Adapting to Rising Tides:

East Contra Costa County Vulnerability Assessment & Adaptation Project

April 2020

bcdc

ADAPTING TO RISING TIDES

DELTA STEWARDSHIP COUNCIL

CALIFORNIA CONTRA COSTA County

By San Francisco Bay Conservation and Development Commission (BCDC), Adapting to Rising Tides (ART)

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About the Adapting to Rising Tides Program

The San Francisco Bay Conservation and Development Commission's (BCDC) Adapting to Rising Tides (ART) Program provides staff support, guidance, tools and information to help agencies and organizations around the Bay Area understand, communicate and begin to resolve complex climate change issues. The ART Program leads and supports multi-sector, cross-jurisdictional projects that build local and regional capacity in the San Francisco Bay Area to plan for and adapt to sea level rise and storm event flooding. Through these efforts, the ART Program continues to test and refine an adaptation method (the ART Planning Process, see Figure 1) that ensures planning processes include a transparent process, collaborative process, and sustainability.

Throughout the Bay Area, the ART Program is helping integrate adaptation in local and regional planning and decision-making in multiple ways. ART leads collaborative adaptation planning projects, develops adaptation responses, builds capacity across the region to increase resilience, assists adaptation planning efforts, helps create evaluation criteria to assess adaptation responses, builds regional capacity for adaptation, and advocates for adaptation through communicating findings, issues, processes, and needs to state and federal agencies. ART also provides the ART Portfolio, which combines a comprehensive set of online resources, including how-to guides, tools, and findings, with Help Desk support from experienced ART Program staff to enable users to make use of Portfolio resources to efficiently and effectively assess and plan for climate impacts.

Figure 2. The ART Planning Process.

Executive Summary

East Contra Costa Adapting to Rising Tides Project

Contra Costa County is one of the nine Bay Area counties and is the ninth most populous county in the state—home to over one million residents. In the coming years Contra Costa faces a number of opportunities, as well as numerous challenges. Many regionally important assets and services are located in the East Contra Costa County, such as passenger and cargo rail lines, communities with affordable housing, industry, agriculture, employment centers, wetlands, creeks, popular parks, boating and recreation hubs, and miles of Bay Trail. The East Contra Costa (ECC) Adapting to Rising Tides Project Area (see Figure 0-1) includes the shoreline cities of Pittsburg, Antioch, Oakley, and the inland adjacent city of Brentwood. Also included in the Project Area are the unincorporated communities of Bethel Island, Discovery Bay, Knightsen, and Byron. Many of the challenges faced in the County are familiar to communities around the Bay Area, such as the need for affordable housing, increased traffic congestion, issues of equity, a need for diverse and well-paying employment, safe and healthy neighborhoods, and current seismic and flood risks. In addition, the County is learning how to view these current challenges in light of the future risks associated with climate change, such as increased flood risk, higher heat, changes in ecological systems and possible changes to drought patterns.

In 2014, local interest in understanding and addressing these challenges led the ART Program to initiate a project to conduct a sea level rise vulnerability assessment and adaptation project along the west and central Contra Costa County shoreline extending from Richmond to Bay Point. The West Contra Costa County ART project concluded in 2016. The ECC Project was initiated in late 2017, funded by the Delta Stewardship Council, and in partnership with Contra Costa County, in order to complete the sea level rise study for the entire County. ART ECC continues from Pittsburg all the way to the eastern edge of the County and south to Clifton Court Forebay. This project builds off of the work done in West Contra Costa County and completes the assessment of the entire County.

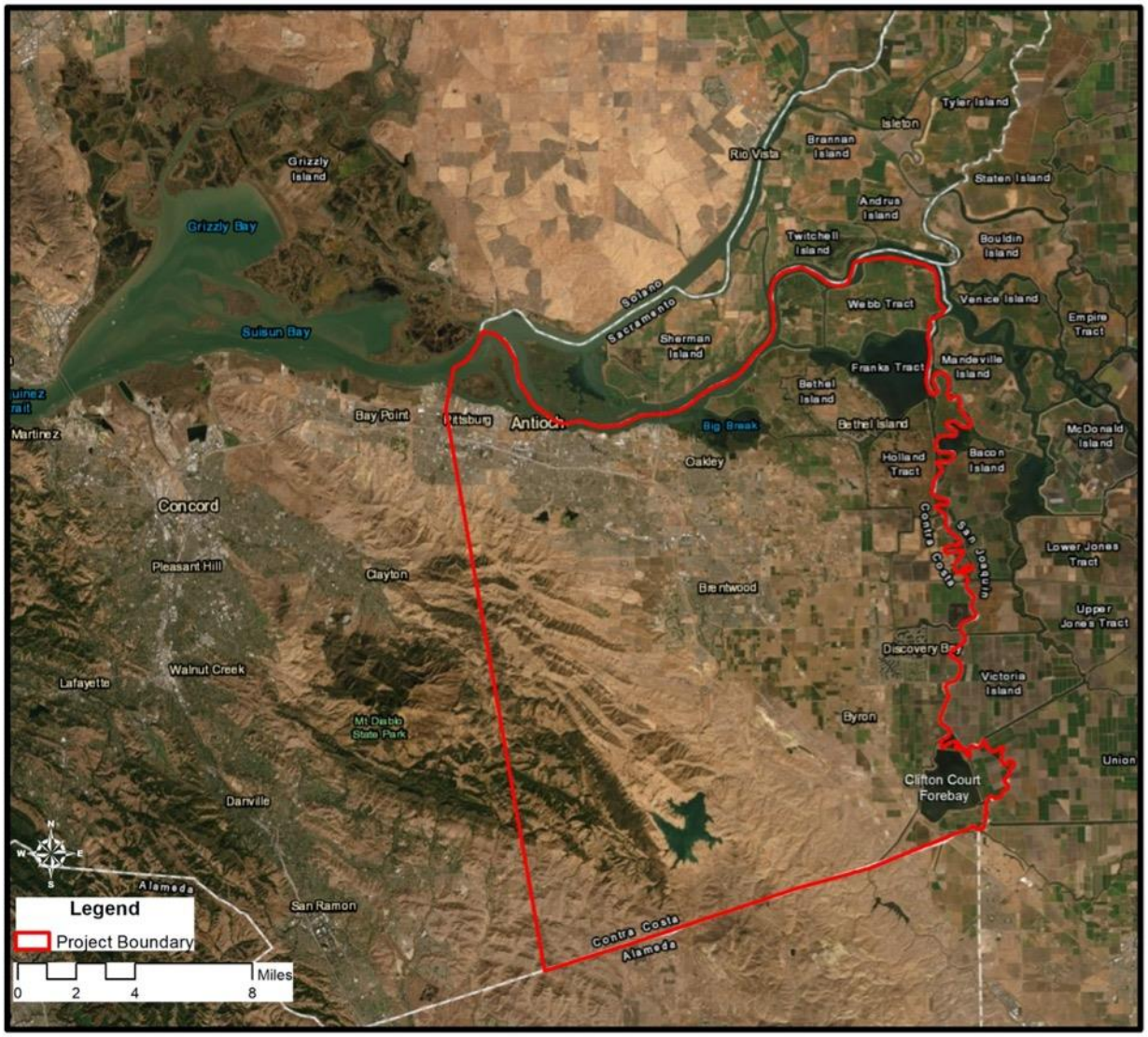

Figure 0-1. East Contra Costa County Project Area is outlined in red.

While many vulnerability and adaptation issues are similar between West Contra Costa and East Contra Costa, the ECC Project Area differs from that of the West Contra Costa ART Project in that it contains significant subsided land ranging from 0 to -15 feet below sea level, has much of its coastline protected by levees, has Delta islands, and is a more rural agricultural landscape. The ECC Project Area includes part of the Delta, which introduces new flooding dynamics and vulnerabilities. This includes risks such as saline intrusion from tidal influences, subsided lands that are more susceptible to flooding, especially with electricity outages due to pump failures, and levee failure on Delta islands.

The Contra Costa shoreline, with its varying local shoreline topographies (wetlands, industries, creeks, etc.), different types of land uses, diverse communities, and the presence of extensive rail and energy infrastructure, offered an excellent opportunity to better understand the varied vulnerabilities and consequences of current and future

flooding. This project, along with others around the region, will increase local and regional capacity address the myriad challenges posed by sea level rise.

Over the past two years, BCDC has worked with key stakeholders such as the Delta Stewardship Council, Contra Costa County agencies, cities within the Project Area, Contra Costa Resource Conservation District, representatives from elected officials' offices, regional and state agencies, nonprofits, and private organizations. The project has produced many work products and partnerships and has increased the knowledge and information needed for long term flood resilience in Contra Costa County. Some of the key outcomes of the work include:

- A diverse and capable working group
- Broad resilience goals
- Locally refined sea level rise maps and shoreline analyses
- An online flood explorer
- A robust vulnerability assessment of the Project Area's assets
- Vulnerabilities and consequences of how flooding may impact the Project Area's assets
- Detailed adaptation responses
- A clear case for taking action
- A path forward toward resilience

Included in This Report

This report is a summary of the products and outcomes from the project team and working group. It is intended to serve as a resource for advancing resilience action in East Contra Costa County, the region and providing information that can be used by other communities around the region. The chapters provide an introduction to the ART Program and a summary of the planning process for this project. The report and its appendices include detailed vulnerability assessments of 34 asset categories from 14 different sectors; key planning issues that summarize the major issues; adaptation responses developed for asset categories and key planning issues; a summary of the mechanisms for evaluating specific adaptation responses; and guidance on next steps to progress adaptation planning in Contra Costa County.

Sectors and Assets Analyzed

The East Contra Costa ART project analyzes 14 sectors and 34 asset categories for vulnerabilities to temporary and permeant inundation. Table 0-1 provides a summary of the sectors and assets considered and subsequent chapters provide detailed information about the vulnerabilities they face, the consequences that could occur if they are impacted, and possible adaptation actions that could be taken to reduce those risks. Table 0-2. Sectors and assets analyzed in the ART ECC Project Area.

Table 0-1. Sectors and assets analyzed

Sector	Asset
Agriculture	• Agriculture
Business and Industry	• Industrial Land Use Categories • Commercial Land Use Categories • Hazardous Materials Sites
Communities	• In-Delta Legacy Communities • Social Vulnerability
Community Engagement	• Community Engagement
Critical Facilities and Services	• Emergency Response Facilities • Public Healthcare Facilities • Faith-Based Organizations • Solid Waste Disposal Sites • Schools
Delta Islands	• Delta Islands and Reclamation Districts
Energy	• Pipelines • Power Distribution • Power Generation • Oil and Gas Production Fields
Natural Areas & Outdoor Recreation	• Shoreline Parks • Water Trail • Marinas • Fishing Piers • Natural Areas
People	• People
Transportation	• Rail • Roadways • Ports
Water	• Water Treatment Facilities • Water Conveyance • Pumps, Diversions and Intakes • Mutual Water Companies • Water Rights
Wastewater	• Wastewater
Flood and Stormwater	• Creeks • Stormwater

The Working Group

During the first step of the ART Planning Process, Scope and Organize, ART staff worked with local representatives to identify and invite a diverse group of stakeholders to participate in the project's Working Group. A primary goal for the Working Group was to

learn from members' strong knowledge and expertise of the communities, services and assets in the Project Area; however, anyone who wanted to participate was welcome. Members of the Working Group included representatives from eight County Departments, four shoreline cities, six special districts, regional transportation and planning agencies, state and federal agencies, as well as private utilities, community-based organizations, and private organizations. The group met five times over the course of the project and helped, create Resilience Goals, review deliverables, refine adaptation responses, and discuss next steps for the project.

Resilience Goals

Project Resilience Goals were developed to help define the desired outcomes of the project and provide a foundation upon which future project decisions could be made. Resilience Goals were developed and refined by the Working Group around four key areas: Governance, Society and Equity, Economy and Environment.

Climate Scenarios and Impacts

The ECC ART Project evaluated both current and future flooding that could either be temporary or permanent in nature. As sea level rises, higher water levels will become more frequent, increasing the extent, depth, and duration of temporary flooding and expanding the area that is permanently inundated. These impacts will not be confined to the Bay-Delta shoreline as sea level rise will also affect tidal creeks and the Delta. As the Bay rises, water levels in tidal creeks and in the Delta will also rise, pushing the extent of tidal influence further upstream, potentially making riverine flooding that already occurs worse.

Climate Scenarios

Future coastal flooding was evaluated for a range of possible futures that modeled both temporary and permanent flooding for ten climate scenarios summarized in Table 0-2.

Table 0-2 ART ECC's ten climate scenarios that were modeled for permanent and temporary flood inundation.

Permanent Flooding Scenarios	Permanent + Temporary Flooding Scenarios
MHHW*	MHHW* + 100-year storm
12"	12" + 100-year storm
24"	24" + 100-year storm
36"	36" + 100-year storm
83"	83" + 100-year storm

*MHHW= Mean Higher High Water. This is the average water height of the highest tides. All other sea level rise scenarios are added to MHHW. For example, 12" of sea level rise is 12" + MHHW.

Flood Modelling And Mapping

The Delta shoreline will be impacted by sea level rise differently than the Bay. The Delta is influenced by both daily tides coming through the Golden Gate and freshwater flowing into the Delta from the Sacramento and San Joaquin Rivers. The ART Program worked with the consultants AECOM and AnchorQEA to model impacts from freshwater inflows and ocean tides. Additional model inputs include historical inflows from rivers, wind, evaporation, and precipitation.

The maps of the model outputs are available to view through an online flood viewer, located at https://eccexplorer.adaptingtorisingtides.org/home, as well as in the Appendix. The ART flood mapping includes inundation locations, depth of flooding, low-lying areas (areas below the modeled water level) and overtopping locations (the lowest location where water breaches the shoreline). These maps were developed through discussions with stakeholders, who reviewed the preliminary maps and provided on-the-ground verification and supplemental data to improve their accuracy.

Climate Impacts

Current and future flooding can have a number of impacts on communities, infrastructure and natural areas. The ECC ART Project considered the following impacts that could occur from either temporary or permanent coastal flooding, riverine or localized nuisance flooding:

- Areas that currently flood may flood more frequently
- More extensive, longer-duration flooding in areas that currently flood and flooding of new areas
- Permanent inundation of areas currently not exposed to regular tides
- Shoreline erosion
- Elevated groundwater and increased salinity intrusion

Key Planning Issues and Adaptation Responses

Seven key planning issues were identified, which encompass many of the vulnerabilities and consequences that may have the greatest impact on the sustainability and resilience of East Contra Costa County. The first five key planning issues were adapted from the West Contra Costa ART Project, while the last two are unique to the ECC Project Area. Below are the key planning issues and a top adaptation responses developed to address them. These adaptation responses were voted on by the working group and include the top voted priority adaptation response and the top voted low-hanging fruit (or easier to implement) adaptation response. The full suite of adaptation responses can be found in the Appendix.

SHORELINE INDUSTRIES
Key Planning Issue: The County's working shoreline is at risk from current and future flooding and is a major source of current and future employment sites (i.e. Northern Waterfront Economic Development Initiative). Marinas, harbors, boat rentals, and bait and tackle shops are major sources of jobs, recreation and tourism for the region (Bethel Island alone would lose 400-700 jobs). The industrial and manufacturing sites on the shoreline (mostly concentrated in Pittsburg and Antioch) rely on utility networks (e.g. water, wastewater, power, and drainage) that are vulnerable to sea level rise, storm events and power outages. Flooding of these industrial sites could also mobilize hazardous materials, impacting the health of the environment, communities, and our water supply. Workers from within and outside of the County commute to employment sites by ferry, bridge, rail, road and bus, which if impacted could prevent employees' ability to get to work. Flooding of critical roads, rail lines, or pipelines both within the County and beyond could disrupt critical supply chains that employment sites rely on, resulting in lost employee wages, reduced output and profit, and impacts to the regional economy through loss of critical oil-based and manufacturing exports.

Top Priority Adaptation Response	Top Low-Hanging Fruit Adaptation Response
Form or expand existing private-public partnerships to develop a regional plan to protect or relocate the nexus of pipelines, marine terminals, roads and rail lines that water-dependent industries rely on for continued operations.	Consider future sea level rise and storm flooding in future iterations to the Northern Waterfront Economic Development Initiative and consider changes in General Plans/zoning that balance incentivizing economic growth with shoreline flood protection.

VULNERABLE COMMUNITIES
Key Planning Issue: Shoreline communities in the Project Area located in or near the floodplain of the Delta or a tidal creek (i.e. Marsh Creek) have low-income communities (e.g. Pittsburg, Antioch, Brentwood, Byron, and the Delta Islands) that are likely to experience flooding from extreme storms, sea levels rise, or a combination of both. Residents of creek- or Delta-side communities have limited control over the maintenance and management of the waterways they live along. Those that are low-income, linguistically or socially isolated, without access to a car, elderly, very young, disabled, homeless, undocumented, or mobility-challenged may be less able to prepare for, respond to, and/or recover from flood events. Vulnerable community members with these specific characteristics can face difficulties evacuating and finding resources and temporary shelter during a flood event due to mobility, transportation, or language issues. Further, unless resources are in place to assist in rebuilding, many of these community members may face permanent displacement or homelessness after damaging flood events.

Top Priority Adaptation Response	Top Low-Hanging Fruit Adaptation Response
Develop a program to simply and directly fund low-income homeowners and owners of affordable rental properties to implement near term flood mitigation strategies, in coordination with seismic retrofitting strategies.	Develop an outreach program conducted in all locally spoken languages to educate communities about their current and future flood risks and the actions they can take to reduce risks.

ACCESS TO SERVICES
Key Planning Issue: A lack of redundant transportation options (i.e. Antioch Bridge, Bethel Island Bridge, Jersey Island Bridge, ferries) and the limited number of public facilities in this part of the County may result in shoreline communities becoming isolated from emergency services, public and private healthcare providers, jobs, schools, grocery stores, and other critical services during flood events. The food grown in ECC may be unable to reach the rest of the County, affecting food supply. Loss of transportation, power, water, and wastewater could have significant consequences on public health and safety, local economies, and community function, and will be a particular challenge for vulnerable communities. Highway 4 and State Route 160 are the only major transportation arteries in the region and may become grid-locked during flood emergencies. The following may be at risk of flooding: 1 fire station, 2 police stations, some retail, 1 school and possibly many other services (such as dentists offices, post offices, etc.) that were not included in the analyzed data set.

Top Priority Adaptation Response	Top Low-Hanging Fruit Adaptation Response
Develop a program to simply and directly fund low-income homeowners and owners of affordable rental properties to implement near term flood mitigation strategies, in coordination with seismic retrofitting strategies.	Build or strengthen relationships between public agencies, private entities, nonprofit, community, and faith-based organizations, and neighborhood groups to increase flood resilience.

AD-HOC FLOOD PROTECTION
Key Planning Issue: Some communities are protected from coastal flooding by rail lines, shoreline parks, and tidal wetlands. Rail lines are typically built on earthen mounds, which can act as a flood barrier. Shoreline parks typically go from sea level and rise in elevation, acting as the first line of defense. Tidal wetlands can help reduce wave height and coastal erosion. While these built and natural areas reduce the flood risks of adjacent communities, assets, and infrastructure, they have not been specifically designed or maintained for this function and, therefore, provide only ad-hoc flood protection. Increased wind, wave, and tidal energy, higher extreme high tides, and more frequent exposure to the tides as sea levels rise can decrease the ability of these ad-hoc systems to maintain the flood protection benefits they currently provide. In areas of ad-hoc flood protection, flood insurance policy rates may be low, so although people think they are protected it can create a false sense of security, resulting in a costly recovery.

Top Priority Adaptation Response	Top Low-Hanging Fruit Adaptation Response
Initiate tidal wetland restorations that will protect and enhance the broad benefits they provide, including flood risk reduction, habitat, biodiversity, and water quality	Advocate for the federal government to require that railroad owners partner with local communities in determining how to protect or relocate rail lines to address sea level rise.

PARKS AND OPEN SPACE
Key Planning Issue: Shoreline parks and open spaces are not only the first line of defense against inland flooding, they are also themselves vulnerable to the early impacts of sea level rise and, therefore, are key early adaptation opportunity sites. However, some areas of the shoreline (e.g. Oakley) have a more concentrated area of shoreline parks that provide these benefits. Damage or loss of these uniquely valuable parks and open spaces would have significant impacts on wildlife habitat, recreational uses, and the health of communities in the project area. Reduction in access to parks, open spaces, bike trails, fishing piers and boat launches would affect some individuals and communities more adversely than others (e.g. homeless and/or low-income populations), depending on their unique needs and capacity.

Top Priority Adaptation Response	Top Low-Hanging Fruit Adaptation Response
Establish a new authority, or expand an existing authority, to plan, fund, manage and maintain shoreline solutions to protect existing parks, open space, and the Bay Trail.	Educate the public about the early risk to parks from sea level rise, the multiple benefits parks provide (flood protection, wildlife, educational and recreational values), and the opportunities for adaptation to protect these functions.

LEVEES, RECLAMATION, AND SUBSIDENCE
Key Planning Issue: Agricultural practices and land reclamation in the Delta have caused significant land subsidence, causing both communities and agricultural fields to rely on levees and pumps to stay dry. Current pumping practices to keep land dry continue to exacerbate subsidence. Reclamation Districts and the Bethel Island Municipal Improvement District are responsible for maintaining the levees and pumps; many of these Districts do not have adequate funds to properly inspect, maintain or rehabilitate these levees. The levees are in various states of safety design standards since some levees protect communities and others protect agricultural land. Some are at a FEMA standard while others, such as agricultural levees, don't provide a level of flood protection considered sufficient for cities and towns by FEMA's National Flood Insurance Program. Additionally, no standards address the risks associated with earthquakes. These levees are funded primarily through State funds, which puts control and decision-making out of local hands. Sea level rise and subsidence could worsen flood risks by increasing hydrostatic pressure on levees, increasing the liquefaction potential during seismic events due to rising groundwater, and by increasing reliance on (and cost of operating) pumps, which are sensitive to flooding and to power outages. Pumps do not always have redundancy through backup pumps or fuel supplies. Loss of communities, homes, businesses, and agricultural lands due to levee failure could cause catastrophic loss of life, livelihoods, and assets, with significant impacts to the State's water quality (i.e. increasing salinity) and the economy. There could be substantial economic losses for the region due to losses in tourism, recreation, agriculture and gas extraction. Farmland could be ruined by salinization of soils through contact with brackish/saline water from the Delta. Finally, if flooded, contaminants from homes, businesses, gas extraction sites, and farms could be mobilized.

Top Priority Adaptation Response	Top Low-Hanging Fruit Adaptation Response
Model how sea level rise and sea level rise combined with major storms will affect levee stability and update design and engineering standards accordingly.	Develop new microgrids to create a more resilient power system less reliant on the regional grid, ensuring that pump and drainage systems do not lose function if the electricity grid is not functioning.

WORSENING WATER QUALITY
Key Planning Issue: Sea level rise is likely to cause a worsening of water quality due to contaminant mobilization and salinity increases from the tidally influenced Bay reaching further into the Delta. Flooding will mobilize contaminants from industries, businesses, homes, roads, lawns, and farms, negatively effecting water quality. Surface water is used for drinking water intakes by many small, local communities in the Delta, as well as East Bay residents and users of the Central Valley Project and State Water Project (millions of users in total). Groundwater could also experience increasing salinity close to the shore, possibly affecting water supplies from wells. There are many private wells in the Project Area. Additionally, increasingly saline water could cause corrosion of infrastructure that were not originally protected against saltwater, such as landfills, septic tanks, wells, pumps, pipes, and water treatment facilities. Finally, habitats can also be affected by contamination and as salinity changes.

Top Priority Adaptation Response	Top Low-Hanging Fruit Adaptation Response
Develop and implement a county-wide program to monitor salinity conditions, including the progress of saltwater up into creeks and salinity conditions in the groundwater near vulnerable infrastructure, wells, or surface water	Educate and provide resources for well users to ensure that they are aware of potential impacts to their wells from flooding or saline conditions and encourage them to have emergency water supplies on hand.

Evaluation and Next Steps

Evaluation Criteria

The development of project-specific evaluation criteria plays a central role in ensuring transparent decision-making in adaptation planning. Evaluation criteria are used to prioritize various adaptation responses and help decide which ones to go forward with. To keep consistency between the two projects within the County, the ECC ART project kept the same evaluation criteria as West Contra Costa ART, which include criteria around feasibility, social benefits, economic benefits, environmental impact, governance and disaster lifestyle.

Implementation

The Working Group discussed ways that the ART process, sea level rise adaptation planning and implementation could be progressed within the County. The following outlines this discussion:

- To get adaptation responses implemented in the County it is necessary to have a core ask, a clear message, and educating elected officials about the ART findings.
- The biggest hurdle to implementing adaptation planning and strategies within the County is due to there being no overarching authority to move any of the actions forward. The Working Group could become the basis to form a JPA to move adaptation planning forward at the County and local scale.
- Continuing the Working Group and expanding it to include more decision-makers, such as additional County agency staff, would enable continued cross-agency collaboration, sharing of local best practices, and the creation of design standards for the shoreline and shoreline buildings.
- Another hurdle to implementation is the lack of funding to do adaptation planning. County and local staff are already overburdened with their existing work. The County needs dedicated staff to be able to move ahead with adaptation recommendations. Grants that could help fund staff and consultants to advance adaptation planning should be sought out.

Introduction

Adapting to Rising Tides Program Introduction and Overview

In 2011, the San Francisco Bay Conservation and Development Commission (BCDC) and NOAA's Office for Coastal Management (NOAA OCM) brought together local, regional, state and federal agencies and organizations, as well as non-profit and private associations for a collaborative planning project along the Alameda County shoreline to identify how current and future flooding will affect communities, infrastructure, ecosystems and economy.

Since then, the ART Program has continued to both lead and support multi-sector, cross-jurisdictional projects that build local and regional capacity in the San Francisco Bay Area to plan for and adapt to sea level rise and storm event flooding. Through these efforts, the ART Program continues to test and refine an adaptation method (the ART Approach) that ensures planning processes include these three core principles:

- Collaborative by Design. Climate change, similar to habitat conservation, hazards, and watershed planning, requires decision-making to happen across jurisdictions, geographies, sectors, and time frames to address complex, cross-cutting issues. ART emphasizes convening and closely collaborating throughout a planning process with a stakeholder-working group representing the diverse values, viewpoints and responsibilities relevant to the project to build relationships that lead to future collaborations.
- A Transparent Process. To build a strong, actionable case for adaptation, the ART Approach adheres to transparent decision-making throughout the planning process. ART Design Your Project guidance and supplies help maintain transparency and support clear communication to stakeholders about decisions and project outcomes, including resilience goals developed and agreed upon by the working group, and evaluation criteria that clearly reflect priorities and objectives.
- Sustainability from Start to Finish. A core aspect of ART is consideration of the relevance and implications of all aspects of sustainability in each step of the planning process, from who is included in the initial working group list to what evaluation criteria are selected to evaluate adaptation responses. ART uses four sustainability frames, discussed in Figure 1-1.

Throughout the Bay Area, the ART Program is helping integrate adaptation in local and regional planning and decision-making in multiple ways:

- Leading collaborative adaptation planning projects that build a comprehensive understanding of climate vulnerability and risk, develop effective and equitable adaptation responses, identify opportunities for implementing these responses, and build capacity across the region to increase resilience.

- Assisting adaptation planning efforts with consistent staff support that includes recommendations, tools, and approaches for selecting climate impact scenarios; tools, approaches, and data to identify vulnerabilities and consequences; assist with selecting adaptation responses through the use of evaluation criteria; and help with process and meeting design, review of work products, and more.

- Providing the ART Portfolio which combines a comprehensive set of online resources, including how-to guides, tools, and findings, with Help Desk support from experienced ART Program staff to enable users to make use of Portfolio resources to efficiently and effectively assess and plan for climate impacts.

- Building regional capacity for adaptation by working with local, regional, state, and federal agencies to find funding, and develop capacity, and support at all scales for this work.

- Advocating for adaptation through communicating findings, issues, processes, and needs to state and federal agencies to ensure that grant and other assistance programs are informed by and responsive to conditions in the Bay Area.

Sustainability From Start To Finish

A core component of ART is considering the relevance and implications of all aspects of sustainability throughout a project. Four Sustainability frames are incorporated into each step of the planning process, beginning with the development of the initial working group list, all the way to the selection of criteria to evaluate adaptation responses. ART frames these components of sustainability as:

Society and Equity	Economy	Environment	Governance
Effects on communities and services on which they rely, with specific attention to disproportionate impacts due to inequalities.	Economic values that may be affected such as costs of physical and infrastructure damages or lost revenues during periods of recovery.	Environmental values that may be affected, including ecosystem functions and services, and species biodiversity.	Factors such as organizational structure, ownership, management responsibilities, jurisdiction, mandates, and mechanisms of participation can affect vulnerabilities.

Figure 1-1. Four frames of sustainability

ART Bay Area is the ART Program's regional look at sea level rise around the nine-county Bay area. Some of the main findings from that study were the eight Regional Key Planning Issues, which summarizes the major vulnerabilities faced by the region by looking at hundreds of qualitative vulnerability and consequence statements cutting across assets and geographies.

Adaptation responses were developed for these Regional Key Planning Issues. These eight issues are referred to as overarching vulnerabilities because it was determined that they applied to the region, not just the study area, and that they needed to be addressed at a broader than local scale. These Regional Key Planning Issues apply to the ECC Project Area as well, and are highlighted below:

1. Local and Regional Transportation System Connection Hubs Flood Together
   Many shoreline areas contain clusters of multiple vulnerable transportation assets that serve as critical nodes and links for regional and local transportation systems. In many cases, these assets lack redundancy and are networked such that loss of function of an asset or portion of a system due to sea level rise would cause significant regional impacts to commuters, access to recreation and services, and movement of goods. This could include regionwide extended transportation times and strain on other transportation systems, loss of economic value from inability to access jobs, services, and goods, as well as disproportionate impacts to service sector workers (unable to telecommute) and people with access to fewer transportation resources (i.e. no car, or transportation cost burdened).
2. Sea Level Rise Decision-Making is Complicated by Ownership, Governance, Management, and Regulatory Issues
   Solving many of the local and regional sea level rise vulnerabilities identified in ART Bay Area and in local planning processes will need to involve a large number of stakeholders that own, manage, regulate, or govern the location, existing assets, or new assets that may be needed. All parties need to fully understand the role they play in the vulnerability of the area, as well as their role in establishing common goals and developing and implementing solutions. Existing structures, decision-making processes, and funding processes may be insufficient to pay for the types or extent of adaptation projects required. Addressing resilience will require innovative forms of planning and decision-making. Of critical importance is the involvement of the local community in this process, as they are the largest stakeholder in many projects, and the one most likely to be overlooked.
3. Interconnected Local and Regional Emergency and Critical Service Functions are at Risk
   In the event of a significant emergency event such as an earthquake, major flood, or wildfire, many critical services are required to move people and goods within the region as well as in and out of the region. Many locally and regionally critical emergency management assets, such as lifeline routes or redundant routes (for example, ferries provide redundancy if bridges are unusable), and police or fire stations are located in flood areas, putting their functions at risk. Additionally, critical services such as water, wastewater, electricity, and communications may also be at

risk, which can exacerbate the impacts of a disaster event or cause cascading emergency situations. Lastly, many community-serving centers like schools, places of worship, and libraries that serve critical functions in emergency events may be inundated and unable to serve both local and regional populations, exacerbating impacts, especially to community members who lack private resources to prepare for, respond to, or recover from a disaster.

4. Contamination Complicates and Exacerbates Flooding Issues
   Many areas at risk of flooding are on or near former industrial sites that have been designated as contaminated areas. Exacerbating this issue is the fact that many vulnerable communities have been pushed to marginal lands adjacent or even on contaminated sites. Development pressure in the Bay Area due to lack of housing is also pushing some of the more centrally located former industrial sites towards new housing and jobs. There is significant uncertainty about how flooding and rising groundwater will exacerbate contamination and increase public health concerns if contaminants are mobilized, or how dry land cleanup standards will perform if lands become submerged. New development, flood control projects, and Considerations for existing vulnerable communities must take into account the risks and uncertainty around shoreline contamination.
5. Sea Level Rise will Amplify Existing Housing Displacement Concerns
   Throughout the Bay Area, a severe housing affordability crisis is exacerbating the social vulnerability of populations throughout the Bay Area to a degree that displacement risk is at an unprecedented high. This pressure is felt most acutely by communities subject to historic and ongoing marginalization, in particular low income and communities of color, but any combination of social vulnerability factors, such as transit dependence, contamination and environmental justice burdens, language barriers, status as renters, or disability, among other factors, can compound vulnerability. Additionally, many vulnerable communities are disproportionately exposed to sea level rise and, in many cases, live in poor quality, older housing that is especially sensitive to flooding, while being least prepared to adapt to sea level rise. This creates another factor for displacement. Displacement, in turn, contributes to loss of community cohesion and social networks, which further adds to vulnerability to hazards like flooding.
6. Future Development Areas can be Critical Tools for Resilience
   A strong economy has added a large number of jobs and people to the region in recent years. There is significant region-wide pressure to add new development to accommodate these jobs as well as provide much-needed affordable housing to ease pressure in a limited housing market. SB 375 and the RHNA process are designed to facilitate new development. New development presents an opportunity to make smart choices about how much new vulnerability we create for future generations, as well as how safe, desirable, connected, and affordable our region will be, but without adequate and timely consideration of long-term pressures such as sea level rise, development decisions may place even more people and jobs at risk down the line.
7. Sea Level Rise will Put Pressure on the Relationship Between Regional Recreation and Habitat

Many of the region's vulnerable recreation areas are co-located with sensitive habitat areas that are also at risk. Additionally, many of these areas of co- location could play critical roles in flood management through nature-based solutions. Different stakeholders may have differing priorities for the management of natural shoreline areas that prioritize people, natural systems, or flood control, amongst other things, over one another. Shoreline adaptation approaches should balance recreational uses such as required public access, access to recreation, and nature-based education with the protection of essential ecosystem functions, especially preservation of habitat for threatened and endangered species, carbon sequestration, sediment management, biodiversity preservation, and flood control.

8. Nearshore Habitats and the Ecosystem Services they Provide are Sensitive to Sea Level Rise Early On
   Nearshore habitats provide significant natural and ecosystem services, such as habitats for endangered species, carbon sequestration, wave attenuation, and contribution to recreation and regional character. However, in many locations, natural ecosystems will be the first locations to be impacted by sea level rise. Protecting, restoring, and enhancing nearshore habitats can provide many benefits. However, to maintain these benefits early action must be taken and careful consideration should be given to several key factors, such as protection of migration space, changes in management of endangered species habitats or fisheries, increasing linkages among different habitats and upland areas, and an understanding of how habitat restoration can or should integrate into longer-term shoreline protection plans.

Some common adaptation responses emerged across the Regional Adaptation Responses. These included:

- Working closely with MTC/ABAG and Plan Bay Area to ensure that regional goals for adaptation are included in transportation, land use, housing, future growth, and conservation area assessments, programs incentives, and funding
- Leverage the upcoming Regional Shoreline Adaptation Strategy to advance coordinated action around financing and supporting local adaptation planning
- Supporting local community engagement and education
- Supporting capacity-building for local and regional government decision-makers to incorporate sea level rise into daily decision-making and existing plans and processes
- Supporting and expanding accelerated shoreline permitting through the Bay Restoration Regulatory Integration Team or a similar team
- Establishing regional priorities and guiding principles
- Encourage protection of vulnerable populations
- Encourage local land use policies that ensure that new development is resilient
- Protect areas critical to the region due to ecosystem value and/or flood protection benefits from future development

The East Contra Costa ART Project

ART in East Contra Costa County

In 2014, based on the strong demonstrated interest from Contra Costa County representatives, the ART Program initiated a project along the west and central Contra Costa County shoreline extending from Richmond to Bay Point. The Contra Costa County ART Project finished in 2017. However, this study was not comprehensive for the whole County—Pittsburg to the eastern border of the County remained unstudied due to differences in flood modeling for the Delta.

ART was approached by the Delta Stewardship Council (DSC) to complete the ART study in the eastern side of the County by providing funding to do the flood modeling, vulnerability assessment, and adaptation planning. Partnering with the County, ART initiated the East Contra Costa County ART Project in 2017, with work starting in 2018. In addition to local interest and the availability of resources to convene and lead a second county-scale project, the ART Program was interested in conducting a project that would continue to provide information to the region and reveal different vulnerabilities, consequences and issues then the West Contra Costa ART Project, building upon the findings and conclusions of that project. The Contra Costa shoreline with its varying local topographies – from Delta island to bluff to wetland to creek mouth – the different types of land uses and communities, and the presence of significant rail, industry, and agriculture offered an excellent opportunity to increase local and regional understanding of both current and future flooding from sea level rise and storm events. Using the ART adaptation planning process, tools, and data, staff from the ART Program worked with local jurisdictions, agencies, and organizations in Contra Costa County to understand the vulnerabilities and consequences the local shoreline communities may face, including the disproportionate impact to community members with characteristics that may make them more vulnerable to flooding, the disruption of transportation and utility infrastructure, the potential loss or disruption of employment sites, the risk faced by levees protecting communities and farms, and limitations on access to goods and services. Ultimately, working with local stakeholders the project identified shared and individual actions that will help improve resilience to sea level rise and storm impacts both along the East Contra Costa shoreline and throughout the region.

The ART Planning Process in East Contra Costa

The ART Program's work in West Contra Costa County was initiated in the fall of 2014, and the work in East Contra Costa was initiated in 2018. Together, the West and East Contra Costa County ART projects complete the flood vulnerability and adaptation responses for the entire County. In ECC, the ART Program worked with local representatives to scope a region wide project that would meet local needs and help increase the region's understanding of the current and future challenges of a rising Bay and Delta. Over a two-year period, the ECC ART staff led a diverse stakeholder working group through a five-step

planning process (see Figure 1-2) that was grounded in the ART approach. Together, staff from the ART Program and a stakeholder working group developed an understanding of how current and future coastal and riverine flooding may impact transportation and utility networks, industrial facilities, and employment sites, residential neighborhoods and community facilities, levees protecting Delta islands, and shoreline park and recreation facilities. The consequences of flooding both within and beyond the communities, assets, and infrastructure in the Project Area were also considered, with a particular focus on the potential for disproportionate consequences to community members with characteristics that may make them more vulnerable to flooding. The project resulted in extensive analyses, maps and other products that will help guide communities and managers in Contra Costa County to build resilience and adapt to rising tides. Figure 1-3 shows the timeline of the project, and the following sections will detail the process, tools, and practices used in in each step of the project's planning process.

Figure 1-2. The ART Planning Process.

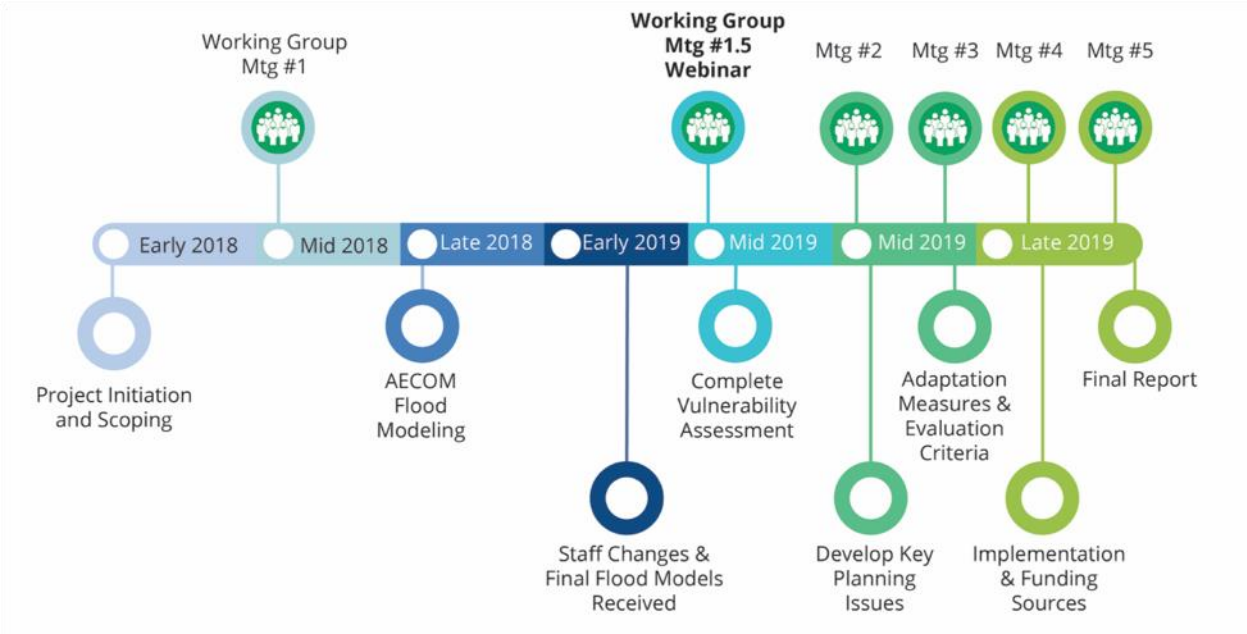

Figure 1-3. ART East Contra Costa timeline

Scope and Organize

The first step in the ART planning process – Scope and Organize – is a critical step in the process and provided the ART Program staff team and the ECC Working Group the opportunity to identify the critical participants, the issues to be addressed, and the assets and services that were important to include in the project. In scoping the project, ART staff worked with local representatives to identify and invite a diverse group of stakeholders to participate in the project's Working Group. A primary goal for the Working Group was to ensure that members had strong knowledge and expertise of the communities, services and assets in the Project Area; however, anyone who wanted to participate was welcome. The Working Group brought together diverse perspectives from city and County agencies, communities, the private sector, community-based organizations and NGOs. Members of the Working Group included representatives from eight County Departments, four shoreline cities, six special districts, regional transportation and planning agencies, state and federal agencies, as well as private utilities, community-based organizations, and private organizations (see below).

Staff from the ART Program convened and led the stakeholder Working Group in defining the scope and scale of the project to determine the expected outcomes of the project. Engaging the Working Group in defining the project was critical to ensuring the outcomes were based on a collaborative, transparent process. In scoping the project, a variety of issues that were important to the Working Group and the ART Program were balanced against available resources and data.

Working Group Members

CITIES

Antioch
Brentwood
Discovery Bay
Pittsburg

COUNTY DEPARTMENTS

Department of Conservation and Development
Health Services
Water Agency
Flood Control and Water Conservation
Office of Emergency Services
Mosquito and Vector Control
Public Works
Office of the Sheriff

DISTRICTS, AUTHORITIES, COMMITTEES

Contra Costa Water District
East Bay Regional Parks District
Contra Costa Transportation Authority
East Contra Costa Fire Protection District
Bethel Island Municipal Improvement District
Contra Costa Resource Conservation District

REGIONAL, STATE AND FEDERAL AGENCIES

California Department of Transportation District 4
Office of Assemblymember Jim Frazier
US Fish & Wildlife
Delta Protection Commission
Delta Stewardship Council
CalOES
EPA
CA Department of Fish and Wildlife
Concord Councilmembers

NON-GOVERNMENTAL ORGANIZATIONS, PRIVATE ORGANIZATIONS, OTHER

Pacific Gas and Electric
Sierra Club
Interfaith Council of Contra Costa County
BARHII
Richmond Community Foundation
Tait Engineering
Placeworks
Diablo Valley College

Program, explained the benefits and outcomes of the ART Approach to adaptation planning, confirmed the geographic boundaries of the project, the climate impacts and scenarios to be considered, and the sectors and assets to be assessed. At this first meeting ART staff began the process of engaging the Working Group in setting the project's Resilience Goals that would guide Contra Costa's adaptation planning process.

Project Area

The Project Area includes the East Contra Costa County shoreline from Pittsburg to Clifton Court Forebay (Figure 1-4).

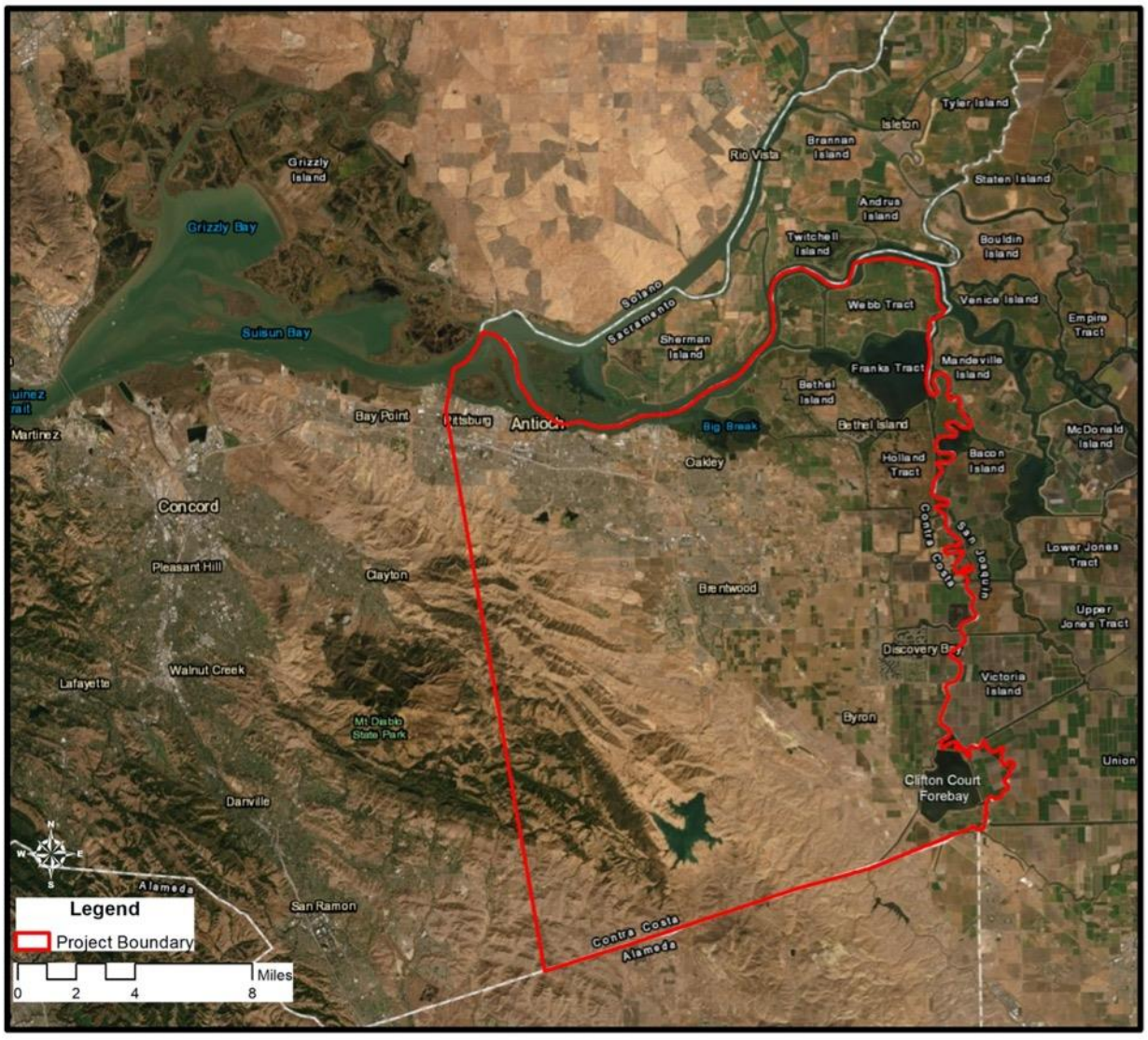

Figure 1-4. East Contra Costa County Project Area is outlined in red.

Climate Impacts And Scenarios

The ECC ART Project evaluated both current and future flooding that could either be temporary or permanent in nature. Temporary flooding is generally short in duration but can have long lasting consequences on some types of assets and services. Some areas

along the Bay-Delta shoreline or along creeks and rivers already experience temporary flooding. This temporary flooding usually occurs when there are storms over the Pacific Ocean during the winter, when high tide coincides with strong winds or when significant rainfall occurs over short durations and causes creeks and rivers to rise over their banks. While some assets and areas can maintain their function after the water recedes, other assets can suffer irreversible damage if exposed to any amount of water, even temporarily. Permanent inundation occurs if an area is exposed to regular daily flooding. Currently, only natural areas such as rivers, tidal flats, wetlands, ponds and creeks, are permanently inundated in the Project Area.

As sea level rises, higher water levels will become more frequent, increasing the extent, depth, and duration of temporary flooding and expanding the area that is permanently inundated. These impacts will not be confined to the shoreline as sea level rise will also affect tidal creeks and the Delta. As the Bay rises, water levels in tidal creeks and in the Delta will also rise, pushing the extent of tidal influence further upstream, potentially making riverine flooding that already occurs worse. Furthermore, many urbanized areas are served by a network of infrastructure that requires gravity to drain. Near the shoreline these networks typically outfall to the Bay-Delta. As sea levels continue to rise, the ability of these systems to move water effectively and efficiently will be impaired, and additional areas may begin to experience localized flooding (i.e., roads, basements, and shoreline trails).

Climate Impacts

Current and future flooding can have a number of impacts on communities, infrastructure and natural areas. The ECC ART Project considered the following impacts that could occur from either temporary or permanent coastal flooding, riverine or localized nuisance flooding:

- Areas that currently flood may flood more frequently: Rising sea levels can lead to more frequent flooding in existing flood-prone areas. This flooding can result in more frequent disruption of power, access to goods, services and jobs; can strain regional and local disaster response and recovery resources; and result in economic losses if job sites, government services, and businesses are disrupted by a loss in communications, utilities, or goods or commuter access.
- More extensive, longer-duration flooding in areas that currently flood and flooding of new areas: As sea levels rise, there is the potential that storm events will flood larger areas for longer periods of time, including areas that flood now and areas that do not currently experience flooding. This can result in damage to structures and contents, disruption of power, water supply, and wastewater services, and reduced access to goods, medical care, schools, jobs and other critical services. Power outages can damage homes and businesses that rely on electric sump pumps to keep below grade work, living, or storage spaces dry. More extensive and longer duration flooding can also create a disproportionate burden on community members that are the least able to prepare, respond or recover from a hazard event.
- Permanent inundation of areas currently not exposed to regular tides: Sea level rise can cause areas that are not currently exposed to regular high tide inundation to be flooded, resulting in the need to either protect or move people and infrastructure,

and the loss of trails, beaches, vistas, and other shoreline recreation areas. Prolonged inundation may cause the mobilization of pollutants from contaminated lands such as closed landfills, the release of sewage, hazardous or toxic materials from wastewater treatment plants, storage tanks, pipelines, or industrial facilities, and can increase sedimentation in tidal creeks and flood control channels.

- Shoreline erosion: More extensive, longer duration flooding can cause shoreline protection, such as levees, berms and revetments, to be damaged or fail to due to increased water levels and wave energy. Erosion or scouring due to tidal and wave energy can damage structures such as roads, bridges, culverts, stream banks, embankments, foundations, bridge footings or piers.
- Elevated groundwater and increased salinity intrusion: As sea levels rise, groundwater and salinity levels are also predicted to rise. This will cause damage to below grade living spaces, finished basements, and electrical/mechanical equipment that is below or at-grade. In addition, increasing groundwater levels can increase liquefaction susceptibility, require pumping in areas that are currently gravity drained, and increase both operations maintenance costs.

Climate Scenarios

The ECC ART Project used both an understanding of today's extreme tides that occur during storm events and tomorrow's future tides based on current best available sea level rise projections to assess how and when temporary or permanent flooding may occur, and to determine what assets may be impacted. Temporary flooding was modeled as a 100-year storm event. This storm event is *not* equal to Federal Emergency Management Agency's (FEMA's) 100-year storm, but is defined in this project as an event with a 1 percent probability of occurrence in any given year.

Projections are based on climate model simulations that depend on assumptions about future global socio-economic and technological conditions and are likely to change as our understanding of the future improves. The most recent science-based sea level rise projections is from the California Ocean Protection Council's "State of California Sea Level Rise Guidance" 2018 update (see Table 1-1).

Table 1-1. Regional sea level rise projections for California. (Source: Adapted from California Ocean Protection Council, "State of California Sea Level Rise Guidance" 2018)

Year	Range of Sea Level Rise (Low risk – Extreme Risk Scenario)	50% Probability that Sea Level Rise Meets or Exceeds:
2030	6” – 12”	5”
2040	6” – 22”	7”
2050	7” – 32”	11”
2060	7” – 47”	12” – 13”
2070	9” – 62”	13” – 17”
2080	11” –79”	16” – 20”
2090	12” – 99”	17” – 25”
2100	12” – 122”	19” – 30”

Future coastal flooding was evaluated for a range of possible futures that modeled both temporary and permanent flooding for ten climate scenarios summarized in Table 1-2. Mean Higher High Water (MHHW) is the average water height of the highest tides. For simplicity, we also refer to this as high tide. Sea level rise is added to the high tide to model permanent flooding (see Figure 1-5). Current temporary flooding is modeled through the 100-year storm event on top of today’s high tide (see Figure 1-6). Future temporary flooding is modeled through the 100-year storm event combined with sea level rise projections (see Figure 1-7).

Table 1-2. ART ECC’s ten climate scenarios that were modeled for permanent and temporary flood inundation.

Permanent Flooding Scenarios	Permanent + Temporary Flooding Scenarios
MHHW*	MHHW* + 100-year storm
12”	12” + 100-year storm
24”	24” + 100-year storm
36”	36” + 100-year storm
83”	83” + 100-year storm

*MHHW= Mean Higher High Water. This is the average water height of the highest tides. All other sea level rise scenarios are added to MHHW. For example, 12” of sea level rise is 12” + MHHW.

Figure 1-5. Sea level rise is added to the high tide (or MHHW) to model permanent flooding

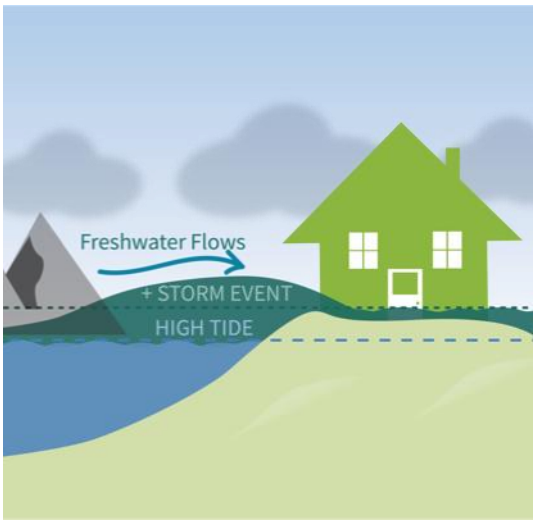

Figure 1-6. Current temporary flooding is modeled through the 100-year storm event on top of today's high tide (or MHHW)

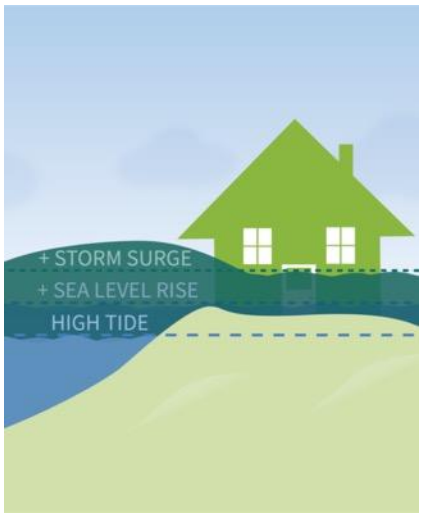

Figure 1-7. Future temporary flooding is modeled through the 100-year storm event combined with sea level rise projections and today's high tide (or MHHW).

Flood Modelling

The Delta shoreline will be impacted by sea level rise differently than the Bay, which is why the ECC Project Area needed to be split out from the western Contra Costa County ART Project. The Delta is influenced by both daily tides coming through the Golden Gate and freshwater flowing into the Delta from the Sacramento and San Joaquin Rivers. Modeling of sea level rise in the Delta suggests increased water heights at the

Golden Gate Bridge may not translate into the same increases in water heights everywhere within the estuary (e.g. one foot of sea level rise at the Golden Gate may not mean one foot of sea level rise in the Delta). This is especially true east of the Benicia Bridge where freshwater inflows from rivers interact with tides in complex ways.

The ART Program worked with the consultants AECOM and AnchorQEA to model sea level rise and storm event scenarios for East Contra Costa County using the UnTRIM model. The UnTRIM model is a three-dimensional model extending from the Pacific Ocean through the entire Sacramento-San Joaquin Delta. The model includes impacts from freshwater inflows and ocean tides and is a great fit for the East Contra Costa ART Project. The UnTRIM model makes predictions through several steps. First, the model calculates current daily high tide (MHHW) and extreme tide levels along the ECC shoreline. The model then simulates several sea level rise scenarios (MHHW + 12", 36", and 83") and produces predictions for the 100-year storm event under each sea level rise scenario, capturing the complex interactions between Bay tides and Delta freshwater inflows. Based on these results, the 24" water level was calculated.

Additional model inputs include historical inflows from rivers, wind, evaporation, and precipitation. Historical operation of salinity control gates, Delta Cross Channel, water export facilities, temporary agricultural barriers, and Delta Island Consumptive Use were assumed.

The UnTRIM model outputs were combined with land elevation data to create maps depicting where overtopping and flooding occur along the East Contra Costa shoreline.

Flood Mapping

Our maps and models use the best science available to show both temporary flood risk from storm events or high tides and permanent flood risk from sea level rise. These maps represent flooding that would occur absent of any adaptation actions. The maps are available to view through an online flood viewer, located at https://eccexplorer.adaptingtorisingtides.org/home. A full map book of the Project Area is included in the Appendix.

The ART flood mapping includes inundation locations, depth of flooding, low-lying areas (areas below the modeled water level) and overtopping locations (the lowest location where water breaches the shoreline) (see Figure 1-8).

Overtopping occurs when water levels rise higher than the shoreline or levee, providing a pathway for water to flow inland. The ART maps depict the location on the shoreline where overtopping may occur, and how deep the water may be when this flooding occurs. Overtopping layers provide insight to help identify low-lying segments of shoreline or levees where water levels overtop and lead to inundation or flooding of inland areas. The overtopping layers on the flood maps show the extent of shoreline or levee overtopping and

the depth by which the water surface exceeds the topography along the delineated shoreline.

The maps also include low-lying areas, or areas that are prone to flooding because they are lower in elevation than the flood level but not currently flooded due to protection by levees or berms. For example, many Delta islands are shown as low-lying areas due to their low elevation, illustrating their reliance on the levees that surround them

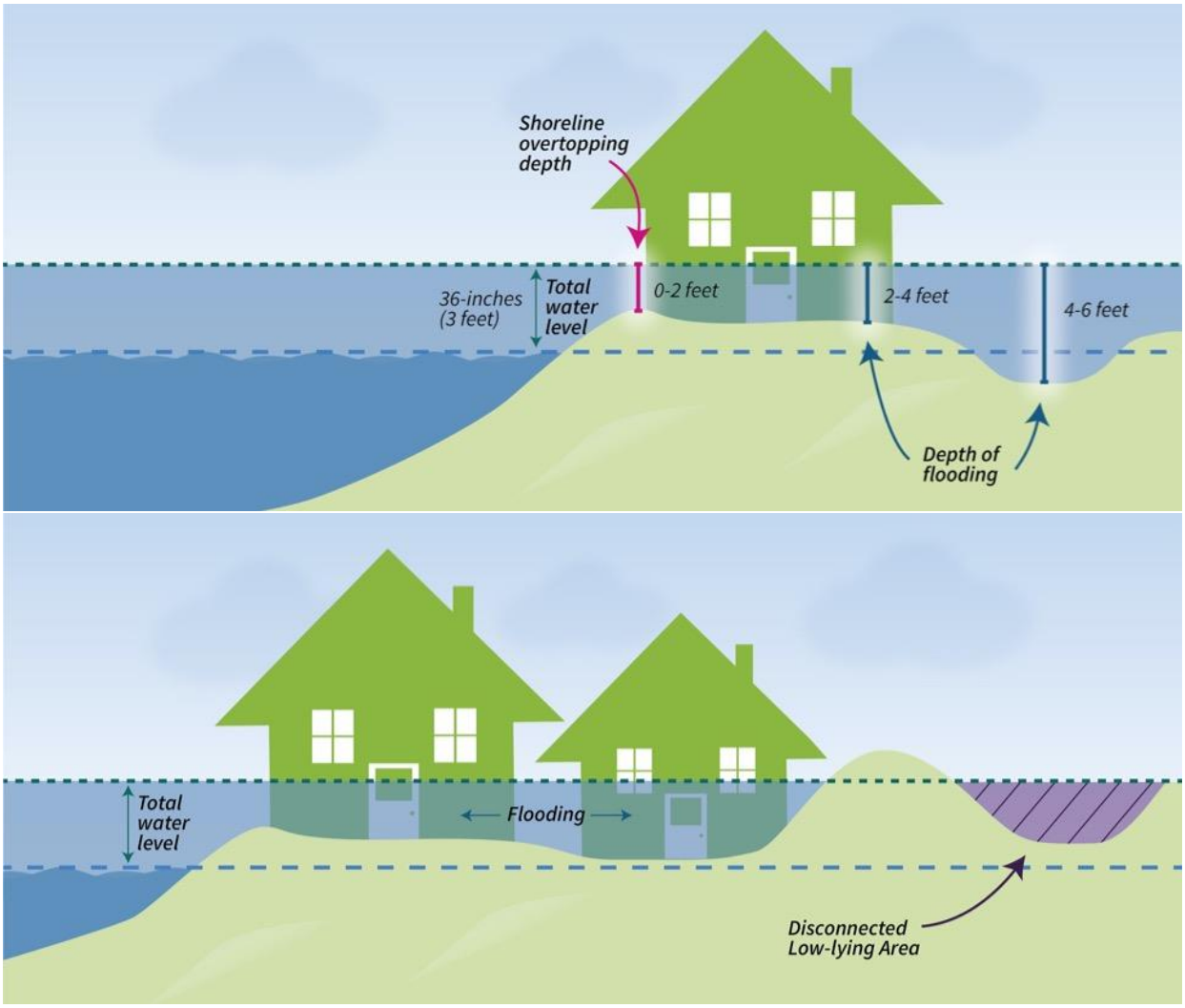

Figure 1-8. This graphic depicts some of the information found in the ART ECC flood maps. Shoreline overtopping and flooding depth (top) and low-lying areas (bottom).

Stakeholder review is key to the ART process and a big part of what makes these sea level rise maps unique. These maps were developed through discussions with stakeholders who reviewed the preliminary maps and provided on-the-ground verification and supplemental data to improve the accuracy of the maps. AECOM reviewed the topographic dataset prior to use in the inundation mapping and made modifications to better represent existing conditions. Modifications reflect comments provided by stakeholders during review of the preliminary inundation layers. Potential issues were identified by examining locations where levee overtopping was projected to occur at low to moderate water levels (such as daily high tide plus one foot of sea level rise) – especially for areas without a history of frequent flooding.

Please see the Appendix for detailed information on the mapping and modeling methods.

Model Limitations and Assumptions

A common expression concerning models is, "All models are wrong, but some are useful." No set of mathematical equations can perfectly represent a dynamic, real-world system. When interpreting flood maps, it's important to keep the assumptions and limitation of the model in mind, including the following:

- Riverine Flooding. Inundation associated with changing rainfall patterns, frequency, or intensity as a result of climate change is not included in this analysis.
- Levee Failure. The mapping assumes that the existing levees will not fail.
- Wave hazards. For shorelines and developments directly along the Bay-Delta shoreline, the consideration of wave hazards is important. Wave hazards, such as wave run-up and overtopping, are dependent on the shoreline type, roughness, slope, and other factors that require more detailed analysis than that presented in this project.
- Pumping. Some locations depicted as flooded may not actually flood due to mechanical pumps removing flood water. The mapping does not consider the existence of pumps or pumping capacity in displaying flood risk.
- Climate change and storminess. Changes in storm frequency and magnitude due to climate change were also not examined in this project, but an evaluation of these dynamics may provide further insight into when adaptation strategies need to be implemented.
- Groundwater. Rising groundwater tables, primarily associated with sea level rise, can also impact flooding and drainage. The impacts of rising groundwater tables on watershed flooding are not well understood. Further evaluation of these factors is recommended.
- Erosion and Subsidence. Geomorphic processes related to levee erosion or subsidence next to levees are not captured in these maps. Our maps present a 'snapshot' of the current shoreline and inland area topography.

Modelling Disclaimer

The inundation maps and the associated analyses provide a sub-regional-scale illustration of inundation and coastal flooding due to specific sea level rise scenarios and are intended to improve sea level rise awareness and preparedness. The maps are not detailed to the parcel-scale and should not be used for navigation, permitting, regulatory, or other legal uses. Flooding due to sea level rise, coastal, and riverine processes is possible in areas outside of those predicted in these maps, and the maps do not guarantee the safety of an individual or structure. Nor do the maps model flooding from other sources, such as local precipitation or stormwater sources (see model limitations above). The contributors and sponsors of this product do not assume liability for any injury, death, property damage, or other effects of flooding. The maps are based on model outputs and do not account for all of the complex and dynamic San Francisco Bay-Delta processes or future conditions such as erosion, subsidence, future construction or shoreline/levee protection upgrades, or other changes to the San Francisco Bay-Delta shoreline or the region that may occur in response to sea level rise.

Sectors and Asset Categories Analyzed

Contra Costa County has a diverse shoreline comprised of natural areas (e.g. tidal marshes, mudflats); and constructed features including flood protection structures (e.g. levees and berms) and features such as railroad tracks that are not specifically intended for flood protection. Many communities and facilities of economic and environmental importance are in areas near the shoreline and so at threat from rising sea levels. The East Contra Costa ART project included 14 sectors and 34 asset categories. Table 1-3 provides a summary of the sectors and assets considered and subsequent chapters provide detailed information about the vulnerabilities they face, the consequences that could occur if they are impacted, and possible adaptation actions that could be taken to reduce those risks.

Table 1-3. Sectors and assets analyzed in the ART ECC Project Area.

Sector	Asset
Agriculture	• Agriculture
Business and Industry	• Industrial Land Use Categories • Commercial Land Use Categories • Hazardous Materials Sites
Communities	• In-Delta Legacy Communities • Social Vulnerability
Community Engagement	• Community Engagement
Critical Facilities and Services	• Emergency Response Facilities • Public Healthcare Facilities • Faith-Based Organizations • Solid Waste Disposal Sites • Schools
Delta Islands	• Delta Islands and Reclamation Districts
Energy	• Pipelines • Power Distribution • Power Generation • Oil and Gas Production Fields
Natural Areas	• Natural Areas
Parks	• Shoreline Parks • Water Trail • Marinas • Fishing Piers
People	• People
Transportation	• Rail • Roadways • Ports
Water	• Water Treatment Facilities • Water Conveyance • Pumps, Diversions and Intakes • Mutual Water Companies • Water Rights
Wastewater	• Wastewater
Flood and Stormwater	• Creeks • Stormwater

Exposure Analysis

ART ECC used an automated exposure analysis tool to determine which assets could be exposed to current or future flooding. The assets listed in Table 1-3, above, are mapped on the computer using a Geographical Information System (GIS). By overlaying the mapped

assets with the flood maps, we can determine which assets intersect with potential flooding, and mark the assets as exposed to flooding.

The ART ECC staff visually inspected assets and flood maps to determine whether assets could be exposed to flooding or not. Sometimes assets could be flooded upon visual inspection, but the automated exposure analysis shows them as not flooded; or, sometimes assets are marked as flooded and upon visual inspection are not.

Project Resilience Goals

Project Resilience Goals were developed to help define the desired outcomes of the project and provide a foundation upon which future project decisions could be made. Project Resilience Goals are set early in an adaptation planning process in order to:

- Build transparency at the outset so that all participants and others with an interest in the project know what will be included and what will be a priority;
- Engage the Working Group early in deciding what shared desired outcomes they will work cooperatively to achieve, and provide an opportunity for them to ask their stakeholders for input and feedback on the project direction;
- Encourage and facilitate the inclusion of all four sustainability frames throughout the project; and
- Provide a framework for evaluating outcomes and recommendations at the end of the project, for example, how well they will help meet the established resilience goals.

The project Resilience Goals were developed with the Working Group in a two-step process. At the first Working Group meeting, held July 24, 2018, ART staff used the ART Functions and Values Mapping engagement exercise to begin a conversation about the factors that are critical to the economy, public health and safety, community, and environment in the Project Area. The mapping exercise helped the Working Group identify the functions and values as a group and formed the basis of the draft project Resilience Goals.

The Resilience Goals were revisited when the assessment was finalized to ensure they aligned with the identified planning issues and continued the values and visions of all in the Project Area. At the fourth Working Group meeting, held on November 7, 2019, ART staff presented the draft project Resilience Goals again. Working Group members provided input during the meeting on the specific Resilience Goals language.

The Working Group wanted the Resilience Goals to be revisited periodically to ensure that they still maintain relevance to the community and stakeholders.

West Contra Costa ART Project Resilience Goals

The West Contra Costa ART Project had the following Resilience Goals that the East Contra Costa Working Group added onto:

Governance Goals

- Prioritize and resource agencies, organizations, private entities, and communities in Contra Costa to work cooperatively to address climate change.
- Improve coordination among regulatory agencies to reduce programmatic or legislative barriers to addressing current and future flood risks.

Society and Equity Goals

- Support communities, and in particular those with characteristics that could make them more vulnerable, in accessing affordable, safe, and healthy housing, utilities and services, recreational opportunities, transportation and transit, and information about risk.
- Protect the health, safety, and welfare of all who live, work, and recreate in Contra Costa County.

Economy Goals

- Maintain and improve local economic vitality and access to diverse employment opportunities by preserving the function of major employment centers, infrastructure and utilities.
- Recognizing Contra Costa County's regional refining and goods movement role, ensure the energy and transportation sectors and the interconnected networks and systems they rely on are resilient.

Environment Goals

- Protect and improve the environment by preserving and restoring habitat, continuing to improve air and water quality, and safely addressing contaminated lands.
- Promote the use of natural and nature-based approaches where possible and appropriate to improve community and economic resilience.

East Contra Costa ART Project Resilience Goals

The East Contra Costa ART Working Group expanded the West County goals in the following ways:

Governance Goals

- Create an agreed-upon collective decision-making process so that various districts, jurisdictions, government agencies, academic institutions, Reclamation Districts, flood control agencies, NGOs, businesses, and community groups in Contra Costa County can work together to successfully complete large-scale sea level rise planning projects. Provide ongoing funding, resources, and appropriate political and community support to the aforementioned groups so that they can continue to work collaboratively. Create structures through which meaningful community engagement can be done so that community voices are elevated, heard, and prioritized by government agencies. Work with stakeholders to identify the best solutions for the community as a whole. Improve coordination between all levels of government agencies, including between those with Bay and Delta jurisdictions,

special districts, and unincorporated areas, to support cohesive planning for current and future flooding across the entire Contra Costa shoreline and creeks.
- Promote adaptive management practices, such as updating vulnerability assessments as more data is gathered or modeling capabilities improve. Look to other successful efforts ongoing throughout the Bay and Delta. Be discerning when permitting for new development in future flood zones.

Society and Equity Goals

- Focus on actions that support communities in developing resilience in areas potentially impacted by flooding through increasing accessible, affordable, safe and healthy housing, services, commerce, jobs, recreational opportunities, and transportation. Prioritize protection and adaptation of communities with characteristics that make them vulnerable, disadvantaged, low-income, elderly, and of limited mobility. Create short- and long-term plans to house residents displaced by flooding, especially low-income residents.
- Protect the health, safety, and welfare of all who live, work, and recreate in Contra Costa County, while also respecting existing land uses. Focus on making critical infrastructure, such as power, wastewater treatment sites, and hospitals resilient to flooding so they remain functional during disasters. Explore ways to evacuate floodwaters as quickly as possible to protect the wellbeing of communities. Prioritize important transportation assets, especially bridges and roads that are sole routes for communities, for emergency evacuation and access to emergency services. Identify other evacuation resources (e.g. boats) ahead of time and formalize plans for how to use these resources in case of emergency. Ensure that vulnerable communities, who may not have access to vehicles, have access to emergency evacuation options.
- Ensure that citizens know how to access emergency communication and that it remains functional during an emergency. Ensure communities are engaged in risk preparedness and have a voice and agency in shaping policies around responding to risk. Educate community members and business owners on risk and provide potential solutions on how to mitigate hazards associated with flooding, particularly chemical storage sites.

Economy Goals

- Maintain and improve local economic vitality and equitable access to diverse employment opportunities by creating local employment centers, infrastructure, utilities, and transportation to local employment sites that are resilient to sea level rise and future flooding. Promote resilience of the industrial sector (especially on the Northern Waterfront), current and future job sites, and the interconnected systems and utilities they rely on. Be cautious in expanding development into flood-prone areas.
- Maintain and improve recreational opportunities for the Delta that are resilient to sea level rise and flooding.
- Improve understanding of the risks to levees and prioritize investments for vulnerable levees that provide protection to communities (especially disadvantaged communities), important assets, and infrastructure.

Environment Goals

- Protect and enhance the environment by preserving and restoring habitats, particularly tidal wetlands, which can drown under sea level rise. Emphasize the importance of agricultural lands in providing flexible upland space for tidal wetlands to transition/retreat to as sea level rises or for nature-based solutions. Continue to improve water quality and reduce floodwaters by building green infrastructure. Safely and proactively address contaminated lands by incorporating future sea level rise impacts into current clean-up plans.
- Prioritize the use of natural and nature-based approaches for flood protection where possible and appropriate.
- Promote sustainable agriculture that reduces subsidence and levee failure risk, such as rice farming.

The Assess Step

The Assess step in the ART planning process is designed to clearly and efficiently identify the underlying causes and components of vulnerability and the associated consequences. During the Assess step, ART staff conducted a robust desktop assessment of asset exposure to temporary or permanent flooding using the best available geospatial data and validated the analysis with working group members. The outcomes of the Assess step in ECC included an exposure analysis and detailed vulnerability and consequences information for 34 asset categories across 14 sectors.

The following assessment questions were asked when doing the Asses step to define the asset, understand its vulnerabilities, and define the consequences if the asset fails.

Types of Assessment Questions

For defining assets:

Existing Conditions: Describes the asset and highlights current conditions or stressors that could affect its vulnerability.

- Where is the asset located?
- What is its function?
- Who owns and manages it?

For defining vulnerabilities:

Information: Determines if data or information is lacking, incomplete, poorly coordinated, or difficult to access.

- What types of information sources for the asset(s) are publicly available?
- What is the quality of available information?
- What types of mechanisms exist to share information between owners of connected infrastructure?

Function: Considers the function of the assets and their relationship to or dependence on other assets.

- What services does the asset rely on?
- Is it physically connected to other assets such that failure in one part of the system disrupts the entire system?
- Does the asset provide functions or services that are limited?

Physical: Identifies conditions or design aspects that make an asset particularly vulnerable to impacts.

- Is the asset co-located with other assets?
- Are water- or salt-sensitive components of the asset located at- or below-grade?

Governance: Identifies challenges with management, regulatory authority or funding options for adapting to impacts.

- What plans, procedures, etc. are in place to manage the assets?
- What types of permits are needed to make changes?
- What funding sources exist that can be used for adaptation?

For defining consequences:

Consequences: Informs how climate change may impact society and equity, the economy and environment.

- Does the asset serve vulnerable communities or critical facilities?
- Are hazardous materials at the asset site that could pose a risk to the environment?
- What is the scale of economic costs if the asset experiences disruptions or damage?

Exposure Analysis

Assets on the Bay-Delta shoreline and along major creeks and channels in the Project Area were analyzed to determine if they were exposed to potential current and/or future flooding. Assets within the 100-year storm event area are currently at a 1% annual risk of flooding, and as sea levels rise, these areas could be at risk of more frequent or extensive flooding. This risk may, however, be underestimated in some locations as the ART models didn't include groundwater, wave hazards, combined riverine flooding from smaller creeks, or changes in future precipitation patterns. In the future, work should be done around many of the creeks and flood channels in ECC. In addition, there are assets not currently at risk of flooding that could be exposed to flooding in the future as sea level rises. Some of these assets may be currently protected from the 100-year storm event, while others may be at a distance from either the Bay-Delta shoreline or creek and channel banks and therefore beyond the extent of current flooding.

Current flood risk was determined by modeling the 100-year storm event, which is not the same model as FEMA's 100-year storm. Future flood risk was determined through the ART developed mapping products at the time the project's exposure analysis was conducted. Further information on the data sources and methodology of the exposure analysis is included in the Appendix.

The exposure analysis is visualized in a series of mapbooks. Figure 1-9 is an example of one of the exposure maps produced for this project. A complete set of the mapbooks available is in the Appendix. The online flood explorer is also available via https://eccexplorer.adaptingtorisingtides.org/.

Locally refined ART sea level rise inundation and shoreline overtopping maps were produced for the project. The new maps were used to identify the areas of the shoreline that were likely to allow flooding and to determine the water level that caused the flooding. This information provided the ART team and Working Group with the information necessary to determine the timing and scale of the actions that could be taken to reduce the flood risk.

The locally refined ART maps depict the potential depth and extent of inundation from increases in sea level from 0 to 83 inches in combination with the 100-year storm event. The mapping and analyses show that as sea levels rise, shorelines will become exposed to more frequent (higher probability) extreme tides. The result of this will be that the current shoreline may no longer protect inland areas from rising waters and these inland areas could experience an increase in flooding events first and then permanent inundation later. In addition, the increased frequency of extreme tides will have important implications on the design of flood protection infrastructure and on the resilience and persistence of valuable natural shoreline habitats. Details on the data and methodologies used for mapping can be found in the Appendix.

Preliminary assessment information was shared with the Working Group at the second Working Group meeting, held July 31, 2019, to ensure that available information, critical

assets or local issues were included in the assessment. The preliminary assessment findings were shared at the third meeting, held September 25, 2019, ART staff provided an overview of the assessment outcomes and shared the draft assessment products, including sector and asset category assessment chapters and draft inundation and shoreline analysis maps.

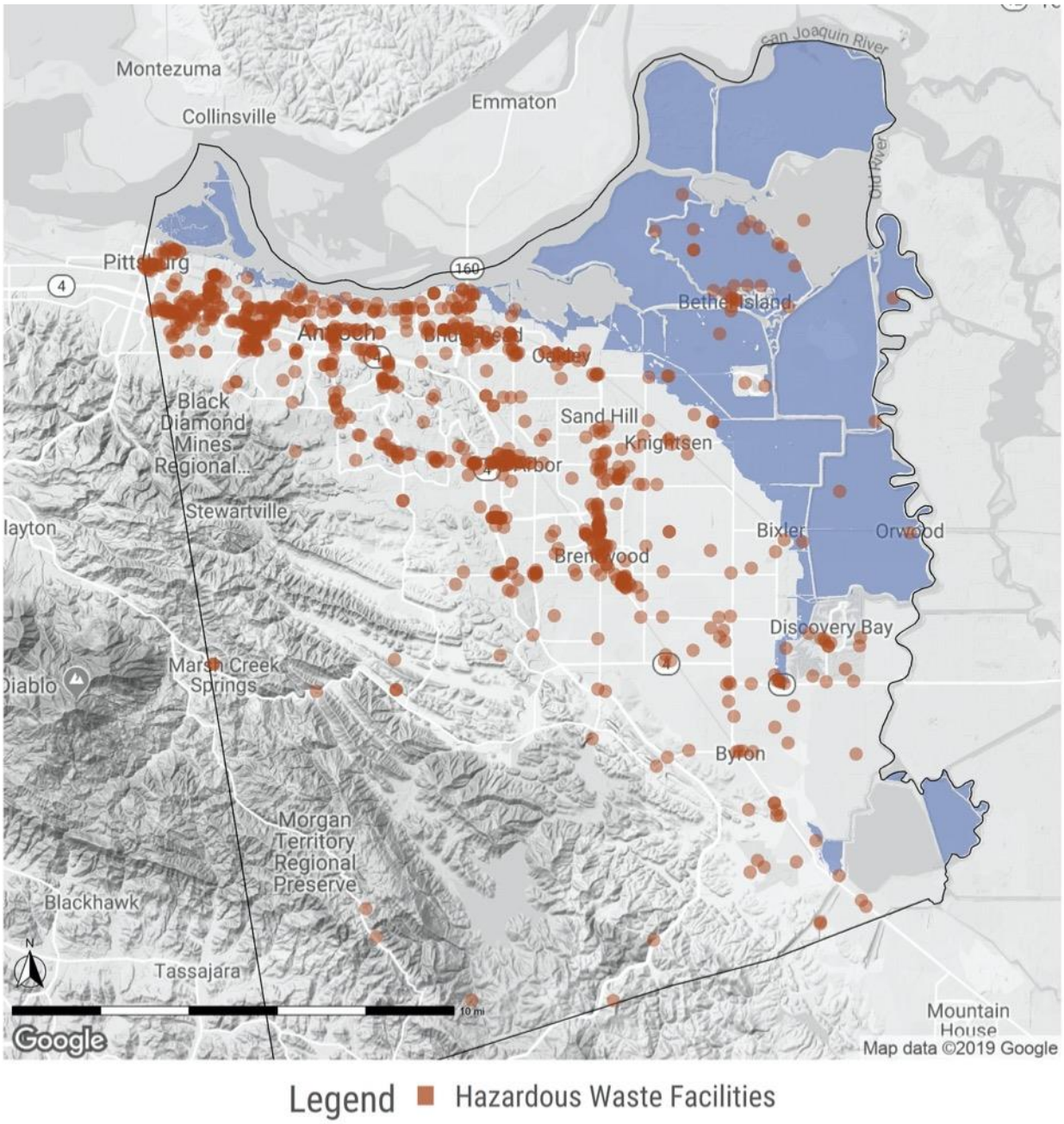

Figure 1-9. Flood exposure analysis for hazardous waste facilities within the Project Area at 12" sea level rise + a 100-year storm event. This is an example of exposure maps within the Mapbook, located in the Appendix.

The Define Step

The Define step is unique to the ART planning process and not used in other climate adaptation planning efforts. The ART team developed the Define step during the first ART Program project in Alameda County and in response to concerns and feedback from the Working Group from that project. The Define step is the way that the ART Program works with Working Groups to prioritize the issues identified in the assessment. It is a foundational step that aids in the transition from Assess to Plan and supports the development of adaptation responses that directly respond to specific and, potentially, multiple vulnerabilities both within and across asset categories. The Define step includes summarizing the assessment into clear, outcome-oriented vulnerability and consequence statements that help the working group prioritize the issues that need attention and the scale of the action that might be taken.

In addition to using the Define step to organize and prioritize actions for asset scale and sector scale vulnerabilities (such as the vulnerability to a particular roadway in the County or to a sector such as parks and recreation), the ART team also engaged the Working Group in identifying the overarching or cross-cutting vulnerabilities and consequences that affect multiple assets and geographies. Based on this input staff developed seven Key Planning Issues that synthesized and summarized the cross-cutting and priority issues emerging from the assessment. The ECC Key Planning Issues built upon those identified in the West Contra Costa ART project.

ART staff presented a brief summary of the Key Planning Issues to the Working Group at the third meeting, which was held September 25, 2019. In small groups Working Group members discussed each of the Key Planning Issues in light of the vulnerable assets, services and dependencies contributing to the issue, the project Resilience Goals, and the potential adaptation responses that would be necessary at the local, County, or regional scale to resolve the underlying vulnerabilities. Based on input from the Working Group, ART staff refined and finalized the seven Key Planning Issues.

See the Executive Summary or Key Planning Issue chapter for the seven Key Planning Issues identified.

The Plan Step

In the ART planning process, the development, review, refinement and evaluation of adaptation responses to address the vulnerabilities is known as the Plan step. Instead of just a list of strategies or actions, adaptation responses also include three important building blocks: a vulnerability or issue; one or more actions; and implementation options. This approach is valuable because it connects actions directly to the assessment outcomes, presents a number of possible stand-alone, or sequenced actions or alternative actions that can be taken, and provides a substantial level of detail about possible implementation partners, funding options and processes. In addition, during the Plan step the project resilience goals are reviewed against the assessment outcomes and, if needed, refined to better reflect the issues identified in the assessment. Additionally, evaluation criteria are selected to help identify benefits and trade-offs of the various adaptation responses identified.

The last step of the ART planning process in Contra Costa County, the Plan step, focused on helping Working Group members develop ways to advance priority actions within their individual agencies or organizations and identifying how to continue to work together on the seven Key Planning Issues that require shared responses. At the fifth and final Working Group meeting, held December 3, 2019, ART staff led the Working Group through a voting exercise that helped them choose both easy-to-implement/low-hanging fruit and priority adaptation actions.

West Contra Costa ART had the following four priority adaptation actions:

- Action 1: Develop and disseminate guidance to business and industry on the best practices for reducing the potential impacts of flooding and sea level rise on their facilities and the services and systems they rely on.
- Action 2: Create a public-private shoreline working group tasked with developing a plan to fund and implement integrated shoreline solutions to reduce flood risk
- Action 3: Develop a county-wide program to monitor, maintain, and repair (as feasible) at risk shorelines most in need of intervention.
- Action 4: Establish a public-private partnership to better understand the consequences of flooding on commercial and industrial supply chains, employee access to job sites and the regional transportation networks goods and commuters rely on.

The ECC working group chose high priority adaptation actions and low-hanging fruit (e.g. easier to implement or actions that are already going on) adaptation actions through voting on Key Planning Issue adaptation actions at working group 5, held on December 3, 2019. The results can be seen in Table 1-4.

Table 1-4. High priority and low-hanging fruit adaptation actions, as voted on by the ECC working group from the key planning issue adaptation actions. Each listed action is followed by its spreadsheet identification number. All key planning issue adaptation actions can be found in the Appendix.

Timeline	Priority Actions	Low-Hanging Fruit / Easier to Implement Actions
Near-Term	Initiate tidal wetland restorations that will protect and enhance the broad benefits they provide, including flood risk reduction, habitat, biodiversity, and water quality.	Build or strengthen relationships between public agencies, private entities, nonprofit, community, and faith-based organizations, and neighborhood groups to increase flood resilience.
Mid-Term	Model how sea level rise and sea level rise combined with major storms will affect levee stability and update design and engineering standards accordingly.	Provide incentives or require facilities that provide critical public services either have access to temporary flood protection devices or retrofit with permanent flood protection solutions.
Long-Term	Develop and implement a county-wide program to monitor salinity conditions, including the progress of saltwater up into creeks and salinity conditions in the groundwater near vulnerable infrastructure, wells, or surface water.	Develop new microgrids to create a more resilient power system less reliant on the regional grid, ensuring that pump and drainage systems do not lose function if the electricity grid is not functioning.

The Implement and Monitor Step

The development of project-specific evaluation criteria plays a central role in ensuring transparent decision-making in adaptation planning. In the West Contra Costa ART project a set of evaluation criteria were developed and applied to a select number of Key Planning Issue adaptation responses. This exercise helped the Working Group more deeply understand the issues and trade-offs that need to be considered when prioritizing and selecting adaptation responses for implementation. To keep consistency between the two projects within the County, the ECC ART project kept the same evaluation criteria so that adaptation responses from West Contra Costa ART could be compared to projects from East Contra Costa ART.

For implementation, the Working Group focused on a robust discussion at the last Working Group meeting on ways that the ART process and sea level rise adaptation planning and implementation could be progressed within the County so that implementation of some of these actions would become more realistic.

What's necessary to get adaptation responses implemented in the County **is a core ask, a clear message, and educating elected officials about the ART findings**. The biggest hurtle

to implementing adaptation planning and implementing strategies within the County is due to there being no overarching authority to move any of the actions forward. Continuing the Working Group and expanding it to include more decision-makers, such as additional County agency staff, would enable continued cross-agency collaboration, sharing of local best practices, and the creation of design standards for the shoreline and shoreline buildings. The Working Group could become the basis to form a JPA to move adaptation planning forward at the County and local scale. Another hurtle to implementation is the lack of funding to do adaptation planning. County and local staff are already overburdened with their existing work, and no one has time to add another item to their agenda. This means that the County needs dedicated staff to be able to move ahead with adaptation recommendations. Grants could help fund staff and consultants to advance adaptation planning.

Vulnerability Assessment Findings

The Contra Costa ART project included an exposure analysis for flood risks and detailed vulnerability assessment of how these flood risks will affect the 34 asset categories across 11 sectors, as well as asset-scale evaluation for representative assets. The sections below present the detailed assessment information describing the vulnerabilities faced and the consequences that could occur if the sectors, asset categories or assets evaluated were impacted. The 11 sectors included in the assessment are:

- Business and Industry
- Community Feedback
- Critical Facilities and Services
- Delta Islands and Reclamation Districts
- Energy
- Flood and Stormwater
- Natural Areas and Outdoor Recreation
- People
- Transportation
- Wastewater
- Water Management

Business, Industry, and Hazardous Materials

Commercial and industrial facilities provide jobs, goods, critical services, and opportunities for economic development and growth. Community members rely on commercial businesses, including medical and dental services, near where they live and work. In addition, community members with limited mobility and those that rely on public transit typically have limited options for travelling outside of their neighborhood to access jobs, necessary services, and critical goods.

The assessment of businesses and industries in the East Contra Costa ART Project Area (Project Area) focused on key commercial and industrial land uses, as well as locations with hazardous materials on site. While the types of uses considered in this chapter are broad, all provide jobs to people living both within and outside of the County, contribute to local and regional economies, and support the research, development and production of critical goods. In addition, the many commercial land uses in the project area provide necessary services to local residents who would need to either travel outside of the County to find what is needed or go without these services if they were disrupted.

Commercial Land Use

Commercial land uses provide goods and services critical to the day-to-day functioning of neighborhoods and communities. Community members tend to shop and access services (e.g., banks, auto service, grocery stores, medical and dental services) near where they live and work. For community members with limited mobility, or for those that do not have a car and rely on public transit, proximity to goods and services is especially important. Commercial land uses of all kinds are also a source of local jobs, and they can contribute to the social cohesion of a neighborhood or community.

A variety of commercial land uses were assessed[1], including stores, supermarkets, auto repair and gasoline stations, medical and dental offices, banks and other financial institutions, restaurants, offices and small commercial businesses of all kinds. Many of these commercial uses, including supermarkets and medical offices, are limited in number and accessibility in the project area, and community members have to travel over distances by car or on public transit to obtain needed goods or services. Additionally, the cost of owning a business varies significantly across the County. For example, retail and office space is more expensive in West and Central County where there is above-average rental pricing and low vacancy rates. East Contra Costa on the other hand has the lowest retail rental prices in the East Bay, with much higher vacancy rates and difficulty filling units.

Issue Statement

Access to commercial facilities may be disrupted due to a flood event, which can have far-reaching consequences on local communities, including workers being unable to report to work, and necessary goods and services becoming unavailable to community members. Most commercial buildings are not designed to withstand flooding, and even those not directly at risk will be vulnerable if roads that provide access are flooded, or if power, water, or wastewater services are disrupted. Even temporary closure of commercial uses can

[1] Commercial land uses were evaluated based on the County Assessor's Parcel data from March 2019, which may not include all commercial land within the Project Area, such as major retail centers.

have significant social and economic impacts on communities and can impede a speedy recovery after a flood event.

Asset Descriptions

Commercial parcels in the project data set were anonymous. As stated above, commercial land uses can include stores, supermarkets, auto repair and gasoline stations, medical and dental offices, banks and other financial institutions, restaurants, offices, and small commercial businesses of all kinds.

In general, in the Project Area the major hospitals are located in Antioch and Brentwood. Major grocery stores, retail outlets, banks, dentists, and health clinics are all located primarily in Pittsburg, Antioch, Brentwood, and Oakley. Discovery Bay has smaller retail, such as a grocery store and bank, but residents typically need to travel further to access other services.

Bethel Island residents and any other residents living on Delta islands have to travel off the islands to acquire medical services, dental services, major grocery stores, banks, and other major retail. However, on the south side of Bethel Island Road the island has a post office, restaurants, bars, boat mechanics, retail, a gas station, Bethel Island Chamber of Commerce and marinas.

Exposure To Current And Future Flooding

In the Project Area there were a total of 24 Retail Business parcels and 9 General Commercial parcels. At the current high tide, 9 retail and business parcels, all located on Bethel Island or Holland Tract, are affected by flooding from tides (see Data Considerations below). By 83" sea level rise the parcels on Bethel Island and Hotchkiss Tract are significantly flooded.

At the current 100-year storm event, there is significant flooding of retail business sites on Bethel Island. Retail businesses on Hotchkiss and Holland Tract are minimally affected. **By the 100-year storm event plus 12" of sea level rise, the retail business sites on Bethel Island, Holland, and Hotchkiss Tracts are significantly affected by flooding.**

Many known retail and commercial parcels are not listed in the analyzed GIS data. Qualitative assessment of the Project Area map reveals that **impacts to businesses begin at 83" sea level rise or the 100-year storm event plus 12" of sea level rise in downtown Antioch, along the shoreline of Hotchkiss Tract where there are shops along the levee, and some of the piers along the Antioch Bridge.**

Even if services are not directly impacted, more critically, **access to services may be blocked**. **While no hospitals are exposed to flooding, by 83" SLR or the 100-year storm event plus 24" SLR, the Town of Discovery Bay and neighboring homes, businesses and roads may be flooded.** This may prevent egress and access to services, such as hospitals,

for these communities. Additionally, some neighborhoods in Knightsen near Eagle Lane may become isolated starting at today's 100-year storm due to the railroad tracks blocking egress on the west and south side and flooding coming from the north and east.

Data Considerations

The County Assessor's data (from March 2019) were used to analyze retail exposure in the Project Area. The best available data for commercial land use in the project area is not exhaustive. The data set only covers a few key areas. This severely limits our ability to assess the full impacts of sea level rise on commercial businesses within the Project Area. There are many other commercial areas within the Project Area, such as strip malls, that were not included in this analysis due to the limited GIS data available. This was discovered through using Google Maps to explore commercial properties within the Project Area.

Of note, is that some parcels identified as exposed to current high tide may have parcel boundaries that extend into the shore/water, so they may be inappropriately flagged as exposed.

Table 2-1. Total number of commercial and retail parcels that may be located in the current 100-year storm event area and/or exposed to future sea level rise with a current 100-year storm, sea level rise combined with a 100-year storm, or exclusively sea level rise.

Asset	Current 100-year Storm Event*	12" + 100-yr	24" + 100-yr	36" + 100-yr	83" + 100-yr	MHHW Today	12"	24"	36"	83"
Retail Business	16	16	16	16	16	9	10	11	13	16
General Commercial	1	1	1	1	1	--	--	--	--	1
Total Sites Exposed	**17**	**17**	**17**	**17**	**17**	**9**	**10**	**11**	**13**	**17**

"--": Unexposed assets

MHHW: Mean Higher High Water refers to the average of today's daily highest tide and is used as the baseline for all flooding scenarios.

* Current 100-year Storm Event: The 100-year storm event reflected in these maps is not equivalent to the FEMA 100-year flood hazard zone.

Vulnerabilities

INFO1: Commercial properties are privately owned, so there is often a lack of publicly available information about the vulnerability of their facilities and operations, the status of their emergency management or contingency plans, or the economic consequences that would result if they were impacted by flooding.
INFO2: There are limited data available to understand where commercial land use exists within the project area, making a thorough assessment of vulnerability difficult.
GOV1: Commercial properties may be operated by landowners that do not have the capacity to engage in local planning or by businesses that lease properties and have little control over improvements to the property where their business is located.
FUNC1: Commercial uses rely on outside infrastructure and services provided by public and private agencies, including roads, electricity, water, and wastewater. Disruption of road access, power, water or wastewater services can impact the commercial use, which may need to be closed, or if open, may not be accessible to customers.
FUNC2: Commercial uses providing medical and dental care are critical because loss of these services or access to them could have significant impacts on community members, in particular those that are mobility limited or rely on public transportation.
FUNC3: Commercial uses that provide neighborhoods and communities with goods and services (such as grocery stores) are particularly important because if they close temporarily or permanently residents will have to do without or travel to find alternative sources.
PHYS1: Most commercial uses are vulnerable to flooding because the buildings and structures were not designed to withstand flooding nor are constructed of waterproof or non-corrodible materials.
PHYS2: Some commercial entities use or store hazardous materials including paints, cleaners, oils, batteries, pesticides, asbestos, and medical waste, which if not stored properly or not elevated above possible flood levels could be released during a flood.
PHYS3: Many buildings rely on electric or mechanical components, such as fans, boilers, and pumps, that are often located below grade or on the ground floor and cannot function if wet.
PHYS4: Commercial uses with unprotected at- or below-grade entrances are at risk of damage if flooded. This is particularly an issue for garages or warehouses with large roll up doors.
PHYS5: Commercial uses that rely on power but that do not have back-up power generation and fuel supplies are more vulnerable to disruption and loss of goods stored on site.

Consequences

Society and Equity: Disruption of commercial uses that provide medical and dental services, groceries, other critical services, or goods and services that are locally limited could have significant consequences on neighborhoods and community members, particularly those who rely on public transportation or have limited mobility. The disruption or closure of commercial uses can have significant consequences for employees, as loss of access to the workplace can lead to loss of income. This will be particularly true for small business owners that might not be able to afford costs associated with closures and/or

recovery from damages. Community members may lose access to goods and services they rely on, impacting neighborhood function and community resilience. Flooding of facilities that store hazardous materials can result in public health or environmental impacts if contaminants are released into floodwaters.

Environment: Flooding of facilities that store materials such as pharmaceuticals, petroleum products, cleaners, pesticides, or toxics can impair water quality if released into the Bay-Delta, river systems, or nearshore habitats.

Economy: Commercial uses provide Contra Costa County with economic benefits that include jobs for residents, services to communities, and tax revenue to the cities and the County. Damage or disruption of commercial uses could result in significant costs of replacement or repair of buildings, equipment, and goods stored onsite. Flooding of commercial uses could cause temporary or permanent job loss for hundreds of workers, resulting in lost business revenues, employee wages, and fees or taxes.

Industrial Land Use

The industrial sector as described in the Contra Costa County General Plan includes industrial activities such as processing, packaging, machinery repair, fabrication, distribution, warehousing and storage, research and development, metalworking, chemical or petroleum product processing and refining, heavy equipment operation, and similar activities. Industrial lands are diverse and include many different types of manufacturing, warehouse and light industrial sites, each with characteristics designed to support different business operations[i].

Issue Statement

Industrial activities on the waterfront are at risk. Property owners and site operators may not be aware of the flood risk they may face in the future and may not have facilities or site operations that can be made resilient to flooding either on or off site. Contaminant mobilization is a huge risk from flood exposure, as well as impacts to the economy if these employment sites are shut down.

Asset Descriptions

Light Industry

Light industrial activities include processing, packaging, machinery repair, fabrication, distribution, warehousing and storage, research and development, and similar uses which emit only limited amounts of smoke, noise, light, or pollutants. It could also include commercial/distribution-scale solar energy generating facilities[ii].

In Pittsburg, this includes the shoreline industries of: USS-POSCO Industries, which manufactures metal sheet products; multiple auto repair shops; CEMCO Steel for steel fabrication; and Generon for manufacturing various gas and compression technologies.

Along the Antioch shoreline, light industries include: Reliance Sheet and Strip for metal manufacturing; Pacific Pride Distribution for warehousing; Verco Decking for manufacturing roof or floor decks; multiple auto repair shops; Minex Engineering for radio telescope and satellite dish design and fabrication; Hunt & Sons for petroleum equipment, bulk fuel delivery, lubricant delivery, and lubricant purification; and Antioch Trailer Storage for storing boats and RVs. The Fulton shipyard is also along the shoreline, but is currently not an active site.

Along the Oakley shoreline is a boat repair shop and in Byron there is the American Underground Contractor for underground utilities near the airport.

Heavy Industry

Heavy industry allows for activities requiring large areas of land with convenient truck, ship, and/or rail access. These uses are typically not compatible with residential uses in close proximity because the operations conducted may be characterized by excessive noise or other conditions requiring spatial separation. Uses may include metalworking, chemical or petroleum product processing and refining, heavy equipment operation, or similar activities. Lands designated as heavy industrial can also be developed according to light industrial definition and standards found in that designation[iii].

In the Project Area, heavy industries along the Pittsburg shoreline include Dow Chemical and Koch Carbon for global sourcing, supply, handling and transportation of bulk commodities, such as petroleum coke, sulfur, or coal. Heavy industry along the Antioch shoreline includes: Georgia-Pacific Corporation which creates tissue and paper products (like Dixie cups), wood paneling and gypsum products for construction, various chemicals, and packaging materials; Amports, which is a vehicle logistics center and deep water port operator; KIE-CON which manufactures precast/prestressed concrete products and has access to water transport; and CEMEX, which produces ready-mix concrete. Along the Oakley shoreline is Foundations Constructors Inc. which provides pile foundations and pile testing. Byron has a small cluster of heavy industry near Clifton Court Forebay including another CEMEX facility for cement production and distribution; Byron Rock & Ready Mix, Inc. for ready-mix concrete delivery; D&D Ready Mix Inc. Concrete Contractor; and Quality Scales Unlimited for weighing equipment. Byron also has G3 Enterprises-Minerals Division for sand mining.

Controlled Manufacturing

Manufacturing typically includes storage facilities, shipping via ruck or rail, processing and refining, heavy equipment operation, and similar activities.

Exposure To Current And Future Flooding

The data analyzed includes 6 light industrial parcels, 6 heavy industrial parcels, and 1 controlled manufacturing parcel. At today's current MHHW, 2 heavy industry parcels are affected by temporary tidal flooding. These are located on the coast of Antioch to Big Break. By 36" sea level rise the shoreside industrial sites near the Antioch Bridge will be more heavily inundated. By 83" sea level rise there will be significant flooding that reaches up to Wilbur Avenue in Antioch. At the current 100-year storm event, heavy industry along the Antioch shoreline to Big Break is also inundated, similar in scale to the 36" of sea level rise scenario. By the 100-year storm event plus 24" of sea level rise, the heavy industrial area near the Antioch Bridge is flooded to Wilbur Avenue.

Storage facilities could either develop emergency plans to remove wastes prior to flooding or incorporate structural engineering solutions. But if these measures failed, the consequences could be serious. Tanks could overflow, containers could float or spill if not properly secured, floating debris or increased hydrostatic pressure could cause structural damage to above-ground or partially above-ground tanks, and saltwater could corrode tanks and containers.[iv]

Some known industrial parcels are not listed in the analyzed GIS data. Qualitatively looking at the Project Area map, impacts begin to happen at 36" of sea level rise or today's 100-year storm near the Antioch Bridge on the piers involving some heavy industry, the Fulton Shipyard, and some industrial sites near Kirker Creek. By 83" sea level rise, there is considerable flooding of the industrial shoreline and for light industry around the waterway of Lake Alhambra.

More importantly, road access to employment sites may be blocked or working piers may be flooded, preventing operations.

Data Considerations

As many industrial parcels are large and located directly on the shoreline the analysis conducted for this assessment could over-estimate the exposure of industrial lands in the Project Area. Importantly, the analysis does not fully reflect the potential impacts of current or future flooding on site operations. Site-based analyses at these facilities are needed to understand what facilities or infrastructure are within the portion of the industrial site at risk of flooding. Additionally, through looking at Google Maps, it became clear that the GIS data analyzed in this project does not include the full list of industrial sites within the Project Area.

Table 2-2. Total number of sites or units of industry parcels that may be located in the current 100-year storm event area and/or exposed to future sea level rise with a 100-year storm event, the combination of sea level rise and a 100-year storm event, or exclusively sea level rise.

Asset	Current 100-year Storm Event*	12" + 100 yr	24" +100-yr	36" + 100-yr	83" + 100-yr	MHHW Today	12"	24"	36"	83"
Heavy Industry	2	2	2	2	2	2	2	2	2	2

MHHW: Mean Higher High Water refers to the average of today's daily highest tide and is used as the baseline for all flooding scenarios.
* Current 100-year Storm Event: The 100-year storm event reflected in these maps is not equivalent to the FEMA 100-year flood hazard zone.

Vulnerabilities

GOV: Although industrial property owners and site operators may have engaged with public agencies on reducing flooding and other risks through existing regulatory programs, planning for sea level rise will require additional non-regulatory collaboration and partnerships between the public and private sector. These partnerships may be able to advance multi-benefit shoreline solutions that balance economic, environmental and social equity goals.
FUNC1: Many industrial land uses rely on off-site utilities connections (e.g., power, telecommunications, water supply, and wastewater treatment or discharge) that may be vulnerable to sea level rise impacts. Connections with off-site services can be critical to maintaining industrial operations, in particular for those facilities that need water for manufacturing processes.
FUNC2: Industrial land uses rely on roads, rail lines, pipelines, airports, seaports, and marine terminals to ensure materials and supplies are imported, goods produced are exported, and employees can get to/from work. Many of these transportation systems are vulnerable to flooding and their disruption could impact operations at industrial facilities of all types.
FUNC3: Because heavy industrial land uses need large amounts of land, have specific operational facility needs, and are dependent on fixed infrastructure for goods movement (e.g., marine terminals and rail lines), it can be difficult, if not impossible, to relocate.
FUNC4: Many industrial processes are continually operating and would need adequate warning time to fully or partially shut down in advance of storm-related flooding.
PHYS1: Industrial buildings, infrastructure, and associated facilities that are not currently within the 100-year floodplain are unlikely to have been constructed to be waterproof or flood resistant.
PHYS2: Industrial buildings, infrastructure, and associated facilities that have at- or below-grade entrances or sensitive equipment are especially vulnerable, including fans, boilers, and pumps that cannot function if they are flooded or exposed to saltwater.
PHYS3: Many industrial land uses generate or store hazardous substances that could have public health or environmental impacts if released into groundwater or surface waters.
PHYS4: Industrial land uses that rely on off-site power and do not have adequate back-up supplies and systems in place are more vulnerable to disruption of operations.

Consequences

Society and Equity: The disruption or closure of industrial land uses can have significant consequences for employees as loss of access to the workplace can cause lost wages. Loss of these industrial facilities may also impact the County and the region more broadly because they produce or distribute critical products used in many other sectors. Unexpected flooding of facilities that store hazardous materials can also result in public health impacts in nearby communities.

Environment: Unexpected flooding of facilities that store hazardous materials can impair water quality, natural habitats, and species if released into the Bay-Delta or nearshore habitats.

Economy: Industrial land uses provide Contra Costa County with economic benefits that include jobs for residents, products needed in other parts of the region, and tax revenue to the cities and the County. Damage or disruption of industrial facilities could result in high costs due to lost productivity, as well as the replacement or repair of buildings, specialized equipment, and goods stored onsite. Temporary or permanent closures of industrial operations of all kinds could have broad economic impacts throughout the region, particularly if heavy industrial facilities are damaged or their connections to goods movement infrastructure is disrupted.

Hazardous Materials Sites

Hazardous materials sites generate, treat, or transport materials that, because of the quantity, concentration, or physical and chemical characteristics, pose a significant present or potential hazard to human health and safety or to the environment if released.[v] Hazardous materials sites are typically located within industrial or commercial land uses, although there are some institutional facilities and utility service providers that use or generate smaller quantities of hazardous wastes.

The Hazardous Materials Program is one of Contra Costa Health Services' core programs that, with a few exemptions, covers most facilities with a hazardous material release potential. The Contra Costa Health Services Hazardous Materials Programs (CCHSHMP) is the Certified Unified Program Agency for all businesses within the County. The CCHSHMP administers regulatory programs including the Hazardous Materials Business Plan Program (HMBP), the California Accidental Release Prevention (CalARP) Program, and the Industrial Safety Ordinance (ISO).

The Hazardous Materials Business Plan Program requires businesses that handle hazardous materials in reportable quantities to submit an annual hazardous materials business plan. Reportable quantities are equal to or greater than 55 gallons, 500 pounds, or 200 cubic feet of gas or extremely hazardous substances above the threshold planning quantity. Businesses are required to submit a revised plan if there are changes in the ownership, address, amount, type or handling of hazardous materials, and the plan is shared with the local fire agency in which the business operates.

The California Accidental Release Prevention Program (CalARP) requires that businesses handling more than a threshold quantity of a regulated substance develop a Risk Management Plan with a detailed engineering analysis of the risks and mitigation actions to prevent an accidental release.[vi] While CalARP is a statewide program, it is implemented at the local level, in this case by CCCHSHMP. The County determines the level of detail required in the Risk Management Plans, reviews submitted plans, conducts facility inspections, and provides the public access to information about these sites.[vii]

A single release from a site administered by CalARP could have a significant one-time impact on public and environmental health, but there is also considerable risk of cumulative

impact from the many small- to mid-sized facilities. In addition, the larger established facilities covered by CalARP typically have pollution prevention measures onsite (e.g., water retention basins), while smaller facilities typically do not.

In addition to the regulatory hazardous materials programs, CCHSHMP is contracted to inspect businesses in unincorporated areas of the County for stormwater compliance under the Contra Costa Clean Water Program and is the primary Hazardous Materials release incident response team (HazMat Team) serving the County. CCHSHMP is also a primary partner in the Community Warning System (CWS) that would alert the public if there is a release of hazardous materials that could impact health and safety. The warning system is coordinated between CCHSHMP, the Office of the Sheriff, and some of the larger industrial facilities that have authority to activate nearby sirens.

The County also has a Hazardous Materials Commission that develops policy recommendations regarding the storage, use, and management of hazardous materials and hazardous waste[viii] and a Hazardous Materials Ombudsman who responds to questions and concerns from the public. Lastly, CCHSHMP chairs the Hazardous Materials Interagency Task Force, which is a coalition of agencies that voluntarily cooperate to enhance public and environmental health and safety. CCHSHMP also co-chairs the Contra Costa County Enforcement Task Force, where local, state, and federal agencies coordinate regulatory and enforcement actions to address problems in the areas of public safety and environmental protection.

Issue Statement

Flooding of hazardous materials sites could result in a release of materials stored onsite that could cause significant impacts to public health and the environment. Facilities may be particularly vulnerable if hazardous materials are stored at- or below-grade, are improperly contained, or if there is not enough time to safely shut down operations in advance of a storm event. Managers and owners of sites not currently in the 100-year storm event area may not be aware of the flood risks, and therefore may not be planning, preparing or operating in a manner to reduce the impacts of flooding should they occur.

Asset Descriptions

The project data represents a list of businesses within the Project Area that have Hazardous Materials Business Plans on file. These businesses vary widely in the amount of hazardous material handled on site and the type of containment employed. Our data did not provide details about type, amount, or method of hazardous material storage.

The locations of these hazardous waste storage sites are concentrated along the Pittsburg Antioch and Oakley shoreline. There are additional sites clustered around Brentwood near the railroad, along Marsh Creek, and on Bethel Island.

Exposure To Current And Future Flooding

There are a total of 752 Hazardous Materials Business Plan sites located in the Project Area, 83 of which are at risk from current and/or future flooding risk. A total of 30

Hazardous Materials Business Plan sites are at least partially within the current 100-year floodplain, concentrated on Bethel Island and scattered along the Project Area's shoreline[2]. Combined flooding from a 100-year storm event with 83"of sea level rise (SLR) could impact 83 sites. When considering SLR alone, no Hazardous Materials Business Plan sites are exposed to flooding until 83" SLR, when 59 sites are potentially exposed to flooding along the shoreline of Pittsburg, Antioch, and Oakley, with a larger concentration in Bethel Island and Discovery Bay.

There are 17 CalARP sites within the Project Area. Two of the CalARP sites are at least partially within the 100-year floodplain[3] and are at risk of more frequent or extensive flooding due to sea level rise. No CalARP sites are exposed to flooding when SLR is considered alone.

Other Risks

Additional hazardous materials sites may be located within low-lying areas adjacent to areas that might flood as sea level rises. These sites are in particular risk of flooding due to failure of the stormwater system to adequately handle additional capacity or drain effectively.

Data Considerations

The data used to analyze hazardous waste sites were derived from a list of businesses in Contra Costa County that have hazardous materials regulated by the County. This includes Hazardous Materials Business Plans (HMBP). **The data used for this analysis were represented as points and thus do not represent the exact location of hazardous materials within the facility. As a result, point data may underestimate the risk of flooding to more extensive facilities.**

2 Hazardous materials sites based on CCHSHMP information and the Contra Costa Assessor's parcel data. As some of these sites are large, site-scale analyses may needed to better understand how flooding could affect the developed portion of the site, and in particular where materials are generated or stored.

3 As some of these sites are large, site-scale analyses may needed to better understand how flooding could affect the developed portion of the site, and in particular where materials are generated or stored.

Table 2-3. Total number of hazardous waste facilities that may be located in the current 100-year storm event area and/or exposed to future sea level rise with a current 100-year storm event, the combination of sea level rise and a 100-year storm, or exclusively sea level rise

Asset	Current 100-year Storm Event*	12" + 100-yr	24" + 100-yr	36" + 100-yr	83" + 100-yr	MHHW Today	12"	24"	36"	83"
Antioch	1	2	2	2	10	--	--	--	--	3
Bethel Island	17	17	17	17	17	--	--	--	--	17
Brentwood	3	4	4	4	4	--	--	--	--	4
Byron	--	--	2	3	7	--	--	--	--	3
Discovery Bay	1	1	12	13	19	--	--	--	--	13
Knightsen	3	3	3	3	4	--	--	--	--	3
Oakley	5	10	13	13	15	--	--	--	--	14
Pittsburg	--	1	1	2	7	--	--	--	--	2
Total Sites Exposed	**30**	**38**	**54**	**57**	**83**	**--**	**--**	**--**	**--**	**59**

"--": Unexposed assets

MHHW: Mean Higher High Water refers to the average of today's daily highest tide and is used as the baseline for all flooding scenarios.

* Current 100-year Storm Event: The 100-year storm event reflected in these maps is not equivalent to the FEMA 100-year flood hazard zone.

Vulnerabilities

INFO1: Hazardous Materials Business Plan information is available through the California Environmental Reporting System (CERS); however, it is not in a format that can be easily used in sea level rise adaptation planning. In addition, there is limited information about the flood prevention or protection measures that may be in place at hazardous materials sites.
GOV1: In Contra Costa, the CalARP sites have a high level of compliance with hazardous material inventories and contingency planning requirements, while the diverse and numerous other hazardous material sites that use, generate, or transport smaller quantities of hazardous materials have variable levels of compliance with operational and regulatory requirements.
GOV2: Because of the number and concentration of heavy industrial land uses in the project area there is already coordination among the multiple entities that respond to hazardous materials emergencies. However, enhanced coordination and contingency planning would better prepare the region if a large storm were to flood multiple hazardous materials sites concurrently.
GOV3: Current emergency planning and response for many hazardous material sites do not require consideration of future flood risk. CalARP stationary sources are required to prepare for external events, including flooding, as part of a Hazard Review or Process Hazard Analysis. As past flooding levels that were once very improbable become a possibility, stationary sources will need to consider the risk of flooding, the safeguards that are in place, and how to reduce the risk to an acceptable level.
PHYS1: Industrial facilities containing hazardous materials are not generally designed to withstand flooding and are difficult and costly to relocate.
PHYS2: Flooding during a storm event could cause releases of hazardous materials if they are not well contained, improperly stored, at ground level, or are difficult to move. This could have public health and/or environmental impacts if released into groundwater or surface waters.
PHYS3: Facilities with hazardous materials stored below ground could be vulnerable to rising groundwater or buoyancy effects.

Consequences

Society and Equity: The flooding or other disruption of hazardous materials sites can expose communities to substances harmful to human health and safety.

Environment: The flooding or other disruption of hazardous materials sites can have serious environmental impacts. The release of persistent and mobile hazardous materials can have long-lasting and far-reaching consequences on wildlife and habitats and can affect water quality.

Economy: Facilities that generate, treat, or transport hazardous materials are usually job sites, and their disruption or closure can result in lost wages and larger-scale economic impacts. Additionally, flooding of hazardous materials sites can strain local emergency resources and result in high cleanup and recovery costs.

Community Feedback

In order to engage the residents of East Contra Costa County and understand the constraints of our data sources, we partnered with the Bay Area Health Inequities Initiative (BARHII) and Ensuring Opportunities the Campaign to End Poverty in Contra Costa County. Together, we staged two community engagement meetings, one in the city of Pittsburg and one in Antioch. Twenty community members total attended these meetings. Community members were given a brief overview of flooding risk and how the project would assess flooding within their communities. This deep-dive community engagement is new in the Adapting to Rising Tides (ART) process. ART recognized the need for more input from residents within the Project Area as these individuals are invested in adaptation outcomes near their homes. While engaging stakeholders within government, industry, and conservation organizations is certainly valuable there is no substitute for discussions with individuals living within communities.

We engaged community members with an exercise to capture the locations of assets they cared about, utilized, or knew to be important to the community at large. This was a mapping exercise where community members were provided a map of the whole Project Area and a map of their city and locations of relevant assets were captured on the maps. We asked community members to mark places where they worked, recreated, accessed transportation, and lived. We emphasized that we were asking individuals to think on both an individual (where is my home) and community (where does my community live) level. We provided maps that were both focused in on the local area (Pittsburg or Antioch) and the entire Project Area. We took these data and created a GIS layer where each asset was converted into a point so exposure analysis could be run. We gathered information from community members on 47 assets that were not included in any of our other data sets. These assets bridged numerous asset categories found in the other chapters of this report including Critical Services, People, Water Supply, and Natural Areas.

Community engagement is a key component of the ART process. In this project and past projects, community feedback has been used to correct flooding maps based on on-the-ground knowledge from members of the working group and others. This effort represents our first attempt to capture unique data from individuals living in the Project Area and analyze this as a unique source of data. Further details about community engagement can be found in the Appendix.

Issue Statement

Through community feedback, we received many assets that were not located in municipal or county datasets. This reveals a huge vulnerability for planners in not having a complete

and up-to-date data set of important community assets, revealing the need for community engagement and updated GIS data sets.

Asset Descriptions

Boat Ramps

Boat ramps were not explicitly captured in any of our other data sets. However, discussion of boat ramps was included in the analysis of the Bay Water Trail. See the Natural Lands and Outdoor Recreation Chapter for a more exhaustive examination of this asset within the Project Area.

City Hall

No city halls were included in our other data sets, representing a clear omission of an important community resource. City halls act as gathering places for community members and are key spaces of organization during emergencies.

Community members identified Antioch City Hall as part of this dataset.

Commercial Areas

Commercial land uses provide goods and services that are critical to the day-to-day functioning of neighborhoods and communities. Community members tend to shop and access services (e.g., banks, auto service, grocery stores, medical and dental services) near where they live and work. For community members with limited mobility, or for those that do not have a car and rely on public transit, proximity to goods and services is especially important. Commercial land uses of all kinds are also a source of local jobs, and they contribute to the social cohesion of a neighborhood or community. See the Business and Industry Sector Chapter for a more exhaustive examination of this asset within the Project Area.

Community members identified four general retail areas, the Slatten Ranch Retail Center, the Somerville Towne Center, the Downtown Pittsburg area, the Sand Creek Crossing Shopping Center, and the Shops At Fairview as part of this dataset.

Emergency Facilities And Critical Services

Emergency response facilities are critical in assisting others in the event of a disaster. These facilities may have service disruptions if exposed to flooding and the services they provide can be compromised if the facilities are damaged, or if access to and from the facilities are disrupted. Emergency response facilities can have an increased capacity to maintain function during a flooding event because police and firefighters are trained emergency responders. Fire stations that are equipped to assist communities with flooding have access to portable pumps and power. In addition, emergency response services are often provided through mutual aid agreements with other cities, districts and counties in the event of insufficient resources are available to address the emergency at hand. See the Critical Facilities and Services Sector Chapter for a more exhaustive examination of this asset within the Project Area.

Community members identified the PG&E Customer Service Office, Contra Costa County Employment, Opportunity Junction, Children Nutrition Services Department, and Contra Costa Waste Services as part of this dataset. Contra Costa County Employment provides jobs to residents. Opportunity Junction is a non-profit that offers career opportunities. Contra Costa Waste Services is a recycling center. These places are important to the community because they offer essential services and utilities to residents.

Hospitals

Public healthcare facilities help communities address a range of issues that are often influenced by physical, social and economic factors. These include chronic diseases, homelessness, communicable diseases, aging and maternal and child health. In Contra Costa County, Contra Costa Health Services (CCHS), public healthcare districts, and a variety of private facilities provide health services to those who live, work and recreate in the county. See the Critical Facilities and Services Sector Chapter for a more exhaustive examination of this asset within the Project Area.

Community members identified Kaiser Permanente Antioch Medical Center, Backup Emergency Operations, Kaiser Permanente, John Muir Health Urgent Care Center, and Antioch Convalescent Hospital as part of this dataset.

Industrial Areas

The Industrial Sector as described in the Contra Costa County General Plan includes industrial activities such as processing, packaging, machinery repair, fabricating, distribution, warehousing and storage, research and development, and similar uses as well as metalworking, chemical or petroleum product processing and refining, heavy equipment operation and similar activities. Industrial lands are diverse and include many different types of manufacturing, warehouse and light industrial sites, each with different characteristics designed to support different business operations.[ix] For example, heavy industrial sites typically have buildings designed to house specialized equipment needed for manufacturing, while light industrial sites where light assembly operations take place have less extensive physical plant and space requirements. See the Business and Industry Sector Chapter for a more exhaustive examination of this asset within the Project Area.

Community members identified both the Koch Carbon facility and a large industrial park as part of this dataset.

Low Income Housing

Low-income housing was not explicitly assessed in any other dataset. Information on vulnerable communities can be found in the People Sector Chapter, but this data occurs at the census block scale and does not capture individual structures designated for low-income housing.

Community members identified Contra Costa Housing Choice, West River Town Apartments, Silver Oak public housing, and Santiago Island Village as part of this dataset.

Marinas

Marinas provide public access to the Bay-Delta and often act as entry points for trail systems in the Project Area. Marinas were examined as part of the shoreline parks dataset. See the Natural Lands and Outdoor Recreation Chapter for a more exhaustive examination of this asset within the Project Area.

Community members identified the Pittsburg Marina as part of this dataset.

Nursing Homes

See the Critical Facilities and Services Sector Chapter for a more exhaustive examination of this asset within the Project Area.

Community members identified both the Antioch Senior Center, Country Place Assisted Living, Friendship Manor Senior, and Brentwood Care Center as part of this dataset.

Places Of Worship

Faith-based organizations play a critical role in building and maintaining community cohesion and resilience. They serve as gathering places for community members and help form community networks that are vital to resilience. To be resilient in the face of sea level rise and flooding, a community must have enough resources to navigate an uncertain future.[x] East Contra Costa County is home to a diverse array of people, practicing a multitude of faiths. Each place of worship and faith-based community organization throughout the Project Area serves a particular role in the resilience of its members and surrounding community both now, and in the face of hazards. See the Critical Facilities and Services Sector Chapter for a more exhaustive examination of this asset within the Project Area.

Community members identified both Grace Bible Fellowship of Antioch and St Anna's Episcopal Church as part of this dataset.

Post Offices

Post offices were not included in any of our other data sets. Loss of postal services can have large impacts during an emergency, especially if other means of long-distance communication, such as phone lines or internet access, are compromised.

Community members identified the Antioch post office as part of this dataset.

Protected Areas & Parks

Shoreline parks and Wildlife Refuges within the East Contra Costa project boundary serve a diverse array of purposes and are owned and managed by several different agencies and jurisdiction. Objectives for protected areas include natural area restoration, community engagement, and new partnerships with neighboring landowners.

Community members identified the Gaylord Sports Complex, Antioch City Marina Boat Ramp, L4 Babe Ruth Fields, and a community park in Antioch as part of this dataset.

Reservoir

Reservoirs were included in our Water Sector Chapter, but this data set only captured a single reservoir, the Pardee Reservoir. Understanding how flooding will impact water supply is of fundamental importance to understanding how resilient communities will be to flooding events. The lack of complete data about reservoirs represents a key missing data set in our Water Sector Chapter. See the Water Sector Chapter for a more exhaustive examination of this asset within the Project Area.

Community members identified the Antioch Municipal Reservoir, Contra Loma Reservoir, and the Los Vaqueros Reservoir as part of this dataset.

Schools

Schools often are critical resources during an emergency, serving as temporary shelters for displaced residents and as bases of operations for relief efforts. In addition, schools are important to community resilience as they help build and maintain social networks, serving as a place for neighbors to meet each other, get information, and receive support services if necessary. The ART Project Area is served by six public school districts and includes 76 public and private K-12 schools. The Antioch Unified School District is the largest school district in the ART Project Area with twelve elementary schools, four middle schools, six high schools, and one public/home partnership school. Pittsburg Unified School District has eight elementary schools, three junior high schools, two high schools, and one adult education school. See the Critical Facilities and Services Sector Chapter for a more exhaustive examination of this asset within the Project Area.

Community members identified Rocketship Delta Prep, Dozier-Libbey Medical High School, Carmen Dragon Elementary School, Prospects High School, Los Medanos College, and Pittsburg High School as part of this dataset.

Exposure To Current And Future Flooding

Detailed exposure analysis was performed for the 47 assets community members helped to identify. At any flooding level only 7 could be exposed to flooding. **While the physical structures may be safe from the impacts of flooding, additional pressure may be placed on these services as the users in exposed areas shift use to service providers outside of the flooded areas.** Similarly, access to these services may be impacted, even if the structures themselves are not flooded. **Impacts to transportation in the Project Area can limit or completely cut off certain parts of the population from accessing services in other parts of the Project Area.**

Of the assets provided by community members, only boat ramps, industrial areas, low income housing, and schools were impacted at any level of flooding. One of the two boat ramps (Antioch City Marina Boat Ramp), two of the low-income housing areas (West River Town Apartments and Santiago Island Village), one industrial area (the industrial park), and

one of the schools (Prospects High School) may experience flooding at 83" of sea level rise. A 100-year storm would expose one boat ramp and one area of low-income housing. Combined flooding from a 100-year storm event and 36" of sea level rise (SLR) exposes the same assets (Antioch City Marina Boat Ramp, West River Town Apartments, Santiago Island Village, the industrial park, and Prospects High School). A 100-year storm event combined with 83" of SLR could expose an additional industrial area (Koch Carbon) and low-income housing area (Contra Costa Housing Choice).

Data Considerations

At both of our community engagement meetings we had limited attendance from the local population. Though we managed to gather information about 47 assets important to those in attendance, total input is a limitation of this dataset. Similarly, these data are not exhaustive in any of its categories and represents opportunistic data gathered during our community engagement events. We did not ask participants to be systematic and instead encouraged them to share information about assets they used or knew to be important to the community. Finally, we know that this dataset in combination with our other data still does not capture every asset within the Project Area. Detailed analyses of most of the asset categories detailed below can be found in corresponding sector chapters, which are indicated in each of the asset descriptions when applicable.

Table 3-1. Total number of site or acres of community identified assets that may be located in the current 100-year storm event area and/or exposed to future sea level rise with a current 100-year storm event, the combination of sea level rise and a 100-year storm, or exclusively sea level rise.

Asset	Current 100-year Storm Event*	12" + 100-yr	24" + 100-yr	36" + 100-yr	83" + 100-yr	MHHW Today	12"	24"	36"	83"
Boat Ramps	1	1	1	1	1	--	--	--	--	1
City Hall	--	--	--	--	--	--	--	--	--	--
Commercial Areas	--	--	--	--	--	--	--	--	--	--
Community Facilities	--	--	--	--	--	--	--	--	--	--
Emergency Facilities	--	--	--	--	--	--	--	--	--	--
Hospitals	--	--	--	--	--	--	--	--	--	--
Industry	--	--	1	1	2	--	--	--	--	1
Low Income Housing	1	1	1	2	3	--	--	--	--	2
Marinas	--	--	--	--	--	--	--	--	--	--
Nursing Homes	--	--	--	--	--	--	--	--	--	--
Places of Worship	--	--	--	--	--	--	--	--	--	--
Reservoirs	--	--	--	--	--	--	--	--	--	--
Post Offices	--	--	--	--	--	--	--	--	--	--
Protected Areas	--	--	--	--	--	--	--	--	--	--
Schools	--	--	--	--	1	--	--	--	--	1
Total Acres/Sites Exposed	**2**	**2**	**3**	**4**	**7**	**--**	**--**	**--**	**--**	**5**

"--": Unexposed assets

MHHW: Mean Higher High Water refers to the average of today's daily highest tide and is used as the baseline for all flooding scenarios.

* Current 100-year Storm Event: The 100-year storm event reflected in these maps is not equivalent to the FEMA 100-year flood hazard zone.

Vulnerabilities

INFO: Lack of complete data for different asset categories necessitates this sort of community data gathering. Ad hoc data collection can be helpful for filling gaps, but it is unclear when data augmentation is exhaustive, which can lead to confusing results.
GOV: Local governments do not keep exhaustive datasets on numerous important assets such as churches, hospitals, elder care facilities, and community centers.
FUNC1: Existing data do not allow planners, nor their communities, to fully understand how key assets are affected by storm events or flooding, preventing adequate disaster planning.
FUNC2: Asking community members to fill data deficits requires an investment of time and emotional labor that may not be uniformly available across all communities within the Project Area.

Consequences

Society and Equity: Lack of complete data from formal entities may leave communities ill prepared to respond to flooding risk.

Environment: Incomplete data for protected areas may limit the ability of communities to leverage funds for green adaptation solutions, such as wetland restoration, which require complete environmental context to effectively implement.

Economy: Data deficits do not allow accurate predictions of how flooding will impact different sectors of the economy and make planning for these economic deficits less effective.

Critical Facilities and Services

Critical services including **healthcare, emergency response and law enforcement, schools that provide K-12 education, places of worship, and waste collection facilities are critical to public health and welfare**. These services **build and maintain community resilience and are key during and after any kind of natural disaster**, including flooding due to sea level rise or storm events. Hospitals and clinics, police and fire stations, schools, waste transfer stations and hazardous household waste sites **assist residents in preparation, response, and recovery to storm events** that cause flooding along the shoreline and inland.

Current and future flooding may impair these critical facilities and services. Flooding could prevent hospitals and health clinics from providing care for patients and police and fire stations from responding to emergencies. These **impacts on public facilities present significant emergency response challenges** because the populations they serve are vulnerable, including medically dependent individuals and young children. Community members' lives may become more at-risk during periods of recovery if public facilities, services, equipment, and supplies are inaccessible, damaged, or depleted.

Emergency Response Facilities

Emergency response facilities are critical in assisting others in the event of a disaster. These facilities and the services they provide can be compromised if the facilities are damaged or if access to and from the facilities are disrupted because of flooding. Emergency response facilities can have an enhanced capacity to maintain function. For example, fire stations that are equipped to assist communities with flooding can provide access to portable pumps and power. Police and firefighters are also trained emergency responders. In addition, emergency response services are often provided through mutual aid agreements with other cities, districts and counties in the event that there are insufficient resources available to address the emergency at hand.

Issue Statement

Fire stations and law enforcement facilities in the Project Area are vulnerable to flooding because their buildings have at-grade openings and were not built to withstand flooding. In addition, emergency response services rely on roads that could be flooded and power supplies that could be disrupted. Ensuring that emergency and disaster response services are not interrupted will require actions to improve the individual facilities and coordination with city, County, and state transportation agencies to ensure road access and utility services are maintained.

Asset Descriptions

Fire Stations

There are 17 fire stations in the Project Area, including ten East Contra Costa County Fire Protection District Stations (50/admin, 52, 53/vacant, 54, 57, 58, 59, 93, 94, and 95), six Contra Costa County Fire Protection District Stations (Admin East, 81, 82, 83, 85, 88), and one San Ramon Valley Fire Protection District Station (37).

Fire stations provide critical day-to-day public safety services as well as emergency and disaster response functions. In addition, the Contra Costa County Fire Protection District and East Contra Costa County Fire Protection District also provide response support during hazardous material spills, leaks, and releases.

Law Enforcement

There are 6 law enforcement facilities in the Project Area including the cities of Pittsburg, Antioch, and Oakley police departments, one Contra Costa County sheriff's office, and the Antioch detention facility. These facilities rely on functional roads, telecommunication infrastructure, and uninterrupted power, and therefore the services they provide could be disrupted even if they are not directly impacted by flooding. In addition, detention facilities may be challenging to evacuate in an emergency. If the incarcerated population is required to shelter in place, then services and supplies, including clean water and food, may be needed in addition to facility access so that employees can get to the facility to work.

Emergency Plans And Emergency Communications

Contra Costa County has an **Emergency Operations Plan** to coordinate response before, during and after an emergency. It can help facilitate multi-jurisdictional and interagency coordination in emergency operations, is used for pre-emergency planning, and establishes the framework of the California Standardized Emergency Management System (SEMS) and the National Incident Management System (NIMS) within Contra Costa County.[xi]

The County has a **Hazard Mitigation Plan**, which focuses on long- and short-term actions implemented before, during and after disasters. Hazard mitigation activities include planning efforts, policy changes, programs, studies, improvement projects, and other steps to reduce the impacts of hazards[xii].

Contra Costa County's **Disaster Debris Management Plan** provides a framework for managing debris after a disaster by addressing the roles and responsibilities of government organizations, private firms, and non-governmental organizations for debris operations.[xiii]

The **Contra Costa Operational Area Earthquake Concept of Operations Plan** is a scenario-specific application of the Contra Costa Operational Area Emergency Operations Plan (EOP). The Plan provides an outline of the Operational Area's response operations, tools for initial decision-making, and procedures for requesting and implementing resources from outside the jurisdiction.[xiv]

The **Airport Emergency Plan for Buchanan Field Airport** provides guidance to airport management personnel, tenants, and Airport mutual aid partners on procedures and roles and responsibilities for emergency actions.[xv]

Finally, emergency broadcast systems/community warning systems are integral to delivering and receiving critical information during emergencies. There are multiple systems throughout the Project Area, including: the Contra Costa County Community Warning System (CoCoCWS), sirens in special safety zones, the Emergency Alert System (EAS) on television and radio (KCBS 740 AM), the Telephone Emergency Notification System (TENS), cell phone alerts, NOAA Weather Radios, and Twitter and Facebook at CoCoCWS.[xvi]

Exposure To Current And Future Flooding

One of the 17 fire stations in the Project Area is within the current 100-year storm event area. An additional fire station is at risk of flooding in a combination of a 100-year storm event with 24" of sea level rise, or in flooding from 83" of sea level rise.

Two of the 6 law enforcement facilities in the Project Area are at risk of flooding in a combination of a 100-year storm event with 36" of sea level rise or in flooding from 83" of sea level rise.

Data Considerations

For the purposes of this analysis, emergency response facilities are defined as law enforcement facilities and fire stations. Additional facilities could be classified as necessary for emergency response, however due to data availability, were not assessed in this analysis. Health facilities, which also serve a critical emergency response role, were assessed separately in this report.

Data are sourced from the California Department of Public Health's Situational Awareness Application and cited as best available data. A complete, locally reviewed dataset is unavailable. Thus, the dataset used may not comprehensively represent every emergency response facility in the project boundary. Additional critical facilities are discussed in the Community Feedback sector chapter.

Table 4-1. Cumulative number of emergency response facilities that may be located in the current 100-year storm event area and/or exposed to sea level rise that might be impacted by a current 100-year storm, sea level rise combined with a 100-year storm, or exclusively sea level rise.

Asset	City	Current 100-year Storm Event*	12" + 100-yr	24" + 100-yr	36" + 100-yr	83" + 100-yr	MHHW Today	12"	24"	36"	83"
East Contra Costa Fire Protection District Station 95	Bethel Island	Yes	Yes	Yes	Yes	Yes	--	--	--	--	Yes
East Contra Costa Fire Protection District Station 58	Discovery Bay	--	--	Yes	Yes	Yes	--	--	--	--	Yes
Antioch Detention Facility	Antioch	--	--	--	Yes	Yes	--	--	--	--	Yes
Antioch Police Department	Antioch	--	--	--	Yes	Yes	--	--	--	--	Yes
Total in Project Area**		1	1	2	4	4	--	--	--	--	4

"--": Unexposed assets

MHHW: Mean Higher High Water refers to the average of today's daily highest tide and is used as the baseline for all flooding scenarios.

*Current 100-year Storm Event: The 100-year storm event reflected in these maps is not equivalent to the FEMA 100-year flood hazard zone.

Vulnerabilities

GOV1: Planning and resources are inadequate to address contingencies and secondary impacts associated with widespread or long-lasting sea level rise or storm event impacts, especially if emergency response facilities are affected. Widespread flooding that affects multiple jurisdictions may worsen these impacts because cities and counties rely on mutual-aid agreements with neighboring communities for support during disasters.
GOV2: Emergency response agencies rely on emergency plans. Not all agencies and communities are in compliance with existing plans, and the lack of coordination among local, regional, and state authorities increases the vulnerability of emergency response services and the people who rely on them.
PHYS1: Most emergency response facilities are susceptible to damage from sea level and groundwater rise because of their construction methods such as at-grade entrances and roll up doorways.
PHYS2: Emergency response facilities that have essential mechanical and electrical equipment below-grade or on the ground floor are vulnerable if flooded because this equipment may be damaged, leading to delayed ability to respond to emergencies and costly repairs.
FUNC1: Emergency response facilities cannot maintain operations if connections to power, clean water, and telecommunications infrastructure are not available, or if vehicles cannot easily access them. This is of particular concern for facilities that play a role in emergency response and recovery such as fire stations and police stations.
FUNC2: Emergency broadcast systems to warn and communicate to communities could become damaged or inaccessible during floods or power outages. Community members may also be unable to listen to emergency broadcast systems if power, cable or internet is down.
FUNC3: Disruption to water supplies could halt emergency response, including hospitals and fire protection.

Consequences

Society and Equity: Fire stations and law enforcement facilities respond to disasters and smaller emergencies in the community, benefitting residents and those who work in the area. Pittsburg and Antioch include communities with vulnerable characteristics and are relatively remote. Connecting residents and visitors with emergency response elsewhere in the county may lead to delays in response time and dangers to public health and safety.

Environment: Emergency response facilities and personnel play a critical role in hazardous materials spills and emergencies, including oil spills and other environmental contamination events. East Contra Costa County includes many major industrial sites with the potential for harmful chemical releases to occur if there is a widespread flood event. Emergency responders provide a critical function in helping protect environmental and human health following these events.

Economy: By protecting the local community, law enforcement and fire stations provide value to the local economy. If emergency response is delayed or impaired due to flooding,

recovery costs could rise and local communities and the region could suffer long-term economic consequences.

Healthcare Facilities

Public healthcare facilities help communities address a range of issues important to the region before, during and after emergencies. Healthcare facilities are one of the largest employers in the County and are essential to residents receiving routine care and vital to residents receiving emergency care during and after emergencies. Contra Costa Health Services (CCHS), public healthcare districts, and a variety of private facilities provide health services to those who live, work and recreate in the county. Within the Project Area there are four private acute-care hospitals and thirteen community clinics.

Issue Statement

Healthcare facilities need to ensure continuity and quality of care for community members, and rely on outside infrastructure, staff, and services to function. Individuals with ongoing medical needs are more likely to be vulnerable in a disaster event, and may require specialized care, equipment or supplies. None of the healthcare facilities in the Project Area flood during a major storm event or sea level rise. However, a major concern in Contra Costa County, particularly in areas with limited public healthcare facility options, is that community members may be unable to access healthcare if their neighborhoods are cut off from the rest of the County.

Asset Descriptions

Hospitals

This project analyzed four acute care hospitals in the Project Area that serve the communities throughout East Contra Costa County. All of these hospitals are located inland from the shoreline and not exposed to flooding.

Sutter Delta Medical Center is located in Antioch at Lone Tree Way and Davison Drive. It is a nationally ranked acute care hospital serving residents of Antioch, Brentwood, Byron, Discovery Bay, Knightsen, Oakley and Pittsburg.. Kaiser Permanente Delta Fair is located in Antioch at Delta Fair Boulevard and Somerville Road. Kaiser Permanente Antioch is located in Antioch at Sand Creek Road and Deer Valley Road. John Muir Medical Center is located in Brentwood at John Muir Way and Balfour Road.

Community Clinics

This project analyzed seven community clinics in the Project Area. None of these clinics are exposed to flooding.

Community clinics analyzed in the Project Area include: Fresenius Medical Care Diablo (Brentwood), Fresenius Medical Care Diablo (East Antioch), Fresenius Medical Care Diablo (West Antioch), Fresenius Medical Care Diablo (Pittsburg), Pittsburg Care Center, Inc. (Pittsburg), Sutter Delta Community Clinic (Antioch), BAART Antioch Clinic (Antioch),

Brighter Beginnings Family Health Clinic (Antioch), Planned Parenthood (Antioch), La Clinica (Oakley), La Clinica (Pittsburg), and RotaCare (Pittsburg).

Exposure To Current And Future Flooding

Of the seventeen hospitals and community clinics analyzed for this project, none are exposed to flooding at any water level scenario. While the physical structures may be safe from the impacts of flooding, additional pressure may be placed on these services as the users in exposed areas shift use to service providers outside of the flooded areas. Similarly, access to these services may be impacted even if the structures themselves are not flooded. Impacts to transportation can limit or completely cut off certain parts of the population from accessing services in other parts of the Project Area.

Data Considerations

Data are sourced from Contra Costa County and cited as best available data. The dataset used may not comprehensively represent every healthcare facility in the project boundary.

Vulnerabilities

GOV1: Healthcare facilities with emergency preparedness and response plans that do not consider current and future flooding are more vulnerable to coastal and riverine storm events.
FUNC1: Healthcare facilities may serve community members with limited mobility, or who have medical needs which require special equipment. Emergency evacuation of these facilities is challenging and may require sufficiently trained staff, a high level of coordination, specialized equipment, and an appropriate location to shelter those who were housed in these facilities.
FUNC2: Healthcare facility programs that serve individuals with limited economic resources, education, or English proficiency may not be easily replaced if the facility is damaged, inoperable, or inaccessible during a flood.
FUNC3: Healthcare facilities rely on outside infrastructure and services to function, such as roads, electricity, clean water, telecommunications, and deliveries of specialized supplies that may be vulnerable to flooding impacts.
FUNC4: Some healthcare facilities provide highly specialized medical care (e.g., dialysis centers) that patients need to access on a regular basis. These facilities serve a critical function that cannot easily be replaced, and generally do not have temporary or mobile back-up facilities available.
FUNC5: Providers of durable medical equipment serve community members that have specific medical needs and can serve individuals that are homebound and rely on a consistent delivery of medical supplies, (e.g., oxygen tanks). These service providers can only operate if roadways are functioning and patients' homes are accessible.
PHYS1: Most buildings, including healthcare facilities, are vulnerable because they are not designed to withstand flooding and may have sensitive equipment at- or below-grade.

Consequences

Society and Equity: Healthcare facilities serve community members who rely on these services for care and quality of life. Disruption of facilities can result in significant hardships

for these community members and their families, who may not have access to alternative care that is equivalent, affordable, and in an easily accessible location. Damage to neighborhoods where staff and clients live may also result in access issues and disconnection from healthcare services, and senior and healthcare facilities may not be able to function.

Environment: Healthcare facilities often store materials such as medical waste, pharmaceuticals, cleaners, and toxics that can impair water quality if released into the Bay-Delta or nearshore habitats.

Economy: Damage to healthcare facilities can result in financial burdens for building owners and operators, as well as staff that may end up out of work. Specialized medical equipment and the facilities that house them can be extremely costly and difficult to replace if damaged. Additionally, disruption or loss of healthcare services can result in community members needing alternative care arrangements or additional time off of work. This can lead to lost wages and may require family members or other caregivers also taking time off of work.

Faith-Based Community Organizations

Faith-based organizations play a critical role in building and maintaining community cohesion and resilience. They serve as gathering places for community members and help form community networks that are vital to resilience. To be resilient in the face of sea level rise and flooding, a community must have enough resources to navigate an uncertain future[xvii].

East Contra Costa County is home to a diverse array of people practicing a multitude of faiths. Each place of worship and faith-based community organization throughout the Project Area contributes to the resilience of its members and surrounding community both now and in the face of future hazards.

Issue Statement

While no faith-based organizations are exposed to flooding in the data the ART project used, there are others exposed to flooding that were not included in the analysis. Faith-based organizations act as community gathering points, a place to access resources, and as emergency shelter. Faith-based organizations that are accessible by unflooded roads need to be included in emergency response plans.

Asset Descriptions

This project analyzed eleven faith-based organizations in the Project Area. None of these clinics are exposed to flooding.

Places of worship analyzed in the Project Area include: Victory Baptist Church (Brentwood), Heritage Baptist Church (Antioch), Brentwood Lighthouse Baptist Church

(Brentwood), Golden Hills Community Church (Brentwood), Saint Ignatius Parish (Antioch), Congregation B'Nai Torah (Antioch), First Baptist Church (Antioch), Islamic Center of East Bay (Antioch), Most Holy Rosary Church (Antioch), Antioch African Methodist Episcopal Church (Antioch), and Pittsburg Islamic Center (Pittsburg).

Exposure To Current And Future Flooding

Of the **eleven faith-based organizations analyzed for this project, none are exposed to flooding at any water level.** While the physical structures may be safe from the impacts of flooding, additional pressure may be placed on these services as the users in exposed areas shift use to service providers outside of the flooded areas. Similarly, **access to these services may be impacted, even if the structures themselves are not flooded.** Impacts to transportation in the Project Area can limit or completely cut off certain parts of the population from accessing services in other parts of the Project Area.

Data Considerations

Data are sourced from the California Department of Public Health's Situational Awareness Application and cited as best available data. A complete dataset is unavailable. Thus, the dataset does not comprehensively represent every faith-based organizations in the project boundary.

Vulnerabilities

GOV1: Faith-based organizations play a critical role in building and maintaining community cohesion and resilience. Many of these organizations do not have the resources to fully participate in climate planning efforts, and government agencies lack the capacity to engage them in the robust and sustained partnerships that may be necessary to plan for climate change equitably.
GOV2: Faith-based organizations are unlikely to own or have control over the shoreline that they rely on for flood protection.
FUNC1: Faith-based facilities rely on roads and other infrastructure, and cannot maintain operations if flooded roads render them inaccessible. This is of particular concern for faith-based facilities that have a central role in community response and recovery.
PHYS1: Faith-based, community serving facilities with mechanical or electrical equipment, habitable spaces, or parking areas below-grade are vulnerable to both flooding and elevated groundwater. Buildings lacking weatherization and those not constructed from waterproof or non-corrodible materials are also vulnerable.

Consequences

Society and Equity: **Disruption of faith-based, community-serving facilities can result in significant hardships for community members who may not have access to alternative services**. Floodwaters can leave mold, mud, waste, and other toxics behind in structures; establishments that are unable to move, temporarily relocate, or adequately repair their facility after a flood are more vulnerable to these impacts.

Environment: Floodwaters that pass through neighborhoods can pick up and carry household debris and hazardous materials (such as cleaners, paint) that can impair water quality and habitats critical to supporting biodiversity.

Economy: Community members immediately affected may bear the cost of replacing or repairing facilities, the cost of temporary or permanent relocation, increased insurance costs, and dislocation from services. The broader community of taxpayers may also bear some of the expense of rebuilding public facilities and infrastructure, even if they do not themselves participate in affected services. Long-term evacuations could result in the permanent relocation of faith based organizations outside of a community, with associated economic consequences for the neighborhoods and residents that remain.

Solid Waste Disposal Sites

Landfills are solid waste management facilities where waste is or once was disposed. California law requires that open and closed landfills be maintained in a manner that protects public health, safety, and the environment. The California Department of Resources Recycling and Recovery (CalRecycle) is responsible for reviewing local permits for active solid waste facilities and for ensuring that operators demonstrate adequate financial assurances for closure and post-closure maintenance, corrective action, and operating liability. The Regional Water Quality Control Board (RWQCB) regulates both active and closed landfills to ensure that nonhazardous wastes do not enter surface waters or groundwater. RWQCB regulations include design standards for protective features (e.g., liners, covers), and requirements for environmental monitoring and cleanup when necessary. Some of CalRecycle and the RWQCB regulatory duties overlap (e.g., margin of safety), while others are split (e.g., the RWQCB's focus on water and leachate and CalRecycle's focus on landfill gas). The California Department of Toxic Substances Control (DTSC) regulates the disposal of wastes classified as hazardous, and other local, state, or federal agencies also issue permits or approvals for solid waste facilities.

Since 2009, RWQCB has required that landfills located adjacent to the Bay, Delta, rivers, or the ocean submit a long-term flood protection plan when updating existing Waste Discharge Requirements (WDRs). WDRs are most commonly updated every 10-15 years, or with a proposed expansion, significant changes in monitoring parameters or well locations, when ownership changes, or if new regulations are promulgated. Long-term flood protection plans must consider feasible options for achieving protection from the 100-year storm event in the face of rising sea levels and increasing flood frequency and intensity. Once in place, these plans must be updated every five years throughout the operational life and post-closure maintenance period of the landfill. In addition, the RWQCB can require consideration of long-term flood protection and sea level rise in actions requiring landfill implementation of site cleanup and other corrective actions.

Issue Statement

Increased flooding, groundwater levels, or tidal, wind, and wave energy could have significant consequences on landfill waste containment systems, potentially impacting public health and nearby ecosystems if contaminants are released. Current RWQCB long-term flood protection requirements are one opportunity for landfills to identify and address increased flood risks due to sea level rise. However, this approach is geared towards site-specific actions, and may not suffice in locations where landscape-scale responses are warranted.

Asset Descriptions

This project analyzed three exposed solid waste disposal sites (out of eight total) in the Project Area.

USS-Posco Industries Waste Management Site Unit II

This disposal site is in Pittsburg on the site formerly owned by United States Steel Corporation. It was used for disposal of metal slag, wire mill scale, waste oils, grease, paints, spent solvents, sodium dichromatem, and other waste through 1980. It was then occupied by and used as a landfill by various other industries. It is located at 900 Loveridge Road, directly adjacent to the Pittsburg shoreline.[xviii]

Jersey Island Ash Disposal Site

The closed disposal site is located eight miles east of Antioch on Jersey Island. Ash (of unknown source) was deposited over 17 acres. Most of the ash is deposited alongside the levees for enforcement. To date, local water quality has not been affected. The Department of Toxic Substances Control has declared the waste a non-hazardous material.[xix]

Holland Tract-Paper Pulp Landspreading

This facility was a paper pulp landspreading operation that suspended operation in 1992. The producer currently disposes waste to landfills in Contra Costa and/or Stanislaus County. Coordination with the Central Valley Regional Water Quality Control Board is necessary to determine status as a disposal site and probable rescission of monitoring requirements.[xx]

Other Sites

There are five solid waste disposal sites in the Project Area that are not exposed to the flooding scenarios analyzed by this project: Contra Costa SLF (Antioch), Antioch City Landfill (Antioch), Antioch Disposal Svc LF-Lynch Site (Antioch), Banks Pumping Plant Waste Fill (Discovery Bay), and US Steel-Posco Industrues-Pittsburg Disposal Site (Pittsburg).

Exposure To Current And Future Flooding

This project analyzed eight solid waste disposal sites within the Project Area. Three of these sites are located within the 100-storm event. The USS-Posco Industries Waste Management site in Pittsburg is at risk from 12” of sea level rise, and both the Jersey Island

Ash Disposal Site and Holland Tract-Paper Pulp Landspreading site are at risk from 83" of sea level rise. Five disposal sites analyzed are not exposed to flooding scenarios analyzed for this project.

Data Considerations

Data are sourced from the CalRecycle. A complete, locally reviewed dataset is unavailable. Thus, the dataset may not comprehensively represent every solid waste disposal site in the project boundary. Additionally, the data are in point form. In some cases, the boundary of the disposal site may reach beyond the boundary of the point data, introducing potential challenges in exposure analysis.

Table 4-2. Cumulative number of solid waste disposal sites that could be located in the current 100-year storm event area and/or exposed to sea level rise which would be affected at with a current 100-year storm, sea level rise combined with a 100-year storm, and from sea level rise exclusively.

Asset	City	Current 100-year Storm Event* (Exposed sites)	12" + 100-yr	24" + 100-yr	36" + 100-yr	83" + 100-yr	MHHW Today	12"	24"	36"	83"
Holland Tract-Paper Pulp Landspreading	Brentwood	Yes	Yes	Yes	Yes	Yes	--	--	--	--	Yes
Jersey Island Ash Disposal Site	Oakley	Yes	Yes	Yes	Yes	Yes	--	--	--	--	Yes
USS-Posco Industries Waste Management Unit II	Pittsburg	Yes	Yes	Yes	Yes	Yes	--	Yes	Yes	Yes	Yes
Total in Project Area		3	3	3	3	3	--	1	1	1	3

"--": Unexposed assets

MHHW: Mean Higher High Water refers to the average of today's daily highest tide and is used as the baseline for all flooding scenarios.

*Current 100-year Storm Event: The 100-year storm event reflected in these maps is not equivalent to the FEMA 100-year flood hazard zone.

Vulnerabilities

GOV: EPA regulations do not require addressing changing water tables for landfill design.
FUNC: Landfills require local road access for site management (e.g. monitoring, repairs or upgrades to waste containment systems). The landfill complexes in the Project Area rely on access roads that are vulnerable to flooding. Short-term disruption of road access during a storm, or longer-term disruption due to more persistent flooding may interrupt ongoing operations and make site management more difficult.
PHYS1: The volume and type of waste contained in shoreline landfills makes it extremely challenging and expensive to relocate them, therefore they need to be protected in place.
PHYS2: While landfill cover systems are designed to prevent water infiltration, leachate extraction systems may or may not be sufficient, depending on the volume of inundation, to collect and dispose of the additional volumes if flooding occurs.
PHYS3: Waste containment systems designed for existing conditions may not be adequate to withstand permanent flooding or increased storm energy depending on their design and maintenance and the location of the landfill. Higher water tables could threaten containment vessels by exerting additional hydrostatic pressure. Furthermore, saltwater can permeate clay liners that are impervious to freshwater. As a result, the risk of wastes leaching through the liners would increase, as well as the potential migration of these wastes onto neighboring properties. Inundation could create a ponding effect, which will cause increased leachate production by adding water to the volume of wastes in the landfill and causing varying degrees of saturation (which may affect structural stability).
PHYS4: The stability of waste containment facilities such as landfill caps or liners, caps over remediated sites, and slurry walls constructed to contain contaminants can be compromised by liquefaction during a seismic event. Liquefaction risk can increase due to rising groundwater levels, increasing the potential damage that could be costly to repair and would make the landfill more vulnerable to flooding.

Consequences

Society and Equity: Landfills pose a risk to public health if contaminants currently contained on-site are released to surrounding surface or groundwater.

Environment: There could be significant water quality impacts if contaminants are released from landfills into the adjacent natural areas that support a variety of species and habitats. Adjacent watersheds in the Project Area support a variety of species, including federally threatened coho salmon, federally threatened steelhead trout, black rails (threatened), and California Ridgway's rails (endangered).

Economy: A release of contaminants from closed or active landfills could strain local emergency resources and could result in high cleanup and recovery costs.

K-12 Schools

Schools are often critical resources during an emergency, serving as temporary shelters for displaced residents and as bases of operations for relief efforts. In addition, schools are

important to community resilience as they help build and maintain social networks, serving as a place for neighbors to meet each other, get information, and receive support services if necessary. The Project Area is served by six public school districts and includes 76 public and private K-12 schools. The Antioch Unified School District is the largest school district in the Project Area with twelve elementary schools, four middle schools, six high schools, and one public/home partnership school. Pittsburg Unified School District has eight elementary schools, three junior high schools, two high schools, and one adult education school.

Issue Statement

Schools are vulnerable to sea level rise and storm event impacts because of their physical construction and function. School buildings are not typically constructed to resist flooding, for example, they have at-grade entrances and critical equipment either at- or below- grade that cannot get wet. In addition, because there are young children, and possibly limited-mobility or special education students on campus, schools are especially difficult to evacuate in the event of an emergency. Even schools that are not directly impacted by flooding may be vulnerable to disruptions in transit, road networks, power, water, sewage, or other services.

Asset Descriptions

Discovery Bay Elementary School

Discovery Bay Elementary School is located in Discovery Bay as part of the Byron Union School District.

Delta Vista Elementary School

Delta Vista Elementary School is located in Oakley as part of Oakley Union Elementary School District.

Delta Vista Middle School

Delta Vista Middle School is located in Oakley as part of Oakley Union Elementary School District.

Vintage Parkway Elementary School

Vintage Parkway Elementary School is located in Oakley as part of Oakley Union Elementary School District.

Prospects High School

Prospects High School is located in Antioch as part of Antioch Unified School District.

Exposure To Current And Future Flooding

Of the 76 public and private schools in the Project Area, one school, Discovery Bay Elementary School in Discovery Bay, is exposed to 83” of sea level rise and is within the 100-year storm event area when combined with 24” of sea level rise or more.

Four other schools, Delta Vista Elementary School, Delta Vista Middle School, Vintage Parkway Elementary School, and Prospects High School are within the 100-year storm event when combined with 83" of sea level rise or more.

Data Considerations

Data are sourced from the Contra Costa County schools database and cited as best available data. A complete, locally reviewed dataset is unavailable. Thus, the dataset may not comprehensively represent every K-12 school in the project boundary. Additionally, the data is in point form. In some cases, the boundary of the school site may reach beyond the boundary of the point data, introducing potential challenges in exposure analysis.

Table 4-3. Cumulative number of schools that could be located in the current 100-year storm event area and/or exposed to sea level rise with a current 100-year storm, sea level rise combined with a 100-year storm, or exclusively sea level rise.

Asset	City	Current 100-year Storm Event*	12" + 100-yr	24" + 100-yr	36" + 100-yr	83" + 100-yr	MHHW Today	12"	24"	36"	83"
Discovery Bay Elementary School	Discovery Bay	--	--	Yes	Yes	Yes	--	--	--	--	Yes
Delta Vista Elementary School	Oakley	--	--	--	--	Yes	--	--	--	--	--
Delta Vista Middle School	Oakley	--	--	--	--	Yes	--	--	--	--	--
Vintage Parkway Elementary School	Oakley	--	--	--	--	Yes	--	--	--	--	--
Prospects High School	Antioch	--	--	--	--	Yes	--	--	--	--	--
Total in Project Area**		--	--	1	1	5	--	--	--	--	1

"--": Unexposed assets

MHHW: Mean Higher High Water refers to the average of today's daily highest tide and is used as the baseline for all flooding scenarios.

*Current 100-year Storm Event: The 100-year storm event reflected in these maps is not equivalent to the FEMA 100-year flood hazard zone.

Vulnerabilities

GOV1: Schools may be protected from flooding by shoreline features that are owned and managed by others, so improving the level of flood protection may require coordination of schools and school districts with other agencies and private entities.
GOV2: Evacuating schools and childcare centers may require careful coordination so that there is adequate supervision of young people and safe locations identified where families can be reunited. Some schools or childcare centers may not have the resources, capacity, or plans in place to manage an evacuation if there is an unexpected flood event.
GOV3: Schools may not have adequate resources or the capacity to improve their buildings, change the access to the school, or plan for the future relocation that may be necessary if the risk of flooding increases as sea level rises.
FUNC1: Many of the schools in the study area are already overcrowded. If one or more school is damaged, or is closed to provide disaster response, finding adequate alternative classrooms for the displaced student would be difficult.
FUNC2: Schools rely on roads, transit, electricity, water, wastewater, and communication services to function. Even short-term disruptions in these services could interrupt school activities and require school cancellations.
FUNC3: Schools need teachers and support staff to function. If staff cannot access the school because of flooding within or outside the area where it is located, school could be disrupted and may not be able to open.
FUNC4: Schools have an important role in emergency response as they both serve children which need special consideration to safely evacuate during disasters and they may serve as temporary shelters during and post-disaster.
PHYS1: Schools that have at- or below-grade facilities and/or mechanical and electrical equipment that could be damaged in a flood event are vulnerable to sea level rise and storm events.

Consequences

Society and Equity: Schools provide a critical community function and contribute to the well-being of the community. They also provide shelter during emergencies for students and community members. Damage to school buildings could result in education disruptions for students and financial burdens for school districts that could exacerbate already stressed schools and districts that face budget shortfalls and overcrowding. Schools that serve low-income, transit-dependent, or linguistically isolated students are even more vulnerable because of the populations they serve. Schools rely on communities for staff, access, funding, and, most importantly, students. If the neighborhoods where students and teachers live are damaged, schools may not be able to fully function.

Environment: Floodwaters that pass through neighborhoods can pick up and carry household debris and hazardous materials (such as cleaners, paint) that can impair water quality and habitats critical to supporting biodiversity.

Economy: If schools are damaged or access to them is disrupted there could be local economic impacts on families that have to either stay home with young children rather than

going to work or find and pay for day care. If schools are closed for long enough periods some families may choose to move to other areas so children can attend a neighborhood school, which could impact local businesses and the economy.

Delta Islands and Reclamation Districts

Acronyms

BIMID	Bethel Island Maintenance Improvement District
CCWD	Contra Costa Water District
CVP	Central Valley Project
EBMUD	East Bay Municipal Utility District
District	Reclamation District
DLIS	Delta Levees Investment Strategy
DWR	California Department of Water Resources
FEMA	Federal Emergency Management Agency
HMP	Hazard Mitigation Plan
ISD	Ironhouse Sanitary District
MSR	Municipal Service Review
Project Area	East Contra Costa Project Area
RD	Reclamation District
SOI	Sphere of Influence
SWP	State Water Project

On the Delta islands, flood control is managed through a series of century-old levees (see Figure 5-1) that hold back water from flooding the land. Levees were built to support farming and land reclamation practices; however these practices have caused substantial land subsidence in the areas behind the levees, increasing flood risks (see Figure 5-2). Reclamation Districts were formed in the early 20th century to manage these levees and drainage systems for the Delta islands. According to the 2015-2016 Contra Costa County Grand Jury, "Many of these levees are fragile, subject to degradation from natural forces and from the effects of human activities. While the Reclamation Districts that own and/or manage the levees have done much to protect and maintain them, often aided by State financial support, more can be done, even within the limits of the Districts' financial resources."[xxi]

Subsidence is the result of microbial oxidation of the drained highly organic soils of the Delta islands. Microbial oxidation is how microbes get energy and results in the decomposition of the organic soils, leading to voids in the soil structure. These voids in the soil collapse over time, lowering the elevation of the land, and causing subsidence. Ongoing subsidence occurs at a rate of between 0.5 and 1.5 inches per year, and results in an average of 6.7 tons of CO2 emissions per acre annually.[xxii] This means that subsidence causes the release of greenhouse gasses into the atmosphere, worsening climate change. The subsidence in combination with sea level rise creates ever greater bidirectional increase in pressure and risk of failure on levees.

Eight of these Delta islands have been designated by the California Department of Water Resources (DWR) as salinity barrier islands, meaning these islands play an important role in blocking saline water from the tidally influenced Bay from coming up into the freshwater Delta. The tidal influence from the Golden Gate goes all the way up to the Delta, and flooding of these salinity barrier islands could allow the movement of more saline water further upstream the Delta, affecting water supplies including the State Water Project (SWP), Central Valley Project (CVP), and water users in the Bay and throughout California (see Water chapter for more information on SWP and CVP). Six of the eight DWR-designated islands are within the Project Area. These Delta islands within the Project Area include: Bethel Island, Holland Tract, Webb Tract, Bradford Island, Jersey Island, and Hotchkiss Tract.

These salinity islands play such an important role in controlling salinity levels in the Delta that DWR installed a temporary rock barrier across False River west of Frank's Tract during the 2015 drought to protect the Delta from extreme salt intrusion due to the limited freshwater inflows from contributing rivers. Upstream reservoir releases are required to maintain adequate flow during droughts to reduce salinity, but in drought conditions low reservoir levels can limit this function. This rock barrier accommodated for reduced Delta outflows while minimizing saline water exports. The barrier was successful in keeping salinity below the required water-quality standards for export.[xxiii] When another drought occurs in the Bay Area, a similar temporary rock barrier might be needed again to maintain water quality.

Occasional levee breaches have occurred over the past several decades. Such breaches are called "sunny-day" breaches. Levee breaches typically result from physical impairment by uneven settling/subsidence, wave erosion, trees on the levee toppling, vegetation growth, burrowing rodents, construction, and/or driving or parking heavy vehicles on the crown of the levee.[xxiv] These hazards can mostly be managed by frequent maintenance and prompt repair. The top two hazards levees face is from earthquakes and high-water levels that could overtop or cause seepage. Delta levees currently have an average of 3-4% annual baseline probability of flooding.[xxv] Sea level rise will only increase these chances. According to the Delta Levee Investment Strategy (DLIS), "The probability of flooding in the Delta under the 2050 high SLR scenario is roughly twice the probability of flooding in 2012."

A breach of levees would have far-reaching impacts within the County because almost 30% of the County (based on the 2010 census) lives within the Delta island area.[xxvi] Many would lose their livelihood, assets and property. This area contains critical infrastructures such as roads, highways, the BNSF rail line, oil and gas wells, oil pipelines, power transmission lines, pumping stations, water intakes, and portions of CCWD's Contra Costa Canal and EBMUD's Mokelumne aqueduct (which supply almost 2/3 of the State's water).

A recent breach on the Upper Jones Tract levee (located in San Joaquin County), occurred June 3, 2004. It is unknown what the cause of the breach was, but it set off a California

State of Emergency followed by a Presidential Declaration of Emergency due to its far-reaching impact and importance. Contra Costa Water District (CCWD) has important water intakes near this Tract and was threatened with increasing salinity and contaminants on the island mobilized by floodwaters. CCWD had to stop pumping from their Old River Intake Station. The BNSF rail-line and East Bay Municipal Utility District's (EBMUD) Mokelumne Aqueduct run through the County. It took four weeks to plug the levee breach and six months to dewater the island, removing a total of 160,000-acre feet of water. The total cost of repairing the levee and pumping out the island was $30 million.[xxvii]

The Delta Stewardship Council (DSC) manages the DLIS, which helps the State to prioritize funding for levee improvements. The DLIS says the State could face the following risks from flooding:

- Loss of life from flooding
- Flood damages to structures, infrastructure, and crops
- Disruption of water deliveries or harm to Delta water quality for maintaining water supplies to the State (the Delta supplies water to over 25 million residents in the State and 3 million acres of agricultural land)[xxviii]
- Harm to high-value non-tidal habitat from flooding
- The effect on Delta communities through flooded properties, loss of farmland, and blocked/flooded road access

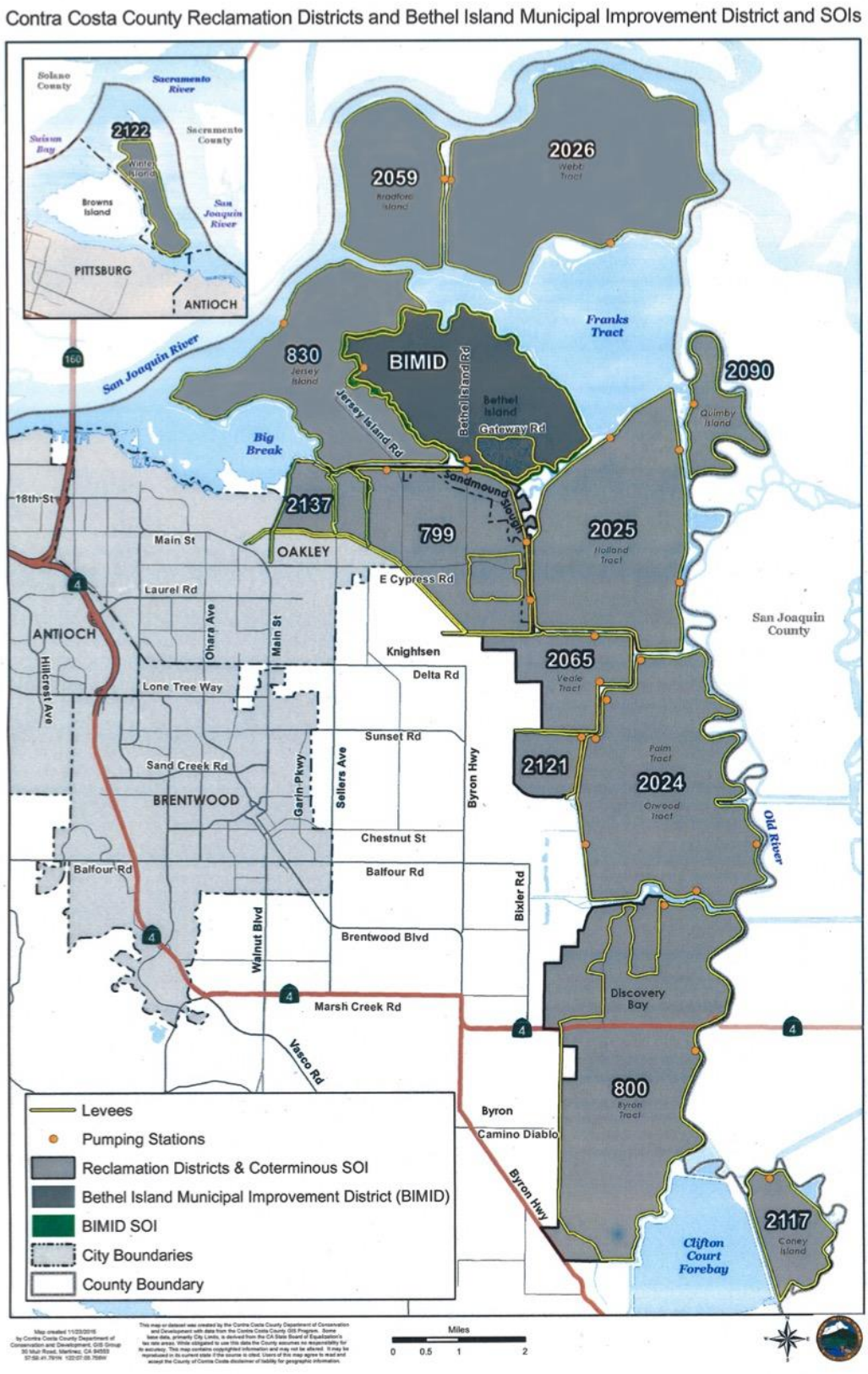

Figure 5-1. Levees (outlined in yellow), pumping stations (orange dots), and Reclamation Districts within the Project Area. (Source: Contra Costa County Department of Conservation and Development).

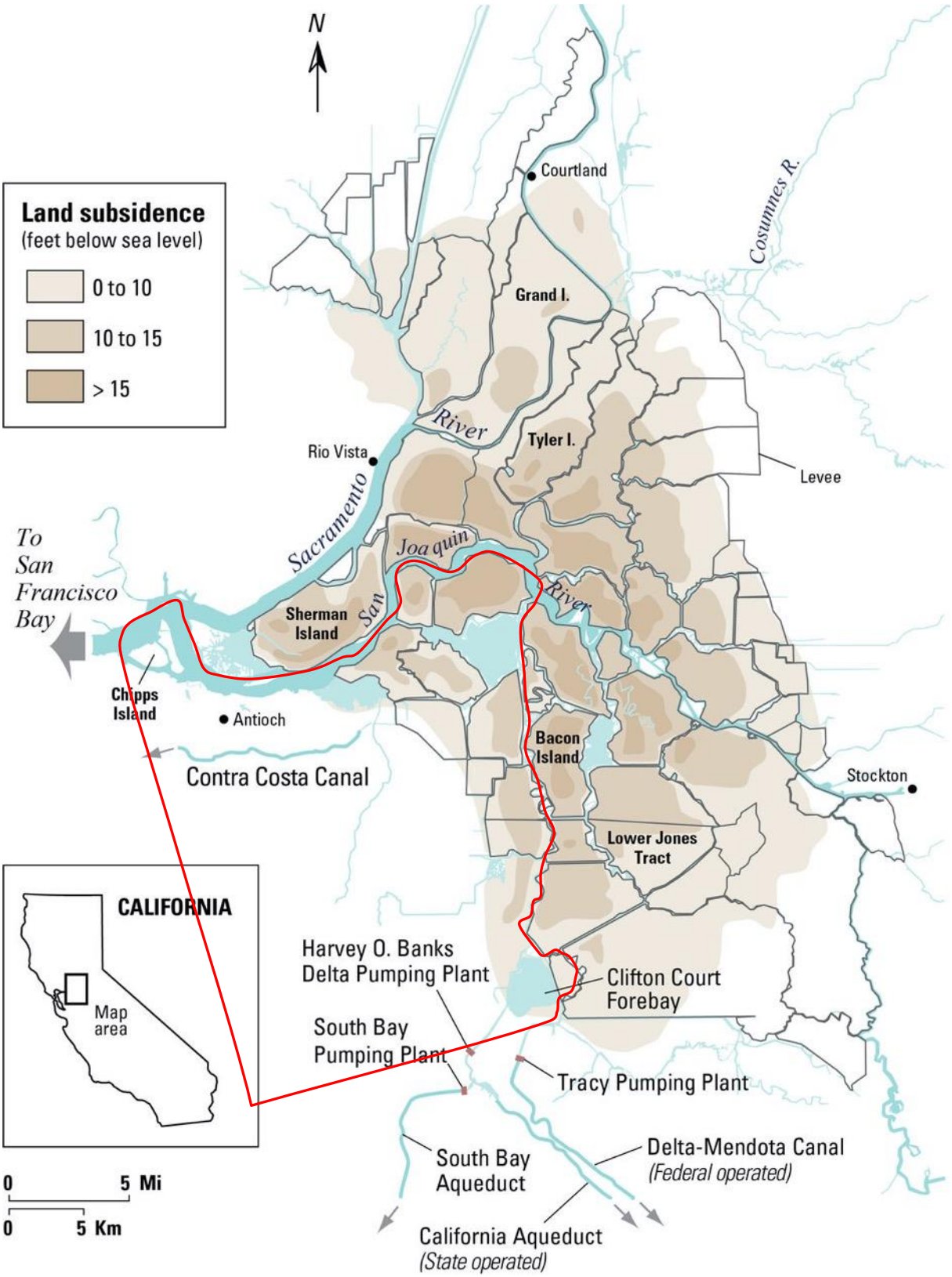

Figure 5-2. Subsidence in the Project Area (outlined in red) varies from 0 to 15 feet below sea level, significantly adding to the region's flood risk. (Source: USGS[xxix])

Levees and Reclamation Districts

Bethel Island's flood infrastructure is managed by the Bethel Island Maintenance Improvement District (BIMID). The other islands have Reclamation Districts (RD) that help manage, operate, and maintain the levees and pumping stations to keep the subsided islands dry. Reclamation Districts, as seen in Figure 5-1 and Figure 5-4, are as follows: Webb Tract (RD 2026), Hotchkiss Tract (RD 799), Jersey Island (RD 830), Holland Tract (RD 2025), Bradford Island (RD 2059), Byron Tract (RD 800), Orwood/Palm Tract (RD 2024), Veale Tract (RD 2065), Quimby Island (RD 2090), Coney Island (RD 2117), Bixler Tract (RD 2121), Winter Island (RD 2122), and Dutch Slough (RD 2137).

Delta island levee system upgrades are funded by the state, most prominently from the State Levee Subvention or Special Project funding. Levee design standards determine the amount of funding awarded for improvements. **However, there are various degrees of funding available depending on the design standards the levees meet.** These design standards are derived from the distance between the levee top and the FEMA 100-year floodplain level. Following a series of significant Delta floods in 1982 and 1983, the Federal Emergency Management Agency (FEMA) and the California Department of Water Resources (DWR) set new standards for non-project levees[4] in response to FEMA's concerns that they were not being maintained to sufficiently high standards to warrant federal disaster relief. All of the levees within the Project Area are non-project levees. FEMA set an initial Short-Term Hazard Mitigation Plan (HMP) that specified minimum standards for levee geometry and crown height. See Figure 5-3 for further details. There are three main design standards for levees:

1. **Hazard Mitigation Plan (HMP) standard**, which requires one foot above the 100-year floodplain. HMP has both height and width requirements, which can be seen in Figure 2. Levees that are HMP rated meet FEMA standards for disaster assistance. Raising levees to HMP may help State or Local Agencies secure federal funds for disaster relief in case of a significant Delta flood event.
2. **FEMA standard**, which requires three feet above the FEMA 100-year floodplain.
3. **Delta Specific PL 84-99 standard**, which requires three feet above the FEMA 100-year floodplain. Levees that meet this standard may be able to qualify for rehabilitation assistance by the U.S. Army Corp. of Engineers (USACE) when the levees are damaged or receive other federal aid.

HMP is seen as an intermediate standard; Delta levees should be modified to meet the federal PL 84-99 standard for maximum resilience. Levees that meet the PL 84-99 standard are eligible for 75% federal/25% local cost-share arrangements for levee repairs. Both HMP and PL 84-99 standards are tied to the 100-year flood water surface elevation

4 "Non-project" levees mean that the levees are not a part of any federal flood control program.

as calculated following the 1986 floods. The hydrology used to set these standards has not been updated since[xxx].

It is important to note that none of the agricultural levee standards provide a level of flood protection considered minimally sufficient for cities and towns by FEMA's National Flood Insurance Program. Additionally, none of these standards address the risks associated with earthquakes. All lands behind these levees, regardless of their certification, are considered to be at high risk of flooding[xxxi].

Much of the information below is adapted from the 2015 Contra Costa Countywide Reclamation District (RD) Municipal Service Review (MSR)/Sphere of Influence (SOI) Update (2nd Round), prepared for the Contra Costa Local Agency Formation Commission (LAFCO). This document focuses on 13 reclamation districts and one municipal improvement district that provide reclamation and levee maintenance services.

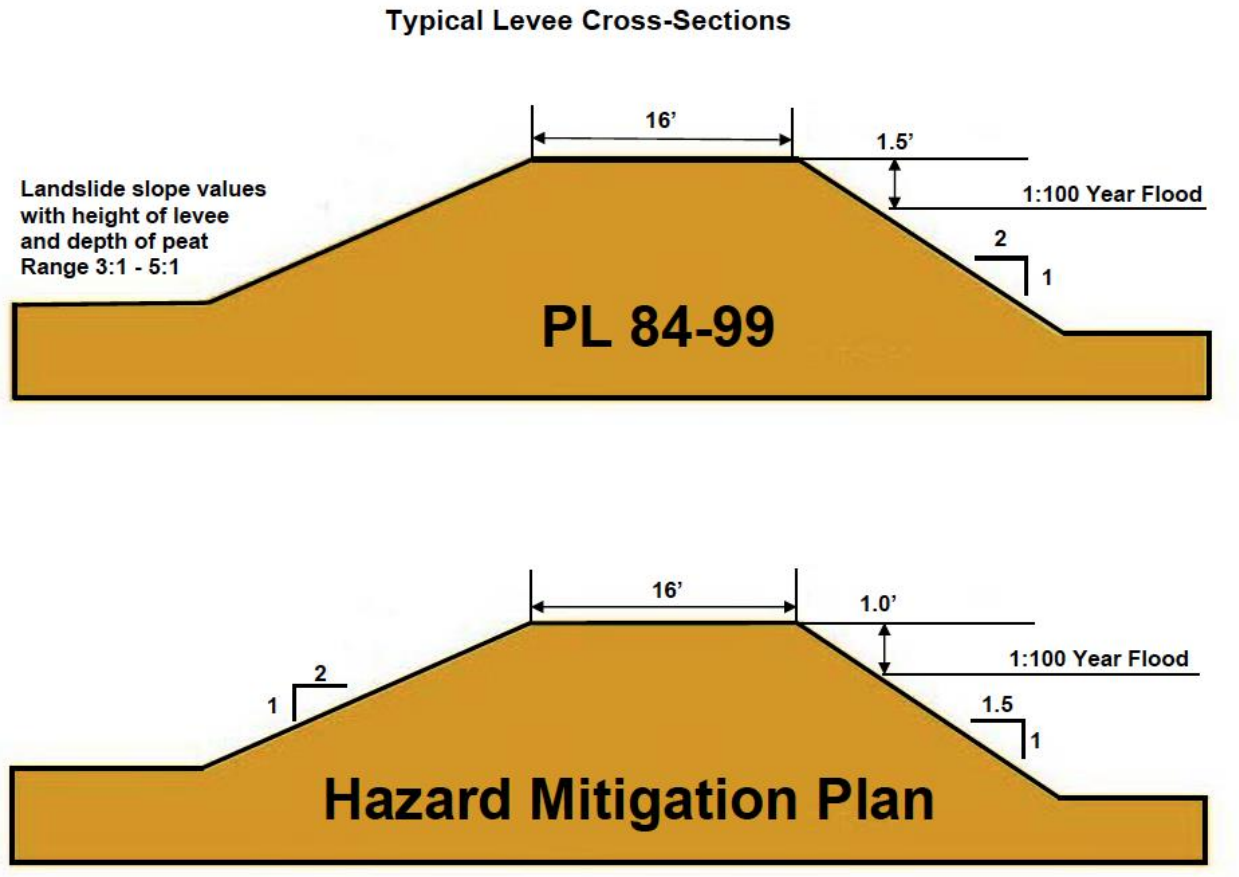

Figure 5-3. Levee design standards for Delta Specific PL 84-99 standards and Hazard Mitigation Plan standards.

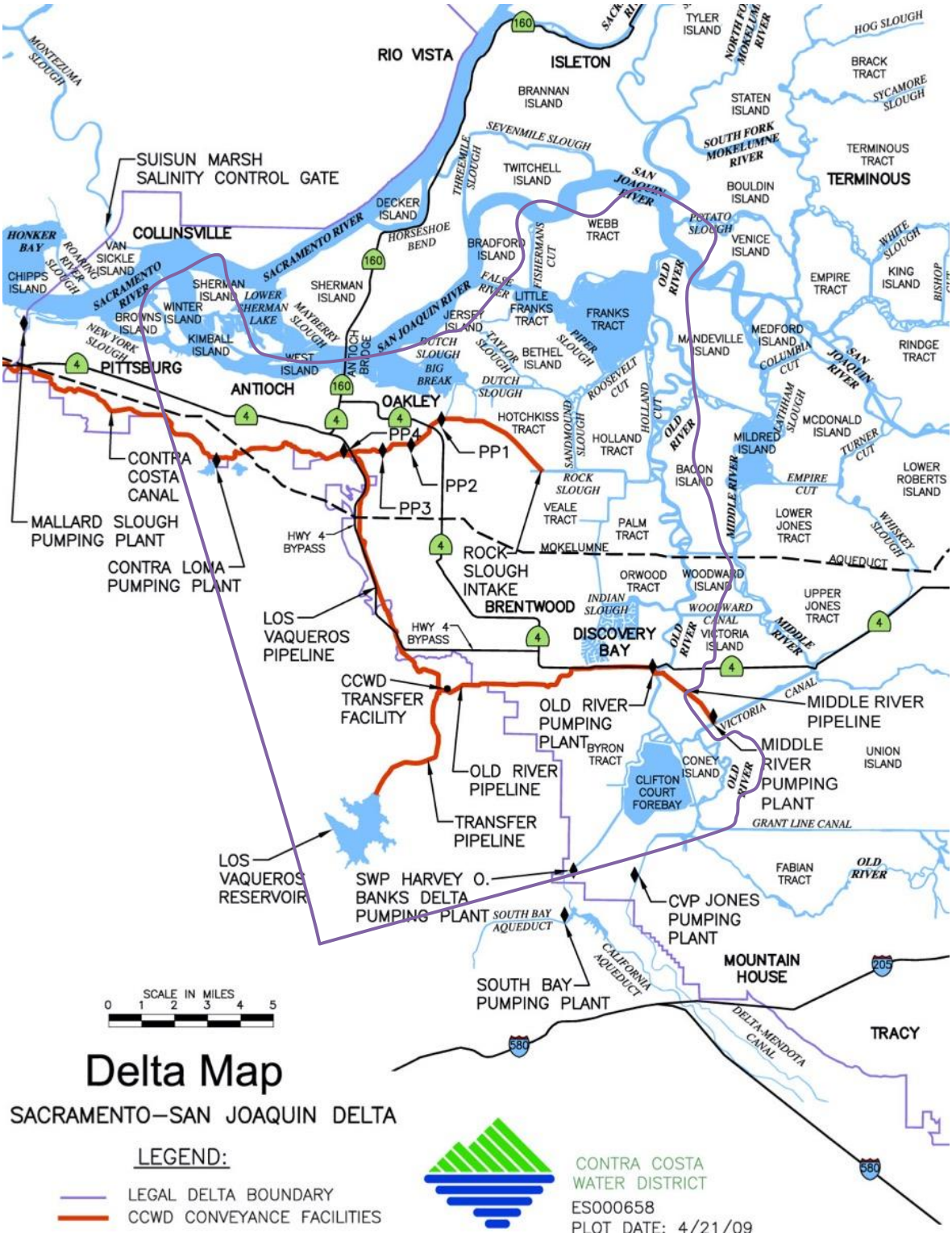

Figure 5-4. A map of the Delta islands. The Project Area is outlined in purple. (Source: Contra Costa Water District, 2009.)

Issue Statement

Breached Delta islands could negatively impact communities in the Delta by destroying their homes and their livelihoods, which includes the recreation/fishing industry and agriculture. Delta islands are important for protecting the state's water supply by preventing tidally influenced saltwater from going further up the Delta. This could change the types of ecosystems present in the Delta, as well as potentially fallow agricultural land from exposure to salt. Levees protect the islands and would experience increasing hydrostatic pressure from sea level rise. Failure of the levees that protect the islands means that the islands could be inundated with floodwater and no longer function as salinity barriers, putting a large majority of the state's water supply at risk from degrading water quality.

Asset Descriptions

For the locations of Delta islands, see Figure 5-4, above.

Bethel Island

Bethel Island is north of Oakley next to the San Joaquin River where fresh and salt water mix, especially during summer dry months. Bethel Island is one of eight Delta islands that California DWR has designated as critical to controlling water quality and salinity in the Delta. Bethel Island is one of the most populated islands in the Delta and would experience high fatalities if a levee breach occurred, and it is more probable that this failure will occur through seismic rather than hydraulic failure.[xxxii] DLIS labels Bethel Island as "very high priority" for levee investment. On Bethel Island, 11.5 miles of levees are managed by the Bethel Island Maintenance Improvement District (BIMID). In 2015, funding was inadequate to properly maintain and improve the BIMID levees.[xxxiii] The District also maintains flood ditches, canals, and the Island's two pump stations. Almost the entirety of the island is below sea level--only 5% remains as dry land. In 2015, voters approved an assessment fee to help fund maintenance and projects. Of the total 11.5 miles of BIMID levees, about 3.5 miles are below Delta Specific PL 84-99 standards and about one mile of the levee system was below the Hazard Mitigation Plan (HMP) standard of one foot above the 100-year floodplain. However, the one mile has since been elevated to the HMP standard.[xxxiv]

Webb Tract, RD 2026

Webb Tract, or Reclamation District (RD) 2026, is located northeast of Bethel Island and on the northern tip of the County line. It is one of the eight western Delta islands that the DWR has identified as critical to control the salinity in the Delta, protecting water quality to all Delta water users in the state. It is more probable that levee failure will occur through seismic rather than hydraulic failure.[xxxv] DLIS labels Webb Tract as "high priority" for levee investment. The RD is owned by the Metropolitan Water District of Southern California. The RD owns and maintains almost 13 miles of earthen levees, eight miles of irrigation canals, and two pumping structures. According to the Contra Costa LAFCO 2015 Countywide RD MSR/SOI Update, "In 2009, the RD reported that all 13 miles of levees met the Hazard Mitigation Plan (HMP) standard of one foot above the 100-year floodplain. Since that time, the RD has rehabilitated approximately 6.25 miles to PL 84-99 standards. The RD has also

completed a 5-year capital improvement plan and received $9 million in grant funding from the DWR with a long-term goal of upgrading the entire levee system to PL 84-99 standards."

Hotchkiss Tract, RD 799

Hotchkiss Tract, or RD 799, is located in Oakley south of Bethel Island. It has been identified by DWR as critical to control the salinity in the Delta and according to the DLIS, “Holland Tract shows the highest conceptual risk because potential levee failure at [this tract] can disrupt multiple water supply functions.” It is more probable that levee failure will occur through seismic rather than hydraulic failure.[xxxvi] DLIS labels Hotchkiss Tract as “high priority” for levee investment. The RD owns and maintains over 11 miles of earthen levees and four pumping stations. According to the Contra Costa LAFCO 2015 Countywide RD MSR/SOI Update, "In 2015, just over three miles of levees met FEMA flood protection standards (three feet above the 100-year flood plain), over five miles of levees meet the Hazard Mitigation Plan (HMP) standard (one foot above the 100-year floodplain), and the remaining three miles of levees met less than the HMP standard." And in 2009 the LAFCO stated that "the RD’s assessments are insufficient to provide adequate levee maintenance throughout the RD. The RD reports that it has managed to conduct general routine maintenance with the exception of being able to complete cleaning and maintenance of all the RD’s drainage ditches in a single year. “High priority” ditches continue to be routinely cleaned using contract labor, but budget constraints preclude cleaning all of the ditches at one time."

Jersey Island, RD 830

Jersey Island, or RD 830, is located directly west of Bethel Island and north of Big Break. It’s owned by the Ironhouse Sanitary District (ISD). It has been identified by DWR as critical to control the salinity in the Delta and it is more probable that levee failure will occur through seismic rather than hydraulic failure.[xxxvii] DLIS labels Jersey Island as “very high priority” for levee investment. The RD owns and maintains 15.5 miles of levees. According to the Contra Costa LAFCO 2015 Countywide RD MSR/SOI Update, "The RD’s territory is primarily used for agriculture, cattle grazing, and habitat preservation. RD 830 has a population of three persons. The most recent purchase of the island by the ISD has changed the focus of land use on the island. Recently, the RD entered into a $6 million agreement with DWR to serve as lead agency providing approximately $5.9 million worth of mitigation credits to all eligible Delta reclamation districts. RD 830 is in a unique situation whereby a single owner has been successful in implementing a habitat preservation plan for both funding and operational benefits on a regional scale. The Jersey Island levee system consists of 15.5 miles of levees, all of which meet HMP height standards, and 14.8 miles meet HMP width standards. A majority of the levees needing toe berms to buttress levee improvements were upgraded during the past six years. The RD’s system of three discharge pipes have been replaced and raised to address subsidence issues. The RD’s one pump station is scheduled to be relocated, and project design is underway."

Holland Tract, RD 2025

Holland Tract, or RD 2025, is located directly east of Hotchkiss Tract and southeast of Bethel Island. It has 18 landowners and about 27 residents. It has been identified by DWR as critical to control the salinity in the Delta and according to the DLIS, “Hotchkiss Tract show the highest conceptual risk because potential levee failure at [this tract] can disrupt multiple water supply functions.” It is more probable that levee failure will occur through seismic rather than hydraulic failure.[xxxviii] DLIS labels Holland Tract as “high priority” for levee investment. According to the Contra Costa LAFCO 2015 Countywide RD MSR/SOI Update, "Since 2009, 7.2 miles (or 65 percent) of the District’s levees have undergone rehabilitation. RD 2025 consists primarily of agricultural and recreational land uses. Local business activities include cattle grazing operations within the RD and marinas located along the Delta waterways, outside of the levees. Delta Wetlands Properties, the island’s largest landowner, owns approximately 75 percent of the island. The RD includes 11 miles of earthen levees, eight miles of irrigation canals and three pumping stations. Currently, all 11 miles of levees meet the PL 84-99 Standard. According to the RD, all planned levee rehabilitation is complete."

Bradford Island, RD 2059

Bradford Island, or RD 2059, is located north of Jersey and Bethel Islands on the northernmost tip of the County. It is inaccessible by road, requiring access by ferry service from Jersey Island. It has been identified by DWR as critical to control the salinity in the Delta and it is more probable that levee failure will occur through seismic rather than hydraulic failure.[xxxix] DLIS labels Bradford Island as “high priority” for levee investment. According to the Contra Costa LAFCO 2015 Countywide RD MSR/SOI Update, "The RD’s land uses include agricultural, commercial, residential, and gas extraction. Local business activity consists primarily of cattle grazing and small commercial operations. RD 2059 operates on revenues from property owner assessments, levee subvention grants and ferry service fees. The RD 2059 levee system consists of 7.5 miles of levees, all of which meet HMP height standards. Additional fill dirt and rock materials are being stockpiled on the island and used where most needed in cooperation with the levee upgrade and maintenance projects. Key infrastructure in the RD includes over seven miles of earthen levees, approximately seven miles of internal drainage ditches, and one pumping station. The RD concluded substantial levee rehabilitation projects in 2014."

Byron Tract, RD 800

Byron Tract, or RD 800, is 6,933 acres, and includes a large part of the unincorporated community of Discovery Bay, including about 7,656 residents. It also includes agricultural lands and some public facilities. DLIS labels Byron Tract as “very high priority” for levee investment. According to the Contra Costa LAFCO 2015 Countywide RD MSR/SOI Update, "The RD provides flood protection to approximately 3,718 properties, including 3,390 residential parcels and 26 non-taxable parcels. Although the predominant use is agricultural, there are varied urban uses within the community of Discovery Bay. RD 800 is co-sponsoring the proposed Kellogg Creek widening which will reduce water velocities in that section of Kellogg Creek and improve boater safety. The widening will also reduce bank erosion and sedimentation, and limit the need for dredging. RD 800 provides direct

services to three types of levees: agricultural non-project levees (9.7 miles), urban levees (6.5 miles), and dry land levees (2.7 miles). The RD began a comprehensive levee retrofit for the entire 9.7 miles of the agricultural levees to meet the PL 84-99 standard. The multi-phase project was completed in 2001. The agricultural levees completed accreditation through the Federal Emergency Management Agency (FEMA) in 2009 and remains current. An urban levee, constructed to FEMA urban levee standards, is located within the original Discovery Bay Development area. The levee segments (integrated into the development as streets or adjacent to streets) help protect the interior of the development including the elementary school, commercial areas, and non-waterfront residential areas. The RD's levees currently provide 100-year flood protection. One issue of note is that the RD provides drainage maintenance services in a portion of the agency area."

Orwood/Palm Tract, RD 2024

Orwood/Palm Tract, or RD 2024, is located near Brentwood on the eastern edge of the County and is about 6,574 acres. DLIS labels Orwood/Palm Tract as "high priority" for levee investment. According to the Contra Costa LAFCO 2015 Countywide RD MSR/SOI Update, "Current population is approximately 40, the majority being seasonal farmworkers. There are 18 landowners within the RD. The predominant land use (approximately 95 percent of the RD territory) within both tracts is agriculture. Portions of each tract are dedicated to wildlife habitat and waterfowl. The RD lands contain limited residential uses – two single family homes and ancillary farmworker and caretaker housing. Key infrastructure in the RD includes 14.6 miles of levees, as well as internal drainage channels, six pump stations, and one flood gate. Levees are constructed out of earthen materials with rock rip rap on the water side. The RD reports that all 14.6 miles of levee system meet the more stringent PL 84-99 standard. The RD has a 5-Year Plan to meet the adopted levee standard (which has a wider crown with corresponding side slopes) for the entire system. To achieve this goal, State funding will be required. Unlike other tracts, RD 2024 does not have a formal levee inspection procedure."

Veale Tract, RD 2065

Veale Tract, or RD 2065, is located west of Palm Tract and south of Hotchkiss and Holland Tracts. It includes over five miles of levees, internal drainage channels and two pump stations. DLIS labels Veale Tract as "other priority" for levee investment. According to the Contra Costa LAFCO 2015 Countywide RD MSR/SOI Update, the "levees are constructed out of earthen materials with rock rip rap on some sections of the water side. RD 2065 reports that 4.2 miles (84 percent) of existing levees meet the HMP Standard. Ground elevations within the interior of the tract vary between 4-feet below sea level to 2-feet above sea level. In the event of a high water event, the entire area would be covered by 5-11 feet of water. The entire RD is currently classified by the FEMA to be within the 100-year floodplain. In February 2014, the RD entered into a Project Funding Agreement with the DWR to provide up to 90 percent of the costs of a $2.2 million levee rehabilitation project."

Quimby Island, RD 2090

Quimby Island, or RD 2090, is located northeast of Holland Tract. It has a population of 1, sometimes with 4 or 5 seasonal workers. DLIS labels Quimby Island as “other priority” for levee investment. According to the Contra Costa LAFCO 2015 Countywide RD MSR/SOI Update, RD 2090 "provides levee maintenance services and internal drainage services through a contract with Ellis Island Farms, the sole landowner. The RD’s land uses are primarily agricultural. There are several structures on the island, including farm buildings, a primary residence, and farmworker housing. The population on the island is one person, with four to five additional persons seasonally. All of the 7.0 miles of levees within RD 2090 meet the HMP standards. The District reports that it has spent considerable resources on levee maintenance and repairs since 2009 and continues to seek funding to continue its rehabilitation efforts."

Coney Island, RD 2117

Coney Island, or RD 2117, is located in the most southeastern part of the County, directly east of Clifton Court Forebay. DLIS labels Coney Island as “other priority” for levee investment. According to the Contra Costa LAFCO 2015 Countywide RD MSR/SOI Update, "The RD covers 935 acres and is under the ownership of a single landowner. The owners live on site and farm portions of the land. The RD maintains 5.48 miles of levees. Hazard Mitigation Plan standards have been met for 98 percent of levee length. Since the 2009 MSR, improvements have been completed to approximately 75 percent of the levee length which now meet PL 84-99 standards. The District’s goal is to meet and exceed the PL 84-99 standard for all agricultural levees." According to the DLIS, Coney Island is highly vulnerable for seismically induced flooding.[xl]

Bixler Tract, RD 2121

Bixler Island, or RD 2121, is 584 acres and located along the western edge of the Delta, close to the City of Brentwood and within the town of Bixler. DLIS labels Bixler Tract as “other priority” for levee investment. According to the Contra Costa LAFCO 2015 Countywide RD MSR/SOI Update, “The RD is a family-run operation that provides maintenance services to non-project levees and internal drainage facilities, including one pump station. Land uses are primarily agricultural. RD 2121 maintains two miles of levees. Levees are constructed out of earthen material with concrete rubble and some rip-rap on the water side, but do not meet any particular standard. The property owners report that some improvements on the levees have been made with rock materials. Unless the RD reactivates its activities and financial reporting, it is assumed that no State Levee Subvention or Special Project funding will be available. RD 2121 does not have a formal levee inspection procedure and does not keep written inspection reports."

Winter Island, RD 2122

Winter Island, or RD 2122, is one of the westernmost Delta islands. It is a 428-acre island located northeast of Pittsburg in the Sacramento River. DLIS labels Winter Island as “other priority” for levee investment. According to the Contra Costa LAFCO 2015 Countywide RD MSR/SOI Update, “The property is only accessible by boat, and there is no ferry service to the island. The sole landowner, Winter Islands Farms, operates a private duck hunting club

on the island. There is no permanent residential population on the island. Maintenance of levees and flood control facilities are completed on an as needed basis and no regular assessments are collected or budgeted. RD 2122 maintains five miles of levees. The RD reports that 1.5 miles of levees meet the HMP standard, and the remaining 3.5 miles of levees do not meet the HMP standard. In June 2012, the District approved a Five Year Plan to support future planning efforts by the RD and the DWR. The RD's goal is to complete all rehabilitation work on the levees to meet the HMP levees standard within five years. Engineering, planning, mitigation and construction are expected to cost approximately $4.482 million, according to the RD's Plan. For purposes of the Plan, the RD assumes that funding will be available under the Special Projects Program and the Subventions Program over the five-year period."

Dutch Slough, RD 2137

Dutch Slough, or RD 2137, is a two-person occupied area of 785 acres located primarily within the City of Oakley along the coast of Dutch Slough. DLIS labels Dutch Slough as "very high priority" for levee investment. According to the Contra Costa LAFCO 2015 Countywide RD MSR/SOI Update, "RD lands make up a majority of the Dutch Slough Restoration Project site which was purchased by DWR in 2003. The design for the Dutch Slough Restoration is near completion and construction should begin once all environmental permits are secured. The RD is comprised of three landowners, one of whom has 93 percent of the assessed valuation. Landowners pay the expenses of the operations and projects not covered by levee grants from DWR. The RD received two Special Project Grants totaling $9.4 million. The RD reports that three miles of the 3.8 mile levee system meet HMP standards which were previously reported in the 2009 MSR. Since 2009, the District has raised the levee crown elevation as part its ongoing maintenance program."

Exposure To Current And Future Flooding

For the Delta islands that act as salinity barriers, assuming no levee breaks, at 36" sea level rise Bradford Island is the first island to get completely inundated. By 83" sea level rise or a current 100-year storm event, many of the other islands are completely inundated, including Bethel Island, Webb Tract, Jersey Island, and Holland Tract. At 12" sea level rise combined with a 100-year storm event Hotchkiss Tract is completely inundated. Any levee break would likely mean that inundation would occur much sooner. **Exposure means that the Delta islands are inundated with floodwater and can no longer function as salinity barriers to the tidally influenced Delta.** This could potentially cause saline water to travel further up the Delta.

Detailed exposure was not analyzed for the fourteen districts in the Project Area. However, the maintenance and restoration of the levees on these Delta islands are integral to protecting water quality for both residents in the Delta and for water exported to the rest of California through the State Water Project and Central Valley Project. Table 5-2, below, describes the levee design standards met, which is a good indicator of how well the island will be able to survive and adapt to sea level rise.

Other Risks

Levees also face risks from liquefaction, subsidence, and water seepage from under the levee.

Data Considerations

The levees in the Project Area were not analyzed for failure within the scope of this project and is a future area of research needed in order to understand the risk faced to these Delta islands. Additionally, salinity intrusion was not modeled in this project and is a future area of research needed in order to understand how water quality will change due to sea level rise and potentially flooded Delta islands.

Table 5-1. Total acres of exposed salinity barrier islands that may be located in the current 100-year storm event area and/or exposed to future sea level rise with a current 100-year storm, sea level rise combined with a 100-year storm, or exclusively sea level rise.

Asset	Total Island Area (acres)	Current 100-year Storm Event*	12" + 100-yr	24" + 100-yr	36" + 100-yr	83" + 100-yr	MHHW Today	12"	24"	36"	83"
Bethel Island	**3,465**	3,233	3,262	3,301	3,317	3,325	6.7	8.0	9.6	11.1	3,320
Webb Tract	**5,409**	5,398	5,406	5,408	5,409	5,409	1.0	1.4	1.8	2.4	5,409
Hotchkiss Tract	2,945	0.6	2,577	2,585	2,593	2,939	--	0.1	0.2	0.4	2,923
Jersey Island	3,463	3,436	3,446	3,458	3,461	3,463	0.8	1.1	1.5	2.0	3,462
Holland Tract	4,232	4,195	4,201	4,209	4,211	4,212	1.4	2.3	3.2	4.1	4,211
Bradford Island	2,136	2,126	2,132	2,135	2,136	2,136	0.6	0.8	1.0	2,121	2,136
Total Acres Exposed	**21,668 acres**	**18,390 acres**	**21,023 acres**	**21,096 acres**	**21,126 acres**	**21,484 acres**	**11 acres**	**14 acres**	**17 acres**	**2,141 acres**	**21,461 acres**

"--": Unexposed assets

MHHW: Mean Higher High Water refers to the average of today's daily highest tide and is used as the baseline for all flooding scenarios.

* Current 100-year Storm Event: The 100-year storm event reflected in these maps is not equivalent to the FEMA 100-year flood hazard zone.

Table 5-2. Total miles of Delta island levees in the Project Area meeting HMP, FEMA, or PL 84-99 levee design standards (as of 2015).[xli]

Delta Island Name	Reclama-tion District	Salinity Barrier Island	Total Miles of Levee	No Standard	HMP Standard	FEMA Standard	Delta Specific PL 84-99 Standard	Miles Needing Rehabilitation
Bethel Island	BIMID*	Yes	11.5 mi agricultural; 3 mi urban	--	11.5 mi	--	8 mi	3.5 mi
Webb Tract	RD 2026	Yes	12.9 mi	--	12.9 mi	--	6.25 mi	NP
Hotchkiss Tract	RD 799	Yes	11.7 mi	3.3 mi	5.2 mi	3.2 mi	--	NP
Jersey Island	RD 830	Yes	15.5 mi	--	14.8 mi	--	--	5.9 mi
Holland Tract	RD 2025	Yes	11 mi	--	--	--	11 mi	--
Bradford Island	RD 2059	Yes	7.5 mi	0.5 mi	7 mi	--	--	0.5 mi
Byron Tract	RD 800	--	18.9 mi	0.7 mi	--	18.9 mi	9.7 mi	--
Orwood/ Palm Tract	RD 2024	--	14.6 mi	12.4**	14.6 mi	--	14.6 mi	--
Veale Tract	RD 2065	--	5.1 mi	0.9 mi	4.2 mi	--	--	0.9 mi
Quimby Island	RD 2090	--	7 mi	--	7 mi	--	--	N/A
Coney Island	RD 2117	--	5.48 mi	--	5.4 mi	--	4.12 mi	NP
Bixler Tract	RD 2121	--	2 mi	2 mi	--	--	--	NP
Winter Island	RD 2122	--	5 mi	3.5 mi	1.5 mi	--	--	3.5 mi
Dutch Slough	RD 2137	--	3.8 mi	0.8 mi***	3 mi	--	--	3.8 mi

"--": 0 or No **NP**: Not provided **N/A:** Not applicable

* Not a Reclamation District

** RD standard is met, not no standard

*** Not all levee cross-sections meet the HMP Standard but vary slightly from the levee height requirement.

Vulnerabilities

GOV1: Protection of salinity barrier islands will require state, regional, and local government coordination.
GOV2: Funding for levee upgrades normally requires state and federal assistance.
GOV3: Some islands do not have the funds to adequately maintain their levees and drainage system.
INFO1: It is uncertain how saline intrusion from the Bay will manifest during sea level rise.
INFO2: It is unclear how rising groundwater will affect inundation of these salinity barrier islands.
INFO3: It is uncertain how increasing forces, including increased hydrostatic pressure, rising groundwater, and increased storm surges due to sea level rise will impact levee stability.
PHYS1: Many Delta islands have subsided and are below sea level and rely on levees and drainage/pumping systems to keep the land dry. Pumping systems rely on electricity to maintain function.
PHYS2: Keeping subsided islands dry through pumping can make subsidence worse.
PHYS3: Rising sea levels and subsided land can put extra strain/hydrostatic pressure on levees and increases under-levee water seepage, potentially causing them to fail.
FUNC1: If Delta islands are breached, it can cause a similar situation to a vacuum, pulling saline water up from the Bay. Once saline conditions have been established in the Delta, it is difficult to return to freshwater conditions. This puts East Bay, Delta, State Water Project and Central Valley Project water users at risk from reduced water quality.
FUNC2: At-risk members of the community, the elderly, young children, people with disabilities, etc. would be particularly vulnerable without replacement water supplies in the event of disruption.

Consequences

Society and Equity: Saline intrusion from the tidally-influenced Bay is a major issue since breached Delta islands will change the salinity in the Delta. This could affect drinking water quality for residents in the East Bay and Delta, who get most of their water from the Delta. Other Californians who get their water from the State Water Project or Central Valley Project would also be impacted.

Breached Delta islands could also negatively impact communities in the Delta by destroying their homes, livelihoods, roadways, and farms.

Environment: Saline intrusion from the tidally-influenced Bay is a major environmental issue since breached Delta islands will change the salinity in the Delta. This could change the types of ecosystems present in the Delta. Levee and island integrity protects opportunities for ecosystem restoration since flooded islands would be prohibitively deep for restoration. Additionally, the Central Valley Project has a certain minimum volume of water flows dedicated to the environment, which if stopped, would negatively impact the ecology of these streams and rivers.

Economy: Breached Delta islands could impact communities in the Delta by destroying their homes and livelihoods. This region depends on recreation and farming for livelihoods. If brackish water flooded agricultural lands, it could cause the land to become fallow from salt, ruining it for farming. Additionally, many of California's farmers use water from the Central Valley Project for their farms, homes, factories and the environment. The State Water Project also serves water to farms, homes and industry, and serves more than 27 million people in northern California, the Bay Area, the San Joaquin Valley, the Central Coast and southern California. Disruption to this water supply would negatively impact the regional and national economy, especially national food supply.

Energy and Fuel Supply

The East Contra Costa ART Project analyzed pipelines, natural gas stations, electrical power distribution (substations), energy generation facilities, and oil and gas fields for vulnerability to sea level rise. Energy infrastructure provides electricity and natural gas to homes and businesses, as well as fuel for multiple modes of transportation, within the East Contra Costa Project Area and beyond to other parts of the region, state, and nation. Energy sector assets share similar vulnerabilities and their damage or disruption can have wide ranging consequences on day-to-day community function as well as emergency response capacity.

The energy industries and infrastructure discussed in this assessment are regulated by a number of State and Federal agencies. The Department of Transportation's (DOT) Pipeline and Hazardous Materials Safety Administration (PHMSA), through the Office of Pipeline Safety (OPS), is the federal regulatory agency responsible for the oversight of pipeline safety. At the State level, the California Public Utilities Commission (CPUC) regulates electric and gas utilities. The State Fire Marshal acts as an agent of PHMSA for pipeline safety. For example, the State Fire Marshal requires some pipeline standardization, such as for pipeline coating and burial depth. They conduct periodic inspections of transmission pipelines, including for corrosion or leak detection, and also survey pipeline right-of-ways for excavation activities or population encroachment.

The consequences of flooding for energy and fuel supply in East Contra Costa County are potentially wide ranging. In 2018, Contra Costa County used approximately 66% more natural gas than neighboring Alameda County[xlii], and much of this infrastructure could be exposed by today's 100-year storm event.[xliii] Loss of power can cause economic losses both to the power industry and power users, such as local businesses. Indirect costs to individual power users are also of concern, but are much more difficult to quantify.[xliv] Power loss can also disrupt access to critical services, limit transportation options (such as electric rail), worsen flooding impacts if pumping stations stop functioning, and slow the transportation of goods and services.

Pipelines

Pipelines transport hazardous liquids and gases, including crude oil, refined petroleum and natural gas to different locations throughout the region for processing or for use. Northern

Contra Costa County is the epicenter of refineries and industrial uses in the Bay and Delta. Pipelines, which span the County, are an essential component to the regional economy. The pipeline system serves an area that extends beyond the region as products are often transported throughout Northern California and beyond. Pipelines are usually buried at a depth of 3 to 4 feet and comprised of high-carbon steel, although natural gas distribution systems have been constructed from many different materials including cast iron, steel, copper, and plastic pipe (commonly installed today for gas distribution systems). The location, construction and operation of these systems are generally regulated by federal and state agencies. Many are located in railroad and state road or highway right-of-ways, and some cross natural areas such as marshes, flood control channels and streams.

Issue Statement

Buried pipelines are directly and indirectly sensitive to higher groundwater table and salinity intrusion. Exposure to saltwater can corrode pipelines that are not protected as specified in federal and state regulations. Rising groundwater levels could increase liquefaction potential leading to additional damage during a seismic event. In the event of flooding, pipelines that are not weighted or anchored may float and become exposed, particularly during prolonged flooding and in marshy or sandy soils. Erosion during storm events could also expose and damage pipelines. Damage to pipelines could result in service disruptions as well as threats to public safety and the environment in the event of an explosion or release of hazardous contents. Abandoned pipelines that are not well documented and may still have remnant toxic substances add an additional vulnerability.

Asset Descriptions

There are five main owners of natural gas pipelines within the Project Area. Pacific Gas and Electric (PG&E), CPN pipeline (a subsidiary of Calpine), and Venoco, Inc. own 64%, 19%, and 17%, respectively, of the natural gas pipeline within the Project Area. Within the Project Area, all natural gas pipelines are 1”-12” diameter pipes that transport liquefied natural gas[xlv]. The natural gas pipelines are located on the Antioch shoreline and crossing the Broad Slough (between Winter and Kimball Islands), three pipelines crossing the San Joaquin River near the Antioch Bridge, two lines going from Brentwood and Oakley crossing into Jersey and Bethel Islands, from Discovery Bay northeast to Old River, and from Discovery Bay down to Clifton Court Forebay.

Oil pipelines are owned by Kinder Morgan (64%) and Chevron (36%). Two oil pipelines are located in Byron going southeast along Byron Highway and one pipeline goes from Discovery Bay east to Woodward Island.

Additionally, abandoned pipelines left within the Project Area may still have residual toxic substances, such as oil. These are not well documented or mapped.

Exposure To Current And Future Flooding

Detailed exposure analysis was performed for 75,762 miles of natural gas pipeline and 20,757 miles of oil pipeline within the Project Area. Exposure indicates flooding of the area

where the pipeline is located. Depending on duration and extent of flooding, impacts may vary. Within the current 100-year storm event area, there are 30,899 miles (41%) of natural gas pipeline and 4,801 miles (23%) of oil pipeline that may be exposed to flooding. Only modest amounts of pipeline may be impacted by sea level rise of up to 36", with 1,314 miles (2%) of the natural gas pipeline and 14 miles (0.1%) of the oil pipeline length potentially exposed flooded. Alternatively, sea level rise of 83" may flood 52,196 miles (69%) of natural gas pipeline and 4,955 miles (24%) of oil pipeline. When this most extreme sea level rise scenario is combined with a 100-year storm event (100-year storm with 83" SLR), 58,184 miles (77%) of natural gas pipeline and 7,946 miles (38%) of oil pipeline may be exposed to flooding.

Data Considerations

Due to the type of analysis conducted, the miles of pipeline reported exposed to existing and future flooding may not be unique and likely overlap.

Table 6-1. Total number of miles of natural gas pipeline that may be located in the current 100-year storm event area and/or exposed to future sea level rise with a current 100-year storm, sea level rise combined with a 100-year storm, or exclusively sea level rise.

Asset	Management	Current 100-year Storm Event*	12" + 100-yr	24" + 100-yr	36" + 100-yr	83" + 100-yr	MHHW Today	12"	24"	36"	83"
Natural Gas Pipeline	**PG&E**	24,913	34,453	40,640	40,981	42,648	104	138	198	898	41,015
Natural Gas Pipeline	**CPN**	5,977	10,268	10,712	10,982	11,848	39	63	95	408	11,169
Natural Gas Pipeline	**Venoco**	9.5	10	11	12	3,688	--	--	6.9	8.2	12
Total Miles Exposed	**-**	**30,900**	**44,731**	**51,374**	**51,975**	**58,184**	**143**	**201**	**614**	**1,314**	**52,196**

"--": Unexposed assets

MHHW: Mean Higher High Water refers to the average of today's daily highest tide and is used as the baseline for all flooding scenarios.

* Current 100-year Storm Event: The 100-year storm event reflected in these maps is not equivalent to the FEMA 100-year flood hazard zone.

Table 6-2. Total number of miles of oil pipeline that may be located in the current 100-year storm event area and/or exposed to future sea level rise with a current 100-year storm event, sea level rise combined with a 100-year storm, or exclusively sea level rise.

Asset	Management	Current 100-year Storm Event*	12" + 100-yr	24" + 100-yr	36" + 100-yr	83" + 100-yr	MHHW Today	12"	24"	36"	83"
Oil Pipeline	**Kinder Morgan**	4,801	4894	4,913	4,950	7,840	4.6	7.6	10	14	4,955
Oil Pipeline	**Chevron**	--	--	--	--	106	--	--	--	--	--
Total Miles Exposed	**-**	**4,801**	**4,894**	**4,913**	**4,950**	**7,946**	**4.6**	**7.6**	**10**	**14**	**4,955**

"--": Unexposed assets

MHHW: Mean Higher High Water refers to the average of today's daily highest tide and is used as the baseline for all flooding scenarios.

* Current 100-year Storm Event: The 100-year storm event reflected in these maps is not equivalent to the FEMA 100-year flood hazard zone.

Vulnerabilities

INFO1: Lack of easily accessible information on pipeline material, age, eccentricities, and weld type make it difficult to understand the vulnerabilities of the different pipelines to sea level rise and the consequences that could occur if they are impacted.
GOV1: Existing operations and maintenance plans may not be well-coordinated or adequately shared with emergency responders and other relevant entities. Additionally, the plans may not clearly describe procedures for shutdown and other measures to minimize damages during a storm event.
GOV2: Pipelines are often co-located with other interconnected infrastructure, like railroads and roads, so governance decisions may require coordination between these agencies, in addition to other stakeholders owning adjacent parcels.
PHYS1: Pipes that are not properly protected are sensitive to corrosion if exposed to saltwater, either by flooding or saltwater intrusion. Sea level rise may cause increasingly saline conditions in the Delta. The material covering some pipelines may be sensitive to corrosion, which could result in direct exposure and potential damage of the pipeline.
PHYS2: Permanently flooded pipelines could become buoyant and float if not weighted or anchored.
PHYS3: Rising groundwater levels increases the risk of liquefaction, which could damage buried pipelines in a seismic event.
PHYS4: Abandoned pipelines left within the Project Area may still have residual toxic substances, such as oil, and may release these substances into the environment if saturated with groundwater or floodwaters. These are not well documented or mapped.

FUNC1: Damage to pipelines could result in service disruptions, affecting critical services, transportation, businesses and homes. Damage to pipelines could also result in threats to public safety and the environment in the event of an explosion or release of hazardous contents.
FUNC2: Pipelines function as interconnected systems such that even if pipelines in the project area are protected all parts of the regional pipeline network must be in working order to maintain system wide function.
FUNC3: Although many pipeline segments have safety valves to allow for a shutdown in an emergency, this process may take some time. Therefore, advance warning is necessary if the pipeline is to be safely shut down.

Consequences

Society and Equity: Direct societal consequences of pipelines flooding will likely depend on the severity of disruption of fuel and natural gas transport and distribution. However, if damaged pipelines explode or leak there could be health risks to nearby populations.

Environment: Pipelines may carry natural gas, petroleum products and/or hazardous materials, which, if released, would harm natural area habitats and sensitive species.

Economy: If the pipelines are disrupted, the movement of goods (oil and gas) would either be suspended or transferred to an alternate means of transport. Pipelines in East Contra

Costa connect to the refineries in West County, which are a major part of the County's economy. Therefore, interruption of pipeline operations in Contra Costa County could have far-reaching economic consequences.

Power Distribution

Substations connect lines within both the transmission and distribution systems and are a critical component of the electrical grid. **High-voltage transmission lines run underground and overhead and carry electricity from where it is generated to substations. Substations transform the power to a lower voltage to be carried by overhead and underground distribution lines to residences and businesses.** Substations function together as a system; while the service area of each substation is local, the transmission lines that connect to them are networked. Additionally, natural gas stations, or compressor stations, in the Project Area help keep the natural gas pressurized so that it maintains its liquid form and can be transported via pipeline.

Issue Statement

Substations provide electricity through a networked grid; if one substation is damaged or disrupted there could be downstream (cascading) consequences even though there is some redundancy within the overall grid. Electricity is critical during an emergency. In addition to enabling communications, electricity is needed to run pumps (stormwater, flood control, wastewater) and maintain emergency response centers and facilities.

Asset Descriptions

Natural Gas Stations

Pacific Gas and Electric (PG&E) is the primary owner of natural gas stations (six out of seven) within the Project Area. Two stations are located on Bethel Island, one station is on Jersey Island, one station is on Hotchkiss Tract, and two stations are on Palm Tract. The other owner of natural gas stations is CPN (a Calpine subsidiary), with one station in Antioch.

Electrical Substations

PG&E is the primary owner of electrical substations (80%) within the Project Area. They have two substations in Byron south of Clifton Court Forebay, one in Antioch across from West Island, and one in Pittsburg across from Browns Island. East Bay Municipal Utility District (EBMUD) is the other owner of an electrical substation in Discovery Bay for their Los Vaqueros pump station.

Transmission Lines

Within the Project Area transmission lines are a mix of 33-92-kilovolt (kv), 110-161-kv, and 220-287-kv lines. Transmission lines within the Project Area are almost exclusively overhead[xlvi]. Overhead transmission lines are less susceptible to some of the complications of flood exposure. However, flooding would still limit maintenance access to this asset. PG&E owns the majority of transmission lines (53%) in the Project Area. Other owners

include TANC, WAPA, and Trans Bay Cable. Transmission lines are located parallel to the Pittsburg-Antioch shoreline; crossing the San Joaquin River towards West Island; from Sherman Island southeast through Jersey Island, Hotchkiss Tract, Veale Tract, and Orwood Tract; and from Discovery Bay south towards Clifton Court Forebay.

Exposure To Current And Future Flooding

Detailed exposure analysis was performed for seven natural gas stations and five electrical substations within the Project Area. These data were in the form of points, and exposure analysis indicates any portion of that point is exposed to flooding. Of these, **five of the natural gas stations and none of the electrical substations may be exposed to flooding from a current 100-year storm event**. Combined flooding of a 100-year storm with 12" of sea level rise may increase flooding exposure, with 6 natural gas stations exposed. A 100-year storm event with 83" SLR results in six of seven stations potentially exposed. One electrical substation may be exposed during a 100-year storm event with 24" SLR. Three of five electrical substations could be exposed to flooding at 100-year storm even with 83" SLR. When considering sea level rise alone, first exposure could occur at 83" SLR, with six natural gas stations and two electrical substations exposed.

Detailed exposure analysis was performed for 120,413 miles of transmission line within the Project Area. **During a current 100-year storm event, 45,341 miles (38%) of the transmission lines may be exposed to flooding. Combined flooding from a 100-year storm event and 83" SLR could expose 99,484 miles (83%) of transmission lines. Only 191 miles (0.2%) of the transmission lines may exposed during a high tide at today's water levels. This figure only increases modestly until 83" SLR, when 87,767 miles (73%) of the transmission lines may be flooded.**

Data Considerations

Data for natural gas stations and electrical substations were represented as points and do not account for location of water-sensitive equipment within the facilities.

Table 6-3. Total number of natural gas stations that may be located in the current 100-year storm event area and/or exposed to future sea level rise with a current 100-year storm, sea level rise combined with a 100-year storm, or exclusively sea level rise.

Asset	Management	Current 100-year Storm Event*	12" + 100-yr	24" + 100-yr	36" + 100-yr	83" + 100-yr	MHHW Today	12"	24"	36"	83"
Natural Gas Station	**PG&E**	5	6	6	6	6	--	--	--	--	6
Natural Gas Station	**CPN**	--	--	--	--	1	--	--	--	--	--
Total Sites Exposed	**-**	**5**	**6**	**6**	**6**	**7**	**--**	**--**	**--**	**--**	**6**

"--": Unexposed assets

MHHW: Mean Higher High Water refers to the average of today's daily highest tide and is used as the baseline for all flooding scenarios.

* Current 100-year Storm Event: The 100-year storm event reflected in these maps is not equivalent to the FEMA 100-year flood hazard zone.

Table 6-4. Total number of electrical substations that may be located in the current 100-year storm event area and/or exposed to future sea level rise or the combination of sea level rise and a 100-year storm event.

Asset	Management	Current 100-year Storm Event*	12" + 100-yr	24" + 100-yr	36" + 100-yr	83" + 100-yr	MHHW Today	12"	24"	36"	83"
Electrical Substations	**PG&E**	--	--	1	1	2	--	--	--	--	2
Electrical Substations	**EBMUD**	--	--	--	--	1	--	--	--	--	--
Total Sites Exposed	**-**	**--**	**--**	**1**	**1**	**3**	**--**	**--**	**--**	**--**	**2**

"--": Unexposed assets

MHHW: Mean Higher High Water refers to the average of today's daily highest tide and is used as the baseline for all flooding scenarios.
* Current 100-year Storm Event: The 100-year storm event reflected in these maps is not equivalent to the FEMA 100-year flood hazard zone.

Table 6-5. Total number of miles of electrical transmission line that may be located in the current 100-year storm event area and/or exposed to future sea level rise, or the combination of sea level rise and a 100-year storm event.

Asset	Management	Current 100-yr	12" + 100-yr	24" + 100-yr	36" + 100-yr	83" + 100-yr	MHHW Today	12"	24"	36"	83"
Transmission Lines	**PG&E**	24,497	34,532	46,535	46,929	50,478	166	318	515	1,109	47,034
Transmission Lines	**TANC**	15,301	21,780	21,815	21,854	24,731	9	16	26	34	22,875
Transmission Lines	**WAPA**	5,541	6,194	16,096	17,376	24,265	16	22	41	52	17,852
Transmission Lines	Trans Bay Cable	2.8	3.8	4.4	5.3	10	0.3	1	1.7	2.1	5.4
Total Miles Exposed	**-**	**45,341**	**62,509**	**84,450**	**86,164**	**99,484**	**191**	**357**	**583**	**1,197**	**87,767**

"--": Unexposed assets
MHHW: Mean Higher High Water refers to the average of today's daily highest tide and is used as the baseline for all flooding scenarios.
* Current 100-year Storm Event: The 100-year storm event reflected in these maps is not equivalent to the FEMA 100-year flood hazard zone.

Vulnerabilities

INFO1: Information was not available regarding the possibilities of load sharing among substations, or if electricity companies plan for or have the operational capacity to load share in the event of shutdowns.
GOV1: Existing operations and maintenance plans of power plants and substations may not include well-coordinated shutdown plans to be implemented in the event of an emergency.
PHYS1: The equipment in substations is sensitive to water. Saltwater in particular may cause corrosion, especially if the plant or station has not been shut down in advance of flooding. Belowground electrical or mechanical equipment may also be sensitive to groundwater intrusion. Sea level rise may cause increasing salinity in the Delta and rising groundwater tables with potentially more saline water.
PHYS2: Structures and equipment may be damaged during a seismic event, especially in areas susceptible to liquefaction, which may become more extensive as groundwater rises.
FUNC1: Substations are part of the electricity grid, and if one substation goes out, electricity can usually be rerouted through another substation to its customers. However, if several substations go out, service could be interrupted and result in downstream consequences.
FUNC2: As transmission lines are networked, exposure of certain areas may have much more wide-ranging impacts on communities.

Consequences

Society and Equity: Disruptions to substations could result in loss of power, with consequences for residents and businesses in the affected areas. Substations contain hazardous materials that could harm people and contaminate their property if released into floodwaters. These impacts are likely to be felt most acutely by vulnerable residents such as the elderly, sick, and very young.

Environment: Substations contain hazardous materials that could harm the health of wetland habitats and sensitive species if floodwaters carry them into the Bay-Delta or nearshore areas.

Economy: The disruption of power could result in business closures and transportation interruptions, with corresponding losses in productivity, revenues, and income.

Power Generation

Power generation is essential to economic and community activities within the Project Area. Contra Costa County has opened four new power plants since 1996, with several others in development. These are all mostly newer gas-fired plants. The relatively small area contributes about 7.5% of the state's power.[xlvii] Within the state of California, new power generation facilities are permitted by the Siting, Transmission, and Environmental Division of the California Energy Commission. Power plants have electronic and mechanical

equipment that are highly sensitive to water, and these facilities may be forced to shut down in advance of potential flooding or could be significantly damaged if exposed to flooding. Damage to peaking and reserve power plants is less likely to disrupt neighborhoods since they generally are not the principal source of power. Some service areas may be connected to more than one substation, and in such cases the power may be transferred from one station to the other, minimizing disruptions to service.[xlviii]

Issue Statement

Power in the project area is provided mainly by PG&E, which has a network of power plants. Having a network of power plants provides a more resilient system. However, ensuring uninterrupted electricity requires protecting the entire network, including transmission lines and substations connecting the power that is generated to customers.

Asset Descriptions

Los Medanos Energy Center

The Los Medanos Energy Center is located on East Third Street in Pittsburg. It is a natural gas burning plant that uses combustion turbines, steam, and heat recovery technology.[xlix]

GWF Power Systems L.P.

This power plant is located across from Browns Island in Pittsburg. Power is generated by burning petroleum and coke. It uses steam technology.

Others

Based on community feedback (see Data Considerations below), we know that there are additional power plants in the Project Area not assessed in our analysis. One of these is the NRG 720-MW Marsh Landing Generating Station, located near the Antioch Bridge, built on a Brownfield, and supplies all its power to PG&E[l]. Georgia-Pacific has a generating station on the Antioch shoreline, a mile-and-half west of NRG.

Exposure To Current And Future Flooding

Our dataset shows only two power generation plants within the Project Area. Neither of the plants is impacted by flooding until a 100-year storm event with 83” SLR, which is our most extreme flooding scenario. At this water level, both power plants may be exposed to flooding.

The Georgia-Pacific plant is located directly on the shoreline, however it seems that levees protect it from all flooding scenarios. The NRG Marsh Landing plant is completely inundated at 83” of sea level rise and begins to see inundation at today’s 100-year storm event. By the 100-year storm event with 24” of sea level rise, the NRG plant is inundated.

Data Considerations

Based on community feedback data and our own manual searches, we know there are additional power plants within the area that are not included in our dataset.

Table 6-6. Total number of power plants that may be located in the current 100-year storm event area and/or exposed to future sea level rise or sea level rise combined with a 100-year storm.

Asset	Management	Current 100-year Storm Event*	12" + 100-yr	24" + 100-yr	36" + 100-yr	83" + 100-yr	MHHW Today	12"	24"	36"	83"
Power Plant	**CalAlpine**	--	--	--	--	Yes	--	--	--	--	--
Power Plant	**GWF Power Systems**	--	--	--	--	Yes	--	--	--	--	--
Total Sites Exposed	**-**	**--**	**--**	**--**	**--**	**2**	**--**	**--**	**--**	**--**	**--**

"--": Unexposed assets

MHHW: Mean Higher High Water refers to the average of today's daily highest tide and is used as the baseline for all flooding scenarios.

* Current 100-year Storm Event: The 100-year storm event reflected in these maps is not equivalent to the FEMA 100-year flood hazard zone.

Vulnerabilities

INFO1: There is a lack of detailed, easily accessible, and well-coordinated information about the ownership, location, and condition of energy infrastructure, which is needed for site- and asset-specific vulnerability and risk assessments.
PHYS1: Many mechanical and electrical components of utility infrastructure are vulnerable to flooding and rising groundwater levels. In the event of storm-related flooding, equipment at power plants could be damaged by water – particularly saltwater, which causes corrosion – as well as by mud or debris carried by floodwaters. If flooding damages power plants, equipment may have to be replaced, resulting in a lengthy recovery period.
PHYS2: Power plants can be shut down to prevent major damage from floodwaters, such as corrosion to transformers, capacitors, switches and other equipment. However, as proper shutdown takes time, advance warning that a flood event may occur is necessary to avoid damages.
FUNC1: Existing operations, maintenance, and emergency response plans and procedures for utility infrastructure may be inadequate to address contingencies associated with storm events.
FUNC2: If energy generation plants go out of commission it hinders the functionality of many critical services, such as emergency services, elderly housing, schools, traffic lights, some transportation, and various other household functions that are important to resident wellbeing.

Consequences

Society and Equity: If power plants must be shut down or are damaged at a time of peak demand, or when reserve sources are needed, the insufficient power generation could affect the entire region.

Environment: Power plants and supporting infrastructure contain hazardous materials that could harm the health of wetland habitats and sensitive species if carried by floodwaters into the Bay-Delta or nearshore areas.

Economy: These plants provide energy to the PG&E grid and support local economies. Temporary or permanent disruptions could affect local businesses and the community.

Oil and Gas Production Fields

The Project Area contains 10,125 acres of oil and gas production fields. These fields are Sand Mound Slough Gas, Bixler Gas, Knightsen Gas, Brentwood E. Gas, Oakley S. Gas, Dutch Slough Gas, Oakley Gas, River Break Gas, Brentwood Gas, and Rio Vista Gas. Oil and gas extraction can be a large source of revenue in industrial areas, and operations within these production fields can be complicated as wells within a production field may be operated by numerous different entities.

Methods associated with extraction can be harmful to the environment. Canals created as part of the extraction process can alter natural hydrology by altering flow, potentially increasing salinity intrusion, and reducing overland flow of water and sediments into the nearshore environment[li]. Additionally, extraction has been associated with land subsidence, exacerbating flooding risk.[lii]

Issue Statement

Oil and gas extraction is an important part of the County's economy. However, sea level rise and storms pose a threat to the longevity of the operations due to equipment vulnerabilities from frequent or permanent inundation, as well as saltwater corrosion.

Asset Descriptions

All well number and status data was sourced from the California Department of Conservation's Well Finder database.[liii]

Sand Mound Slough Gas

Sand Mound Slough Gas is a relatively small production field with eight total wells. Seven of these are plugged and abandoned wells and one is a canceled well.

Bixler Gas

Bixler Gas is a relatively small production field containing four wells, all of which are plugged and abandoned.

Dutch Slough Gas

Dutch Slough Gas has the second-most amount of wells compared to other production field within the Project Area. It extends inland to the junction of Knightsen Avenue and Tule Lane and out across much of Bethel Island. According to the California Department of Conservation, this field contains 68 total wells. Eight of these are active wells, one is a canceled well, eight are idle wells, and 51 are plugged and abandoned wells. Our data on active wells indicates there are 20 active wells on this site.

River Break Gas

River Break Gas production field overlaps much of the marsh at Big Break Regional Shoreline park and extends inland in a narrow band just west of Highway 4. It contains 54 total wells. Three of these are canceled wells and the remaining 51 are plugged and abandoned wells.

Rio Vista Gas

Rio Vista Gas production field has the most wells, containing 556 total wells. Of these, 144 are active wells, 31 are canceled wells, 156 are idle wells, four are new wells, and 221 are plugged and abandoned wells. However, the production field extends to the north and west of the Project Area, and only those wells on Bradford Island and Webb Tract are within the Project Area. According to our data, six of the active wells are within the Project Area.

Oakley Gas

Oakley Gas is a relatively small production field with nine total wells. Three of these wells are plugged dry holes and six are plugged gas wells.

Active Private Wells

All other wells analyzed are private natural gas wells located in the Delta Islands: Hotchkiss Tract, Bethel Island, Webb Tract, Bradford Island, and Jersey Island. They are located predominantly on two gas fields: the Dutch Slough Gas field and the Rio Vista Gas field.

Exposure To Current And Future Flooding

Detailed exposure analysis was performed for six oil and gas production fields within the Project Area. Under the most extreme flooding events modeled in this project, four production fields are never flooded. These unimpacted areas account for 53% of the asset acreage within the project boundary. For these analyses, exposure is expressed in acres of the total asset covered by flood waters in our models. Flooding from a current 100-year storm event could have immediate impacts by flooding 2,952 acres (29%) of the production fields within the Project Area. Sand Mound Slough Gas, Bixler Gas, Dutch Slough Gas, and Rio Vista Gas all experience large amounts of flooding from a current 100-year storm event combined with sea level rise. A 100-year storm event with 83" of SLR could result in 4,770 acres of production fields being flooded.

During a high tide today areas of the production fields around tidal channels could experience some flooding totaling 22 acres. At 24" of SLR, 112 acres of the total production field acreage are flooded with most flooding is concentrated within River Break Gas (6% flooded). However, at 36" SLR 216 acres (6%) of Dutch Slough Gas could be flooded (up from 0.2% flooded) and 907 acres (80%) of Rio Vista Gas could be flooded (up from 2%). At 83" of SLR flooding becomes widespread across the impacted production fields, and 4,474 acres (44%) of the production fields in the Project Area could be exposed.

Other Risks

In some cases, oil and gas extraction can cause land subsidence[liv], mainly limited to the area of the production field, which can compound flooding risks. Subsidence can enlarge existing fractures and cause new ones in the subsurface rocks in the production field. Rock fracturing modifies gas production, allows for gas to migrate upwards, and damages surface and subsurface structures. If there are paths for escape from a gas pool, free gas can migrate to the surface, which may be a cause of explosions and fires. In areas subjected to earthquakes, the upward gas migration can be a major hazard.[lv] Additionally, subsidence has produced buckling of casing strings and wellhead failures.[lvi]

Data Considerations

Our analysis on oil and gas field production was performed on the number of acres exposed and does not take into account if wells are impacted and if those wells are active.

Table 6-7. Total number of acres of oil and gas production fields that may be located in the current 100-year storm event area and/or exposed to future sea level rise or to sea level rise combined with a 100-year storm event.

Asset	Location	Current 100-year Storm Event*	12" + 100-yr	24" + 100-yr	36" +100-yr	83" + 100-yr	MHHW Today	12"	24"	36"	83"
Sand Mound Slough Gas	**Oakley**	6	53	54	54	54	3	6	6	6	54
Bixler Gas	**Brentwood**	296	299	302	304	306	1	2	2	3	304
Dutch Slough Gas	**Oakley, Jersey Island, Bethel Island**	1620	2884	2945	3013	3161	5	6	8	216	3029
River Break Gas	**Oakley**	94	103	123	139	309	--	44	78	89	147
Rio Vista Gas	**Bradford Island**	936	939	939	939	939	13	17	18	907	939
Oakley Gas	**Oakley**	--	--	--	--	1	--	--	--	--	--
Total Acres Exposed	**-**	**2,952**	**4,278**	**4,362**	**4,449**	**4,770**	**22**	**74**	**112**	**1,221**	**4,474**

"--": Unexposed assets

MHHW: Mean Higher High Water refers to the average of today's daily highest tide and is used as the baseline for all flooding scenarios.

* Current 100-year Storm Event: The 100-year storm event reflected in these maps is not equivalent to the FEMA 100-year flood hazard zone.

Table 6-8. Total number of active private natural gas wells that may be located in the current 100-year storm event area and/or exposed to future sea level rise or to sea level rise combined with a 100-year storm event.

Asset	Production Field	Current 100-year Storm Event*	12" + 100-yr	24" + 100-yr	36" + 100-yr	83" + 100-yr	MHHW Today	12"	24"	36"	83"
Active Natural Gas Wells	**Dutch Slough Gas**	15	20	20	20	20	--	--	--	--	20
Active Natural Gas Wells	**Rio Vista Gas**	6	6	6	6	6	--	--	--	4	6
Total Wells Exposed	**-**	**21**	**26**	**26**	**26**	**26**	**--**	**--**	**--**	**4**	**26**

"--": Unexposed assets

MHHW: Mean Higher High Water refers to the average of today's daily highest tide and is used as the baseline for all flooding scenarios.

* Current 100-year Storm Event: The 100-year storm event reflected in these maps is not equivalent to the FEMA 100-year flood hazard zone.

Vulnerabilities

GOV: Oil and gas production fields are owned by various companies and more entities still own and operate individual wells on these production fields. These various groups would need to coordinate to respond to flooding vulnerabilities.
INFO1: Information about active wells is not kept up to date in a readily accessible format.
INFO2: There are few studies on how flooding may mobilize contaminants from production fields. Existing studies mostly focus on subsidence and are based in the Gulf of Mexico.
FUNC1: Products of extraction need to be transported to facilities for processing, mostly by rail or truck. Transportation assets impacted by flooding could prevent goods from being moved.
PHYS1: Extraction of gas and oil can cause additional subsidence of land, increasing flooding risks.
PHYS2: Subsidence from oil and gas drilling can potentially cause gas leakage to the surface from subsurface oil and gas reservoir by causing rock fractures up to the surface. Fracturing modifies production, gives rise to upward gas migration, and damages surface and subsurface structures. If there are paths for escape from a pool, free gas migrates to the surface, which may be a cause of explosions and fires. In areas subjected to earthquakes, the upward gas migration can be a major hazard.[lvii]
PHYS3: Subsidence or earthquakes can cause buckling of casing strings and wellhead failures due to force reversals in the production casing strings of oil and gas wells.[lviii] If there are paths for escape from a well, free gas may migrate to the surface, which may be a cause of explosions and fires. In areas subjected to earthquakes, the upward gas migration can be a major hazard.[lix]
PHYS4: Equipment used for extraction may be sensitive to flooding damage either through electrical damage or corrosion after exposure to saline water. This could lead to potential for spills of extracted products.

Consequences

Society and Equity: Extraction can lead to land subsidence, increasing flooding to nearby communities. Flooding of production fields may lead to mobilization of contaminants, but few studies exist on the extent of this mobilization or its impacts on human health. As vulnerable communities are often disproportionally located near sites of extraction, this is a strong research need.

Environment: Extraction can lead to land subsidence, increasing flooding to nearby ecosystems. Additionally, if flooding causes equipment malfunctions that result in spills of extracted products, this could have long-ranging impacts on ecosystem health.

Economy: Oil and gas extraction is a large portion of the economy within the Project Area. Loss of these production fields to permanent flooding from sea level rise could have large impacts on local jobs and the regional economy. Temporary flooding from storm events could cause pulsed losses of revenue and loss of work days for local laborers.

Flood Control and Stormwater

Acronyms

BIMID	Bethel Island Maintenance Improvement District
CCWD	Contra Costa Water District's
District	Contra Costa Flood Control and Water Conservation District
DWR	California Department of Water Resources
FEMA	Federal Emergency Management Agency
HMP	Hazard Mitigation Plan
ISD	Ironhouse Sanitary District
MSR	Municipal Service Review
Project Area	East Contra Costa Project Area
RD	Reclamation District
USACE	U.S. Army Corp. of Engineers

Creeks and Flood Control Channels

Sea level rise will affect many creek and flood control channels that drain to the Delta. As the level of the Bay and Delta rises, the tide will push further up the Delta and its creeks, reducing the capacity of tidal creeks and channels to accept stormwater runoff. This will cause backups or flooding in low-lying areas and increase the risk of overbank flooding, in particular when rainfall events coincide with King Tides or extreme storm events.

Flood management responsibilities in the East Contra Costa Project Area (Project Area) are managed by the county-wide Flood Control and Water Conservation District (District), which owns property throughout the county for the purpose of constructing and maintaining regional flood control basins, channels, and creeks. In addition, there are other public agencies, such as Caltrans, and private entities, such as the Union Pacific Railroad, commercial shopping centers, campuses, and multi-family residential properties, that manage larger stormwater collection and conveyance systems (as opposed to single family homes) that are connected to the public flood protection infrastructure. The interconnected nature of flood protection and stormwater management systems means that vulnerabilities are shared, and solutions to increase resilience will need to address both systems and their connected components.

Countywide, the District manages 79 miles of channel and 29 dams and detention basins with an estimated value of over $1 billion. Many of these channels have engineered (improved) sections, but some are undersized for the amount of land development that has occurred in the contributing watershed. In addition, others may have been designed to

convey flows for the 100-year flood standard protection level but have lost capacity over time due to sediment accumulation. The District has a maintenance backlog due to overall insufficient funding which is further impeded by the high cost and difficulty of completing sediment removal projects for some channels (e.g. low gradient tidally influenced channels) that quickly re-accumulate sediment. Many of the District's major facilities were constructed in partnership with the federal government and have ongoing federal oversight with increasing protection requirements and decreasing funding, making improvements or conducting ongoing maintenance difficult.

Projects to address flooding can run into the tens of millions of dollars. However, finding funding for flood control projects is difficult as there is public opposition to additional property-based assessments, limited grant funding, and decreasing Federal funding. Public support for flood control projects in creeks may also be at odds with public support for habitat preservation and increased community expectation and involvement. The District's ability to maintain or improve the county's flood protection system was sharply impacted and in some watersheds virtually eliminated by Proposition 13 in 1978 and Proposition 218 in 1996, which strictly limits cities' power to impose fees for property-related services and requires a public hearing with a majority protest process before adopting any fees for a property-related service. Presently, the District has no mechanism to increase revenues in these watersheds even while they confront aging infrastructure and deferred maintenance. Even with these challenges, the District has developed a "50-year Plan," adopted in 2009, to convert traditional flood protection infrastructure (concrete and rip-rap lined channels) to natural systems through multi-objective creek enhancement efforts.

One way to garner funds for flood control was the creation of Flood Control Zones and Drainage Areas. The County's Flood Control District approves developments in these two areas and receive a portion of property tax within the boundaries of some Flood Control Zones for the design, construction, and maintenance of regional drainage facilities within the Flood Zone.[lx] Within the Project Area, as can be seen in Figure 7-1, Flood Control Zone 1 includes Marsh Creek, Flood Control Zone 2 includes Kellogg Creek, Brushy Creek and Frisk Creek, Flood Control Zone 10 includes the Delta islands, Flood Control Zone 11 includes East Antioch Creek, Flood Control Zone 12 includes West Antioch Creek, and Flood Control Zone 13 includes Kirker Creek and Los Medanos Wasteway.

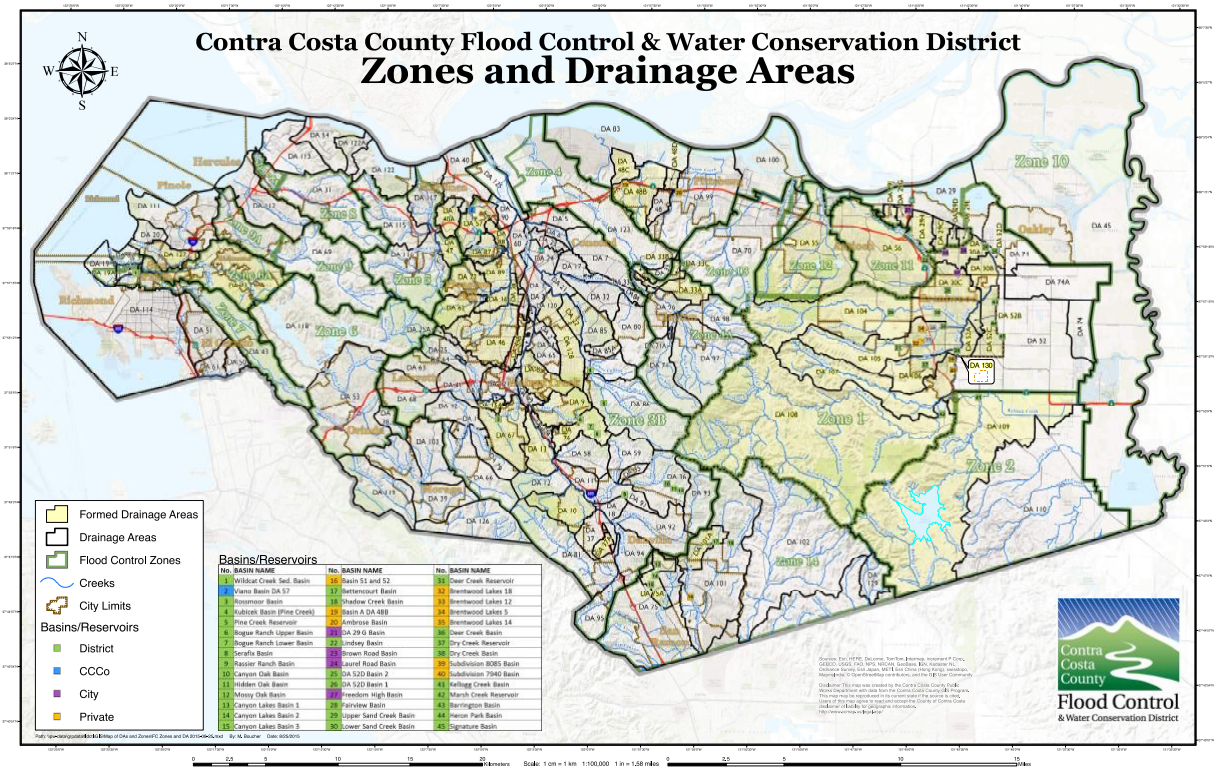

Figure 7-1. Drainage Areas and Flood Control Zones for Contra Costa County Flood Control District. (Source: Contra Costa County Flood Control & Water Conservation District)

Issue Statement

Sea level rise coupled with ongoing sediment accumulation in low-gradient tidal creeks and channels will reduce the amount of flood protection in the project area. Funding is severely limited, and in some locations conflicting goals mean that maintenance or improvement activities are especially difficult and costly. To better understand the risks to the flood management system, watershed-scale hydraulic models are needed, and it is critical that planners work with flood managers to better understand the vulnerability of nearby homes, businesses, utilities, and community facilities. With this information, the county and cities can engage stakeholders in long-range planning and develop funding strategies to implement projects that improve resilience to sea level rise, while providing other community and environmental benefits.

Asset Descriptions

Los Medanos Wasteway

Kirker Creek originally flowed directly north to the Delta but was diverted in the 1940s to bypass the U.S. Steel property. The creek now makes a 90-degree turn and flows into the Los Medanos Wasteway. Los Medanos Wasteway is within Flood Control Zone 13 within Pittsburg near Los Medanos College.

Frisk Creek

Frisk creek is located in the southeastern corner of the County. It originates in the foothills of Mount Diablo and flows northeast towards Byron and terminates into the Los Vaqueros Pipeline. Flood Control Zone 2 includes Kellogg Creek, Brushy Creek and Frisk Creek.

East Antioch Creek

East Antioch Creek is managed by the Contra Costa Flood Control District and located on the eastern edge of Antioch. East Antioch Creek flows from headwaters near Lone Tree Way in Antioch. A number of detention basins and levees have been constructed along the creek to prevent flooding into the Marsh Creek drainage area. Land uses in the East Antioch Creek watershed consist of 87% urban lands and 13% open space, parks and recreation areas, and water.[lxi] East Antioch Creek is within Flood Control Zone 11.

West Antioch Creek

West Antioch Creek is on the western edge of Antioch. It's managed by the Contra Costa Flood Control District. Markley Canyon Creek and other unnamed tributaries feed into West Antioch Creek before it discharges into the Sacramento-San Joaquin Delta near the western boundary of Antioch. The main stem of West Antioch Creek remains above ground for most of its length, though it flows through a constructed channel in its lower half. Large sections of its tributaries have been routed underground through more developed areas to provide flood protection and drainage. Land uses in the West Antioch Creek watershed consist of 5% agricultural lands, 47% urban lands, and 48% open space, parks and recreation areas, and water.[lxii] West Antioch Creek is within Flood Control Zone 12.

Kirker Creek

Kirker Creek is located in Antioch and runs north from Clayton to near the Dow Wetlands Preserve. Kirker Creek flows north from the foothills of Mount Diablo to the Sacramento-San Joaquin Delta. Though most of Kirker Creek runs through an open channel, culverts direct the creek underground at road crossings and through some urban areas. Kirker Creek originally flowed directly north to the Delta but was diverted in the 1940s to bypass the U.S. Steel property. The creek now makes a 90-degree turn and flows into the Los Medanos Wasteway. Kirker Creek flows during the rainy winter season and dries out in the summer, though irrigation and related urban runoff keep some portions of the creek wet throughout the year.[lxiii] Kirker Creek and Los Medanos Wasteway are within Flood Control Zone 13.

Brushy Creek

Brushy Creek feeds into Clifton Court Forebay from Byron Hot Springs and is one of the most southeasternly creeks in the County. The watershed is comprised entirely of unincorporated County land, with minimal developed areas. Land uses in the Brushy Creek watershed consist of 81% agricultural lands; 11% urban areas; and 8% open space, parks and recreation areas, and water. Brushy Creek was diverted and altered/moved by farmers in the north and eastern parts of the watershed, where Marsh, Kellogg and Brushy Creeks enter the flatter regions of the county[lxiv]. Flood Control Zone 2 includes Kellogg Creek, Brushy Creek and Frisk Creek.

Kellogg Creek

Kellogg Creek is located near Discovery Bay, feeds into Woodward Island and is fed from Byron Hot Springs. It is just north of Frisk and Brushy Creek in the southeastern part of the County. It is managed by the Contra Costa Flood Control District and is located within Flood Control Zone 2, which was a zone created to provide funding for construction and maintenance of the drainage within the Kellogg Creek watershed. Contra Costa Water District's (CCWD) Los Vaqueros Reservoir significantly changed the flow of Kellogg Creek. Current projects in the watershed focus on sediment reduction and ecosystem restoration. The District has partnered with Reclamation District 800 to construct the Lower Kellogg Creek Bio-Filter / Retention Pond proposed to be located north of Highway 4 near where Kellogg Creek drains into Discovery Bay to improve water quality by reducing sediment movement into the Bay-Delta.[lxv] Flood Control Zone 2 includes Kellogg Creek, Brushy Creek and Frisk Creek

Exposure To Current And Future Flooding

Detailed exposure was analyzed for seven creeks in the Project Area. Even at today's MHHW (high tide), five of the seven creeks have minimal flooding. It is natural for creeks to experience tidal flooding, but with sea level rise these higher water levels could cause creeks to flood more frequently. Creeks could potentially be main flood pathways for water to travel inland, potentially leading to flooding of nearby residences, businesses and roads.

Data Considerations

Limitations in the ART modeling included major riverine flows from the San Joaquin and Sacramento Rivers for the 100-yr storm—however, other riverine flooding from precipitation was not included in the models (e.g. flooding from Deer Creek in Brentwood or Kirker Creek in Antioch). Flood channel exposure to sea level rise was evaluated by overlaying the ART sea level rise inundation maps with GIS layers of creeks in the Project Area. While this approach can suggest if there is a potential risk of joint coastal-riverine flooding, only watershed-scale hydraulic modeling can accurately quantify the combinations of Delta water levels, sea level rise, and riverine flows that will cause adjacent areas to flood. Without this joint coastal-riverine flood modeling, the potential for an increase in flood risk in the current 100-year storm event due to sea level rise may be underestimated, and low-lying areas that rely on the flood control and stormwater management system to remain dry during storm events may be underrepresented.

Table 7-1.Total feet of creeks that may be located in the current 100-year storm event area and/or exposed to future sea level rise or the combination of sea level rise or a 100-year storm event.

Asset	City	Current 100-year Storm Event*	12" + 100-yr	24" + 100-yr	36" + 100-yr	83" + 100-yr	MHHW Today	12"	24"	36"	83"
Los Medanos Wasteway	Antioch	**1879'**	**1999'**	**2756'**	**3094'**	**4577'**	**549'**	**741'**	**1254'**	**1278'**	**3512'**
Frisk Creek	Brentwood	**--**	**--**	**2897'**	**3394'**	**4770'**	**--**	**--**	**--**	**--**	**3433'**
East Antioch Creek	Antioch	**2999'**	**3106'**	**3465'**	**6388'**	**8141'**	**--**	**--**	**2099'**	**2145'**	**6498'**
Kirker Creek	Pittsburgh	**2347'**	**2360'**	**2362'**	**2364'**	**5400'**	**891'**	**1535'**	**2233'**	**2321'**	**2370'**
Brushy Creek	Byron	**796'**	**797'**	**801'**	**801'**	**1808'**	**789'**	**789'**	**798'**	**796'**	**801'**
Kellogg Creek	Discovery Bay	**2358'**	**2761'**	**3254'**	**3563'**	**4948'**	**215'**	**292'**	**563'**	**1311'**	**3600'**
West Antioch Creek	Antioch	**1787'**	**1893'**	**2305'**	**2309'**	**4234'**	**377'**	**470'**	**489'**	**559'**	**2313'**

"--": Unexposed assets

MHHW: Mean Higher High Water refers to the average of today's daily highest tide and is used as the baseline for all flooding scenarios.

* Current 100-year Storm Event: The 100-year storm event reflected in these maps is not equivalent to the FEMA 100-year flood hazard zone.

Vulnerabilities

INFO1: 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. Joint probability analysis of riverine and coastal events will be necessary to understand the likely increases in elevation and extent of the 100-year floodplain as sea levels rise.
INFO2: The lack of up-to-date watershed-scale hydraulic models for all creeks and channels in the project area limits the understanding of current and future flood risks for those without models. These models are needed to evaluate various combinations of Delta water levels and sea level rise to determine the potential that combined coastal-riverine flooding will impact adjacent communities and infrastructure.
INFO3: Not all creeks and/or flood control channels are included in the project's data set.
GOV1: Flood managers from the County and the cities in the Project Area currently have to compete for grants to improve 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: Contra Costa County and cities have no dedicated funds for capital improvements or long-range flood management planning to address the impacts of sea level rise, or for flood mitigation actions such as purchasing properties in the existing 100-year floodplain as they become available.
GOV3: City and County flood managers do not have adequate maintenance funding to preserve what limited flood capacity exists in the channels they manage.
GOV4: For some of the creeks, the railroad bridges are the most significant hydraulic constriction, and the dimensions of these bridges affect future flooding.
GOV5: 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. Since flood risk management is a long-term investment, it can take decades to develop concepts, obtain funding, build public support, and design and permit plans before initiating a multi-phase project.
FUNC1: Creeks and channels provide flood protection to adjacent land uses, and sea level rise may diminish this function, exacerbating conditions in existing floodplains and causing new areas to be designated as floodplains.
PHYS1: Sea level rise will increase tidal action and reduce the capacity of the seven major creeks in the Project Area to convey and discharge flood flows, particularly when rainfall events coincide with high tide. This may lead to overbank flooding or backwater affects if channel water levels are too high to allow stormwater to drain by gravity.
PHYS2: There may be a limit to the efficacy of traditional engineering flood protection solutions in low-lying areas, at which point flood managers, planners, regulators, community groups, business owners and decision makers, among others, will need to leverage their collective expertise and resources to pursue land use planning solutions.
PHYS3: Creeks may experience more saline conditions due to the rising levels of tidal inundation from sea level rise, meaning areas that previously were freshwater may change to brackish ecological conditions.

Consequences

Society and Equity: Increased flooding in creeks and channels that currently provide adjacent communities flood protection could result in extreme burden on socio-economically disadvantaged communities. Sea level rise may reduce available freeboard (distance between top of channel and the water level), and channel levees may need to be rebuilt to regain accreditation, which would require some residents and property owners in the newly designated floodplain to purchase flood insurance, which could pose a significant financial burden.

If storm events and sea level rise shut down shoreline wastewater treatment plants, even temporarily, untreated wastewater could back up into homes, businesses, and neighborhoods and spread disease. Furthermore, mobilization of contaminants from facilities that have hazardous materials, some which are within the current 100-year floodplain, could pose a risk to public health.

Environment: Increased flooding in creeks and channels may mobilize hazardous substances from adjacent industrial sites, landfill/waste facilities, and wastewater treatment plants, decreasing water quality and affecting marsh habitat and endangered species, such as saltmarsh harvest mouse populations or Threatened coho salmon (Federally listed), Threatened steelhead trout (Federally listed), Threatened black rails (California State Threatened Species), and Endangered California ridgeway rails (California State and Federally Endangered Species). Additionally, rising heights of saline tidal inundation may change the ecology of some freshwater creeks.

Economy: If the creeks and channels cannot provide adequate flood protection, there could be disruptions to local roads, damage to energy services, shutdowns to treatment plants serving residents and businesses, and lack of railroad service. This loss of goods, services and jobs will have a significant impact on the regional economy. Flooding may impact both local and regional jobs if industrial sites located near the creeks and channels are flooded or are inaccessible.

Stormwater

Stormwater runoff is generated when rainfall or snowmelt runs overland rather than infiltrating into the ground. In urban areas stormwater runoff is typically collected by curbs and gutters, ditches, and catch basin systems, and then conveyed in underground pipes to outlet locations, which are in most cases a flood control channel, although in some areas, they are conveyed to the Bay-Delta shoreline. Where the grade allows, stormwater is conveyed by gravity. In low-lying areas where gravity is not adequate, stormwater pump stations are needed to transport water to a higher elevation before it can drain to an outfall location. This is the case in the Delta islands, where subsidence has caused the land to be below the water level and water needs to be pumped over the levee.

Stormwater runoff can also be retained, detained or treated prior to discharge, which is typical for runoff from industrial land uses or large developed areas. In some locations, pumping is necessary to manage systems, such as lagoons that provide retention/detention but are tidally influenced. The combination of water control structures (tide gates) and pumping in advance of rainfall events helps to ensure there is adequate capacity for runoff storage until the tide is low enough to allow for discharge.

The stormwater assessment for the Project Area considers how sea level rise will impact stormwater management systems – that is, how higher Bay-Delta water levels will affect the drains, pipe network, pump stations, and outfalls that collect and convey stormwater. A discussion of how current and future precipitation may interact with higher sea levels, potentially resulting in reduced flood management capacity, is discussed below. It should be noted, however, that **in addition to sea level rise the amount and timing of precipitation may shift due to climate change. Changing precipitation patterns could cause flooding even far from the shoreline, for example where existing stormwater management systems do not have adequate capacity to handle larger rainfall runoff events.**

Issue Statement

The capacity to collect, convey and discharge flows to flood control channels or the Bay-Delta will be reduced by sea level rise. Outfalls that are below the new high tide or storm event water level may need to be elevated, have one-way check valves installed to prevent backups, or need to be pumped rather than drain by gravity, relying on energy. In addition, cities, counties and Reclamation Districts (discussed in the Delta Islands chapter) are extremely limited in their ability to raise revenues for stormwater system maintenance or improvement (i.e. Proposition 218), even to address currently undersized systems or deferred maintenance, which will make taking action to adapt to sea level rise and storm flooding even more challenging.

Asset Descriptions

In the ART Project Area, public stormwater management systems typically collect and convey runoff from roadway or public facilities, and are owned and managed by the County, the cities, and Caltrans. Large private landowners own and maintain their own stormwater systems, which may or may not connect to the public stormwater system depending on the land use and location. Both public and private stormwater systems can ultimately discharge to flood channels, most of which are owned and operated by the Contra Costa County Flood Control and Water Conservation District.

For the Delta islands, more information on flood and stormwater control can be found in the Chapter on Delta Islands.

Stormwater discharges are regulated through National Pollution Discharge Elimination System (NPDES) permits under the federal Clean Water Act. NPDES directs states to adopt and enforce water quality standards, establish maximum allowable pollution levels for water bodies, and monitor and regulate discharges into water bodies. The State Water Resources Control Board, which has overall responsibility for water quality, delegates the

administration of NPDES permits to its regional boards. Contra Costa County is within the jurisdiction of two water boards, the San Francisco Bay Regional Water Quality Control Board (RWQCB) and the Central Valley Regional Water Quality Control Board, although the Project Area is within the jurisdiction of the Central Valley RWQCB only. Each local jurisdiction must implement specified activities year-round, including incorporating stormwater pollution prevention into municipal operations; inspecting local businesses and construction sites; enforcing prohibitions against non-stormwater discharges entering creeks or storm drains; performing specified public outreach activities; requiring new developments to manage runoff pollutants; reducing the quantity of trash, copper, mercury, and PCBs entering creeks and storm drains; and, monitoring water quality, among other activities.[lxvi]

The Contra Costa Clean Water Program (CCCWP) includes the County, 19 cities/towns (Antioch, Brentwood, Oakley, and Pittsburg in the Project Area), and the Contra Costa County Flood Control and Water Conservation District, which are NPDES co-permitees. CCCWP assists with permit compliance by providing guidance and training, and by implementing public outreach and water-quality monitoring that can be done most cost-effectively at the countywide scale.

Exposure To Current And Future Flooding

The impact that exposure to sea level rise and storm events will have on the stormwater management systems depends on the current storage and flow capacity, the elevation and location of outfalls, whether the system is gravity drained or pumped, and whether there are check valves to prevent Bay-Delta water from entering the stormwater system and taking up pipe capacity needed to convey and store stormwater. If elevated Bay-Delta water levels coincide with a precipitation event, the stormwater system may not have enough capacity to store and convey runoff, which could result in backups and inland flooding.

If outfalls do not have storm gates or check valves to prevent Bay-Delta water from entering the stormwater system, where upstream pipe capacity is insufficient to store both stormwater and Bay-Delta water, there is the potential for street and basement flooding during extreme tides or storm events. This is already a problem in many low-lying areas along the shoreline.

Finally, increased flows from groundwater infiltration and precipitation-related inflow can add additional strain on wastewater systems. Infiltration occurs when groundwater enters sewer pipes through cracks, pipe joints, and other system leaks. Inflow occurs when rainwater enters the system from improper drain connections (e.g., yard, patio, roof gutter, footing), uncapped cleanouts, cross-connections with the stormwater system, and manhole covers. Sea level rise can exacerbate precipitation-related infiltration and inflow problems in East Contra Costa. Sea level rise may permanently inundate pipes leading to larger amounts of infiltration. This would require larger volumes of water needing treatment,

increasing the demand for wastewater treatment. See the Wastewater Chapter for more information on how stormwater can affect wastewater treatment plants.

Data Considerations

Due to data limitations, an exposure analysis was not completed for the stormwater systems in the Project Area since no GIS files of the stormwater pipe system were available for analysis.

Vulnerabilities

INFO1: Studies to analyze stormwater system capacity to store and drain various combinations of future Bay-Delta water levels and precipitation events are needed to develop operational, maintenance and capital improvement plans to improve system resilience to sea levels rise.
INFO2: Information critical to evaluating the exposure of stormwater system components, such as outfall elevations and pipe capacity, is not readily available in GIS for all systems in the Project Area.
GOV1: City and County resources for stormwater management are strained and limited in raising funds (i.e. Proposition 218), leaving very limited or no resources to support the long-range planning necessary to address the impacts of sea level rise.
GOV2: The authority to raise taxes or fees to pay for stormwater management activities has been sharply constrained by voter initiatives, and most municipalities are unable to shift General Fund revenues to pay for stormwater activities. In addition, Contra Costa municipalities with a stormwater assessment have had level funding since 2009 even though NPDES permit compliance costs have increased.
GOV3: An integrated planning, regulatory, and funding framework for comprehensive, watershed and community-based stormwater and flood control management does not currently exist even though sea level rise impacts will increase the need for coordination and shared decision making among cities, property owners, and flood control managers.
FUNC1: Stormwater system components that rely on gravity drainage are often at the lowest elevation in the system, and these low-lying areas could be at the highest risk of flooding. These components will not function at full capacity as Bay-Delta water levels rise, therefore flooding in these areas may last longer than expected.
FUNC2: Pump stations rely on uninterrupted power to operate. While backup generators and onsite fuel storage can help avoid service disruption, the ability to resupply fuel and undertake necessary maintenance may be limited if the local streets and roads that provide access to the station are flooded.
FUNC3: In areas that already require pumping to manage stormwater and control flooding, pumps will have to lift water above the new, elevated Bay-Delta water level, which may exceed system design capacity.
PHYS1: As sea level rises, the capacity of stormwater pipes may be insufficient to store both rainfall runoff and the Bay-Delta water that could enter pipes if outfalls are below the high tide or storm event water level and check valves are not in place to keep tidal flows out.
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 or replaced. For example, corrugated metal pipes do not have as long a lifespan as other material types, and exposure to flooding or seawater could cause them to fail earlier than expected.
PHYS3: Higher groundwater levels could impact stormwater management systems, in particular, pipe networks that are subject to infiltration, green infrastructure and low impact development practices, as well as traditional stormwater detention and retention facilities
PHYS4: Pump stations that have sensitive electric or computerized components that are exposed to flooding could be temporarily interrupted or become permanently damaged, such as if corrosion due to saltwater exposure occurs.
PHYS5: If pump stations operate more frequently, or pump water to higher elevations, energy and maintenance costs will increase, and pumps will not last as long.

Consequences

Society and Equity: Reduced discharge capacity of the stormwater system and failures of pump stations could cause flooding of basements, streets and roads, neighborhoods, job centers and parks, and disrupt access to homes, schools, jobs and needed services. Stormwater system failures that cause street and road flooding could impede emergency response, important not only for the immediate problems caused by flooding, but also for medical or other emergencies that require urgent attention. If floodwaters are not removed quickly, they could become breeding grounds for mosquitoes and other disease vectors. There are also equity concerns, as some low-lying areas that are currently pumped to maintain positive drainage have lower income residents that are particularly vulnerable to flood impacts and displacement, especially when language barriers or poorly maintained infrastructure that could exacerbate existing street and basement flooding.

Environment: Damage, disruption or failure of the stormwater system could cause flooding in industrial or post-industrial areas, as well as commercial and residential properties, where hazardous materials may not be stored securely above floodwaters. This may mobilize contaminants and impact wetland habitat and water quality if stormwater moves the contaminants. An impaired stormwater system would distribute contaminated runoff more broadly; rather than flowing directly to the Bay-Delta, pollutants could be deposited onto soil wherever the stormwater backups flow.

Economy: There will be a direct impact on the economy if stormwater systems are damaged, as the cost of water removal, cleanup, and repairs to damaged structures and landscapes could be quite high. Flooding or exposure to saltwater that damages stormwater system components, such as pumps, pipes, inlets, and outfalls, could also lead to costly system repairs or the need for replacement. Flooding of streets and roads due to diminished function of the stormwater system could disrupt access to local goods, jobs and services and affect local and regional economies, such as if hospitals or industrial sites are inaccessible or unusable. 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 must relocate where they live or work, especially if the disruption is long enough or the damage is severe.

Natural Lands and Outdoor Recreation

Natural lands and outdoor recreation areas are important parts of the history and character of East Contra Costa County, especially along the shoreline. However, due to their shoreline location, many of these areas are at particular risk of flooding, especially permanent flooding from sea level rise. Historically, coastal habitats keep pace with sea level rise by accumulating mineral sediment and by moving upward and landward in the tidal frame. **The currently accelerating rates of sea level rise, in tandem with declining sediment inputs into the Delta[lxvii], may outpace the capacity of these natural dynamic systems.** Recreation and park facilities, which provide the public access to many of the natural features along the shoreline, are likewise not resilient to flooding outside the current tidal extremes. This chapter examines the flooding risk to these important natural lands and recreation facilities, recognizing that natural lands within the Project Area are under various types of protection and management programs. **The analysis presented here focuses on wetland habitats, wildlife refuges and ecological reserves, shoreline and near-shoreline parks, the San Francisco Bay Water Trail, marinas, and fishing piers.**

Across the Bay-Delta region, there are **more than one million acres of open space** including regional, local, and state parks. However, only **25,000 acres total of this open space is along the shoreline**. These open spaces share the shoreline with seaports, residential development, airports, interstate highways, business parks and many other uses. The high density of development along the mainland shoreline leaves little space for developing new major shoreline parks, so **current and future demand for shoreline recreation may need to be met by existing parklands**. However, as sea level rises and storm events begin to cause more extensive and longer duration flooding, **park and recreation assets along the shoreline may become costlier to maintain, have services disrupted and compromised, or disappear entirely**. Much of the shoreline in the Project Area is either bordered by levees or developed, which leaves **few opportunities for habitats to naturally migrate inland.** This may diminish the important regional role natural areas and recreational facilities serve in providing ecosystem and community services, and in defining, improving, and maintaining the quality of life for communities in the Project Area.

Natural lands and recreation areas provide **economic benefits to communities and regions**. Shoreline parks and reserves are most often used for walking, nature-viewing, and picnic areas, but they also provide shoreline-specific recreational opportunities such as kayak launches, beach access, and fishing piers. The East Bay Regional Parks Department (EBRPD) analyzed the economic benefits of all its 111,000 parkland acres in Contra Costa and Alameda counties, including shoreline parks, and found the park system provides $200 million in direct regional economic benefits[lxviii]. The Trust for Public Land has observed that strong park systems can increase property values by 5% in cities across the country, therefore contributing to the tax revenue[lxix]. The combined economic, environmental, and community benefits of shoreline parks demonstrates that planning for sea level rise resilience must be a priority for the entire region, not just park supervisors and decision makers.

Within East Contra Costa County, natural areas along the shoreline are often comprised of marsh habitat, wetlands, and coastal dunes, which can help bring communities in direct contact with the Bay-Delta and its natural resources. In addition to recreation, these natural areas provide a variety of benefits, including critical habitat for plants and wildlife, reduced flood risks to inland communities, and improved public health. These valuable services may be lost as these natural shorelines face increased wave and tidal energy, and in some locations, longer duration periods of temporary or permanent flooding as sea level rises.

Natural shoreline areas serve as de facto coastal flood protection in many parts of Contra Costa County However, these areas were developed and are managed as parks and preserves, not coastal flood protection for inland areas. In some parks this protection consists of structural shoreline components, such as levees and riprap; others provide natural shoreline protection through wetlands and coastal dunes. Natural areas and open space along the shoreline buffer Bay-Delta communities from flooding events in three ways. First, stormwater is detained in wetlands and other naturally permeable surfaces. Second, wetlands reduce the height and strength of waves, which decreases the need for expensive shoreline protection like levees and seawalls. Third, natural areas on the shoreline serve as a setback from the Bay-Delta, separating denser and more sensitive development from storms and sea level rise. Sea level rise may increase the importance of the role of shoreline parks and natural areas as critical flood and stormwater management services.

Natural Ecosystems

Open space and natural areas are important to the resilience of East Contra Costa County and are a large part of the Bay-Delta's historic character. East Contra Costa County's position at the interface between the fresh waters of the San Joaquin and Old Rivers and the brackish Suisun Bay support multiple wetland types that provide ecosystem processes and services, including augmenting flood protection from engineered structures, accreting sediment, slowing currents, and sequestering carbon. Coastal ecosystems throughout the Bay-Delta Area, including those within the Project Area, are unlikely to survive without support and interventions. The currently accelerating rates of sea level rise, in tandem with declining sediment inputs into the Delta[lxx], may outpace the capacity of these naturally dynamic systems. Potential support includes increasing sediment supplies, allowing for inland migration, among other protection and restoration measures. Wetlands and aquatic areas are essential to the Delta as a place due to their values as a recreational setting and wildlife habitat.

Several wetland types can be found within the Project Area. We examined the impacts of flooding on tidal wetlands, managed wetlands, freshwater emergent wetlands, and seasonal wetlands.

Issue Statement

Wetland habitats within the Project Area are vital both for their habitat value to important wildlife and the ecosystem services that they provide for human communities, including

flood abetment. The flooding impacts on wetland habitats depend on both the temporal nature of the flooding and the specific type of wetland considered. Permanent flooding from sea level rise alters hydrology and salinity conditions, which can have extensive impacts on all wetland habitats. Alternatively, 100-year storm flooding is temporary and, if pumping equipment is not damaged, impacts can be largely mitigated. Tidal wetlands, while very resilient to temporary flooding, will not persist under permanent inundation unless higher elevation migration space is made available and restoration projects move forward with sufficient lead time to overcome regulatory hurdles. Managed wetlands are often already very low-lying and, thus, are particularly vulnerable to levee failure, which could result in permanent flooding of the area, converting it to subtidal habitat. Additionally, damage to pumping equipment from flooding by saltwater could result in longer than average flooding periods, and this issue may require dedicated funding to accommodate. All wetland types are sensitive to changes in water salinity that could result from sea level rise. Altered salinity can change plant communities, which has trickle-up effects for the other organisms using the habitat.

Asset Descriptions

Wetland descriptions below are generalized from Classification of Wetlands and Deepwater Habitats of the United States.[lxxi]

Tidal Wetlands

The Bay-Delta's complex of tidal wetlands add resilience to the area. These are extremely endangered habitats, covering only 20% of their former area,[lxxii] with the remaining marshes highly altered, managed, and/or impacted by invasive species.[lxxiii] Tidal marshes are one of the most productive systems on the planet and provide numerous ecosystem services, including coastline protection, flood abatement, erosion control, carbon sequestration, and water purification[lxxiv]. Water purification by marshes is estimated to save $785-15,000 per acre when compared to traditional wastewater treatment procedures, and salt marsh carbon sequestration saves money on the price of carbon offsets[6]. Most of this vulnerable tidal marsh area is in the eastern portion of the Project Area on Brown's Island and the nearby shoreline.

Though tidal wetlands are regularly inundated by daily high tides, permanent flooding from sea level rise could shift these habitats to unvegetated tidal flats or subtidal habitat, severely limiting their ecological functions. In most areas of East Contra Costa County there is little or no space for tidal wetlands to migrate upland in elevation as sea levels rise because the shoreline is bounded by flood protection infrastructure and urban or industrial areas. Tidal wetlands may be able to increase in elevation within their current footprint through trapping and compaction of sediment.

Managed Wetlands

Many of the remaining wetlands in East Contra Costa County are managed wetlands. Within the Project Area managed wetlands are concentrated on Winter Island and Holland Tract, with other small areas occurring across the shoreline and Delta Islands. These wetland types are managed so as to control the movement of water in and out of the

wetland complex. These wetland habitats are generally managed for production of fish and game, protection of water quality, and access to recreation. Within our Project Area managed wetlands have the largest acreage of any wetland type and provide important economic benefits to the region in the form of recreational revenue.

Freshwater Emergent Wetlands

Freshwater emergent wetlands are created by high groundwater tables creating waterlogged soils where wetland plants can thrive. Within the Project Area this wetland type is found mainly around the edges of the Delta Islands and along the shoreline near Big Break Regional Shoreline Park. These wetland types are particularly sensitive to changes in hydrology. We did not model how groundwater levels within the project level might change due to sea level rise, but this would almost certainly alter the hydrologic regimes of these wetlands. Additionally, flooding with saline water during storms or through sea level rise could persistently alter the salinity of these wetlands, leading to shifts in plant communities with knock-on impacts to associated wildlife.

Seasonal Wetlands

Seasonal wetlands occur for only part of the year and are often driven by inputs of precipitation into the system. Within the Project Area seasonal wetlands are not the dominant wetland type, with the most acreage occurring on Holland Tract. Seasonal wetlands often form in low-lying areas where rain water and run-off can accumulate and sit on top of an impermeable soil layer. If these areas are flooded, flood water could persist over long timeframes as the water has no way to escape except through evaporation. Evaporation of saline flood waters from these areas could alter the salinity of the wetland and shifts plant communities and associated wildlife.

Exposure To Current And Future Flooding

Detailed exposure analysis was performed for 5,305 acres of wetland habitat within the Project Area. Due to their position relative to the shoreline, wetland types are particularly vulnerable to flooding. However, it is important to note that tidal wetlands and managed wetlands are robust to periodic flooding, as temporary flooding is part of the natural cycle of these ecosystems. For these analyses, exposure is expressed in acres of the total asset covered by flood waters in our models.

Of the 5,305 acres of habitat, 4,379 acres (83%) may be exposed to flooding during a current 100-year storm event. During a current high tide event 500 acres (9%) of the wetland habitat in the Project Area may be exposed to flooding. A current 100-year storm event in combination with 83” of sea level rise (SLR) could flood 4,871 acres (91%) of the wetland habitat within the Project Area. Permanent inundation from sea level rise floods only small amounts of wetland area until 36” of SLR when 1,870 acres (35%) of the wetland habitat may be exposed. Permanent flooding from 83” of SLR could flood 4,812 acres (84%) of the wetland habitat.

Of the wetland habitat types assessed, managed wetlands and tidal wetlands were at the highest risk for early exposure. Permanent flooding form 12” of SLR could flood 185 acres

(20%) of the tidal marsh, which could result in the downgrading of the marsh into tidal flats or subtidal habitat types. By 36" of SLR, 632 acres of tidal wetland could be permanently flooded. Managed wetlands have tidal gates that could potentially be used to managed some portion of flooding, but at high water levels these gates will no longer function to protect habitats. At 36" of SLR, 943 acres (30%) of the managed wetland habitat could be permanently flooded, and by 83" of SLR 3,215 acres (99%) may be exposed to permanent flooding.

Other Risks

Many of the managed wetlands are behind levees and would be permanently flooded if levees failed, quickly converting these areas to subtidal habitat. Flooding risk for these habitats is also exacerbated by the potential of erosion to decrease habitat elevation and total area. Changes in groundwater levels could alter hydrology across many wetland types. Increases in salinity of Bay-Delta waters could also impact wetlands, as salinity is a major structuring force for wetland plants across the estuary.

Data Considerations

Data of different wetland types likely overlap with the data layers used for the analyses in the Ecological Reserves and Shoreline Parks. It is important to consider these analyses when planning for overall habitat distribution within the Project Area and keep in mind when protecting wetland habitat may have co-benefits with outdoor recreation facilities.

Table 8-1. Total acres of wetland habitat area that may be located in the current 100-year storm event area and/or exposed to future sea level rise, or sea level rise combined with a 100-year storm event.

Asset	Current 100-year Storm Event*	12" + 100-yr	24" + 100-yr	36" + 100-yr	83" + 100-yr	MHHW Today	12"	24"	36"	83"
Tidal Wetlands	727	769	781	785	803	104	185	364	632	785
Managed Wetlands	3,089	3,144	3,193	3,214	3,227	335	373	404	943	3,215
Freshwater Emergent Wetlands	422	439	456	456	467	61	142	188	269	457
Seasonal Wetlands	141	155	347	354	374	0	0.3	5.1	27	355
Total Acres Exposed	**4,379**	**4,506**	**4,776**	**4,809**	**4,871**	**500**	**700**	**962**	**1,870.3**	**4,812**

"--": Unexposed assets

MHHW: Mean Higher High Water refers to the average of today's daily highest tide and is used as the baseline for all flooding scenarios.

* Current 100-year Storm Event: The 100-year storm event reflected in these maps is not equivalent to the FEMA 100-year flood hazard zone.

Vulnerabilities

INFO1: There is a limited understanding of how tidal marshes will respond to accelerating sea level rise or how these habitats will be affected by management actions (e.g., increasing sediment supply or building transition zone habitat).
GOV1: Proactive management of tidal marshes to improve resilience to sea level rise and storm events involves addressing regulatory requirements related to state and federal threatened, endangered, and special status species. Maintenance of tidal marshes requires review and authorization from multiple state and federal agencies, often with limited work windows and restrictions on the type of actions that can be taken.
GOV2: The process of obtaining permits from U.S. Army Corps of Engineers, the National Marine Fisheries Service, the U.S. Fish and Wildlife Service, the San Francisco Bay Regional Water Quality Control Board, the California Department of Fish and Wildlife, and the San Francisco Bay Conservation and Development Commission as well as obtaining local authorization from cities or counties is cumbersome and time-consuming. The San Francisco Bay Restoration Authority Funding for Bay Restoration Regulatory Integration Team (BRRIT) will help to alleviate this vulnerability. Projects that include railroad tracks, highways, pipelines, and PG&E towers require additional approvals.
GOV3: The combination of the prevailing model of fragmented regulatory decision-making, the predominant goals of natural resources law, passive management, and historical preservation limit the ability to attend to uncertainty and change in marsh restoration and enhancement projects. Since each project is considered separately, designing a single large project area can make it easier to satisfy regulatory requirements. However, as sea level rise rates accelerate, the lack of regional framework guiding marsh restoration and enhancement will inhibit shoreline resilience planning and advances in nature-based solutions.
PHYS1: Species, especially plants and fish, within wetlands are sensitive to changes in salinity and flooding regimes. Alterations in these two physical drivers could have large consequences for habitat structure and function.

Consequences

Society and Equity: Loss of marshes would be a loss of shoreline recreational opportunities since people enjoy views of marshes and the species within them. Natural areas buffer developed areas from inundation, including disadvantaged communities, and when these natural areas disappear there is a net loss of ecosystem services.

Environment: Marshes provide habitat for threatened and endangered species. Storm event flooding force marsh animals to take refuge in the upland, makes them more vulnerable to predation, and can reduce reproductive success in some bird species if nests are flooded. Downshifting habitat means marshes will be flooded more often until conversion to marsh to mudflat and complete loss of tidal marsh species. This series of changes may occur too quickly for species dependent on marsh habitat to persist within the Project Area.

Economy: Loss of nature-based flood protection would increase the height and cost of structural shoreline protection.

Wildlife Refuges and Ecological Reserves

Protected areas within East Contra Costa County represent a **wide variety of ecosystem types**, but only a subset of shoreline habitats were exposed to flooding in our analysis. These vulnerable habitats (wetlands, coastal dunes, and Delta islands) are important natural features within the Bay-Delta landscape. These **natural shoreline types help reduce incoming wave heights, protecting shoreline structures from wind, waves, and tidal energy**. These ecosystems also **buffer neighboring communities** of all kinds, including disadvantaged and vulnerable communities, from sea level rise, storm surge, and associated salinity intrusion. Their **loss can place shoreline communities at greater risk** by increasing the likelihood that structural shoreline protection is overtopped or fails, and can increase the cost of maintaining, repairing, and upgrading these already expensive structural protection assets. Many of these areas provide habitat to numerous **state-listed or federally threatened and endangered species as well as migrating and wintering birds** that rely on them for breeding and foraging. Additionally, they offer opportunities to view wildlife, provide access to the shoreline, and offer scenic and aesthetic benefits.

Issue Statement

Of the various habitats found in the protected lands within the Project Area, the most exposed are those containing wetlands. Additionally, the proportionally smaller areas of other protected lands impacted by flooding are rare habitat types (ex: coastal dunes) and are habitats for several federally endangered species, which will not persist unless land managers fold sea level rise adaptation into their endangered species management plans. For the deeply impacted wetland refuges, sea level rise alters both hydrology and salinity conditions, which can have extensive impacts on all wetland habitats. Wetlands will not persist unless higher elevation migration space is made available and restoration projects move forward with sufficient lead time to overcome regulatory hurdles. Managed wetlands are particularly vulnerable to levee failure or damage to pumping equipment from flooding by saltwater, which will require dedicated funding to accommodate. Wetlands are sensitive to changes in water salinity and altered salinity conditions can change plant communities, which has trickle up effects for the other organisms using the habitat.

Asset Descriptions

Antioch Dunes National Wildlife Refuge

Antioch Dunes National Wildlife Refuge is owned and managed by the United States Fish and Wildlife Service. The site is the last remnant of a historic dune system, mostly lost to sand mining. Coastal dune systems help stabilize shorelines, protect neighboring developments, and provide unique habitat for native flora and fauna. The Antioch Dunes NWR protects the habitat of one federally endangered animal, the Lange's metalmark (*Apodemia mormo langei*) butterfly, and two endemic, endangered plants, the Antioch Dunes Evening Primrose (*Oenothera deltoides spp. howellii*), and the Contra Costa wallflower (*Erysimum capitatum spp. angustatum*).[lxxv]

Ten percent (5.8 acres) of the site is exposed to flooding from sea level rise at 83". Flooding from 100-year storm events in combination with sea level rise can increases flooding up to 14% (7.9 acres). Any loss of habitat is significant, as both the Antioch Dunes Evening Primrose and the Contra Costa wallflower are confined almost entirely to the site. Similarly, flooding can alter dune system dynamics, destabilizing dune systems and shifting the vegetative community. The most recent Conservation Plan for the site (2002) did not mention sea level rise as a management concern.[lxxvi]

Rhode Island Wildlife Area

Rhode Island Wildlife Area is a 67-acre Delta island owned and managed by the California Department of Fish and Wildlife. Marsh vegetation, including tules and cattails, borders the site, along with alder, willow, and blackberry. During high tides, the marsh vegetation may be submerged to several feet in depth. River otters, beavers, muskrat, and various bird species utilize the island habitat.[lxxvii]

Only a small portion of the site (less than 5%) is exposed to flooding at any flood level. However, this flooding primarily occurs in the band of wetland vegetation around the island, decreasing the prevalence of this valuable ecosystem.

Wetland Reserve Program Sites

Both Wetland Reserve Program sites (6691041000Y2B and 6691049800FRQ) are managed by local land owners through the Wetland Reserve program of the United States Department of Agriculture's Natural Resource Conservation Service. The Wetland Reserve Program provides technical and financial services to landowners on a voluntary basis. The program aims to protect, restore, or enhance wetlands in exchange for retiring eligible land from agriculture. Depending on the type of easement or agreement, compensation may be available for all or part of the cost of conservation practices that may improve wildlife habitat and restore natural ecosystems.[lxxviii]

Neither site is impacted by sea level rise flooding until 83", when the entirety of the site may be inundated. Alternatively, 100-year storm events result in complete flooding of the site, though until these flood events are paired with 83" of sea level rise, there is no permanent flooding of the sites.

Other Protected Areas Not Exposed To Flooding

Of the 12 protected areas in the Project Area, eight were not exposed at any of the flooding levels we examined. These preserves are Black Diamond Mines Regional Preserve, Byron Vernal Pools Regional Preserve, Clayton Ranch Regional Preserve, Eagle Ridge Preserve, Morgan Territory Regional Preserve, Roddy Ranch Agricultural Preserve, Vasco Caves Regional Preserve, and Vasco Hills Regional Preserve.

Exposure To Current And Future Flooding

Of the 12 protected areas within East Contra Costa County, four are flooded in our analysis. All these sites represent unique habitat types within the Project Area and provide

valuable shoreline protection, wildlife habitat, and other ecosystem services. Small sections of shoreline habitat are exposed to current tidal flooding, with only small increases in flooding until 83" of sea level rise. Protected areas within East Contra Costa County are much more exposed to a current 100-year storm event, which floods 7% of the total asset area.

Data Considerations

When these data include a protected area with a wetland habitat type, they likely overlap with the data found in wetland habitat analysis found in the previous section. When interpreting our exposure analysis, it is important to consider the potential for this double-counting and consider what data set best addresses the needs of each project.

Table 8-2. Total acres and percentages of wildlife refuges and ecological preserves that may be located in the current 100-year storm event area and/or exposed to future sea level rise or sea level rise combined with a 100-year storm event.

Asset	Total Area	100-year Storm* Event Only	12" + 100-yr	24" + 100-yr	36" + 100-yr	83" + 100-yr	MHHW Today**	12"	24"	36"	83"
Antioch Dunes National Wildlife Refuge	56	1.4 (3%)	1.5 (3%)	1.7 (3%)	5.3 (10%)	7.9 (14%)	0.3 (<1%)	0.6 (1%)	0.9 (2%)	1.2 (2%)	5.8 (10%)
Rhode Island Wildlife Area	85	1 (1%)	1.2 (1%)	1.3 (2%)	1.4 (2%)	1.5 (2%)	0.5 (<1%)	0.6 (<1%)	0.7 (<1%)	0.8 (1%)	1.4 (2%)
Wetlands Reserve Program (WRP) 6691041000Y2B	649	649 (100%)	649 (100%)	649 (100%)	649 (100%)	649 (100%)	--	--	--	--	649 (100%)
Wetlands Reserve Program (WRP) 6691049800FRQ	492	492 (100%)	492 (100%)	492 (100%)	492 (100%)	492 (100%)	--	--	--	--	492 (100%)
Total area not exposed to flooding in analysis	15,422	--	--	--	--	--	--	--	--	--	--
Total in Project Area	16,704	1,144	1,144	1,144	1,148	1,15	0.7	1.2	1.7	2	1,149

"--": Unexposed assets

MHHW: Mean Higher High Water refers to the average of today's daily highest tide and is used as the baseline for all flooding scenarios.

*Current 100-year Storm Event: The 100-year storm event reflected in these maps is not equivalent to the FEMA 100-year flood hazard zone.

**Many parks exposed at MHHW today are characterized by tidal wetland habitats that, by nature, are temporarily flooded daily.

Vulnerabilities

INFO1: The importance of coastal habitats in protecting adjacent development is often poorly communicated between land managers and developers. Lack of communication can limit the ability of group to collaborate for the greatest co-benefits.
GOV1: Proactive management of shoreline habitats to improve resilience to sea level rise and storm events involves addressing regulatory requirements related to state and federal threatened, endangered, and special status species. Maintenance of these ecosystems requires review and authorization from multiple state and federal agencies, often with limited work windows and restrictions on the type of actions that can be taken.
GOV2: The combination of the prevailing model of fragmented regulatory decision-making, the prominent goals of natural resources law, and passive management and historical preservation limit the ability to attend to uncertainty and change in habitat restoration and enhancement projects. Since each project is considered separately, designing a single large Project Area can make it easier to satisfy regulatory requirements. However, as sea level rise rates accelerate, the lack of regional framework guiding marsh restoration and enhancement will inhibit shoreline resilience planning and advances in nature-based solutions.
GOV3: Land managers will need to coordinate with neighboring landowners, county and city departments, and railroad companies to address shoreline erosion and coastal flooding impacts.
FUNC1: Wetland Preserve Program sites contain tidal marsh habitat that may downshift and/or disappear if sediment supplies and upland transition zones are insufficient to accommodate future flood levels.
FUNC2: Reserves and preserves rely on roads and trails for access that are vulnerable to current and future flooding. The county and cities manage these roads, so land managers will need to coordinate with local government to maintain access.
PHYS1: Species within the reserves and preserves are sensitive to changes in salinity and flooding regimes.

Consequences

Society and Equity: Natural areas buffer developed areas from inundation, including disadvantaged communities. Residents and business owners could lose shoreline access and wildlife viewing recreation opportunities if the park is damaged or disrupted.

Environment: Wildlife refuges and ecological reserves provide habitat for threatened and endangered species. Storm event flooding makes these species seek refuge in the upland where they are more vulnerable to predation and can reduce reproductive success if nests are flooded. Downshifting means marshes within ecological reserves and wildlife refuges may be flooded more often, until conversion of marsh habitat to mudflat, which may result in complete loss of tidal marsh species at these sites.

Economy: Loss of nature-based flood protection would increase the height and cost of structural shoreline protection.

Shoreline and Near-Shoreline Parks

Shoreline parks within the East Contra Costa ART Project Area serve a diverse array of purposes and are owned and managed by several different agencies and jurisdictions. East Bay Regional Park District (EBRPD) owns and manages the regional shoreline parks in the Project Area. EBRPD is responsible for providing recreation and open space in a highly developed and growing area. EBRPD's role has expanded over the years to include a greater range of management objectives on the parklands it owns and operates, including natural area restoration, community engagement, and new partnerships with neighboring landowners. In addition to regional shoreline parks, several shoreline parks are managed by local governments, including Contra Costa County and individual cities within the Project Area.

Issue Statement

EBRPD shoreline parks face flooding, groundwater infiltration, erosion, habitat shifts, and habitat loss and degradation from sea level rise and future flooding. These regional shoreline parks contain important wetland habitat, unique historical resources, and large-scale recreation assets including trails, economically important fishing opportunities, and wildlife viewing. Though some of these assets, such as tidal marshes, are robust to temporary flooding, permanent flooding from sea level rise could lead to conversion of this valuable habitat type. Sea level rise and future flooding will not only affect parks and shoreline habitats but also inland areas in places where EBRPD provides the official or de facto shoreline protection. EBRPD will need to protect its park and recreation areas as well as work with the inland neighbors that its shoreline parks protect from flooding, such as transportation authorities, cities, and private landowners.

Asset Descriptions

8TH Street Greenbelt

The 8th Street Greenbelt Park is a ten-block linear stretch of the center median on Pittsburg's Eighth Street, which is managed by the City of Pittsburg. The Greenbelt includes a seasonally dry creek, filled with various grasses and stones. In addition to these features, there are several community amenities in the park, including benches, a picnic area, and a BBQ pit located at 8th and Cumberland. Two playground facilities are also located within the Greenbelt.[lxxix]

Big Break Regional Shoreline

Big Break Regional Shoreline is regional park managed by East Bay Regional Park District at the edge of the San Joaquin River in Oakley. Big Break provides critical wildlife habitat, serving as a stopover for a wide variety of species, particularly birds and fish. Big Break is home to 70 species of birds and several species of mammals. The park habitats have the potential to offer habitat to 27 special-status wildlife species, and there are recorded occurrences of six of these species. The park provides a visitor center with educational programs, hiking trails, a pier, a boat launch, and wetland and transition habitat[lxxx].

Big Break Regional Trail

Big Break Regional Trail is an 8.7 mile trail located near Big Break Regional Shoreline in Oakley, California. The trail offers several activity options and is accessible year-round.

Browns Island Regional Shoreline

Browns Island Regional Shoreline is located in the Delta at the junction of the Sacramento and San Joaquin rivers off the shoreline of Pittsburg. It is a 595-acre island with no public facilities. Browns Island provides habitat for six species of rare or endangered plants and also provides habitat and foraging rounds for numerous aquatic birds[lxxxi].

Cornell Park

Cornell Park is a small neighborhood park located in the canal area of Discovery Bay. It has many amenities including a playground, basketball and bocce ball courts, soccer fields, softball facilities, picnic tables and barbecues, tennis courts, horseshoes, restaurants, and a large grassy area.

Cypress Grove Community Park

Cypress Grove Community Park opened in 2008 and is managed by the City of Oakley. It has a large grassy area, a playground, tables, barbecues, and a drinking fountain.

Delta Access Regional Recreation Area

Delta Access Regional Recreation Area is a newly acquired EBRPD property located one mile south of Oakley and two miles east of Knightsen, on the east side of Byron Highway. The park district intends to restore farmland within the property to tidal and freshwater wetlands with native vegetation to provide habitat for rare species and to provide flood protection for neighboring communities.

Dutch Slough

Managed by the California Department of Water Resources, Dutch Slough is the water body located between Jersey Island and Oakley. The Dutch Slough Tidal Marsh Restoration Project intends to convert 1,187 acres of land into tidal marsh, with the major goal being provision of habitat for salmon, other fish, and native wildlife within the Sacramento-San Joaquin Delta.[lxxxii]

Lakewood Drive Park

Lakewood Park opened in 2009 and is managed by the City of Oakley. It has a small grassy area, barbecues, picnic tables, a playground, benches, and a bicycle rack.

Legless Lizard Preserve

The Legless Lizard Preserve is a 7.5-acre site that includes tree-covered sand dunes, found to be a natural habitat for the legless lizard. The site is managed by EBRPD and located in the Big Break Regional Shoreline Area. It is home to an endangered species of the legless lizard and was fenced off to provide protection and habitat for research and study.

Manresa Park

Manresa Park opened in 2009 and is managed by the City of Oakley.

Proserville Park

Prosserville Park is a small, recently refurbished neighborhood park located in Antioch at O Street and 6th Street. It has basketball courts, a playground, and a large grass area.

Slifer Park

Slifer Park is a neighborhood park located just west of the canal area of Discovery Bay. It has a playground, basketball courts, a soccer field, picnic tables and barbecues, and a large grassy area.

Summer Lake Community Park

Summer Lake Park opened in 2008 and is managed by the City of Oakley. It has a grass area, picnic tables, benches, trail access, sports fields, a playground, tennis courts, and a restroom.

Sycamore Drive Park

Sycamore Park opened in 2009 and is managed by the City of Oakley. It has a grassy area, picnic tables, and benches.

Other Parks Not Exposed To Flooding

Of the twenty-three shoreline parks in the Project Area, eight were not exposed at any of the flooding levels we examined. These parks are: Central Park, Gaylord Sports Park, Jacobsen Park, Meadow Brook Park, Almondridge Park, Claremont Bay, Main Street Park, and Briarwood Park.

Exposure To Current And Future Flooding

Detailed exposure was analyzed for **twenty-three shoreline or near-shoreline parks in the Project Area**. **Five parks are shown as exposed high tide today** due to open water and/or wetland habitat within the parks. This exemplifies the daily temporarily flooding that is, by nature, part of the character of wetland habitats. However, **when temporary flooding of wetland habitats becomes permanent habitat, park area may be lost**.

Park flooding potential is variable within the Project Area. Most notably, **~4000 acres of shoreline parks could be flooded to a flood event today with a 100-year storm event**. This highlights the **importance of planning for resilience to current and future flooding.**

Data Considerations

These data are a subset of the Bay Area Protected Areas Database, which includes all protected lands throughout the Bay Area. As such, there is some overlap with other asset categories evaluated in this project, such as the wetland habitat analyses found earlier in this chapter.

Table 8-3. Acres and percentages of shoreline parks that may be located in the current 100-year storm event area and/or exposed to future sea level rise or the combination of sea level rise and a 100-year storm event.

Asset	Manage-ment	Total Acres in Project Area (Acres)	Current 100-year Storm Event*	12" + 100-yr	24" + 100-yr	36" + 100-yr	83" + 100-yr	MHHW Today**	12"	24"	36"	83"
Big Break Regional Shoreline	EBRPD	1,604	208 (13%)	213 (13%)	218 (14%)	222 (14%)	228 (14%)	27 (2%)	106 (7%)	179 (11%)	199 (12%)	223 (14%)
Big Break Regional Trail	EBRPD	4.1	1 (24%)	1 (24%)	1.3 (32%)	1.5 (37%)	3.4 (83%)	--	0.1 (2%)	0.7 (17%)	0.9 (22%)	1.7 (41%)
Delta Access Regional Recreation Area	EBRPD	987	871 (88%)	897 (91%)	925 (94%)	943 (96%)	974 (99%)	0.3 (<1%)	0.5 (<1%)	0.6 (<1%)	0.8 (<1%)	947 (96%)
Slifer Park	County	6.5	0.1 (1%)	0.1 (1%)	0.4 (6%)	3.3 (50%)	6.5 (100%)	--	--	--	<0.1 (<1%)	3.8 (58%)
Dutch Slough	State (DWR)	1,185	655 (55%)	1,083 (91%)	1,099 (93%)	1,110 (94%)	1,119 (94%)	0.1 (<1%)	1.2 (<1%)	3.3 (<1%)	638 (54%)	1,113 (94%)
Browns Island Regional Shoreline	State Lands Commission	600	510 (85%)	541 (90%)	549 (92%)	551 (92%)	551 (92%)	76 (13%)	135 (23%)	255 (43%)	443 (74%)	551 (92%)
Summer Lake Community Park	City (Oakley)	18	--	0.03 (<1%)	0.04 (<1%)	0.05 (<1%)	18 (100%)	--	--	--	--	18 (100%)
Cornell Park	County	14	--	--	9.3 (66%)	12 (86%)	14 (100%)	--	--	--	--	12 (86%)
Cypress Grove Community Park	City (Oakley)	5.1	--	--	--	4.8 (94%)	5.1 (100%)	--	--	--	--	4.9 (96%)
8th Street Greenbelt	City (Pittsburg)	3.4	--	--	--	--	0.3 (8%)	--	--	--	--	<0.01 (<1%)

Asset	Manage-ment	Total Acres in Project Area (Acres)	Current 100-year Storm Event*	12" + 100-yr	24" + 100-yr	36" + 100-yr	83" + 100-yr	MHHW Today**	12"	24"	36"	83"
Manresa Park	City (Oakley)	0.3	--	--	--	--	0.3 (100%)	--	--	--	--	0.3 100%
Sycamore Drive Park	City (Oakley)	0.3	--	--	--	--	0.3 (100%)	--	--	--	--	0.3 (100%)
Lakewood Drive Park	City (Oakley)	0.5	--	--	--	--	0.5 (100%)	--	--	--	--	0.3 (100%)
Prosserville Park	City (Antioch)	1.5	--	--	--	--	0.6 (40%)	--	--	--	--	--
Legless Lizard Preserve	EBRPD	7.9	--	--	--	--	1.4 (18%)	--	--	--	--	0.1 (1%)
Total Acres Exposed in Project Area		4,482	2,250	2,741	2,808	2,854	2,986	104	244	442	1,287	2,882

"--": Unexposed assets

MHHW: Mean Higher High Water refers to the average of today's daily highest tide and is used as the baseline for all flooding scenarios.

*Current 100-year Storm Event: The 100-year storm event reflected in these maps is not equivalent of the FEMA 100-year flood hazard zone.

**Many parks exposed at MHHW today are characterized by tidal wetland habitats that, by nature, are temporarily flooded daily.

Vulnerabilities

GOV: Several Parks Master Plans do not account for the impact of climate change on park facilities or services.
PHYS1: Shoreline parks already experience shoreline erosion and may face trail damage and disconnection as the erosion continues.
PHYS2: Several parks include low-lying and salt-sensitive turf that may be damaged by storm event flooding and/or groundwater intrusion.
PHYS3: Shoreline parks like Big Break Regional Shoreline already experience shoreline erosion and may face trail damage and disconnection as the erosion continues.
PHYS4: City Parks are vulnerable to shoreline erosion and saltwater intrusion in lawn areas.
PHYS5: Restrooms and parking lots can be damaged by short term flooding and require costly repairs.
FUNC1: Shoreline parks contain extensive wetland habitat that may downshift and/or disappear if sediment supply and upland transition zone are insufficient to accommodate future flood levels.
FUNC2: Shoreline parks rely on roads for access that are vulnerable to current and future flooding. The county and cities manage these roads, so park management may need to coordinate with local government to maintain park access.
FUNC3: City parks rely on roads for access and power and water for restrooms and lights that are vulnerable to current and future flooding.
FUNC4: There are limited city parks in the East Contra Costa Project Area. If these parks are lost or damaged by flooding, this park shortage could be further exacerbated.

Consequences

Society and Equity: Residents and business owners could lose shoreline access and wildlife viewing recreation opportunities if shoreline parks are damaged or disrupted. Several communities located near the Bay-Delta shoreline—Antioch, Oakley, Pittsburg, etc.—are vulnerable communities for which shoreline park and recreational facilities provide open space and recreational access, as well as serve as protection from the Bay-Delta. This consequence may be more severe for transit-dependent or limited-mobility residents who cannot access substitute recreation further away from their homes.

Environment: Marsh habitat in shoreline parks may downshift or drown due to future flood levels if there is not sufficient sediment supply and upland space for transgression. This could lead to habitat loss and impacts on shoreline species.

Economy: EBRPD alone provides $16.7 Million dollars in recreation value each year to all of Contra Costa County and regional residents and visitors. City parks provide recreation value to residents and help maintain healthy and safe communities.

Water Trail

The San Francisco Bay Area Water Trail is a network of sites for non-motorized water crafts (e.g. kayaks, stand-up paddleboards, wind and kite surfing, etc.) around the San Francisco Bay and includes the San Joaquin River, Napa River, and Petaluma River.

Although the Water Trail is a regional program, **each Water Trail site is individually owned and managed**, and sites are designated on a voluntary basis. A single site may be owned and managed by different entities. Whether privately owned or not, each designated site must be **open to the public** to be part of the Water Trail. Sites can be "un-designated" in the case that a site owner or manager is no longer able or willing to remedy a site issue.

If a site is inundated by permanent flooding that may cause a site to lose facilities or be an interesting or useful stop-over site, this would be a consequence of loss of the Water Trail Site to the program. There may be additional management concerns for the owner or manager, if they are not able to or not willing to maintain the site for public access due to changes from sea level rise, then the site would not be appropriate to the Water Trail Program.

The Enhanced Water Trail Plan (2011) identified all sites within the Bay Area where there is access for non-motorized small boats. The **Water Trail Staff currently work with property owner/manager to officially designate a site through the Water Trail Designation process**. The goal over the long-term is to eventually add all eligible existing sites identified in the plan into the official Water Trail network. In the meantime, all launch and destination sites for non-motorized small boats are mapped on the Water Trail website and basic information about each site is given.

Issue Statement

The Water Trail and fishing piers are valuable recreation assets which will be exposed to sea level rise and storm event flooding due to their shoreline location. Although docks and some types of boat launches are able to accommodate changes in water levels (already established at higher elevations or retrofitted to float with changing water levels), they rely on local roads and park facilities to give the community access to these assets. The Water Trail relies on connectivity in its function as a regional network, so even small sections of damage can disrupt the use of large segments. In addition, the Water Trail is managed and funded by many different agencies, so adaptation will require extensive coordination to maintain trail alignments and connectivity.

Asset Descriptions

Antioch Marina Designated Trailhead

The Antioch Marina is a major launching point for non-motorized boats. The main boat launch is in the eastern part of the marina. This boat launch has two boat ramps, with three docks located next to the ramps that extend 150 feet from the shore. The Boat Ramp is ADA accessible.[lxxxiii]

Big Break Designated Trailhead

Big Break Regional Shoreline operated by EBRPD is a primary launch point for many types of boating activities including bird watching, exploration of nearby islands, views of historic sites along the river, and fishing. To access the boat launch, visitors walk down a ¼ mile paved path from the Visitor Center to a beach access point. Wheeled kayak carts can be borrowed for free from the Visitor Center.[lxxxiv]

Exposure To Current And Future Flooding

Both Water Trail Designated Trailheads within the Project Area may be flooded in a current 100-year storm event. The Antioch Marina trailhead may be flooded at 12" of sea level rise and the Big Break trailhead may be flooded at 24" of sea level rise, though as a **sandy beach boat launch it may experience earlier impacts of sea level rise and flooding**. In addition to the flooding of the trailhead boat launch sites, **flooding of nearby roads, parking lots and trails will impact access to the water trail sites.**

Data Considerations

Due to the in-water nature of water trail sites and activities, evaluating flood risk to sites is challenging. As such, this analysis focuses on consequences of permanent flooding that may cause a site to lose access or facilities.

Table 8-4. site exposure of water trail sites that may be located in the current 100-year storm event area and/or exposed to future sea level rise or sea level rise combined with a 100-year storm event.

Asset	City	Current 100-year Storm Event* Only	12" + 100-yr	24" + 100-yr	36" + 100-yr	83" + 100-yr	MHHW Today	12"	24"	36"	83"
Antioch Marina Designated Trailhead	Antioch	Yes	Yes	Yes	Yes	Yes	--	Yes	Yes	Yes	Yes
Big Break Designated Trailhead	Oakley	Yes	Yes	Yes	Yes	Yes	--	--	Yes	Yes	Yes
Total Exposed in Project Area		2	2	2	2	2	--	1	2	2	2

"--": Unexposed assets

MHHW: Mean Higher High Water refers to the average of today's daily highest tide and is used as the baseline for all flooding scenarios.

*Current 100-year Storm Event: The 100-year storm event reflected in these maps is not equivalent to the FEMA 100-year flood hazard zone.

Vulnerabilities

GOV1: Water trail sites are individually owned and managed. While all sites must provide publicly available opportunities to recreate, there is no overarching plan for how all these different sites will have to prepare for and manage rising sea levels, as well as coordinate with local agencies on how to ensure local access to the sites continues to function.
FUNC1: The Antioch Marina designated trailhead is in a marina. Developed sites are less physically vulnerable to sea level rise than beach water trail sites but depend on other infrastructure such as transportation for access. Access to this water trail site occurs primarily local roads and relies on the marina parking lot. Inundation of local roads and the parking lot will impact access to this water trail site.
FUNC2: Any damage to water trail sites limits the access of persons interested in accessing the water, particularly for those with any disabilities that would benefit from these sites designed for ADA public access. Impacts to the water trail sites in this area may reduce functional access for residents and visitors, including from vulnerable communities.
PHYS1: The Big Break Water Trail site is a sandy beach boat launch, and thus less able to adapt to flood events than water trail sites that are floating docks.

Consequences

Society and Equity: Water Trail sites provide free access to the shoreline and water for neighboring vulnerable community members. Loss of access or function to these water trail sites would result in limited access to shoreline recreation.

Environment: Water Trail sites provide access to shoreline natural environments, increasing connections between humans and nature. Loss of access or function to water trail sites could limit awareness and stewardship of the natural environment.

Economy: Water Trail sites bring people from around the region to put money into the local economy. Loss of water trail site access would result in loss of visitation and economic inputs.

Marinas

The Project Area includes twenty-two active public and private marinas spread across East Contra Costa County from Pittsburg to Discovery Bay and Bethel Island. Marinas provide public access to the shoreline for water recreation as well as sail and motorboat access. Marinas can also house live-aboard residents and many marinas have inland facilities including office space, restaurants, and housing. Marinas often provide power, water treatment, and refueling services to boats that moor either in permanent berths or temporary slips. Marinas provide unique shoreline recreation and are difficult to expand or relocate due to their need for unique shoreline conditions such as natural harbors to minimize dredging.

Issue Statement

Marinas are vulnerable to sea level rise and storm event flooding because of their shoreline location and sensitive onshore equipment. Although boats and docks are able to accommodate changes in water levels, onshore facilities are not waterproofed and often contain hazardous materials like fuel, wastewater, sewage, and motor oil. Marinas provide water-oriented recreation and housing and are not easily relocated within the region. Additionally, marinas often house public facilities such as restrooms and stores selling food and supplies, which could be cut off from populations depending on these services during flooding.

Asset Descriptions

Big Break Marina, Oakley

Big Break Marina is privately owned and provides berths for motorized and non-motorized boats, as well as RVs. The marina also provides on-site kayak, paddleboard, and jet ski rentals, dry storage, and a picnic area.

Driftwood Marina, Oakley

Driftwood Marina is privately owned and provides covered, uncovered, and end tie berths up to 50 feet for both motorized and unmotorized boats.

Carol's Harbor, Oakley

Carol's Harbor and Marina is a public marina and launch site that provides fishing tackle sales, ice vending, restrooms, and showers.

Hennis Marina, Oakley

Hennis Marina is a public marina, launch site, and dry storage (130 capacity) that provides a boat washdown area, picnic area, fish cleaning stations, haul out and boat repair, ice vending, launching services, a restaurant, restrooms, shore boat service, showers, and transient berths or tie ups.

Wood's Yacht Harbor, Oakley

Wood's Yacht Harbor is a private marina that provides a boat launch, restrooms, dry storage and electric slips.

Holland Riverside Marina, Brentwood

Holland Riverside Marina is privately owned with covered and uncovered transient and permanent slips, two launch ramps, boat trailer storage, restrooms, laundry, grocery store, and a pump out station.

Lighthouse Landing Marina, Brentwood

Lighthouse Landing Marina is privately owned and provides campsites and a swimming area.

Cruiser Haven, Brentwood

Cruiser Haven is a private marina with slips up to 50 feet, restrooms, showers, laundry, boat trailer storage, and a picnic area.

Antioch City Marina, Antioch

Antioch Marina is publicly owned with 310-berths and a boat launch.

Discovery Bay Yacht Harbor, Discovery Bay

Discovery Bay Yacht Harbor is privately owned with wet and dry berths, trailer storage, a gas dock, pump out station, a public launch ramp, and propane and ice services.

Bethel Island Private Marinas

Anchor Marina, Caliente Isle Harbor, Beacon Harbor, Mazikeen's Landing, Russo's Marina, Rusty Porthole, Bethel Harbor, D'Anna's Bethel Island Marina Resort, Emerald Point Marina, Frank's Marina, Mariner Cove Marina, and Willowest Harbor are all small, privately owned marinas located on Bethel Island offering a wide variety of services, berths, and launches for both permanent and visiting boaters in the Delta.

Exposure To Current And Future Flooding

All twenty-two marinas are exposed to current and future flood risk because of their shoreline location and functions. **Sixteen of the twenty-two marinas in the Project Area may be flooded in a current 100-year storm event. This highlights the need to plan for flooding in the near-term**. The **nature of this vulnerability may vary depending on the unique infrastructure within each marina site**. For example, sites with floating docks will likely be more resilient to flooding due to their ability to go up and down with the tide. Sites with critical infrastructure, such as restroom facilities, gas services, etc. directly on the shoreline may face higher risks in the case of flooding.

Data Considerations

The best available dataset to analyze the exposure of marinas within the Project Area is a point dataset. These point likely do not cover the entire footprint of marina docks, buildings, facilities, etc. As such, exposure results may not represent the exact flood level at which marina or harbor facilities, or properties are first exposed.

Table 8-5. Marinas that may be located in the current 100-year storm event area and/or exposed to future sea level rise or the combination of sea level rise and a 100-year storm event.

Asset	City	Current 100-year Storm Event* Only	12" + 100-yr	24" + 100-yr	36" + 100-yr	83" + 100-yr	MHHW Today	12"	24"	36"	83"
Big Break Marina	Oakley	Yes	Yes	Yes	Yes	Yes	--	Yes	Yes	Yes	Yes
Antioch City Marina	Antioch	Yes	Yes	Yes	Yes	Yes	--	Yes	Yes	Yes	Yes
Driftwood Marina	Oakley	Yes	Yes	Yes	Yes	Yes	--	--	Yes	Yes	Yes
Anchor Marina	Bethel Island	Yes	Yes	Yes	Yes	Yes	--	--	--	--	Yes
Holland Riverside Marina	Brentwood	Yes	Yes	Yes	Yes	Yes	--	--	--	--	Yes
Lighthouse Landing Marina	Brentwood	--	Yes	Yes	Yes	Yes	--	--	--	--	Yes
Caliente Isle Harbor	Bethel Island	Yes	Yes	Yes	Yes	Yes	--	--	--	--	Yes
Beacon Harbor	Bethel Island	--		Yes	Yes	Yes	--	--	--	--	Yes
Mazikeen's Landing	Bethel Island	Yes	Yes	Yes	Yes	Yes	--	--	--	--	Yes
Russo's Marina	Bethel Island	Yes	Yes	Yes	Yes	Yes	--	Yes	Yes	Yes	Yes
Rusty Porthole	Bethel Island	Yes	Yes	Yes	Yes	Yes	--	--	--	--	Yes
Bethel Harbor	Bethel Island	Yes	Yes	Yes	Yes	Yes	--	--	--	--	Yes
Carol's Harbor	Oakley	--	Yes	Yes	Yes	Yes	--	--	--	--	Yes

Asset	City	Current 100-year Storm Event* Only	12" + 100-yr	24" + 100-yr	36" + 100-yr	83" + 100-yr	MHHW Today	12"	24"	36"	83"
D'Anna's Bethel Island Marina Resort	Bethel Island	Yes	Yes	Yes	Yes	Yes	--	Yes	Yes	Yes	Yes
Emerald Point Marina	Bethel Island	Yes	Yes	Yes	Yes	Yes	--	Yes	Yes	Yes	Yes
Frank's Marina	Bethel Island	Yes	Yes	Yes	Yes	Yes	--	--	--	--	Yes
Hennis Marina	Oakley	--	Yes	Yes	Yes	Yes	--	--	--	--	Yes
Mariner Cove Marina	Bethel Island	Yes	Yes	Yes	Yes	Yes	--	Yes	Yes	Yes	Yes
Willowest Harbor	Bethel Island	Yes	Yes	Yes	Yes	Yes	--	Yes	Yes	Yes	Yes
Wood's Yacht Harbor	Oakley	--	Yes	Yes	Yes	Yes	--	--	--	--	Yes
Cruiser Haven	Brentwood	Yes	Yes	Yes	Yes	Yes	--	--	--	--	Yes
Discovery Bay Yacht Harbor	Discovery Bay	--	--	Yes	Yes	Yes	--	--	--	--	Yes
Total Exposed Project Area		16	20	22	22	22	--	8	8	8	22

"--": Unexposed assets

MHHW: Mean Higher High Water refers to the average of today's daily highest tide and is used as the baseline for all flooding scenarios.

*Current 100-year Storm Event: The 100-year storm event reflected in these maps is not equivalent to the FEMA 100-year flood hazard zone.

Vulnerabilities

GOV1: Marinas are often privately owned or managed and may not have the information or capacity to plan for sea level rise impacts.
PHYS1: Marinas are always located in low-lying shoreline areas and their dryland facilities are vulnerable to flood impacts because of their construction. Facilities such as restaurants, clubhouses and bathrooms are not elevated or waterproofed.
PHYS2: Marinas often provide refueling, oil change, and recycling services to boaters. These services include the storage and transport of hazardous materials, which may be mobilized during flood events impairing water quality.
FUNC1: Marinas rely on roads, parking lots, and other vulnerable access ways to function as recreation sites.
FUNC2: Marinas need adequate water depths both within the marina and between the marina and deeper Bay-Delta waters. Therefore, they can only be built and maintained along certain parts of the shoreline with appropriate sediment accumulation patterns. If flooding damages marinas, there may not be adequate capacity within the region to expand existing or create new marinas to replace the lost uses.
FUNC3: Marinas provide limited live-aboard housing to vulnerable residents. These residents may need special consideration when planning for flood events and for eventual relocation.

Consequences

Society and Equity: Marina residents and visitors rely on marinas for recreation and housing. If marinas are damaged or closed due to future flooding, other facilities may not be available.

Environment: Marinas create, store, and transport hazardous materials like fuel and motor oil. If these facilities are flooded, hazardous materials may be mobilized and lead to impaired water quality and environmental habitat degradation.

Economy: Marinas provide unique shoreline recreation value and direct economic activity through berth rentals, recreational fishing including sport fishing tournaments, and inland businesses, such as restaurants. In addition, residents living in and around marina in Delta islands have vested economic interests that may be lost in the case of flooding. The closure of marinas may impact local economies and tax revenue.

Fishing Piers

Fishing Piers provide public access to recreational fishing along the shoreline throughout the Project Area. The Delta is a popular location to fish for catfish, striped bass, and sturgeon. Within the Project Area, there is a mix of recreational and subsistence fishing. Fishing piers provide free (with a license) recreation. The Contra Costa County Northern Waterfront Atlas (2014) mapped four official fishing piers within the Project Area, however

this mapping exercise was limited to both the northern waterfront area and "official" fishing piers.[lxxxv] Four fishing piers were identified through this work:

- Antioch Fishing Pier
- Antioch Pier
- Antioch/Oakley Regional Shoreline Pier
- Big Break Regional Shoreline Pier

Issue Statement

The fishing piers are valuable recreation assets which will be exposed to sea level rise and storm event flooding due to their shoreline location. Although docks and some types of boat launches are able to accommodate changes in water levels (already established at higher elevations or retrofitted to float with changing water levels), they rely on local roads and park facilities to give the community access to these assets.

Exposure To Current And Future Flooding

Due to the limited geographic area of this dataset, as well as challenges with analyzing exposure of fishing piers due to their elevation above open-water, this project opted to qualitatively discuss vulnerabilities and consequences of fishing piers to current and future flooding, rather than quantitatively analyze an incomplete dataset.

Data Considerations

Fishing pier data for the full Project Area are not available. Even in the case that they were available, gauging the impact of sea level rise and flooding on fishing activities is extremely challenging due to the nature of the activity. One can fish almost anywhere along the shoreline, regardless of whether a pier is present. Thus, "official fishing piers" represent only a fraction of true fishing activity in the Project Area. Additionally, the flood maps generate for this project begin at the MHHW line, which is often inland of a fishing pier that extends waterward of MHHW into an open water body.

Vulnerabilities

INFO1: There is a lack of knowledge regarding where people fish within the Project Area.
FUNC1: Though fishing piers themselves are often a safe elevation above MHHW to escape flood events, they rely on access roads and trails that may be flooded during storm or sea level rise events.
PHYS1: Fishing piers rely on pylons into the Bay-Delta to support their elevated structure. These may experience increased scour and erosion with sea level rise and storm events.

Consequences

Society and Equity: Fishing piers in the Project Area are used for many purposes, including recreational and subsistence fishing by local community members. Loss of fishing pier access in the Project Area may result in loss of affordable recreation activities and/or loss of food source to local community members, particularly those from vulnerable communities in Pittsburg, Antioch, and Oakley.

Environment: Recreational fishing often **helps control fish populations**, especially invasive fish species. Loss of access or function of fishing piers may result in **shifting population dynamics of fish species** within the Project Area.

Economy: Recreational fishing **brings money into the economy** through the purchasing of fishing licenses and supplies at local stores. Loss of access to fishing piers in the Project Area may result in **loss of economic revenue to the surrounding local communities.**

People and Communities

Communities

People are the most important asset in any community. The health and resilience of a community is dependent on the health and resilience of the people within it. People are the workers, students, clients, customers, neighbors, volunteers and members that make up our cities, communities and region. People are responsible for creating the social and personal support networks, the culture and values, and the local economies that contribute to the resilience of communities. **It is critical, therefore, to understand the needs, challenges and strengths of the people within each community when evaluating the potential risks faced from hazards such as flooding, sea level rise, and storm events.**

Current and future flooding impacts a community when people are disrupted from getting to work, school and elsewhere, are injured, lives are lost, and/or when homes and possessions are damaged. Flooding can also have significant impacts on a community if important services and transportation routes are disrupted in the days and weeks after the event. As flood hazards become more frequent and severe as the climate changes, greater proportions of the region's population may be either directly or indirectly impacted. The consequences of flood events may be more severe for communities within existing coastal or riverine floodplains. In addition, communities where people are underserved, have limited personal resources, rely on public services such as healthcare, require specialized housing, need accessible transportation options, rely on others for daily living and personal care needs, or are otherwise disadvantaged, are at even greater risk both during and after flood events.

For the East Contra Costa ART project assessment, community vulnerability is described using the approach developed for Stronger Housing, Safer Communities[lxxxvi] and built upon by the ART Program for the ART Bay Area project. Stronger Housing, Safer Communities selected ten socioeconomic vulnerability indicators (indicators) that represent **characteristics of individuals and households that affect their ability to prepare for, respond to, and recover from a disaster**. These indicators include financially constrained households, renters, non-English speakers, people of color, educational attainment, transit dependent individuals, the elderly, and the very young. Indicators were mapped at a regional scale to identify areas (by Census block groups) that may have a higher than average concentration of one or more indicators. Together, these ten **indicators begin to present a picture of community vulnerability across the region**, with key themes that

emerge being **age-related vulnerabilities, language and ethnicity vulnerabilities, cost-burdened residents, housing related issues, and access to resources**. The ART Bay Area project built upon this methodology by adding two additional indicators to characterize increased risk to flooding based on stakeholder and community engagement: citizenship and housing cost burden. Through stakeholder and community engagement, these indicators were chosen to be added due to their link to a decreased ability to prepare for, respond to, or recover from a flood event. For example, those who are not U.S. citizens may be less likely to seek needed help or assistance from authorities in the case of a flood. The final twelve socioeconomic vulnerability indicators evaluated for this project are populations or households that are:

- Renters
- Under 5 years old
- Very low income
- Not U.S. citizens
- Without a vehicle
- People with disability
- Single parent families
- Communities of color
- 65 years old and over and living alone
- Limited English proficiency
- Without a high school degree
- Severely housing cost burdened

In addition, contamination vulnerability was also investigated**. The presence of contaminated lands and water raises health and environmental justice concerns, which worsen with flooding and sea level rise through increased risk of mobilization of contaminants**. A rank of highest, high, moderate, and lower for the severity of contamination in each block group was calculated using data compiled by CalEPA Office of Environmental Health Hazard Assessment (OEHHA) for use in CalEnviroScreen 3.0. The 5 specific types of contamination evaluated for this project are:

- Land with hazardous substances undergoing cleanup actions. Original source data are from Department of Toxic Substances Control (DTSC) and US EPA (Superfund Sites).
- Sites that may impact groundwater and require cleanup. Original source data are from State Water Resources Control Board.
- Presence of hazardous waste generators and permitted facilities that are involved in the treatment, storage, or disposal of hazardous waste. Original source data are from DTSC.
- Water bodies that do not meet water quality standards, listed as impaired under Section 303(d) of the Clean Water Act. Data are from State Water Resources Control Board.
- Presence of solid waste sites and facilities. Original source data are from CalRecycle and DTSC.

The assessment that follows presents the key themes and findings for the East Contra Costa ART Project Area. It is based on the regional analysis of the twelve socioeconomic vulnerability indicators as well as research on readily available city- and neighborhood-scale information about the people and community resources that may underlie specific vulnerabilities or impart resilience.

Issue Statement

Individuals, households and neighborhoods in East Contra Costa County have characteristics that could affect their ability to prepare for, respond to, and recover from a flood event. These characteristics include low-income households, individuals with low educational attainment, people of color, renters, mobile home occupants, and households without a vehicle. In addition, across the project area most residents are housing and transportation cost-burdened.

Exposure To Current And Future Flooding

The East Contra Costa ART Project Area includes the **shoreline cities of Pittsburg, Antioch, Oakley, and the inland adjacent city of Brentwood. Also included in the Project Area are the unincorporated communities of Bethel Island, Discovery Bay, Knightsen, and Byron.**

An analysis of the population that could be impacted by current and future flooding was conducted using census block data from the 2010 US Census, which is the smallest available geographic unit. **There are 82,356 residential households in the Project Area, and approximately 11,714 residential households are at risk from current and future flooding** (14% of the Project Area population). This includes people living in the current 100-year storm event area and those living in areas that could be exposed to 83" of sea level rise both within and outside of the current 100-year storm event area. Within the Project Area **there are 3,647 residential households living within the current 100-year storm event area.**

Data Considerations

The socioeconomic vulnerability indicators included are only those with publicly available data that can be consistently compared (quantitatively) across the region, and are not exhaustive. Socioeconomic vulnerability indicators were developed as a regional screening tool to help identify neighborhoods where community members may be at greater risk to the effects of flooding. Residential sea level rise exposure was calculated using the most current sea level rise and flooding data available in 2018; exposure to very high levels of sea level rise (which correspond with later time horizons) should be used cautiously as they were not calculated using population projections.

Asset Descriptions

Within the East Contra Costa County ART Project Area, **communities in Pittsburg, Antioch, Bethel Island, Brentwood, Byron, Knightsen, Discovery Bay, and Oakley have characteristics that could affect their ability to prepare for, respond to, and recover from a flood event**. For example, the socioeconomic vulnerability indicators suggest that in these locations there are low-income households, individuals with low educational attainment,

people of color, and a high number of renters and households without a vehicle. In addition, across the Project Area most residents are housing and transportation cost-burdened.

In addition to the socioeconomic vulnerability indicators that were considered, information was gathered about communities in the Project Area to better understand the potential factors that could impact vulnerability and resilience. This chapter describes four cities and four unincorporated areas, two of which are Delta Legacy Communities. These are communities that have played a key role in the historical and agricultural development of the Sacramento Valley, as designated by the Sacramento-San Joaquin Delta Conservancy Act of 2010.

These eight areas were selected because of potential exposure to coastal and/or riverine flooding and to include community members that exhibit characteristics that could limit their ability to prepare for, respond to, or recover from flooding.

The data used in this analysis were obtained from publicly available sources, primarily the US Census. Data were screened to understand community vulnerability by assessing socioeconomic factors, contamination presence, and future flooding impacts by using a tool developed by BCDC's Adapting to Rising Tides Program building on the Stronger Housing, Safer Communities Project.

Pittsburg

The Pittsburg shoreline is a mix of residential, commercial, and industrial areas. The three census block groups on or near the shoreline that may be flooded from sea level rise have a population of about 4,600 people according to the 2010 census. Pittsburg was originally formed as a coal mining town in 1849 and eventually moved to the fishing industry, canning, manufacturing, and cargo transfer in in the late 19th century.[lxxxvii] Today, it still has manufacturing in the area, such as Dow Chemical. People in Pittsburg are first exposed to flooding at 12" of sea level rise with a 100-year storm event, or at 83" of sea level rise.

The ART socioeconomic vulnerability indicators rank the areas that may be exposed as ranging from moderate social vulnerability to highest social vulnerability (see appendix on ART Social Vulnerability and Contamination Burden Mapping). Specifically, these areas have a significantly higher (70th-90th percentile of Bay area residents) number of people with the following characteristics, with those in the 90th percentile shown in bold:

- Children Under 5,
- Very low income,
- Not U.S. citizens,
- People with disability,
- Single parent households,
- Communities of Color,
- Limited English proficiency,
- People without a high school degree,
- Severely housing cost burdened,
- Renters,

- **People without a vehicle,** and
- **People over 65 and living alone.**

Across exposed census blocks, an average of 84% of people are people of color, an average of 54% are renters, and an average of 50% are very low-income households.

The communities on the Pittsburg shoreline are all considered highly vulnerable to contamination threats, including hazardous cleanup activities, groundwater threats, hazardous waste facilities, impaired water bodies, and solid waste facilities.[lxxxviii] The presence of contaminated lands and water raises health and environmental justice concerns, which worsen with flooding and sea level rise due to mobilization of contaminants.

Additionally, according to the UC Berkeley Displacement and Gentrification Typologies, communities in this area are already experiencing or are at risk of displacement and gentrification.

Antioch

Antioch is the second largest city in Contra Costa County with over 100,000 people, and acts as an urban hub for East Contra Costa County. Residential and commercial space is affordable compared with other parts of the Bay Area. This has led to major growth in the city as many people who cannot afford to live in other areas of the Bay relocate to the area. The town was formed in 1850 as an area for ships to moor while waiting for cargo or delayed by weather and was the first to incorporate as a city in the County.[lxxxix] **People in Antioch are first exposed to flooding with a current 100-year storm event, or at 24" of sea level rise.**

The Antioch shoreline has large areas of natural lands that include the Antioch Dunes and the Dow Wetlands, a downtown commercial district, and residential areas. The eight census block groups on or near the coast that may be exposed to flooding from sea level rise have a population of approximately 12,000 according to the 2010 census. The ART socioeconomic vulnerability ranks the areas that may be exposed as ranging from moderate social vulnerability to highest social vulnerability (see ART Social Vulnerability user guide). Specifically, these areas have a significantly higher (70th-90th percentile of Bay-Delta area residents) number of people with the following characteristics, with those in the 90th percentile shown in bold:

- **Children Under 5,**
- **Very low income,**
- Not U.S. citizens,
- **People with disability,**
- **Single parent households,**
- Communities of Color,
- **Limited English proficiency,**
- **People without a high school degree,**

- Severely housing cost burdened,
- Renters,
- People without a vehicle, and
- People over 65 and living alone.

Across flooded census blocks, an average of 60% of households rent, an average of 50% of households earn below 200% of the federal poverty rate, and an average of 35% of households have someone with a disability in them.

Exposed census block groups on the Antioch shoreline have contamination threats ranging from moderate to low vulnerability. The threats impacting these communities include hazardous cleanup activities, groundwater threats, hazardous waste facilities, impaired water bodies, and solid waste facilities.[xc]

The risk of gentrification/displacement varies along the Antioch Shoreline. Some of the block groups along the shoreline have ongoing displacement, others are at risk, and one block group is not losing low-income households.[xci]

Bethel Island (Delta Legacy Community)

Bethel Island is an unincorporated Census Designated Place composed of two block groups that represent a full-time population of about 2,200. The town also has a significant part-time resident population of visitors who come to Bethel Island for fishing, boating, and other water-related recreational opportunities. Bethel Island is a Delta Legacy Community. These communities have played a key role in the historical and agricultural development of the Sacramento Valley, and are important cultural centers defining the character of the Delta as a place. A single bridge from Oakley accesses the Island. Bethel Island is located entirely below sea level and is surrounded by an 11.5-mile levee that protects the five square mile island from the waters of the Delta. The State Legislature created the Bethel Island Improvement District (BIMID) in 1960, replacing Reclamation District No. 1619. BIMID maintains the levee that surrounds and protects Bethel Island and manages the distribution of water for public and private purposes; parks and playgrounds; airports; and stormwater drainage. See the Delta Islands chapter for more information. People in Bethel Island are first exposed to flooding with a 100-year storm event, or at 83" of sea level rise.

The ART socioeconomic vulnerability indicators rank the two exposed census block groups on Bethel Island as having moderate social vulnerability (see ART Social Vulnerability user guide). Specifically, these areas have a significantly higher (70th-90th percentile of Bay area residents) number of people with the following characteristics, with those in the 90th percentile shown in bold:

- Very low income,
- People with disability,
- People without a high school degree,
- People who are severely housing cost burdened,
- People without a vehicle, and
- People over 65 and living alone.

Across exposed census block groups in Bethel Island, an average of 56% of households are very low income, an average of 25% of households are over 65 and living alone, and an average of 50% of households have someone with a disability.

Exposed census blocks on Bethel Island rank low for contamination vulnerability.[xcii]

Census block groups on Bethel Island are not losing low-income households or experiencing gentrification.[xciii]

Brentwood

Brentwood is a city located in eastern Contra Costa County, south of Oakley and west of Knightsen. The city has a long, rich agricultural history that has persisted since its incorporation in 1948, primarily growing cherries, corn, and peaches. The city has been experiencing increasing residential pressure since the 1990s. According to the 2010 census, the population of Brentwood was about 51,000 people.

Due to its inland location, **none of the 17 census block groups within Brentwood are exposed to any of the flooding scenarios detailed in this project.**

Byron

Byron is a Census Designated Place in unincorporated Contra Costa County composed of one census block group, and a population of about 1,200 people. It is located southwest of Discovery Bay. The town was established in 1878 as a resort to access the Byron Hot Springs.[xciv] **People in Byron are first exposed to flooding at 83" of sea level rise with a 100-year storm event.**

The ART socioeconomic vulnerability indicators rank the exposed census block in Byron as having moderate social vulnerability (see ART Social Vulnerability user guide). Specifically, these areas have a significantly higher (70th-90th percentile of Bay area residents) number of people with the following characteristics, with those in the 90th percentile shown in bold:

- Very low income,
- Limited English proficiency,
- People without a high school degree, and
- **Severely housing cost burdened.**

In the exposed census block group in Byron, 39% of households are very low income, 39% are people of color, and 33% are renters.

Byron has a medium rank for contamination vulnerability when compared to the rest of the state.[xcv]

Discovery Bay

Discovery Bay is an unincorporated Census Designated Place in unincorporated Contra Costa County composed of seven block groups, and a full-time population of about 15,000

people. Established in the 1970s, Discovery Bay was originally a weekend and summer resort community. It has now become a year-round community, with 60% of Discovery Bay homes located in the original part of town, and the remaining homes located in Discovery Bay West. The original part of Discovery Bay was built behind a network of man-made dikes surrounded by water. Many homes have private docks, and there is a full depth yacht harbor. The waterways surrounding the community provide access to the Sacramento–San Joaquin River Delta and the San Francisco Bay. California State Route 4 provides the primary road access to Discovery Bay. **People in Discovery Bay are first exposed to flooding with a 100-year storm event, or at 12" of sea level rise.**

The ART socioeconomic vulnerability metrics rank Discovery Bay as having low social vulnerability (see ART Social Vulnerability user guide). Some block groups do, however, have certain characteristics that are high. Specifically, these areas have a significantly higher (70th-90th percentile of Bay area residents) number of people with the following characteristics, with those in the 90th percentile shown in bold:

- **People with disability,**
- **People who are severely housing cost burdened,**
- Single parent households, and
- People who are over 65 and living alone.

Across exposed census block groups in Discovery Bay, an average of 20% of households are owner occupied and housing cost burdened, an average of 18% of households have someone with a disability in them, and an average of 16% of households are very low income.

Discovery Bay ranks low for contamination vulnerability.[xcvi]

According to the UC Berkeley Displacement and Gentrification Typologies, census block groups in Discovery Bay are not losing low-income households or experiencing gentrification.

Knightsen (Delta Legacy Community)

Knightsen is a Census Designated Place in unincorporated Contra Costa County composed of one block group, and a full-time population of about 2,300 people. **Knightsen is a Delta Legacy community**. These communities have played a key role in the historical and agricultural development of the Sacramento Valley, and are important cultural centers defining the character of the Delta as a place. Much of the area in and around Knightsen is designated as agricultural land and the town is known for the horse ranches that are there.

Due to its inland location, the census block group within Knightsen is **not exposed to any of the flooding scenarios detailed in this project.**

Oakley

Oakley is the easternmost city on Contra Costa's northern waterfront. It has a population of approximately 40,000, about 9,500 of which live in four potentially exposed block groups

along the shoreline. The City of Oakley incorporated in July 1999 and is one of California's newest cities. Oakley has grown rapidly in the past decades from a small farming community of 2,800 people (according to the 1980 census) to the estimated population of 40,000 today. People in Oakley are first exposed to flooding with a 100-year storm event, or at 12" of sea level rise.

While the block groups throughout Oakley show a diversity ranging from low to high social vulnerability (see ART Social Vulnerability appendix), the rankings for the four block groups exposed to flooding exhibit low social vulnerability. Some block groups do, however, have a significantly higher (70th-90th percentile of Bay area residents) number of people with the following characteristics, with those in the 90th percentile shown in bold:

- Households with children under 5,
- People with disability,
- People without a high school degree,
- Single parent households, and
- Severely housing cost burdened households.

Across exposed census block groups in Oakley, an average of 54% of households are people of color, an average of 15% of households are single parent households, and an average of 27% of households are very low income.

Oakley ranks low for contamination vulnerability.[xcvii]

According to the UC Berkeley Displacement and Gentrification Typologies, these block groups are not at immediate risk for displacement and gentrification.

Table 9-1. Number of residential units that may be located in the current 100-year storm event area and/or exposed to future sea level rise or sea level rise combined with a 100-year storm event.

Place	2010 Total Residential Units	Current 100-year Storm Event* (Residential units exposed)	12" + 100-yr	24" + 100-yr	36" + 100-yr	83" + 100-yr	MHHW Today	12"	24"	36"	83"
Antioch	36,386	107	156	499	728	1,217	--	--	96	102	786
Bethel Island**	1,545	1,412	1,480	1,543	1,545	1,545	315**	440	549	615	1,545
Brentwood	19,301	--	--	--	--	--	--	--	--	--	--
Byron	163	--	--	--	--	11	--	--	--	--	--
Discovery Bay**	5,949	1,987	1,996	3,270	3,553	5,919	1,249**	1,800	1,923	1,975	3,597
Knightsen	381	--	--	--	--	--	--	--	--	--	--
Oakley**	12,723	141	424	496	1,393	2,881	28**	54	95	127	2,321
Pittsburg***	5,908	--	80	90	93	141	--	--	--	--	95
Total Residential Units in Project Area	**82,356**	**3,647**	**4,136**	**5,898**	**7,312**	**11,714**	**1,592****	**2,294**	**2,663**	**2,819**	**8,344**

"--": Unexposed assets

MHHW: Mean Higher High Water refers to the average of today's daily highest tide and is used as the baseline for all flooding scenarios.

*Current 100-year Storm Event: The 100-year storm event reflected in these maps is not equivalent to the FEMA 100-year flood hazard zone.

**Some parcels shown as exposed at today's MHHW due to residential parcels that extend into the Bay-Delta (i.e. docks).

***These values do not represent the full city of Pittsburg, as the project boundary and flood data begins east of the Pittsburg Marina.

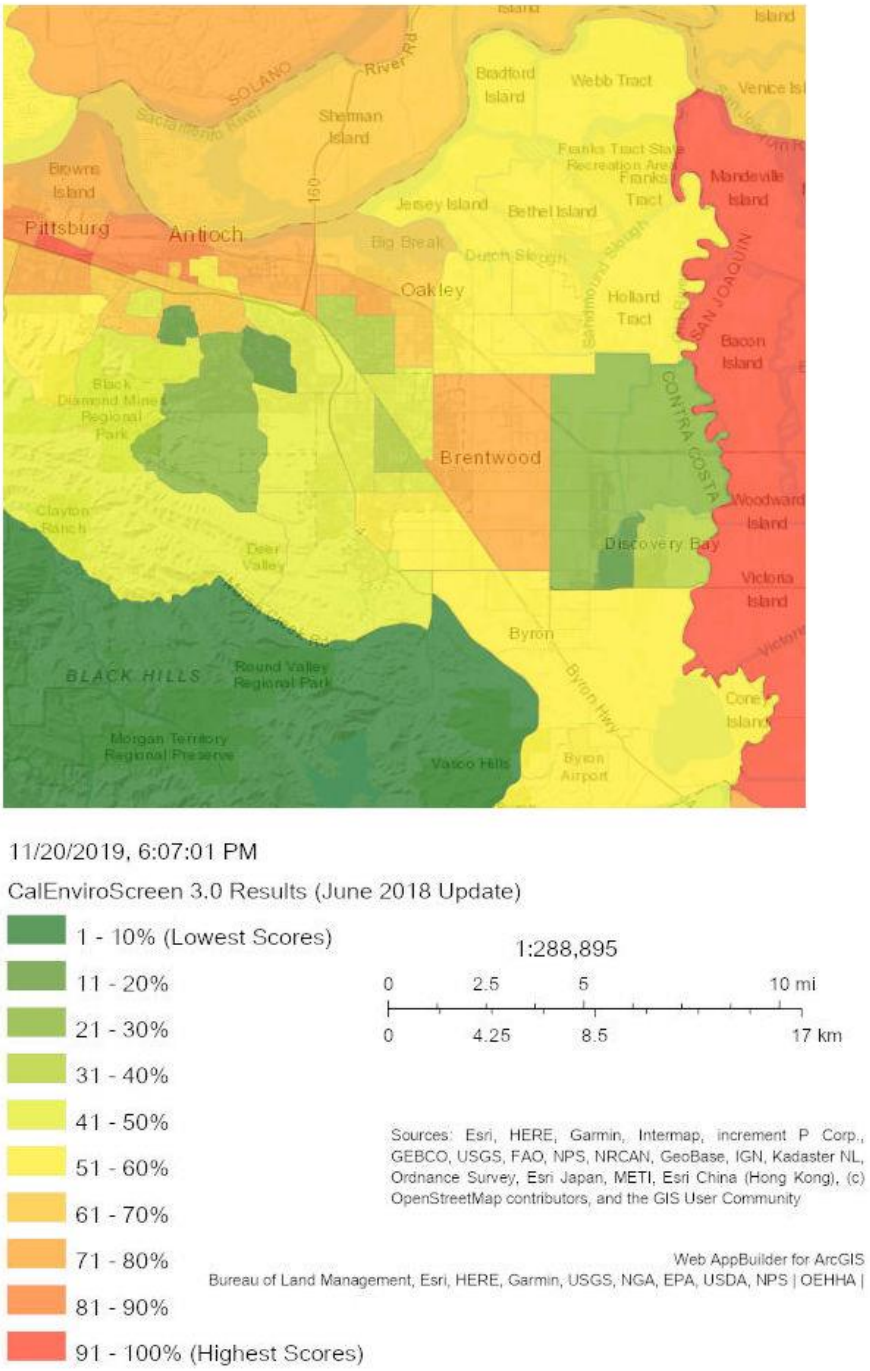

Figure 9-1. CalEnviroScreen results for the Project Area. (Source: CalEnviroScreen 3.0)

Vulnerabilities

INFO1: Decision-makers and emergency responders have limited information about the specific characteristics and/or needs of individuals and households.
INFO2: Social network strength and community capacity can be limited if community members have insufficient information about the specific characteristics and/or needs of individuals and households in their community, and/or surrounding neighborhoods.

GOV1: Renters and mobile home owners have a limited ability to make improvements to their homes or the properties where they reside to reduce flood risk.
GOV2: Individuals and households are unlikely to own or have control over the shoreline that serves as their flood protection. Communities rely on tidal marshes and levees for flood protection, and the marshes may not keep up with sea level rise. Communities additionally rely on railroad embankments for protection from flooding. Embankments were not constructed for this purpose, and their level of protection was calculated based solely on their elevation, when in reality these embankments have culverts through which water may pass through.
GOV3: Some communities, such as Byron, depend on neighboring cities or the county for emergency services, and/or may not have community or public buildings or spaces that can provide a place for gathering, information, or shelter.
GOV4: Non-profit, faith, and community-based organizations play a critical role in building and maintaining community resilience. Many of these organizations do not have the resources to fully participate in climate planning efforts, and government agencies lack the capacity to engage them in the robust and sustained partnerships that may be necessary to address climate change in an equitable, environmentally conscientious, and economically feasible manner.
FUNC1: In vulnerable communities, residents are housing cost burdened, and therefore have limited capacity to endure any other housing-related costs, such as flood proofing, recovery after a flood, or relocation. Temporarily or permanently relocating residents affected by flood events will be challenging, particularly for those residents that are already housing cost burdened or are low income. Displaced residents may not have access to equivalent or affordable replacement housing near the jobs, schools, services, and facilities they rely on.
FUNC2: Many renters do not have flood insurance, which could provide assistance with replacing damaged personal belongings. Additionally, rental units lost during a flood event may not be rebuilt, or may return at market rate.
FUNC3: Communities are highly dependent on private vehicles, and there are limited public transportation options. Some communities have very few or singular access roads. Many residents commute to work outside their municipality, and disruptions to the limited roadways impedes their ability to get to work, as well as access services.
FUNC4: People rely on infrastructure and services provided by public and private agencies to function, such as roads, transit, shoreline recreation and trails, electricity, food, water, wastewater, waste management, and telecommunications. If these services are damaged or disrupted, it may not be safe or healthy for residents to stay in their homes until repairs or upgrades are completed. The health of a community may decline if important services are disrupted in the days and weeks after the event.
FUNC5: Flooding of wastewater treatment plants, waste transfer stations, and landfills may pose health risks to the surrounding community.
FUNC6: Non-English speakers, people with disabilities, such as vision and hearing impairment, and socially isolated individuals and households may face communication difficulties in responding to and preparing for flooding.
FUNC7: Neighborhoods are informal networks whose function depends on the relationships among the individuals and services within them. These informal connections are easily severed during disasters and are often difficult to rebuild once disrupted.

Residents who are socially disconnected from their community are more vulnerable to hazards, as they have less access to information and fewer people to rely on in an emergency.
FUNC8: Elderly, very young, and disabled or mobility-challenged people are less able to prepare for, respond to or recover from flood events. People exhibiting these characteristics face difficulties during an evacuation, as they depend on others for mobility, care and consideration, and in finding suitable shelter-in-place facilities, as they require special care or equipment.
FUNC8: People work, play, shop, and live in their communities. If people must relocate, the local businesses, schools and other neighborhood services that rely on employees and customers for their livelihood can be impacted.
PHYS1: Community facilities—potential gathering locations or places for emergency information centers—that are not designed to withstand flooding, are not constructed from waterproof or non-corrodible materials, or were built to have only the first floor above the current 100-year storm event are vulnerable. Facilities with mechanical or electrical equipment (heating, cooling, appliances, electrical panels, etc.) or parking areas below-grade are vulnerable to both flooding and elevated groundwater. Older facilities with deferred maintenance such as older roofs, a lack of weatherization, or without flood mitigation to protect below-grade spaces (e.g. functioning sump pumps) may not be as able to withstand a major storm or flood event.

Consequences

Society and Equity: Flooding can result in significant impacts, injuries and the loss of life, damage or loss of personal items and financial information; dislocation from homes, jobs and schools; and disconnection from community services and ties. Individuals and households that are currently underserved or disadvantaged may be disproportionally burdened by these impacts both during and after a flood event. Displaced residents may not have access to equivalent or affordable replacement housing near the jobs, schools, services, and facilities they rely on. Even temporary relocation of residents can sever long-standing neighborhood relationships, disrupting the social network that imparts collective strength and resilience.

Environment: Floodwaters that pass through neighborhoods can pick up and carry household debris and hazardous household products that can impair water quality, expose residents to hazardous materials and impair habitats critical to sustaining biodiversity.

Economy: Impacted community members may bear the cost of replacing or repairing belongings and homes, the cost of temporary housing or permanent relocation, increased insurance costs, if insured, and dislocation from jobs, schools and other services. The broader community of taxpayers and ratepayers may also bear some of the expense of rebuilding even if they do not themselves live in affected areas. Long-term evacuations could result in the permanent relocation of residents, employees, or entire business sectors outside of a community, with associated economic consequences for the neighborhoods, residents and employers that remain. The closure of schools and facilities serving

vulnerable populations could result in parents and caretakers taking time off work, resulting in lost wages.

Ground Transportation

Unlike other parts of the state where major transportation corridors are located inland, **a significant proportion of the Bay-Delta's critical transportation systems are located on the shoreline at low elevations.** Transportation systems, including freeways, ports, railroads, airports, local roads, mass transit, and bicycle and pedestrian facilities, connect shoreline communities to each other and to the rest of the region, state, and nation. In addition, **much of the Project Area's highest density development, businesses and industries are located on the shoreline and rely on a functioning transportation system.**

Ground transportation assets include rail lines, local streets and roads, and state highway routes. Other transportation related assets include marinas and bicycle and pedestrian trails that link people to the shoreline and provide active transportation and recreation opportunities. These are discussed in other chapters (see the Natural Lands and Outdoor Recreation chapter).

Transportation assets link people with community facilities and services, jobs, schools, family and friends, shopping, recreation, and other important destinations. East Contra Costa County is a bedroom community with 134,900 employed residents in 2015, with 62,000 local jobs, and 90,600 outbound commuters. In 2015, **more than half of all new employed residents in the region work outside the County**. While outbound commuting for the Project Area grew 30% from 2005 to 2015, most residents do still live and work within the region. In 2015, East Contra Costa County exported the most net workers to Central Contra Costa County (23,400 workers), to the San Francisco metro area (13,800), to parts of Alameda County (12,600), to Livermore/Pleasanton (8,900), and to San Jose metro area (6,300). The largest increases in outbound commuting over the last decade occurred in the San Francisco region (44% growth) and other parts of Alameda County (24% growth).[xcviii]

Current commuting dynamics and the lack of building housing in the Bay Area puts a burden on the Project Area's infrastructure. This can be seen most clearly in commute times, where Antioch and Pittsburg have some of the most affordable housing prices in the region but the longest commute times. About 25% of the County's employed residents commuted more than 60 minutes each day for work (the State average is 12%) in 2016 and is increasing. County residents commuting more than 60 minutes to work grew by about 60% from 2011 to 2016.[xcix]

The majority of commuters in Contra Costa County (over 80%) use a vehicle, which is higher than the Bay Area average of 77%, with 70% driving alone and 12% carpooling. Regionally, almost 90% of commuters drive and two-thirds of those drive alone. **Congestion on the Project Area's core freeways has increased since 2004. The 11th most congested highway segment in the Bay Area is morning rush-hour on RT-4 starting in Pittsburg within the Project Area and going westbound.**[c]

In addition to being critical to commuters, ground transportation networks (truck and rail) link goods to markets, with the County having one of the highest number of goods movement-dependent industries in the nine-county Bay area.[ci] RT-4 and the Burlington Northern Santa Fe (BNSF) rail line from Stege/Port Chicago to Stockton are the major goods transport routes serving refineries and chemical manufacturers in the County and connections to Central Valley.[cii]

Previous ART projects in the Bay Area region, including a focused assessment of West Contra Costa County, have demonstrated that flooding of the transportation network - even if temporary - can cause significant impacts on both goods and commuters, and the ability of emergency managers to provide critical response services. The lack of resilience in the transportation system is due, in part, to the lack of alternate routes with adequate capacity to serve all needs. In particular, there are very few options for rerouting goods to/from the region's seaports, airports, and shoreline industries, many of which rely on both truck and rail cars to move freight.

At the same time that many of the region's roadways could be flooded, the rail system, which is highly sensitive to even small amounts of flooding, could also be impacted. The rail system functions as a fixed network, and even if a small portion of track is damaged there can be closures of many miles of connected track. The region's capacity to withstand impacts to rail infrastructure is further hampered by the lack of redundant or alternative rail lines. Relocating or adding new rail track and right-of-ways is costly, and significant time and money are needed for planning, financing and implementing changes to the rail network. If the rail system is disrupted, truck traffic from the region's seaports would likely increase, having negative and widespread effects on road congestion, air quality, noise and quality of life for those living and working near the ports.

Freight and Passenger Rail

Since the late 1800s rail has supported goods and commuter movement locally, regionally, across the state, and nationally. In the Bay-Delta region, goods and commuters both move by rail, on a shared track, along the shoreline of the Project Area. The rail lines that cross the Project Area are critically important and support inter- and intra-regional goods and commuter movement. Goods moved by rail typically consist of high-value manufactured products from refineries and chemical manufacturers, as well as agricultural and food products transported to Stockton and has connections to Central Valley. Rail provides a vital service in the region, supporting economic growth and connecting commuters to regional jobs.

The majority of commuter movement by passenger rail in the project area is provided by the Amtrak San Joaquin line (Oakland-Bakersfield), which uses the BNSF route through the Project Area, with a station at Downtown Antioch and a planned station at Cypress Ave in Oakley.

Goods and commuter movement rely on a network of fixed, connected railroad assets including the railroad track, signal system, bridges, passenger stations, and maintenance facilities. Ownership and management of railroad assets can be complex since the operators of the commuter and freight trains do not own or manage the rail line or other connected assets. For instance, Amtrak operates the passenger trains but only rail owner, BNSF, can initiate actions to protect the rail line from flooding.

Issue Statement

Given the interconnected nature of rail a disruption of any segment, either within or beyond the Project Area, could have significant impacts. Rail in the Project Area is critical to moving agricultural, automotive, chemical, industrial, petrochemical and other goods from the region's seaports to local and national markets and are integral to inter-city passenger rail service. In addition, in many locations the rail line serves as the first line of defense against inland flooding. Collaboration between private rail owners (Burlington Northern Santa Fe (BNSF)), local agencies that own or manage adjacent lands, and those that rely on rail either for providing service or for flood protection, will be necessary to find and implement appropriate, multi-benefit solutions to address flood risks.

Asset Descriptions

Burlington Northern Santa Fe And AMTRAK / San Joaquins

Within the Project Area **Burlington Northern Santa Fe (BNSF)** owns the right-of-way for the rail line. The Surface Transportation Board classifies the BNSF railroad as Class 1, which means that the annual operating revenue is over $489.9 million (which is the revenue threshold for classification purposes used in 2018). Goods moved by rail in the Project Area include rail carload commodities (e.g., motorized vehicles and petroleum products other than gasoline or fuel oils) and intermodal rail shipments (shipping containers that can be moved by container ship, rail or truck). Most of the BNSF rail line in the Project Area is directly on the shoreline up until Oakley, and then passes through subsided areas on its way east. The rail line crosses several tidal creeks over railroad bridges. The rail line provides an important landside connection to a number of large, water-dependent industries located on the shoreline.

Amtrak's San Joaquin Line has passenger rights on the BNSF rail line through the Project Area. The San Joaquin is operated by the San Joaquin Joint Powers Authority which contracts with the San Joaquin Regional Rail Commission to provide day-to-day management and with contracts with Amtrak to operate the service and maintain the cars. The San Joaquin is Amtrak's seventh busiest route in the nation.[ciii]

Bay Area Rapid Transit

Bay Area Rapid Transit (BART) is a rapid transit public transportation system that serves the San Francisco Bay Area. The system connects San Francisco and Oakland with urban and suburban areas in Alameda, Contra Costa, and San Mateo counties. The terminus of the San Francisco Airport-Antioch line is within the Project Area, including 7 miles of track and the new Antioch Station. The other new station is Pittsburg Center, just outside the

Project Area. This new route provides traffic relief for State Route 4. The track runs on the median of State Route 4 and connects with the existing BART system at a Transfer Platform at the Pittsburg Bay Point Station.[civ] The Antioch Station is very popular and marked 1 million passengers after just five months of operation. In October of 2018 it was carrying 8,622 passengers per weekday.[cv] BART Director Joel Keller, said, "It has proven to be an incredible, state-of-the-art commute option for residents in the region, carrying as many people as an additional lane on Highway 4." The station is so popular that it needs more than the 1,016 parking spaces it has. BART plans to add 800 more.[cvi]

Exposure To Current And Future Flooding

There are 102 miles of rail in the Project Area. A total of 2.8 miles of rail are within the current 100-year storm event area, especially in locations where the rail is close to the shoreline or in subsided areas. A total of 3.8 miles of rail may be flooded from sea level rise, with the most significant impacts experienced from 83" of sea level rise.

Data Considerations

Due to the type of analysis conducted, the miles of rail exposed to existing versus future flooding is reported separately even though they may not be unique and it is likely that these segments overlap. Given the shoreline location of the rail in the Project Area, most of the miles that are exposed to sea level rise are likely within the existing storm event area.

Table 10-1. Miles of freight and passenger rail that may be located in the current 100-year storm event area and/or exposed to future sea level rise or sea level rise combined with a 100-year storm event.

Asset	Owner	Total Miles	Current 100-year Storm Event* Only	12" + 100-yr	24" + 100-yr	36" + 100-yr	83" + 100-yr	MHHW Today	12"	24"	36"	83"
Heavy Rail	BNSF**	19.5	1.0	1.5	2.1	2.8	5.8	<0.1	<0.1	<0.1	0.1	3.0
Rail	Amtrak**	19.5	1.0	1.5	2.1	2.8	5.8	<0.1	<0.1	<0.1	0.1	3.0
BART Line	BART	7.4	--	--	--	--	--	--	--	--	--	--
BART Station* **	BART	1	--	--	--	--	--	--	--	--	--	--

"--": Unexposed assets

MHHW: Mean Higher High Water refers to the average of today's daily highest tide and is used as the baseline for all flooding scenarios.

*Current 100-year Storm Event: The 100-year storm event reflected in these maps is not equivalent to the FEMA 100-year flood hazard zone.

** Amtrak uses BNSF's rail line

***Units are stations affected, not miles

Vulnerabilities

INFO1: There is insufficient public information available about existing track or siding type, level-of-use, condition, or planned capital improvements in the project area and beyond to thoroughly evaluate the vulnerability of the rail system.
GOV1: Planning for sea level rise and storm event impacts is challenging given that rail lines are owned and maintained by private entities that have not been willing in the past to coordinate and share information and resources, or work directly with local decision makers to find shared solutions for past or current issues.
GOV2: Significant coordinated decision making will be required to maintain rail service given the number of asset owners, managers, and service providers that need to work together.
GOV3: Improvements to rail track and associated infrastructure requires permits from a number of different regulatory agencies which increases the time needed to design and implement changes.
GOV4: A significant level of coordination and cooperation will be required to ensure solutions that address the needs of the railroads also benefit co-located assets such as pipelines and utilities, adjacent areas rail currently protects, the natural areas that sit between the rail and the Bay-Delta, and the tidal creeks the rail crosses that provide flood protection to upstream communities.
GOV5: Funding rail improvements may be complicated or controversial as large public investments may be necessary to protect rail infrastructure, which is privately owned.
PHYS1: In the event of an emergency, maintenance and repair of rail infrastructure may be delayed until a specialized team and custom materials are secured. Multiple disruptions throughout the system may further delay the recovery process.
PHYS2: Some segments of the rail line located along the shoreline serve as the first line of defense during storm events, but rail (track bed and ballast materials) is not constructed or maintained to prevent inland areas from flooding. In places where the railroad serves as the first line of defense, a failure of the railroad would result in flooding of inland communities and infrastructure.
PHYS3: A rising groundwater table could damage the track bed and ballast materials. If constantly saturated, more frequent maintenance is necessary to prevent the rail line from becoming structurally unsound.
PHYS4: Storm events and wave action have the potential to damage the ballast and embankment and cause the rail tracks to become structurally unsound.
PHYS5: Disruption of rail line within the Project Area can also cause increased risk to the surrounding populations, including vulnerable communities, due to hazardous material releases due to possible derailment.
FUNC1: Power is needed for traffic signal operation and functionality of passenger rail stations. Temporary protocols and backup supplies may not be sufficient during a prolonged outage or during system-wide failures. In addition, power outages pose a safety concerns at signalized intersections and will likely require direct human supervision until power returns.
FUNC2: If any segment of the rail line were disrupted the entire system would shut down.
FUNC3: There is no redundancy in the commuter rail system that would provide the same capacity as currently exists. Commuters could use alternate modes; however, highways

and roads could be flooded at the same time as the rail line and are unlikely to provide the same level of service, resulting in longer commutes and delays.
FUNC4: There is no redundancy in the goods movement rail system that would provide the same capacity as currently exists. Depending on the location of the disruption, freight could be rerouted; however, this would result in increased costs and may not accommodate all types of cargo currently moved by rail. In addition, the roadways may not have the capacity needed to move freight in a timely manner.
FUNC5: Transportation of goods via rail has a lower driver injury rate than via truck. Disruption of rail line within the Project Area can cause increased injuries or accidents if commodities are transported via truck rather than rail.
FUNC6: Disruption of rail line within the Project Area could divert hazardous materials transportation from rail to trucking, resulting in higher hazardous materials transportation accident rates, as rail is a safer means for bulk transportation of hazardous materials. This could cause a greater chance of hazardous material releases into the environment.

Consequences

Society and Equity: Disruption of the railroad would affect commuters, goods movement, the economy, and the region as a whole. Everyone sharing the road would spend more time in traffic and may have a difficult time getting to work or obtaining necessary goods and services. In the long run, commuters would have to spend more money to use their personal vehicles. Neighborhoods adjacent to alternate routes would be exposed to more air pollution, putting residents at greater risk of health problems (e.g., asthma). Additionally, in places where the railroad serves as the first line of defense, a failure of the railroad would result in flooding of developed or natural areas inland of the rail line. Disruption of rail line within the Project Area could cause the release of hazardous substances due to derailment, as well as increased injuries or accidents if commodities are transferred to alternative transportation, such as trucking.

Environment: Long-term disruption would lead to more cars and trucks on the road, which would increase greenhouse gas emissions. Disruption of rail line within the Project Area could divert hazardous materials transportation from rail to trucking, resulting in higher hazardous materials transportation accident rates and a greater chance of hazardous material releases into the environment, impacting ecological habitats and water quality within the Bay-Delta.

Economy: The railroads provide a key service moving agricultural, automotive, chemical, industrial, and other goods from the region's ports to local and national markets. Similarly, commuter movement is an important asset for the region.

Roadways

The roadways in the Project Area are a networked system of freeways and expressways that connect to local streets and roads. Generally, arterials in the Project Area provide access to the state highway system via local interchanges that connect cities and function as major corridors within cities. Local roads and streets then serve as connections between

these major corridors. Some smaller roadways and bridges, such as the Bethel Island bridge or State Route 160, provide the only means of vehicular access to particular neighborhoods, industrial areas, or Delta Islands, and are therefore critical to keeping people and goods moving to and from those areas. A large part of the Project Area is rural without a dense network of roadways.

Public transit operators that rely on the road network in the Project Area include TriDelta Transit, Rio Vista Delta Breeze, and County Connection. These service providers offer regularly scheduled bus transit service that links together different parts of the County, as well as connects the County to the rest of the region, and importantly, to the intra-regional BART system.

Roadways in the Project Area are owned and managed by a number of different agencies, including the California Department of Transportation, cities, and the County. Public works departments within each of the cities and the County are responsible for road maintenance and improvements including the storm drainage system, while planning departments are responsible for ensuring land development patterns that support greenhouse gas reduction goals by focusing on transit-oriented development and encouraging opportunities for active transport. In addition, the Contra Costa Transportation Authority manages the County's transportation sales tax program and conducts Countywide transportation planning in coordination with four Regional Transportation Planning Committees that help guide transportation projects and programs.

Issue Statement

Many local roads flood, putting communities at risk of being isolated from critical services, blocking evacuation routes, or disrupting access to homes or businesses. Short term closures of the roadway or bridge network could have significant social and economic costs as there is limited redundancy for car or bus commuters in the Project Area, especially those that live in isolated communities, and if there are alternative routes they may not be able to accommodate the same capacity. Residents without access to a vehicle may be most vulnerable since rerouted buses would result in delays that could impact their ability to get to work, especially those that connect to other transit modes such as the intra-regional BART system.

Asset Descriptions

Local And County Streets And Roads

Local streets and roads support commuter and goods movement within a city, and between a city and the County, region and beyond. Residents, businesses and public service providers all need functioning roads. Among many other services, these roads are critical for a functioning emergency response system.

Flooding of local streets and roads may be caused by storm events that overtop the shoreline or by a failure of stormwater infrastructure to maintain function as sea level rises.

In the Delta, many local roads are atop of levees. Some communities have only one road going in and out, such as Bethel Island. Addressing local street and road vulnerabilities will require collaboration among different departments within a city, for example planning and public works, and may necessitate partnerships with other agencies and entities including the County, Metropolitan Transportation Commission, California Department of Transportation, adjacent private landowners, entities with right-of-way easements, and others. For roads on top of levees, this would involve State coordination, as they are the main funder of levee rehabilitation. There are a number of local streets and roads at risk of flooding in the Project Area, with many of the noted segments at risk where the roadways either cross over tidal creeks or are located in subsided areas.

Table 10-2. Local streets and roads at risk of flooding in a 100-year storm event with 12" of sea level rise.

Antioch	**Bethel Island***		
E 6th Street	N Stone Road	Alcott Court	Sea Meadow Court
W 1st Street	W Willow Road	Alcott Circle	Golf Course Road
W 3rd Street	N Willow Road	Slough Place	Sugar Barge Road
W 2nd Street	S Willow Road	Overland Street	Southwind Street
L Street	Willow Road	Channel Place	Morrison Ranch Road
C Street	Gateway Road	Lisa Lane	Airstream Drive
J Street	Riverview Drive	Riverview Place	Stone Road
A Street	Benet Court	Jamboree Street	Marina Street
Mc Elheny Road	Windsweep Road	Piper Road	Delta Coves Drive
Wilbur Avenue	Shoreline Place	Canal Road	Bombardier Lane
K Street	Fairway Drive	Grey Whale Court	Taylor Place
B Street	Harbor Road	Ranch Lane	Taylor Road
Fulton Shipyard Road	Holiday Street	Sandy Lane	Porter Circle
Fleming Lane	Komfort Street	Sunset Road	Shelly Lane
Second Way	Cottage Lane	Park Lane	
Bridgehead Road	Point Place	Hawthorne Drive	
Foot of Bridgehead Road	Sea Drift Drive	Hawthorne Road	

Discovery Bay*	**Knightsen***	**Oakley**	
Oasis Drive	Mountain View Drive	E Cypress Road	Marsh Creek Regional Trail
Newport Drive	Eagle Lane	Knightsen Avenue	Sandmound Boulevard
Harbor Drive	Delta Road	Big Break Road	Jersey Island Road
Clubhouse Drive	Byron Highway	Broadway Street	Lauritzen Lane
	Tule Lane	Franklin Lane	Aspen Road
	Virginia Lane	Sellers Avenue	Big Break Regional Trail
	Poe Lane	Merlot Court	Dutch Slough Drive
		Merlot Lane	Dutch Slough Road
		Bethel Island Road	
		Bynum Way	

		Rutherford Lane	
Pittsburg			
E 3rd Street Bay Crest Drive	Riverway Drive	Harbor Street	Edgewater Place

* Located in unincorporated Contra Costa County

Table 10-3. Transit routes at risk of flooding in a 100-year storm event with 12" of sea level rise.

Transit lines at risk of flooding in a 100-year storm event with 12" of sea level rise:	
County Connection	**TriDelta Transit**
None	383, Antioch/Brentwood 387, Pittsburg Bay Point BART/Antioch BART 388, Pittsburg Bay Point BART/Antioch 392, Pittsburg Bay Point BART/Antioch BART
Rio Vista Delta Breeze	
None	

State Routes

There are two state routes within the Project Area: SR-4 and SR-160. State Routes in the Project Area provide access to employment sites and public services within Contra Costa County, are critical for goods and commuter movement along the East Bay and Delta shoreline, and connect Contra Costa to the rest of the East Bay, Sacramento, the Delta, and the San Joaquin Valley. The segments of state routes in the Project Area that are at risk of flooding are described in more detail below.

State Route 4 South of Discovery Bay

State Route 4 varies from a two- to eight-lane highway in the Project Area that runs from Hercules to the Sierra Nevada Mountains. In East Contra Costa County, it serves as a critical commuter corridor for residents commuting into both the San Francisco Bay Area and the Sacramento Valley (see introduction to this chapter, Ground Transportation). A BART line runs along the median of SR-4 from the western boundary of the Project Area to Antioch. Truck traffic ranges from 4,000 near Byron to 6,800 average annual daily traffic (AADT)[5] on the western edge of the Project Area. Total vehicle traffic ranges from 26,000 AADT near Byron to 148,000 near Bay Point.[cvii]

5 Annual average daily traffic (AADT) is the total volume of vehicle traffic on a highway or road for a year divided by 365 days

The segment of State Route 4 most vulnerable to flooding in the Project Area is south of Discovery Bay, from Newport Drive east to the Contra Costa/San Joaquin County line. This segment connects commuters and residents of East Contra Costa to inland Delta cities, including Stockton. It also serves as a critical access road for residents of Discovery Bay.

State Route 160 Antioch Bridge Approach

State Route 160 links State Route 4 in Antioch to the broader Sacramento and the Delta area. It is an essential evacuation route for the Project Area. The segment of State Route 160 most vulnerable to flooding in the Project Area is the Antioch Bridge approach, from Bridgehead Road to the Delta. This segment connects Antioch and East Contra Costa with the broader Delta region and is used for both commuter and goods movement. Truck traffic within the Project Area is 866 AADT and total vehicle traffic is 13,300 AADT.[cviii]

Exposure To Current And Future Flooding

Three classes of roadways were included in the exposure analysis: local roads, County roads, and state routes. Of the 1,163 miles of roadway evaluated, **42 miles are within or cross over the existing 100-year storm event area** and **130 miles are potentially flooded by sea level rise**. **Most of the roadway miles that are within or cross over the current 100-year storm event area are local roads**, which is proportional to the relative miles of each road class analyzed. While some roads are only exposed for very short segments (e.g. SR-4 has less than 0.1 mile exposed at current 100-year storm events), since roads are a linear asset, disruption to even a small segment can disrupt the entire road network.

Data Considerations

Because the analysis of road miles in the existing storm event area and exposed to sea level rise were conducted separately, some of the miles reported may overlap while others do not; that is, some miles within the 100- year storm event area may be at risk of more extensive or longer duration flooding due to sea level rise, while others may be only at risk from sea level rise.

Table 10-4. Total miles of roads that may be located in the current 100-year storm event area and/or exposed to future sea level rise or the combination of sea level rise and a 100-year storm event.

Asset	Class	Total Miles in Project Area	Current 100-year Storm Event* Only	12" + 100-yr	24" + 100-yr	36" + 100-yr	83" + 100-yr	MHHW Today	12"	24"	36"	83"
Hwy J4 (Byron Hwy)	County Road	5.1	--	--	--	--	0.1	--	--	--	--	--
Rd J4	County Road	1.5	--	--	--	--	--	--	--	--	--	--
State Rte 4	State Route	34	<0.1	<0.1	2.2	2.3	3.5	<0.1	<0.1	<0.1	<0.1	2.3
State Rte 160	State Route	4.4	<0.1	<0.1	<0.1	0.1	0.2	--	<0.1	<0.1	<0.1	0.1
All	Local Roads	1,118	42	60	90	116	182	0.1	0.2	0.6	3.9	128
Total Miles	**--**	**1,163**	**42**	**60**	**92.2**	**118.4**	**185.7**	**0.1**	**0.2**	**0.6**	**3.9**	**130.4**

"--": Unexposed assets

MHHW: Mean Higher High Water refers to the average of today's daily highest tide and is used as the baseline for all flooding scenarios.

*Current 100-year Storm Event: The 100-year storm event reflected in these maps is not equivalent to the FEMA 100-year flood hazard zone.

Vulnerabilities

GOV1: Agency coordination is required to maintain regional connections between highways, local roads, and regional alternative transportation corridors, trails, and bicycle facilities; Coordination increases the complexity, time, and cost involved in reducing flooding impacts on the functionality of the roadway network.
GOV2: Improvements to local streets, roads, highways, or bridges that impact the Bay-Delta, shoreline, creeks, rivers, wetlands, or other natural habitats may require permits from several regulatory agencies which increase the time needed to design and implement changes.
GOV3: The lack of planning funds, capital improvement financing, regulatory mechanisms, incentives, or internal priority limits the ability of public agencies to assess and address the impacts of sea level rise and storm events on local streets and roads. This issue is particularly pertinent where flooding will be caused by diminished capacity of the stormwater system or where sea level rise will increase riverine flood risks.
GOV4: Other assets are often co-located with streets and roads, such as buried electrical or communication utilities, roadway drainage systems, or pipelines. Road improvements will require close coordination with public and private utility companies.
GOV5: Caltrans will need to collaborate with the County, local jurisdictions, and private landowners to improve the flood resilience of highways, bridges, and their approaches within and beyond the Project Area.
PHYS1: Saltwater intrusion may corrode the reinforcing in concrete structures that support the elevated portion of SR-4 and SR-160. Protective measures are in place for only some portions of structures that would be exposed to salinity (e.g., steel coated with epoxy protecting it from salt corrosion, and bridge anchorage buildings equipped with pumps and other flood resistant items).
PHYS2: A rising groundwater table could damage the at-grade pavement structural sections, in particular if the roadbed is constantly saturated. This will be a particular problem where the pavement is very low and already requires protection from current groundwater levels.
FUNC1: There are limited alternative routes for commuters if any of the state route segments in the Project Area are flooded. Local streets do not provide adequate redundancy, as they cannot accommodate the same traffic capacity, which is projected to increase considerably.
FUNC2: There are limited redundancies among transit providers serving corridors parallel to SR-4. Even where alternatives are possible, it is unlikely these transit providers could provide commuters an adequate alternative in terms of capacity and desired routes because the geography and land use context of East County make it challenging for transit providers to implement frequent, reliable service.
FUNC3: There is no redundancy for some bridges throughout the Project Area, such as the Antioch Bridge and bridge to Bethel Island.
FUNC4: Damage to the local street network near state routes, including damage to on- and off- ramps to/from the local street network, would impede traffic movement.
FUNC5: Power is needed for local traffic signal operation and it is not known if there are alternative power supplies to maintain signal function in the event of an outage. Signalized intersections would likely be treated as three/four-way stops during power outages

presumed to be temporary, with city workers, vehicles, equipment, power, and communication needed to effectively reroute traffic.
FUNC6: While traffic can be rerouted in the event of flooding, highly congested areas could experience significant disruption at the same time SR-4 could be impacted, further exacerbating traffic and delaying relief efforts.

Consequences

Society and Equity: SR-4 is one of the most congested roadways in the Project Area, and even minor disruptions to its level of service will significantly affect commuters. Moreover, SR-4 and SR-160 facilitate local and regional access to shoreline recreation. Local streets and roads in the Project Area are key routes that if not fully functional, would affect commuters, residents, and the movement of goods. Neighborhoods served by a single access road, such as Bethel Island, are at risk of being disconnected from emergency services and are less likely to be able to remain in their homes after a flood event. Those without access to a vehicle may be most vulnerable since there are limited alternative routes in the Project Area and the only transit alternative to buses, which rely on local streets and roads, is BART and the San Joaquin Line passenger rail, which is not affordable for short commuter trips. Rerouting buses would result in delays that could impact commuters' ability to get to work on time.

Environment: Disruption of local streets and roads that public transit relies on could cause more individuals to drive, which could affect air quality. In addition, the loss of a portion of the transportation network may increase congestion, potentially resulting in greater emissions and lower fuel efficiency. Lastly, prolonged flooding of segments of a state route, such as SR-4, that are adjacent to natural areas and marshes could cause trash and pollutants to mobilize and stress habitat. Transit disruptions and delays could cause more individuals to drive, increasing air pollution overall, and disproportionately affecting air quality in neighborhoods adjacent to alternate and/or key commute routes.

Economy: State Routes in the project area are critical to both the flow of goods (such as manufactured materials or agricultural goods) and the ability of commuters to access local and regional jobs. As many workers commute outbound from the Project Area, disruption of SR-4, local approaches and on/off ramps could have significant consequences on both the local and regional economy. In particular, workers who rely on vulnerable public transit assets or roads may be unable to get to work, affecting not only their wages but the economy of the region as a whole. Additionally, recreation is a huge economic engine of the region, which would be impacted if tourists can't access the Delta. Any increased congestion resulting from temporary or long-term damage to a part of the transportation network could have significant costs to the region. Disruption to SR-4 would affect access to BART in the Project Area. The industrial businesses located near the waterfront in Antioch and Oakley would be negatively impacted if access was hindered due to a disruption to the local roadway network.

Ports

Marine terminals and wharfs within the Project Area bring in bulk cargo of raw materials and semi-processed inputs used in the manufacturing of finished goods. These terminals and wharfs are a key provider of jobs within East Contra Costa County. Within the County the manufacturing sector employs 15,700 people and the wholesale trade sector employs 9,800 people.[cix] One of the County's largest employers is USS-Posco, which uses a wharf in Pittsburg.

Marine terminals and wharfs require a number of on-site and off-site facilities and services that can be disrupted or damaged by temporary flooding, storm surge, or permanent flooding, such as utilities, transportation, storm water, and pipelines. In other studies of seaport vulnerability there have been five key risks identified, including: increased exposure of port operations to a range of climate hazards such as sea-level rise, storm surge, extreme waves and wind; interrupted shipping movements, material and container handling, and inland transportation into and out of ports; disruptions in transportation and storage of sensitive goods such as agricultural products or fuel; greater sensitivity of in-transport infrastructure to climate hazards; and an increased vulnerability of ports to disruptions to utilities, such as water and electricity.

Facility operations rely on other systems that are vulnerable, most notably rail lines, which are located along the shoreline and cross tidal creeks throughout the region. Damage at any point in the rail system can result in system-wide disruptions, and loss of rail service to the ports could result in increased truck traffic, affecting congestion and air quality in surrounding neighborhoods, local roadways, and highways.

Issue Statement

Sea level rise and storm events will affect operations by limiting access to and from seaports. Temporary or permanent disruption of local road access and rail lines would disrupt seaport operations. In particular, loss of rail service, which moves bulk materials and automobiles, would have significant impacts on the local and regional economy, as these goods may not be easily moved by truck.

Asset Descriptions

Antioch Plant Wharf

The Antioch Plant Wharf is owned by Georgia Pacific Gypsum LLC. The wharf is used by the plant for receiving gypsum rock, which is processed at the plant to make wallboard products.[cx] They have from 50-99 employees.[cxi] Georgia-Pacific Corporation creates tissue and paper products (such as Dixie cups), wood paneling and gypsum products for construction, various chemicals, and packaging materials. The wharf is located in Antioch near Minaker Dr.

Amports

Amports is a vehicle logistics center and deep water port operator. This includes washing, applying wrap guard, performing mechanical and body repairs, homologation, customization, undersealing, and engine coating. Their Benicia port is at capacity, so the

Antioch port will have space for up to 175,000 vehicles annually.[cxii] The wharf is located in Antioch across from West Island.

California Mill Wharf And Pier

The California Mill Wharf and Pier is owned by Gaylord Container Corporation, and it receives miscellaneous dry bulk commodities.[cxiii] The wharf is located in Antioch across from West Island on the San Joaquin River.

Fulton Shipyard Pier

The Fulton Shipyard Pier is owned by Fulton Shipyard, Incorporated and is used for mooring of vessels for conversion, outfitting, and repair.[cxiv] The pier is located in Antioch near the Fulton Shipyard Rd.

Contra Costa Power Plant Wharf

The Contra Costa Power Plant Wharf is owned by the Pacific Gas and Electric Company. It occasionally receives fuel oil by tanker, as well as other shipments by barge.[cxv] The wharf is located in Antioch on the San Joaquin River near just west of the Antioch Bridge.

Pittsburg Plant Wharf

The Pittsburg Plant Wharf is owned by Dow Chemical Company and is used for the receipt and shipment of caustic soda.[cxvi] They employ 250-499 people.[cxvii] The wharf is located in Pittsburg on the New York Slough across from Winter Island.

Pittsburg Wharf And Dock

The Pittsburg Wharf and Dock are owned by USS-Posco Industries, and is used for the occasional mooring of tugboats.[cxviii] USS-Posco Industries is listed as one of the County's largest employers.[cxix] They employ from 1,000-4,999 people.[cxx] USS-Posco is light industry for metal sheet manufacturing. The wharf is located in Pittsburg on the New York Slough immediately west of Pittsburg Point.

Diablo Service Corp, Pittsburg Wharf

The Diablo Service Corporation Pittsburg Wharf is owned by Tosco Corporation. The Wharf is used for the receipt of caustic soda by barge and the shipment of petroleum coke by vessel.[cxxi] The wharf is located in Pittsburg near Harbor St.

Exposure To Current And Future Flooding

All of the wharfs are directly on the water and are likely to be impacted by low levels of flooding. Depending on wharf construction, the facilities may have the ability to respond to water level fluctuations within the range of extreme high tides. However, more extreme water levels, both temporary and permanent, could render these facilities inaccessible. However, in our analysis, we found that zero of the seven shipping wharfs and piers were impacted by flooding from a current 100-year storm event, sea level rise, or any combination of the two. This result is driven by our exposure analysis method (see Data Considerations below).

Since some piers are not listed in the analyzed GIS data, qualitatively looking at the Project Area map, impacts to piers begin to happen at 36" of sea level rise or today's 100-year storm near the Antioch Bridge on the piers involving some heavy industry, the Fulton Shipyard, and some industrial sites near Kirker Creek. By 83" sea level rise, there is considerable flooding of the industrial shoreline around the waterway of Lake Alhambra. More importantly, road access to employment sites may be blocked or working piers may be flooded, preventing operations.

Data Considerations

When delineating the shoreline for the project area, some assets that directly interact with the water were marked as being in the water. As a result, these assets were not shown as being exposed to flooding at any water level. This resulted in the likely underestimation of flooding impacts on these assets.

Our datasets are not entirely comprehensive of all port operators in the Project Area. Importantly, the analysis does not fully reflect the potential impacts of current or future flooding on site operations. Site-based analyses at these facilities are needed to understand what facilities or infrastructure are within the portion of the industrial site at risk of flooding.

Vulnerabilities

INFO1: There is a lack of detailed and easily accessible information about private marine terminals.
GOV1: Different entities own and manage the marine terminals and the vital transportation systems, such as rail (Burlington Northern Santa Fe), interstates (Caltrans), County roads, and local access roads (Cities) that operations rely on.
GOV2: Although industrial property owners and site operators may have engaged with public agencies on reducing flooding and other risks through existing regulatory programs, planning for sea level rise will require additional non-regulatory collaboration and partnerships between the public and private sector. These partnerships may be able to advance multi-benefit shoreline solutions that balance economic, environmental and social equity goals.
PHYS1: Flooding could damage electrical equipment located at- or below-grade.
PHYS2: Industrial buildings, infrastructure, and associated facilities that have at- or below-grade entrances or sensitive equipment are especially vulnerable, including fans, boilers, and pumps that cannot function if they are flooded or exposed to saltwater.
PHYS3: Many industrial land uses generate or store hazardous substances that could have public health or environmental impacts if released into groundwater or surface waters.
PHYS4: Industrial land uses that rely on off-site power and do not have adequate back-up supplies and systems in place are more vulnerable to disruption of operations.
FUNC1: Rail, highways, and local roadways that connect to the marine terminals are vulnerable to flooding and lack redundancy, with no alternative route for rail cargo and little additional capacity for truck traffic on existing or alternative routes.

FUNC2: In the event that a large portion of marine terminals operations are disrupted, there could be insufficient capacity at either on- or off-site terminals to handle displaced shipping needs, which could cause a ripple effect in the economy.
FUNC3: Marine terminal operations rely on electrical power, domestic water, and sanitary sewer services provided by external agencies.
FUNC4: Operations rely on local road access and some of the marine terminals have only one road leading in and out.
FUNC5: Because heavy industrial land uses need large amounts of land, have specific operational facility needs, and are dependent on fixed infrastructure for goods movement (e.g., marine terminals and rail lines), it can be difficult, if not impossible, to relocate.

Consequences

Society and Equity: Temporary or permanent disruption of marine terminals would affect the capacity to ship and receive goods, and this could impact employment, especially in manufacturing jobs, ship workers, and truck drivers. Disruption of rail service could result in increased road traffic—and the associated negative consequences—within the surrounding neighborhoods' local roads and highway system. Loss of these industrial facilities may also impact the County and the region more broadly because they produce or distribute critical products used in many other sectors. Unexpected flooding of facilities that store hazardous materials can also result in public health impacts in nearby communities.

Environment: Hazardous materials present at various sites could be released into the water by floodwaters or contaminate rising groundwater. If the rail is disrupted, the use of trucks to bring goods to and from the seaport may increase. This would lead to greater air pollution from the increased road traffic.

Economy: Industrial land uses provide Contra Costa County with economic benefits that include jobs for residents, products needed in other parts of the region, and tax revenue to the cities and the County. Damage or disruption of industrial facilities could result in high costs due to lost productivity, as well as the replacement or repair of buildings, specialized equipment, and goods stored onsite. Temporary or permanent closures of industrial operations of all kinds could have broad economic impacts throughout the region, particularly if heavy industrial facilities are damaged or their connections to goods movement infrastructure is disrupted. Loss of power or the disruption of rail or highway access would impact the goods movement network and result in economic losses for the city, region, and state. Disruption of rail access to marine terminals could be significant because it could result in increased truck traffic and disruption to goods movement.

Wastewater

Acronyms

DDSD	Delta Diablo Sanitary District
ISD	The Ironhouse Sanitary District
IWWTP	Ironhouse Wastewater Treatment Plant
MGD	million gallons per day
SFHA	Special Flood Hazard Area by FEMA
SOI	sphere of influence

Wastewater is the liquid waste material that enters the sewer from sinks, showers, clothes washers, toilets, chlorinated pools, commercial car washes, and industrial processes. To protect public and environmental health and to comply with environmental regulations, wastewater is collected and treated prior to discharge to the Delta or other nearby water sources by wastewater service providers. Treated wastewater can be reclaimed and recycled for reuse at special facilities associated with the main treatment plant. Wastewater service providers own and manage systems that are typically large and complex and include interconnected infrastructure such as sewer pipes, pump stations, wastewater treatment plants, storage and discharge facilities, monitoring stations, and overflow outlets. Interconnected infrastructure is often owned and operated by different service providers as well as by public and private entities. For example, individual property owners maintain the privately-owned sewer laterals that connect properties to the public collection system. The public collection system, including sewer mains, interceptors, force mains and pump stations that lift wastewater throughout the collection system, may be owned and managed by one service provider, while the treatment plant and discharge facility can be owned and managed by another.

Within the Project Area there are three wastewater service providers. The Ironhouse Sanitary District serves Oakley, Bethel Island, and other unincorporated areas and serves an estimated 42,000 customers. It is bound by the San Joaquin River to the north, the Delta Diablo Sanitation District to the west, the City of Brentwood to the south, and includes the unincorporated area in the Holland Tract to the east. The Delta Diablo Sanitary District includes Antioch and Pittsburg and serves an estimated population of over 190,567 residents. The Town of Discovery Bay operates two wastewater treatment plants on the eastern part of the town and serves a population of over 13,300 people.

There are a number of existing stressors on wastewater systems, including changes in demand due to population and economic growth. This is particularly the case if capacity is already limited, if there is a lack of system redundancy, and if there is aging infrastructure that requires ongoing operation and maintenance. There is also stress on the system from pollutants and organic loading factors that can reduce treatment efficiency.

Increased flows from groundwater infiltration and precipitation-related inflow can add additional strain on wastewater systems. Infiltration occurs when groundwater enters sewer pipes through cracks, pipe joints, and other system leaks. Inflow occurs when rainwater enters the system from improper drain connections (e.g., yard, patio, roof gutter, footing), uncapped cleanouts, cross-connections with the stormwater system, and manhole covers. Service providers can reduce infiltration and inflow by investing in capital improvements such as pipeline rehabilitation, manhole cover replacement, and tree root eradication, but sources of infiltration and inflow on private property must also be addressed in order to reduce overall system impacts. Inflows during precipitation- induced flooding or illegally pumped water can overload wastewater infrastructure.

Pollutants and organic loading factors impact the integrity of the wastewater system. Wastewater treatment plants and satellite facilities that store and manage flows during wet weather events (called wet weather facilities) ensure pollutants are removed prior to discharge to water bodies. Organic loading levels depend on the amount of organic matter disposed. These organic compounds include the remains of plants or animal waste products. In addition to organic matter, wastewater may contain metals; sediment; hazardous household materials such as motor oil, paint, household cleaners, and pesticides; and high-strength or toxic substances from industries and commercial enterprises. Pretreatment programs and industrial permits can significantly reduce the concentration of these materials, such as by limiting the strength and contaminant levels in industrial and commercial wastewater. In addition, service providers can charge increased rates or surcharges on high strength wastes or provide incentives for industrial and commercial water recycling and reuse. If sea level rise causes direct discharges without treatment to the Bay-Delta, these hazardous materials will directly enter the Bay, threatening human and environmental life.

Sea level rise can exacerbate precipitation-related infiltration and inflow problems in East Contra Costa. Sea level rise may permanently inundate pipes leading to larger amounts of infiltration. This would require larger volumes of water needing treatment, increasing the demand for wastewater treatment. Rising sea levels can also raise the groundwater level. Groundwater could also overwhelm wastewater treatment plants due to increasing amounts of infiltration into the sewer pipes.

Issue Statement

Wastewater treatment plants are large, expensive, and complex, and are interconnected with collection, conveyance, and discharge systems. These systems are highly vulnerable to sea level rise and storm events because there is little to no redundancy within these systems, and they rely on roads, power, materials, and supplies from off site. Flooding could result in significant wastewater service disruptions. Additionally, the combination of existing infrastructure problems and limited funding may prevent some agencies in East Contra Costa County from planning and implementing adaptation responses to address the challenges of sea level rise.

Asset Descriptions

The Ironhouse Sanitary District (ISD)

The Ironhouse Sanitary District (ISD) provides sewage services to Oakley, the unincorporated area of Bethel Island, and other unincorporated areas of the County including the area covered by the East Cypress Corridor Specific Plan. ISD has a separate sewer-storm system (stormwater and sewage are collected through two different piped systems). ISD is bounded by the San Joaquin River to the north, the Delta Diablo Sanitation District to the west, Brentwood to the south, and includes part of the Holland Tract to the east.

ISD serves an estimated 42,000 customers in an area of about 37 square miles. ISD's infrastructure includes gravity and pressure pipelines, pumping stations, the Ironhouse Wastewater Treatment Plant (IWWTP), and lands for effluent/nutrient disposal, which includes some areas on the mainland and Jersey Island (it owns about 3,500 acres). The IWWTP is located on 285 acres to the south side of Big Break. The IWWTP has a capacity to treat 2.7 million gallons per day (MGD) with average dry weather flows of 2.6 MGD, which is approaching 96 percent capacity of the plant. ISD owns 120 miles of pipeline and 34 pump stations.

The Ironhouse Treatment Plant is a water recycling facility of 4.3 MGD that uses the nutrients collected for irrigation water (stored in an on-site pond) or applied to 334 acres of agricultural land on Jersey Island. Otherwise, the effluent is discharged into San Joaquin River through a 550-foot outfall with 16 diffusers.[cxxii]

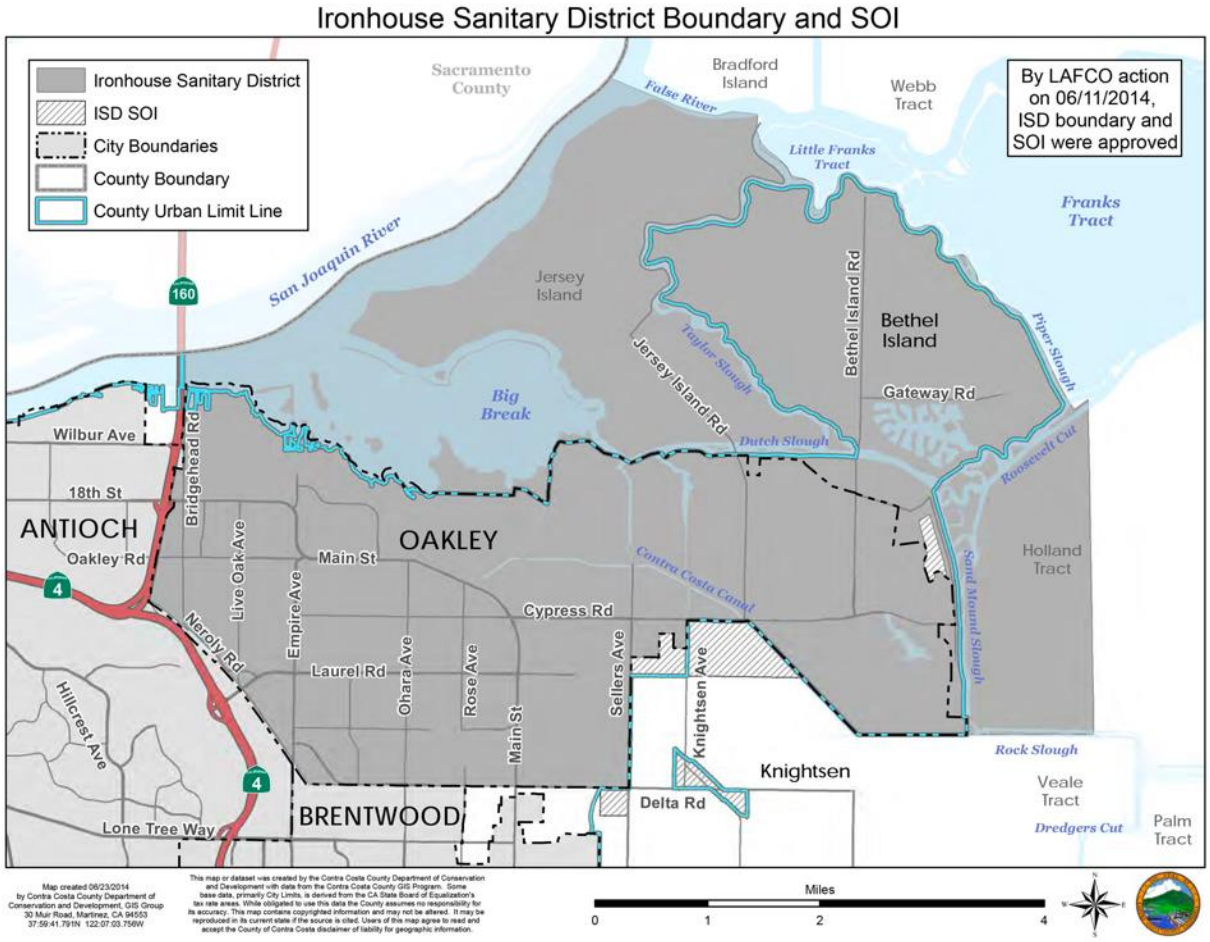

Figure 11-1. Ironhouse Sanitary District Boundary. (Source: Contra Costa County Department of Conservation and Development)

The Delta Diablo Sanitary District (DDSD)

The Delta Diablo Sanitary District (DDSD) was founded in 1976 and provides wastewater services for Antioch, Pittsburg, and the unincorporated community of Bay Point (outside the Project Area). It is a dependent special district, which is a public agency created to provide one or more specific services to a community, such as water service, sewer service, parks, fire protection, and others, and the governing board of either a city or county serve as decision-makers for the special district.[cxxiii]

DDSD serves an estimated population of over 190,567 residents in an area of about 52 square miles.

The DDSD has a wastewater treatment plant (capacity of 16.5 MGD) and recycled water facility that was started in 2001 and expanded in 2008 (capacity of 12.8 MGD). DDSD has 71 miles of sewer main, 5 wastewater pump stations and 16 miles of recycled water pipeline. DDSD converts 50% of its wastewater into recycled water and the other 50% discharges to New York Slough through deep water outfall. The benefit to a deep-water

outfall is that it is not subject to failure due to flooding since the discharge is already underwater.

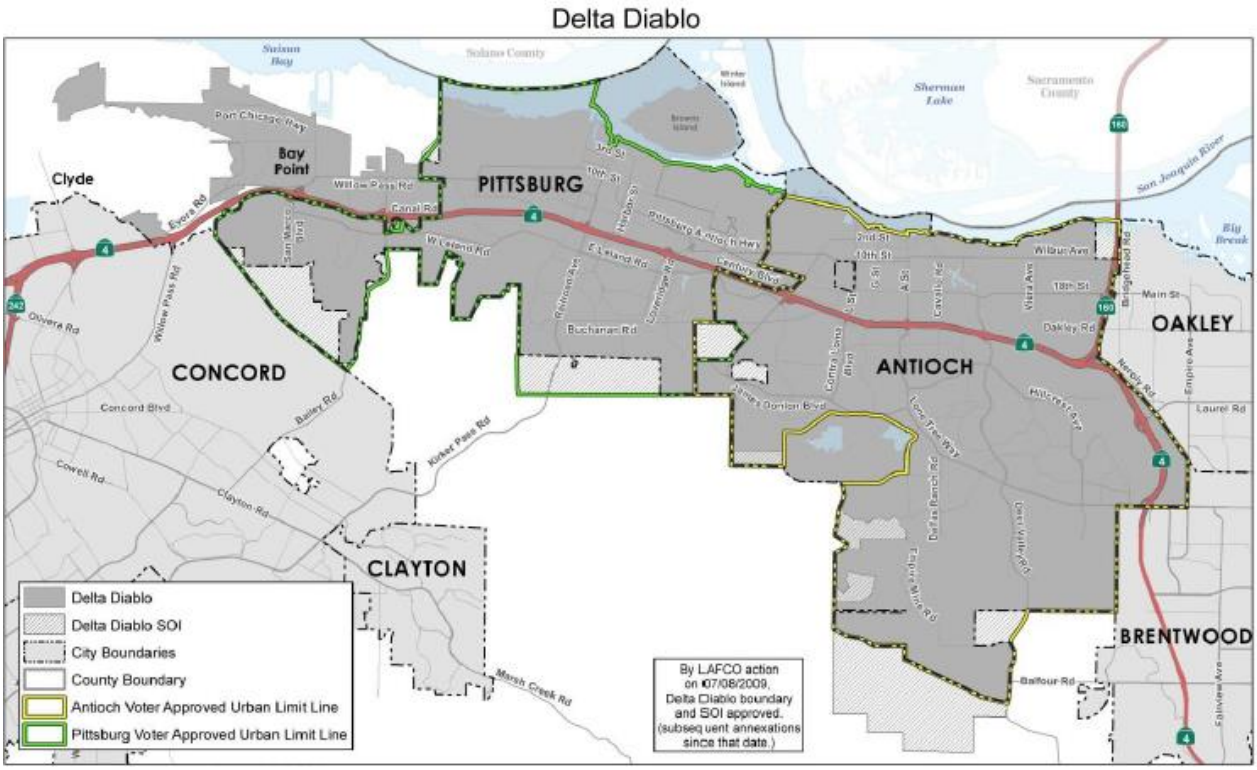

Figure 11-2. Delta Diablo Sanitary District boundary. (Source: Contra Costa County Department of Conservation and Development)

DDSD has continuous capital improvements conducted and a Five Year Capital Improvement Program that ends in 2023 with planned capital projects, which is listed on their website. DDSD has also completed a Sewer System Master Plan, which lists improvements required over the next decade in the order of $51 million.[cxxiv]

Discovery Bay Community Services District

The Town of Discovery Bay operates two wastewater treatment plants totaling in 1.8 MGD. They serve a population of over 13,300 people. Both wastewater plants are located on the eastern edge of town. Both plants have recently undergone major capital investments to ensure that the systems will continue to function into the near future.

Discovery Bay owns fifteen wastewater lift stations that transport the raw wastewater to the main wastewater treatment facility and 60 miles of sewer mains. Their water and wastewater facilities are operated and maintained by Veolia Water. Discovery Bay has also partnered with the University of California, Berkeley on a Wetlands Trial Project that is experimenting with removing pharmaceuticals, salinity, and certain metals from their effluent.

Exposure To Current And Future Flooding

Detailed exposure was analyzed for six wastewater treatment plants and a discharge point in the Project Area. One of the six wastewater treatment plant sites in the project area is within the existing 100-year storm event: the Holland Riverside Marina on the Holland Tract, which is in the town of Brentwood. All of the six wastewater treatment plants are affected by 83" of SLR without a 100-year storm event. Many facilities could be impacted by sea level rise due to being in low-lying areas protected by levees. Hydrostatic pressure from rising water levels could cause levee failures and may require upgrades to levees.

Other Risks

Most of the Project Area is within a potential liquefaction zone, posing risks to facilities during earthquakes. Subsidence has been an issue in the Delta since land reclamation began and could pose risks to existing gravity-fed sewer lines and treatment facilities.

Data Considerations

The exposure analysis had both points and polygons representing wastewater treatment plants, and exposure means that the point or part of the polygon intersected with current or future flooding.
Watershed-specific hydraulic modeling is needed to improve the understanding of the impact that higher Delta water levels could have on flood risks within and beyond the existing 100-year storm event boundary.

The exposure analysis presented below is for a point and not the entire treatment plant site footprint, which varies in size depending on the type of service provided and service area. For larger treatment plants, site-specific exposure analyses will be needed to understand which, if any, infrastructure assets or components are at risk. In addition, public sewer lines (including mains, force mains and interceptors), pump stations, and private sewer laterals were not evaluated in the exposure analysis but are considered in the discussion of overall vulnerability and risk to the function of the wastewater system.

Table 11-1. Number of wastewater treatment plants that may be located in the current 100-year storm event area and/or exposed to future sea level rise or the combination of sea level rise with a 100-year storm.

Asset	City	Current 100-year Storm Event*	12" + 100-yr	24" + 100-yr	36" + 100-yr	83" + 100-yr	MHHW Today	12"	24"	36"	83"
Holland Riverside Marina	Brentwood	Yes	Yes	Yes	Yes	Yes	--	--	--	--	Yes
Town of Discovery Bay Community Service District Treatment Plant 1	Discovery Bay	--	--	Yes	Yes	Yes	--	--	--	--	Yes
Town of Discovery Bay Community Service District Treatment Plant 2	Discovery Bay	--	--	Yes	Yes	Yes	--	--	--	--	Yes
Town of Discovery Bay WWTP Discharge 3	Discovery Bay	--	--	--	--	Yes	--	--	--	--	Yes
City of Bryon WWTP	Byron	--	--	Yes	Yes	Yes	--	--	--	--	Yes
Ironhouse WWTP	Oakley	--	--	Yes	Yes	Yes	--	--	--	--	Yes
Delta Diablo Wastewater Treatment Plant	Antioch/ Pittsburg	--	--	--	Yes	Yes	--	--	--	--	Yes
Diablo Water Treatment Plant (Recycled Water)	Oakley	--	--	--	--	Yes	--	--	--	--	--
Ironhouse Treatment Plant (Recycled Water)	ISD	--	--	Yes	Yes	Yes	--	--	--	--	Yes
Total Assets Exposed in Project Area**	**9**	**1**	**1**	**6**	**7**	**9**	**--**	**--**	**--**	**--**	**8**

"--": Unexposed assets

MHHW: Mean Higher High Water refers to the average of today's daily highest tide and is used as the baseline for all flooding scenarios.

*Current 100-year Storm Event: The 100-year storm event reflected in these maps is not equivalent to the FEMA 100-year flood hazard zone.

Vulnerabilities

GOV1: Wastewater agencies collaborate with other entities to treat and discharge wastewater collected in their respective service areas and will therefore need to collaborate on 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., electricity and access roads) 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.
GOV3: Directing resources to long-term planning to address the risks posed by sea level rise may not be a priority given existing capital demands. The majority of the wastewater plants have collection systems, which consist of aging infrastructure with numerous pipe segments in need of repair or replacement in the short term.
FUNC1: Wastewater treatment systems are large, expensive, and complex, and there is little to no redundancy within each system, making them highly vulnerable to sea level rise and storm events. Many pipes and pump stations have no redundancy.
FUNC2: Storm events and extreme high tides have the potential to reduce outfall and diffuser capacity and exacerbate wet weather flows. Existing capacity limitations will be further reduced as sea levels rise, which would have consequences on how wastewater treatment plants handle wet weather flows and may threaten the overall performance of their respective systems.
FUNC3: Wastewater service providers rely on road access to maintain their infrastructure and facilities, obtain necessary supplies and equipment, and ensure employees can reach work sites. If flooding impacts the roads and highway system that provide access to and from wastewater facilities, the ability to provide continuous service may be interrupted.
FUNC4: Wastewater treatment plants and effluent pump stations require an uninterrupted power supply to maintain function. Flooded substations or a compromised electrical grid can cause interruptions to service.
PHYS1: The wastewater treatment plants are mostly located on predominantly low soil strength bay muds/muck and artificial fill and could be subjected to greater risk of liquefaction during a seismic event due to a high groundwater table.
PHYS2: Rising groundwater will increase the potential that interceptor pipelines will become buoyant and float, making them susceptible to damage that will increase the need for maintenance, repair, and replacement.
PHYS3: Flooding can increase infiltration from stormwater to interceptor pipelines through manholes and other structures. This increase in wet weather flows will further limit the capacity to convey and treat wastewater prior to discharge or reclamation/recycling.
PHYS4: Electrical and mechanical components at the wastewater facility, including pumps and control panels, are at or below grade and are not waterproofed or salt-resistant, they could be damaged and the treatment plant may not be able to fully function.
PHYS5: Holding ponds may be flooded, resulting in the release of untreated sewage to the environment.
FUNC4: If groundwater or infiltration inflow is saline, it could significantly corrode sewer pipes and conveyance equipment, such as pumps, possibly leading to service interruption.

Consequences

Society and Equity: Wastewater treatment plants provide a critical and essential public health and safety function. If storm events or sea level rise overwhelm and compromise the system, then a plant's ability to treat and discharge wastewater could be affected. Without service, sewer backups could occur in the affected cities and unincorporated areas, driving residents out of their homes, at least temporarily, and businesses to close. Hospitals, schools, and nursing facilities may experience exacerbated public health issues due to the sensitive populations they serve.

Environment: If storm events or sea level rise overwhelm and compromise the treatment plants, toxic substances and excessive nutrients could overflow into the adjacent shoreline areas and Bay-Delta, degrading water quality, violating the Clean Water Act, and harming fish and other aquatic organisms. Water quality would likely be impacted by any disruption of wastewater facilities. Consequences range from minor pollution to serious public health and ecological damages.

Economy: A wastewater system disruption could potentially have wide-ranging consequences in the communities serviced by the wastewater treatment plants. Cumulative impacts on commercial and industrial businesses and the associated employment, goods, and services they provide could also be significant. Operations, maintenance, and capital improvement costs could increase with storm event and sea level rise flooding. Disruptions can range broadly and have various impacts. Small disruptions, including overloading, may result in fines from state and federal regulators. Major disruptions would have economic impacts not only on the facility managers but also the communities that rely on them, including cleanup costs from spills, costs of rebuilding damaged infrastructure, and direct and indirect costs from damaged services. Businesses in the service area may need to close until services are restored.

Water Management

The following chapter explores how water management facilities and infrastructure in the Project Area will be affected by current and future flooding from sea level rise, 100-year storm events[6], and the combination of the two. The chapter follows the following organization and looks at the impacts to the following assets:

- Water management
  - Water treatment facilities
  - Water conveyance

[6] This project's 100-year storm events are *not* equal to FEMA's 100-year floodplains.

- Pumps, diversions and water intakes
- Groundwater and wells
- Mutual water companies
- Water rights

Acronyms

AF	Acre-feet
CCCSD	Central Contra Costa Sanitation District
CCWD	Contra Costa Water District
cfs	Cubic feet per second
CVP	Central Valley Project
DDSD	Delta Diablo Sanitation District
DWD	Diablo Water District
DWR	California Department of Water Resources
EBMUD	East Bay Municipal Utility District
ECC	East Contra Costa
ECCID	East Contra Costa Irrigation District
FIRMs	Flood Insurance Rate Maps, by FEMA
FEMA	Federal Emergency Management Agency
LAFCO	Local Agency Formation Commission
MAF	Million acre-feet
MG	Million gallons
MGD	Million gallons per day
MPP	Multi-Purpose Pipeline, CCWD pipeline
Project Area	East Contra Costa Project Area
SWP	State Water Project
WTP	Water Treatment Plant

Water Supply

An intricate network of water supply infrastructure conveys water from the Sacramento-San Joaquin Delta to residents within East Contra Costa County and throughout the state. The Delta is the confluence of California's largest watersheds, draining almost 40% of California's land surface area. Delta water is used by more than 27 million people throughout California, including within the Delta, and in the San Francisco Bay Area through local water intakes and state and federal aqueduct projects, such as the State Water Project (SWP) and Central Valley Project (CVP). Delta water provides a portion of irrigation water for about 3 million acres of farmland and plays a critical role in sustaining the state's economy and the nation's food supply. Water exports out of the Delta are constrained by annual inflows and regulations to protect water quality and endangered fishes. "In an average year, the two water projects combined export about 5.1 million acre-

feet[7] (MAF) or 24% of the Delta's inflows; however, this amount can vary from as low as 3 MAF in dry years to around 6.5 MAF in wet years".[cxxv] Although the Delta is mostly freshwater, it is strongly tidally influenced because of its proximity and connection to the saltwater San Francisco Bay, and as such is vulnerable to salinity intrusion during low-precipitation years. Although historically the Delta naturally experienced such brackish conditions during periods of low inflow, this now poses an issue for water management.


Photo: Army Corps of Engineers

East Contra Costa obtains most of its water from the Delta, but some water supplies are from groundwater wells, especially in Discovery Bay and users of the Diablo Water District. It is important to note that salinity intrusion could affect both surface and groundwater users not just from affecting water quality, but also from saltwater corroding infrastructure. Physical inundation of sites could be an issue at higher sea level rise scenarios.

Contra Costa County has two distinct water supply and retail service zones[8] – the Eastern/Central Region and the Western Region. Sources of water supply to the East Contra Costa Project Area (Project Area) located within the Eastern/Central Region include the San Joaquin River, local groundwater, some recycled water, and the Central Valley Project (CVP). Within the ART Project Area, water suppliers in the Eastern Region include the Contra Costa Water District (CCWD), which wholesales and retails water sourced from the Delta through the Central Valley Project. In the Western Region, the East Bay Municipal Utility District (EBMUD) sources water from the Mokelumne River and the Pardee Reservoir for retail and wholesale in Contra Costa as well as other counties in the East Bay. While the Project Area does not receive water from EBMUD, the Mokelumne Aqueduct is located within the Project Area.

As the source of water can be far from the ultimate end user, many water systems extend well beyond the Project Area and the county line. Water suppliers manage large and complex conveyance systems that include aqueducts, reservoirs, water treatment plants, pumps, water mains, and other infrastructure. The California State Water Project (SWP) and the (federal) CVP are the largest human-made storage and conveyance systems in the state and export water from the Delta. The SWP provides supplemental water for 27 million Californians and irrigation water for an estimated 750,000 acres of farmland; it has allowed

[7] Acre-feet is a way to measure the volume of water. One acre-foot could be visualized as an acre of land with water one foot high.
[8] Water wholesalers supply water to other water agencies or suppliers and do not provide services to individual users, where water retailers sell water directly to customers.

for and sustains Southern California's population growth, helps manage floods in the Sacramento Valley, and is integral to the agricultural sector.[cxxvi,cxxvii] The CVP provides flood protection and water for the Central Valley. It also supplies water to cities in the Sacramento and San Francisco Bay areas, produces electrical power, and offers various recreational opportunities.[cxxviii]

Sea level rise may increase salinity in the Delta, impacting the water quality in the Delta. While some water supply assets within the Project Area are located in areas at risk of flooding, **the greatest potential impact of sea level rise on water service in the Sacramento-San Joaquin Delta will be due to water quality degradation from increasing salinity.** Tides from the Golden Gate affect water levels far into the Delta. With these tides comes saline water from the Pacific. The extent of salinity intrusion into the Delta is determined by the volume of freshwater flows into the Delta from precipitation, which is a highly-managed system and driven by regulatory requirements, the sea level height, and tidal energy. Climate models predict that California will have less snow[cxxix] and higher sea level. This reduced snow melt could result in increased freshwater flows during the winter and less during the spring months, possibly resulting in higher salinity during Spring-Summer months. Extreme tides have also increased dramatically since the early 1900s.[cxxx] From these higher sea levels, reduced storage, and lessened runoff during Spring-Summer months into the Delta, salinity is expected to increase as sea level rises.[cxxxi,cxxxii] During drought years or dry summer months, the salinity is higher because there are less freshwater inflows. According to Fleenor et. al:

> With 30.48 cm (1 ft) of sea level rise and no other changes to the [model], salinity in the Delta may still be low enough for irrigation during the growing season, but southern Delta salinity increases substantially. On average, Clifton Court Forebay annual average salinity concentration increases by approximately 4% to 26% and for CCWD by approximately 35% to 49%.

Currently, eight 'islands' in the western Delta act as salinity barriers, six of which are in the Project Area. These include Hotchkiss Tract, Holland Tract, Jersey Island, Bethel Island, Bradford Island, and Webb Tract (see the Delta Islands chapter for more information). Sea level rise could also increase the stresses on levees that encircle these islands, increasing the risk for levee failure and island flooding. **Loss of these salinity barrier islands would alter Delta hydrology, allowing more tidally-driven saltwater to enter the Delta; this may render water quality unsuitable for irrigation or municipal uses faster than sea level rise alone.**

Levee failures, whether caused by storm event flooding, rising sea levels, or seismic event liquefaction, may also put water conveyance infrastructure at risk. Failure of the levees could result in damage to the Mokelumne Aqueduct and disruption of water supply to the western region of Contra Costa County, the SWP, and the CVP. While many large aqueducts and canals are seismically retrofitted, liquefaction could damage other water supply assets such as treatment intakes, plants, conveyance canals, and reservoirs.

Contra Costa County has an expected population growth rate of 27% between 2010 and 2040[cxxxiii] and will need to find new opportunities to improve water supply resilience to both accommodate growth and adapt to a changing climate.

Water Management Agencies

Water management agencies in the Project Area are described below.

Contra Costa Water District (CCWD)

Contra Costa Water District (CCWD) provides water service to approximately 522,000 customers in central and northeastern Contra Costa County. CCWD delivers approximately 119,420 acre-feet annually of treated and untreated water to its customers, which include retail and wholesale customers, municipalities, agricultural users and industrial customers. 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 originate within the Sierra Nevada and are diverted from the Sacramento-San Joaquin Delta. CCWD operates four water intakes in the Delta: Mallard Slough in Bay Point, Rock Slough near Oakley, Old River near the town of Discovery Bay and nearby Middle River along the Victoria Canal. 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 industrial customers and serves as a redundant facility for a portion of the canal.

CCWD has several untreated and treated water interties with neighboring agencies that can be used in the event of an 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. The MPP can transport treated water in reverse to east Contra Costa County from the Bollman Water Treatment Plant in Concord. During an emergency that disrupts Canal operations, such as mudslides or seismic activity, the MPP can convey untreated water if needed.

CCWD owns and operates four reservoirs, including the Los Vaqueros Reservoir located near the City of Brentwood, Contra Loma in Antioch, Mallard in Concord, and the Martinez Reservoir. The Los Vaqueros Reservoir is an off-stream reservoir that has 160,000 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. The reservoir has a planned expansion to increase its storage. The reservoir provides up to 70,000 acre-feet of emergency supply in wet years and up to 44,000 acre-feet in dry years.

The Los Vaqueros Reservoir provides a minimum of 3 to 6 months of emergency storage that may be utilized during a catastrophic interruption of CCWD's Delta supplies.[cxxxiv] Contra Loma Reservoir has a capacity of 1,200 AF and is primarily used as a regulating reservoir for peak demands and short-term supplies. Mallard Reservoir provides water to Bollman WTP and used for emergency, flow regulation, and blending with a capacity of 2,100 AF. The Martinez Reservoir is located at the terminus of the Contra Costa Canal and Shortcut Pipeline is primarily used by the City of Martinez for its treatment plant and has a capacity of 230 AF.

CCWD serves both treated and untreated water. Major untreated water municipal customers include the Diablo Water District (DWD) and the Cities of Antioch, Pittsburg and Martinez. Treated water is distributed to individual customers living in the following communities: Clayton, Clyde, Concord, Pacheco, Port Costa, and parts of Martinez, Pleasant Hill, and Walnut Creek. In addition, CCWD treats and delivers water to the City of Brentwood, Golden State Water Company (Bay Point), and the City of Antioch. CCWD also conveys East Contra Costa Irrigation District water to the City of Brentwood under contracts with these municipalities as well as operates and maintains the Brentwood Water Treatment Plant to deliver treated water to the portion of Brentwood outside CCWD service area.

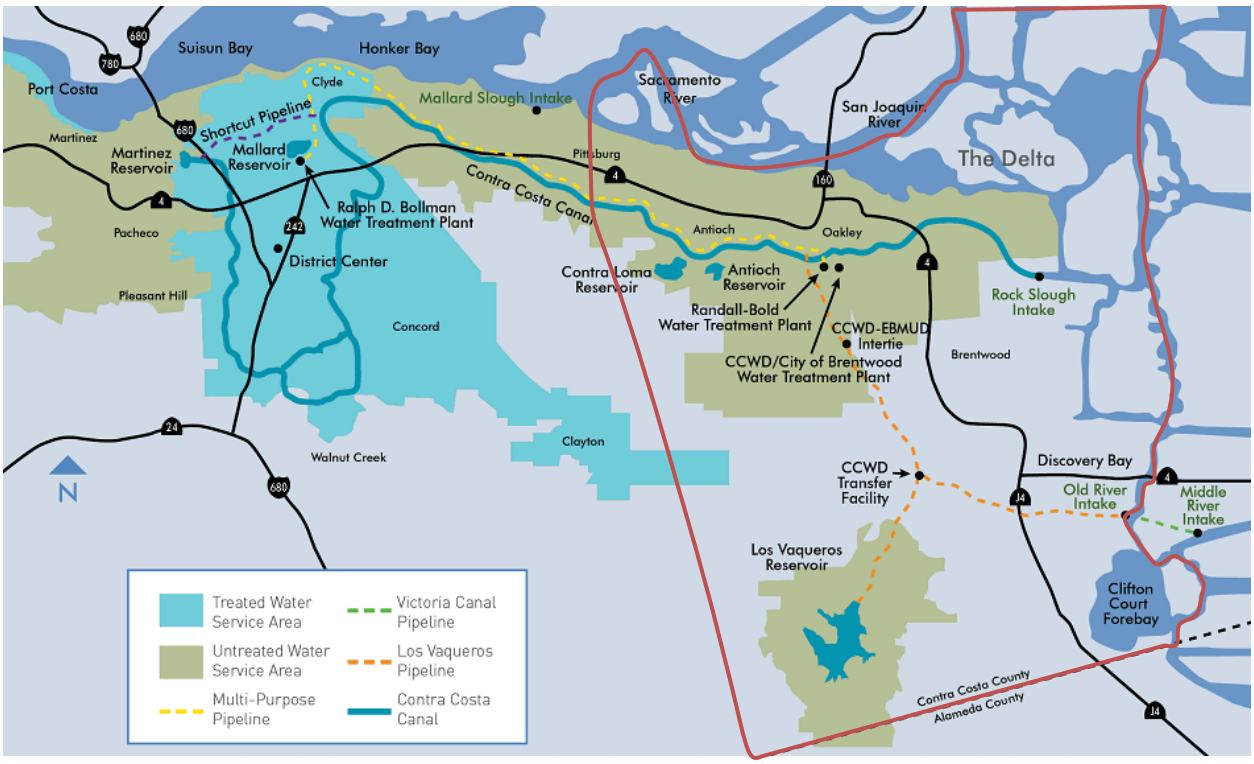

Figure 12-1. CCWD's service area. The Project Area is outlined in red. (Source: CCWD)

CCWD Assets In Project Area

- Randall-Bold Water Treatment Plant (50 MGD), CCWD/City of Brentwood Treatment Plant (16.5 MGD)

- A portion of the Multi-Purpose Pipeline and Contra Costa Canal.
- Los Vaqueros Pipeline (19 mi)
- Los Vaqueros Reservoir (160,000 acre-feet[9] (af))
- Screened intakes: Rock Slough (350 cubic feet per second (cfs)); Old River (250 cfs); and Middle River (250 cfs)
    - The Old River and Middle River Pumping Plants, both intakes for the Los Vaqueros Reservoir and the Contra Costa Canal, are protected by USBR embankments for the canal (not flood protection levees)
- Untreated Water Inter-tie with EBMUD
- Los Vaqueros Energy Recovery Facility (1 megawatt)

CCWD Assets Outside Project Area

- Approximately 820 miles of treated water distribution pipelines including the Multi-Purpose Pipeline (22 miles total), 31 pump stations, 41 active reservoirs (72 million gallons (MG)), and Ralph D. Bollman Water Treatment Plant (75 million gallons per day (MGD))
- Mallard Slough screened intake (39 cfs)
- Conveyance: Contra Costa Canal (48 miles); Short Cut Pipeline (5 miles)
- 3 reservoirs: Mallard (2,100 af); Contra Loma (1,200 af); and Martinez (230 af)

Diablo Water District (DWD)

The Diablo Water District (DWD) was formed in 1953. The District serves about 28,000 people in a 17 square mile area. Their service area includes Oakley and unincorporated areas such as the Hotchkiss Tract; East Cypress Corridor Specific Plan Area; Summer Lakes development; Knightsen; and certain communities on Bethel Island including Delta Coves. The District has the San Joaquin River to the north, the Antioch to the west, Brentwood to the south, and Holland Tract/unincorporated areas to the east.

DWD primary source of water originates from Shasta and Friant Dams and flows into the Sacramento-San Joaquin Delta. DWD purchases untreated water from the CVP from CCWD, which is conveyed through the Contra Costa Canal and Los Vaqueros System which is ultimately treated at the jointly owned Randall-Bold Water Treatment Plant (RBWTP), operated by CCWD.

DWD mostly supplies domestic treated water, but also does “purple pipe”/non-potable water for irrigation. Treated water from RBWTP is conveyed to two reservoirs with two pump stations and through 97 miles of water pipelines. DWD also operates two groundwater wells in the San Joaquin Valley Basin. These are the Glen Park well and

[9] Acre-feet is a volumetric measure of water. One acre-foot can be visualized as one acre of land covered in one foot of water.

Stonecreek well which add 4 MGD of local water supply.[cxxxv] The surface water is treated and blended with groundwater before delivery.[cxxxvi]

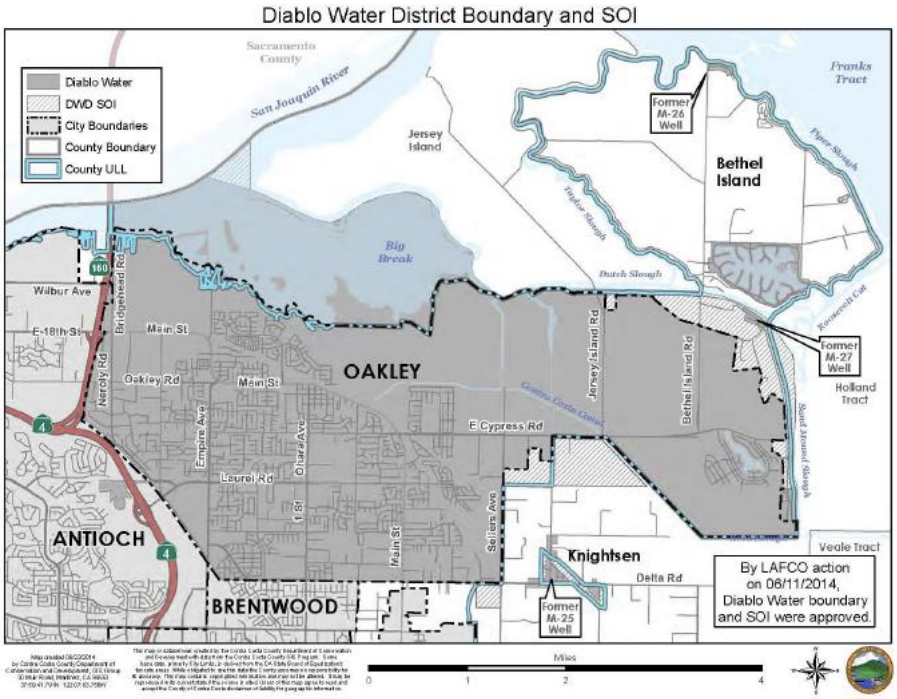

Figure 12-2. Diablo Water District Boundary

City Of Antioch

The City of Antioch provides water service within its boundaries to about 112,000 residents. Approximately 30% of Antioch's water comes from the city through a drinking water intake from the San Joaquin River, with the other 70% of their water from CCWD through the Contra Costa Canal. During the dry seasons, depending on San Joaquin River water quality, the city uses CCWD water. Antioch has the ability to buy both treated and untreated wholesale water from CCWD. The City of Antioch has the following assets: the City of Antioch Water Treatment Plant (38 MGD), 339 miles of main, 7 pump stations, and 11 reservoirs.[cxxxvii] The City provides water service within its boundaries, with distribution through seven pump stations and 339 miles of pipeline in four pressure zones.

According to the City of Antioch, "The quantity and quality of the water at the City's San Joaquin River intake is impacted largely by factors outside of the City's control (e.g. other delta projects, climate change, sea level rise, and state water project operations). The amount used from each source depends on the time of year and the type of year (dry or wet). The City uses river water as much as possible, because it is less expensive than water purchased from CCWD. However, over the years as the salinity of the river water has increased steadily, the City has been forced to purchase more water from CCWD."[cxxxviii]

City Of Brentwood

The City of Brentwood provides water services to over 17,000 customers in a service area of about 15 square miles. Their main source of water comes from the San Joaquin Basin (groundwater) and San Joaquin River Delta (through agreement with East Contra Costa Irrigation District); the City also purchases treated water from CCWD. The City has nine groundwater wells that produce 5 MGD. Brentwood purchases raw water from the East Contra Costa Irrigation District and treats it at the City of Brentwood Water Treatment Plant (16.5 MGD) for delivery as potable water. This water then goes through seven booster pumps and through 172 miles of water pipeline. The City also owns a share 6 MGD at the RBWTP, which is operated by the CCWD.[cxxxix]

City Of Pittsburg

Only a portion of Pittsburg is within the Project Area. The City provides water treatment and distribution for its residents and businesses and serves a population of 64,294. The majority of Pittsburg's untreated water comes wholesale purchased from CCWD. Untreated water purchased from CCWD is treated at the City of Pittsburg Water Treatment Plant (32 MGD), transported through 215 miles of pipelines by 7 pump stations, and stored in 8 drinking water storage reservoirs. 8.8 MGD of water is purchased from the CCWD. Water supplies are supplemented by locally produced groundwater through 2 municipal wells that supply on average 12% of the water demand.[cxl]

Town Of Discovery Bay Community Services District

The Town of Discovery Bay Community Services District (CSD) provides water to a population of about 13,000. The water is drawn from the Sacramento-San Joaquin Valley groundwater basin through 6 wells from an aquifer about 300 feet below the ground, and is then sent through a treatment, filtration, and storage process.[cxli] The Town has two water treatment plants, booster pumps, 4 reservoirs, and 45 miles of pipeline. The two water treatment plants are the Willow Lake Water Treatment Plant (1.5 MG) and the Newport Water Treatment Plant (1.0 MG).[cxlii] The Town of Discovery Bay CSD is also responsible for levee maintenance.

Figure IV-28, Boundary/SOI Map – Town of Discovery Bay Community Services District

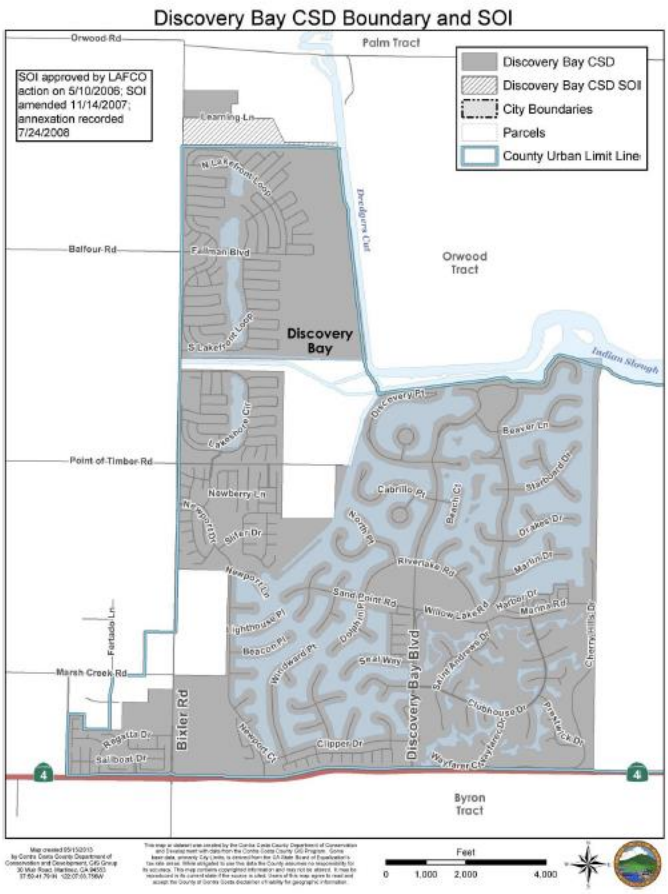

Figure 12-3. Discovery Bay service area.

Water Treatment Facilities

Many water treatment facilities sit on the shore of the Delta, some protected by levees. Water treatment facilities can be vulnerable to sea level rise due to their locations on the water's edge.

CCWD is the major water supplier for the region. The District 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 in central Contra Costa County and also provides wholesale treated water to municipalities along the way. CCWD co-owns the Randall-Bold Water Treatment Plant (50 MGD), and CCWD/City of Brentwood Treatment Plant (16.5 MGD) as well as the Bollman Water Treatment Plant (75 MGD, outside Project Area).

Individual municipalities distribute treated water to individual customers living in the City of Brentwood, Golden State Water Company (Bay Point) and the City of Antioch. Antioch, Pittsburg, and Discovery Bay all also own and operate their own water treatment plants.

Issue Statement

Due to water treatment plants being located along the shore of the Delta, they are vulnerable to sea level rise. While levees may protect some plants, sea level rise may cause increased hydrostatic pressure and can cause levee failure. Disruption to water treatment would cause severe impacts to communities, businesses and emergency services.

Asset Descriptions

Randall-Bold Water Treatment Plant (RBWTP)

The Randall-Bold Water Treatment Plant (RBWTP), built in Oakley in 1992, is jointly owned by the CCWD and the DWD and operated by CCWD. The plant treats 50 MGD and can be expanded to 80 MGD. Treated water is stored in a 5 MG underground reservoir on site. Additionally, the City of Brentwood purchases up to 6 MGD from the RBWTP.

City Of Brentwood Water Treatment Plant

The City of Brentwood provides potable water service by utilizing purchased raw water from the East Contra Costa Irrigation District and treating it at the City of Brentwood Water Treatment Plant, which has a capacity of 16.5 MGD.

Town Of Discovery Bay CSD Treatment Plant

The Town of Discovery Bay has water operations that provide a potable treatment capacity of approximately 2.5 MGD. They have two water treatment plants, the Willow Lake Water Treatment Plant (1.5 MG) and the Newport Water Treatment Plant (1.0 MG). The primary source of water is 6 groundwater supply wells.[cxliii]

Antioch Water Treatment Plant

The City of Antioch's principal sources of untreated water supply are the San Joaquin River through intakes and the Contra Costa Canal (purchased from CCWD). The City of Antioch has the City of Antioch Water Treatment Plant (38 MGD) that treats the San Joaquin River water.[cxliv] Due to the increasing salinity of the San Joaquin River, the main source of drinking water for Antioch, the City has started design of a 6 MGD desalination plant at the site of the Water Treatment Plant, to be opened in early 2022.[cxlv]

Pittsburg Water Treatment Plant

The City of Pittsburg provides water treatment and retail services through the operation of its Pittsburg Water Treatment Plant (WTP). The WTP has a capacity of 32 MGD and an average production of 8.8 MGD of water is purchased from the CCWD. While technically the WTP is outside of the Project Area boundaries, it is included in this analysis because it was not looked at in the Contra Costa ART Project that covered West Contra Costa County.

Exposure To Current And Future Flooding

Assets, which include the water treatment plants within the Project Area, were analyzed to determine if they were exposed to either current or future flooding. Current flood risk was determined using the current 100-year storm event. Most treatment plants, which are

protected by levees, are not exposed to current or future flooding. However, the Town of Discovery Bay CSD Treatment Plant will potentially be exposed to flooding in the future due to sea level rise or a combination of sea level rise and a 100-year storm event

Only a portion of the CCWD service area and infrastructure are within the Project Area. 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, but rather impacts to water quality in the Delta.[cxlvi] As the sea level rises the Delta will become increasingly saline, which will limit fresh water supplies. Treatment plants are not currently designed to handle saline water and could require desalination, seasonal use, use pipes from less saline areas, or other options.

It is important to note that some of these treatment plants are protected by levees, so if any of the levees experience failure, so would the water treatment facilities. This analysis assumes that levees do not fail.

Other Risks

Water treatment facilities could also be at risk from liquefaction, especially if levees protecting the facilities fail.

Data Considerations

Within the Water Facilities GIS (see GIS Data Sources Appendix), sanitation and water facilities are mixed in one file. GIS shapefiles were polygons (rather than points), meaning a more accurate representation of exposure is available, because if only a corner of the site is exposed, it is marked as exposed.

It is important to note that some facilities are missing from the ART East Contra Costa Project data set, such as the second Discovery Bay water treatment plant. While technically the Pittsburg WTP is outside of the Project Area boundary, we would like to include it in this analysis because it was not looked at in the Contra Costa ART Project that covered West Contra Costa County.

Table 12-1. Number of water treatment plants that may be located in the current 100-year storm event area and/or exposed to future sea level rise or the combination of sea level rise and a 100-year storm event.. This does not include treatment plants effected by saline water quality.

Asset	Management	Current 100-year Storm Event*	12" + 100-yr	24" + 100-yr	36" + 100-yr	83" + 100-yr	MHHW Today	12"	24"	36"	83"
Town of Discovery Bay CSD Treatment Plant	Discovery Bay	--	--	Yes	Yes	Yes	--	--	--	--	Yes
City of Brentwood Water Treatment Plant	Brentwood	--	--	--	--	--	--	--	--	--	--
Antioch Water Treatment Plant	Antioch	--	--	--	--	--	--	--	--	--	--
Randall-Bold Water Treatment Plant	CCWD	--	--	--	--	--	--	--	--	--	--
Pittsburg Water Treatment Plant	Pittsburg	--	--	--	--	--	--	--	--	--	--
Total Sites Exposed**		**--**	**--**	**1**	**1**	**1**	**--**	**--**	**--**	**--**	**1**

"--": Unexposed assets

MHHW: Mean Higher High Water refers to the average of today's daily highest tide and is used as the baseline for all flooding scenarios.

* Current 100-year Storm Event: The 100-year storm event reflected in these maps is not equivalent to the FEMA 100-year flood hazard zone.

Vulnerabilities

FUNC1: The assets are part of a networked system and if key parts of the system are disrupted, the function of the other assets may be compromised.
FUNC2: Treatment plants rely on power to run the facilities. If flooding impacts power supplies the ability to provide water to customers may be constrained. Flooded substations or a compromised electrical grid can cause interruptions to service.
FUNC3: Treatment plants rely on road access to maintain their infrastructure and facilities, obtain necessary supplies (e.g. chemicals for treatment) and equipment, and ensure employees can reach work sites. If flooding impacts the roads and highway system that provide access to and from wastewater facilities, the ability to provide continuous service may be interrupted.
FUNC4: If treatment plants are disrupted and the emergency supply exhausted, the economic and social disruption would be significant. Disruption to water may halt emergency responses, including hospitals and fire protection, businesses, and homes from functioning properly.
FUNC5: At-risk members of the community, the elderly, young children, people with disabilities, etc. would be particularly vulnerable without replacement water supplies in the event of disruption.
PHYS1: Water treatment facilities are not designed to handle saline water; increasing salinity with sea level rise may damage equipment.
PHYS2: Water treatment facilities may be located on low soil strength bay muds and artificial fill and could be subjected to greater risk of liquefaction during a seismic event due to a high groundwater table.
PHYS3: If electrical and mechanical components, including pumps and control panels, are at or below grade and are not waterproofed or salt-resistant, they could be damaged and the treatment plant may not be able to fully function.
PHYS4: Floodwaters as well as rising groundwater will increase the potential that pipelines become buoyant and float, making them susceptible to damage and increasing the need for maintenance, repair, and replacement.

Consequences

Society and Equity: Water is critical for a well-functioning society. It could affect 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 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. Those who are financially well-off may have the capability to purchase bottled water or private filtration systems.

Environment: If sea level rise causes more saline water to travel upstream into the Delta, it could affect the Delta by both effecting water quality and changing from fresh to brackish water ecosystems. This means brackish ecosystems found typically in the Bay would get pushed farther up the Delta, where it typically has freshwater ecosystems. This may revert the Delta back to the habitat existing prior to widespread human modification.

Economy: If the ability to provide water is disrupted and emergency supplies are exhausted, the economic disruption would be significant throughout the County. The commercial customer users vary from laundries and linen supplies to restaurants and health care facilities, and from car washes to hotels and retail stores. There are also industrial users who rely on water for manufacturing.

Water Conveyance

Water is conveyed through structures in the Project Area to the Bay Area and Southern California via the Mokelumne Aqueduct, the California Aqueduct, and the Contra Costa Canal. Other important water conveyance structures are the city-owned pipelines that deliver water from the treatment plants to residents' homes.

Issue Statement

Important conveyance structures pass through the Project Area, including EBMUD's Mokelumne Aqueduct and CCWD's Contra Costa Canal. Both of these conveyance structures are buried pipelines and could experience buoyancy problems due to rising groundwater and possible corrosion due to saline water intrusion into groundwater. Additionally, areas along or downstream of CCWD's Contra Costa Canal are susceptible to flooding if there was a levee failure.[cxlvii] CCWD supplies a large portion of the County with raw and treated water and the Mokelumne Canal is the sole water supply for 1.4 million people in the East Bay. Finally, for shoreline communities, city or privately-owned water supply pipelines that deliver water to residents' homes may be affected by pipe buoyancy or corrosion from rising, saline groundwater.

Asset Descriptions

California Aqueduct

The California Aqueduct is the major aqueduct to convey water for the California SWP managed by the California Department of Water Resources (DWR). It delivers water from the Sierras to southern California. The Aqueduct begins at Clifton Court Forebay, which continues south to the Banks Pumping Station (see Pumps, Diversions and Water Intakes section below), which pumps from the Clifton Court Forebay south into the Bethany Reservoir (outside the Project Area). In addition to serving the California Aqueduct for southern California, the Bethany Reservoir is a forebay for the South Bay Aqueduct (outside of Project Area) that conveys water to Alameda and Santa Clara Counties. From the Bethany Reservoir, the California Aqueduct flows by gravity further south and ends when it splits into three branches that continue further south into Santa Barbara, Los Angeles, and San Bernardino Counties. See Figure 12-4.

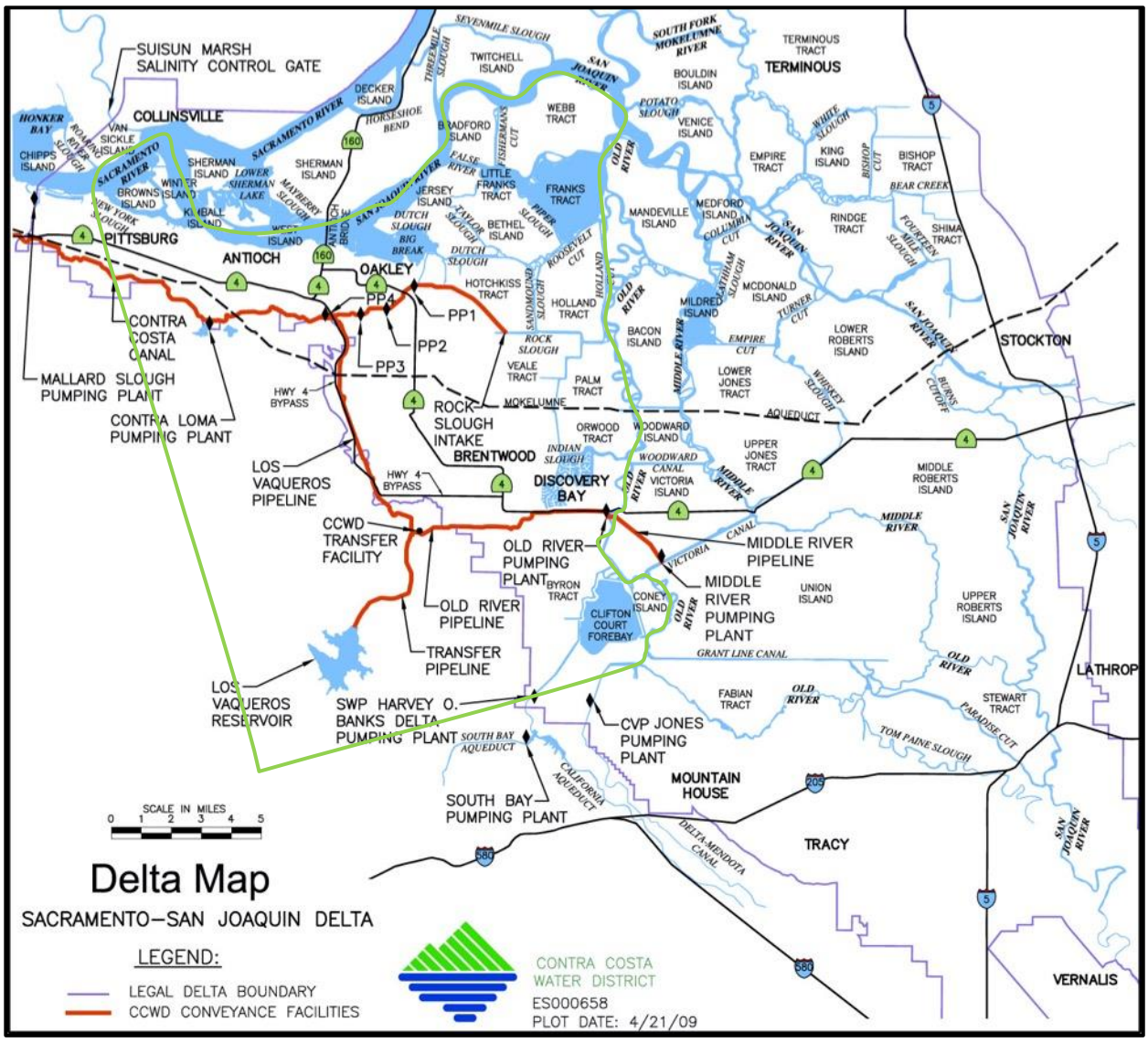

Figure 12-4.Water conveyance infrastructure within the Project Area, which is outlined in green. (Source: Contra Costa Water District)

Clifton Court Forebay

While not a conveyance channel, the Clifton Court Forebay is an important water conveyance related asset. It is an intake reservoir that stores water before entering the Delta-Mendota Canal for the CVP[cxlviii] and the California Aqueduct for the SWP. It also feeds the South Bay Aqueduct (outside the Project Area) off of the California Canal.

The integrity of the Clifton Court Forebay depends on the operation of a set of intake gates and outlet gates to control the forebay. The Clifton Court Forebay is built using levees (see Figure 12-5), which can also put the forebay at risk from liquefaction.

Figure 12-5. An aerial view of Clifton Court Forebay facing south. (Source: "Clifton Court Forebay" by Eric Allix Rogers is licensed under CC BY 2.0)

Contra Costa Canal

The Contra Costa Canal is a 48-mile facility and is CCWD's main conveyance facility (see Figure 12-6). It was completed in 1948 as part of USBR's CVP and is currently pending ownership transfer to CCWD (as of late 2019). The Contra Costa Canal, which conveys untreated water from Rock Slough, passes through many cities and communities before terminating at the Martinez Reservoir located in the City of Martinez (outside of the Project Area). The Canal also conveys water to an untreated water pipeline called the Shortcut Pipeline, which provides water service to several industrial customers and delivers water to Martinez Reservoir. The Contra Costa Canal has two distinguishable segments: 1) the Main Canal, which is a 26-mile stretch from the District's Rock Slough intake to Clyde and delivers 99% of the District's untreated water; and 2) the Loop Canal, a smaller, 22-mile section that carries water through Concord, Walnut Creek and Pleasant Hill before ending in Martinez. The Loop Canal (outside of the Project Area) provides redundancy to the CCWD Shortcut Pipeline and serves about 200 small water users.[cxlix]

CCWD has undergone maintenance and improvements to their assets.[cl] Of note is the Canal Replacement Project, which consists of encasing approximately four miles of the

Contra Costa Canal from the Rock Slough Intake to Pumping Plant No. 1 (see Figure 12-4). The purpose of this project is to improve source water quality at the Rock Slough Intake by hydraulically isolating the high saline groundwater from the Canal. The project will also increase public safety and flood control.[cli] Projects similar to this can be looked to as an example of how to protect freshwater conveyance and storage from rising saline groundwater due to sea level rise.

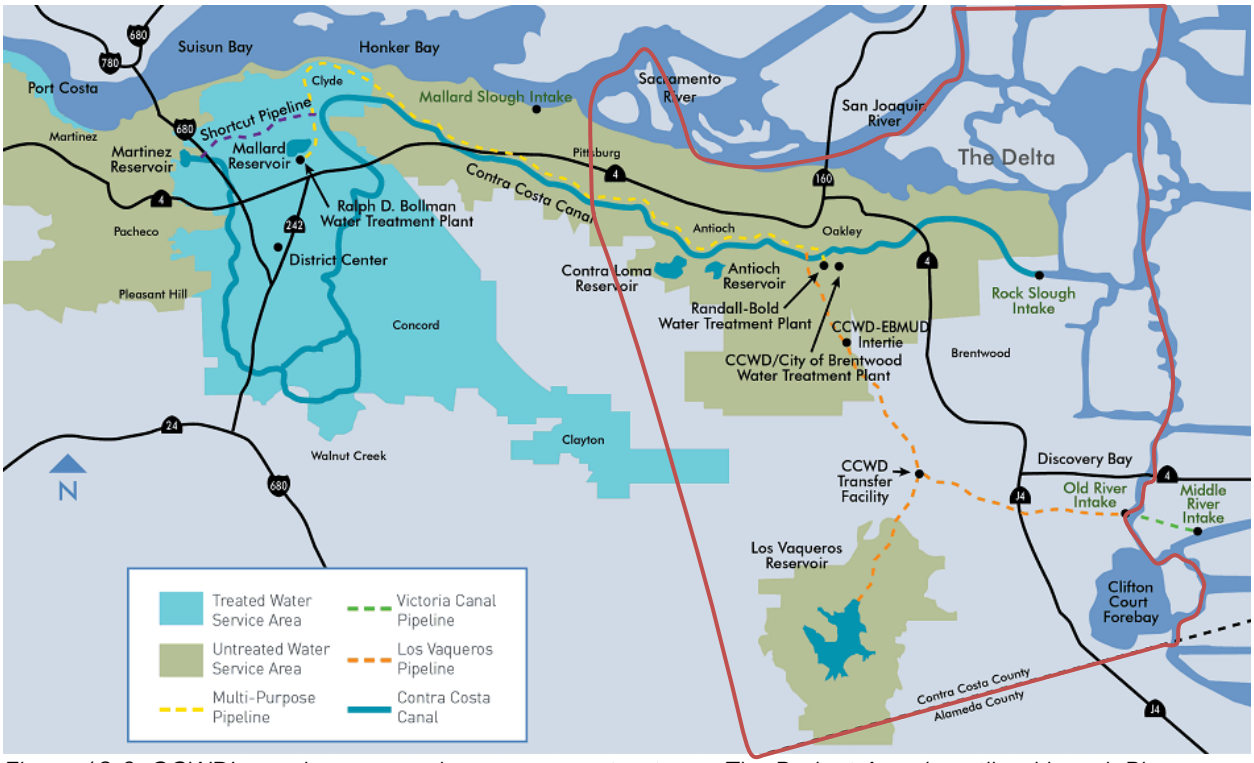

Figure 12-6. CCWD's service area and conveyance structures. The Project Area is outlined in red. Please note that Victoria Canal Pipeline is also called Middle River Pipeline and is outside the Project Area.

Delta-Mendota Canal

The Delta-Mendota Canal (see Figure 12-4) is a part of the CVP and managed by the USBR and the San Luis and Delta-Mendota Water Authority. Its purpose is to replace water in the San Joaquin River that is diverted into other canals and reservoirs, as well as to provide irrigation water to the San Joaquin Valley.[clii] It begins at the C.W. Bill Jones Pumping Plant (formerly the Tracy Pumping Plant), which pumps water from the Delta. It runs south, parallel to the California Aqueduct, and eventually empties into the San Joaquin River near the City of Mendota. The Delta Mendota Canal also depends secondarily on the outflows of the Clifton Court Forebay.

Los Vaqueros Pipeline

The Los Vaqueros Pipeline (see Figure 12-7) is part of CCWD's Los Vaqueros system and starts from the end of the Old River Pipeline and connects to the Contra Costa Canal, with an intertie to the Mokelumne Aqueduct. It has a capacity of 400 cfs.

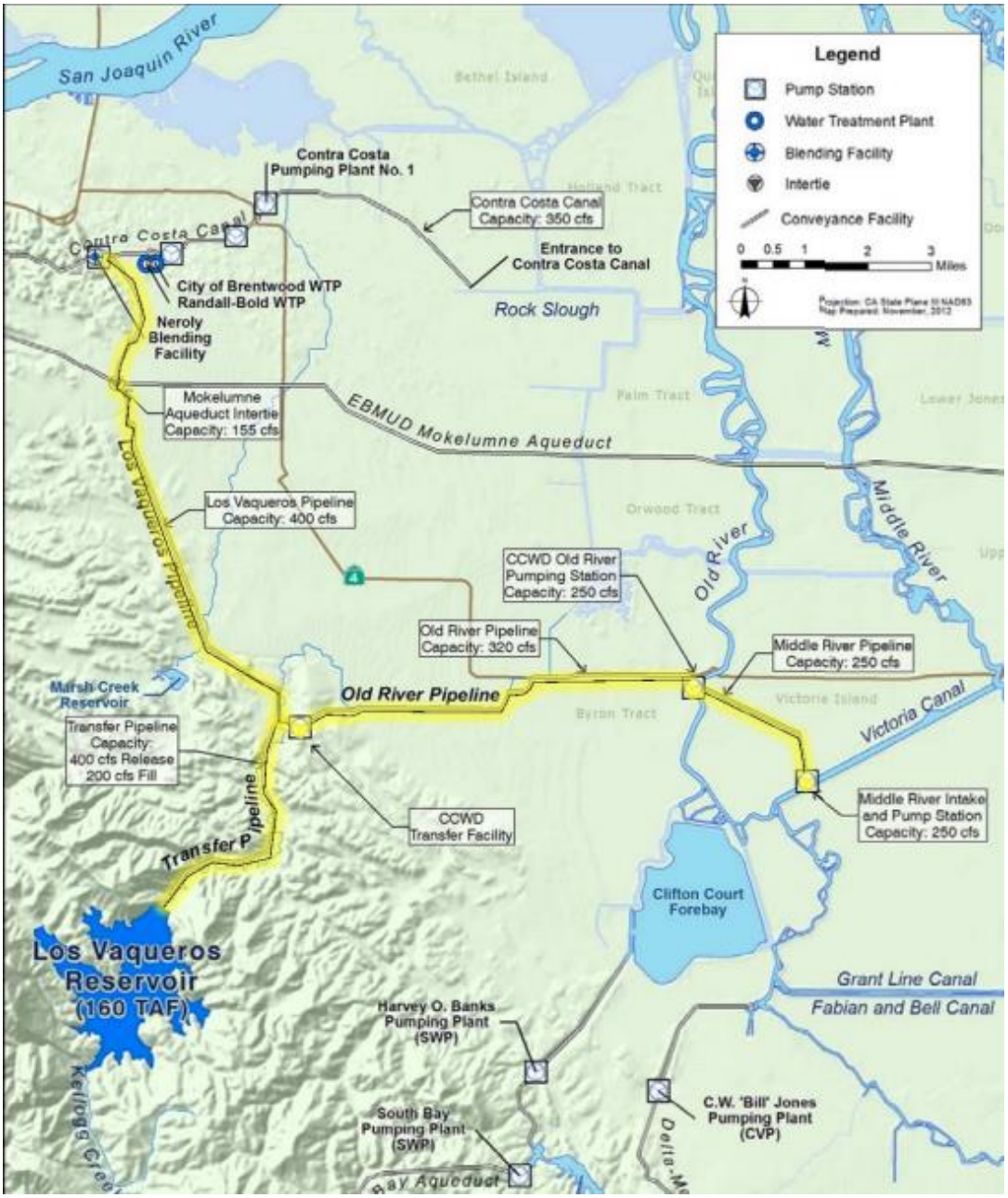

Figure 12-7. Water infrastructure within the Project Area. Highlighted in yellow is CCWD's pipelines. Of note is that Middle River Pipeline (also called Victoria Canal Pipeline) and Intake is outside of the Project Area. (Source: Contra Costa Water District)

Mokelumne Aqueduct

The East Bay Municipal Utility District (EBMUD) sources water from the Mokelumne River and the Pardee Reservoir for retail and wholesale in Contra Costa as well as other counties in the East Bay. The Mokelumne Aqueduct (see Figure 12-8) travels through the Project Area, although it does not directly supply water to users within the Project Area. EBMUD's Mokelumne Aqueduct is an 82-mile water conveyance system consisting of three separate buried steel pipelines, although there are also some aboveground segments conduits. It

starts at Pardee Reservoir, crosses the foothills and the Central Valley, goes across the Delta to Walnut Creek, and then sent to EBMUD's filtration plants or to a terminal reservoir.[cliii] The Mokelumne Aqueduct provides over 90% of the District's water. It is the sole water supply for 1.4 million people in the East Bay.

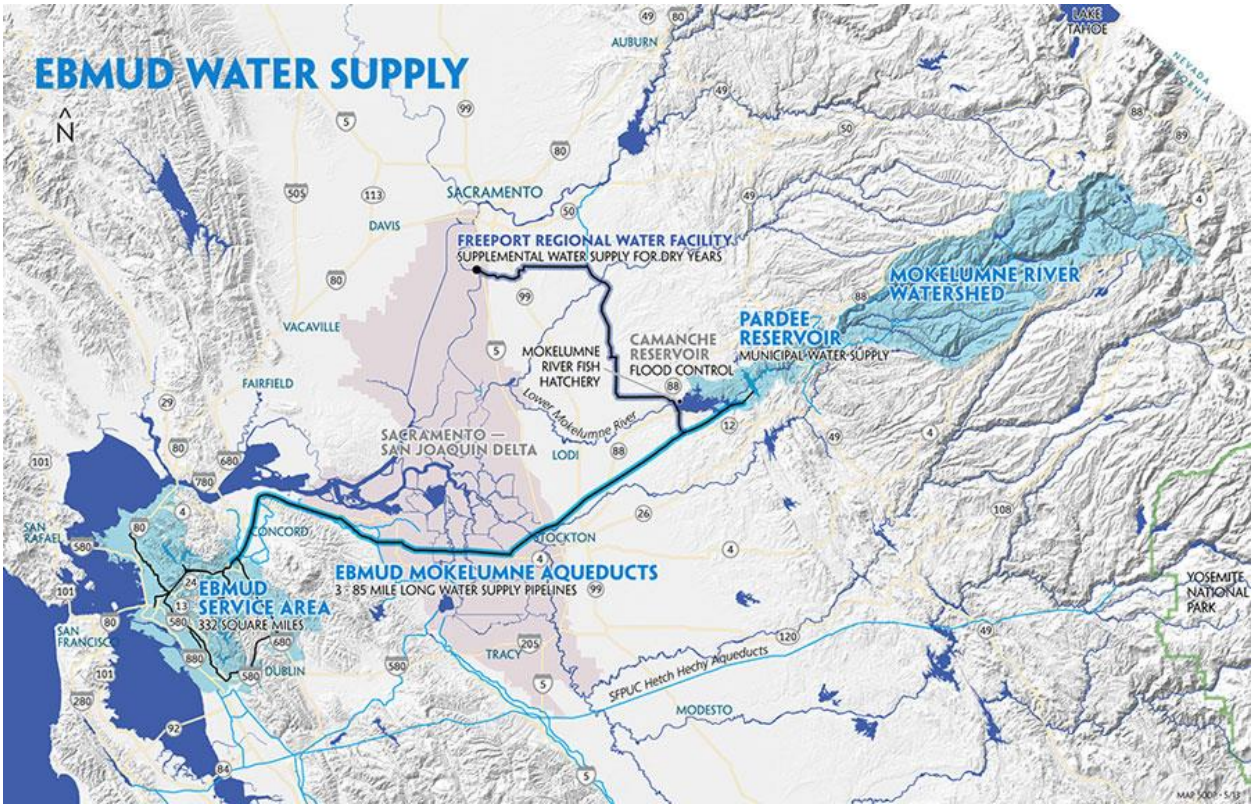

Figure 12-8. Mokelumne Aqueduct. (Source: Maven's Notebook, "Mokelumne Aqueduct.")

Old River Pipeline

The CCWD Old River Pipeline (see Figure 12-7) takes water from the Old River Pumping Plant west to the CCWD Transfer Facility. The pipeline has a 320 cfs capacity.

Transfer Pipeline

The CCWD Transfer Pipeline (see Figure 12-7) connects the Old River Pipeline from the CCWD Transfer Facility south to the Los Vaqueros Reservoir. It has a 200 cfs fill and 400 cfs release capacity.

Middle River Pipeline (Also Called Victoria Canal Pipeline)

Of note is that the Middle River Pipeline (see Figure 12-6), also called Victoria Canal Pipeline, is outside of the Project Area but is described here for context. CCWD has seasonal fluctuations in water quality in the Delta at the pumping station located on Old River. The Middle River provides fresh water during those months. The Middle River Intake (outside of Project Area), owned and operated by CCWD, is located on a levee at the south end of Victoria Island along the Victoria Canal in San Joaquin County. Water pumped at the

station is sent via the Middle River Pipeline northwest across the island where it connects to the Old River Pipeline. From there, the water can be pumped to Los Vaqueros Reservoir in Byron or conveyed via the Los Vaqueros Pipeline to the Contra Costa Canal and ultimately sent to a treatment facility.[cliv]

Exposure To Current And Future Flooding

Detailed exposure was analyzed for the Mokelumne Aqueduct, Contra Costa Canal, Victoria Canal, Los Vaqueros Pipeline, California Aqueduct and Delta Mendota Canal.

The most at-risk water conveyance structures are Mokelumne Canal, the Contra Costa Canal, and the Old River Pipeline. Almost three miles of the Mokelumne Canal could be inundated at 12" of SLR combined with a 100-year storm event, affecting EBMUD and those who purchase retail or wholesale water in Contra Costa, as well as other counties in the East Bay. The Mokelumne Canal serves millions of people in the East Bay and is a critical piece of water infrastructure in the Project Area. Additionally, areas along or downstream of the Contra Costa Canal are susceptible to flooding if there was a levee failure.[clv] At 24" SLR combined with the 100-year storm event, CCWD's Old River Pipeline has 2.5 miles exposed. CCWD supplies a large portion of the County with raw and treated water. Both of these conveyance structures are buried pipelines and could experience buoyancy problems due to rising groundwater and possible corrosion due to saline water intrusion into groundwater. The Contra Costa Canal has just under a quarter mile of canal that would be flooded during today's 100-year storm event. Since this canal is open-air, it is very vulnerable to flooding from surface waters.

Sea level rise can affect water conveyance through multiple ways. **Direct flooding of aqueducts or canals can affect water quality by contaminating the water supply with potentially saline Delta water. Underground pipelines that are submerged are at risk of buoyancy, which is when the pipe starts to float and can compromise the structural integrity.** For shoreline communities, the latter issue would affect city or privately-owned water supply pipelines that deliver water to residents' homes.

Other Risks

While many water agencies have seismically retrofitted their canals and pipelines, there is still risk of seismic liquefaction, which could damage water conveyance structures.

Data Considerations

Only those segments of water conveyance infrastructure located within the Project Area were analyzed. This means that in certain situations, only segments of conveyance infrastructure (such as the California Aqueduct or Mokelumne Aqueduct) were analyzed for exposure to flooding, even though the structure may start or continue outside the Project Area. Some conveyance structures not listed above may be missing from our data set.

Table 12-2. Total feet of conveyance structures that may be located in the current 100-year storm event area and/or exposed to future sea level rise or the combination of sea level rise with a 100-year storm event.

Conveyance Structure	Management	Current 100-year Storm Event*	12" + 100-yr	24" + 100-yr	36" + 100-yr	83" + 100-yr	MHHW Today	12"	24"	36"	83"
Mokelumne Aqueduct	EBMUD	14,742	14,781	14,787	14,802	17,127	--	357	1,260	1,299	14,868
Contra Costa Canal	CCWD	1,191	1,941	2,178	2,403	3,123	60	99	324	690	2,487
Los Vaqueros Pipeline	CCWD	--	--	--	--	--	--	--	--	--	--
Old River Pipeline	CCWD	--	--	13,611	13,623	16,662	--	--	--	--	13,626
Transfer Pipeline	CCWD	--	--	--	--	--	--	--	--	--	--
SWP California Aqueduct**	CA DWR	--	--	--	--	11,667	--	--	--	--	--
CVP Delta-Mendota Canal**	USBR	--	--	--	--	--	--	--	--	--	--
Total Feet of Canal Exposed		15,933	16,722	30,576	30,828	48,579	60	456	1,584	1,989	30,981

"--": Unexposed assets

MHHW: Mean Higher High Water refers to the average of today's daily highest tide and is used as the baseline for all flooding scenarios.

* Current 100-year Storm Event: The 100-year storm event reflected in these maps is not equivalent to the FEMA 100-year flood hazard zone.

** These canals continue south outside of the Project Area, so may experience more flooding than what is shown here.

Table 12-3. Conveyance structures that may be located in the current 100-year storm event area and/or exposed to future sea level rise or the combination of sea level rise and a 100-year storm event.

Conveyance Structure	Manage-ment	Current 100-year Storm Event*	12" + 100-yr	24" + 100-yr	36" + 100-yr	83" + 100-yr	MHHW Today	12"	24"	36"	83"
Clifton Court Forebay	**CA DWR**	**--**	**--**	**Potentially**	**Potentially**	**Yes**	**--**	**--**	**--**	**--**	**--**

"--": Unexposed assets

MHHW: Mean Higher High Water refers to the average of today's daily highest tide and is used as the baseline for all flooding scenarios.

* Current 100-year Storm Event: The 100-year storm event reflected in these maps is not equivalent to the FEMA 100-year flood hazard zone.

Vulnerabilities

GOV1: Local cities or smaller water agencies may not have the capital to improve affected conveyance structures.
PHYS1: The pipelines located on predominantly low soil strength bay muds may be subject to a high groundwater table because of their proximity to San Francisco Bay. Saturated soils are more likely to experience liquefaction, potentially damaging conveyance structures.
PHYS2: Rising groundwater with sea level rise will increase the potential that pipelines will float, making them susceptible to damage that will increase the need for maintenance, repair, and replacement.
FUNC1: The conveyance systems are part of a networked system and if key parts of the system are disrupted, the function of the other assets may be compromised. CCWD has built some redundancy in the system to address seismic hazard vulnerabilities, which could also help avoid service disruption during a flood event.

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 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: Some amount of CVP and SWP water diversions are designated for environmental flows to provide fisheries and wildlife enough water to survive. If disruption to these environmental flows happen, it could negatively affect the ecosystems in these areas. Additionally, if sea level rise causes more saline water to travel upstream, it could affect the Bay-Delta by changing from fresh to brackish water ecosystems.

Economy: If the ability to provide water is disrupted and emergency supplies are exhausted, the economic disruption would be significant throughout the County. The commercial customer users vary from laundries and linen supplies to restaurants and health care facilities, and from car washes to hotels and retail stores. There are also industrial users who rely on water for manufacturing.

Pumps, Diversions, and Water Intakes

This project analyzed four drinking water intakes and nine pumping facilities, all which help move water throughout the service areas. These facilities require electricity to operate and are integral to the proper functioning of potable water distribution systems. The pumping stations help water flow by gravity by raising the water up using electricity.

Issue Statement

Drinking water intakes and pump stations are affected by sea level rise. Water intakes are protected by levees, but sea level rise could cause increased hydrostatic pressure, leading to potential levee failure.
Flooding of these assets means that if roads are flooded, this could block access to the facility. It also means any electrical equipment may become unusable due to water damage. Failure of these pumping facilities would mean a failure of the water system on a whole, with impacts to the economy and wellbeing of people.

Asset Descriptions- Water Intakes

Middle River Intake (Also Called Victoria Canal Intake)

The Middle River Intake (see Figures 12-6 and 12-7) is outside of the Project Area but is included here for context. The intake takes water from the Victoria Canal and pumps it west through the Middle River Pipeline (outside of Project Area) to the CCWD Old River Pumping Station. The station, owned and operated by CCWD, is located on a levee at the south end of Victoria Island along the Victoria Canal in San Joaquin County. CCWD has seasonal fluctuations and deteriorating water quality in the Delta at the pumping station located on Old River. The water quality declines in late summer and early fall, when saltwater from the Bay enters the Delta.

Rock Slough Intake

This intake is located at the beginning of Contra Costa Canal and is a CCWD asset. The intake is located on the southwestern portion of Holland Tract. See Figure 12-6.

Old River Intake

This intake is located on the Old River at the beginning of Old River Pipeline (see Figure 6 and 7). Water quality here fluctuates depending on the season.

The City Of Antioch Drinking Water Intake

The City of Antioch Water drinking water intake is in the San Joaquin River and is located near the Fulton Shipyard. Water quality fluctuates depending on the season.

Pittsburg Plant Water Intake

This PG&E asset, The Pittsburg Plant, intakes water from the San Joaquin River and is located near Koch Carbon Inc. in Pittsburg.

Asset Descriptions- Pumps

CCWD Pumping Plant #1, #2, #3, And #4

From the Rock Slough Intake, water is lifted via four pumping plants into the beginning of the Contra Costa Canal. The four pumping plants are located along the Canal in Oakley and lift the water from sea level to 124-feet to enable gravity flow for the remainder of the canal. Pumping Plant #1 is located in Oakley on the Contra Costa Canal near the

Ironhouse Sanitary District. Pumping Plant #2 is located about 4,000 feet further downstream near O'Hara Park Middle School. Pumping Plant #3 is located an additional 6,000 feet downstream. Pumping Plant #4 is located Brentwood near the Randall-Bold Water Treatment Plant, an additional 6,000 feet downstream. See Figure 12-7.

CCWD Transfer Pump Station

This pump station is located on the start of Los Vaqueros Pipeline in Brentwood about halfway between Los Vaqueros Reservoir and the Old River Pumping Facility. See Figure 12-7.

CCWD Old River Pumping Plant

This CCWD asset is located on Old River at the start of Old River Pipeline and is the pumping facility for the Old River water intake. See Figure 12-7. CCWD has seasonal fluctuations and deteriorating water quality in the Delta at the pumping station located on Old River. The water quality declines in late summer and early fall, when saltwater from the Bay enters the Delta.

CCWD Middle River Intake And Pump Station (Also Called Victoria Canal Pumping Plant)

The Middle River Intake (see Figure 12-6 and 12-7), also called Victoria Canal Intake, is outside of the Project Area but described here for context. The station, owned and operated by CCWD, is located on a levee at the south end of Victoria Island along the Victoria Canal in San Joaquin County. CCWD has seasonal fluctuations and deteriorating water quality in the Delta at the pumping station located on Old River. The water quality declines in late summer and early fall, when saltwater from the Bay enters the Delta. The Middle River (or Victoria Canal) Pumping Plant, which started operation in 2010, connects to Victoria Canal to provide fresh water during those months. It operates at 250 cfs.

Bixler Pumping Plant

This EBMUD asset is located in Bixler on the Mokelumne Aqueduct and allows water to continue flowing west.

Harvey O. Banks Pumping Plant

This DWR asset is located on the southern boundary of our Project Area. It is 2.5 miles southwest of the Clifton Court Forebay and is the first pumping plant for the California Aqueduct and the South Bay Aqueduct. It provides water for the SWP and allows the water to flow southwards for 80 miles. It pumps water to 19 million residents and 750,000 acres of farmland.[clvi] The plant initially flows into the Bethany Reservoir, outside of the Project Area. See Figure 12-7.

The Banks Plant running depends on the integrity of the Clifton Court Forebay (see Figure 12-5) and the operation of a set of gates intake and outlet gates to control the forebay. The Clifton Court Forebay is built using levees, which can also put the forebay at risk from liquefaction.

CA Aqueduct Intake Gates

This DWR asset is located at the outlet of the Clifton Court Forebay. The California Aqueduct intake gates at the southwest corner of the Forebay control water entering the California Aqueduct.

Exposure To Current And Future Flooding

Detailed exposure was analyzed for various water intakes and pumps within the Project Area. For pumps and diversions, out of the nine pump facilities and four drinking water intakes analyzed, one pump station and two drinking water intakes are affected by the current 100-year storm event.

In the Project Area, CCWD water supply assets that could be impacted by flooding are the Old River intake at 83" SLR combined with the 100-year storm event. The Old River and Middle River Pumping Plants, both intakes for the Los Vaqueros Reservoir and the Contra Costa Canal, are protected by levees. Localized flooding has been experienced at District facilities in the past. Levees are at risk from liquefaction and could potentially experience increased hydrostatic pressure.

Flooding of these assets means that if roads are flooded, this could block access to the facility. It also means any electrical equipment may become dysfunctional due to water or saline damage. Failure of these pumping facilities would mean a failure of the water system as a whole.

Additionally, the Clifton Court Forebay is built using levees, which can put the forebay at risk from liquefaction. This forebay provides water for the South Bay, CVP and SWP.

Data Considerations

This project utilized automated data analysis, noting where flood waters intersected with the assets of concern. However, for some assets this automated analysis did not show flood exposure, but upon visual inspection, we believe the facilities may be affected at 83" SLR, which is noted in Table 12-4. Some of this is because the water intake is located in the water and outside the project boundary. Additionally, many cities operate numerous pumping facilities along their conveyance structures, and the only ones analyzed are delineated in this section.

Table 12-4. Pumping facilities that may be located in the current 100-year storm event area and/or exposed to future sea level rise or the combination of sea level rise and a 100-year storm event.

Pumping Facilities	Management	Current 100-year Storm Event*	12" + 100-yr	24" + 100-yr	36" + 100-yr	83" + 100-yr	MHHW Today	12"	24"	36"	83"
Transfer Pump Station	CCWD	--	--	--	--	--	--	--	--	--	--
Old River Pumping Facility	CCWD	Yes	Yes	Yes	Yes	Yes	--	--	--	--	Yes
State of CA Aqueduct Intake Gates (pumping)	DWR	--	--	--	--	Yes	--	--	--	--	--
Pumping Plant #1	CCWD	--	--	--	--	Yes	--	--	--	--	--
Pumping Plant #2	CCWD	--	--	--	--	--	--	--	--	--	--
Pumping Plant #3	CCWD	--	--	--	--	--	--	--	--	--	--
Pumping Plant #4	CCWD	--	--	--	--	--	--	--	--	--	--
Bixler Pumping Plant	EBMUD	--	--	--	--	--	--	--	--	--	Yes**
Harvey O. Banks Pumping Plant	EBMUD	--	--	--	--	--	--	--	--	--	Yes**
Total Sites Exposed		1	1	1	1	3	0	0	0	0	3

"--": Unexposed assets

MHHW: Mean Higher High Water refers to the average of today's daily highest tide and is used as the baseline for all flooding scenarios.

* Current 100-year Storm Event: The 100-year storm event reflected in these maps is not equivalent to the FEMA 100-year flood hazard zone.

** Automated data analysis did not show flood exposure, but upon visual inspection, we believe the facilities may be affected at this water level.

Table 12-5. Number of drinking water intakes that may be located in the current 100-year storm event area and/or exposed to future sea level rise or the combination of sea level rise and a 100-year storm event.

Water Intake	Management	Current 100-year Storm Event*	12" + 100-yr	24" + 100-yr	36" + 100-yr	83" + 100-yr	MHHW Today	12"	24"	36"	83"
Antioch Intake	City of Antioch	--	--	Yes**	Yes**	Yes**	--	--	--	--	Yes**
CCWD- Old River Intake***	CCWD	--	--	--	--	Yes	--	--	--	--	--***
CCWD- Rock Slough Intake	CCWD	Yes**	Yes**	Yes**	Yes**	Yes**	--	--	--	--	Yes**
Pittsburg Plant	PG&E	Yes**	Yes**	Yes**	Yes**	Yes**	Yes**	Yes**	Yes**	Yes**	Yes**
Total Sites Exposed		2	2	3	3	4	1	1	1	1	3

"--": Unexposed assets

MHHW: Mean Higher High Water refers to the average of today's daily highest tide and is used as the baseline for all flooding scenarios.

* Current 100-year Storm Event: The 100-year storm event reflected in these maps is not equivalent of to the FEMA 100-year flood hazard zone.

** Automated data analysis did not show flood exposure, but upon visual inspection, we believe the facilities may be affected at this water level.

*** Old River Intake is protected by a levee. If this levee failed the facility could be inundated

Vulnerabilities

FUNC1: The intakes and pumps are part of a networked system and if key parts of the system are disrupted, the function of the other assets may be compromised.
FUNC2: Power is necessary to run the pumps and intakes. If flooding impacts power supplies, the ability to provide water to its customers may be constrained.
FUNC3: Road access is necessary to ensure workers can reach pumps and intakes for maintenance and repair.
FUNC4: If intakes and pumps are disrupted and the emergency water supply exhausted, it would disrupt any systems or users dependent on Delta water.
PHYS1: Some pumping plants are protected by levees, which may be subject to seismic failure or failure due to additional stress from rising sea levels.
PHYS2: Saline water may corrode or destroy mechanical or electrical pumping equipment.

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 would impact all customers, especially sensitive members of the community, such as the elderly or young children, who are more vulnerable to health effects due to contaminants in drinking water.

Environment: Some USBR and California water diversions are designated for environmental flows. If disruption to these flows happen, it could negatively affect the ecosystems in these areas. Additionally, if sea level rise causes more saline water to travel upstream, it could affect the Bay-Delta by changing from fresh to brackish water ecosystems.

Economy: Water from the Project Area is essential to industry, agriculture, and commercial and residential buildings. These businesses and industries provide a significant source of jobs and revenue to Contra Costa County and the State of California. If the ability to provide water is disrupted and emergency supplies are exhausted, the economic disruption would be significant throughout the County. The commercial customer users vary from laundries and linen supplies to restaurants and health care facilities, and from car washes to hotels and retail stores.

Groundwater and Wells

Most cities and towns within the Project Area have groundwater wells as either their main source of water supply, or to supplement their water supply.

Only a couple years ago wells were virtually unregulated in California. However, today, the Sustainable Groundwater Management Act, or SGMA, which was adopted in 2014, requires critically overdrafted groundwater basins to adopt plans for wells to be sustainably managed by 2040. Medium and high priority basins have an additional two years to comply. Groundwater Sustainability Agencies, or GSAs, were to be formed to sustainably manage these basins. Within the Project Area, there is the East Contra Costa Subbasin, also called the San Joaquin Valley Basin, which is a Medium priority groundwater basin.[clvii] There are multiple GSAs within the San Joaquin Valley Basin, which can be seen in Figure 12-9 below. Those GSAs include Contra Costa County GSA, Discovery Bay Community Services District GSA, Diablo Water District GSA, City of Antioch GSA, City of Brentwood GSA, East Contra Costa Irrigation District (ECCID) GSA, and Byron-Bethany Irrigation District (BBID) GSA.

Also within the Project Area is the Pittsburg Plain Basin, managed by the City of Pittsburg. However, this groundwater basin has very low priority, meaning it is not being critically overdrafted.

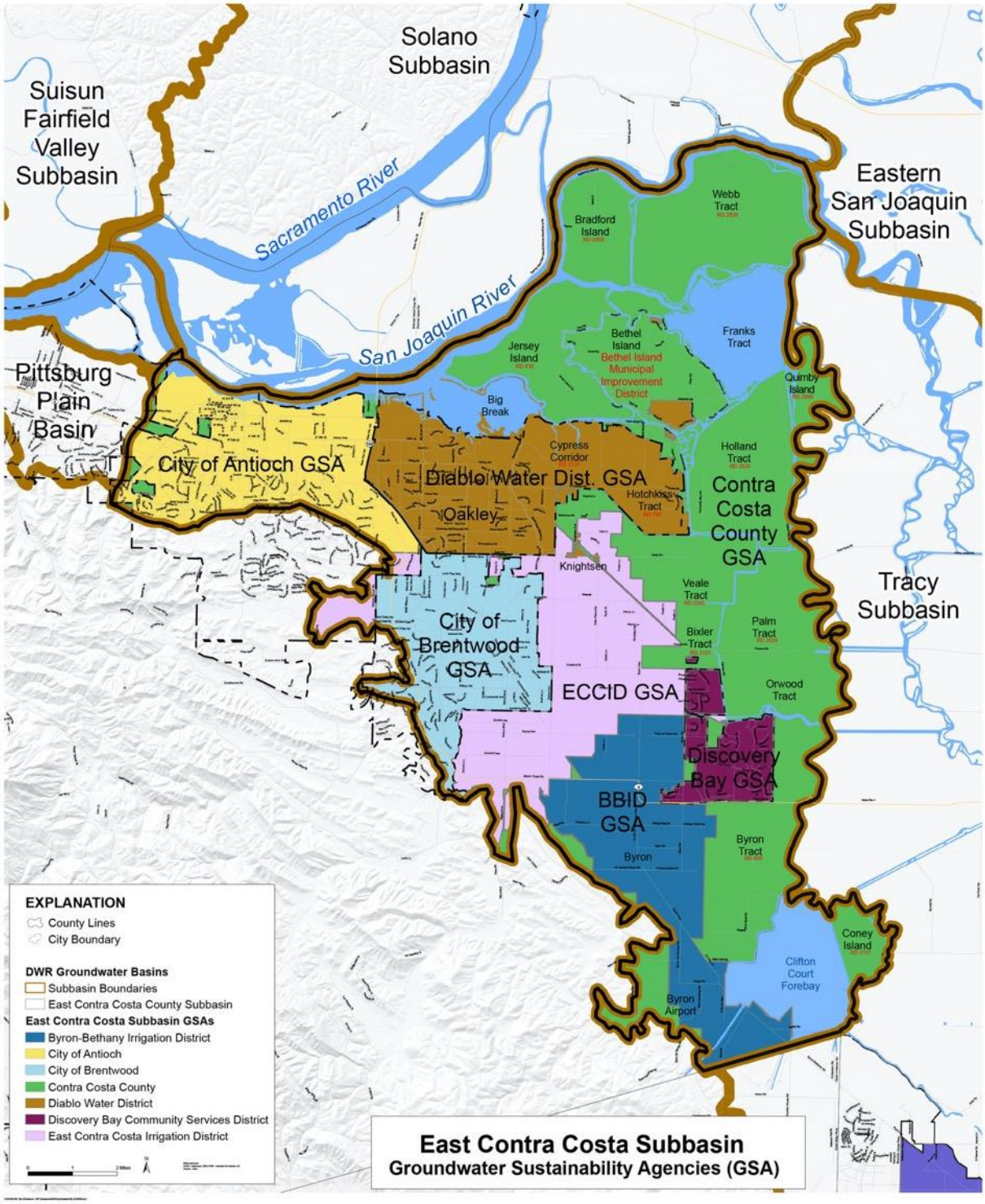

Figure 12-9. East Contra Costa Subbasin, or San Joaquin Valley Basin, is a medium priority groundwater basin regulated by the following Groundwater Sustainability Agencies. (Source: East Contra Costa County Integrated Regional Water Management)

Issue Statement

As sea level rises, groundwater can become more saline both because seawater would rise further up into the Delta and groundwater levels would rise, pushing saline groundwater further upwards, decreasing water quality. Wells could be impacted by direct overland flooding and by saline intrusion into groundwater supplies, which could possibly ruin electrical or pumping equipment.

Asset Descriptions

Discovery Bay gets most of its water from six wells. Delta Water District operates two groundwater wells in the San Joaquin Valley Groundwater Basin, the Glen Park well and Stonecreek well. The City of Brentwood also gets their main source of water from the San Joaquin Groundwater Basin. Brentwood has nine groundwater wells that supply a base amount of water of for the city. Finally, some mutual water companies also use groundwater wells.

Exposure To Current And Future Flooding

No data for the Project Area was available, so the following analysis is only qualitative. Groundwater wells could be impacted by sea level rise and storm events in two ways: by direct overland flooding and by saline intrusion into groundwater supplies.

Direct overland flooding, either by levee breaches or from runoff from large storm events, could affect wellheads, pumps, and any electrical equipment. If the levee is breached, the water may be saline, which could corrode equipment, possibly destroying it. Levee breaches could also corrode water supply pipelines or cause them to become buoyant, possibly breaking them. Runoff from storms could also flood pumping or electrical equipment, possibly requiring replacement.

If groundwater supplies encounter saline groundwater, well equipment and pipelines could be corroded from the saltwater. Saline groundwater could also impact well users by degrading the water quality, requiring new sources of water or desalination plants, which could be expensive.

Data Considerations

No data for the Project Area was available, so analysis is only qualitative.

Vulnerabilities

GOV1: Wells have not been well regulated in the past, so for planning purposes, there is not a comprehensive understanding of who uses groundwater and when.
GOV2: Groundwater Sustainability Agencies are new, and it is unclear how these agencies will regulate wells, function as an agency, and enforce its Groundwater Sustainability Plans.

GOV3: Some well users are likely not well funded, so it would be difficult to construct improvements for wells to be resilient to sea level rise and salinity or fund construction of alternative water supplies.
INFO1: It is uncertain how saline intrusion from the Bay will occur during sea level rise and affect groundwater supplies.
FUNC1: Disruption to the water supply could have effects on the livelihoods, economy, tourism and livability of the region.
FUNC2: At-risk members of the community, the elderly, young children, people with disabilities, etc. would be particularly vulnerable without replacement water supplies in the event of disruption.
PHYS1: Saline groundwater or flooding could corrode wells, wellheads and equipment.
PHYS2: Flooding of Delta islands would likely ruin electrical or mechanical equipment, requiring replacement.
PHYS3: Some well users, especially in agricultural areas are likely physically isolated from municipal infrastructure and might not have easily accessible backup supplies.

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 would impact all users, and in particular members of the community such as the elderly or young children who are particularly in need of safe drinking water. Those who live in rural areas normally do not have access to alternative supplies of water. If desalination is required, the cost of construction and operation could be prohibitively expensive for lower-income residents.

Environment: The use of wells could exacerbate salinity intrusion in groundwater by using up freshwater supplies and bringing up surrounding saline water, ruining groundwater supplies. This could also have impacts on surrounding habitats by changing the salinity levels, and thereby the speciation of the area.

Economy: Water from the Project Area is essential to industry, agriculture, and commercial and residential buildings. These businesses and industries provide a significant source of jobs and revenue to Contra Costa County and the State of California. If the ability to provide water is disrupted and emergency supplies are exhausted, the economic disruption would be significant throughout the County. The commercial customer users vary from laundries and linen supplies to restaurants and health care facilities, and from car washes to hotels and retail stores. If saline groundwater or surface water supplies are the only water supply available, desalination plants or alternative sources of water would be needed, which could be prohibitively expensive.

Mutual Water Companies

California's mutual water companies (MWCs) are private, not-for-profit organizations that provide water service in rural areas that have no substitute water supplies. They also

operate in urban pockets where property owners hold shares in their mutual water company. Some MWCs are owned by a collective of cities who share the maintenance costs, while others serve neighborhoods supplemented by imported water from regional public water suppliers. These small systems – some private and some shared wells – provide water service in lieu of a public agency or Public Utilities Commission regulated utility. According to the California Association of Mutual Water Companies:

> Mutual water companies are organized under California Corporations Code 14300, regulated under the US EPA Safe Drinking Water Act, report to Local Agency Formation Commissions (LAFCOs) which exist in each California county as independent public agencies, and operate under a myriad of local/statewide/federal rules and regulations. Mutual water companies are regulated by California's Water Code, Health and Safety Code and must abide by open meeting and records disclosure laws similar to many public water utilities. In operating a public water system, mutual water companies are also subject to regulation by the California Department of Public Health and must comply with requirements imposed by the State Water Resources Control Board and our local Regional Water Quality Control Board.[clviii]

Assembly Bill 54, enacted in 2012, has imposed new requirements on LAFCOs and mutual water companies that own and operate public water systems. The requirements are intended to improve access to information about the location of mutual water companies and the quality of water they provide. Contra Costa LAFCO has identified 28 mutual water companies that meet the requirements for reporting to LAFCO certain information regarding their service area, including maps, infrastructure, water quality and rate information.

Table 12-6 identifies the 28 mutual water companies Contra Costa LAFCO has identified as meeting the AB 54 threshold. As noted in the table, several mutual water companies did not report or respond to multiple requests for information regarding their facilities and operations, which places them in non-compliance with AB 54.[clix]

Issue Statement

Many mutual water companies use groundwater pumped from wells or surface water from the Delta. With sea level rise, the tidal saline influence may rise further up into the Delta, impacting the water quality of surface and groundwater. This would impact the water supply of many small communities within the Delta.

Asset Descriptions

Mutual Water Companies

Within the County there are a number of mutual water companies. Most of the mutual water companies in the Project Area serve a population of a couple hundred people, totaling about 4,000 people served in total within the Project Area. While 28 MWCs were listed by the Contra Costa LAFCO (see Table 12-7), our data set only included GIS locations for the 21 MWCs that are located within the Project Area boundary.

Ten of the 21 East Contra Costa mutual water companies are located on Bethel Island, four are located across Dutch Slough in Oakley, and the rest are scattered throughout the County. These facilities are privately owned, are providing water service to the County's residents from surface and groundwater resources and are impacted by the same concerns for supply reliability, water quality, and costs as the public sector providers.

The assets analyzed include the area the MWC operates in and does not include any physical equipment or assets the MWC owns or operates. If exposed, flooding could possibly effect the MWC's assets, but further refinement of the analysis would be necessary to determine whether specific equipment was effected.

Exposure To Current And Future Flooding

As described in "Data Constraints" below, **when the mutual water companies are fully inundated, it also means that the levees are breached and Delta islands are inundated. What is important to consider is that these mutual water companies located on the shoreline may be affected at earlier water levels than depicted depending on when tidal saline water from the Bay starts to degrade water quality.** This may be earlier than those water levels depicted below. Another important factor to consider is at what water level the levees become structurally unsound.

Mutual water companies on Bethel Island and the opposing coast of Oakley on Sandmound Slough may experience inundation from a current 100-year storm event. All of the mutual water companies on Bethel Island and the Orwood Resort MWC in Brentwood are affected at the same water levels, which begin at 83" sea level rise or the current 100-year storm event. All the mutual water companies in Oakley are exposed during future sea level rise paired with 100-year storm events and at 83" sea level rise.

Data Considerations

The only available data for mutual water companies was the area delineating their service area. Analysis did not include locations of equipment, pipelines, or intakes.

Many mutual water companies are exposed at current MHHW (high tide) due to a sliver of the mutual water companies' area overlapping with the current shoreline. However, this does not necessarily mean that these mutual water companies are currently at risk. Given this, only those mutual water companies that were fully inundated (the shape was 100% flooded, rather than just a sliver) were considered affected and fully inundated.

Finally, while 28 MWCs were listed in by the Contra Costa LAFCO (Table 12-7), our data set only included GIS locations for the 21 MWCs that are located within the Project Area boundary.

Table 12-6. Mutual water company assets that may be located in the current 100-year storm event area and/or exposed to future sea level rise or by the combination of sea level rise and a 100-year storm event.

Mutual Water Company	Location	Current 100-year Storm Event*	12" + 100-yr	24" + 100-yr	36" + 100-yr	83" + 100-yr	MHHW Today	12"	24"	36"	83"
Angler's Subdivision #4	Bethel Island	Yes	Yes	Yes	Yes	Yes	--	--	--	--	Yes
Angler's Ranch Subdivision WC	Bethel Island	Yes	Yes	Yes	Yes	Yes	--	--	--	--	Yes
Bethel Island MWC	Bethel Island	Yes	Yes	Yes	Yes	Yes	--	--	--	--	Yes
Russo's Mobile Park	Bethel Island	Yes	Yes	Yes	Yes	Yes	--	--	--	--	Yes
Sandmound MWC	Bethel Island	Yes	Yes	Yes	Yes	Yes	--	--	--	--	Yes
Flamingo Mobile Manor	Bethel Island	Yes	Yes	Yes	Yes	Yes	--	--	--	--	Yes
Farrar Park Property	Bethel Island	Yes	Yes	Yes	Yes	Yes	--	--	--	--	Yes
Frank's Marina	Bethel Island	Yes	Yes	Yes	Yes	Yes	--	--	--	--	Yes
Pleasantimes MWC	Bethel Island	Yes	Yes	Yes	Yes	Yes	--	--	--	--	Yes
Riverview Water Association	Bethel Island	Yes	Yes	Yes	Yes	Yes	--	--	--	--	Yes
Casa Medanos Water System	Antioch	--	--	--	--	--	--	--	--	--	--
Camino Mobilehome	Byron	--	--	--	--	--	--	--	--	--	--
Doubletree Ranch Water System	Livermore	--	--	--	--	--	--	--	--	--	

Mutual Water Company	Location	Current 100-year Storm Event*	12" + 100-yr	24" + 100-yr	36" + 100-yr	83" + 100-yr	MHHW Today	12"	24"	36"	83"
Delta MWC	Oakley	--	Yes	Yes	Yes	Yes	--	--	--	--	Yes
Sandy Point Mobile	Oakley	--	Yes	Yes	Yes	Yes	--	--	--	--	Yes
Marina Mobile Manor	Oakley	--	Yes	Yes	Yes	Yes	--	--	--	--	Yes
Oakley Mutual Water	Oakley	--	Yes	Yes	Yes	Yes	--	--	--	--	Yes
Orwood Resort MWC	Brentwood	Yes	Yes	Yes	Yes	Yes	--	--	--	--	Yes
Villa de Guadalupe SWS	Brentwood	--	--	--	--	--	--	--	--	--	--
Clayton Regency LLC	Brentwood	--	--	--	--	--	--	--	--	--	--
Colonia Santa Maria	Brentwood	--	--	--	--	--	--	--	--	--	--
Total in Project Area	**21**	**11**	**15**	**15**	**15**	**15**	**0**	**0**	**0**	**0**	**15**

"--": Unexposed assets

MHHW: Mean Higher High Water refers to the average of today's daily highest tide and is used as the baseline for all flooding scenarios.

* Current 100-year Storm Event: The 100-year storm event reflected in these maps is not equivalent of to the FEMA 100-year flood hazard zone.

Vulnerabilities

INFO1: It is not well understood how these various mutual water companies fare under various seismic or drought conditions.
INFO2: It is unclear how rising groundwater will affect these various mutual water companies. 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. Rising groundwater could also lead to saline intrusion to wells, which is the major water source for these mutual water companies.
INFO3: Some mutual water companies do not comply with AB 54 reporting requirements.
FUNC1: These assets are part of networked systems, and disruption to the water supply could have effects on the livelihoods, economy, tourism and livability of the region.
FUNC2: Mutual water companies may depend on chemicals for water treatment and road access to maintain their assets and ensure workers can reach their facilities. If flooding impacts roads and highway system that provide access to and from these facilities, the ability to provide water to their customers may be constrained.
FUNC3: Mutual water companies may depend on power to run their facilities. If flooding impacts power supplies, the ability to provide water to their customers may be constrained.
FUNC4: Disruption of water would halt emergency response, including hospitals and fire protection.
FUNC5: At-risk members of the community, the elderly, young children, people with disabilities, etc. would be particularly vulnerable without replacement water supplies in the event of disruption.
FUNC6: Residents on Bethel Island are particularly vulnerable due to their physical isolation from lack of redundancy to access the island.
PHYS1: Flooding could destroy electrical equipment such as wellheads.

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 would impact 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: None

Economy: Development, tourism, livelihoods, restaurants, businesses and industries will all suffer if there is disruption to the water supply.

Table 12-7. Mutual Water Companies' public reporting to comply with AB 54. (Source: Contra Costa LAFCO)

Mutual Water Company	Site Address	Address Location	Year Formed	Population Served	Service Connections	Fees	Infrastructure
ANGLER'S RANCH #3 - SWS	2118 TAYLOR RD	BETHEL ISLAND	1946	100	42	$21-$40/Mo	1/2 mi pipeline
ANGLER'S SUBDIVISION #4	1850 TAYLOR RD	BETHEL ISLAND	1948	168	104	$21-$40/Mo	6,000 ft of pipeline
BELLA VISTA WATER SYSTEM	1570 WILLOW PASS RD	PITTSBURG	Not Provided	93	33	Not Provided	Not Provided
BETHEL ISLAND MUTUAL WATER CO	3100 STONE RD	BETHEL ISLAND	1937	56	38	$21-$40/Mo	1 mi pipeline
CAMINO MOBILEHOME	14530 BYRON HWY	BYRON	Not Provided	210	75	Not Provided	Not Provided
CASA MEDANOS WATER SYSTEM	2727 PITTSBURG ANTIOCH HWY	PITTSBURG	1940s	55	17	$20/Mo	1 mi pipeline, pump/purification system
CLAYTON REGENCY WATER SYSTEM	16711 MARSH CREEK RD	CLAYTON	Not Provided	287	119	Not Provided	Not Provided
COLONIA SANTA MARIA	3700 CONCORD AVE	BRENTWOOD	Not Provided	50	8	Not Provided	Not Provided
DELTA MUTUAL WATER COMPANY	5305 SANDMOUND BLVD	BETHEL ISLAND	1949	180	116	$21-$40/Mo	1 mi pipeline
DOUBLETREE RANCH WATER SYSTEM	MORGAN TERRITORY RD	UNKNOWN	1975	49	20	$81-$100/Mo	2 mi pipeline/arsenic removal system
DUTCH SLOUGH WATER WORKS	2368 DUTCH SLOUGH RD	BETHEL ISLAND	Not Provided	49	18	Not Provided	Not Provided
FARRAR PARK WATER SYSTEM	2566 TAYLOR RD	BETHEL ISLAND	1947	140	73	$20/Mo	1 mi pipeline
FLAMINGO MOBILE MANOR SWS	4400 GATEWAY RD	BETHEL ISLAND	1976	200	62	$20/Mo	1 mi pipeline
FRANK'S MARINA	7050 RIVERVIEW DR	BETHEL ISLAND	1972	290	64	$20/Mo	1 mi pipeline
HERTZ WATER SYSTEM	83 SOLANO AVE	PITTSBURG	Not Provided	35	16	Not Provided	Not Provided
MARINA MOBILE MANOR SWS	3255 WELLS RD	BETHEL ISLAND	Not Provided	75	24	Not Provided	Not Provided
MC COSKER RANCH SWS	MC COSKER RANCH RD	CANYON	Not Provided	90	22	Not Provided	Not Provided
MORAGA HEIGHTS MUTUAL WATER	PINEHURST RD	CANYON	1929	60	20	$81-$100/Mo	water purification/storage systems
OAKLEY MUTUAL WATER COMPANY	4508 SANDMOUND BLVD	OAKLEY	1963	170	54	$20/Mo	.6 mi pipeline
ORWOOD RESORT	4451 ORWOOD RD	BRENTWOOD	Unknown	350	15	$20/Mo	waste treatment plant
PLEASANTIMES MUTUAL WATER CO	GATEWAY RD	BETHEL ISLAND	1983	380	190	$21-$40/Mo	3 mi pipeline/3 wells
RIVERVIEW MOBILE HOMES	1526 WILLOW PASS RD	PITTSBURG	1985	216	46	No Charge	2,000 ft pipeline, liquid chlorination unit
RIVERVIEW WATER ASSOCIATION	3753 WILLOW RD	BETHEL ISLAND	1948	230	89	$20/Mo	1 mi pipeline
RUSSO'S MOBILE PARK	3995 WILLOW RD	BETHEL ISLAND	Not Provided	110	35	Not Provided	Not Provided
SANDMOUND MUTUAL	3330 STONE RD	BETHEL ISLAND	1947	160	107	$21-$40/Mo	2 mi pipeline
SANDY POINT MOBILE HOME PARK	5625 SANDMOUND RD	BETHEL ISLAND	Not Provided	94	28	Not Provided	Not Provided
VALLEY ORCHARD WATER SYSTEM	85 ORCHARD ESTATES DR	WALNUT CREEK	1954	26	10	$100/Mo	1,300 ft pipeline,1 storage tank, pressurized tanks, booster pumps electrical control panel, chlorinator fence
VILLA DE GUADALUPE SWS	1910 WALNUT BLVD	BRENTWOOD	Not Provided	26	7	Not Provided	Not Provided

Water Rights

This dataset looks at exposure of water right points of diversion. The water rights in this dataset include "Statement of Diversion and Use" and "Appropriative." Many others are blank, and riparian water rights may be included in only the Statement of Diversion and Use water rights. If the type is blank, the name/owner is also blank.

According to the Water Education Foundation, riparian water rights are when:

> Owners of land that physically touches a water source have a right to use water from that source that has not been deemed appropriated by another party…The use of riparian water is limited to the watershed of the source from which the water is taken…Because riparian rights are not lost by non-use, the owner of idle land bordering an unadjudicated water source has riparian rights to use the water any time he deems necessary. Because riparian rights are almost always older and superior to appropriative rights, appropriators could lose part or all of their water supplies upon exercise of the dormant riparian right.[clx]

For appropriative rights, the Water Education Foundation says:

> California law allows surface water to be diverted at one point and used (appropriated) beneficially at a separate point…It is based on physical control, beneficial use and, if initiated after 1914, on a permit or license…They depend upon continued use and may be lost by non-use. Appropriative rights may be sold or transferred. Unlike riparian rights, long-term storage of water is considered an acceptable exercise of an appropriative right…In 1914, the Water Commission Act formalized the appropriation system and centralized appropriative water right records at the state level (now the State Water Resources Control Board). Under the act, the state required new appropriators to obtain a permit from the state prior to diverting water…In times of drought when there is not enough water in the stream to satisfy all claims, the most recent claim is the first to reduce its diversion. Appropriators with superior (generally older) claims are denied water in inverse order of priority. If the water shortage is extreme, even the most senior appropriators will be required to give way to all riparian rights on the water source.[clxi]

A "Statement of Diversion and Use," according to the California State Water Resource Control Board is from:

> California Water Code §5101 [which] requires each person or organization that uses diverted surface water or pumped groundwater from a known subterranean stream after December 31, 1965 to file with the State Water Board a Statement of Water Diversion and Use…An initial Statement should be completed for each point of diversion and should identify the amount of water used during the first calendar year…The main purpose of the Statement Program is to create a central repository for records of diversions and uses of water. This repository differs from the records of appropriated water rights that are registered, permitted and licensed. A Statement is not a confirmed water right; it is simply a statement made by the person or organization who diverted and used the water. Divisions of Water Rights

staff do not analyze the contents of a Statement, or research the legal water right status of the diverter at the time of receipt.[clxii]

Failure to file a Statement of Diversion and Use results in a fine.

Issue Statement

Since some water rights are based on riparian rights, these may be exposed to future permanent flooding from sea level rise and may cause issues and/or changes due to the changing shoreline, and therefore changing riparian locations. This could cause future uncertainties in riparian water rights if properties were flooded and would need to involve the state of California to decide how these rights should be dealt with on a state, regional and local level. Additionally, existing locations of riparian and appropriative water rights may become unusable in the future due to increasing saline conditions from tidal influences of the Bay that may reach further upstream into the Delta from sea level rise.

Asset Descriptions

CCWD Water Rights

CCWD has 4 appropriative diversions. According to CCWD's 2015 Urban Water Management Plan:

> CCWD holds a separate Los Vaqueros water right that allows diversion of excess Delta Flows to Los Vaqueros Reservoir for storage…Other agencies within CCWD's service area also maintain surface water diversions and are considered as part of the existing supply portfolio. The City of Antioch maintains pre-1914 water rights for diversion from the San Joaquin River and use within the City's limits. The City of Antioch is only able to use their diversion when water is fresh and its use is often limited by high salinity levels. When salinity becomes too high at Antioch's intake, CCWD provides water to the City.
>
> Several industrial users within CCWD's service area also maintain surface water diversions…Inland Container (formerly Gaylord Container) and Tesoro (formerly Tosco Corporation) have rights to divert up to 28,000 AFY and 16,650 AFY, respectively, from the San Joaquin River. Other industries that hold rights to water from the San Joaquin River are Dupont and USS-Posco. These supplies…are variable because of poor water quality due to seawater intrusion. Thus, these industries rely on untreated water deliveries from CCWD to meet demand.[clxiii]

City Of Antioch

The City of Antioch has 2 water rights, 1 was named and 1 was unlisted. The named water right is a statement of diversion and use from the San Joaquin River for treatment at the Antioch Water Treatment Plant. The unlisted water right is for diversion from West Antioch Creek. According to CCWD's Urban Water Managements Plan:

> The City of Antioch maintains a diversion from the San Joaquin River and a municipal reservoir. Antioch maintains pre-1914 water rights for diversion from the San Joaquin River and use within the City's limits. However, seawater intrusion and

associated high salinity levels limit the use of the intake to times when the Delta outflow is sufficient to maintain salinity at acceptable levels. Therefore, Antioch relies on untreated water deliveries from CCWD to meet remaining customer demand.

East Bay Regional Park District Water Rights

East Bay Regional Park District has 1 listed appropriative water right from near Woodward Island in the Werner Dredger Cut, located on the west of the island, in the same area as EBMUD.

East Contra Costa Irrigation District

East Contra Costa Irrigation District has 1 listed statement of diversion and use water right near Discovery Bay and Woodward Island from Indian Slough. According to CCWD's Urban Water Management Plan, "[East Contra Costa Irrigation District] maintains a pre-1914 water right on Indian Slough on Old River and has an agreement with CCWD to provide supplies in normal and dry years."[clxiv]

Ironhouse Sanitary District Water Rights

Ironhouse Sanitary District has two listed statement of diversion and use water rights near Jersey Island. One is from Marsh Creek and the other is on Jersey Island from the San Joaquin and False Rivers.

Jersey Island Reclamation District 830 Water Rights

Jersey Island Reclamation District 830 has 8 appropriative water rights all located on Jersey Island. Two are from the Taylor Slough, two are from the Dutch Slough, two are from the San Joaquin River, and two are from the False River.

Holland Tract Reclamation District 2025 Water Rights

Reclamation District 2025 has 6 appropriative water rights located near Holland Tract. Two are from the Holland Cut, two are from Rock Slough, and two are from the Roosevelt Cut.

Webb Tract Reclamation District 2026 Water Rights

Reclamation District 2026 has 8 appropriative water rights located on Webb Tract. Two are from False River, two are from San Joaquin River, two are from Old River, and two are from Fishermans Cut.

USBR Water Rights

The U.S. Bureau of Reclamation (USBR) has 25 appropriative water rights that are clumped into 3 locations. Twelve water rights are at the southeast corner of Clifton Court Forebay from Old River, ten water rights are from Old River just south of Route 4, and three water rights are in Oakley from Rock Slough located between Rock Slough and CCWD's Main Canal.

DWR Water Rights

California Department of Water Resources (DWR) has two appropriative water rights located in the Italian Slough to the west of Clifton Court Forebay.

All Other Water Rights

The water rights listed as "other" are those that belong to individual owners/plots of land, usually used for irrigation or other uses. There were 271 water rights that had unlisted owners.

Exposure To Current And Future Flooding

There were 333 water rights analyzed within the Project Area. Fourteen water rights were exposed at today's MWWH. Due to the shoreside location of these water rights, it is no surprise that there are water rights exposed at today's high tide and low sea level rise scenarios. For today's 100-year storm event, 105 water rights are exposed to temporary flooding.

Since some water rights are based on riparian (shoreline) rights, these may be exposed to future permanent flooding from sea level rise and may cause issues and/or changes due to the changing shoreline, and therefore changing riparian locations. This could cause future uncertainties in riparian water rights and would need to involve a more detailed exploration from the state and watermasters. This is less of an issue for 100-year storm events, since these flooding scenarios represent temporary flooding.

Additionally, existing locations of riparian and appropriative water rights may become unusable in the future due to increasing saline conditions from tidal influences of the Bay that may reach further upstream into the Delta from sea level rise.

Data Considerations

The water rights data are shown as points. Some of these points are already exposed to current MHHW due to their shoreside/riparian location. These data are from the State Water Resources Control Board's Electronic Water Rights Information Management System (eWRIMS), which is a database of water rights for the state. Although there are known issues with some aspects of the data, it is the best available state-wide database of water rights data. The eWRIMS database provides the water right status, water right type, primary owner, water right ID, and the source of water. It is important to note that many water rights have their name and water right type left blank and were recorded as "all other water rights."

Table 12-8. Number of water rights that may be located in the current 100-year storm event area and/or exposed to future sea level rise or the combination of sea level rise and a 100-year storm event.

Water Rights	Total Points of Diversion	Current 100-year Storm Event*	12" + 100-yr	24" + 100-yr	36" + 100-yr	83" + 100-yr	MHHW Today	12"	24"	36"	83"
CCWD	4	--	--	1	3	7	--	--	--	--	4
City of Antioch	2	2	2	2	2	2	2	2	2	2	2
EBMUD	1	--	1	1	1	1	--	--	--	--	1
EBRPD	1	--	1	1	1	1	--	--	--	--	1
Ironhouse Sanitary District	2	2	2	2	2	2	--	--	1	1	2
Jersey Island RD 830	8	4	4	4	4	4	2	4	4	4	4
Holland Tract RD 2025	6	5	5	5	5	5	2	2	2	2	5
Webb Tract RD 2026	8	4	4	4	4	4	2	4	4	4	4
USBR	25	--	--	--	--	--	--	--	--	--	--
DWR	2	2	2	2	2	2	--	--	--	--	2
All Other Water Rights	271	90	107	138	153	192	6	14	28	42	154
Total Sites Exposed	328	104	123	157	173	241	14	26	41	55	177

"--": Unexposed assets

MHHW: Mean Higher High Water refers to the average of today's daily highest tide and is used as the baseline for all flooding scenarios.

* Current 100-year Storm Event: The 100-year storm event reflected in these maps is not equivalent of to the FEMA 100-year flood hazard zone.

Vulnerabilities

GOV1: Riparian water rights may be exposed to future permanent flooding due to sea level rise, possibly requiring rights modifications due to the changing shoreline and riparian locations. This could cause future uncertainties in riparian water rights and would need to involve the State of California to decide how these rights should be dealt with on a state, regional and local level.
FUNC1: Existing locations of riparian water rights may become unusable in the future due to increasing saline conditions from tidal influences of the Bay that may reach further upstream into the Delta
PHYS1: Depending on the type of water system used, future rising water levels and salinity may damage mechanical equipment such as pumps or pipes.

Consequences

Society and Equity: Changes in water rights may impact the delivery of water and water quality, which would have a larger impact on members of the community such as the elderly or young children who are particularly in need of safe drinking water. 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.

Environment: Some USBR and California water diversions are designated for environmental flows. If disruption to these flows happen, it could negatively affect the ecosystems in these areas since they would not receive the adequate water levels needed for certain aquatic species to successfully survive. Additionally, if sea level rise causes more saline water to travel upstream, it could affect the Bay-Delta by changing from fresh to brackish water ecosystems. This means that brackish Bay ecosystems could transition to further upstream the Delta, changing the Delta's freshwater ecosystems into brackish ecosystems.

Economy: CCWD and USBR water rights serve many business customers, especially agriculture. Changes in water delivery or water quality (e.g. more saline water) would negatively impact local, regional, and national economies, in particular the agriculture industry.

Project Evaluation, Adaptation, and Implementation

Project Key Planning Issues

Key planning issues are the challenges that require the collective focus of the project team, the working group and other stakeholders to take action. In the ART Approach to adaptation planning, the identification of key planning issues also serves as a process that summarizes and organizes the assessment findings across the sectors and assets so they can be clearly and succinctly communicated. In addition, the process of determining key planning issues gives the working group an opportunity to consider their shared priorities and lays the groundwork for the actions necessary to resolve some of the most challenging issues uncovered in the assessment.
In the East Contra Costa ART project, seven key planning issues emerged that cut across the sectors, geographies and governance challenges identified in the assessment.

The key planning issues are as follows:

1. Shoreline Industries
2. Vulnerable Communities
3. Access to Services
4. Ad-Hoc Flood Protection
5. Parks and Open Space
6. Levees, Reclamation and Subsidence
7. Worsening Water Quality

Why define key planning issues?

ART Program projects like other adaptation efforts develop adaptation actions for the individual assets, asset categories and sectors. These actions can be implemented by individual asset managers, owners, agencies or organizations to address asset-specific issues.

Key planning issues are the cross-cutting challenges and vulnerabilities that should not be solved separately because they require collaborative problem-solving by the working group and other stakeholders. ART has found that focusing on key planning issues with the working group makes the best use of often limited time and resources, and helps lay a pathway towards the collective action that will be necessary to achieve the project resilience goals.

Key Planning Issue #1: Shoreline Industries

The County's working shoreline is at risk from current and future flooding and is a major source of current and future employment sites (i.e. Northern Waterfront Economic Development Initiative). Marinas, harbors, boat rentals, and bait and tackle shops are major sources of jobs, recreation and tourism for the region (Bethel Island alone would lose 400-

700 jobs). The industrial and manufacturing sites on the shoreline (mostly concentrated in Pittsburg and Antioch) rely on utility networks (e.g. water, wastewater, power, and drainage) that are vulnerable to sea level rise, storm events and power outages. Flooding of these industrial sites could also mobilize hazardous materials, impacting the health of the environment, communities, and our water supply. Workers from within and outside of the County commute to employment sites by ferry, bridge, rail, road and bus, which if impacted could prevent employees' ability to get to work. Flooding of critical roads, rail lines, or pipelines both within the County and beyond could disrupt critical supply chains that employment sites rely on, resulting in lost employee wages, reduced output and profit, and impacts to the regional economy through loss of critical oil-based and manufacturing exports.

Contra Costa County's shoreline industries rely on transportation and utility networks that are vulnerable to sea level rise and storm events. Flooding of critical roads, rail lines, or pipelines both within the county and beyond could hinder critical goods export and import as well as processing operations within the County, negatively impacting the local and regional economy.

All of these industrial facilities are large, sit at fairly fixed locations, and rely on both waterside and landside connections to move goods on and off-site as well as in and out of the region. Their continued operation depends on a functioning regional network of pipelines, rail lines, roadways and interstates, on- and off-site energy supplies, water and wastewater services. These facilities also rely on local road access, which is critical to ensuring that necessary materials and supplies, as well as workers, can reach them, and that goods and products can be shipped from the facilities to other locations.

Transportation and utility connections both within and outside the County are vulnerable to flooding and sea level rise. Damage or disruption to these connections could cause the slow down or cessation of operations at the facilities they serve. For example, while some shoreline sites may not be damaged, disruption of the Burlington Northern Santa Fe rail lines due to sea level rise or storm damage would significantly impact operations because commodities such as automobiles and bulk materials cannot be easily moved by truck. The rail lines in the project area, which serve many shoreline industries, runs through a subsided part of the Project Area, runs directly along the shoreline in many locations, and crosses multiple creeks and channels on bridges. In addition, the entire rail network is highly vulnerable because damage at any point in the system can result in system-wide disruptions. Loss of rail service could result in increased truck traffic, congestion, and air quality impacts in surrounding neighborhoods, local roadways, and interstates.

Flooding of local streets and roads, as well as local access to the region's interstates, will impact the shoreline industries that rely on them. These challenges will only increase as sea levels rise, and along with it the frequency, extent, and duration will cause these critical locations to be at a higher risk of flooding.

Utility networks that serve shoreline industrial uses, in particular those that rely on buried pipelines, are at risk from sea level rise impacts including higher groundwater levels, salinity intrusion and flooding, Exposure to salt water can corrode pipes, rising groundwater can increase liquefaction potential during a seismic event, and in the event of flooding, pipelines that are not weighted or anchored may float or break, particularly during prolonged flooding in marshy or sandy soils. Damage to pipelines will result in disruption or possibly a shut down of the marine oil terminals and refineries west of the Project Area, as well as threaten public safety and the environment in the event of an explosion or release of hazardous materials.

Multi-agency cooperation, public-private partnerships, and coordinated local and regional action will be necessary to improve the resilience of East Contra Costa County's shoreline industries. Outreach is needed to educate businesses and industries that may be unaware that sea level rise can impact their operations by damaging or disrupting the transportation and utility networks they rely on. Additionally, clear guidance for how best to assess and respond to rising sea levels, as well as incentives and regulatory requirements to do so, will help shoreline industries and others proactively address their own vulnerabilities. Outreach and educational efforts can also increase the participation of business and industry in collaborative efforts to address regional transportation system vulnerabilities and improve the resilience of goods movement networks serving East Contra Costa County and the rest of the region.

Key Planning Issue #2: Vulnerable Communities

Shoreline communities in the Project Area located in or near the floodplain of the Delta or a tidal creek (i.e. Marsh Creek) have low-income communities (e.g. Pittsburg, Antioch, Brentwood, Byron, and the Delta Islands) that are likely to experience flooding from extreme storms, sea levels rise, or a combination of both. Residents of creek- or Delta-side communities have limited control over the maintenance and management of the waterways they live along. Those that are low-income, linguistically or socially isolated, without access to a car, elderly, very young, disabled, homeless, undocumented, or mobility-challenged may be less able to prepare for, respond to, and/or recover from flood events. Vulnerable community members with these specific characteristics can face difficulties evacuating and finding resources and temporary shelter during a flood event due to mobility, transportation, or language issues. Further, unless resources are in place to assist in rebuilding, many of these community members may face permanent displacement or homelessness after damaging flood events.

The socioeconomic vulnerability indicators suggest that in these locations there are low-income households, individuals with low educational attainment, people of color, and a high number of renters and households without a vehicle. In addition, across the Project Area most residents are housing and transportation cost-burdened. This can impact the outcome both during and after a flood event. For example, low-income households, renters and cost-burdened households may not find affordable replacement housing within or near their community, even if for a short period of time, and may not be able to easily get to work or access the services they need, resulting in their permanent displacement from the community.

Addressing current and future flood management challenges in Contra Costa County will require new levels of coordination between state, federal, and local agencies, special districts, private landowners and communities. Flood managers, planners, private landowners, and others will need to work together to develop a shared understanding of the vulnerabilities of the infrastructure and communities within each watershed. This includes assessing the characteristics that will place some communities and community members at greater risk from flooding and at a disadvantage during recovery. Inviting community members to engage early on will increase the amount of community knowledge, values, and issues that are heard and addressed, and will ensure that community members know about and will more readily participate in the effort.

Key Planning Issue #3: Access to Services

A lack of redundant transportation options (i.e. Antioch Bridge, Bethel Island Bridge, Jersey Island Bridge, ferries) and the limited number of public facilities in this part of the County may result in shoreline communities becoming isolated from emergency services, public and private healthcare providers, jobs, schools, grocery stores, and other critical services during flood events. The food grown in ECC may be unable to reach the rest of the County, affecting food supply. Loss of transportation, power, water, and wastewater could have significant consequences on public health and safety, local economies, and community function, and will be a particular challenge for vulnerable communities. Highway 4 and State Route 160 are the only major transportation arteries in the region and may become grid-locked during flood emergencies. The following may be at risk of flooding: 1 fire station, 2 police stations, some retail, 1 school and possibly many other services (such as dentists offices, post offices, etc.) that were not included in the analyzed data set.

Shoreline communities in the Project Area rely on public services provided by law enforcement, fire districts, county health services, school districts, water, wastewater and solid waste districts. Several of these public services are already limited, and increased community needs both during and after a flood even will add an additional strain. And while reduced or lost access to services will impact all community members, those with characteristics such as limited income or mobility, may be disproportionally impacted if they cannot reach the healthcare providers, jobs, schools, and other critical services they rely on.

During widespread flooding events, many of the County health services in the Project Area could be inaccessible at the same time, including the regional medical centers, health centers and school-based clinics. At the same time, the County's mobile clinics may not be able to reach those communities with the greatest need. In addition, emergency and other critical services provided by law enforcement and fire districts could be affected if the facilities providing these services are flooded, or if the local streets and roads used by emergency responders to access those in need are flooded.

The lack of redundancy in the shoreline transportation system will not only mean that flooding of local streets and roads, critical intersections, and major routes and thoroughfares will impact community members' ability to access necessary services, it may

also impede or delay emergency services from reaching neighborhoods and communities. While some storm related flooding could result in relatively short disruptions or delays, even temporary flooding can damage streets, roads and other transportation assets such as bridges, requiring a significant amount of time and funding to repair and resulting in longer travel times due to re-routing or increased congestion. The loss of transportation or transit options in areas that already have few alternatives, coupled with the already limited availability of public services, could translate to higher economic costs and health burdens on all shoreline community members, although those who are mobility or economic challenged or socially or linguistically isolated may experience even greater impacts.

Updating emergency and hazard mitigation plans to consider and address the future flood risks of critical services and the roadway system will help communities be better prepared both before and after an event occurs. In addition to considering future flooding, updates that incorporate the unique characteristics and needs of the people who live in areas at risk will result in a more effective response and a more resilient recovery. By increasing knowledge sharing between first responders and community members, not only will the planning be stronger, but also relationships between those that may be in need and those that are responding to those needs will be improved. For example, inclusion of community members and leaders in planning can ensure the use of culturally and ethnically appropriate communication methods during an emergency. In addition, working together, flood managers, planners, public service providers, emergency responders, transportation agencies and community members can create hazard mitigation plans to ensure neighborhoods do not become isolated from necessary services by flooding. Lastly, all of these efforts can help communities develop and maintain strong social capital that will help them be more resilient to changing conditions. Social capital—that is the informal relationships, supportive social ties, social cohesion and communication networks—helps buffer individuals and neighborhoods from stressors, keeping communities functioning when public services fail or are overwhelmed during disasters.

Key Planning Issue #4: Ad-hoc Flood Protection

Some communities are protected from coastal flooding by rail lines, shoreline parks, and tidal wetlands. Rail lines are typically built on earthen mounds, which can act as a flood barrier. Shoreline parks typically go from sea level and rise in elevation, acting as the first line of defense. Tidal wetlands can help reduce wave height and coastal erosion. While these built and natural areas reduce the flood risks of adjacent communities, assets, and infrastructure, they have not been specifically designed or maintained for this function and, therefore, provide only ad-hoc flood protection. Increased wind, wave, and tidal energy, higher extreme high tides, and more frequent exposure to the tides as sea levels rise can decrease the ability of these ad-hoc systems to maintain the flood protection benefits they currently provide. In areas of ad-hoc flood protection, flood insurance policy rates may be low, so although people think they are protected it can create a false sense of security, resulting in a costly recovery.

Communities in the Project Area that are protected by ad-hoc flood protection vary, and some have characteristics that may place them at greater risk, for example those with residents with limited resources, that are living in mobile homes, have mobility challenges,

or lack access to information, transportation and public service options. Characteristics such as these can hinder communities and their member's ability to prepare for, respond to, and recover after, a flood event. Because these communities are currently protected—albeit in an ad-hoc manner—many have not experienced coastal flooding and therefore may not be aware of current risks or have sufficient information about the potential changes in flood risk that will result as sea level rises. Particular consideration and support will be necessary for communities that linguistically, socially or historically disconnected from political processes and decision-making regarding shoreline and flood protection improvements.

Miles of rail line that lay in between Pittsburg and Oakley serve as ad hoc flood protection. Rail lines are neither constructed nor maintained to prevent inland areas from flooding, and there are often culverts or passages in the track that could allow coastal water through during a storm. Some segments of rail line in the Project Area have wetlands on their Bay-Delta side to help protect them from tidal and wave action, such as near Big Break Regional Shoreline and DOW Wetlands Preserve. Other segments of rail line are the first line of defense along the shoreline, which is the case in Antioch. As sea levels rise, higher water levels during extreme tides and storm events will increase the risk that track embankments and ballasts will be damaged. In addition, rising groundwater can damage the track bed and ballast materials, causing the rail line to become unstable. While ongoing maintenance may help prevent rail lines from becoming structurally unsound in the short term, rising Bay-Delta water levels coupled with a rising groundwater table calls for a new solution to protect both the function of rail lines and the inland areas they protect.

Some of the communities protected by rail lines have limited resources or live in aging homes that are highly susceptible to flood damage. For example, Antioch has a large elderly and low-income population. Failure of the rail embankment during a storm event, or the loss of tidal marsh habitat due to rising sea levels, will increase the risk that homes in downtown Antioch may flood.

Shoreline parks in East Contra Costa County also serve as a buffer to inland communities and protect against sea level rise and storm event flooding. Shoreline parks were developed and are managed for recreation and natural habitat preservation, and not as coastal flood protection systems. The degree of flood protection provided varies park to park, as some have structural shoreline components such as levees and riprap, while others have natural shorelines such as wetlands and coastal bluffs. East Bay Regional Park District (EBRPD) owns and manages four (Brown's Island, Antioch Shoreline, Big Break Regional Park, and Delta Access) regional shoreline parks in the Project Area. Many of these parks are already experiencing shoreline erosion, and the tidal wetlands within these parks are at risk from accelerating rates of sea level rise coupled with declining sediment supply.

Current complexities in land ownership, permitting requirements and limited funding mean that new approaches will be required to address how ad-hoc protection is maintained or improved as sea levels rise. For example, EBRPD, the cities, the Bay Trail, and BNSF railroads, and neighboring landowners will need to work together to address areas where

shoreline erosion and tidal wetlands loss are increasing the risk to shoreline rail and inland communities. Working to initiate collaborative planning among these entities is even more important, and challenging, given the railroads have not yet directly participated in sea level rise planning in East Contra Costa County, are hesitant to openly share information about their operations and assets, and often do not engage locals in their planning or management decisions. This challenge is complicated further because large public investments are likely to be necessary to protect the functions of privately-owned rail infrastructure.

Key Planning Issue #5: Parks and Open Space

Shoreline parks and open spaces are often the first line of defense against inland flooding and are themselves very vulnerable to the early impacts of sea level rise. Damage or loss of parks and open spaces in the project area, many of which would be difficult to replace, would have significant impact on recreational access, with consequences on the health of communities and their members. The loss of parks and open spaces will impact some individuals and communities more than others. The degree to which the loss is felt will depend on the unique needs of community, where community members live and work, and what capacity they have to seek and access alternative recreational opportunities.

In the Contra Costa Project Area there are many parks, trails and natural areas. This includes large regional parks owned by EBRPD, small city parks owned by various municipalities, public and private marinas, and an extensive Bay Trail network owned and managed by many different organizations. These recreation assets are vulnerable to sea level rise impacts depending on their location, form and function, although the risks are higher in areas where there is ongoing shoreline erosion, habitat downshifting, or loss of vegetation due to rising groundwater levels or salinity intrusion. Because parks, trails and natural areas are some of the first shoreline areas that will be impacted by sea level rise, they can also be key early adaptation sites. Successfully adapting parks can both reduce flood risks on inland communities and increase public awareness about sea level rise.

The EBRPD shoreline parks in the Project Area will face flooding, elevated groundwater and salinity levels, increased shoreline erosion, and habitat impacts including loss of tidal marshes as sea levels rise. These regional shoreline parks contain extensive marsh habitat, unique historical resources, and large-scale recreation assets including trails, fishing, wildlife viewing, and off-leash dog areas. EBRPD parks in Contra Costa provide recreation for many visitors, and the types and capacity of recreation provided cannot be replaced within the County.

Possible adaptation solutions include educating the public about the early risk to parks from sea level rise, the multiple benefits parks provide (flood protection, wildlife, educational, recreational values, etc.), and the opportunities for adaptation to protect these functions. Another option is to form or expand existing partnerships among park districts, park and recreation departments, private entities, community-based organizations and community members to develop a shared vision for protecting and jointly maintaining the function of parks and open space in the project area where feasible. Finally, a new authority could be

established, or expand an existing authority, to plan, fund, manage and maintain shoreline solutions to protect existing parks, open space, and the Bay Trail.

Key Planning Issue #6: Levees, Reclamation, and Subsidence

Agricultural practices and land reclamation in the Delta have caused significant land subsidence, causing both communities and agricultural fields to rely on levees and pumps to stay dry. Current pumping practices to keep land dry for residences and farming continue to exacerbate subsidence. Reclamation Districts and the Bethel Island Municipal Improvement District are responsible for maintaining the levees and pumps; many of these Districts do not have adequate funds to properly inspect, maintain or rehabilitate these levees. The levees are in various states of safety design standards since some levees protect communities and others protect agricultural land. Some are at a FEMA standard while others, such as agricultural levees, don't provide a level of flood protection considered sufficient for cities and towns by FEMA's National Flood Insurance Program. Additionally, no standards address the risks associated with earthquakes[clxv]. These levees are funded primarily through State funds, which puts control and decision-making out of local hands.

Sea level rise and subsidence could worsen flood risks by increasing hydrostatic pressure on levees, increasing the liquefaction potential during seismic events due to rising groundwater, and by increasing reliance on (and cost of operating) pumps, which are sensitive to flooding and to power outages. Pumps do not always have redundancy through backup pumps or fuel supplies. Loss of communities, homes, businesses, and agricultural lands due to levee failure could cause catastrophic loss of life, livelihoods, and assets, with significant impacts to the State's water quality (i.e. increasing salinity) and the economy. There could be substantial economic losses for the region due to losses in visitation, recreation, agriculture and gas extraction. Farmland could be ruined by salinization of soils through contact with brackish/saline water from the Delta. Finally, if flooded, contaminants from homes, businesses, gas extraction sites, and farms could be mobilized.

There are many miles of levees in the Project Area. All of the Delta islands and tracts are protected by levees. These are all at various design standards and levels of safety. They are all managed by the Reclamation District they're within, so have various levels of maintenance and inspection. Other important water assets, such as wastewater treatment plants, drinking water pumping stations, and Clifton Court Forebay, are all protected by levees.

Adaptation solutions could include expanding or forming partnerships among agencies, private entities, organizations and community members to facilitate coordinated decision-making regarding levee improvements and new flood protection investments. The County or Delta Stewardship Council could also study how sea level rise and storms could affect levee stability and update design and engineering standards accordingly. A land trust could be created to buy out subsided Delta islands and convert them to wetter land uses (i.e. rice

cultivation, managed wetlands, pasture) by either reducing pumping or breaching the levees. Finally, new microgrids could be created so that a more resilient power system that's less reliant on the regional grid could ensure that pump and drainage systems do not lose function if the electricity grid is not functioning.

Key Planning Issue #7: Worsening Water Quality

Sea level rise is likely to cause a worsening of water quality due to contaminant mobilization and salinity increases from the tidally influenced Bay reaching further into the Delta. Flooding will mobilize contaminants from industries, businesses, homes, roads, lawns, and farms, negatively effecting water quality. Surface water is used for drinking water intakes by many small, local communities in the Delta, as well as East Bay residents and users of the Central Valley Project and State Water Project (millions of users in total). Groundwater could also experience increasing salinity close to the shore, possibly affecting water supplies from wells. There are many private wells in the Project Area. Additionally, increasingly saline water could cause corrosion of infrastructure that were not originally protected against saltwater, such as landfills, septic tanks, wells, pumps, pipes, and water treatment facilities. Finally, habitats can also be affected by contamination and as salinity changes.

There are many hazardous materials sites within the Project Area that face possible inundation and mobilization from temporary or permanent flooding. This includes both sites that store hazardous waste materials, such as shoreline industry or manufacturing, but also includes sites such as Brownfields, which have been remediated or need to be remediated for hazardous wastes. Previously remediated sites may mobilize contaminants if inundated, as clean-up standards for sites do not assume permanent inundation at the site.

There are also landfills and solid waste disposal sites within the Project Area that are within the potential inundation zone, such as a landfill is located in Pittsburg directly on the shore, right across from Brown's Island. There is another solid waste disposal sites on Holland Tract for paper pulp and an ash waste disposal site on Jersey Island.

With rising sea levels, increasing salinity levels can creep up the Delta, negatively influencing water quality. Since millions of people and hundreds of thousands of acres of farmland rely on water from the Delta, protecting this area from saline intrusion from the Golden Gate is imperative. Freshwater inflows from the Delta impact how saline the water is. With a changing climate and snowfall patterns, saline conditions in the Bay-Delta may change as well.

Adaptation solutions could include increasing green infrastructure and low impact development near the shore to increase freshwater infiltration and reduce saline groundwater. The County and State can improve their understanding of salinity, including compiling studies on salinity in the Delta, updating salinity models when more information is available to maintain up-to-date models, and understanding impacts on groundwater, surface water, and infrastructure components. Coordination and communication can be improved with major users of the Delta (e.g. Central Valley Project or State Water Project)

to ensure they have emergency plans that include backup water supplies if Delta water supplies become unusable. Finally, the County could develop and implement a program to monitor salinity conditions in the Project Area, including the progress of saltwater up into creeks and salinity conditions in the groundwater near vulnerable infrastructure, wells, or surface water.

Adaptation Responses

Adaptation responses were developed for the project's 34 asset categories and 7 Key Planning Issues. ART adaptation responses go beyond a list of adaptation strategies; rather they are a comprehensive "package" of adaptation information that:

- Presents a number of possible stand-alone or sequenced actions
- Connects actions to the assessment outcomes (i.e. the vulnerabilities and key planning issues)
- Identifies possible implementation partners and processes
- Provides greater transparency and support for evaluation and implementation

The adaptation response approach is valuable because it connects the action to the vulnerability assessment, presents a number of possible steps that can be taken, and provides detail about possible implementation partners and processes. As a package, the adaptation response helps to make a case for why certain actions are necessary and who needs to be involved in their implementation.

The East Contra Costa ART project adaptation responses reflect the prominence of the following overarching themes:

- A collective decision-making framework to align various interests and agencies;
- Strengthening relationships between agencies, NGOs, nonprofits, faith-based organizations, and community groups;
- A resilient transportation and energy system;
- Having a regional understanding and monitoring program for salinity, sea level rise, and levee stability;
- Wetland and Delta island restoration;
- Education and outreach; and
- Creating a system of prioritization for improving the shoreline.

These themes highlight opportunities where synergies may be found, for example by implementing actions that, while similar, address vulnerabilities and consequences of a range of assets, geographies, and communities.

The summary that follows describes a number of actions that can be taken to address these overarching themes, as well as the project-wide Key Planning Issues that were identified.

The adaptation responses for the project are organized in two ways: by asset category and by Key Planning Issue. In this way, the summary is both a guide to how County agencies, organizations and communities can seek efficiencies in implementation, and serves as an indicator of the most pressing actions needed to address the challenges faced in the Project Area as the Bay-Delta rises.

The complete set of adaptation responses for all 34 assets categories and the 7 key planning issues are presented in the Appendix.

The Three Components of an ART Adaptation Response

1. The **vulnerability** being addressed by the adaptation response. Including this provides a direct link to the outcomes of the assessment and ensures that the most critical issues are addressed. Identifying the key vulnerability that is addressed is a transparent way to ensure that each adaptation action is connected to a planning issue.

2. Adaptation actions (one or more). While some vulnerabilities can be addressed by a single action, most require multiple, often coordinated actions. Some actions can be taken at the same time, while others require a series of sequential steps that incrementally build towards resilience.

3. Implementation options for each action. These provide alternatives for initiating adaptation actions such as incorporating them into existing planning or processes or creating new initiatives. The options also should identify agencies and organizations – public and private – that have a role in implementing the actions.

Asset Category Adaptation Responses

The asset category adaptation responses included a variety of actions to address specific vulnerabilities identified during the assessment. Many of the actions are specific to the physical characteristics and conditions of assets within the asset category or sector that impart a greater vulnerability to flooding. Other actions focus on the function of the asset category or sector, for example in providing critical public services; ensuring people can reach their homes, jobs and necessary services and employers can maintain supply chains and employees can reach work sites; and that communities have power, clean water, wastewater services, and access to recreation and open space. Lastly, many actions are targeted at addressing a wide array of information and governance challenges that cut across sectors, jurisdictions and geographies.

Example actions to address shoreline system vulnerabilities that impact many asset categories:

- Expand or form partnerships among agencies, organizations and community members to facilitate cooperative decision-making regarding shoreline improvements and new investments.
- Develop and implement a regional permit authorization program to expedite the ongoing maintenance, minor repair, or upgrade of shorelines that are already experiencing erosion.
- Develop a decision-making framework for planning and implementing resilient, multi-benefit flood management projects that clearly weigh the trade-offs among short and long term impacts and benefits to the economy, environment and social equity.

Example actions to address transportation system vulnerabilities that impact many asset categories:

- Conduct a "hot spot" assessment to identify and evaluate vulnerable local and regional critical transportation routes and nodes necessary to maintaining commercial supply chains, ensuring employees can access industrial job sites, and allowing responder access during an emergency.
- Expand or form broad public-private partnerships to guide the planning and implementation of multi-objective transportation and goods movement improvements to ensure existing infrastructure and new investments are resilient to sea level rise impacts.

Many of the asset category adaptation responses include actions to increase the resilience of transportation systems including the network of roads, rail lines, seaport and marine terminals that are critical to the movement of goods, commuters and community members. Some of the actions are narrowly focused on a specific asset that, if disrupted, would have widespread consequences. For example, disruption of the BNSF rail line would interrupt goods shipments as well as commuters through disrupting Amtrak. Other actions are broader and, if implemented, would address vulnerabilities in the shoreline transportation system that impact many of the asset categories assessed (see sidebar).

Adaptation responses to address shoreline vulnerabilities were developed for many of the asset categories assessed, including Parks and Recreation, Natural Areas, and Water Management. For example, there is a regional parks adaptation response calling for the development of agency-specific guidance to ensure shoreline plans and projects consider the impact of sea level rise and include actions to address potential future flood challenges. A similar adaptation response is also included for Natural Areas, however in this case the guidance specifically encourages setbacks and buffers adjacent to tidal marshes to help maintain public access while supporting future marsh migration. In addition to improved guidance to assist shoreline owners and managers consider future flooding, there are a number of adaptation responses reflecting the need to address the governance challenges that currently impede creation of integrated shoreline management systems (see sidebar).

The need to create, implement, and sustain targeted education and outreach efforts was a theme that cut across all sectors. While many education and outreach actions included in the adaptation responses are asset category specific, there are many similarities among them. For example, most of the adaptation responses call for a collaboration of public, private and non-profit partners to develop and deliver the educational campaign. This includes the Business, Transportation, and Housing Sectors. This presents an opportunity for coordination and collaboration, the exchange of ideas and best practices, and leveraging of expertise across outreach campaigns. For example, there is a need to engage communities living or working within the existing floodplain as well as those that are protected from flooding by rail lines. A coordinated campaign could be a resource efficient approach for increasing broad community awareness about current and future flooding and the actions that can improve flood resilience and could spawn new partnerships and future collaborations among those that come together to lead the campaign.

Key Planning Issue Adaptation Responses

The adaptation responses for the seven Key Planning Issues address the challenges that cut across assets, communities and geographies. They typically required the collective focus of Working Group members and other stakeholders because the underlying vulnerabilities cannot (or should not) be solved by individual agencies, organizations, asset managers or communities. The Key Planning Issue adaptation responses, while not exhaustive, are a guide for how a broad coalition could work together towards solving some of the cross-cutting issues faced in the Project Area. To provide the Working Group a guideline for the timing of initiation and to support implementation, actions within each

response were categorized as “near-term”, “mid-term”, or “long-term”. In general, near-term actions focus on investigation or conducting new analysis, education or outreach, or maintaining current assets. Mid-term actions focus on increasing coordination, building new partnerships, and planning for programs to address future conditions. Long-term actions focus on potential policy changes, complex planning projects, or efforts that require shared decision-making, funding and management. Action implementation leads and supporters are also identified, including agencies and organizations that function local, regional, statewide and federal scales.

The following is a summary of the top adaptation actions developed for the seven Key Planning Issues. They include both the top priority adaptation action and the low-hanging fruit/easier to implement adaptation action for the near-term, mid-term, and long-term. These were voted for by Working Group members in the last Working Group meeting.

1. Shoreline Industries

Timeline	Priority Adaptation Response	Low-Hanging Fruit Adaptation Response
Near-term	In coordination with a broad business and industry sea level rise education program, develop targeted outreach to water-dependent and shoreline business or industry owners and operators about the impacts sea level rise could have on land-based facility operations and the movement of goods and products by pipeline, water, road and rail.	Convene a shoreline working group that includes large shoreline landowners, industrial business owners, railroads, utility providers, public agencies, and private entities to develop a business and industry education and outreach program, improve County and facility emergency response planning, and provide input on a shoreline management and improvement plan.
Mid-term	Form or expand existing private-public partnerships to develop and disseminate guidance for water-dependent and shoreline business or industry owners and operators for incorporating sea level rise into Operations, Emergency, and Contingency Plans, including best practices for limiting disruptions that could occur if pipelines, marine terminals, roads or rail lines are damaged.	Consider future sea level rise and storm flooding in future iterations to the Northern Waterfront Economic Development Initiative and consider changes in General Plans/zoning that balance incentivizing economic growth with shoreline flood protection.
Long-term	Form or expand existing private-public partnerships to develop a regional plan to protect or relocate the nexus of pipelines, marine terminals, roads and rail lines that water-dependent industries rely on for continued operations.	--

-- means no adaptation action was voted for in that category

2. Vulnerable Communities

Timeline	Priority Adaptation Response	Low-Hanging Fruit Adaptation Response
Near-term	Develop a program to simply and directly fund low-income homeowners and owners of affordable rental properties to implement near term flood mitigation strategies, in coordination with seismic retrofitting strategies.	Develop an outreach program conducted in all locally spoken languages and inclusive of sensory impaired people to educate communities living near creeks and the shoreline about their current and future flood risks with sea level rise and the actions they can take to reduce risks, such as building individual and neighborhood social capital.
Mid-term	Develop a decision-making framework for planning and implementing resilient, multi-objective shoreline adaptation projects that helps to clearly weigh the trade-offs among short and long term impacts versus benefits to the economy, environment and social equity.	Work with decision-makers to provide public funds for community groups to participate in local climate resilience building efforts, for example, in developing and implementing local climate adaptation plans or conducting public education on local climate impacts and emergency response in multiple languages.
Long-term	Support community-driven proactive relocation out of high hazard areas by providing funding and technical assistance, particularly to low-income households, renters, and those that do not own vehicles.	Develop and fund a program to purchase properties in the existing 100-year floodplain as they become available, prioritizing creekside and shoreline parcels that can contribute to an integrated shoreline protection solution.

3. Access to Services

Timeline	Priority Adaptation Response	Low-Hanging Fruit Adaptation Response
Near-term	Conduct locally refined analyses to determine the sources of, and potential solutions to resolve, flooding that could damage or disrupt local and regional routes and nodes that are critical for emergency response and for communities to access necessary services.	Build or strengthen relationships between public agencies, private entities, nonprofit, community, and faith-based organizations, and neighborhood groups to increase flood resilience.
Mid-term	Develop and fund a county-wide plan to increase the redundancy of the shoreline road system, including increasing the number and capacity of alternative routes, to ensure emergency responders can get to those in need and that community members, including those that rely on public transit, can continue to reach services.	Provide incentives or require facilities that provide critical public services either have access to temporary flood protection devices or retrofit with permanent flood protection solutions.
Long-term	Develop or update unified county-wide emergency operations and hazard mitigation plans that describes the risks from current hazards and the impacts of climate change and identifies a suite of solutions that were developed with robust community input.	Evaluate the continued siting of critical public services, including schools, childcare centers, health services, water, wastewater, and waste transfer stations, in areas at risk of current and future flooding, determine the feasibility of relocating existing facilities in areas currently at risk, and consider whether siting supports smart growth goals.

4. Ad-Hoc Flood Protection

Timeline	Priority Adaptation Response	Low-Hanging Fruit Adaptation Response
Near-term	Initiate tidal wetland restorations that will protect and enhance the broad benefits they provide, including flood risk reduction, habitat, biodiversity, and water quality.	Form a coalition of stakeholders to actively outreach to and educate railroad owners and those that rely on the region's rail system to increase railroad owner participation in sea level rise planning.
Mid-term	Initiate a planning process to determine where rail should be moved inland to allow for multi-benefit flood protection projects that provide habitat and recreation value, and where rail should be protected in place to maintain the function of the rail network and protect inland communities.	Establish a shoreline working group of public and private partners (including industrial and rail owners) that develops and implements a plan to select and advance integrated shoreline solutions with a particular focus on improving the shoreline for communities that are currently protected by ad hoc flood protection.
Long-term	Establish a Joint Powers Authority to fund, manage and maintain integrated shoreline solutions that reduce the flood risk of inland communities and assets.	Advocate for the federal government to require that railroad owners partner with local communities in determining how to protect or relocate rail lines to address sea level rise.

5. Parks and Open Space

Timeline	Priority Adaptation Response	Low-Hanging Fruit Adaptation Response
Near-term	Develop guidance for regional shoreline park planning and project development activities that consider sea level rise to ensure impacts are factored into tidal wetland restoration and park management activities.	Educate the public about the early risk to parks from sea level rise, the multiple benefits parks provide (flood protection, wildlife, educational and recreational values), and the opportunities for adaptation to protect these functions.
Mid-term	Form or expand existing partnerships among park districts, park and recreation departments, private entities, community-based organizations, and community members to develop a shared vision for protecting and jointly maintaining the function of parks and open space in the project area where feasible.	Develop a county-wide park enhancement and protection plan that identifies opportunities for increasing the resilience of parks that are vulnerable to sea level rise and the capacity of parks that are not at risk.
Long-term	Establish a new authority, or expand an existing authority, to plan, fund, manage, and maintain shoreline solutions to protect existing parks, open space, and the Bay Trail.	--

-- means no adaptation action was voted for in that category

6. Levees, Reclamation and Subsidence

Timeline	Priority Adaptation Response	Low-Hanging Fruit Adaptation Response
Near-term	Expand or form partnerships among agencies, private entities, organizations, and community members to facilitate coordinated decision-making regarding levee improvements and new flood protection investments.	Build coalitions and lobby to state and national groups for funding to improve levees, citing the need for protecting the Delta's water quality and economic and food supply impacts to the region and nation.
Mid-term	Model how sea level rise and sea level rise combined with major storms will affect levee stability and update design and engineering standards accordingly.	Identify locations that are currently pumped that could stop or reduce pumping because either the site has a land use that could tolerate more moisture and/or change land use to one that does not rely on dry land.
Long-term	Develop new microgrids to create a more resilient power system less reliant on the regional grid, ensuring that pump and drainage systems do not lose function if the electricity grid is not functioning.	--

-- means no adaptation action was voted for in that category

7. Worsening Water Quality

Timeline	Priority Adaptation Response	Low-Hanging Fruit Adaptation Response
Near-term	Increase green infrastructure and low impact development near the shore to increase freshwater infiltration and reduce saline groundwater.	--
Mid-term	Improve understanding of salinity, including compiling studies on salinity in the Delta, updating salinity models when more information is available to maintain up-to-date models, and understanding impacts on groundwater, surface water, and infrastructure components.	If saline conditions occur, have preemptive management contracts with large water users (e.g. Central Valley Project or State Water Project) to reduce pumping from the Delta to flush out the saline conditions with fresh water.
Long-term	Develop and implement a county-wide program to monitor salinity conditions, including the progress of saltwater up into creeks and salinity conditions in the groundwater near vulnerable infrastructure, wells, or surface water.	Educate and provide resources for well users to ensure that they are aware of potential impacts to their wells from flooding or saline conditions and encourage them to have emergency water supplies on hand.

-- means no adaptation action was voted for in that category

Evaluation and Implementation

Evaluation Criteria

The development of project-specific evaluation criteria plays a central role in ensuring transparent decision-making in adaptation planning. Evaluation criteria are used to prioritize various adaptation responses and help decide which ones to go forward with. They can help identify how to adjust or refine adaptation responses to best achieve the Resilience Goals; help understand the benefits, trade-offs and consequences of different adaptation responses; help understand an adaptation response's weaknesses, and help select high priority adaptation responses for implementation.

In the West Contra Costa ART project a set of evaluation criteria were developed and applied to a select number of Key Planning Issue adaptation responses. This exercise helped the Working Group more deeply understand the issues and trade-offs that need to be considered when prioritizing and selecting adaptation responses for implementation. To keep consistency between the two projects within the County, the ECC ART project kept the same evaluation criteria so that adaptation responses from West Contra Costa ART could be compared to projects from East Contra Costa ART.

The Working Group from West Contra Costa ART noted that using the evaluation criteria was beneficial in informing them of how they could improve the transparency of their decision-making. Some of the group did note however that it will be more straight forward to evaluate actions that are fairly detailed, for example with specific implementation leads and very concrete outcomes. In addition, the Working Group acknowledged that for some responses the evaluation process would be easier for individuals with specific knowledge or experience in owning, operating, or managing the asset, asset category, or sector. For the following reasons, ART ECC did not include applying the evaluation criteria, as this step would be better suited for individuals or entities that have an understanding of a fairly well developed project.

Table 13-1. The project evaluation criteria spanned all four sustainability frames – society and equity, the environment, economy and governance – and reflected the project's resilience goals.

Criteria Type	Description
Feasibility	• Administrative: Can the action be accomplished with existing operations or procedures? • Community support: Will a strong advocate or local champion support the action? • Legal: Can the action be done with existing authorities or policies?
Social Benefits	• Access: Will the action protect car, transit, bike or pedestrian access to housing, jobs or services? • Life safety: Will the action protect public health and safety? • Vulnerable residents: Will the action protect especially vulnerable community members? • Community: Will the action preserve community function, and/or advance other community objectives? • Recreation: Will the action maintain recreational or educational opportunities?
Economic Benefits	• Jobs: Will the action promote or retain jobs? • Commuter movement: Will the action maintain commuting? • Goods movement: Will the action maintain goods movement? • Service and networks: Will the action reduce service or network disruptions?
Environment	• Habitats and biodiversity: Will the action create or maintain appropriate habitat and biodiversity? • Water quality: Will the action maintain or improve water quality? • Nature based: Will the action promote grey to green, nature-based solutions?
Governance	• Decision-making: Will the action support or create collaborative, transparent decision-making? • Partnerships: Will the action encourage broad public and/or private sector partnerships?
Disaster Lifecycle	• Preparedness: Will the action build disaster preparedness? • Response: Will the action improve disaster response? • Recovery: Will the action encourage resilient recovery?

Implementation

In the West Contra Costa County ART project, the last step was developing implementation pathways for four near-term, priority actions to help address the four overarching themes identified in the project. The implementation pathways provided the working group a roadmap with specific recommendations for the timing, partners, and processes necessary to advance the action. In addition, the implementation pathways include a description of the key outcomes of each action. Lastly, using the implementation pathway for each action was evaluated against a subset of the project evaluation criteria as a quick check on whether when implemented the action would help achieve the Resilience Goals. The criteria used to evaluate the four action implementation pathways were:

- Improves or protects multi-modal access housing, jobs or services
- Protects public health and safety
- Protects especially vulnerable community members
- Maintains recreational and educational opportunities
- Promotes or retains jobs
- Maintains commuter movement
- Maintains goods movement
- Reduces service or network disruptions
- Creates or maintains appropriate habitat and biodiversity
- Maintains or improves water quality
- Promotes grey to green and nature-based solutions
- Supports or creates collaborative, transparent decision-making
- Encourages broad public and/or private sector partnerships

However, the ART ECC Project did not have the Working Group develop implementation pathways, as it was agreed that once leads were created for the adaptation response, the implementation pathways could be filled out more easily by that lead. Instead, the focus was on a robust discussion at the last Working Group meeting on ways that the ART process and sea level rise adaptation planning and implementation could be progressed within the County so that implementation of some of these actions would become more realistic. The following paragraphs outline the Working Group discussion.

What's necessary to get adaptation responses implemented in the County is a core ask, a clear message, and educating elected officials about the ART findings. The Working Group brainstormed ways this could happen. For communicating the findings from this project, the Working Group recommends the following:

- Doing public engagement, including social media, newspapers, videos, websites, public meetings, and TV
- Targeted messaging presented to impacted stakeholders, in partnership with subject matter or asset experts from the Working Group
- School curriculum and student education programs
- Meet with elected officials through forums such as the East Bay Leadership Council and Mayors Conference. Meet with City and County staff through various forums, such as the City Managers monthly meeting

- Get County Board of Supervisors on board, as they are a reasonable way to drive authority
- Get industry involved through targeted presentations to various sectors, such as the Industrial Association

The most critical steps for integrating West Contra Costa ART and East Contra Costa ART are:

- Introduce ECC findings to the West Contra Costa Working Group
- Highlight the differences between East and West County
- Host a forum in a central location to combine adaptation responses into one plan
- Develop a short report that compares the two studies, focusing on common issue statements and Key Planning Issues
- Work with Contra Costa Resource Conservation District, as they work across the whole County in both incorporated and unincorporated lands
- Work with East Bay Regional Parks
- Create targeted outreach materials and 1-pagers for East, Central, and West County
- Focus on top priority actions that could be started immediately

The biggest hurtle to implementing adaptation planning and implementing strategies within the County is due to there being no overarching authority to move any of the actions forward. Working Group members are excited to continue the momentum. However, Working Group members repeatedly stated that the County needs a convening entity that can take the lead and that has authority. Some Working Group members suggested that the County may not be not the right scale and instead that multiple counties, or even the whole region, should work together. Working Group members have varying abilities to implement change at their own organizations, but there needs to be an actual authority that is County- or Bay-wide, such as the directors of different County programs or a Joint Powers Authority (JPA), that can make the necessary policy, financing, or programmatic changes. Defined roles and responsibilities are critical to advancing this work.

Continuing the Working Group and expanding it to include more decision-makers, such as additional County agency staff, would enable continued cross-agency collaboration, sharing of local best practices, and the creation of design standards for the shoreline and shoreline buildings. The Working Group could become the basis to form a JPA to move adaptation planning forward at the County and local scale.

Another hurtle to implementation is the lack of funding to do adaptation planning. County and local staff are already overburdened with their existing work, and no one has time to add another item to their agenda. This means that the County needs dedicated staff to be able to move ahead with adaptation recommendations. Grants could help fund staff and consultants to advance adaptation planning.

Conclusion and Recommendations

The completion of the last two steps of the ART planning process is not the end of adaptation planning, rather it is a jumping off point for local and regional action implementation, the advancement of further collaborations and partnerships, and the identification of additional strategies for building resilience both within and beyond the Project Area. The ART Program will continue using advocacy, research, guidance and regional planning to support working group members and their stakeholders as they advance their own planning and engage in regional efforts to advance climate resilience efforts.

Actions to increase flood resilience in Contra Costa will include a continued commitment to partnerships and collaboration at the local, county, regional, state and federal scales. The County has the opportunity to partner with other county-scale efforts to exchange ideas as well as participate in ongoing and planned of regional efforts. Examples of ongoing efforts include:

- Exchange ideas with San Mateo and Marin Counties (SeaChange San Mateo and BayWAVE)
- Engage with BCDC's ART Program on developing an adaptation plan
- Track progress on the region's Resilience by Design effort and advocate for a design team to work in Contra Costa County
- Work with representatives from unincorporated Contra Costa County and from the smaller towns to build understanding and capacity for advancing resilience efforts on the shoreline
- Apply for grants to fund adaptation planning in the County
- Engage with the region's Sustainable Community Strategy update and encourage the inclusion of flood resilience in long-range planning in the 2021 plan
- Work with Delta Stewardship Council's Sea Level Rise Vulnerability Assessment
- Incorporate sea level rise into General Plan updates at the City and County scale
- Incorporate sea level rise into future transportation and goods movement plans
- Work with the Northern Waterfront Economic Development Initiative to incorporate sea level rise into future planning

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