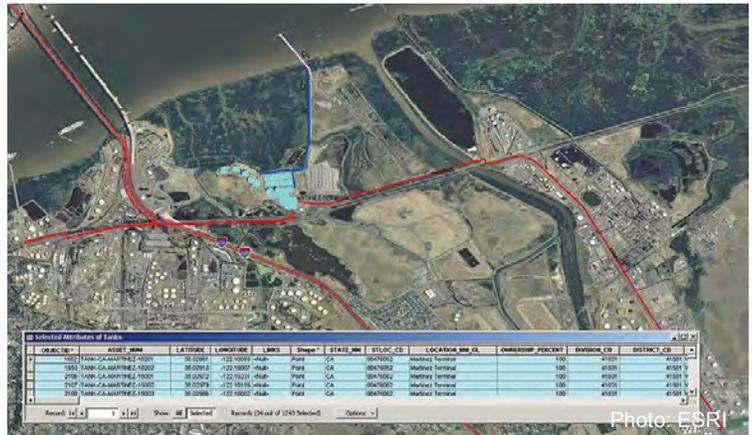
Economy: If Pinole Creek cannot provide adequate flood protection, damage to local residences and businesses could affect the local economy and disruptions to wastewater and railroad service could affect the regional economy.

ENERGY SECTOR

Plains Products Martinez Marine Oil Terminal

Key Issue Statement

The assets the terminal relies on, including the system of pipelines, roads and power serving the facility, are vulnerable to flooding and could cause a disruption in terminal operations. The terminal’s land-based operations are in the 100-year flood zone, and surrounding land is low-lying and vulnerable to immediate sea level rise impacts.



Asset Description

The Plains Products Martinez Marine Oil Terminal is a 225-acre site located in Martinez owned and managed by Plains All American Pipeline. The shoreline portion of the terminal includes a wharf leased from the State Lands Commission with a single-vessel docking facility, associated pumps, pipelines, electrical utilities, and other mechanical equipment. The upland portion of the site has a bulk storage tank farm, an inactive truck loading rack, an inactive rail spur, pumps and associated pipelines, vapor collection and combustion systems, and an office building. Cargo pumps for vessel loading are located in the upland portion of the site, about 1 mile from the wharf. The terminal is required to complete MOTEMS (Marine Oil Terminal Engineering and Maintenance Standards) audits, including an assessment of a seismic risk. All major deficiencies have since the last audit in 2011 been addressed, and the terminal is continually under consideration for capital improvements and investment.

The Tesoro, Shell and Valero refineries, as well as Kinder Morgan, have pipeline connections to the terminal. These and other connections both within and beyond the terminal are essential to operations. Pipes, pumps, electrical utilities, and other mechanical equipment on site are necessary to maintain operations and the terminal relies on external utility sources (electrical, natural gas, water, sewer) as well as local roads and the interstate to connect to services and markets located off site.

Exposure to Flooding

The terminal and bulk storage facility are located in the 100-year flood plain. The maps show that the terminal has most of its infrastructure on higher elevation, but even with as little as one foot of sea level rise, the terminal’s connections are vulnerable to inundation.

Vulnerabilities

INFO: There is a limited amount of publicly available information about the terminal site or how it operates, as it is owned and managed by a private entity. Information requests can be made directly to Plains Products Terminal LLC.

PHYS1: Pipelines and electrical components connecting the terminal to land-based product storage areas and refinery facilities may begin to corrode if they are exposed to salt water.

PHYS2: Linear, networked infrastructure such as pipelines and rail lines may be more susceptible to damage during a seismic event if liquefaction potential increases due to higher groundwater.

FUNC1: The site relies on power to function. The disruption of the power sources may cause the terminal to shut down.

FUNC2: Access to and from the site could be disrupted if flooding during storm events disrupts key roads, for example Waterfront Road, or access to these roads.

FUNC3: There are no existing systems to manage groundwater, however the terminal does have portable pump systems that can be utilized to alleviate flooding. While there is some below grade equipment they are located in vaults, and none of the at grade facilities have openings below grade.

Consequences

Environment: Contaminants present on site could be carried with floodwaters into inland areas or released into the Bay, and have the potential to contaminate rising groundwater. However, while there is the potential for water quality impacts because the asset handles petroleum products the terminal has been designed with systems to temporarily contain an accidental release of stored materials of specified volumes.

Economy: Plains Products Terminal in Martinez employs a small number of people (approximately 25), so the temporary closure of the terminal would have minimal direct impact to the local economy. However, the terminal imports and exports petroleum products, and if it was damaged or operations were disrupted there would be impacts on the petroleum refining industry as well as the refined products distribution system in Northern California and Northern Nevada. If operations were disrupted for an extended period of time there could be ripple effects on the regional economy.

WASTEWATER SERVICES SECTOR

Point Isabel Wet Weather Facility

Key Issue Statement

The Point Isabel Wet Weather Facility (PIWWF) is not in the floodplain, however, the EBMUD assets that direct flows to this facility and outside of the County, the North Interceptor and Force Main, may be at risk of damage. Although the PIWWF facility is planned for retirement by 2035, more frequent storm events may cause inflow and infiltration (I/I) beyond current levels. A high groundwater table may also increase liquefaction potential adding to the risk of damage during a seismic event. Before PIWWF is retired, EBMUD would need to monitor and plan for short-term maintenance in the event of damage to the assets.



Since outfall capacity is further reduced during high storm tides, sea level rise and storm events will exacerbate existing issues, resulting in more frequent and potentially longer lasting occurrences when discharge capacity is limited. In the event of flooding around the facility, it may not be accessible to workers due to flooded roadways. Additional problems may arise if the plant's power is compromised, and workers cannot access the facility with additional fuel for back up power supplies needed to maintain plant operations.

Asset Description

Wastewater, or sewage, is the refuse liquid and waste materials from washing, flushing or manufacturing. Wastewater is collected, conveyed, treated, and discharged through an interconnected network of structures and facilities. Wastewater collection assets are those facilities that protect public health by conveying wastewater from its source to treatment and discharge facilities.

EBMUD was established in 1923 and provides wastewater, recycled water, and drinking water service throughout the East Bay, including Contra Costa County. EBMUD provides wastewater disposal services in the unincorporated community of Kensington, the cities of El Cerrito and Richmond through Stege Sanitary District - serving a population of approximately 28,107. Stege Sanitary District collects wastewater from these cities and delivers it to EBMUD's North Interceptor, which is then directed to EBMUD's Main Wastewater Treatment Plant outside of Contra Costa County. During peak wet weather flow conditions, wastewaters from the North Interceptor are diverted to the Point Isabel Wet Weather Facility (PIWWF) for discharge via the Point Isabel Wet Weather Facility Outfall and diffuser to the Richmond Inner Harbor.

Wastewater treatment plants are permitted to discharge a specific amount of wastewater based on its capacity allowance. The PIWFF and the Outfall have a design capacity of 100 million gallons per day (MGD). The outfall extends approximately 300 feet into the Bay, with the last portion being a diffuser section designed to ensure maximum dilution and mixing with deep Bay waters. Wet weather overflows have declined in frequency since the PIWWF began operating, however according to the RWQCB, EBMUD's

“annual discharge volumes for all [wet weather facilities] exceed the long-term design goal of 100 million gallons per year.” EBMUD is planning for long-term changes to the system since negotiating a consent decree with the USEPA effective September 2014. In this agreement, EBMUD and its satellite collection agencies will implement projects to reduce inflow and infiltration in the collection system and gradually eliminate need for the wet weather facilities. PIWWF is scheduled for retirement by 2035.

Exposure to Flooding

Assets on the Bay shoreline and along major creeks and channels in the project area were analyzed to determine if they were exposed to either current or future flooding. Current flood risk was determined using the most current FEMA Flood Insurance Rate Maps (FIRMS) available when the analysis was conducted. Some assets that are within the FEMA-designated 100-year floodplain are also at risk of more frequent or extensive flooding in the future due to sea level rise. The potential for increased flood risks as sea level rises within the current 100-year floodplain may be underestimated as the increase in riverine flooding due to elevated Bay water levels has not been fully resolved. Lastly, there are assets that are not currently within the FEMA-designated 100-year floodplain but will potentially be exposed to flooding in the future due to sea level rises. Some of these assets may currently be protected from the 100-year flood by the existing shoreline while others may be at a distance from either the Bay shoreline or creek and channel banks and therefore beyond the extent of current flooding. The PIWWF is not located in the flood plain but the North Interceptor and Force Main that direct flows to this facility and outside of the County may be at risk of damage.



Figure 1: EBMUD's PIWWF

Vulnerabilities

GOV1: EBMUD owns the wastewater conveyance and disposal assets that Stege Sanitary District depends on to discharge their waste. The various agencies involved need to collaborate with funding, planning, and decision-making to avoid system-wide failures.

GOV2: Wastewater infrastructure is interconnected to, and affected by, other systems and assets (e.g., stormwater contributes to wet weather flows to wastewater treatment plants) that are owned and managed by different public and private entities. The process and relationships may not be in place to support the coordination and collaboration that will be needed to address these shared vulnerabilities.

PHYS: The EBMUD North Interceptor runs through predominantly low soil strength bay muds and artificial fill and it is subject to a high groundwater table because of its proximity to San Francisco Bay. Flooding increases I/I, particularly inflow of stormwater to the interceptor through manholes and other structures, limits the capacity of the interceptor for sewage. Flooding also increases liquefaction potential, adding to the risk of damage due to seismic event.

FUNC1: Storm events have the potential to reduce outfall and diffuser capacity and exacerbate wet weather flow capacity issues. The discharge capacity of the outfall and diffuser may be reduced during existing high storm tides, which could occur more often with climate change. The reduced capacity will have consequences on how EBMUD handles wet weather flows and may threaten the overall performance of the EBMUD system.

FUNC2: The wastewater facility relies on roads and highways to bring employees, fuel, and other materials to the site and if the roads used to access the facility experiences extensive flooding, the plant may not be able to continue operations. For example, PIWFF may be inaccessible if Central Avenue or I-580 flood.

Consequences

Society and Equity: EBMUD provides a critical public health and safety function. If storm events or sea level rise overwhelm and compromise the system, it could affect EBMUD's ability to treat and discharge wastewater. Without EBMUD's service, Stege Sanitary District, which serves the communities of El Cerrito, Kensington, and a portion of the Richmond Annex would have to direct its wastewater to another treatment plant.

Environment: If storm events or sea level rise overwhelm and compromise EBMUD assets, untreated sewage could overflow into the environment. Toxic substances and excessive nutrients degrade water quality and harm fish and other aquatic organisms.

Economy: A system disruption could potentially have wide-ranging consequences in the communities along the North Interceptor. Cumulative impacts on commercial and industrial businesses and the associated employment, goods, and services they provide could also be significant. Operations and maintenance cost, as well as capital improvement costs could increase with storm event and sea level rise flooding.

FLOOD CONTROL

REFUGIO CREEK

(Tidal reach from the mouth to Avocet Dr.)

Key Issue Statement

Given the past and current flood risk in Lower Refugio Creek, it is critical that planners work with flood managers to better understand the vulnerability of proposed development homes, utilities, businesses, and parks to combined tidal-riverine flooding. With this information, the City of Hercules can ultimately construct a project that provides multiple benefits and engage the community in long-range sea level rise resilience planning.

Asset Description

Refugio Creek drains approximately 5 square miles of mostly open space and residential land uses in the upper watershed, and future mixed commercial and residential uses in the lower watershed. Lower Refugio Creek is a natural channel managed by the City of Hercules through a stormwater assessment fund that is currently \$37 per household. The creek has not been engineered to provide a specific level of flood protection; instead, Refugio Creek downstream of San Pablo Avenue is a “regulated floodway”, meaning Hercules must regulate development in the creek and designated adjacent land uses to ensure discharge of the 100-year flood event. The creek was realigned and restored in the early 2000s as part of the remediation for an explosives manufacturing facility that began in the 1980s. While this improved flood capacity in Lower Refugio Creek, portions of the 100-year floodplain extends beyond the channel banks and into area slated for development.



Map of 2015 FEMA flood zones overlain with +6 feet sea level rise above MHHW (NOAA SLR Viewer; increasingly dark shades of blue indicate increasing flood depth).

Currently, Hercules is pursuing construction of a Regional Intermodal Transit Center (RITC) near the mouth of the creek that will include a passenger rail platform and station, ferry terminal, bus transit hub, Bay Trail connections, and associated mixed-use, transit-oriented commercial and residential development. While impacts of the project on peak riverine flows will be minor because the area represents just slightly more than one percent of the overall watershed area, portions of the proposed development that are low-lying areas adjacent to Refugio Creek could be flooded, depending on the City's final designs for Refugio Creek. Furthermore, previous hydraulic modeling shows that the existing bridge and culverts at the Union Pacific Railroad (UPRR) crossing are not adequate to convey a 100-year riverine flow.

Exposure to Flooding

Storms that coincide with high tides have historically resulted in the most extensive flooding, and sea level rise will exacerbate riverine flooding. Tidal influence currently extends approximately 650 feet from the mouth to Avocet Drive and sea level rise will cause the tides to extend further ('migrate') upstream and raise water levels in the creek. This will progressively reduce the capacity of the creek to discharge riverine flows, such that smaller, more frequent storms will cause overbank flooding and stormwater backups, particularly in low-lying areas that will no longer be able to effectively gravity drain against the higher downstream tidal condition.

While overlaying FEMA Flood Insurance Rate Maps (FIRMs) and sea level rise inundation maps suggests the risk of joint coastal-riverine flooding, watershed-scale hydraulic modeling is needed to quantify the combinations of Bay water levels, sea level rise, and riverine flows that cause flooding. Without this joint coastal-riverine flood modeling, the potential for an increase in flood risk in the current 100-year floodplain due to sea level rises may be underestimated. Furthermore, this modeling will clarify the potential for areas that currently are not within the floodplain to be at risk due to sea level rise.

Vulnerabilities

INFO: FEMA FIRMs do not factor in sea level rise, which make it difficult for flood managers and communities to prepare for future flooding. The City of Hercules has to work with consultants to model how proposed development may be vulnerable to combinations of Bay water levels, sea level rise, and riverine flows that cause flooding. FEMA FIRMs show the overlay of the 100-year riverine and coastal floodplains, whereby the 100-year riverine flow sets the upstream and the 100-year tidal condition sets the downstream flood extent. The joint probability of riverine and coastal events likely increases the elevation and extent of the 100-year floodplain, but FEMA FIRMs depict riverine and coastal flooding as independent events and use the higher of the two flood elevations where riverine and coastal floodplains overlap.

GOV: The existing bridge and culverts at the UPRR crossing are not adequate to convey the 100-year riverine flow and changes to these structures require coordination with UPRR. The City's RITC project is proposed to improve the flow capacity at the railroad bridge to reduce risks of local flooding. Funding for these improvements is being sought by the city, and therefore they are contingent on obtaining grant funds as well as permits from various regulatory agencies.

PHYS: Refugio Creek provides less than 100-year flood protection and increased tidal action due to sea level rise will further diminish its capacity to discharge flood flows, particularly when rainfall events coincide with high tide.

Consequences

Society and Equity: If Refugio Creek flooding becomes more frequent and extreme, community members could suffer damages to homes and businesses in the Bayside subdivision and proposed Regional Intermodal Transit Center development.

Environment: Since there is minimal marsh habitat adjacent to Refugio Creek, there are minimal flooding consequences to species.

Economy: If Refugio Creek cannot provide adequate flood protection, damage to local residences and businesses could affect the local economy and disruptions to UPRR service could affect the regional economy.

FLOOD CONTROL

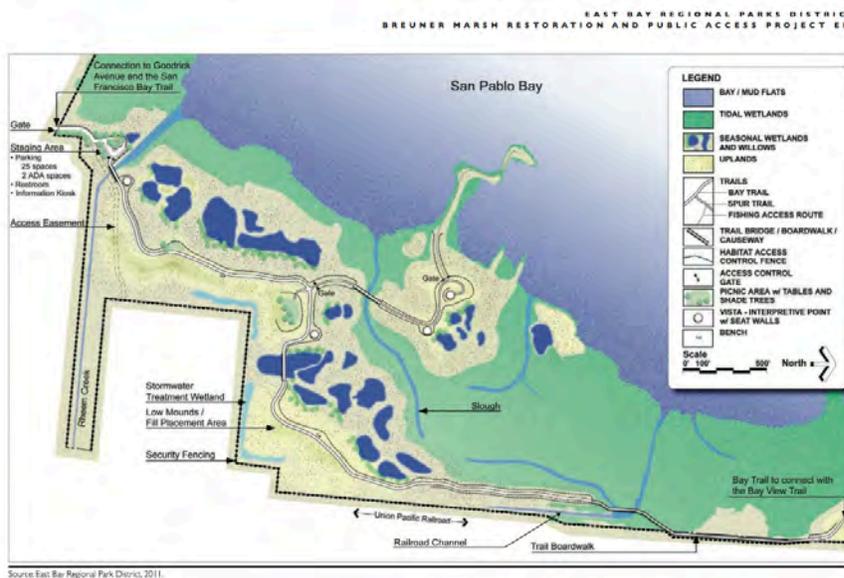
RHEEM CREEK

(Tidal reach estimated from the mouth to Goodrick Ave.)

Key Issue Statement

Lower Rheem Creek provides flood protection for less than a 15-year storm and sea level rise will further reduce flood capacity, which could cause more frequent and extensive flooding of the Bruener Marsh Restoration and Public Access Project. While Rheem Creek offers less than 100-year flood protection, there are there are minimal flooding consequences because the area adjacent to the creek is marsh and overbank flooding is a natural process.

Asset Description



Rheem Creek drains approximately 3 square miles of mostly residential land uses in the City of San Pablo, flowing adjacent to East Bay Regional Park District's (EBRPD) Bruener Marsh before entering the Bay. In 1960, the U.S. Army Corps of Engineers (USACE) constructed a trapezoidal, unlined earth channel from the Bay edge to Giant Road. The design storm was 800 cubic feet per second (cfs), which represents approximately the 15-year

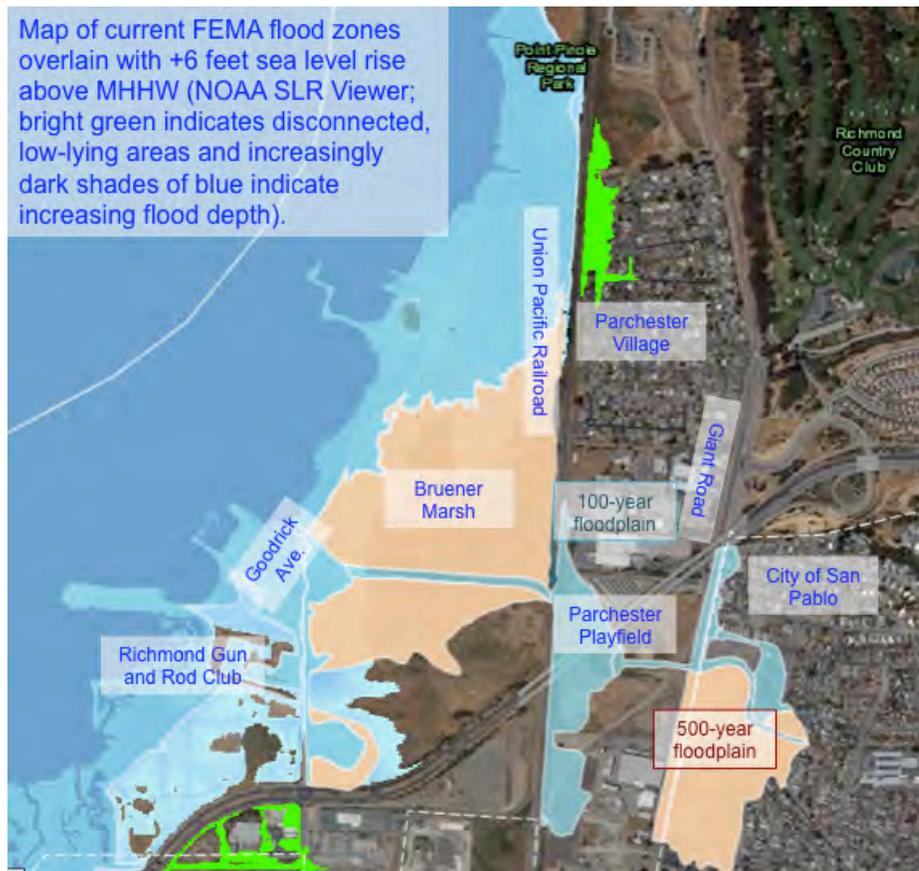
riverine flow believed to be 1.5 times more flow than had caused a flood in 1955. It was determined that engineering the channel to this flow with 1-foot of freeboard was the highest degree of protection that was economically justified. Since significant urbanization has occurred subsequent to the construction of the flood control project, the channel now provides protection from less than the 15-year riverine flow and outdated FEMA Flood Insurance Rate Maps (FIRMs) underestimate the community flood risk. As the local sponsor, the Contra Costa County Flood Control and Water Conservation District (CCCFC&WCD) owns and maintains the channel. However, CCCFC&WCD receives 15 to 20% of the funding necessary for maintenance due to funding restrictions associated with Propositions 13 and 218 to maintain Rheem Creek. This lack of flood capacity is the most significant hydraulic constraint (as opposed to road or railroad bridge dimensions).

Sea level rise will exacerbate riverine flooding. Tidal influence currently extends to approximately Goodrick Avenue (downstream of the Union Pacific Railroad) and sea level rise will cause the tides to extend further ('migrate') upstream and raise water levels in the creek. EBRPD considered sea level rise in planning the

Bruener Marsh Restoration and Public Access Project – the restoration will establish gradual transition zones to accommodate marsh migration as sea level rises and public access improvements were designed to be resilient to mid-century and adaptable to end-of-century. Sea level rise will progressively reduce the capacity of the creek to discharge flood flows, such that smaller, more frequent storms will cause overbank flooding. However, unlike urbanized lower Pinole and Rodeo Creeks, the area adjacent to lower Rheem Creek is marsh and overbank flooding is a natural process.¹ EBRPD considered lowering the level of the north bank of Rheem Creek to allow tidal flooding and increase flood capacity, but ultimately decided not to pursue this project element because changes to Rheem Creek as a federal facility must be consistent with USACE requirements, e.g., Section 408 of the Rivers and Harbors Act.

Exposure to Flooding

While overlaying FEMA FIRMs and sea level rise inundation maps depicts potential joint coastal-riverine flooding, watershed-scale hydraulic modeling is needed to quantify the combinations of Bay water levels, sea level rise, and riverine flows that cause flooding. Without this joint coastal-riverine flood modeling, the potential for an increase in flood risk in the current 100-year floodplain due to sea level rises may be underestimated. Furthermore, this modeling may reveal new areas at risk that were not exposed by simply overlaying FEMA FIRMs and sea level rise inundation maps.



Vulnerabilities

INFO: FEMA FIRMs do not factor in sea level rise, which make it difficult for flood managers and communities to prepare for future flooding. Furthermore, FEMA FIRMs show the overlay of the 100-year riverine and coastal floodplains, whereby the 100-year riverine flow sets the upstream and the 100-year tidal condition sets the downstream flood extent. The joint probability of riverine and coastal events likely increases the elevation and extent of the 100-year floodplain, but FEMA FIRMs depict riverine and coastal flooding as independent events and use the higher of the two flood elevations where riverine and coastal floodplains overlap.

¹ Overbank flooding will likely cause sediment-laden water to flow over the marsh and cause sediment deposition to occur as the floodwaters recede.

GOV1: CCCFC&WCD does not have adequate maintenance funding to address maintenance, capital improvement, and long-range flood management planning needs in Rheem Creek.

GOV2: Since Rheem Creek is a federal facility, improvements must be consistent with USACE policy to remain eligible for federal disaster relief. This requirement does not incentivize reconnecting marshes and creeks to improve habitat quality and flood capacity.

Consequences

Society and Equity: Since EBRPD intends, and its BCDC permit requires, that it maintain, modify, or replace public access improvements in response to actual sea level rise, there are minimal flooding consequences to Bay Trail access and connectivity.

Environment: Endangered rail and saltmarsh harvest mouse populations will need to seek high tide refuge during flood events, which was the basis for EBRPD's restoration design including transition zones. Contamination consequences will also likely be minimal because sources have already been identified and remediated, e.g., American Standard Products waste disposal area on the bank of the creek.

Economy: Since the reach exposed to sea level rise is within the EBRPD Point Pinole Regional Shoreline, there are minimal flooding consequences to the local and regional economy.

FLOOD CONTROL

RODEO CREEK**(Tidal reach from the mouth to 3rd St.)****Key Issue Statement**

Lower Rodeo Creek provides flood protection for approximately a 15 to 20-year storm and ongoing sedimentation and sea level rise will further reduce flood capacity, which could cause more frequent and extensive flooding of low-income single and multiple-family residential units and struggling businesses located in downtown Rodeo. CCCFC&WCD does not have a funding mechanism for flood protection improvements, which would need to be consistent with USACE standards since Lower Rodeo Creek is a federal facility. It is critical that planners work with flood managers to better understand the vulnerability of downtown communities and businesses to combined tidal-riverine flooding using watershed-scale hydraulic models and communicate this information to stakeholders interested in developing projects that improve resilience to sea level rise and provide multiple benefits.

Asset Description

Rodeo Creek drains approximately 10 square miles of mostly open space and agricultural lands in the upper watershed and the community of Rodeo in the lower watershed. In 1960s, the U.S. Army Corps of Engineers (USACE) constructed a flood control project from the mouth to I-80 to provide 100-year flood protection, where the lowermost 0.3 miles from the Bay to 3rd Street is a rectangular concrete channel with limited right-of-way and the 0.8 miles upstream is a trapezoidal earthen channel. As the local sponsor, the Contra Costa County Flood Control and Water Conservation District (CCCFC&WCD) owns and maintains the channel as part of Flood Control Zones 8 and 8A.

Sediment accumulates in the tidal reach of Rodeo Creek because of conditions created by the original USACE design. CCCFC&WCD receives only 5% of the funding necessary to perform channel maintenance such as desilting due to funding restrictions associated with Propositions 13 and 218. Since desilting is both expensive and difficult to permit, the last sediment removal effort was in mid-1990s. As a result of this sedimentation, the channel now only conveys approximately the 15 to 20-year riverine flow. The 2005/2006 New Year's Eve storm events almost caused overbank flooding.

Exposure to Flooding

Sea level rise will exacerbate riverine flooding. Tidal influence currently extends from the mouth to 3rd Street and sea level rise will cause the tides to extend further ('migrate') upstream and raise water levels in the creek. This will progressively reduce the capacity of the creeks to discharge flood flows, such that smaller, more frequent storms will cause overbank flooding and stormwater backups, particularly in low-lying areas that will no longer be able to effectively gravity drain against the higher downstream tidal condition. Analysis conducted by CCCFC&WCD to evaluate the impacts of the City of Hercules proposed sports park near the Conoco-Phillips Coke Plant off of Highway 4 (plans have since been abandoned) showed that construction of detention basins in the upper watershed would provide some storage capacity, but that the effect would be limited to minor storm events, and the 100-year riverine flow would still overtop the creek in downtown Rodeo.

Current coastal & riverine flood risk

**Future coastal & riverine flood risk
(Current conditions + Sea level rise)**



Map current FEMA flood zones (left) overlain with +6 feet sea level rise above MHHW (right; NOAA SLR Viewer, where increasingly dark shades of blue indicate increasing flood depth).

I-80

Further modeling is needed to evaluate the combinations of Bay water levels, sea level rise, and flood flows that cause flooding and inform community planning processes that aim to refine a watershed vision where the creek provides a range of benefits, included but not limited to flood protection. While overlaying FEMA Flood Insurance Rate Maps (FIRMs) and sea level rise inundation maps suggests the risk of joint coastal-riverine flooding, it may underestimate the potential for an increase in flood risk in the current 100-year floodplain due to sea level rises. Furthermore, simply overlaying FEMA FIRMs and sea level rise inundation maps may overlook areas at risk from joint coastal-riverine flooding.

Vulnerabilities

INFO: While FEMA FIRMs are believed to be generally accurate for Rodeo Creek, the maps do not factor in sea level rise and therefore do not illustrate the community’s future increased flood risk. Furthermore, FEMA FIRMs show the overlay of the 100-year riverine and coastal floodplains, whereby the 100-year riverine flow sets the upstream and the 100-year tidal condition sets the downstream flood extent. The joint probability of riverine and coastal events likely increases the elevation and extent of the 100-year floodplain, but FEMA FIRMs depict riverine and coastal flooding as independent events and use the higher of the two flood elevations where riverine and coastal floodplains overlap.

GOV1: CCCFC&WCD does not have adequate maintenance funding to preserve what limited flood capacity exists nor funding to plan and implement improvements to increase the level of flood protection.

GOV2: Since Rodeo Creek is a federal facility, improvements must be consistent with USACE policy to remain eligible for federal disaster relief. This limits CCCFC&WCD's options for sediment management because the original design promoted deposition, and even with increased tidal prism associated with sea level rise, there will not likely be sufficient volumetric exchange to naturally scour the channel.

PHYS: Downtown Rodeo is already in the 100-year FEMA floodplain and increased tidal action due to sea level rise will reduce the capacity of Rodeo Creek to discharge flood flows, particularly when rainfall events coincide with high tide.

Consequences

Society and Equity: If downtown Rodeo Creek flooding becomes more frequent and extreme, community members could suffer damages to homes and businesses.

Environment: Since there is little to no habitat in the rectangular concrete channel that characterizes lower Rodeo Creek, there are minimal flooding consequences to species.

Economy: If Rodeo Creek cannot provide adequate flood protection, damage to local residences and businesses could affect the local economy and disruptions to railroad service could affect the regional economy.

ENERGY SECTOR

Tesoro Martinez Refinery

Key Issue Statement

A portion of the Tesoro Martinez Refinery site is low-lying and vulnerable to future coastal storm flooding, and a portion is adjacent to Lower Walnut Creek and could be impacted by future riverine flooding. The site may also be exposed to rising groundwater levels and salinity intrusion as sea levels rise. Flooding during storm events could damage or disrupt the pipelines, roads, rail lines, buildings, and the wastewater treatment facilities the refinery relies on to maintain operations.



Photo: Tesoro

Improving the resilience of refinery operations will require coordination with asset owners and managers that operate on-site as well as those that provide goods and services from off site.

Asset Description

The primary purpose of an oil refinery is to process crude oil to make petroleum products and other chemicals, including motor fuel and lubricants. These products are then transported to distributors and consumers. Bay Area oil refineries are located near the shoreline because they rely on marine oil terminals. They also depend on many other sectors, including road and rail goods movement corridors, pipelines, power generation and distribution, water supply and wastewater services. Often, refinery operations and associated industries are co-located.

The Tesoro Martinez Refinery site includes many different types of assets and facilities. In addition to Tesoro's refinery operations the site includes the Amorco (import) and Avon (export) Marine Oil Terminals and seven facilities that are owned and operated by other companies who either own or lease the land where the facility is located. These include a Chevron Products Company bulk fuel terminal; a Monsanto catalyst and chemical manufacturing plant; a Shell Oil Company crude oil pump station and pipeline; a Kinder Morgan refined product pump station and the Santa Fe pipeline; a Foster Wheeler cogeneration plant; an Air Liquid plant where CO₂ and compressed natural gas are manufactured; an Air Products hydrogen gas plant. In addition, Wickland Oil Company and Shore Terminals LLC own and operate pipelines on the refinery siteⁱ.

Connections to the Tesoro site are essential to refinery operations. Pipes, pumps, electrical utilities, and other mechanical equipment connect services and operations located on site. Transmission lines, roads, interstate roads (i.e. I-680 and Waterfront Road), terminals, pipelines (i.e. Kinder Morgan) and rail (i.e. Union Pacific) connect the refinery to services and markets located off site although the Refinery relies mainly on pipe lines for its exports. Although Burlington Northern Santa Fe (BNSF) has a rail line that cuts through the refinery perpendicular to Solano Way and Walnut Creek, it does not service the Refinery. Tesoro receives water from the Contra Costa Water District and is developing a plan to use recycled water from Central Contra Costa Sanitary District. The refinery treats and discharges wastewater to Suisun Bay via a diffusion line under a NPDES permit, while clean stormwater is discharged to Pacheco Slough or Hastings Slough.

Exposure to Flooding

Assets on the Bay shoreline and along major creeks and channels in the project area were analyzed to determine if they were exposed to either current or future flooding. Current flood risk was determined using the most current FEMA Flood Insurance Rate Maps (FIRMS) available when the analysis was conducted. Some assets that are within the FEMA-designated 100-year floodplain are also at risk of more frequent or extensive flooding in the future due to sea level rise. The potential for increased flood risks as sea level rises within the current 100-year floodplain may be underestimated as the increase in riverine flooding due to elevated Bay water levels has not been fully resolved. Lastly, there are assets that are not currently within the FEMA-designated 100-year floodplain but will potentially be exposed to flooding in the future due to sea level rises. Some of these assets may currently be protected from the 100-year flood by the existing shoreline while others may be at a distance from either the Bay shoreline or creek and channel banks and therefore beyond the extent of current flooding. Tesoro Martinez Refinery's shoreline, Lower Walnut Creek and Point Edith Wildlife area are located in the 100-year flood plain. The maps show that the Refinery has low-lying areas near Point Edith Wildlife. Low elevation areas on the site, which may include some wastewater treatment ponds, are vulnerable to flooding.

Vulnerabilities

INFO: There is a limited amount of publicly available information about the refinery site or operations as it is a private entity.

GOV: The operations and management of the refinery site, the number of agencies that regulate planning and operations, the number of associated facilities, and the reliance on others to provide access and services (i.e. energy, wastewater) will complicate planning and implementing changes necessary to improve the resilience of refinery operations.

PHYS1: Some of the facilities and network systems, such as the onsite wastewater treatment plant, roads, rail and pipelines, on the Tesoro site are located in low-lying areas and are unlikely to have been constructed to withstand flooding, higher groundwater levels, or salinity.

PHYS2: Pipelines and electrical components connecting the Marine Oil Terminals to land-based refinery facilities may be impacted if they are exposed to salt water.

PHYS3: Linear, networked infrastructure such as pipelines and rail lines may be more susceptible to damage during a seismic event if liquefaction potential increases due to higher groundwater.

PHYS4: The refinery was constructed at a time when anchors and supports for subsurface pipelines for anything other than lateral thrust were not contemplated nor required. As such, buried pipelines are vulnerable to groundwater rise and liquefaction, which can cause the pipelines to break.

FUNC1: The refinery relies on power and water. The disruption of the onsite Cogeneration Plant or wastewater treatment plant may cause the refinery to slow down production or even shut down.

FUNC2: The refinery operates continuously, so the process of safely shutting down requires a lot of time and effort. During an emergency shut down, such as during an unexpected flood event, a rapid refinery shut down could have consequences beyond the economy, for example if excessive flaring impacts public health.

FUNC3: Temporary or permanent disruption at the ship/rail terminal would affect the capacity to ship and receive goods, and potentially disrupt the refinery's ability to function. The Refinery receives most of its raw materials through its shipping terminals, so this would impact the Refinery's production.

FUNC4: Access to and from the refinery could be disrupted if key roads or access to these roads is disrupted by flooding during a storm events, for example Waterfront Road, which currently floods with extreme high tides and at King Tide, Highway 4, Imhoff Drive, or Marsh Drive all which cross Walnut Creek.

Consequences

Society and Equity: Disruption of refinery operations could impact local and regional jobs both on site and in the sectors serving the refinery. Flooding of the refinery site could result in public health impacts if there is an unscheduled disruption in operations. In addition, the refinery has been designated as Critical Infrastructure by the Department of Homeland Securityⁱⁱ and disruption of operations could have debilitating impacts on national security, public health and safety and the economy.

Environment: Contaminants present on site could be carried with floodwaters into inland areas or released into the Bay, and have the potential to contaminate rising groundwater. If rail is disrupted, and additional trucks are used to bring goods to and from the site, there may be an increase in local air pollution and greenhouse gas emissions.

Economy: If any part of the refinery site is disrupted for a long period of time, jobs at the refinery or with associated facilities and services could be lost. There are 650 employees at this facility and thousands of jobs affiliated with operations at the Tesoro Refinery. If refinery operations are disrupted, and if there is limited regional redundancy in refining because other operators are also disrupted, there could be significant impacts on the regional economy

ⁱ RWQCB Transmittal of Order No.R2-2004-0056 (2004)

http://www.waterboards.ca.gov/sanfranciscobay/board_decisions/adopted_orders/2004/R2-2004-0056.

ⁱⁱ The term "critical infrastructure" has the meaning provided in section 1016(e) of the USA Patriot Act of 2001 (42 U.S.C. 5195(e), namely systems and assets, whether physical or virtual, so vital to the United States that the incapacity or destruction of such systems and assets would have a debilitating impact on security, national economic security, national public health or safety, or any combination of those matters.

FLOOD CONTROL

WALNUT CREEK

(Tidal reach from the mouth to Highway 4)

Key Issue Statement

Lower Walnut Creek provides flood protection for approximately a 40-year storm and ongoing sedimentation and sea level rise will further reduce flood capacity, which could cause more frequent and extensive flooding of roads and railroads around the Tesoro Refinery. CCCFC&WCD is conducting public outreach and studies to inform the restoration of Lower Walnut Creek and develop alternatives that provide multiple benefits.

Asset Description

Walnut Creek is the largest watershed in Contra Costa County, draining over 150 square miles and containing eight cities and over 300,000 residents. Starting in 1963, the U.S. Army Corps of Engineers (USACE) constructed about 22 miles of channel improvements consisting of channel enlargement, channel stabilization, and levees along Lower Walnut Creek and its tributaries to provide 100-year flood protection. The existing project is a classic trapezoidal earthen channel with levees on one or both banks, which has historically needed de-silting to maintain the design capacity. For example, in 1973 just 10 years after the project was constructed, USACE dredged over 850,000 cubic yards of sand and mud from the lower channel. As the local sponsor, the Contra Costa County Flood Control and Water Conservation District (CCCFC&WCD) owns and maintains the channel as part of Flood Control Zone 3B, receiving only 75% of necessary maintenance funding due to restrictions associated with Propositions 13 and 218. Very high tides typically overtop the channel levees along the west side of lowermost Walnut Creek and flood Waterfront Road (parallel to Union Pacific Railroad, UPRR), blocking traffic into and out of the Tesoro Refinery. The west side of the creek between UPRR and BNSF also has drainage issues.

CCCFC&WCD is working on the innovative Lower Walnut Creek Restoration Project to reduce current flood risk, accommodate sea level rise, manage sediment, improve wildlife habitat, and provide more recreation opportunities. While Lower Walnut Creek was designed to provide 100-year flood protection, the current level of protection is approximately a 40-year storm due to increased development in the watershed and channel sedimentation. CCCFC&WCD requested from Congress that the lowermost four miles of the USACE Walnut Creek Project be deauthorized so that it is no longer subject to USACE standards. When CCCFC&WCD prepared to dredge the channel in the early 1990s, significant wildlife habitat had developed in the channel and dredging would have involved removing all the vegetation (and habitat) to restore the channel to the 1960s configuration. CCCFC&WCD believed that the channel had reached an equilibrium *including* this habitat and that it would take decades to reestablish the vegetation if it was removed. From 2004 through 2012, CCCFC&WCD worked closely with the USACE to reevaluate the operation of the channel and design a more sustainable project, but lack of consistent federal funding hindered progress. Now that the creek is deauthorized and exclusively under local control, CCCFC&WCD has developed a vision for Lower Walnut Creek and hired consultants to conduct public outreach, feasibility studies, and conceptual designs for the restoration. Walnut Creek is also one of three creeks in the Bay being studied as part of Flood Control 2.0, an effort to redesign flood control channels so that they provide both future flood conveyance and ecological benefits under climate change.

Just upstream of the Lower Walnut Creek Restoration Project, CCCFC&WCD is working with Central Contra Costa Sanitary District (CCCSD) to rehabilitate the levees protecting the Wastewater Treatment Plant just north of Highway 4. The levees protecting the plant currently provide protection from a 100-year storm but lack freeboard. CCCFC&WCD and CCCSD are sharing the cost to increase flood protection to a 500-year storm with freeboard, taking sea level rise into account, because the facility is extremely sensitive to flood damage. Project completion is anticipated by the end of 2018.

Exposure to Flooding

Sea level rise will exacerbate coastal and riverine flooding in Lower Walnut Creek. Tidal influence currently extends approximately 3.5 miles from the mouth to the CCCSD Treatment Plant pipe crossing near Highway 4 and sea level rise will cause the tides to extend further ('migrate') upstream and raise water levels in the creek. This will progressively reduce the capacity of the creek to discharge flood flows, such that smaller, more frequent storms will cause overbank flooding and stormwater backups, particularly in low-lying areas that will no longer be able to effectively gravity drain against the higher downstream tidal condition. While overlaying FEMA Flood Insurance Rate Maps (FIRMs) and sea level rise inundation maps suggests the risk of joint coastal-riverine flooding, analysis is needed to better understand the extent of flooding caused by combinations of Bay water levels, sea level rise, and flood flows and CCCFC&WCD is conducting this analysis through the Lower Walnut Creek Restoration Project.



Vulnerabilities

INFO: FEMA FIRMs do not factor in sea level rise, which make it difficult for flood managers and communities to prepare for future flooding. Results of CCCFC&WCD's joint coastal-riverine flood modeling will quantify how sea level rise will worsen conditions in existing floodplains and bring new areas into floodplains.

GOV: At present, there is no framework for planning and permitting innovative, multi-benefit flood protection projects. Each agency is constrained by its mandate and regulations, resulting in generally static and fragmented decision-making, passive management, and an emphasis on historic preservation despite the fact that climate change is expected to lead to unforeseen and potentially detrimental impacts.

PHYS: Land adjacent to Lower Walnut Creek is in the 100-year floodplain and increased tidal action due to sea level rise will reduce the capacity to discharge flood flows, particularly when rainfall events coincide with high tide.

Consequences

Society and Equity: While there are no communities or parks along Lower Walnut Creek, there would be consequences to society and equity if Tesoro Golden Eagle Refinery, Central Contra Costa Sanitary District (CCCSD) Treatment Plant, and landfill/waste facilities (Acme Landfill, Vine Hill Complex, and Contra Costa Waste Transfer Station) were flooded. Disruption of refinery operations could impact local and regional jobs both on site and in the sectors serving the refinery. The CCCSD Treatment Plant is extremely sensitive to flood damage and if storm events and sea level rise shut down the treatment plant, even temporarily, untreated wastewater could back up into homes, businesses, and neighborhoods and spread disease. Furthermore, mobilization of contaminants on landfill/waste facilities poses a risk to public health.

Environment: Increased flooding in Lower Walnut Creek could also mobilize hazardous substances from adjacent industrial sites, landfill/waste facilities, and the treatment plant and decrease water quality in the creek, adjacent marshes (Bullhead Marsh, Pt. Edith Marsh, Pacheco Marsh), and the Bay. The Walnut Creek Watershed supports a variety of species, including federally threatened Coho salmon, federally threatened steelhead trout, black rails (threatened), and California Ridgway's rails (endangered).

Economy: If Lower Walnut Creek cannot provide adequate flood protection, disruptions to local roads, damage to energy services, shutdown of the one treatment plant serving 467,500 residents and 3,000 businesses in the area, and lack of railroad service could affect the regional economy. With or without the Lower Walnut Creek Restoration Project, increasing tides will make flooding of Waterfront Road worse and limit access to the north end of the Tesoro Refinery.

CONTAMINATED LANDS SECTOR

West Contra Costa Sanitary Landfill

Key Issue Statement

The West Contra Costa Sanitary Landfill provides permanent containment for non-hazardous and municipal wastes. The WCCSL is vulnerable to flooding because of its proximity to the Bay, limited access, type of onsite facilities and uses, and the potential for long-term flooding. The direct disruption of the closed landfill, particularly the HWMF, could have significant consequences for public health and nearby ecosystems if contaminants were released into the environment. While there is currently a leachate collection system in place, the current system may or may not be sufficient to collect and treat additional water volumes that might result from sea level rise.



Photo: City Lab

Asset Description

The West Contra Costa Sanitary Landfill (also known as the West County Sanitary Landfill or WCCSL) is a closed and capped facility that includes both Class I and Class II landfill components. The Class I landfill is located within the Class II landfill and is a Hazardous Waste Management Facility (HWMF). The HWMF is 28 acres and the Class II landfill is approximately 160 acres. The HWMF and the Class II landfill are each surrounded by slurry walls with leachate extraction and monitoring wells. Leachate is conveyed to the nearby West County Wastewater Treatment Plant for treatment and discharge.

The WCCSL is located at Parr Boulevard and Garden Tract Road in Richmond, adjacent to tidal wetlands (including Wildcat Marsh) and San Pablo Bay. The Golden Bear Transfer Station and the three-megawatt Nove power generation facility are located within the footprint of the landfill. Additional permitted activities at WCCSL include a concrete crushing plant, a green waste grinder, and a construction and demolition debris recycling facility. The WCCSL provides public access and recreational benefits and there is Bay Trail access around the closed the landfill (Wildcat Marsh and Landfill Loop Trails).

West County Landfill, Inc. owns the facility, and West Contra Costa Sanitary Landfill, Inc. operates the facility. They are both subsidiaries of Republic Services, Inc. Additionally, Republic Services is the parent company for Nove Power (Nove Investments, Inc.), which owns the on-site power generation facility. The State Department of Toxic Substance Control (DTSC) oversees the HWMF, and the Regional Water Quality Control Board (RWQCB) oversees the Class II landfill. The WCCSL is under the jurisdiction of the City of Richmond and Contra Costa County, and the Bay Trail segment on the landfill is managed by the East Bay Regional Park District.

The WCCSL is a closed landfill with site closure and postclosure maintenance plans submitted and adopted with approval from CalRecycle, the RWQCB, the County Local Enforcement Agency (LEA), and with RCRA Subtitle D prescribed regulations for final cover. The final cover consists of a foundation layer of greater than 2 feet, a clay barrier of 1 foot, a vegetative layer of 1 foot, and on working surfaces, an additional 3-foot

working/protective layer of soil concrete and or rubble. The landfill final cover has been designed to prevent water infiltration. A bay mud barrier wall and slurry walls serve to confine any leachate formed. The top elevation of this confinement barrier varies around the site perimeter. The top is approximately elevation +9 feet MSL on the south side to +17 on the north and west (Bay) side. The tops of these walls have been connected to the clay barrier layer of the final cover, where the final cap has been placed on the landfill and HWMF. Finally, the landfill has a leachate extraction system that may or may not be sufficient, depending on the volume of inundation, to collect and dispose of the additional leachate should a flood occur.

Exposure to Flooding

The majority of the WCCSL site is unlikely to be directly impacted from current or future flooding due to its elevation. However, lower-elevation facilities onsite may be at risk, and the single access road on and off the site is also at risk from current and future flooding. Additional exposure to storm events, including increased tidal and wave energy, could result in an increase need for maintenance of landfill perimeter closest to the Bay, which is currently protected by rip rap, or for other interventions. The landfill is currently protected from groundwater, which could rise as sea levels rise, by a slurry wall. The slurry wall is constructed around the perimeters of the landfill and HWMF, and provides additional protection from leachate and water intrusion. A significant depth of natural bay mud underlies the landfill. The thickness of the mud is approximately 100 feet. This mud and the upward movement of the ground water provide control against downward travel of the leachate from the base of the landfill. Lateral waste and leachate containment control facilities include the bay mud barrier wall and slurry walls, which are keyed into the underlying bay mud, and the leachate collection and removal drains.

Vulnerabilities

GOV1: The HWMF and WCCSL serve multiple objectives, including hazardous and municipal waste storage, respectively, and are subject to a complex regulatory process. Any comprehensive planning or major changes at the site would require Republic Services to coordinate internally among its subsidiaries, as well as obtain multiple permits and coordinate with multiple entities, including DTSC, RWQCB, BCDC, City of Richmond, Contra Costa County, West County Wastewater District, and EBRPD.

FUNC1: The landfill site has one access road, and both this road and local surface streets are at risk from current and future flooding. With long-term flooding of this access, the WCCSL could effectively become an island, and site management (e.g. monitoring, repairs or upgrades to waste containment systems) will become difficult.

FUNC2: The WCCSL is a multi-use asset, and the Bay Trail loop on the landfill provides important public recreation opportunities and scenic views. The portion of the Bay Trail east of the WCCSL along Richmond Parkway does not provide redundancy for shoreline access, but does provide connectivity between Bay Trail points north and south of the WCCSL loop.

PHYS1: The waste contained in the landfill would be very challenging and expensive to relocate, and most likely needs to be protected in place.

PHYS2: While the landfill final cover has been designed to prevent water infiltration, there is a leachate extraction system in place which may or may not be sufficient, depending on the volume of inundation, to collect and dispose of the additional leachate should flooding occur.

PHYS3: The current waste containment systems may not be designed to withstand permanent flooding and increased storm wave erosion.

Consequences

Society and Equity: The WCCSL poses a risk to public health if onsite contaminants are released, particularly from the HWMF. However, in place leachate collection systems may or may not be sufficient to collect and treat additional water-intrusive volumes. Flooding could also result in a disruption or loss of public access and recreation, including the use of picnic areas and trails suitable for walking, biking, and wheelchair access.

Environment: There could be significant water quality impacts if there was a release of contaminants from the landfill, particularly from the HWMF. The site provides habitat for a variety of species, both as part of the covered and vegetated landfill and at a 40-acre onsite retention pond. If the asset were disrupted, it could cause the direct loss of habitat and species onsite, as well as having impacts on surrounding natural areas such as San Pablo Bay, San Pablo Creek, San Pablo Creek Marsh, and Wildcat Marsh.

Economy: A release of contaminants from the landfill could strain local emergency resources and could result in high cleanup and recovery costs. Additionally, onsite services and facilities, such as Nove Power and the Golden Bear Transfer Station, could cease operation either temporarily or permanently, resulting in the need for alternative and comparable services. Jobs at onsite facilities could also be impacted.

WASTEWATER SERVICES SECTOR

West County Wastewater District Water Pollution Control Plant

Key Issue Statement

The West County Wastewater District's Water Pollution Control Plant is in the process of upgrading aging infrastructure, which may delay sea level rise planning even though the berms that protect the facility may need to be improved to protect the plant beyond 2030. Storm events as sea levels rise have the potential to reduce outfall and diffuser capacity, and will have consequences on how the wet weather



flows are handled and could threaten overall system performance. In addition, in the event of flooding, the treatment plant may not be accessible to workers due to flooded roadways, and if electrical power supply is compromised or there is an interruption of the natural gas supply to the equalization basin pumps there may not be adequate backup diesel fuel supply to operate the 2 megawatt emergency generators for the duration of the disruption.

Asset Description

West County Wastewater District (WCWD) was formed in 1921 and currently provides wastewater disposal service to 16.9 square miles of Contra Costa County, including unincorporated areas (43% of District), portions of the cities of Richmond (40% of District), San Pablo (15% of District) and Pinole (2% of District). Wastewater from these areas is conveyed through a system of pipes and pumps to the Water Pollution Control Plant (WPCP) for discharge or reuse. Currently, most of WCWD's 8 million gallons per day (MGD) average dry weather flow secondary treated effluent is sent to EBMUD's North Richmond Water Reclamation Plant (NRWRP) and the Richmond Advanced Recycling Expansion (RARE) for reuse by Chevron's Richmond Refinery. Flows in excess of 12.5 MGD and those that do not meet the quality required by EBMUD for recycling and reuse are dechlorinated and discharged to the Bay through the West County Agency deep water outfall. WCWD serves a population of approximately 92,976 residents, as well as industrial, commercial and public customers. WCWD owns and manages the treatment plant and entered into a joint powers authority, the West County Agency, with the City of Richmond's Municipal Sanitary Sewer District to construct and maintain the outfall and diffuser.

Wastewater treatment plants are permitted to discharge a specific amount of wastewater based on a capacity allowance. The WCWD WPCP has a rated capacity of 12.5 MGD average dry weather flow and a rated peak wet weather capacity of 21 MGD. The West County Agency outfall has a design capacity of 58.94 MGD. The outfall extends approximately 4,700 feet into Central San Francisco Bay, with the last portion being a diffuser section designed to ensure maximum dilution and mixing with deep Bay waters. As part of WCWD's Capital Improvement Plan (CIP), the agency has implemented a sewer and lateral

replacement program to reduce existing wet weather inflow and overflows. The CIP also includes funding for pump station rehabilitation and plant upgrades to meet regulatory requirements.

Exposure to Flooding

A portion of the WCWD’s treatment plant is located in the current 100-year floodplain of San Pablo Creek and Wildcat Creek, and much of the remainder is within the 500-year floodplain. The treatment plant is also at risk from future flooding with as little as 1 foot of sea level rise, although the potential for increased riverine flood risks in the current 100-year floodplain due to sea level rise and elevated Bay water levels has not been fully resolved. Infrastructure within the portion of the treatment plant site that may be impacted include the main lift station that pumps wastewater to then flow by gravity through the treatment plant, the effluent pump station that pumps treated effluent to two EBMUD water reclamation facilities and/or the deep water outfall, and the equalization basin pump station that pumps influent flows in excess of 21 MGD to 53 million gallon storage basins. The north side of the plant is protected from San Pablo Creek by a levee maintained by the Contra Costa County Flood Control, which is planning to improve the portion of levee near the treatment plant in 2016 to increase the level of protection provided (See the Wildcat and San Pablo Creek Profile Sheet). Additionally, the WCWD maintains 9-10 foot high berms around the treatment plant, which should protect the function of the plant through 2030, but may leave the plant exposed if not adequately adapted to withstand future flooding and storm events.

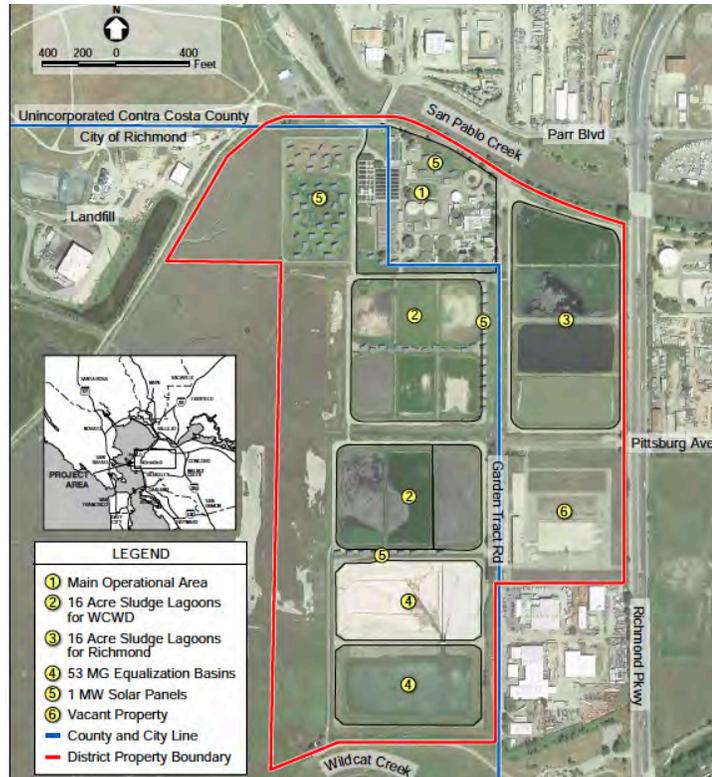


Figure 1: 2377 Garden Tract Road, Richmond

Vulnerabilities

GOV1: Unincorporated areas of Contra Costa County, portions of the cities of Richmond, San Pablo and Pinole depend on the WCWD’s treatment plant for wastewater services. WCWD discharges treated effluent to a deep Bay outfall jointly owned and managed with the City of Richmond’s Municipal Sanitary Sewer District as well as provides treated effluent to EBMUD for water reclamation and reuse by Chevron’s Richmond Refinery. Maintaining discharge capacity requires the ongoing coordination and collaboration with both City of Richmond and EBMUD, which may complicate planning and funding decisions to address sea level rise and future storm event challenges.

GOV2: Wastewater infrastructure is interconnected to, and affected by, other systems and assets that are owned and managed by different public and private entities. For instance, a county-maintained levee

provides flood protection to the treatment plant from San Pablo Creek. Hydraulic deficiencies in certain locations along both San Pablo Creek and Wildcat Creek have been identified and are being addressed by the county, which will serve to protect the treatment plant. Future flood challenges will require ongoing and increasing coordination and collaboration to address shared vulnerabilities of the treatment plant and other important community assets nearby.

GOV3: Directing resources for long-term planning to address the risks posed by sea level rise may not rise in priority given existing capital demands. For example, WCWD's collection system consists of aging infrastructure with numerous pipe segments in need of repair or replacement in the short term.

PHYS1: The earthen berms that prevent any overflows from the sludge drying ponds and equalization facilities to reach the Bay may also provide some level of protection from coastal flooding. Berm elevation ranges from 9.3 feet to 10 feet and surround the treatment plant on three sides, and WCWD estimates that these structures could provide protection up to 2030, however the structural stability and adaptability of these berms is unknown.

PHYS2: WCWD's assets, including the earthen berms, are located in an area of very high liquefaction susceptibility, placing them at risk of damage during an earthquake. Higher groundwater levels could increase these risks further.

PHYS3: WCWD's interceptor pipelines that are in areas subjected to flooding area and rising groundwater levels could become buoyant, resulting in the need for maintenance, repair, and replacement.

PHYS3: Wastewater treatment plants require an uninterrupted power supply to function. If electrical and mechanical components of the facilities, including pumps, control panels, and standby power generation, are at or below grade and are not waterproofed or salt-resistant, the facility will not be able to function. Major upgrades of the wastewater treatment plant and pump stations are scheduled that could address this vulnerability.

PHYS4: Flooding in the WCWD service area could increase wet weather flows, and stress the treatment and discharge capacity of the system. This is particularly an issue if inflow of stormwater to interceptor pipelines through manholes and other structures is increased due to coastal or localized backups or nuisance flooding, and/or if infiltration into the system increased due to rising groundwater.

FUNC1: WCWD relies on sludge lagoons to dry solids for landfill disposal and land application. Although WCWD is evaluating a mechanical dewatering process to replace the sludge drying lagoons, the project would be implemented during FY 26/27-28/29 at a cost of \$22.8 million. WCWD does not have a plan to decommission Lagoons No. 5, 7, and 9. It is uncertain if the drying lagoons will be protected from sea level rise prior to the implementation of the new mechanical dewatering process.

FUNC2: The equalization basin is low-lying and at risk of future flooding. The equalization facilities have sufficient capacity to handle wet weather flows from a 5-year storm event. If the WCWD's berms fail or in the event of a larger storm event, these facilities will not be functional and result in sewer system overflows.



Figure 2: Liquefaction Susceptibility
(<http://gis.abag.ca.gov>)

FUNC3: There are solar panels located in an area vulnerable to increased flooding due to storm events and sea level rise and if they are not waterproof, salt tolerant, or relocated, WCWD will lose the 1MW of low-cost, renewable energy they provide.

FUNC4: Storm events have the potential to reduce outfall and diffuser capacity and exacerbate wet weather flow capacity issues. The discharge capacity of the outfall and diffuser may be reduced during existing high storm tides, which may occur more often with climate change and may eventually require an effluent pump station. The reduced capacity will have consequences on how the WPCP handles wet weather flows and may threaten the overall performance of the system.

FUNC5: Wastewater treatment systems are large, expensive, and complex, and the aged sewer collection system increases the vulnerability to sea level rise and storm events.

FUNC6: The WCWD wastewater facilities rely on roads and highways to bring employees, fuel, and other materials to the site and if the roads used to access this facility experience extensive flooding, the plant may not be able to continue operations. For example, Richmond Parkway, or Pittsburg Avenue, and in particular Garden Tract Road as it provides the main access to the plant.

Consequences

Society and Equity: The water pollution control plant provides a critical public health and safety function. If storm events or sea level rise overwhelm and compromise the system, it could affect the plants' ability to treat and discharge wastewater. With only one wastewater treatment plant serving such a large area, the cities and county areas depending on WCWD may not have the ability to direct their wastewater to another plant, potentially resulting in residents being displaced from their homes and businesses needing to close.

Environment: WCWD has a history of sewer overflows and if storm events or sea level rise overwhelm and compromise the treatment plant, toxic substances and excessive nutrients could overflow into the adjacent shoreline areas and Bay, degrading water quality and harming fish and other aquatic organisms.

Economy: A wastewater system disruption could potentially have wide-ranging consequences in Contra Costa County. Cumulative impacts on commercial and industrial businesses and the associated employment, goods, and services they provide could also be significant. The WCWD's treated wastewater serves as recycled water for Chevron's Richmond Refinery and disruption of the treatment plant would trigger additional losses to EBMUD and Chevron and employees that work there. Operations and maintenance cost, as well as capital improvement costs could increase with storm event and sea level rise flooding.

FLOOD CONTROL

WILDCAT AND SAN PABLO CREEKS

(Tidal reach from the mouth to Garden Tract Rd. and Richmond Parkway, respectively)

Key Issue Statement

After the levee rehabilitation project is completed, lower Wildcat and San Pablo Creeks will provide 100-year flood protection. However, ongoing sedimentation and sea level rise will further reduce flood capacity, which could cause flooding at the West County Wastewater Plant and North Richmond community. Lack of funding and conflicting flood management and habitat goals also make it difficult for CCCFC&WCD to maintain and improve the creeks.

Asset Description

Wildcat and San Pablo Creeks drain approximately 11 and 42 square miles, respectively. Once the creeks exit the upper watershed canyons, they flow westward and parallel to each other through San Pablo, Richmond, and North Richmond passing through an area of mostly industrial land uses before reaching Wildcat Marsh. From 1987 to 1992, U.S. Army Corps of Engineers (USACE) constructed a flood control project (referred to as Phase I¹) on Wildcat and San Pablo Creeks to provide protection to development downstream of Union Pacific Railroad for the 100-year riverine flow at mean higher high water (MHHW). As the local sponsor, the Contra Costa County Flood Control and Water Conservation District (CCCFC&WCD) owns and maintains the channels as part of Flood Control Zones 6 and 7.

CCCFC&WCD is currently planning a levee rehabilitation project on Wildcat and San Pablo Creeks expected to begin in 2016. CCCFC&WCD found that in some locations the channel levees do not meet minimum Federal Emergency Management Agency (FEMA) freeboard requirements. Observations and modeling indicated that accumulated silt, despite the 2006 desilting effort, causes freeboard and channel bank deficiencies. Due to the difficulty in obtaining environmental permits and paying for mitigation for silt and vegetation removal, CCCFC&WCD decided to raise the levees to meet FEMA requirements, which are more stringent than the USACE original design. The levees were decertified in 2010 and recertification is required to remove the flood insurance requirements from the adjacent properties, including the West County Wastewater Plant and low-income North Richmond neighborhood. CCCFC&WCD receives only 8% of the funding necessary to maintain Wildcat and San Pablo Creeks due to funding restrictions associated with Propositions 13 and 218. As such, CCCFC&WCD applied for and received a Local Levee Critical Repair grant from the Department of Water Resources for the levee rehabilitation project.

Exposure to Flooding

Sea level rise will exacerbate riverine flooding. Tidal influence in Wildcat and San Pablo Creeks is within the USACE Phase I project and current levee rehabilitation project, currently extending to Garden Tract Road in Wildcat Creek and to Richmond Parkway in San Pablo Creek. Sea level rise will cause the tides to extend further ('migrate') upstream and raise water levels in the creek. This will progressively reduce the capacity of

¹ Significant flooding occurs upstream of Phase I; numerous efforts to initiate a Phase II flood control project have thus far been unsuccessful.

the creeks to discharge riverine flows, such that smaller, more frequent storms will cause overbank flooding and stormwater backups, particularly in low-lying areas that will no longer be able to effectively gravity drain against the higher downstream tidal condition. However, even before flooding, sea level rise will reduce available freeboard and levees may lose their FEMA accreditation, which would require residents and property owners in the floodplain to purchase flood insurance.



Map of current FEMA flood zones overlain with +6 feet sea level rise above MHHW (NOAA SLR Viewer; bright green indicates disconnected, low-lying areas and increasingly dark shades of blue indicate increasing flood depth).

While overlaying FEMA Flood Insurance Rate Maps (FIRMs) and sea level rise inundation maps suggests the risk of joint coastal-riverine flooding, it may underestimate the potential for an increase in flood risk in the current 100-year floodplain due to sea level rises. Furthermore, simply overlaying FEMA FIRMs and sea level rise inundation maps may overlook areas at risk from joint coastal-riverine flooding. CCCFC&WCD performed sensitivity analysis as part of levee rehabilitation project hydraulic modeling and determined that the designed raised levees as can accommodate approximately 2 feet of sea level rise above MHHW before overtopping. Further analysis is needed to better understand the extent of flooding caused by combinations of Bay water levels, sea level rise, and flood flows.

Vulnerabilities

INFO: FEMA FIRMs do not factor in sea level rise, which make it difficult for flood managers and communities to prepare for future flooding. Furthermore, FEMA FIRMs show the overlay of the 100-year riverine and coastal floodplains, whereby the 100-year riverine flow sets the upstream and the 100-year tidal condition sets the downstream flood extent. The joint probability of riverine and coastal events likely

increases the elevation and extent of the 100-year floodplain, but FEMA FIRMs depict riverine and coastal flooding as independent events and use the higher of the two flood elevations where riverine and coastal floodplains overlap.

GOV1: CCCFC&WCD has to compete for grants to maintain flood control channel condition and capacity. A reliable financing mechanism is needed to address outstanding maintenance, capital improvement, and long-range flood management planning.

GOV2: Since Wildcat and San Pablo Creeks are federal facilities, improvements must be consistent with USACE policy to remain eligible for federal disaster relief. The USACE original design was constructed to include significant vegetation (not only for mitigation, but as a sustainability feature). However, subsequent USACE policy prohibits vegetation on any part of flood control levees. These conflicting vegetation goals make channel maintenance difficult.

PHYS: Wildcat and San Pablo Creeks will offer 100-year flood protection, but sea level rise will diminish its capacity to discharge flood flows over time.

Consequences

Society and Equity: Increased flooding in Wildcat Creek could result in extreme burden for North Richmond community members because they have limited resources to pay for flood insurance as well as prepare for, respond to, and recover from flood events.

Environment: Increased flooding in Wildcat Creek could affect marsh habitat and endangered rail and saltmarsh harvest mouse populations in Wildcat Marsh. Increased flooding in Wildcat and San Pablo Creeks could also mobilize industrial substances and introduce contaminants to surrounding areas.

Economy: Increased flooding along Wildcat and San Pablo Creeks could lead to disruptions to wastewater and transportation services, affecting the regional economy.