Climate Change Adaptation Plan

Preparing Benicia for a Resilient Future

Prepared for:

THE CITY OF BENICIA CALIFORNIA

Prepared by:

ICF International

PlaceWorks

Moffat & Nichol

Michael Baker International

Date: October 2016

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the assistance from the following groups:

CITY OF BENICIA

The City of Benicia City Council, City of Benicia Community Sustainability Commission, Alex Porteshawver, Christina Ratcliffe, Dan Marks, Mike Roberts, Vic Randall, Nick Thomas, Amy Million, Rick Knight, Gina Eleccion, Steve Soloman, Mario Giuliani, Graham Wadsworth, Steven Yee, Jason Riley, Suzanne Thorsen, Heather McLaughlin, Jim Lydon, Brad Kilger, Jeff Gregory, Anne Cardwell and Karin Schnaider.

TECHNICAL ADVISORY COMMITTEE

Matt Walsh, County of Solano; Randy Scott, AMPORTS; Laura Thompson, San Francisco Bay Trail Project; Wendy Goodfriend, Bay Conservation and Development Commission (BCDC); Lindy Lowe, BCDC; Kelly Malinowski, California Coastal Conservancy; Dana Brechwald, Association of Bay Area Governments; Maureen Gaffney, SF Bay Trail Project, Stefanie Hom, Metropolitan Transportation Commission; Craig Conner, US Army Corps of Engineers; and Amy Dao, Pacific Gas & Electric Company.

City staff listed above also participated in the Technical Advisory Committee.

Invited but unable to attend meetings: Michael Stacy, Solano County Health Department; Bob Macaulay, Solano Transportation Authority; Joe Muehlbauer and Sue Fisher Jones, Valero; Bruce Riordan, Bay Area Joint Policy Committee; Sandra McLean, Solano County Water Agency; Galli Basson, SF Bay Area Water Trail; Mona Babauta, SolTrans; Matt Heberger, Pacific Institute; and Crystal Spurr, California Department of Fish and Wildlife.

COMMUNITY ADVISORY GROUP

Ric Small, Benicia Chamber of Commerce; Janice Adams, Benicia Unified School District; Larnie Fox, Arts Benicia; Dennis Cullen and John Mahoney, Portside Village; Maggie Trumbly, Historic Preservation and Review Commission; Rod Sherry, Planning Commission; Constance Beutel, Community Sustainability Commission; Rich Payne, Benicia Parks Recreation & Cemetery Commission; and Marilyn Bardet, Benicians for a Safe & Healthy Community.

Invited but unable to attend meetings: Stephanie Christiansen, Benicia Chamber of Commerce; Nancy Martinez, Benicia Main Street; Kathy Kerridge, Good Neighbor Steering Committee; Viola Robertson, Community Action Council; Jeff McEuen, Iron Workers Union; Pattie and Doug Elmore, Rancho Benicia; Lisa Lawson Stark, Union Pacific Railroad; Kenneth Trosien, The Terrace HOA; John Ash, Benicia Harbor Corporation; and Steve Goetz, California Native Plant Society.

SPECIAL RECOGNITION

The City of Benicia would like to thank the California Coastal Conservancy for its Climate Ready Grant which made this work possible, and the Bay Conservation and Development Commission for its invaluable support and guidance while working through the Adapting to Rising Tides adaptation planning process.

Table of Contents

Executive Summary....1

1. Introduction....3
   - 1.1 General Project Approach....4
   - 1.2 Project Area....7
2. Our Climate is Changing....11
   - 2.1 Today's Challenges....11
   - 2.2 Preparing for a Range of Futures....11
3. How Will Climate Change Impact Benicia?....15
   - 3.1 Key Impacts....15
4. Charting a Course of Action....42
   - 4.1 A Vision of Resiliency....42
   - 4.2 Adaptation Strategy Evaluation Process....43
5. Moving Toward Resiliency – Priority Adaptation Strategies....45
   - 5.1 Advance Current Efforts....49
   - 5.2 Win-Win Strategies....52
   - 5.3 Increase Tracking and Monitoring....60
   - 5.4 Update Existing Plans and Processes....66
   - 5.5 Coordinate with the Community and Local Businesses....78
6. Legal Considerations of Adaptation....89
   - 6.1 Possible Legal Issues....89
   - 6.2 Adaptation Strategies....91
7. AMPORTS Case Study....93
   - 7.1 Projected Climate Impacts and Vulnerabilities....93
   - 7.2 Adaptation Strategies....96

7.3 Funding Sources for Adaptation Strategies 99
8. Climate Change Adaptation Strategies for Businesses and Homeowners 103
8.1 Extreme Temperatures 103
8.2 Sea Level Rise, Storm Surge, and Flooding 104
9. Moving Forward 105
Appendix A: Evaluation Criteria A-1
Appendix B: Compendium of Adaptation Strategies B-1
Appendix C: UC Berkeley Legal Report C-1
Appendix D: AMPORTS Energy Efficiency/Renewable Energy Case Study D-1
Appendix E: Vulnerability Assessment E-1
Appendix F: Existing Conditions Report F-1
Appendix G: Climate Science Summary G-1
Appendix H: Carbon Lighthouse/OpTerra AMPORTS Reports H-1

TABLE OF TABLES

Table 1: Range of Projected Changes in Temperature 12
Table 2: OPC Sea Level Rise Projections 14
Table 3: Key Climate Change Impacts on Benicia 16
Table 4: Adaptation strategies by type, geographic area, and start year 46
Table 5: Order of magnitude costs for strategy implementation 48

TABLE OF FIGURES

Figure 1: Adapting to Rising Tides Planning Process. 5
Figure 2: Location of the City of Benicia 8
Figure 3: Project Area Map 9
Figure 4: Citywide sea level rise inundation map for the 2-foot total water level scenario 17
Figure 5: Downtown and the Port sea level rise inundation map for the 2-foot total water level scenario 19
Figure 6: Citywide sea level rise inundation map for the 5-foot total water level scenario 21
Figure 7: Downtown and the Port sea level rise inundation map for the 5-foot total water level scenario 23
Figure 8: Comparison between the FEMA 100-year flood zone and 5 feet of sea level rise 25

Figure 9: Current Benicia State Recreation Area Marsh Conditions 31
Figure 10: Benicia State Recreation Area in 2050, low vertical accretion and low levels of organic material. 33
Figure 11: Benicia State Recreation Area in 2050, high vertical accretion and high levels of organic material 35
Figure 12: Benicia State Recreation Area in 2090, low vertical accretion and low levels of organic material 37
Figure 13: Benicia State Recreation Area in 2090, high vertical accretion and high levels of organic material 39
Figure 14: Fully armored breakwaters, such as this one in Alameda, can help reduce flooding from coastal storms but may make conditions worse elsewhere 49
Figure 15: Glass flood wall. 51
Figure 16: Oakland Adopt a Drain program website. Green markers are adopted drains and hovering over them will display the name of the individual (and the name of their workplace, if desired) that adopted the drain. 53
Figure 17: A ready supply of sandbags helps make it easier for City staff to construct flood barriers before a storm occurs 55
Figure 18: Green infrastructure rain garden. 59
Figure 19: Aerial photograph of the WWTP and the proximity to Carquinez Strait. Sea walls are indicated in red. 66
Figure 20: Five feet of sea level rise overlaid on the City's land use map 73
Figure 21: Downtown and Port focused overlay of 5 feet of sea level rise and the City's land use map 75
Figure 22: Image of Sulphur Springs Creek (highlighted in blue) 83
Figure 23: Five feet of sea level rise traveling up the creek (highlighted in blue) 85
Figure 24: FEMA 100-year flood zone and 5 feet of sea level rise 87
Figure 25: Flooding in the Port area with 5 feet change in total water level 95

EXECUTIVE SUMMARY

The City of Benicia has prepared this Adaptation Plan to address environmental vulnerabilities caused by climate change and to proactively prepare for these hazards and reduce the potential harm to the community. Benicia, located along the north shore of the Carquinez Strait in the San Francisco Bay Area, is vulnerable to a variety of natural hazards that are likely to become more frequent and more severe due to the effects of climate change. The effects of climate change in Benicia include sea level rise, more frequent and intense heat waves, and an increase in the number of flood events. A number of different locations and assets in Benicia are likely to be affected by these hazard events, including:

Heat waves

- Key local government facilities, such as City Hall, the Benicia Community Center, schools, the police station, and the fire station

Sea Level Rise/Flooding

- Waterfront properties, including homes and nonresidential buildings
- Parts of the Benicia Industrial Park
- The Benicia Marina
- Waterfront roads and trails
- The Port of Benicia
- The Benicia Wastewater Treatment Plant
- Marshland at Benicia State Park, the Benicia Industrial Park, and the Benicia Marina
- Energy and stormwater infrastructure

City staff explored 121 potential adaptation strategies, evaluating each strategy for its environmental impacts, ability to protect people, economic effects, costs relative to benefits, co-benefits, and political feasibility. Following an extensive evaluation process, City staff, including departmental leads, identified 11 priority strategies for near-term implementation to include in the plan. Additional strategies that were not prioritized will be periodically reexamined and implemented as feasible. These 11 priority adaptation strategies are:

- Prepare a Downtown sea level rise adaptation strategy.
- Develop a "Maintain-A-Drain program."

- Increase emergency preparedness for the wastewater collection system.
- Train Public Works Department employees in flood response and coordinate with the Fire Department on the BERT program.
- Increase pre-event storm water infrastructure maintenance, and invest in green infrastructure.
- Track extreme weather costs.
- Monitor the need to expand the Wastewater Treatment Plant's flood protection measures.
- Incorporate consideration of sea level rise into the City's Capital Improvement Program, and into the design and funding of infrastructure.
- Incorporate additional climate change considerations into City plans and codes.
- Incorporate sea level rise and coastal flooding potential into existing and future recovery plans.
- Coordinate flood planning along Sulphur Springs Creek.

Each priority strategy includes information on the responsible City department and supporting agencies, the ability to integrate the strategy with existing City plans, costs and benefits of the strategy, and a timeline for a strategy implementation.

Beyond these priority strategies, the City will have to implement strategies that address other critical issues related to climate change adaptation. Adequate staffing, collaboration with external agencies is vital to successful implementation efforts, as is securing the necessary funding to implement these other strategies.

1. INTRODUCTION

The City of Benicia is a waterfront community in the San Francisco Bay Area. As one of California's early capitals, it is full of history—home to the first West Coast US Army post, a railroad car ferry, and numerous other historic sites. Today, Benicia is home to a thriving arts community, beautiful weather and scenic vistas, and a downtown full of charming boutiques and antique shops.

Adaptation is typically defined as recognition that future conditions in Benicia may not necessarily match historic conditions, as climate change affects temperatures, precipitation, and sea levels. Benicia will have to prepare for these new conditions, implementing proactive strategies to lessen the impacts of climate change and reduce risk to key areas and assets throughout the city. This adaptation plan is a forward-looking document, intended to help Benicia prepare for and adapt to the effects of climate change.

In order to maintain its high quality of life, prosperous businesses, productive ecosystems, and vibrant neighborhoods, Benicia is proactively planning for the challenges that a changing climate brings. To do so, Benicia has completed a comprehensive climate change vulnerability assessment and adaptation planning process to identify adaptation measures that are sustainable, equitable, economically viable, cost-effective, and, where feasible, able to be integrated into existing and future City plans. This Adaptation Plan will help Benicia become a more resilient city that can manage the risks of today, as well as those of tomorrow.

Building on the ART Project

The City of Benicia climate change adaptation project is modeled after the San Francisco Bay Conservation and Development Commission's (BCDC) Adapting to Rising Tides (ART) project. During the ART project, BCDC, with support from the National Oceanic and Atmospheric Administration Coastal Services Center (NOAA CSC), undertook a detailed sea level rise vulnerability assessment project in Alameda County.

The ART project developed and piloted a process for conducting vulnerability assessments by bringing together a broad suite of stakeholders and experts to collectively gain a better understanding of how climate change will affect the ecosystems, infrastructure, and economy of Alameda County.

The City of Benicia is using the tools and framework developed for the ART project as much as feasible. Due to the differing scales of analysis (city versus region) and project timeline, the tools have been customized for a local planning effort. For more information on the ART project, please see http://www.adaptingtorisingtides.org/.

This plan provides an overview of projected climate changes and the vulnerability assessment report (see Appendix E), a description of the adaptation strategy development process (a complete set of adaptation strategy evaluation criteria and strategies can be found in the report appendices), and an in-depth description of 11 priority strategies.

This work is funded through the California Coastal Conservancy's Climate Ready Grant Program (Round 1). The grant program seeks to help California's coastal communities act now to prepare

for climate change effects. Approval or adoption of this Adaptation Plan does not bind the City to take action on the items included herein, but such items should be considered and implemented as feasible and appropriate. In 2014, the City completed the Urban Waterfront Enhancement and Master Plan in partnership with the Coastal Conservancy, a master plan for a 16-acre waterfront park that included sea level rise adaptation and long-term resilience as core objectives. This waterfront park master plan has been incorporated as one discrete project recommended by this Adaptation Plan, which includes recommendations to guide adaptation efforts in vulnerable areas along the entire 10-mile Benicia shoreline. The City of Benicia is using its grant to build upon prior and ongoing sustainability efforts in the city, such as Climate Action Plan (CAP) implementation. The City is committed to reducing greenhouse gas emissions by implementing CAP strategies such as increasing renewable energy and making City facilities more efficient. In this effort, the City is examining ways to prepare for a future climate that is different from that of today.

Recent legislation and government guidance supports climate adaptation planning. In 2015, California adopted Senate Bill 379, requiring upon the next revision of a local hazard mitigation plan on or after January 1, 2017, and beginning on or before January 1, 2022 that communities address the effects of climate change in the Safety Element of their General Plan. City staff has already utilized hazard information and adaptation strategies from this Plan as it updated the Local Hazard Mitigation Plan, which satisfies part of the SB 379 requirements. The information included in this adaptation plan will also allow Benicia to easily integrate discussions about the effects of climate change and policies the City can take to reduce climate change-related impacts into the next General Plan update or update of the Safety Element on or before January 1, 2022. In 2016, the Federal Emergency Management Agency (FEMA) began requiring state hazard mitigation plans to address the effects of climate change to maintain eligibility for certain grant funds. While California's mitigation plan already meets this requirement, the Benicia adaptation plan is consistent with federal and state efforts to address climate change, and can serve as an example to neighboring jurisdictions.

1.1 GENERAL PROJECT APPROACH

This project follows the Adapting to Rising Tides Planning Process (see Figure 1), developed by the San Francisco Bay Conservation Development Commission (BCDC), and includes the following phases:

FIGURE 1: Adapting to Rising Tides Planning Process.

Source: BCDC

- Scope and Organize. The scoping process was completed in September 2014, and included three primary activities.

  First, two advisory groups were convened to provide input throughout the project. The Technical Advisory Committee (TAC) consists of local, regional, and state public agencies that own, operate, or otherwise contribute to the planning and funding of infrastructure in Benicia. The Community Advisory Group (CAG) consists of members of the public with a vested interest in the project (e.g., homeowners, business owners, community group representatives, and City commissioners). The project team held a three-hour kickoff meeting with each group. Both groups learned about project objectives, identified existing conditions, and brainstormed project goals. The TAC provided more technical information related to existing assets and infrastructure. For example, Pacific Gas and Electric Company (PG&E) discussed its critical infrastructure in the project area.

  Second, Benicia climate change projections were created using downscaled data on climate change (i.e., generating locally relevant data from global climate models) from publicly accessible data sets and tools. Climate scenarios were developed for sea level

rise and storm surge (total water levels[1]), precipitation, and changing temperatures. Based on the severity of the climate change variables, sea level rise and extreme temperatures were selected for focused evaluation in the vulnerability assessment. The climate scenario data is summarized in Section 2 of this report and presented in detail in Appendix G: Climate Science Summary.

Third, the TAC and CAG provided input on the selection of community assets and geographic areas for analysis in this study. The project team selected a diverse range of assets to 1) cover different types of infrastructure and community assets found in the project area, and 2) serve as representative assets that can provide insight on other vulnerable assets in the project area that were not selected for further analysis (e.g., not *all* roads were assessed, only select roads in key locations). A summary of these assets is presented in Section 3 and further information is presented in Appendix E: Vulnerability Assessment.

- Assess. The City of Benicia is already vulnerable to current hazards such as flooding, earthquakes, and wildfires. It is important to understand how infrastructure has been affected in the past and how asset managers might deal with the same or exacerbated future events. This information is documented in Appendix F: Existing Conditions Report.

- Define. The vulnerability report discusses how sea level rise, storm surge, and changes in temperature will impact Benicia. It discusses potential vulnerabilities in the following sectors: community facilities and services, transportation, Port of Benicia, wastewater, storm water, natural areas/shoreline protection, and energy and pipeline infrastructure. Vulnerabilities are summarized in Section 3 in this report and the full report is included in Appendix E: Vulnerability Assessment.

- Plan. Section 4 of this report outlines the process of developing and selecting high priority climate change adaptation strategies for the City of Benicia. The project team developed evaluation criteria to help focus this plan on priority adaptation strategies (see Appendix A: Evaluation Criteria). A wide range of potential adaption strategies was developed and evaluated using the evaluation criteria (See Appendix B: Compendium of Adaptation Strategies). The highest priority strategies were then evaluated further in this plan. These strategies underwent a qualitative evaluation to determine their impacts on the economy, the environment, and social equity to determine priority actions. The top adaptation strategies are described in more detail in Section 5. Legal implications of potential adaptation strategies are presented in Section 6 and described in greater detail in Appendix C: UC Berkeley Legal Report. A case study is presented for AMPORTS in

[1] "Total water level" refers to the absolute water level resulting from any combination of sea level elevations, tidal influence, and storm surge. This allows consideration of a range of potential flooding conditions. For example, a studied total water level may correspond to current 100-year storm conditions as well as future 50-year or 20-year storm conditions combined with certain levels of sea level rise.

regard to sea level rise in Section 7 and an energy efficiency and renewable energy study is presented in Appendix D: AMPORTS Energy Efficiency/Renewable Energy Case Study. Section 8 provides information on adaptation strategies that could be implemented by local businesses, and Section 9 presents next steps.

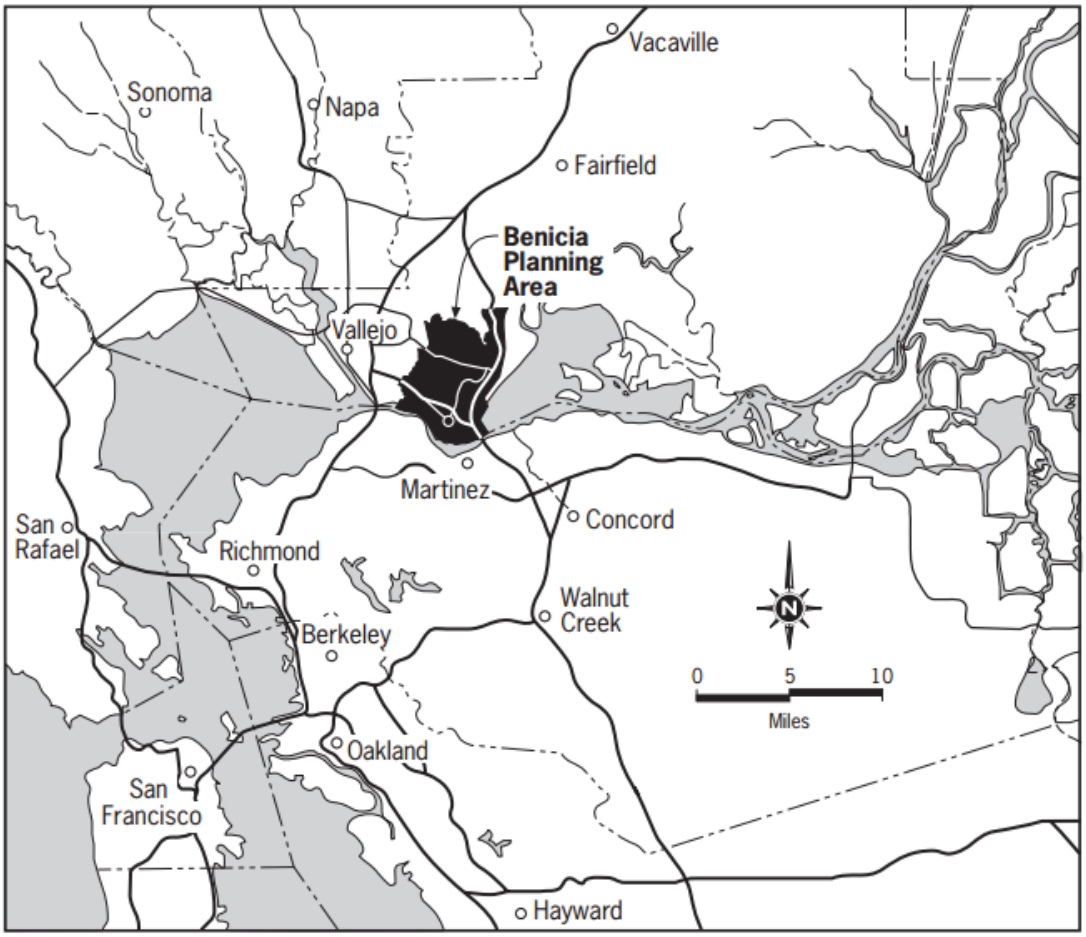
- Implement and Monitor (following this project). Although outside the scope of this project, implementing and monitoring climate change and adaptation strategies will be vital steps in the climate change resiliency process.

1.2 PROJECT AREA

The 1999 General Plan describes Benicia's location (see Figure 2) in the region as follows:

> "Benicia is approximately 35 miles northeast of San Francisco and 57 miles southwest of Sacramento. It lies on the north shore of the Carquinez Strait, where the combined flow of the Sacramento and San Joaquin rivers have cut a deep gorge through the coast range. The Strait is a crucial link in Northern California's inland waterway, connecting San Pablo Bay and San Francisco Bay to the west with the Sacramento and San Joaquin river delta to the east. Through the Strait, ocean-going ships can reach the Port of Benicia, or can continue on to the Central Valley ports of Sacramento and Stockton.
>
> The city is built on a peninsula of land that reaches south from the main body of Solano County and creates a prominent bend in the Carquinez Strait. From this peninsula, highway and railroad bridges span the Strait to connect Benicia with the Contra Costa County cities of Martinez and Concord. This is the one place where both trucks and railroad cars can cross the San Francisco Bay/Sacramento River waterway. The rail line and I-680 provide easy access to Benicia from the north and south; I-780 (which the city straddles) provides access from the west.
>
> The landscape is made up primarily of rolling hills, rising to an elevation of 1,160 feet. On the west boundary, Sulphur Springs Mountain reaches approximately 950 feet. Two major drainages—Sulphur Springs Creek in the west, and Paddy Creek in the east—run approximately north-south through the Planning Area. The flow from Sulphur Springs Creek is contained by Lake Herman before being joined by Paddy Creek and continuing into the Benicia Industrial Park.
>
> The rolling hills reach almost to the shoreline; very little of Benicia is flat. On the southern margins of the city, the land slopes gently down to the Carquinez Strait. Most of the older residential areas and the Downtown are here. The eastern city limits are bordered by the marshlands of Suisun Bay. Relatively flat areas adjacent to the marshes provide sites for industry. At the southwestern boundary of the Planning Area, another flat, marshy area has been preserved as the "Benicia State Recreation Area."

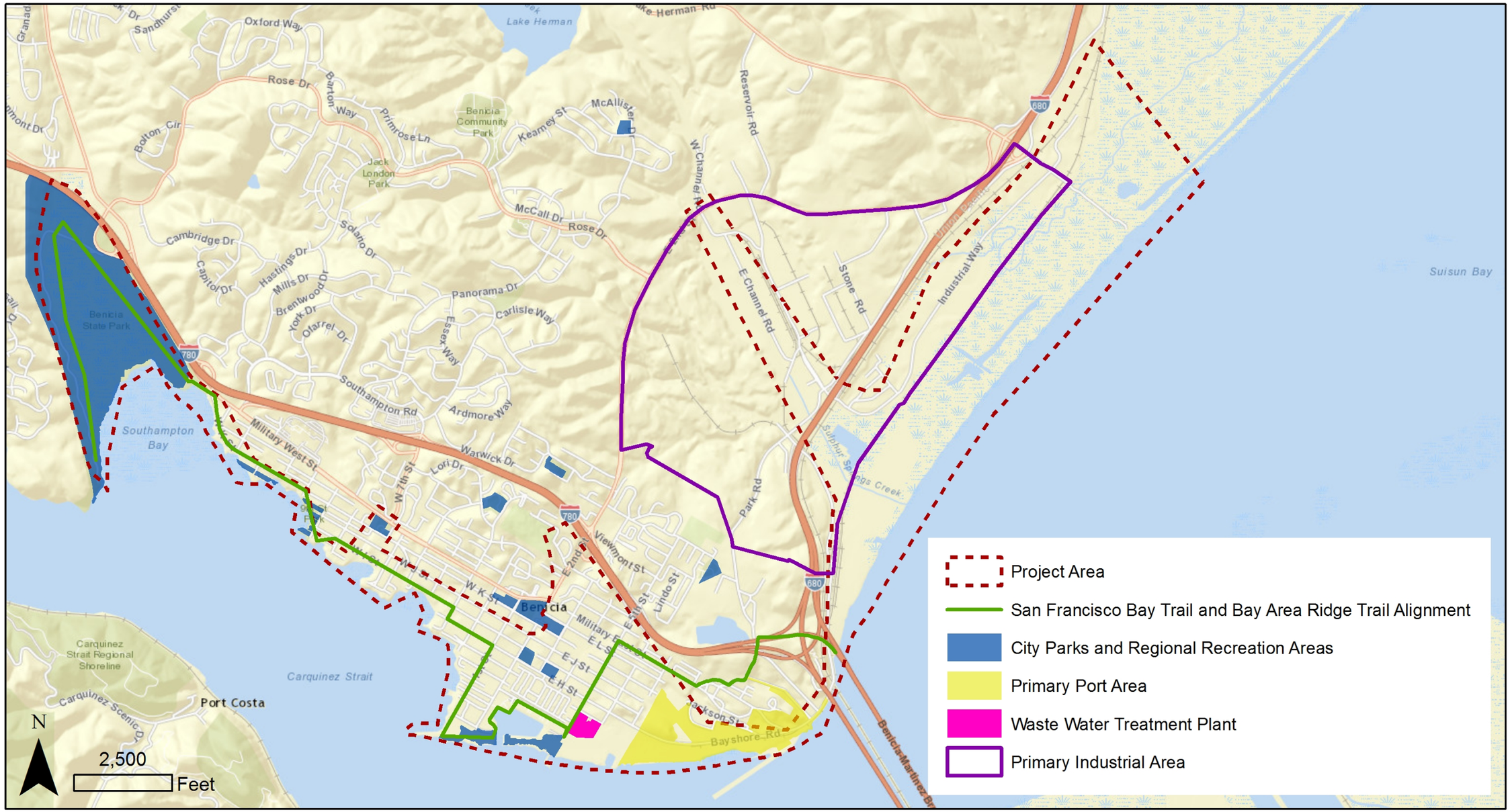
FIGURE 2: Location of the City of Benicia



Source: Benicia General Plan

The project area for the adaptation plan is located along the City's shoreline, extending from the Benicia State Park in the west to the City's eastern extent, just past the east end of the Benicia Industrial Park, as can be seen in Figure 3. The project area near the shoreline is relatively flat and then slopes upward in general as one proceeds farther from the shoreline. The project area has a strong and relatively persistent breeze. The shoreline area encompasses a variety of land uses, including natural areas (e.g., marshes, wetlands, parks, beaches); park areas (some of which contain natural habitat); residential, commercial, and industrial development; critical infrastructure, such as the Wastewater Treatment Plant; certain roadways; and the Port of Benicia. The industrial area of Benicia borders a large residential neighborhood, a military cemetery, a park, a National Guard facility, and an open space buffer. The purple line in Figure 3 is intended to illustrate the general Industrial Park area, but may include nonindustrial areas that directly border the Industrial Park.

FIGURE 3: Project Area Map



There is no content on this page

2. OUR CLIMATE IS CHANGING

2.1 TODAY'S CHALLENGES

Benicia currently experiences natural hazards that impact residents, businesses, and infrastructure. These stressors, as identified by the project team and addressed in the Benicia General Plan (1999), include earthquakes, storm surge, flooding, wildfires, landslides, extreme temperatures, and drought. Some of these existing stressors are projected to be exacerbated by climate change, such as sea level rise, storm event intensity and frequency, inland flooding, extreme temperatures, and drought. Planning for a more resilient future can also help to alleviate the issues of today. For example:

- In 2005, a 40-year storm event coupled with extreme high tides with heavy rain resulted in coastal water overtopping local flood protection structures. Because the storm water outfalls were submerged during the high tide event, the water could not drain out of the storm drain system and water backed up in the drains. Flooding occurred in inland areas including Fitzgerald Field and private property along the alley between East G and East H Streets and between First and East Second Streets. With sea level rise, storm water drainage issues are expected to increase as outfalls become submerged and there is no place for the water to drain. This combination of high seas with heavy rain events is projected to occur more frequently, resulting in further flooding of downtown, waterfront residential neighborhoods, and other portions of the city.

- With summer temperature increases and lengthening heat waves, mortality rates during heat waves are anticipated to rise. Particularly severe heat waves, such as the heat event in July 2006, can kill hundreds of people at a time over the affected area, or even in a single city (a 1995 heat wave killed 739 people in Chicago alone). Some populations, such as elderly persons and young children, are especially vulnerable, as are people who spend a lot of time outdoors. Communities with mild climates, such as Benicia, are also more vulnerable to extreme heat than more inland locations because coastal areas are less used to such high temperatures.

- A 2012 storm event resulted in a series of significant flooding events for the residents of St. Augustine Drive and other locations in the city. In total, it will cost the City over $900,000 to design and build improvements to increase storm water drainage capacity. Similar and significant storms also took place in 2014.

More information on these existing natural hazards and historical impacts on City of Benicia infrastructure can be found in Appendix F: Existing Conditions Report.

2.2 PREPARING FOR A RANGE OF FUTURES

Climate change projections vary based on future global emissions assumptions and the models used. The projections show a range of future climate conditions that are all considered equally plausible at the projected point in time. For this project, Benicia-specific climate change

projections were created using downscaled climate change data (i.e., generating locally relevant data from global climate models) from publicly accessible data sets and tools. The downscaled data shows that in Benicia, the two climate stressors that would change the most from historical patterns are sea level rise and temperature extremes. Therefore, these two stressors are the focus of the assessment of impacts to Benicia and selection of adaptation strategies. Additional information on the climate change projections and the methods and tools used for the projections can be found in Appendix G: Climate Science Summary.

Temperatures are Rising

Temperature projections are derived from the World Climate Research Programme's Fifth Coupled Model Intercomparison Project (CMIP5). CMIP5 averages the projections of many climate models under different future greenhouse gas emissions scenarios. This report used the US Department of Transportation's CMIP5 Climate Data Processing Tool[2] to process the model outputs into variables that are useful for planning and engineering.

While the average annual temperature is projected to only increase by a few degrees under these scenarios, Benicia may experience many more days of extreme heat (defined as days over 92.4°F in Benicia; see Table 1 for more information). Between 2046 and 2065, there is projected to be an average of approximately two months (54 to 66 days) of temperatures over 92.4°F (historically, 95% of days in Benicia have fallen below this temperature). In the recent past, temperatures reached this threshold only 18 days per year on average. Looking out to 2080 to 2099, these high temperatures may occur even more frequently (up to 62 to 101 days per year).

Additional information on the hottest days and the length and intensity of heat waves is included in Table 1.

TABLE 1: RANGE OF PROJECTED CHANGES IN TEMPERATURE

VARIABLE	BASELINE (1950–1999) OBSERVED	MIDCENTURY (2046–2065) PROJECTED	END-OF-CENTURY (2080–2099) PROJECTED
Average Annual Mean Temperature	59°F	62–63°F	63–67°F
Hottest Temperature of the Year	102°F	107–108°F	108–112°F

[2] More information and access to the tool is available at: https://www.fhwa.dot.gov/environment/climate_change/adaptation/adaptation_framework/modules/index.cfm?moduleid=4#tools

VARIABLE	BASELINE (1950–1999) OBSERVED	MIDCENTURY (2046–2065) PROJECTED	END-OF-CENTURY (2080–2099) PROJECTED
Average Number of Days per Year above 92.4°F (95% of days in Benicia have historically fallen below this temperature)	18 days	54–66 days	62–101 days
Maximum Number of Consecutive Days per Year above 92.4°F (lengthening heat waves)	5 days	Up to 36-48 days days	Up to 44 to 83 days
Average Summer Temperatures	84° F	88–89° F	89–93° F
Highest 4-Day Average Summer Temperature	98° F	102–104° F	103–107° F

Source: CMIP5 Climate Data Processing Tool

Rising Sea Levels are Increasing Coastal Flooding

Sea levels have risen in the past and are projected to continue rising at an increased rate due to climate change. For Benicia and other coastal communities, without intervention, this will lead to further flooding, or even permanent inundation of critical structures, infrastructure, and natural habitats. Consistency among planning agencies allows for an apples-to-apples comparison of the future effects of sea level rise and appropriate adaptation measures. Many agencies in California, including the California Coastal Conservancy, are using the state Ocean Protection Council (OPC) 2013 guidance, which includes the scientific findings of the National Research Council Sea Level Rise for the Coasts of California, Oregon, and Washington study, released June 2012. These findings model sea level rise north and south of Cape Mendocino (approximately 200 miles northwest of Benicia, in Humboldt County). Cape Mendocino is an appropriate dividing point because there are different geologic pressures and factors north of the cape than there are south of it, resulting in different amounts of sea level rise. Sea level rise south of Cape Mendocino is more applicable to Benicia.

This guidance recommends assessing between 5 and 24 inches of sea level rise by midcentury and between 17 and 66 inches by the end-of-century (see Table 2). In 2010, the Adapting to Rising Tides project (BCDC and NOAA) suggested using16 inches of sea level rise by midcentury and 55 inches by end of century; however, BCDC now recommends using the higher OPC numbers.

TABLE 2: OPC SEA LEVEL RISE PROJECTIONS

TIME PERIOD	NORTH OF CAPE MENDOCINO	SOUTH OF CAPE MENDOCINO (APPLICABLE TO BENICIA)
2000–2030	-4 to 23 cm (-1.6 to 9 inches)	4 to 30 cm (1.6 to 11.8 inches)
2000–2050	-3 to 48 cm (-1.2 to 18.8 inches)	12 to 61 cm (4.7 to 24 inches)
2000–2100	10 to 143 cm (3.6 to 56 inches)	42 to 167 cm (16.6 to 65.8 inches)

This project used three sea level rise scenarios:

1. 12 inches (1 foot) representing the low midcentury projection.
2. 24 inches (2 feet) representing the high midcentury projection as well as the low end-of-century projection.
3. 60 inches (5 feet) representing the high end-of-century projection.

Fortunately, these three levels can represent far more than static points in time when using the total water level approach, which allows for the simultaneous consideration of changes in short-term storm-related flooding as well as long-term permanent inundation areas. Permanent inundation occurs when an area is exposed to regular daily tidal inundation. A permanently inundated area can no longer be used in the same way due to the frequency of its exposure to the Bay's tides. In contrast, periodic flooding occurs when an area is exposed to episodic, short duration such as extreme tide events of greater magnitude than normal tide levels. Inland areas may be temporarily flooded during an extreme tidal event while maintaining at least a portion of their functionality once the floodwaters recede. However, sensitive assets may suffer irreversible damage if exposed to any amount of water, even temporarily.

The NOAA Digital Coast Sea Level Rise data was used to produce project maps which are presented in the next section. This resource uses the most recent Light Detection and Ranging (Lidar) digital elevation data sets to determine areas of inundation that are hydrologically connected to the water. Hydrologic connectivity is important because it takes into account some of the existing shoreline protection features and changes in elevation. Although it cannot be guaranteed that all existing shoreline protection measures will be maintained into the future, it would be inaccurate and unrealistic to assume that all will disappear. The shoreline protection features that are not adequately captured in the NOAA dataset include thin/narrow infrastructure such as flood walls. Therefore, the sea level rise maps may overstate the extent of flooding in certain locations, such as the Benicia Wastewater Treatment Plant, which is protected by a seawall, so this area may appear to be flooded earlier than would occur in reality.

3. HOW WILL CLIMATE CHANGE IMPACT BENICIA?

Extreme temperatures and sea level rise, particularly in combination with storm surges and extreme high tides, are expected to affect Benicia, including the local economy and natural environment, in coming years and decades. The project team prepared a vulnerability assessment for Benicia, which examined the susceptibility of community assets (buildings, infrastructure, ecosystems, key services, etc.) to climate change effects. The full results of the vulnerability assessment are shown in Appendix E.

The vulnerability assessment focused on key assets in the community. Key stakeholders, including community members and businesses, were invited to identify these key assets and areas of concern. Some of these stakeholders elected not to participate or provided only limited information; these entities may be conducting vulnerability assessments or planning for future climate-related impacts on their own. The TAC and CAG selected key sectors for further evaluation, based on input from asset managers, the results of a public survey, the project team's professional judgement, and existing literature on the issue. The following key sectors were examined:

- Buildings and infrastructure in Benicia
- Community members
- Local transportation networks, including roads, transit systems, bicycle and pedestrian paths, and rail lines
- The Port of Benicia
- The Benicia Wastewater Treatment Plant
- Benicia's storm water systems
- Natural habitats along the Benicia shoreline
- Energy infrastructure in Benicia

3.1 KEY IMPACTS

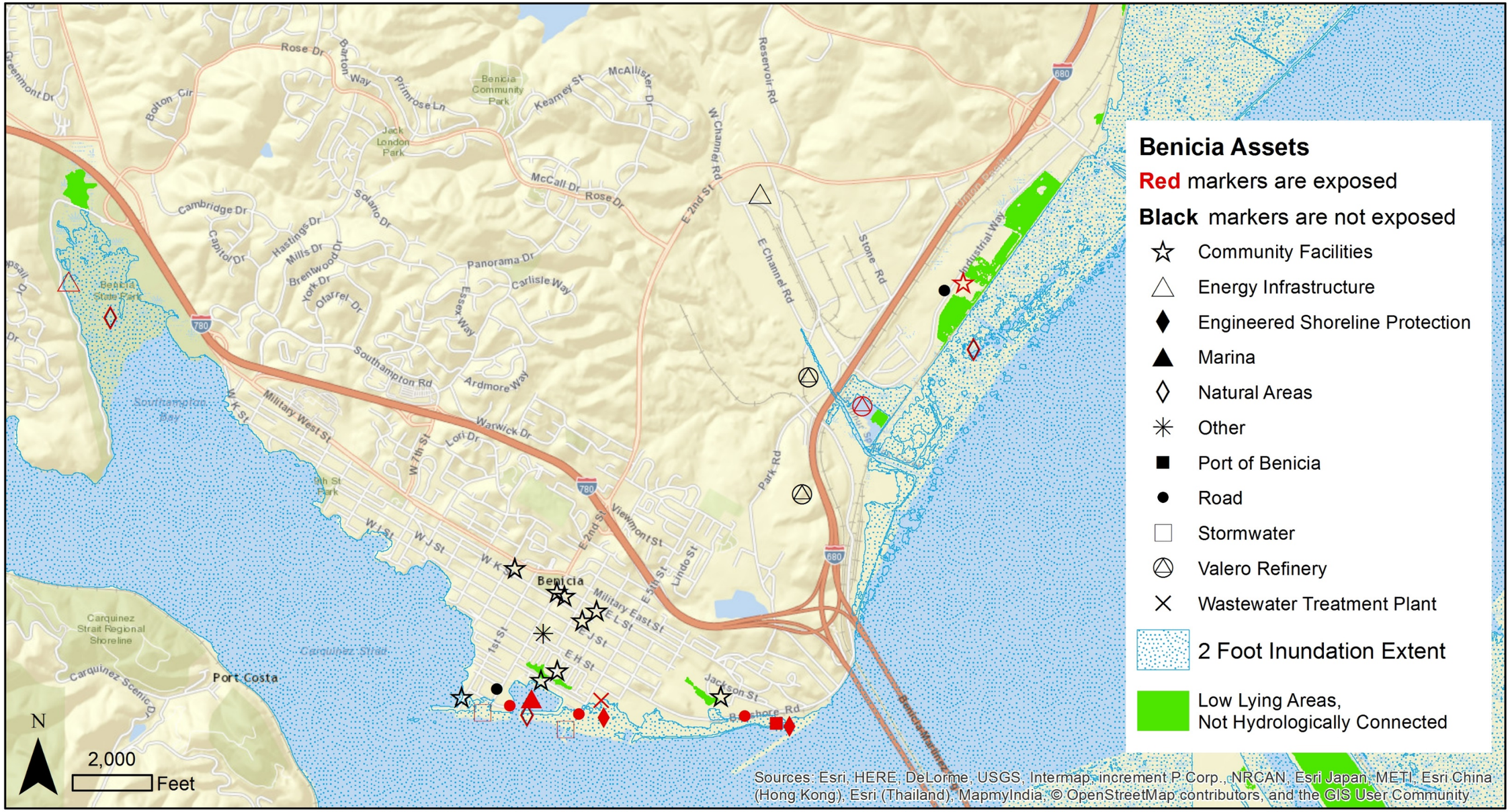
Climate change is expected to have a number of different effects on Benicia. These effects are summarized in Table 3 and discussed in greater detail on the next page.

TABLE 3: KEY CLIMATE CHANGE IMPACTS ON BENICIA

SECTOR	KEY IMPACTS
Buildings and infrastructure	Risk of damage or inundation from sea level rise and flooding. Mechanical and electrical infrastructure subject to increased stress from extreme heat.
Community members	Risk of death, injury, and property damage from sea level rise and flooding. Persons with mobility challenges may have trouble evacuating. Extreme heat is very dangerous for young children, the elderly, and outdoor workers. Lower-income persons are more vulnerable.
Transportation networks	Some streets and trails are subject to temporary or permanent flooding from sea level rise. Rail lines may be flooded. Disruption to transportation networks can affect local businesses.
Port of Benicia	Sections of the Port may temporarily flood, reducing Port activity. Port workers are at risk from extreme heat.
Benicia Wastewater Treatment Plant	Facility may be flooded from sea level rise and coastal storms. Discharge pipe could be less effective with sea level rise. Wastewater treatment services may be scaled back or halted.
Storm water systems	Sea level rise can damage storm drains or reduce their effectiveness, leading to local flooding. Standing water may attract mosquitos.
Natural habitats	Marshlands may convert to mudflats, changing local habitats and reducing ecosystem services.
Energy infrastructure	Extreme heat can stress electricity infrastructure and reduce service reliability. Sea level rise can corrode pipelines and other infrastructure, causing outages.

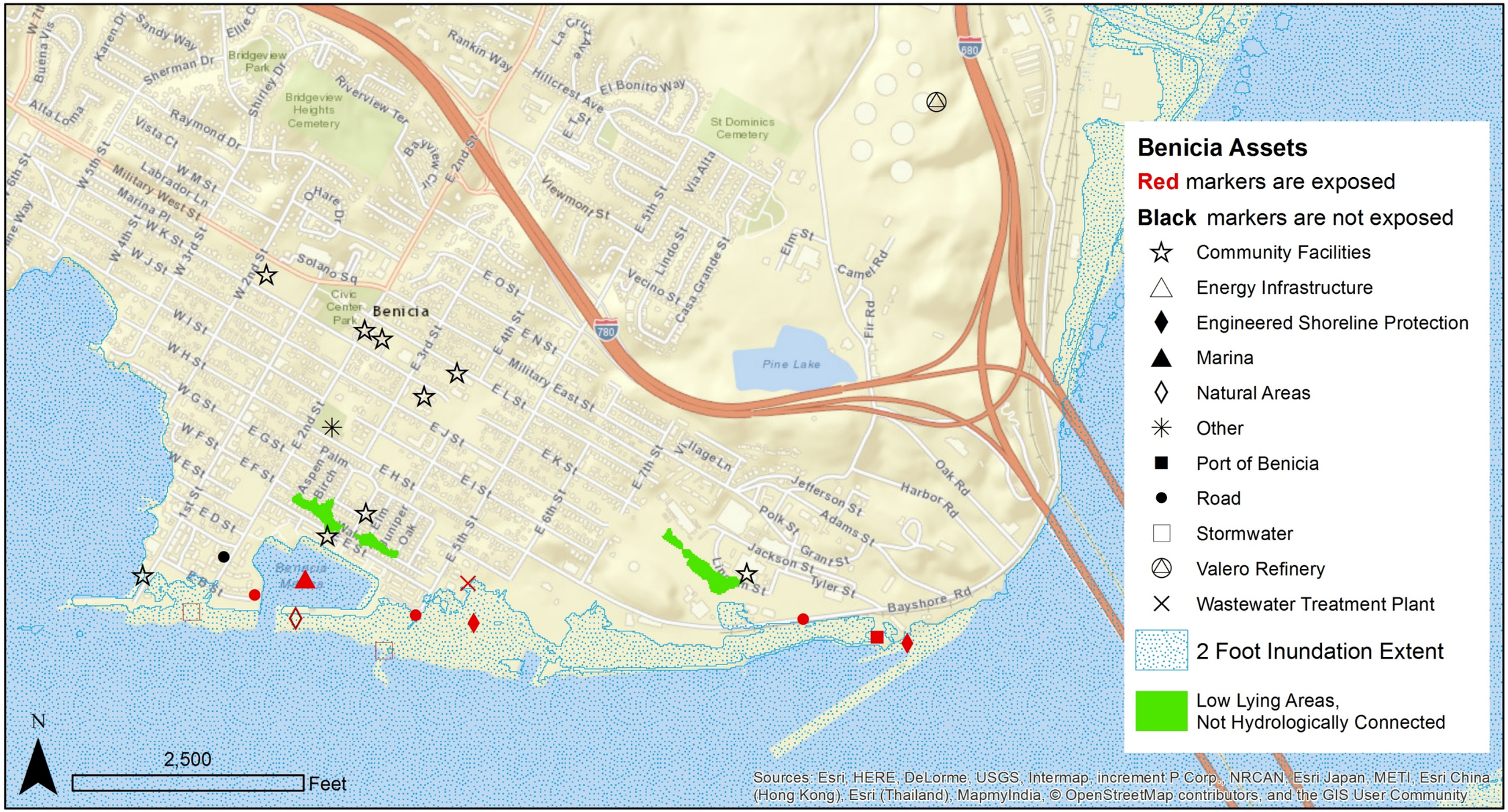
Some of Benicia's buildings and infrastructure are highly vulnerable to sea level rise and associated flooding, which in turn puts residents and employees at risk. Many of these facilities have previously flooded during storm events and high tide/storm events due to inadequate drainage, and a number of properties may be temporarily or permanently inundated in the future. By the middle of the century, the Benicia Marina area (specifically land between 1st and E. 5th Street, north of I Street) is likely to face daily flooding. At least one storm drain in this area is already surcharged during king tide events and causes the well-used parking lot to flood. A number of other facilities, including parts of the downtown commercial area, the Benicia Industrial Park, and several residential complexes, may face daily flooding by 2100. The flooding risk is also compounded by the vulnerability of Benicia's storm water infrastructure (discussed in greater detail below). Figures 4 through 8 show community assets that may be affected by permanent sea level rise and temporary flooding linked to it. Buildings in Benicia are generally more resilient to extreme heat, and are unlikely to face direct structural damage during very high temperatures. However, some mechanical or electrical infrastructure may break down or become stressed during extreme heat events.

FIGURE 4: Citywide sea level rise inundation map for the 2-foot total water level scenario



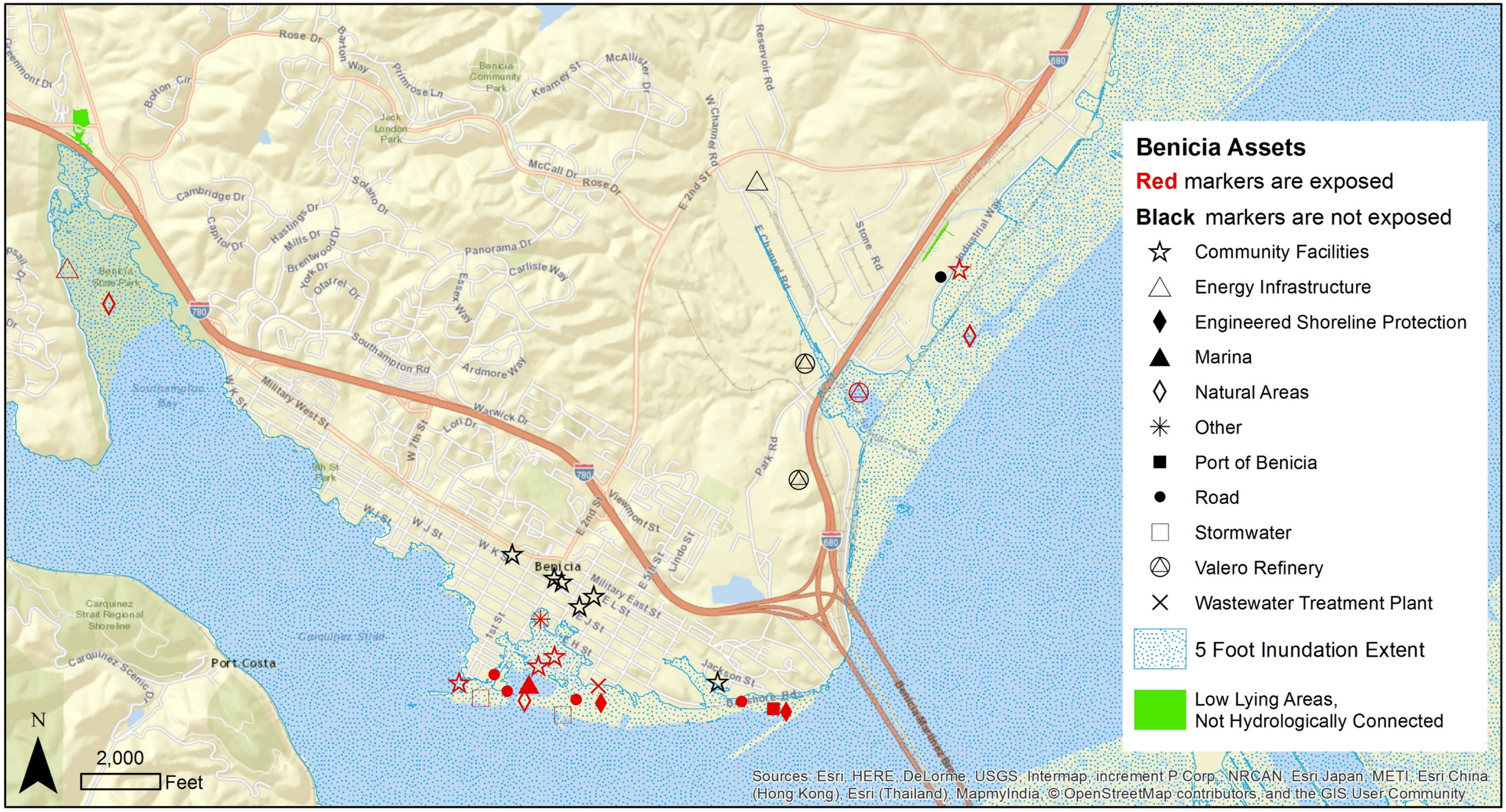
There is no content on this page.

FIGURE 5: Downtown and the Port sea level rise inundation map for the 2-foot total water level scenario



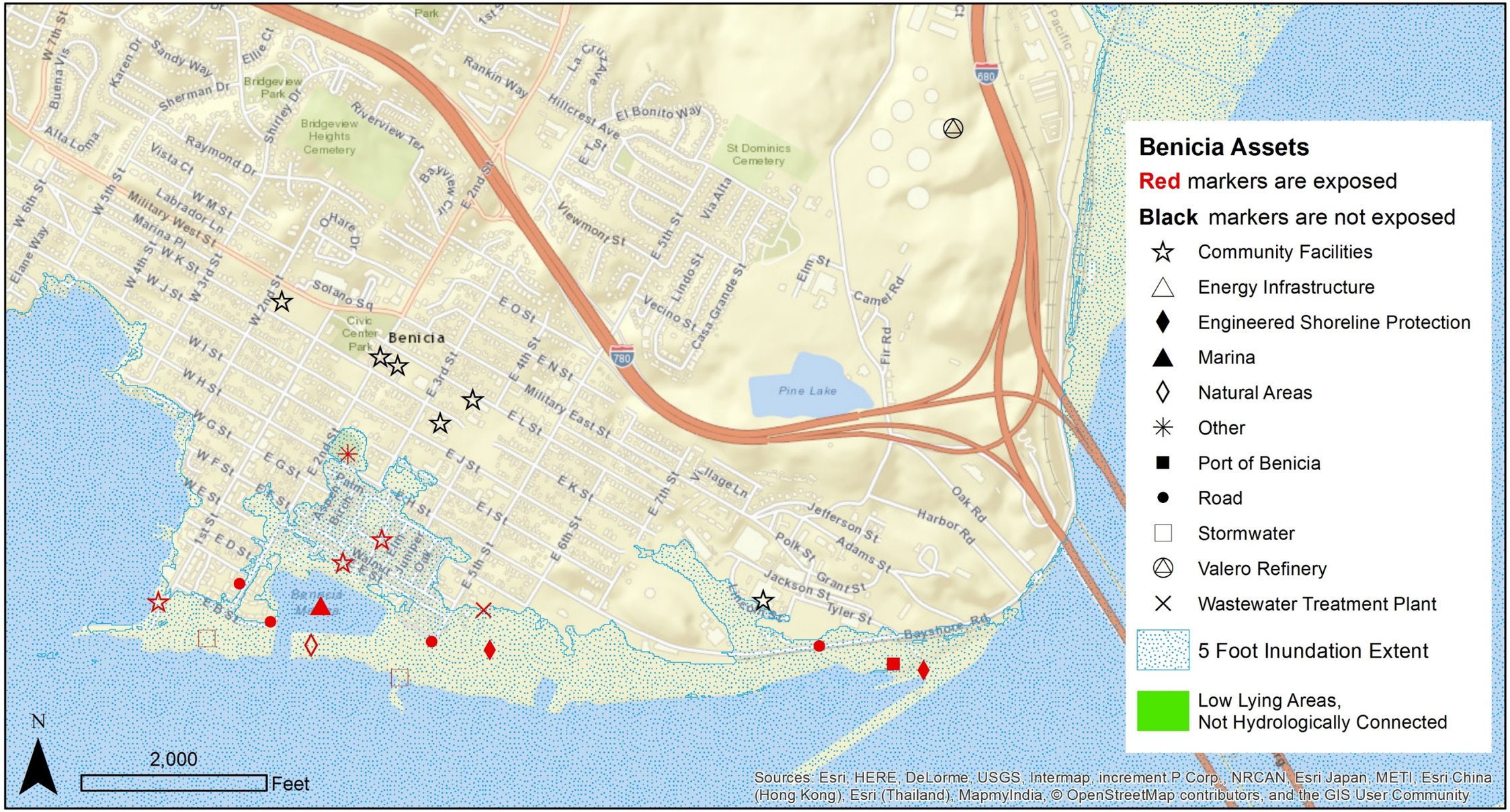
There is no content on this page

FIGURE 6: Citywide sea level rise inundation map for the 5-foot total water level scenario



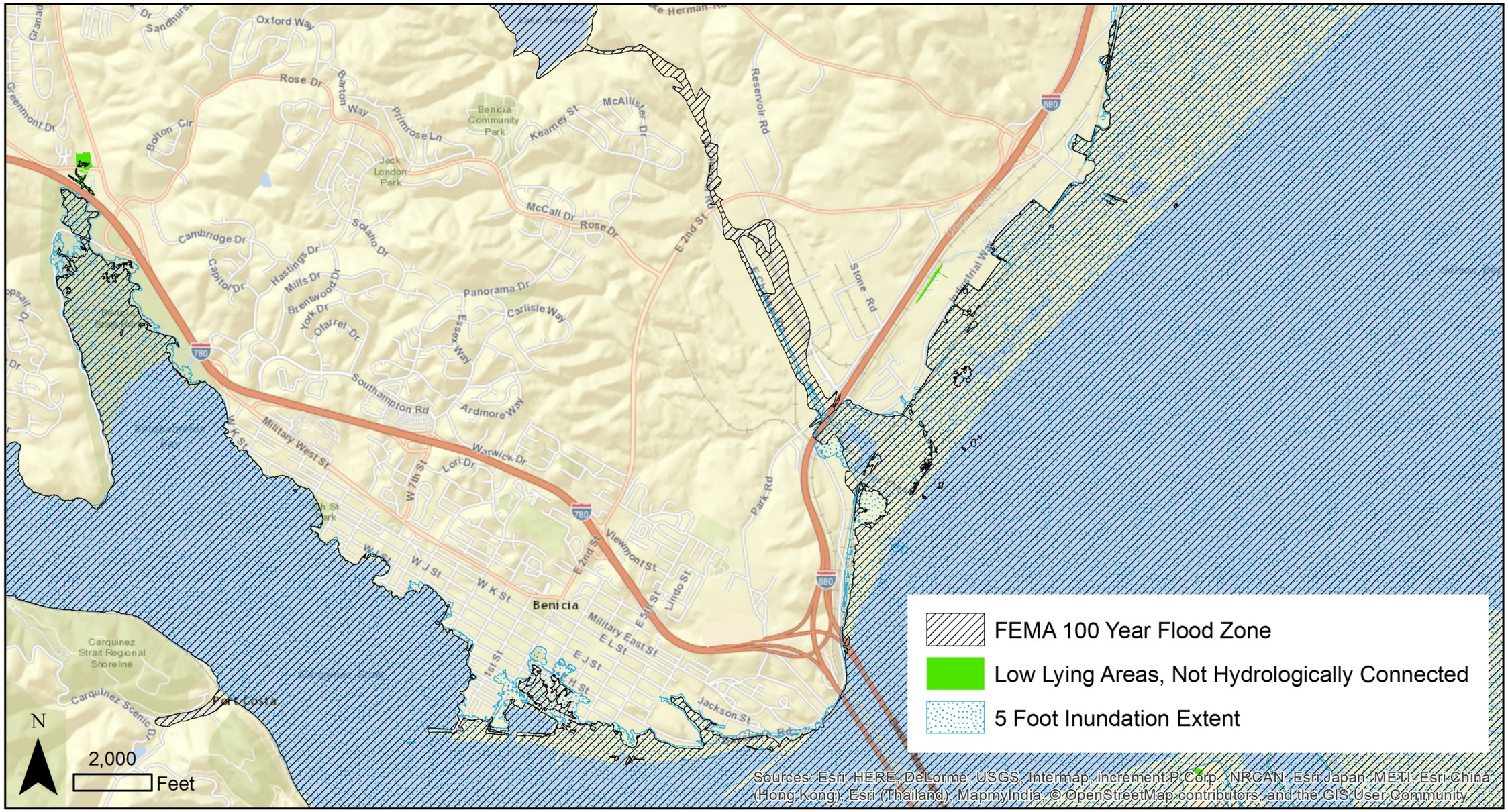
There is no content on this page

FIGURE 7: Downtown and the Port sea level rise inundation map for the 5-foot total water level scenario



There is no content on this page.

FIGURE 8: Comparison between the FEMA 100-year flood zone and 5 feet of sea level rise



There is no content on this page

Benicia residents, employees, and visitors may be at risk due to flooding and extreme heat. Persons who have physical challenges responding to emergency conditions may be particularly vulnerable. This includes individuals with mobility challenges (such as physically disabled or elderly persons), young children, or immunocompromised persons or individuals with certain chronic health issues. Lower-income persons face increased vulnerability as well, as they are more likely to live in rental units (and thus unable to retrofit their homes to be more resilient). Lower-income persons who own their home may also not have the financial resources to make the necessary improvements to reduce vulnerability, which may be as simple as ensuring the home has sufficient cooling during a heat wave. Individuals without a car can face increased vulnerability from flooding, as these persons may have a harder time evacuating if necessary.

The primary threat to Benicia's transportation network is from flooding. A number of roadways and trails already flood at times due to inadequate drainage, including parts of East Second Street, East B Street, and the Bay Trail. As sea levels rise, leading to permanent and temporary flooding in various locations, additional transportation infrastructure may face similar hazards. This includes Industrial Way, Bayshore Road, and the Union Pacific (UP) railroad tracks. Extreme heat may also create hazard situations by softening asphalt and buckling railways, although this requires very high surface temperatures (in excess of 147ºF) and is likely to remain a rare occurrence. Disruptions to transportation networks can force vehicles, bicyclists, and pedestrians to seek alternative routes, which can create increased congestion, particularly during peak commute periods, and may not be as safe for pedestrians and cyclists. Businesses located along disrupted routes can suffer a loss of business, leading to economic consequences. The disruptions can also exacerbate evacuation challenges if they occur during a natural disaster event.

Although the UP railroad tracks were not fully assessed for their vulnerability, they were assessed for their exposure to sea level rise. It is projected that portions of the track near Sulphur Springs may be exposed to daily inundation with 24 inches of sea level rise. Under the high range of the end-of-century sea level rise projections, significant portions of the tracks that pass to the east of the Benicia Industrial Park and adjacent to the Port will be inundated on a daily basis. UP did not participate in the development of this plan, but indicated to the City that it regularly raises railroad tracks by adding fill material on top of the tracks and then shaking the tracks to allow the material to settle and ultimately raise them to prevent inundation. The City is preempted from passing any regulations or requiring UP to develop a plan to deal with potential climate change-related impacts.

The Port of Benicia, which is a major hub for automobile imports and exports of petroleum by-products produced by the Valero Benicia Refinery, is vulnerable to changes in sea level rise and resulting flooding. Existing infrastructure helps to protect the Port from current flood events, although flooding has occurred occasionally in the past and the risk is likely to increase due to climate change. Mechanical equipment at the Port is located in areas that may be temporarily

flooded, and flooding at the Port's paved surfaces could reduce its capacity. The Port does have protocols in place to manage flood events, as well as excess storage capacity that could be used if the regular storage areas are flooded, which can help reduce disruptions to Port operations. Employees at the Port are also vulnerable to extreme heat events, and may require changes in equipment or additional breaks during heat waves.

Benicia's Wastewater Treatment Plant (WWTP), which is owned by the City, treats sewage generated by the community and is located on East Fifth Street near the coast. Flood walls constructed in 2000 help to protect the WWTP from coastal storms, although these measures may be insufficient toward the end of the century. The flood wall does not completely surround the WWTP, and eventually temporary floodwaters may be high enough to go around the wall. Existing pump systems at the facility can help reduce flood damage, although a severe enough flood can reduce the WWTP's capacity and create a community-wide service shortage. There are also concerns that the existing discharge pipe, into the Carquinez Strait, may be less effective with sufficient sea level rise.

The Valero refinery operates a separate wastewater treatment plant for its own operations. This plant was not comprehensively reviewed as part of the vulnerability assessment, although there are concerns that the holding ponds at Valero's facility are vulnerable to flooding from Sulphur Springs Creek. With 3 feet of sea level rise, these holding ponds may be fully inundated. If flooded, this could release contaminated material into Sulphur Springs Creek and Suisun Bay.

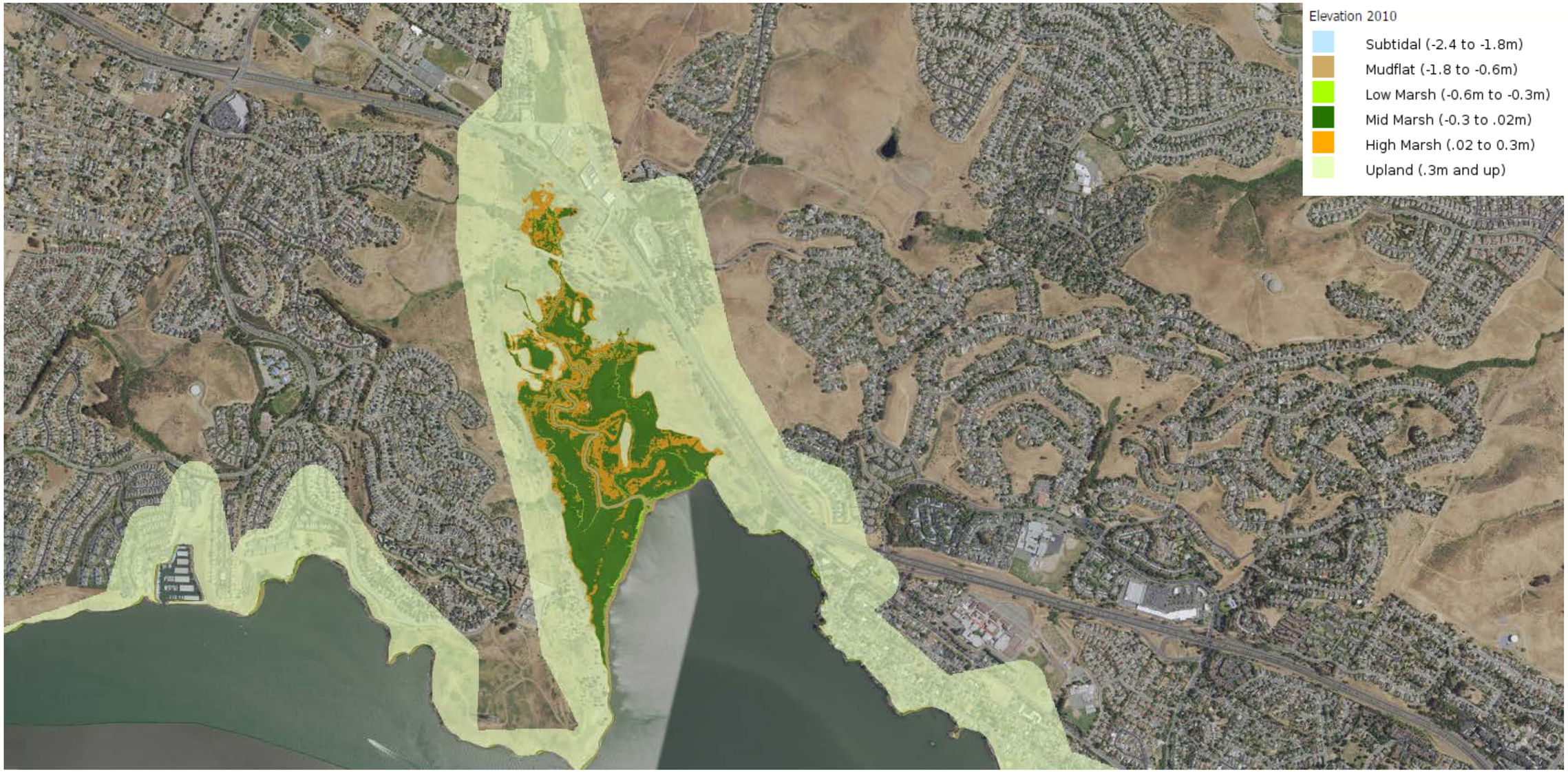
Benicia's storm water system, including storm drains, underground pipes, and discharge pipes, may be affected by sea level rise. Rising sea levels can cause seawater to infiltrate into local groundwater basins, raising groundwater levels and potentially damaging pipes. Sea level rise can submerge the outlet pipes, which may not operate when underwater. These combined effects can decrease the effectiveness of storm drains, causing water to back up and create localized flooding throughout the community. Standing flood waters that are not removed quickly can also create a public health risk, as they may be a breeding ground for mosquitos and other disease vectors.

Natural habitats in and around Benicia, including the Benicia State Recreation Area, parts of the Suisun Marsh Primary Management Area along the Benicia shoreline, and other coastal marshes, are at risk due to sea level rise and associated flooding. These marshland areas have historically been able to respond to changing sea levels by migrating inland and/or by adding material and building up (vertical accretion). However, the comparatively rapid sea level rise caused by climate change is expected to occur faster than marshlands can naturally respond. Also, hardscaping and development on the upland edge of the tidal wetlands function as a barrier to wetland migration. These factors contribute to the eventual conversion of marshland to mudflats, impacting existing species and leading to a loss in protection from storm surge and flood waters. If the amount of sediments and other particles flowing into the marshland

decreases, which can be an unintended consequence of urban development and flood control methods, the amount of marshland converted to mudflats may increase. Sea level rise may also lead to the permanent inundation of some areas of marshland, resulting in additional changes to habitats and biological integrity. Figures 9 through 13 show current and projected conditions of wetland habitats in Benicia State Recreation Area.

There is no content on this page

FIGURE 9: Current Benicia State Recreation Area Marsh Conditions



Source: Point Blue Conservation Science

There is no content on this page.

FIGURE 10: Benicia State Recreation Area in 2050, low vertical accretion and low levels of organic material.

Source: Point Blue Conservation Science

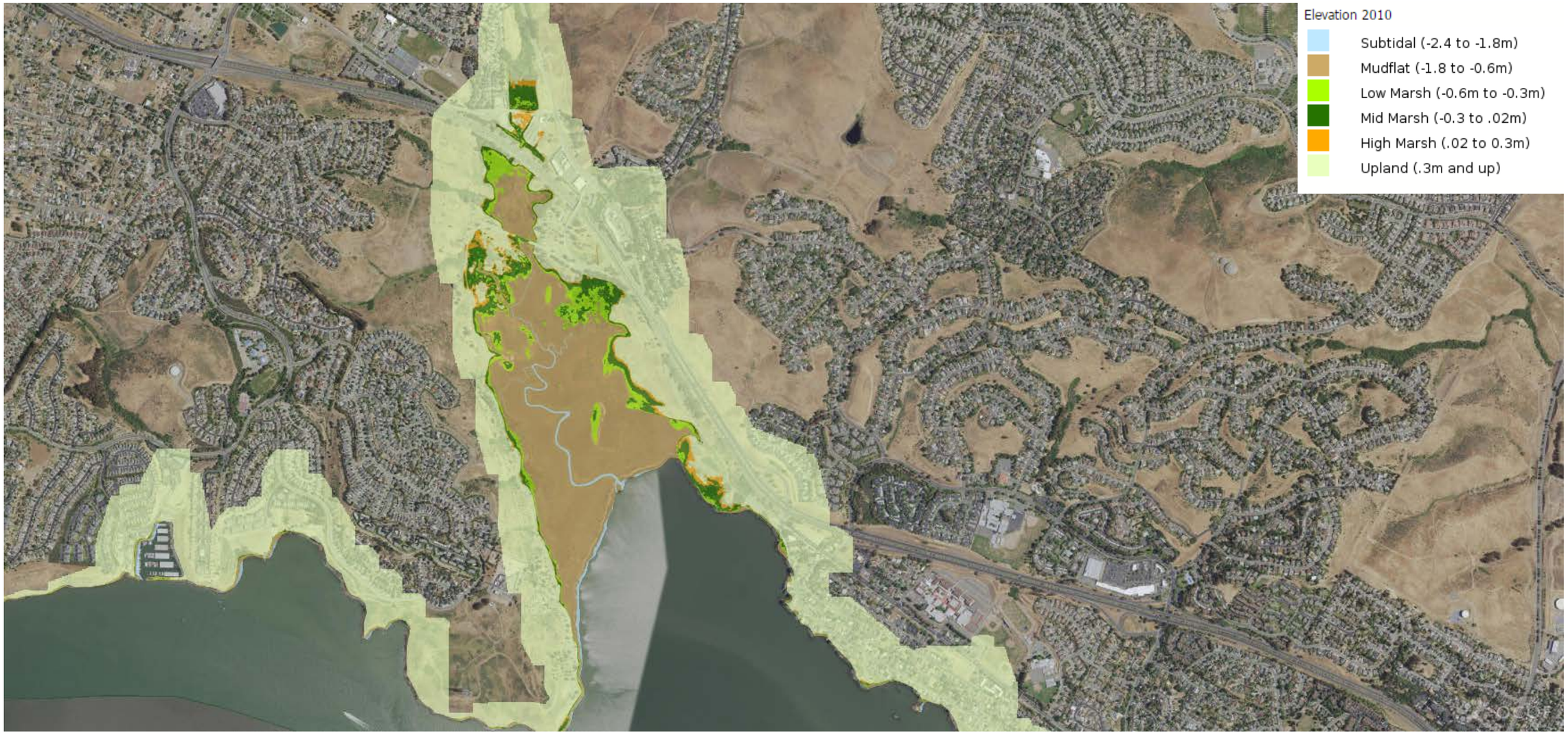
There is no content on this page.

FIGURE 11: Benicia State Recreation Area in 2050, high vertical accretion and high levels of organic material

Source: Point Blue Conservation Science

There is no content on this page.

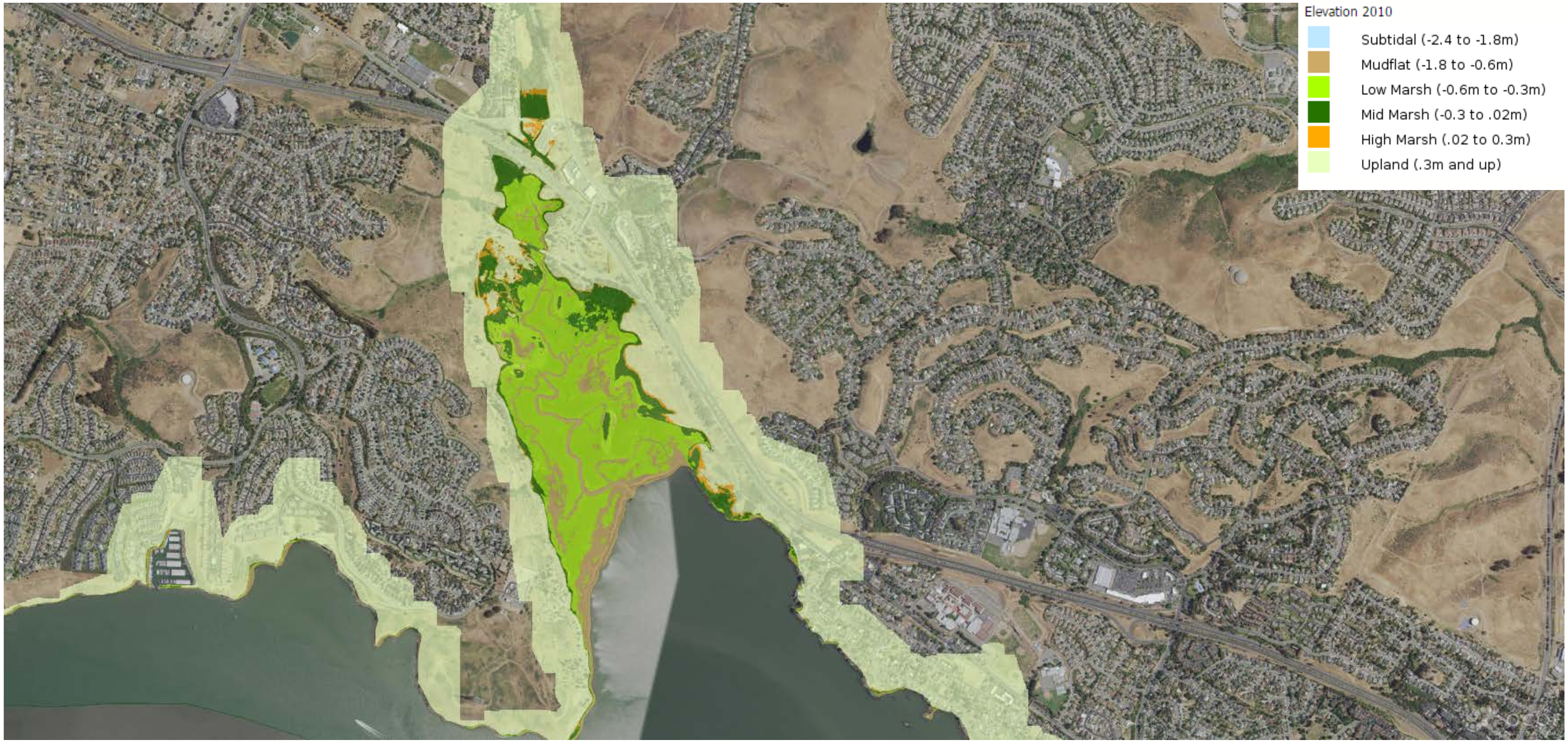
FIGURE 12: Benicia State Recreation Area in 2090, low vertical accretion and low levels of organic material



Source: Point Blue Conservation Science

There is no content on this page.

FIGURE 13: Benicia State Recreation Area in 2090, high vertical accretion and high levels of organic material



Source: Point Blue Conservation Science

There is no content on this page.

Local energy infrastructure, such as power lines and substations, are at risk from extreme heat and may be at risk from sea level rise. Although Benicia participates in the Marin Clean Energy (MCE) community choice aggregation program, and most of Benicia's residents and businesses purchase their electricity through MCE, the energy is delivered through infrastructure owned and maintained by PG&E. High temperatures stresses electricity infrastructure, causing it to become less efficient. At the same time, high temperatures increase electricity demand because there is a greater need to run air conditioning units. The combination of these factors can cause power shortages and blackouts.

Benicia's electrical substations are not expected to be at risk from midcentury sea level rise, according to analyses conducted by PG&E. However, these facilities may be at risk from end-of-century sea level rise, which was not evaluated in PG&E's study. Any electricity infrastructure in a sea level rise hazard zone may be damaged by saltwater, which can corrode electrical and mechanical components. Underground natural gas pipes could also be harmed by sea level rise and associated flooding, which in severe instances can lead to pipeline ruptures. This in turn may create the risk of fire or explosions.

Since the vulnerability assessment was prepared, City staff has provided additional relevant information. While these issues may not be comprehensively addressed in this Adaptation Plan or in the vulnerability assessment included in Appendix E, they should be noted and included in future plan updates:

- The Port of Benicia is privately owned and operated by AMPORTS; however, a small portion of the underlying land (public trust lands) is owned by the City of Benicia. While AMPORTS has a broad degree of latitude to make changes to these underlying lands, some activities may require working with the City. This collaboration may prove challenging, although it also offers an opportunity for AMPORTS to take advantage of resources available to the City. Some of these issues are addressed in the AMPORTS Case Study, Section 7 of this plan.

- Fitzgerald Field has a secondary function as a retention pond area to which some storm water can be diverted during flood conditions before reaching Rancho Benicia and the adjacent downtown neighborhood. However, there are concerns that during the most extreme rain storms, Fitzgerald Field may not be able to retain a sufficiently large amount of water to avoid a flooding emergency.

4. CHARTING A COURSE OF ACTION

4.1 A VISION OF RESILIENCY

To address the vulnerabilities identified in the previous section, Benicia is proactively planning for the challenges of a changing climate. With the Benicia Climate Adaptation Goals in mind (see text box), the City identified actionable adaptation measures and evaluated whether they are sustainable, equitable, economically viable, cost-effective, and able to be integrated into existing and future City plans. Adaptation planning will help Benicia prepare for the effects of climate change and become a more resilient city that can manage the risks of today, as well as those of tomorrow.

Benicia Climate Adaptation Goals

These goals were developed with input from the TAC and CAG and were revised at the beginning of the adaptation plan development process. They currently serve as aspirational goals, the implementation of which will extend beyond the life of this project.

1. Identify cost-effective measures to protect the beauty and functionality of the many assets that support Benicia's high quality of life, including historic districts and buildings, the shoreline, wetlands, marshes and shoreline recreational features.
2. Support all of Benicia's residents and businesses where they live and work in the face of climate change vulnerability, and help them to proactively plan for climate change and recover quickly from climate-related events.
3. Mainstream planning for all hazards, including climate change vulnerability and adaptation, in all City functions, including planning, public works, parks and recreation, and emergency preparedness.
4. Revise local land use plans (including the General Plan) on an ongoing basis, and develop regulations and building codes to aid and protect future development projects in the face of climate change and other hazards.
5. Serve as a regional leader and model in planning for climate change and adaptation, and cooperate with regional agencies and neighboring jurisdictions in planning for regional readiness and resilience.
6. Educate the public on the risks of climate change through public art and education, and on the need for personal disaster preparedness, adaptation, and investment in resilient infrastructure.

In addition to input from the TAC and CAG throughout the project, the City of Benicia sought input from the public in the development of adaptation strategies. At an open house in November 2014, the project team provided an overview of the climate change projections, project goals, existing conditions, vulnerabilities, and initial adaptation strategies. The open house featured several "stations" explaining the potential climate change adaptation strategies.

Community members were able to learn about and comment on specific strategies and propose their own. Following the open house, an online discussion forum was launched through Open Town Hall to allow the public to provide feedback on the project goals, identify key geographies of concern, and rank their preferred adaptation strategies. Based in part on the information and ideas gathered through these venues, the project team identified adaptation strategies appropriate for Benicia.

The City has selected to focus this adaptation report on strategies it can undertake and implement; however, a number of broader, and arguably more impactful, strategies will also need to be undertaken at the regional, state, or national scale. For example, large-scale infrastructure financing such as flood map revisions that account for projected sea level rise and flood insurance regulations will need to be tackled at the state and federal level. Despite not being the focus of this plan, Benicia will continue to work with the region to comprehensively address climate change.

4.2 ADAPTATION STRATEGY EVALUATION PROCESS

In total, 121 potential adaptation strategies were developed to prepare Benicia for sea level rise (85 strategies) and temperature change (36 strategies) across multiple sectors and geographies. All of these strategies are important for ensuring a robust and resilient Benicia, and City departments will work to advance, implement, and integrate these strategies into their practices as feasible over the coming years.

To focus the City's initial climate change adaptation efforts, a three-step evaluation of the potential adaptation strategies was undertaken. First, the City developed 20 qualitative evaluation criteria related to the economy, protection of populations of concern, environmental quality, and political feasibility.[3] These evaluation criteria were developed to assist City staff in selecting and prioritizing actions that will result in a balanced adaptation response. The criteria allowed the City to recognize the trade-offs between individual adaptation actions, highlight the lowest-cost and highest-benefit actions, emphasize co-benefits, and minimize unintended consequences such as negative impacts to water quality, energy use, and greenhouse gas emissions. For more information on these evaluation criteria, see Appendix A: Evaluation Criteria.

Following this initial analysis, the project team worked with City staff to narrow the evaluation criteria to a set of key metrics so that City senior management's review could focus on assessing the costs and benefits of key strategies for near-term implementation:

[3] These categories are based on the Adapting to Rising Tides four assessment frames: Society and Equity, Economy, Environment, and Governance.

- Level of urgency (i.e., does a strategy need to be implemented in the short term to reduce vulnerability?)
- Implementation, operating, and maintenance costs
- Potential to avoid future damage (effectiveness)
- Political feasibility

Using these four priority evaluation criteria, the adaptation strategies were narrowed to 36 priority actions.

Last, in a collaborative meeting, senior management and staff were asked the following questions about the 36 options:

- Is the strategy a high priority for the City?
- Would the strategy address existing City priorities in addition to future adaptation needs?
- Can the City take action on the strategy in the next five years?
- Can the City take action on the strategy using its own resources or is outside funding needed?
- Would the strategy benefit from greater elaboration, for example, a more detailed cost estimate?

At the conclusion of this process, the City narrowed the list of priority adaptation actions to 11 strategies that it felt could be implemented if staffing is available and if additional information (cost, design, and responsibility for implementing) were developed. These 11 strategies are examined in further detail in Section 5. Although these 11 strategies were selected for additional development now, the City will also periodically review the full set of adaptation strategies and implement them into plans, policies, and infrastructure upgrades as feasible.

5. MOVING TOWARD RESILIENCY – PRIORITY ADAPTATION STRATEGIES

Using the evaluation process outlined in the previous section, 11 adaptation strategies were selected for additional analysis and development by ICF International (policy), PlaceWorks (land use planning), and Moffat and Nichol (engineering cost estimates). Five of the strategies address specific locations that were determined to be highly vulnerable while the remaining seven strategies will increase overall city resiliency and preparedness for climate change. The strategies are classified into five types as specified in Table 3. The magnitude of the costs presented in this table are described in greater detail in Table 4. The costs provided here are estimates for planning purposes. The actual capital and operating costs to implement these strategies may be more or less than the costs shown here. The City should pursue a variety of funding sources to implement adaptation strategies including general fund, special districts, grants, loans, and public-private partnerships. For example, some businesses and non-profit organizations are already working collaboratively to identify innovative funding mechanisms that allow cities to increase resilience by implementing adaptation measures similar to those prioritized by the city as part of this planning effort.

TABLE 4: ADAPTATION STRATEGIES BY TYPE, GEOGRAPHIC AREA, AND START YEAR

STRATEGY TYPE	STRATEGY	GEOGRAPHIC AREA	RECOMMENDED START YEAR	CAPITAL COSTS	OPERATING COSTS
5.1 Advance Current Efforts	Prepare a Downtown sea level rise adaptation strategy	Waterfront from First Street to the Marina	2017	This strategy involves a number of individual strategies, each with separate costs	
5.2 Win-Win Strategies	Develop a "Maintain-a-Drain" Program	Citywide	2018	Low	Low
	Increase emergency preparedness for the wastewater collection system	Wastewater Treatment Plant (between E Fifth and E Sixth Street)	2017	The range of costs vary significantly depending on specific implementation actions	
	Train Public Works Department employees in flood response and coordinate with the Fire Department on the BERT program	Not geographically specific	2019	Low	Low
	Increase pre-event storm water infrastructure maintenance and invest in green infrastructure	Citywide	2017	The range of costs vary significantly depending on specific implementation actions	
Increase Tracking and Monitoring	Track extreme weather costs	Citywide	2018	Medium	Low

STRATEGY TYPE	STRATEGY	GEOGRAPHIC AREA	RECOMMENDED START YEAR	CAPITAL COSTS	OPERATING COSTS
	Monitor the need to expand the Wastewater Treatment Plant's flood protection measures	Wastewater Treatment Plant (between E Fifth and E Sixth Street)	2021	Low	Low
5.4 Update Existing Plans and Processes	Incorporate consideration of sea level rise into the City's Capital Improvement Program, and into the design and funding of infrastructure	Not geographically specific	2017	Low	Low
	Incorporate additional climate change considerations into City plans and codes	Not geographically specific	2017	Low	Low
	Incorporate sea level rise and coastal flooding potential into existing and future recovery plans	Not geographically specific	2019	Low	Low
Coordinate with the Community and Local Businesses	Coordinate flood planning along Sulphur Springs Creek	Sulphur Springs Creek	2017	Low	Low

The strategies do not geographically cover all vulnerable areas in Benicia, as that was not a requirement of the selection process (see Section 4). For example, the Benicia State Park and other natural areas are vulnerable to sea level rise but not included in the priority adaptation strategies. For information on strategies that may be appropriate in other geographic areas, please see Appendix B: Compendium of Adaptation Strategies.

Each strategy write-up provides information on:

- The implementing city department(s) and supporting groups.
- An expanded description of the strategy.
- The potential for integration with existing City plans.
- Order of magnitude costs and benefits of the strategy.
- A potential timeline for implementation based on the strategy's urgency.

Throughout the strategy write-ups, order of magnitude costs and benefits have been identified. Table 5 defines the ranges of costs for strategy implementation, and operating and maintenance costs, assuming that the City maintains sufficient staffing levels to perform this work.

TABLE 5: ORDER OF MAGNITUDE COSTS FOR STRATEGY IMPLEMENTATION

COST CATEGORY STRATEGY IMPLEMENTATION	DEFINITION	EXAMPLE
Low	<$10,000	Revising internal City processes
Medium	$10,000-$100,000	Public-facing plan updates
High	>$100,000	Heavy infrastructure projects
COST CATEGORY STRATEGY O&M		
Low	<$1,000/year	Periodically review literature to update sea level rise projections
Medium	$1,000/year - $10,000/year	Increased annual inspection and maintenance costs
High	>$10,000/year	None

For the following strategies, Moffat & Nichol, an engineering firm, developed a budgetary order of magnitude cost estimates:

- Prepare a Downtown Sea Level Rise Adaptation Strategy.
- Monitor the need to expand the WWTP's flood protection measures.
- Coordinate flood planning along Sulphur Springs Creek.

The estimates are based on either the cost per square foot/linear foot of materials or the cost per unit as developed during prior engineering studies of similar projects. These estimates will need to be refined as designs are developed.

5.1 ADVANCE CURRENT EFFORTS

Although this climate change adaptation plan is the first of its kind in Benicia, it is not the first time that the City has recognized the potential impacts of climate change. The City of Benicia should implement and expand upon existing plans to increase resilience to climate change, and continue to advance existing work with additional planning and design processes.

Prepare a Downtown Sea Level Rise Adaptation Strategy

Description: This strategy works to reduce temporary and permanent flooding in the downtown and waterfront area, between E. 5th Street on the east and I Street (includes the ball fields used for stormwater retention, Rancho Benicia, where flooding already occurs during a storm event and where older, more vulnerable individuals live, and most of the historic salt marsh footprint) First Street and the Marina. It combines two approaches: a near-term implementation of the Urban Waterfront Enhancement and Master Plan (UWEMP), and a long-term process to study, develop, and implement a flood control system for the downtown and waterfront area.

Benefits: This strategy will reduce current and future flood issues in the downtown area. This will help avoid near-term disruption and long-term loss of recreational amenities, residential buildings, and economic activity in the downtown area. Costs for emergency response and flood damage are likely to decline. The strategy will likely lead to expansion of marsh habitat, supporting biological integrity and helping to reduce greenhouse gas emissions through carbon sequestration. Green infrastructure investments can beautify the downtown and contribute to placemaking goals while reducing the extent and duration of current

Figure 14: Fully armored breakwaters, such as this one in Alameda, can help reduce flooding from coastal storms but may make conditions worse elsewhere

Source: Alameda Point Environmental Report

stormwater and tidal flooding impacts. Some types of green infrastructure, such as the raingardens included in the UWEMP, can be readily colocated and integrated into pedestrian safety enhancements and other streetscape enhancements. The overall project is likely to increase a sense of safety and well-being in the community. Additionally, construction activity will generate temporary jobs.

Reason for Strategy: The downtown area is a popular visitor attraction and a point of pride for Benicia. As such, it is critical to the community's identity and an important part of the local economy. However, it is a low-lying coastal area and was partially built on filled marshland, making it highly susceptible to flood events as sea level rises. While recent drain system improvements have helped reduce flooding, they have not eliminated the problem, and flood risks in the area are likely to increase in the future due to climate change.

Recommended Start Year: 2017

Implementation Details:

- Implement the short-term strategies in the UWEMP, including elevating the green to create a physical sea level barrier, expanding the principal coastal salt marsh, and constructing and planting rain gardens along B Street.
- Study the feasibility of a storm water lift station at the low point of B Street, and design and construct if appropriate.
- Install tide gates on stormwater outfalls to reduce water backup from the Carquinez Strait.
- Explore, design, and construct appropriate flood walls near the Marina.
- In the future, consider managed retreat if flood hazards cannot be effectively reduced through other approaches.
- Explore, design, and reconstruct B Street.
- Apply for Measure AA funding through the San Francisco Bay Restoration Authority and California Coastal Conservancy, and other agencies if applicable.

Lead Departments: Parks and Community Services Department; Public Works Department

Supporting Departments: City Attorney's Office; Community Development Department

Coordinating External Agencies: California Coastal Conservancy; San Francisco Bay Conservation and Development Commission; California Department of Fish and Wildlife; United States Army Corps of Engineers; United States Fish and Wildlife Service; San Francisco Bay Trail Project; Bay Area Ridge Trail Council; California Native Plant Society

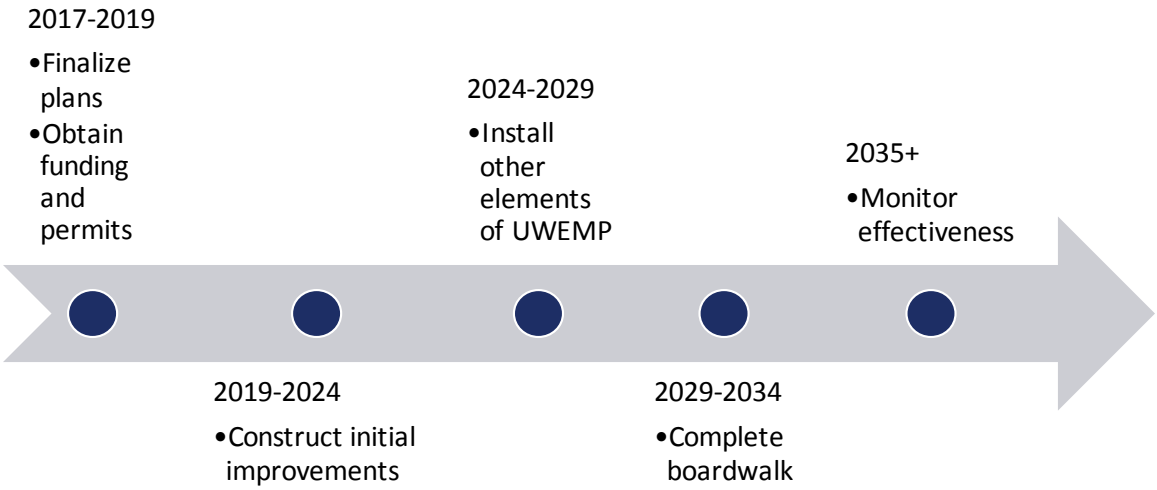
Figure 15: Glass flood wall.

Source: Flood Control International

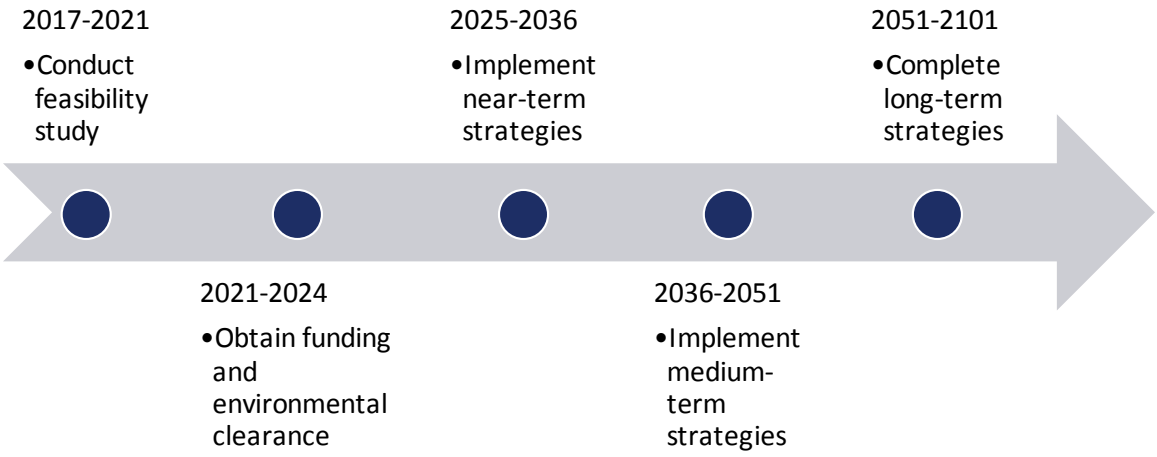
Approximate Anticipated Costs:

- UWEMP implementation: **$8.5 million**
- B Street storm water lift station: **$9 million** (including contingency funds)
- Tide gates: **$240,000**
- Future floodwalls, levees, raised roadways, and other infrastructure: **To be determined by feasibility studies**
- Operations and Maintenance Costs: **$1,000 to $10,000 annually**

Short-term UWEMP Timeline:



Long-term Strategies Timeline:



5.2 WIN-WIN STRATEGIES

Preparing for climate change is a challenge given the uncertainties and long time frames associated with the impacts. Therefore, the City has identified these "win-win" or "no-regrets" strategies that may be easier to implement in the near term because they address existing problems while also providing benefits, regardless of sea level rise projections. These strategies will help improve community resiliency to near-term hazards such as flooding (see Appendix F: Existing Conditions Report for a summary of current flooding issues), while enhancing the City's ability to adapt to long-term sea level rise.

Develop a "Maintain-a-Drain" Program

Description: The Maintain-a-Drain program, based on a similar program at the City of Oakland and other communities, encourages local residents to "adopt" a storm drain inlet and check at least once a month to make sure it is clean. Residents are asked to clean up debris in a 10-foot radius of the drain. The City provides guidelines for volunteers, some supplies, a safety vest, and access to other City resources as needed. This measure offers an opportunity for the City to engage students at local schools, who can participate in the program as volunteers and even educate their parents or caretakers about the its benefits and relationship to climate change adaptation.

Benefits: The program helps ensure that storm drain inlets are clear, which reduces the risk of localized flooding. It supplements (but does not entirely replace) City maintenance efforts, helping to save City funds and staff time. The activities of Maintain-a-Drain volunteers help keep trash out of storm water, which helps to protect water quality and keeps debris out of natural waterways. Cleanup activities also help to support a sense of neighborhood and civic pride, and are an opportunity for residents and businesses to be more involved in community welfare.

Reason for Strategy: Storm drains inlets require regular cleaning and maintenance to stay in proper working order. While Public Works Department maintenance crews are responsible for the upkeep of Benicia's storm drains, it is difficult for staff to maintain the large number of inlets (approximately 500) at existing staffing and funding levels. The Maintain-a-Drain program helps keep inlets clean while conserving City resources.

Recommended Start Year: 2018

Implementation Details:

- Develop marketing and outreach materials, and conduct outreach efforts to local community members.
- Create program website, sign-up information, and guidance documents.
- Obtain and provide resources to volunteers as needed.
- Maintain and grow the program through periodic marketing programs and appropriate revisions.

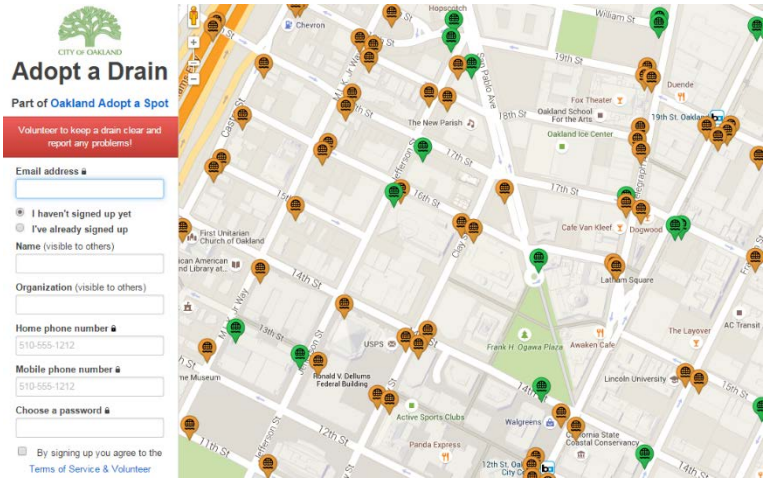


Figure 16: Oakland Adopt a Drain program website. Green markers are adopted drains and hovering over them will display the name of the individual (and the name of their workplace, if desired) that adopted the drain.

Source: City of Oakland

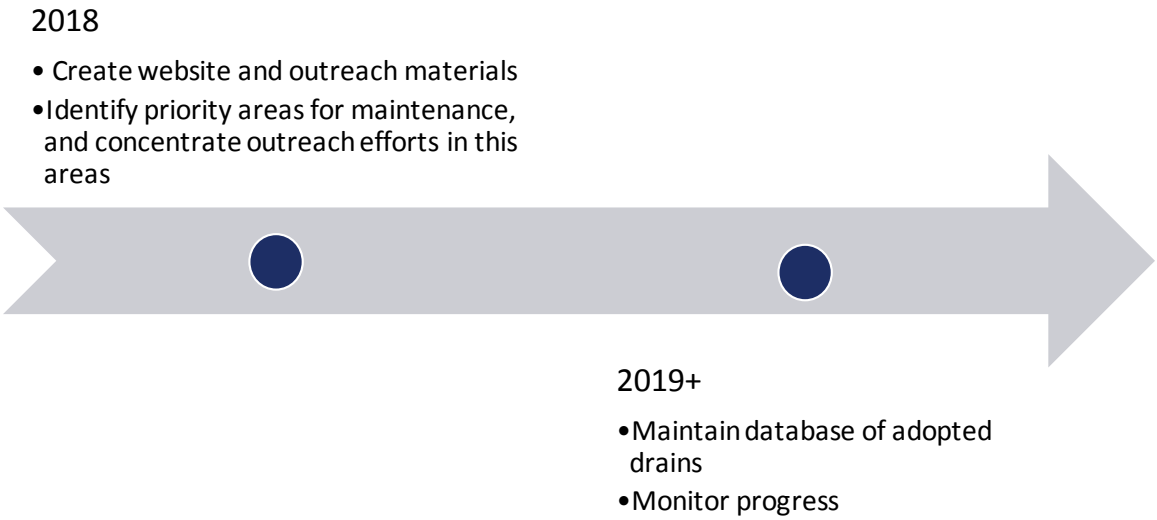
Lead Department: Public Works Department (Streets Division)

Supporting Departments: Others as applicable

Coordinating External Agencies: Others as applicable

Approximate Anticipated Costs: No specific costs have been estimated for this program. It is assumed that the majority of costs will be spent to establish the website, prepare guidance information, and conduct the initial public outreach efforts. Continuing maintenance is expected to be low.

Implementation Timeline:



Increase emergency preparedness for the wastewater collection system

Description: Emergency preparedness activities at Benicia's WWTP help to ensure that the WWTP can continue to provide services to the community during flood emergencies and immediately after such an event. These activities include stockpiling emergency supplies and storing them in areas outside of the flood hazard zone, erecting flood barriers and erosion protection control measures before major storms, and ensuring that the facility has sufficient fuel and electricity to remain operational if normal energy services are disrupted. The WWTP can also take this opportunity to train facility staff on flood prevention and response strategies.

Benefits: This strategy will help minimize service disruptions at the WWTP during a flood event or other emergencies, ensuring that Benicia residents and businesses can continue to receive this critical service. Effective emergency preparedness can reduce damage to the WWTP, saving money, staff time, and other resources on repair activities. Improved resiliency at the WWTP reduces the risk of a significant failure event, which would have a number of undesired consequences. A failure event could cause some businesses to close due to lack of wastewater services; release contaminated water that could affect local habitat; and create a public health emergency by potentially exposing community members to pathogens in wastewater.

Reason for Strategy: The Benicia WWTP is the sole wastewater service provider in the community. Continued operation of the WWTP is critical for public and environmental health. This strategy improves the resiliency of the WWTP to flood hazards, helping to reduce damage and keep the facility operational during flood events and in the recovery phase immediately after.

Recommended Start Year: 2017

Implementation Details:

- Stockpile supplies of sandbags and riprap to construct flood barriers and stabilize erosion-prone areas in advance of a storm. Pre-position these materials in easily accessible locations throughout the city, ideally in areas that are relatively protected from floods.

- Enter into agreements with vendors that rent emergency equipment such as generators to ensure priority use, and enter into joint powers agreements (JPAs) with other public agencies to share emergency resources.

- Maintain sufficient supplies of chemicals and fuel in anticipation of supply disruptions during a flood. Ensure that these supplies are stored at or near the WWTP property in a protected area.

Figure 17: A ready supply of sandbags helps make it easier for City staff to construct flood barriers before a storm occurs

Image from FEMA.

- Work with PG&E to install infrastructure as needed to allow for rapid connection of generators during outages, and to prioritize restoration of power to the WWTP after any outages.

- Train staff on how and when to shut down and start up power and gas supplies, electrical controls, operating systems, and other equipment in system facilities.

- Install on-site solar panels or wind turbines to reduce dependence on the electrical grid and to potentially serve as supplemental backup power.

- If cost-effective, replace nonsubmersible pumps with submersible pumps, replace standard electrical conduits with sealed waterproof conduit, and replace electrical panels with submersion-rated enclosures.

- Install green infrastructure within or beyond the boundaries of the WWTP to attenuate, divert, or retain flood water.

- Install saltwater-resistant equipment and storage tanks for chemicals, fuel, and other critical supplies.

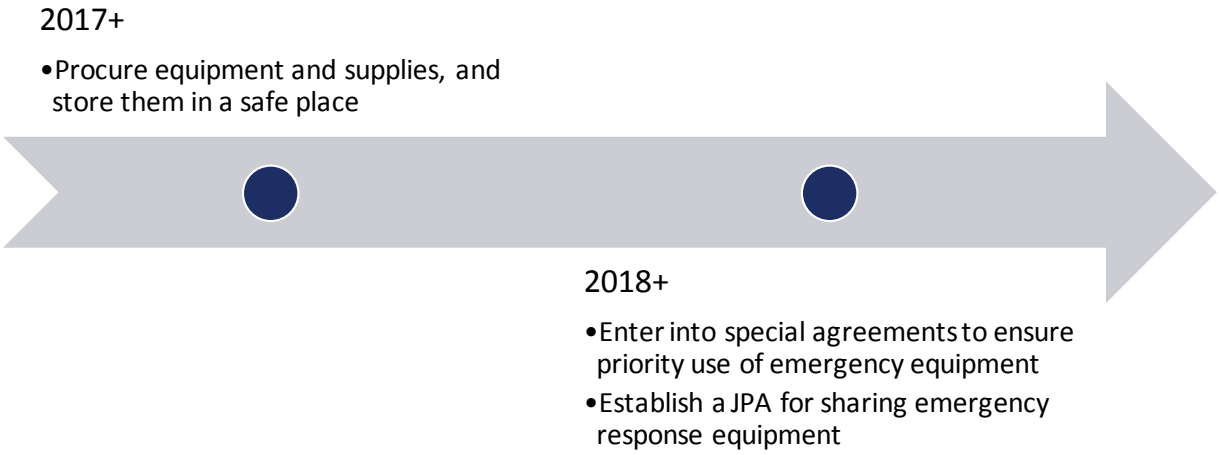
Lead Department: Public Works Department

Supporting Departments: Others as applicable

Coordinating External Agencies: San Francisco Bay Conservation and Development Commission; San Francisco Bay Regional Water Quality Control Board

Approximate Anticipated Costs: Specific costs associated with this strategy are unknown. Up-front and ongoing costs are highly variable, depending on the individual actions and necessary materials.

Timeline:



Train Public Works Department employees in flood response and coordinate with the Fire Department on the BERT program

Description: Public Works Department employees should be familiar with the necessary measures and protocols to follow in preparation for a flood event, and to carry out response and recovery operations as needed. This includes ensuring that necessary supplies are accessible during an emergency; carrying out actions to reduce flooding and erosion during a flood event; and assisting with other emergency response activities. This strategy is designed to give Public Works Department employees the necessary training on an annual basis, in coordination with Benicia's other emergency preparation trainings.

Benefits: This strategy provides Benicia's Public Works Department employees with regular, up-to-date training on flood prevention and response. Public Works employees will be able to help minimize damage from flooding and related conditions, and can free up City resources for other activities. This strategy also serves to keep flood training up-to-date and assist with staff succession planning, ensuring that important knowledge is not lost as staff transition to different positions.

Reason for Strategy: Benicia Public Works employees frequently carry out flood prevention activities in the course of their regular duties. However, staff members carry out these actions in response to their own experience, not necessarily as part of any formalized training. Given

that climate change is expected to result in the increased frequency and/or severity of flood events, a more formal, annual training program will help to codify these flood prevention activities as part of staff duties. This also allows Public Works Department employees to coordinate with other flood prevention training activities, such as the Benicia Emergency Response Training (BERT) program and AMPORT'S flood training for its own employees.

Recommended Start Year: 2019

Implementation Details:

- Develop training protocols and measures, which should address the following items:
    - Public outreach on flood prevention
    - Debris removal
    - Hillside stabilization
    - Construction of sandbag walls and other flood barriers
    - Pre-positioning response materials in accessible, flood-resilient locations in advance of a storm
    - Assisting emergency responders with evacuation and response activities as needed
- Coordinate with the Benicia Fire Department on the BERT program, with AMPORT, and with other organizations in Benicia that offer emergency training. Ensure that training programs communicate with each other on materials and information to create a more unified response, and allow for sharing of other resources during emergency conditions.
- Conduct annual trainings for Public Works employees.
- Incorporate the training program into Benicia's Emergency Operations Plan.

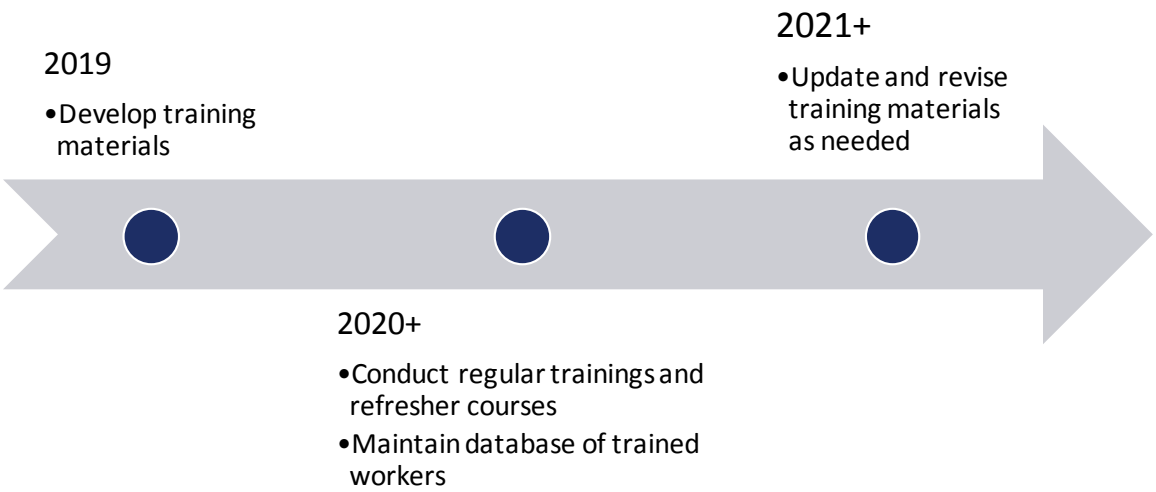
Lead Department: Public Works Department

Supporting Department: Fire Department

Coordinating External Agencies: Others as applicable

Approximate Anticipated Costs: The up-front costs for this measure will be to develop the training materials. Maintenance costs will occur every year for staff to review the material, update it as needed, and conduct the trainings themselves. Specific costs will depend on the length and complexity of the training.

Timeline:



Increase pre-event storm water infrastructure maintenance and invest in green infrastructure

Description: This strategy improves maintenance of Benicia's storm water infrastructure, allowing the system to more effectively accommodate the water from strong storm events and thereby reduce local flooding due to inadequate drains. In addition to improving existing traditional storm water infrastructure, this approach also promotes the use of green infrastructure, which uses strategically placed and designed landscaped areas to capture, filter, and drain urban runoff. Both strategies work to increase the overall capacity of Benicia's storm water infrastructure, allowing it to better handle expected changes in intense precipitation. The Benicia Community Gardens group is already implementing a green infrastructure program called the Sustainable Backyard Program. This program has installed rainwater runoff gardens at seven houses, reducing the amount of storm water run-off.

Benefits: Increasing maintenance of existing storm water infrastructure, in combination with new green infrastructure in flood-prone locations, will help reduce localized flooding in Benicia. This

in turn will help reduce property damage, economic losses, risks to public health and safety, and other consequences of flooding. Regular maintenance of existing infrastructure can reduce the need for staff to respond to malfunctioning drains during flood events, conserving City resources or allowing staff to focus on other items of importance. Green infrastructure helps to filter urban runoff, maintaining a high level of water quality which in turn helps protect the local environment, and can recharge local groundwater supplies. Green infrastructure also serves a landscaping benefit, beautifying streetscapes, parking lots, and other outdoor areas.

Reason for Strategy: Benicia's existing storm water infrastructure helps to minimize flooding by draining rainfall and urban runoff into outlet pipes that release into the Carquinez Strait. However, the system is occasionally blocked by clogged storm drains and other maintenance issues, leading to localized flooding. As climate change is expected to increase the frequency and severity of flood events (both tide- and storm-related), these maintenance issues may cause greater challenges for the community. This strategy improves maintenance activities of the existing storm water infrastructure and supplements it with green infrastructure. This increases the amount of water that the system can regularly handle and help ensures that it functions properly, decreasing the amount of localized flooding during intense storms.

Figure 18: Green infrastructure rain garden.
Source: EPA

Recommended Start Year: 2017

Implementation Details:

- Revise maintenance protocols for existing storm water infrastructure.
    - Monitor weather conditions and invest in emergency cleanings prior to storm events.
    - Prioritize cleaning and other maintenance of drains in locations that are known to flood.
    - Codify new maintenance protocols in the Emergency Operations Plan, in an internal severe weather plan, or in other appropriate locations.
- In coordination with local property owners, select demonstration sites for green infrastructure.
- Monitor the performance of green infrastructure demonstration sites, and construct new green infrastructure in strategic locations as feasible.

- Update the City's low-impact development guidance to incorporate lessons learned from green infrastructure demonstration sites.

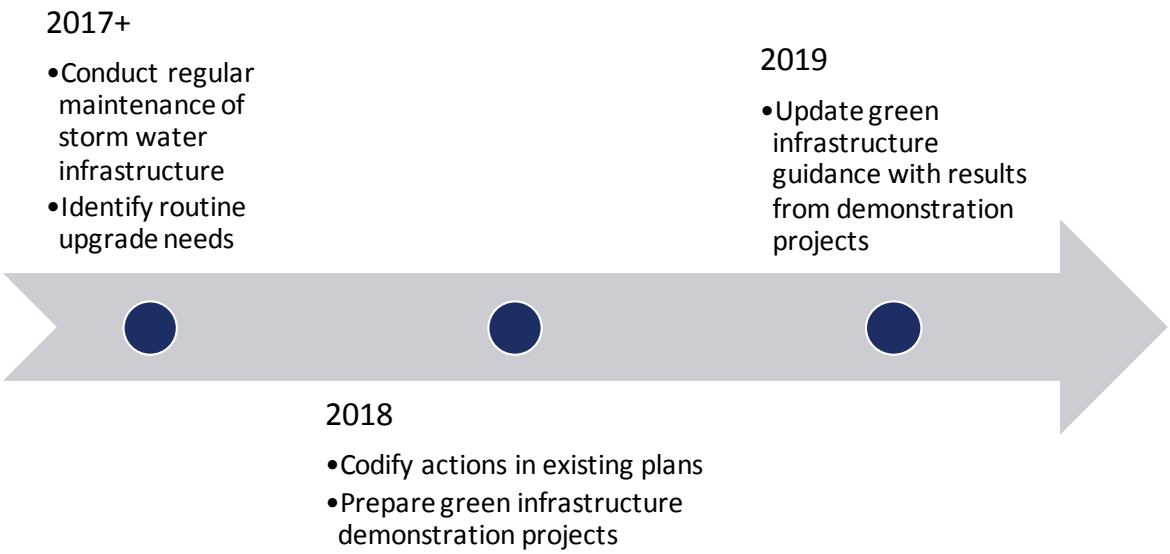
Lead Department: Public Works Department

Supporting Department: Parks and Community Services Department

Coordinating External Agencies: California Department of Fish and Wildlife; San Francisco Bay Conservation and Development Commission; San Francisco Bay Regional Water Quality Control Board; US Army Corp of Engineers; US Fish and Wildlife Service

Approximate Anticipated Costs: There are expected to be low additional costs for increased maintenance of existing storm water infrastructure and to update City documents. Moderate costs are expected to install demonstration green infrastructure and additional sites as needed, with low costs for green infrastructure maintenance. Specific costs will depend on site design, location, and size. There may be opportunities for local businesses to sponsor green infrastructure to reduce costs. Some of the components described above may be designed and implemented in conjunction with the development of the UWEMP.

Timeline:



5.3 INCREASE TRACKING AND MONITORING

Some of the specific impacts and costs of climate change are still intangible due to the uncertainty surrounding climate change projections and the long time frame associated with changes in sea level rise and temperature. To make informed decisions about adaptation to climate change, the City needs to track the impacts of extreme weather events over time and monitor the effectiveness of current coastal protection systems. This information can shed light

on when, where, and how to invest the limited funds available for adaptation and can help bring in additional funding to respond to a documented need.

Track extreme weather costs

Description: This strategy allows the City to effectively track detailed municipal costs associated with extreme weather events, such as a flood. These costs may include increased staff time (for event preparation, response, and recovery), costs for materials and equipment, replacement and reconstruction costs depending on damage, and others as the situation calls for. This strategy also includes integration with planned asset management systems and labor tracking systems.

Benefits: By tracking the specific costs associated with extreme weather events, in combination with an increased understanding of changes to extreme weather regimes as a result of climate change, Benicia can more effectively plan for these events as part of municipal budgeting activities. This helps lead to more intelligent long-term decision making, creating a more resilient and efficient community. Knowing which materials are needed in connection with extreme weather events will allow the City to more efficiently procure, maintain, and replace these assets. Making climate change a more fundamental component of the City's planning activities will also make it easier to integrate resiliency activities into ongoing regular City processes.

Reason for Strategy: Currently, the City has only a limited understanding of the costs and issues associated with extreme weather events, including preparation, emergency response, and recovery operations. Because these numerous costs and issues are not effectively tracked in a central location, the City cannot reasonably and accurately plan for them. Increased tracking will allow for long-term, accurate planning of the costs associated with extreme weather events, helping to inform more effective planning and grant applications. This information can be integrated into asset management and labor tracking systems, addressing climate change in a more unified way for increased efficiency.

Recommended Start Year: 2018

Implementation Details:

- Integrate the tracking of extreme weather-related costs and other resource needs into the City's work order and labor tracking systems.
    - Allow for tracking of work orders associated with individual extreme weather events or categories of extreme weather events.
    - Allow for tracking of labor costs (regular and overtime), contractor costs (budgeted and overruns), material costs, and equipment costs for each individual or category of extreme weather events.

- Integrate the tracking of extreme weather-related costs and other resource needs into the City's asset management programs. The asset management programs should track the following metrics associated with each tracked asset:
    - Location and elevation
    - Age, current condition, composition (e.g., the materials used to make the asset), and remaining service life
    - Total number of associated work orders
    - Utilization (e.g., number of employees working at the asset, number of people served)
    - Replacement value, or cost of installation
    - Operations and maintenance costs
    - Total capital investments
    - Historic status
    - Function in an emergency event (e.g., if the asset serves as a community shelter, cooling center, staging area)
    - If the services provided by the asset are covered in emergency operations plans
- Analyze the results of the tracking systems, and integrate them into long-term planning and decision-making documents and processes.
- Monitor the effectiveness of the tracking systems and make revisions as needed.

Lead Department(s): Public Works, Fire Department and Finance.

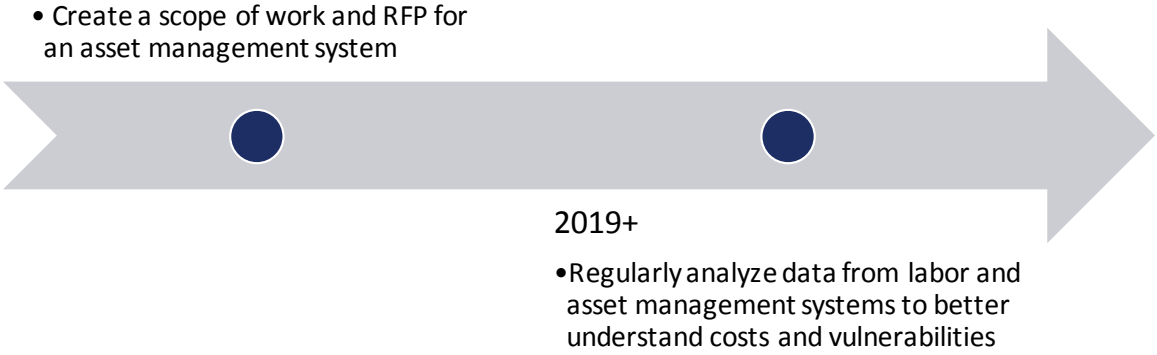
Supporting Departments: All other City departments

Coordinating External Agencies: Others as applicable

Approximate Anticipated Costs:

- $300,000 to $750,000 for a new asset management and work order system.
- Staff time to update the current labor tracking system. The specific costs are unknown, and will depend on the preferred workflow and complexity of tasks involved.
- Minimal to low added staff to use new systems.

Timeline:



Monitor the need to expand the Wastewater Treatment Plant's flood protection measures

Description: This strategy seeks to improve the protective infrastructure at the Benicia WWTP, making the vital facility more resilient to sea level rise and the flooding associated with it. These actions include monitoring existing infrastructure like the current seawall to ensure its effectiveness, and adding new protective features to improve resiliency against observed and anticipated changes in sea levels.

Benefits: Monitoring the flood protection features at the Benicia WWTP and expanding these features as the need arises will help make the facility more resilient to flood events. This in turn will help ensure that the WWTP can continue to operate effectively during floods, avoiding the significant consequences that may result if the facility is inundated and service is interrupted. These consequences may include public health consequences from the lack of service or the accidental release of untreated wastewater; environmental damage if untreated wastewater is released; loss of economic activity if wastewater treatment service is halted or limited; and fines associated with the release of untreated wastewater. Flood protection at the WWTP can minimize damage to the facility, which could result in high replacement or repair costs. This strategy also helps protect shoreline recreation resources, such as the segment of the Bay Area Ridge Trail on E. 5th Street, adjacent to the WWTP site.

Reason for Strategy: The Benicia WWTP is expected to be at risk of flooding from occasional storms and extreme high tide events by 2050, and may face permanent inundation by 2100. This facility provides a critical service to the community. Flood damage at the WWTP may interfere with the effective treatment of community-generated wastewater, which can create a

public and environmental health emergency. Monitoring the WWTP's flood protection measures and expanding them as needed helps to reduce the risk of service interruptions and the associated consequences.

Recommended Start Year: 2017

Implementation Details:

- Monitor changes in sea level rise and associated flooding conditions in Benicia, and note when the WWTP may face temporary or permanent inundation.
- Determine the best strategy to protect the WWTP from temporary or permanent inundation, including costs, feasibility of construction, and appropriateness for community character.
- Construct improved flood protection measures, monitor effectiveness, and expand or alter flood protection measures as needed or as conditions change.

Lead Department: Public Works Department

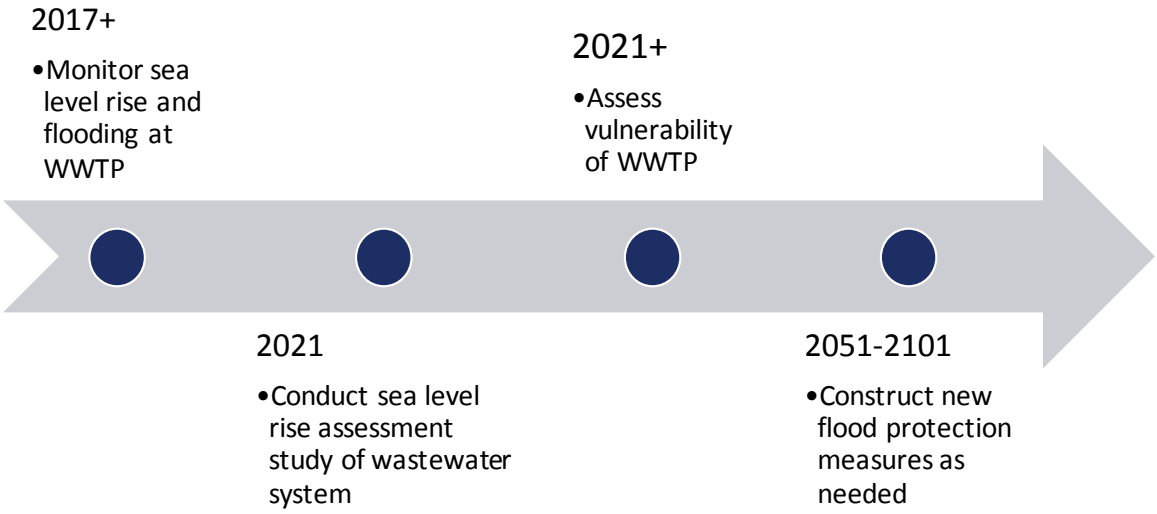
Supporting Departments: Others as applicable

Coordinating External Agencies: Nearby cities; San Francisco Bay Conservation and Development Commission; San Francisco Bay Regional Water Quality Control Board; US Army Corp of Engineers

Approximate Anticipated Costs:

- Monitoring costs and maintenance costs of existing flood protection measures are expected to be low.
- Costs of new flood protection measures will depend on the specific measure.
    - The cost to raise the existing flood wall by 2 feet is estimated at approximately $630,000.
    - The cost to extend the existing flood wall up East Fifth Street is estimated at approximately $2.4 million.
- Operations and maintenance costs of new flood protection measures will depend on the specific measures, but are expected to be low.

Timeline:



5.4 UPDATE EXISTING PLANS AND PROCESSES

For climate change adaptation to be sustainable and implemented on a wide scale, it must be incorporated, integrated or "mainstreamed" into existing plans and policies. Policies and plans guide the strategic investment in and growth of a city; without climate change as a core issue, adaptation will never be considered on equal footing with other threats. There are numerous opportunities for the City to integrate the findings of this report into policy.

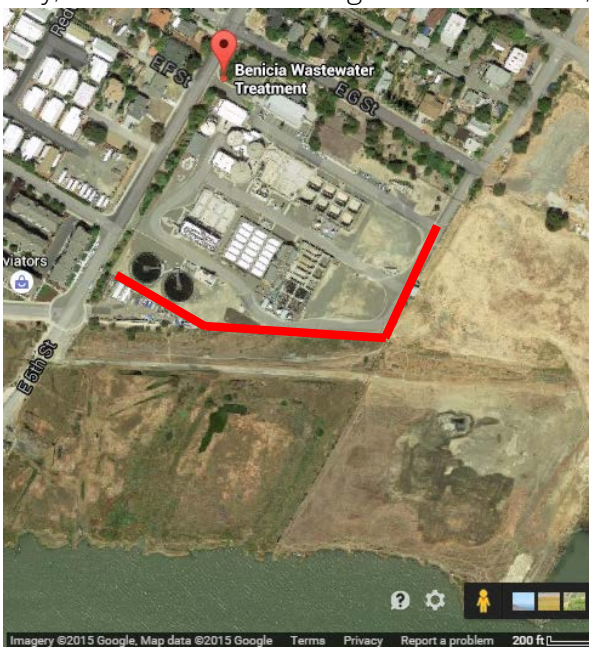


Figure 19: Aerial photograph of the WWTP and the proximity to Carquinez Strait. Sea walls are indicated in red.

Source: Google Maps

Incorporate consideration of sea level rise into the City's Capital Improvement Program, and into the design and funding of infrastructure

Description: This strategy helps to integrate sea level rise and the associated considerations into Benicia's Capital Improvements Program. It ensures that new construction and maintenance/replacement of City facilities and infrastructure are designed and implemented so as to be more resilient to sea level rise and related flooding. This measure includes guidance on assessing capital investments for sea level rise and storm surge as well as preventing City investments from being located in areas that are

at risk of sea level rise. The guidance resulting from this measure will look at longevity of the asset, its existing or proposed location, and the consequence of damage to the asset (including the tolerance for failure, and the ease of repairing or rebuilding the asset if needed).

Benefits: Sea level rise will expose some areas of Benicia to increased risk of flooding or permanent inundation. This strategy will help either avoid locating new City investments in these areas to the extent possible, or ensure that protective measures are incorporated into new investments so as to minimize risks. This will reduce the chance of the City having to spend significant funds to rebuild, relocate, or repair infrastructure that may be damaged or destroyed by future sea level rise. By reducing the risk of damage to City facilities or infrastructure, this measure reduces the risk of service disruptions or other effects that could harm public health, public safety, and the local economy. It also supports the integration of climate change into City planning efforts at a more fundamental level, ensuring that the risks from climate change are more effectively addressed.

Reason for Strategy: City facility and infrastructure assets often have a long life, usually at least a few decades and sometimes up to 100 years. At the same time, sea level rise and other effects of climate change mean that areas which are largely dry now may be temporarily or permanently underwater by the middle or end of the century, within the lifespan of many of these assets. This strategy will allow Benicia to effectively evaluate whether it makes sense to make new facility and infrastructure investments in areas at risk from sea level rise and associated flooding, and what steps the City should take to protect new or renovated assets against damage.

Recommended Start Year: 2017

Implementation Details:

- Develop guidance for evaluating the sea level rise risks of City investments, based on existing guidance documents prepared by other communities and state/federal agencies. The guidance should, at a minimum, cover the following topics:
    - Determine if the project is located in a sea level rise-prone area, and if so, the time frame the project is likely to be affected by sea level rise and associated hazards, with a horizon greater than the expected lifespan of the project.
    - Identify the risks and potential scope of damage from sea level rise and associated hazards.
    - Explore alternative locations to the project where the risks would be reduced or eliminated.
    - If no alternative location exists where there would be no reasonable threat of sea level rise or related hazards, determine effective measures to protect the project against sea level rise.

- Produce and share findings with members of the public and other key stakeholders.
- Decide on appropriate course of action.
- Implement proposed project at the selected site with protective measures as applicable.

- Integrate guidance into other appropriate City documents.
- Monitor the effectiveness of this guidance, and revise as needed.
- Evaluate the feasibility of applying a similar evaluation process to private development projects.

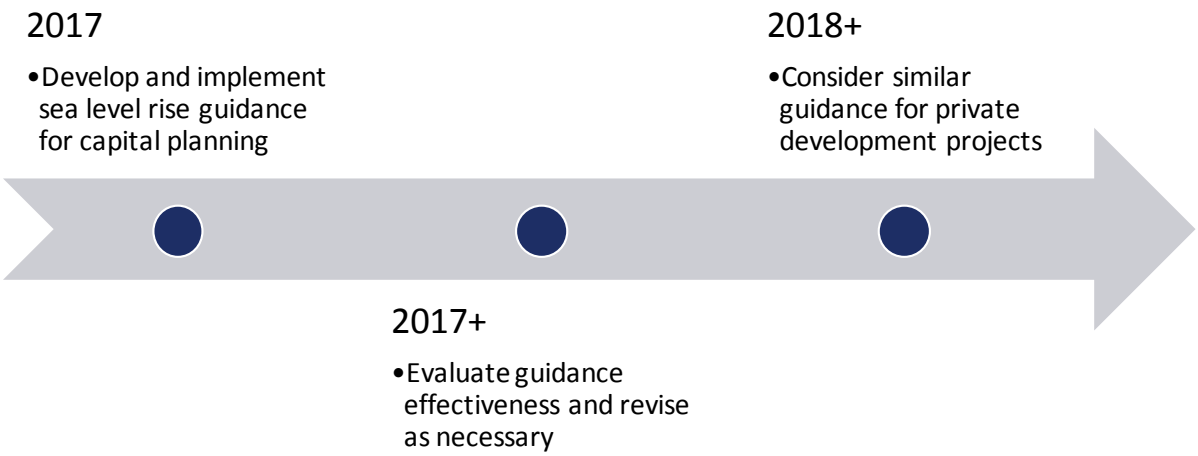
Lead Department: Community Development Department

Supporting Departments: Others as applicable

Coordinating External Agencies: Others as applicable

Approximate Anticipated Costs: Costs to develop the guidance and for initial implementation are expected to be low, but could require somewhat higher costs depending on the specifics of initial implementation. Costs to comply with the guidance and to make revisions as needed are expected to be low, consistent with the costs to comply with and update other City guidance documents. Specific cost estimates are not available.

Timeline:



Incorporate additional climate change considerations into City plans and codes

Description: This strategy incorporates the various factors and considerations of climate change into numerous City plans, codes, and ordinances. This increased integration ensures that climate change is effectively addressed throughout these documents, allowing Benicia to more effectively reduce the associated risks. This strategy identifies Benicia's Municipal Code, General Plan, Parks Trails and Open Space Master Plan, Local Hazard Mitigation Plan, Emergency Operations Plan, and Capital Improvement Plan as existing documents that could benefit from addressing climate change at a more fundamental level.

Benefits: Integrating climate change into various City documents ensures that the unique considerations associated with climate change are adequately reflected in Benicia's plans, codes, and ordinances. While specific benefits depend on the documents and the precise nature of the revisions, they may include financial savings for the City government and community members, local economic growth, reduced damages for City and private property, decreases in repair and operations/maintenance costs, improved environmental conditions, and improvements in public health and safety.

Reason for Strategy: Climate change is expected to alter the climate conditions that Benicia is used to, potentially substantially so. As a result, existing policies, practices, and programs may be insufficient to address climate change or may become less relevant. For example, large sections of Benicia with important land uses may be temporarily or permanently inundated by sea level rise by the end of the century, as shown in Figures 21 and 22. Integrating climate change into City documents helps ensure that Benicia is planning for climate change and is more prepared for the various impacts.

Recommended Start Year: 2017

Implementation Details:

- Update the General Plan and Zoning Ordinance to reflect climate change considerations.
    - Evaluate increasing setbacks in the coastal area.
    - Explore limits or prohibitions on redevelopment of flood-damaged buildings or other structures in highly vulnerable areas, in a manner consistent with existing laws and using resources made available by the National Flood Insurance Program.
    - Evaluate requirements for increasing structure elevations to ensure that new development projects are constructed above the anticipated sea level rise hazard zone for the lifetime of the project, while ensuring consistency with existing height limits and other standards.

    - Consider the appropriate zoning designation and development potential of vulnerable sites to minimize potential future damage.

- Continue to update the Floodplain Ordinance (Section 15.48.010), to reflect projected changes in flood frequency and severity. The most recent version of the ordinance went into effect on May 9, 2016.

    - Consider increasing the lowest floor elevation requirements.
    - Explore increasing the watertight flood-proofing requirement to extend above the base flood elevation height.
    - Evaluate mandatory low-impact development requirements.

- Continue to update the Local Hazard Mitigation Plan to holistically address climate change, and to incorporate regional efforts such as the Association of Bay Area Governments' Resilience Program and the San Francisco Bay Conservation and Development Commission's Adapting to Rising Tides Program.

- Update the Benicia Emergency Operations Plan to include the projected impacts of climate change, and develop strategies for improving the City's ability to respond to climate change-related impacts.

    - Include a communication protocol for government agencies, community organizations, and facilities that serve the community and can be activated during an extreme heat event or loss of power.
    - Explore the creation of a new online Emergency Notification Contact System.
    - Include an Extreme Heat Response Plan that discusses public cooling shelters, cancellation policies for outdoor activities, and inputs for ways to improve the program. Identify partners, vulnerable populations, and evaluation criteria.
    - Launch a pilot program, potentially with other local governments, to protect vulnerable neighborhoods from extreme heat health impacts through structure retrofits, improved social connections, and information sharing.
    - Ensure that public safety staff are trained to recognize and respond to the physical and behavioral signs of heat-related illness.

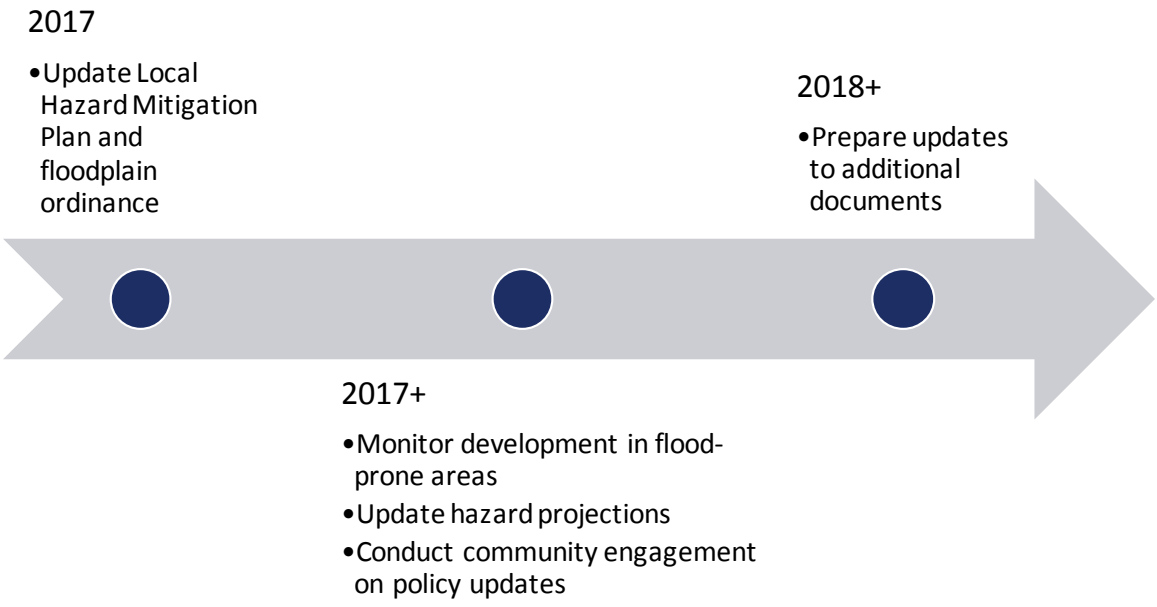
Lead Departments: Community Development Department; Fire Department; Public Works Department

Supporting Departments: Others as applicable

Coordinating External Agencies: San Francisco Bay Conservation and Development Commission

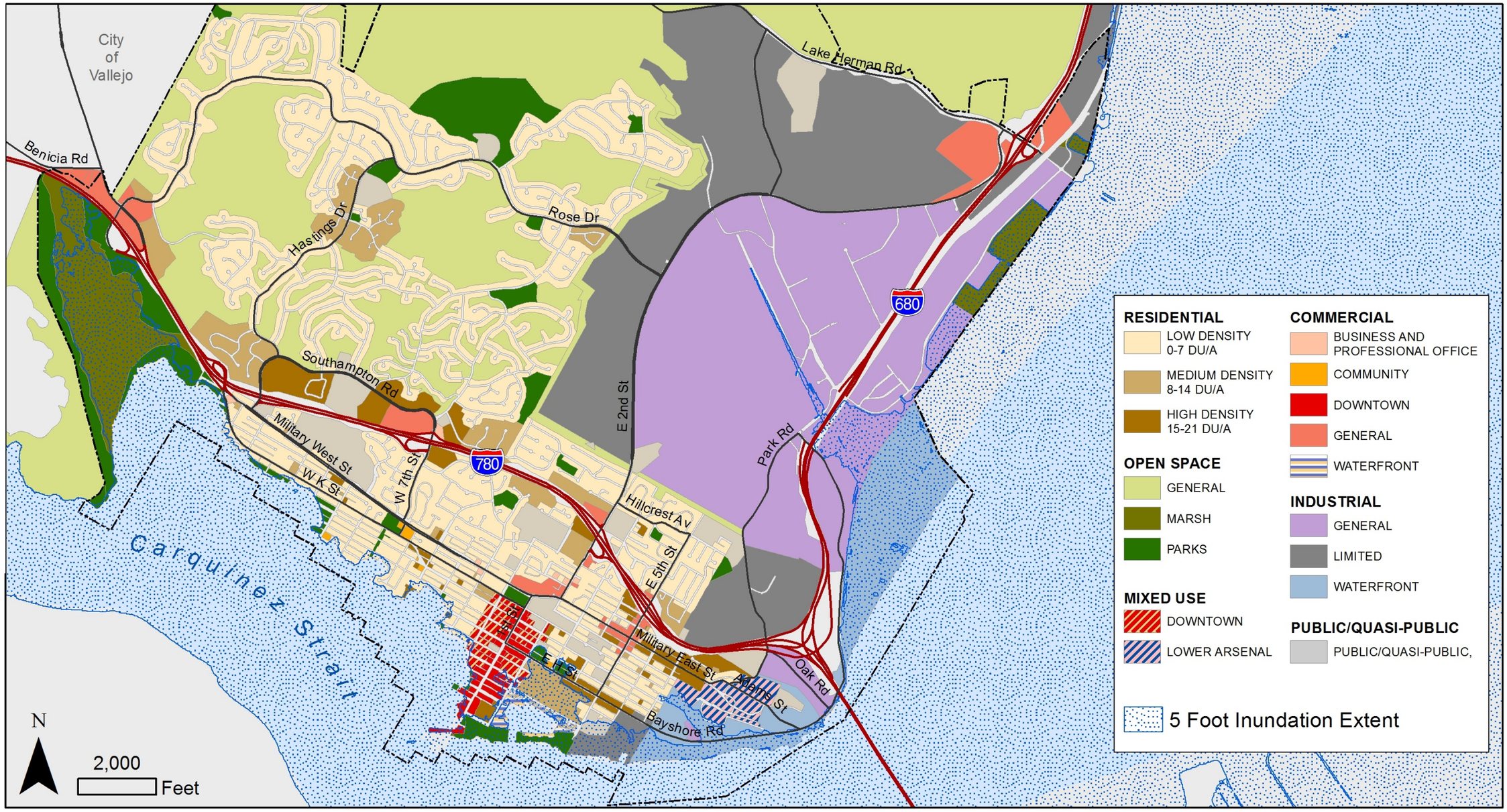
Approximate Anticipated Costs: Specific costs will depend on the breadth of the updates and the document being updated. Costs may be minimal for small-scale updates to existing documents that can be accomplished with existing staff resources, to over $1 million for a General Plan update and associated documents with support from a consultant team.

Timeline:



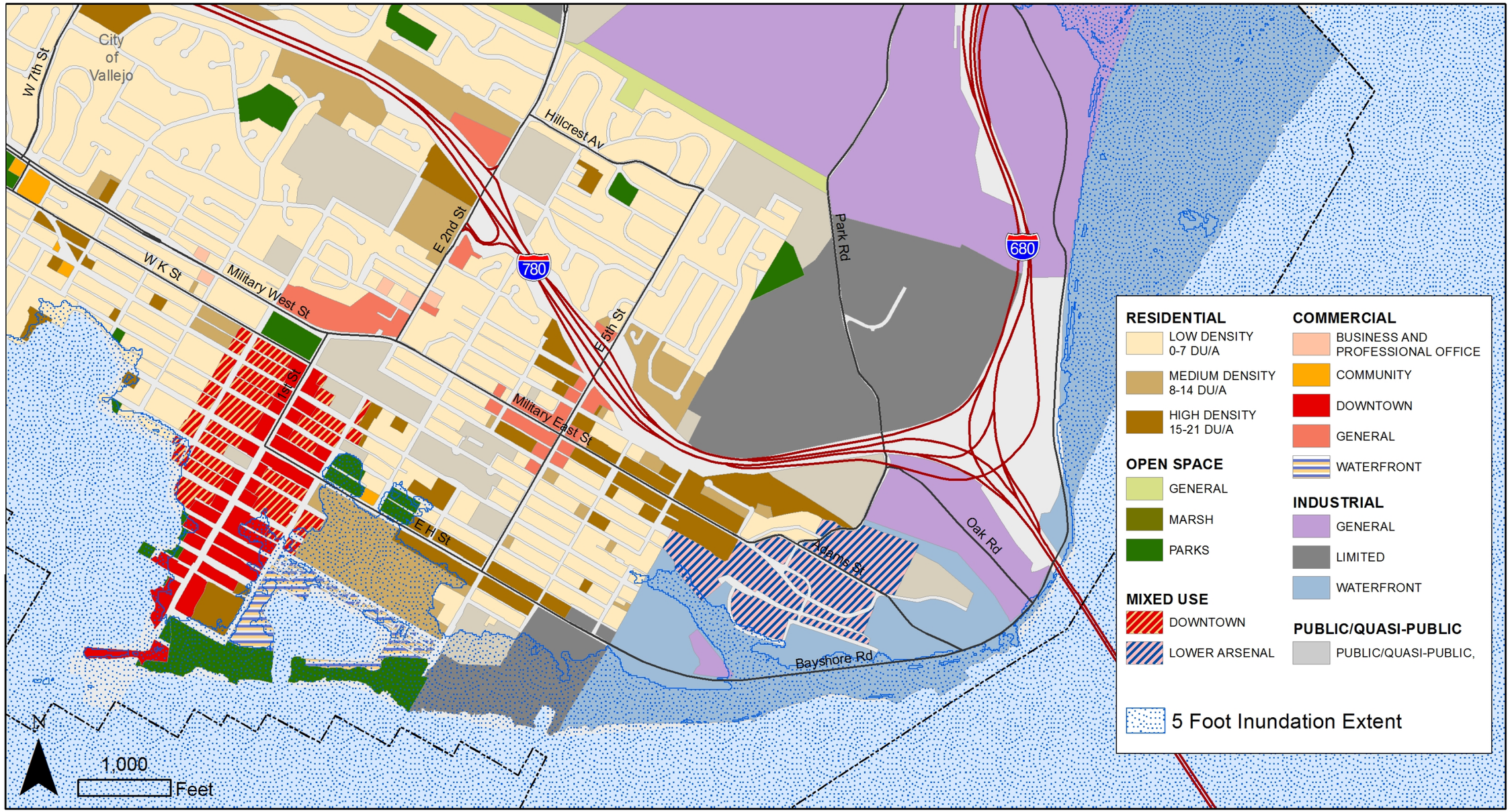
There is no content on this page.

FIGURE 20: Five feet of sea level rise overlaid on the City's land use map



There is no content on this page.

FIGURE 21: Downtown and Port focused overlay of 5 feet of sea level rise and the City's land use map



There is no content on this page.

Incorporate sea level rise and coastal flooding potential into existing and future recovery plans

Description: This strategy integrates sea level rise and related hazards, such as coastal flooding, into Benicia's recovery plan. A recovery plan outlines how Benicia should rebuild following a major emergency event. This strategy ensures that sea level rise and related considerations are evaluated when deciding how to rebuild City facilities and infrastructure, and that reconstructed assets are not unnecessarily exposed to sea level rise hazards. These considerations should include whether to rebuild, and if so, where and how. This strategy can involve either a stand-alone plan or can be integrated into existing documents.

Benefits: Rebuilding City facilities and infrastructure to be more resilient to sea level rise and other climate change-related hazards aids in minimizing future damage to these assets. This reduces the risk to public health and safety, saves the City money on repair and reconstruction costs, and improves the overall community well-being by minimizing the risk of service interruptions. Additionally, this process improves community awareness about climate change-related hazards and may increase the likelihood of receiving disaster mitigation funding from FEMA. Depending on the assets in question, rebuilding some assets with reduced vulnerability to climate change hazards can also support the local economy and minimize environmental damage.

Reason for Strategy: While emergency situations can be devastating, they offer communities a chance to learn and rebuild in a smarter manner. Incorporating information about the effects of climate change into recovery plans helps ensure that, when reconstruction activities occur, they are carried out in a way that reduces the future risk of climate change-related hazards. Benicia's existing Emergency Operations Plan does include recovery-related issues, but is intended to guide City government activities and is not a plan for rebuilding damaged facilities and infrastructure.

Recommended Start Year: 2019

Implementation Details:

- Develop climate change-related recovery policies for City facilities and infrastructure.
    - Create a review process for deciding whether an asset should be rebuilt if destroyed or significantly damaged by climate change-related hazards.
    - Determine how to decide if an asset should be rebuilt at an existing location or moved to another site.
    - Identify policies to reduce the vulnerability of reconstructed assets.
- Integrate recovery policies into existing plans or compile them into a stand-alone plan as appropriate.

- Conduct trainings on recovery policies.
- Monitor the effectiveness of recovery policies and revise on a regular basis.

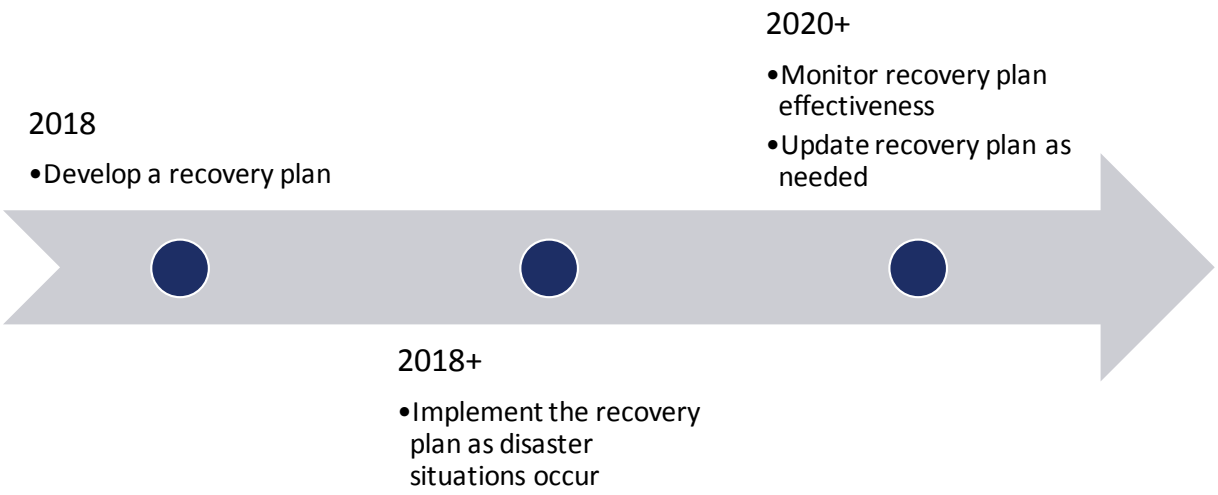
Lead Department: Fire Department

Supporting Departments: Community Development Department; Public Works Department

Coordinating External Agencies: Others as applicable

Approximate Anticipated Costs: The costs associated with this measure are the staff time necessary to develop the recovery policies, integrate or compile them as appropriate, and periodically update them. Specific costs are unknown, but expected to be fairly low.

Timeline:



5.5 COORDINATE WITH THE COMMUNITY AND LOCAL BUSINESSES

While the City has a major role to play in increasing the resilience of Benicia, City staff cannot do it alone; it is only with the support of the community and local businesses that Benicia can fully prepare for the impacts of climate change. This plan was developed with a robust public input process but the final plan also needs to be shared, and the next steps determined hand-in-hand, with the community.

Coordinate flood planning along Sulphur Springs Creek

Description: This strategy works to ensure a more unified approach to flood planning efforts along Sulphur Springs Creek, shown in Figure 23. Such an approach will ensure that property owners along the creek are aware of the flood risks and how climate change may influence these risks. This also gives surrounding property owners the chance to collaborate on strategies to improve flood resiliency, and to respond to any flood events in a coordinated manner.

Benefits: A coordinated flood planning approach along Sulphur Springs Creek will allow affected property owners to decrease the vulnerability of their own assets to flood events. This will save these property owners money by reducing the possibility of having to reconstruct damaged or destroyed assets, and will reduce economic losses associated with flooding. Some flood planning strategies, such as restoring the creek ecosystem to improve natural flood control benefits, will also improve the condition of local riparian habitats.

Reason for Strategy: Sulphur Springs Creek occasionally floods, which affects a number of surrounding businesses, such as the Valero oil refinery and AMPORTS. The flooding also affects important infrastructure, including the shoreline trail, the UP railroad tracks, and access to key roadways. Due to sea level rise and changes in intense precipitation patterns, increased flooding of Sulphur Springs Creek is likely, as shown in Figures 24 and 25. This strategy allows local property owners to participate in a comprehensive flood planning effort, helping to reduce the impacts of future flood events.

Recommended Start Year: 2017

Implementation Details:

- Engage with property owners along Sulphur Springs Creek. Share information about changes in flood events and build support for a unified flood adaptation effort.
- In coordination with property owners and regulatory agencies, evaluate potential strategies to reduce flood risk along Sulphur Springs Creek, which may include:
    - Enhancing vegetation control practices.
    - Managing and/or increasing water storage in Lake Herman or the former Paddy Lake.
    - Creating increased storm water retention capacity in upper Sulphur Springs Creek, Paddy Creek, or the West End open space.
    - Dredging Sulphur Springs Creek.
    - Constructing floodwalls or installing pumps on private property adjacent to Sulphur Springs Creek.

    - Relocating infrastructure or buildings out of the most flood-prone areas.
    - Creating new wetlands to offset development activities.
- If feasible and appropriate, conduct a hydrodynamic analysis of Sulphur Springs Creek to determine the specific ways that the creek could respond under different conditions. As detailed topographic maps are necessary for this analysis, the City may have to generate these maps using Light Detection and Ranging (Lidar) data collected in a future aerial photography flight, or comparable technologies, if maps are not readily available.
- Incorporate flood mitigation strategies into City planning documents, including Benicia's Local Hazard Mitigation Plan.
- Implement feasible strategies in coordination with local property owners including AMPORTS, who currently pumps water off of bordering properties during flood events.
- Continue to coordinate with federal, state, and regional regulatory agencies on issues related to Sulphur Springs Creek flooding and flood mitigation strategies.

Lead Departments: Community Development Department; Public Works Department

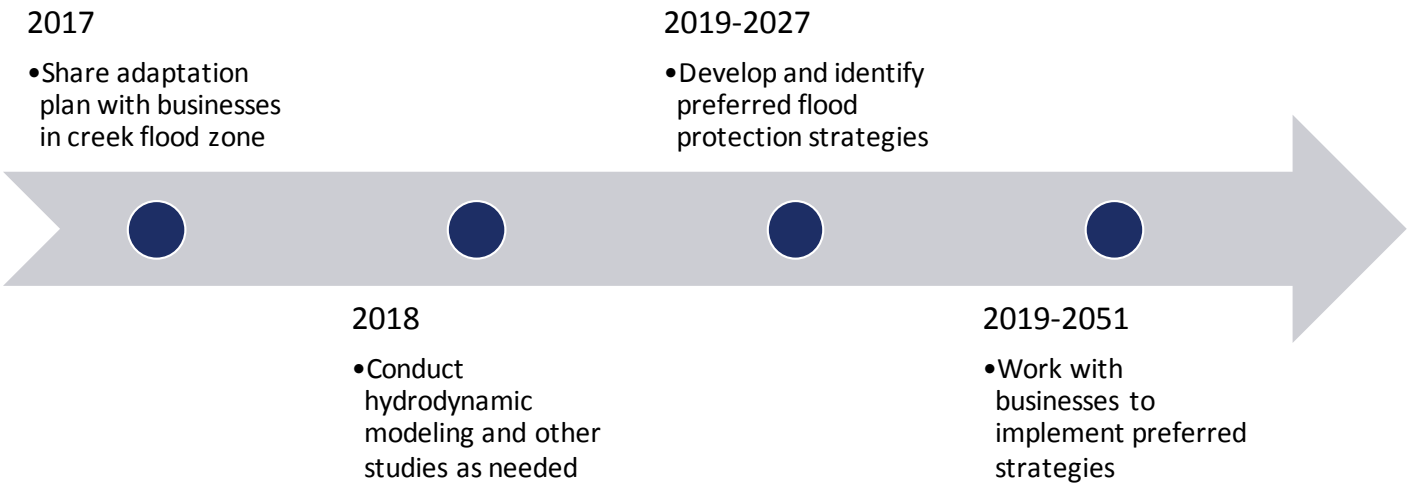
Supporting Departments: Parks & Community Services; Others as applicable

Coordinating External Agencies: California Department of Fish and Wildlife; FEMA; San Francisco Bay Conservation and Development Commission; San Francisco Bay Regional Water Quality Control Board; US Army Corp of Engineers; US Fish and Wildlife Service

Approximate Anticipated Costs:

- Specific costs for planning activities are unknown but depend on the level of effort involved. Costs may be high to plan for some strategies if extensive environmental review is required.
- Hydrodynamic modeling, if necessary, is anticipated to cost approximately $100,000.
- The costs for strategy implementation will depend on the strategies chosen.
- Participating businesses may be able to contribute significantly to the cost of strategy development and implementation, reducing the cost to the City.

Timeline:


2017
•Share adaptation plan with businesses in creek flood zone
2018
•Conduct hydrodynamic modeling and other studies as needed
2019-2027
•Develop and identify preferred flood protection strategies
2019-2051
•Work with businesses to implement preferred strategies

There is no content on this page.

FIGURE 22: Image of Sulphur Springs Creek (highlighted in blue)

Source: Google Earth

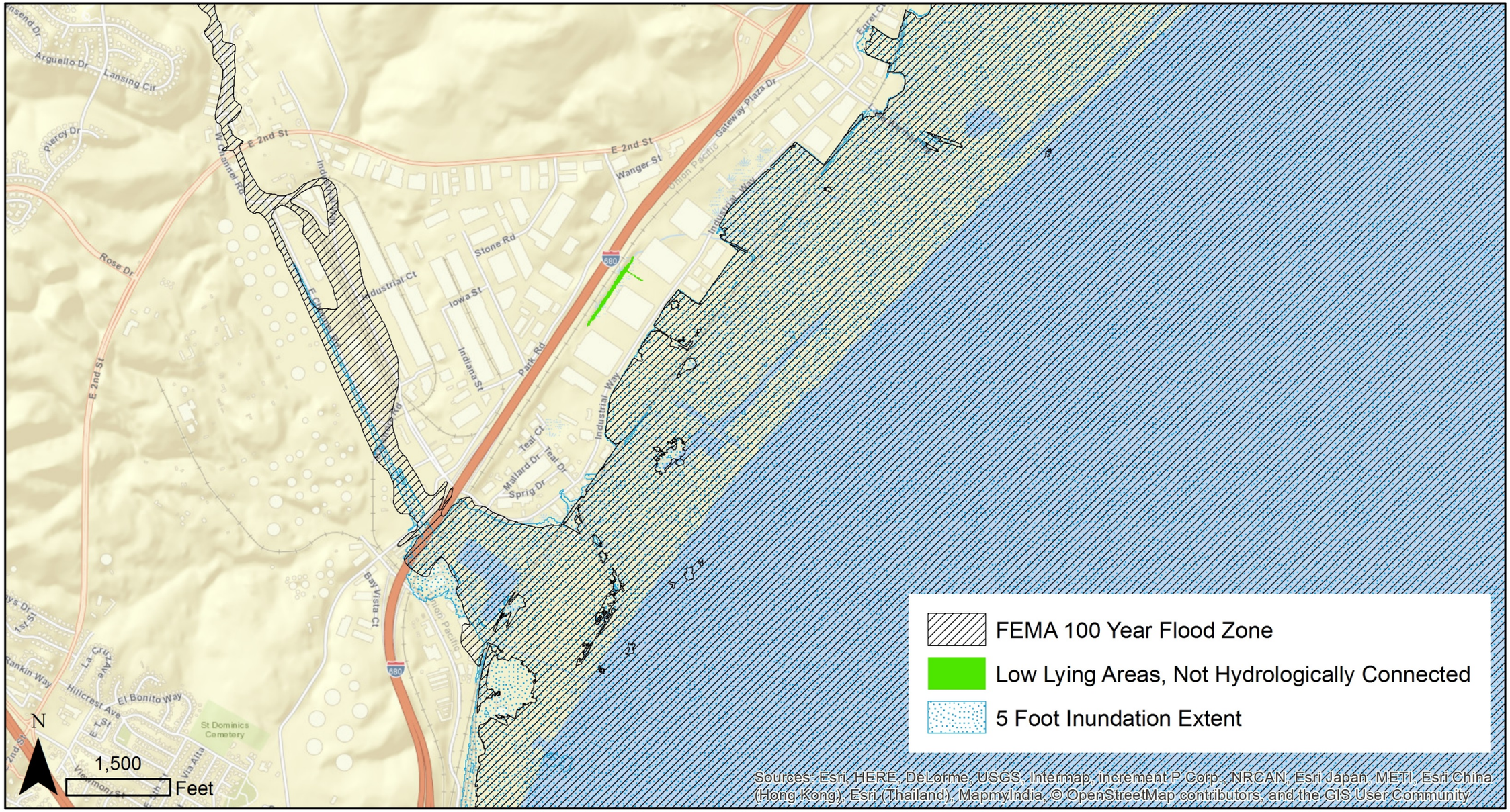
There is no content on this page.

FIGURE 23: Five feet of sea level rise traveling up the creek (highlighted in blue)

Source: NOAA

There is no content on this page.

FIGURE 24: FEMA 100-year flood zone and 5 feet of sea level rise



There is no content on this page.

6. LEGAL CONSIDERATIONS OF ADAPTATION

As part of the City's adaptation planning process, the City of Benicia wanted to better understand potential legal issues associated with implementing priority adaptation strategies selected by the public and City staff. The City partnered with the UC Berkeley School of Law to conduct preliminary legal research, identify potential legal issues, and develop recommendations to prepare the City to successfully implement adaptation strategies. The memo (Appendix C: UC Berkeley Legal Report) is not to be construed as legal advice. Instead, it serves as a source of information the City can consult as it moves forward with increasing resilience. The following is an overview of the memo.

6.1 POSSIBLE LEGAL ISSUES

The UC Berkeley team (two law students and the director of the Energy Program at the Center for Law, Energy & the Environment) identified three major legal issues with a number of subissues. The three primary issues are explained briefly below.

Public Trust Doctrine

Beginning in 1964, the State of California granted the City title and interest in various trust land parcels. The City then leased those lands to Benicia Industries, Inc. (now AMPORTS), and the parcels later became the Benicia Industrial Park and the Benicia Port (privately owned and operated by AMPORTS). These lands must be managed and maintained consistent with the public trust doctrine.

Changes to public trust property lines can occur through different processes including accretion/alluvion[4], avulsion[5], and submergence/erosion. These changes have disparate impacts on property owned by the City and leased by AMPORTS. As the sea level rises, property may be gained or lost.

[4] "Alluvion" refers to an increase in the area of land due to sediment (alluvium) deposited by a river.
[5] "Avulsion" refers to the removal of soil due to a change in a river's course or by flood from the land of one owner to another.

LEGAL ISSUE	RULE	OUTCOME FOR PROPERTY OWNER
Accretion and Alluvion	Natural accretion is the slow addition of land by deposition of waterborne sediment. Artificial accretion is directly caused by human activities in the immediate vicinity of the accreted land.	If accretion is natural, the property owner gains additional land; if artificial, it belongs to the State. Courts presume to give ownership to the property owner.
Avulsion	Avulsion occurs in a quick, sudden act.	If increased storm intensity due to climate change (or other "sudden violence") causes sudden changes in the banks of a water body, the owner may reclaim it within a year.
Submergence/Erosion	Submergence and erosion cause property lines to shift gradually.	Title to land that is gradually submerged by the rise in water levels reverts to the State "in order to guarantee full public enjoyment of the watercourse." The plaintiff has the burden of proof to show that changes in property lines are a result of avulsion versus submergence.

Landlord Obligations and Liability Issues

The City is currently a landlord, and AMPORTS is the lessee/tenant of certain public trust parcels. The existing lease was executed in February 1965 and expires in 2031 (66-year term). Under the current lease, AMPORTS must use the lands consistent with the public trust doctrine. Additionally, AMPORTS assumes responsibility for all repair and maintenance on the premises. In the context of sea level rise and flooding, the Port would be responsible for any adaptations or actions required by law or regulation and those needed to remain in compliance with the public trust doctrine.

As part of the vulnerability assessment process, the City analyzed climate change impacts and risks to these parcels, including sea level rise and storm surge/flooding. AMPORTS also volunteered to conduct a site-specific assessment and share the findings and recommendations in a case study (see Section 7 and Appendix D: AMPORTS Energy Efficiency/Renewable Energy

Case Study.). Both AMPORTS and the City are well aware of the potential impact to trust lands and need to consider these issues as they prepare to renegotiate the existing lease.

Takings

State and local governments have the power, known as the right of "eminent domain," to take private property for public use. Both the United States and California Constitutions place limits on this power; private property may not "be taken for public use, without just compensation." When the government asserts its eminent domain powers, it proactively engages in direct condemnation as opposed to inverse condemnation. There are generally two types of inverse condemnation—a physical taking (loss of property resulting from an invasion or damage) or a regulatory taking (loss of value or use of property due to government regulations). Actions taken by the City may result in liability for inverse condemnation actions if plaintiffs (property owners) can prove certain elements. The City may also be liable for failure to make improvements on its own property that result in damage to nearby private property. Courts typically pay deference to cities, and it is hard for plaintiffs to prove that damage resulted from a city's affirmative and unreasonable actions.

Several cities near Chicago were sued by homeowners and insurance companies because of damage caused by flooding and storm surge. The court found that the City of Chicago Heights was not liable because it did not have exclusive control over the maintenance of the sewer lines (exclusive control is a requirement to prove *res ipsa loquitur* or the occurrence of an accident implies negligence). The City of Benicia should consider that courts have also found that as long as breakwaters or sea walls are constructed for the purpose of controlling navigation or exercising other public trust rights, a public entity is not liable if private property was subsequently damaged as an incidental consequence.

The City must also be careful not to pass regulations that result in a taking of private property. For example, a total ban on construction in flood-prone areas and in areas vulnerable to sea level rise may amount to inverse condemnation. Instead the City should focus on its role as a property owner or holder of trust lands. It has broad authority to implement projects consistent with the public trust doctrine. Finally, to avoid exactions, the City should consider broad/general policies that apply to all property owners versus a select few, e.g., an ad hoc decision about a specific permit. Appropriating fees or land from individual owners may be considered an exaction if not roughly proportional to the impact of concern.

6.2 ADAPTATION STRATEGIES

The UC Berkeley team reviewed a list of priority strategies selected by City staff, assessed potential legal issues, and made recommendations on what the City could do to avoid legal challenges as it implements those strategies. A complete list of strategies and recommendations can be found in Appendix C: UC Berkeley Legal Report. Recommendations include the following:

- Conduct additional research on strategy-specific legal issues.

- Identify existing codes, regulations, and plans that need to be updated to address sea level rise and storm events.
- Draft proposed language for stricter building code standards related to flood hazard reduction.
- Consult with coastal property owners and tenants.
- Partner with regulatory agencies, e.g., the Bay Conservation Development Commission (BCDC), to identify solutions.
- Review financing options for making proposed improvements that would reduce climate change risk.
- Identify vacant parcels or potential redevelopment areas that are currently or will be susceptible to flooding and sea level rise; identify zoning code changes or permit conditions to protect existing and new development.
- Work with BCDC to identify the preferred hardened shoreline protection approach, e.g. sea walls or breakwaters.

The UC Berkeley memo outlines a range of potential legal issues the City may consider as it moves forward with Adaptation Plan implementation. The team indicated that further research, planning, and legal analysis is needed before implementing priority adaptation strategies. This includes additional review of City plans, codes, and regulations and continued collaboration with regional entities like BCDC. The memo serves as a starting point as the City moves forward with increasing the resilience of its businesses, homes, and facilities.

7. AMPORTS CASE STUDY

To understand the potential impacts of climate change on local business and develop some adaptation strategies, the City worked with AMPORTS (at the Port of Benicia). This chapter covers potential vulnerabilities to flooding associated with sea level rise and rising temperatures and associated potential adaptation strategies. A more detailed assessment of strategies to increase energy reliability and energy independence, including energy-efficiency upgrades and renewable energy, is presented in Appendix D: AMPORTS Energy Efficiency/Renewable Energy Case Study.

The Port of Benicia is privately owned and operated by AMPORTS, an automotive services company and port terminal operator. While most of the land is owned by AMPORTS, small parcels under the footings of the pier and adjacent to the AMPORTS land is owned by the City of Benicia. AMPORTS's lease on the City-owned parcels of land is set to sunset in 2032, and until that time, AMPORTS is responsible for all maintenance and upgrades to the property. The Port spans 645 acres within the 4,000-acre Benicia Industrial Park, with 140,000 square feet of vehicle processing buildings and a 38-foot-deep shipping channel. The 2,400-foot-long deepwater pier has the capacity to berth 3 ships, while on-terminal rail access from Union Pacific can potentially utilize 170 railcars. The Port of Benicia is a trading hub with Japan, South Korea, and Australia, and handles general cargo. The Port is the Northern California hub for domestic distribution of Ford and Chrysler, and Toyota delivers to Northern California solely through the Port of Benicia. AMPORTS also serves as a vendor and landlord to Valero for whom it exports oil products from the Valero Benicia Refinery and leases land.

In the future, there are anticipated to be increased instances of flooding from sea level rise and storm events, and increased temperatures which may impact operations. This case study serves to identify vulnerabilities and propose potential adaptation actions that could be taken by AMPORTS or the City.

7.1 PROJECTED CLIMATE IMPACTS AND VULNERABILITIES

Temperature

The number of high heat days, defined as having temperatures above 92.4°F, is projected to increase at the Port of Benicia by between 36 to 48 days by midcentury and 44 to 83 days by end-of-century. The average summer temperature at the Port is projected to increase by 4° to 5°F by midcentury and 5° to 9°F by end-of-century.

Increased temperatures could damage infrastructure facilities at the Port. For example:

- Pavements could deteriorate under extreme temperatures, resulting in rutting and shoving, especially with trucks transporting heavy loads over them. The temperature thresholds for the pavement at the Port are unknown. Additionally, high heat combined with drought could crack and increase the likelihood of potholes (Heitzman, 2010).

- The processing buildings could overheat and be damaged by the expansion and contraction of the metal (U.S. CCSP, 2008). Hot internal temperatures may pose concerns over working conditions as well.

- Outdoor AMPORTS employees, and to some extent indoor employees in buildings with limited air conditioning, are vulnerable to the hot conditions that are projected to become more prevalent by mid- and end-of-century. Temperatures over 90°F can cause heat exhaustion for workers and heat exhaustion is likely if temperatures exceed 105°F (OFCM, 2002). OSHA recently lowered its temperature threshold to 80° F for increased access to water and breaks.

Sea Level Rise, Storm Surge, and Flooding

Historically, flooding at the Port property has occurred approximately once every 10 years with minimal damage. Inventory was moved to other locations and the Port closed for approximately one day. Lasting damages were minimal. On a frequent basis, even during the summer months, AMPORTS must use its electric levee pumps to remove water from the property that collects due to drainage issues along Sulphur Springs. In the event of a power outage, the Port can use diesel generators to power the pumps. The majority of the Port's concerns regarding flooding stem from the inland flooding from Sulphur Springs. As water travels down Sulphur Springs, it intercepts the rail bridge and floods into the property. During very heavy storms, the Valero WWTP ponds can spill over and increase the level of flooding. AMPORTS currently pumps the water from these events off its own property and also directs water away from neighboring properties who do not own pumps.

Sea levels are projected to rise in Benicia by 12 to 24 inches by midcentury and by 24 to 60 inches by the end of the century, resulting in daily inundation of parts of the city. However, this inland flooding could occur much sooner on an infrequent basis due to storm events. In the City of Benicia, 36 inches of sea level rise will permanently flood roughly the same area as a current 100-year storm which could occur at any time. As mentioned above, flooding in the Port area is exacerbated by poor drainage of Sulphur Springs Creek.

While the Port is currently protected from coastal flooding by levees, water traveling up Sulphur Springs Creek from higher sea levels and increased future flooding events may cause property damage. Figure 24 shows the Port of Benicia in relation to a 50-year high tide event on top of 18 inches of sea level rise (alternatively, this same level of flooding could also be achieved with 24 inches of sea level rise and no storm surge, or a 1 foot increase in sea level, projected to occur sooner than midcentury, coupled with a 100-year storm). While the Port has levees that protect against current flooding conditions, future flooding events like the one shown in Figure 26 could result in overtopping of the current levee system. The current levees are at an elevation of approximately 3 feet higher than today's high tide. The mapping tools used in this study indicate that the levee system would begin to be overtopped with 24 inches of total water level

(the combination of sea level rise and storm surge) with complete overtopping under the 60-inch total water level scenario. Should overtopping occur, large parts of the paved cargo storage area below the levees would be inundated. Additional research would be required in order to pinpoint how the levee system will respond to sea level rise and storm surge since precise elevation information is unavailable.

FIGURE 25: Flooding in the Port area with 5 feet change in total water level

Source: NOAA

Increased flooding events and storm surge can damage infrastructure and facilities at ports. For example:

- Mechanical equipment sensitive to saltwater, such as the Port's pumps and generators, may fail during severe flooding events. If the levees were overtopped, then the pumps would flood. Currently, the Port checks the levees weekly to ensure they are dry and operating properly. The saltwater in the Bay has increased over the years, leading to faster rates of corrosion.

- The Port is also vulnerable to sea level rise and flooding impacts on transportation assets located outside of AMPORTS's property, such as the UP rail lines leading into the property and segments of Bayshore Road, which could limit Port access. While UP can easily raise its rail lines, it cannot as easily moved fixed assets such as switch stations, bridges, and culverts.

- Increased upstream erosion can also increase dredging needs as sedimentation increases, though this may be offset by increases in sea level, and thus channel depth (NRC, 2008). The Port is currently investigating the purchase of a jet pump to help maintain the channel depth by stopping sediment from settling there.

- Flooding events are also projected to increase burdens on the Port's drainage system and susceptibility to liquefaction from earthquakes as groundwater penetrates further into the Port. Currently, the stationary and portable pumps assist with drainage issues.

- From a supply chain perspective, sea level rise, storms, and flooding may impact the supply and shipment of vehicles from around the world.

Negative impacts from sea level rise and flooding could lead to a loss of jobs and economic output if companies choose to move their products through other ports.

Similar to extreme heat events, sea level rise and flooding will require further study to identify more detailed future flood scenarios for the Port, weak spots in the levee system, erosion impacts, and design thresholds of equipment with respect to inundation and exposure to salt water.

7.2 ADAPTATION STRATEGIES

The following section describes adaptation strategies that the Port of Benicia can employ to increase resilience against heat and flooding impacts. The Port is making progress on some of these measures, but should continuously evaluate potential to both expand existing initiatives and implement new ones.

Priority Adaptation Strategies

As determined in the meeting between Benicia and AMPORTS on May 21, 2015, the following adaptation strategies are top priorities for the Port.

- The City and AMPORTS should work together to study and address flooding issues along Sulphur Springs Creek. AMPORTS's preference is to dredge the creek; however, this would require permits and coordination with regulatory agencies (e.g., USACE, USFWS, CDFW, BCDC, RWQCB). Addressing flooding along Sulphur Springs is also a priority in the City of Benicia Adaptation Plan, and the City is planning to explore the potential for:

    - Enhanced vegetation control practices.
    - Dredging the creek.
    - Constructing floodwalls or installing pumps on surrounding private properties.
    - Installing a tidal gate to prevent sea level rise and storm surge from traveling up the creek.

    - Relocating infrastructure or businesses out of flood-prone areas to expand the floodplain.
    - Creating compensatory wetland mitigation to offset any infrastructure impacts.

- The City and AMPORTS can evaluate the feasibility of raising the elevation of the road that leads to the dock or installing roadside flood walls to prevent flooding from sea level rise and storm surge. This is currently the only low point of the property that would allow for flooding from Carquinez Strait.

- The City and/or AMPORTS can work with Marin Clean Energy to install a solar PV array to reduce peak power demand and increase resiliency to power interruptions. The array could be located on the hillside by the Benicia clock tower, which is too steep for AMPORTS to develop into surface parking lots. This potential strategy is further evaluated in Appendix D.

- Potential energy-efficiency programs could be implemented at the Port. This potential strategy is further evaluated in Appendix D and could include the following:

    - Install cool roofing and/or reflective roofing using colored or cooler materials to reduce interior temperatures.
    - Implement building insulation strategies via roof deck insulation, wall insulation, high performance windows, and building orientation.
    - Invest in alternatives to active cooling systems such as solar-powered air conditioners and fans, and cold water systems.
    - Invest in HVAC optimization strategies to reduce worker heat stress and reduce electricity costs.
    - Implement other energy-efficiency measures.

Lower Priority Temperature Strategies

Although the following strategies are not identified for immediate action, they may be important for increasing the Port's overall preparedness for future extreme temperatures.

- Continue collaborations between AMPORTS, the City, and local stakeholders (e.g., UPRR, Valero) on climate change issues, including the sharing of asset condition information, plans for upgrades/maintenance of facilities, and maintaining access to facilities after extreme weather events.

- When conducting regular maintenance of paved surfaces, evaluate the potential life cycle costs of changing the pavement binder to be able to withstand higher temperatures or using of cool pavements.

- Consider permanently shifting summer work schedules to earlier in the morning or later at night, when temperatures are lower. This would also increase efficiency at the Port since this is when vehicles can be loaded to leave the Port. Note that shift work is already implemented when the weather forecasts very hot temperatures for several days. In order to shift work, the Port must provide employees with at least a week's advance notice.

Lower Priority Sea Level Rise, Storm Surge, and Flooding

Although the following strategies are not identified for immediate action, they would contribute to the overall resiliency of the Port to flooding issues.

- Formally measure the rates of subsidence. The lots behind the levees have significantly subsided. Subsidence may increase the local rate of sea level rise and increase the frequency of flood events.

- Identify the potential for increased erosion, scour, and wear due to increased tide and wave energy. The portions of the dock with wooden pilings is more susceptible to damage.

- Assess water flow paths on the Port property in order to determine "weak links" or low points in the levee system that may be ripe for increased protection from sea level rise and storm surge. Follow the process established in the Adapting to Rising Tides second transportation study.

- Evaluate and monitor the need for increasing the capacity or coverage of the storm pumps and on-site generators to minimize flooding and maintain operations; however, this is not anticipated to be required in the near term. The current pumps are used during rain events and even during summer months due to Sulphur Springs. The existing backup pumps are larger than the main pumps and portable pumps provide some additional coverage.

- Continue weekly groundkeeping to ensure that rodents do not bore through and undermine the levees.

- Ensure that the Emergency Operations Plan includes information on climate change and the potential impacts (and appropriate response to) sea level rise and extreme weather events. The Port already operates a robust extreme weather event training program with an annual refresher that includes information on where and how to strategically place sandbags.

- Support partnership among the City, AMPORTS, and local stakeholders to engage in collaborative multi-objective planning to improve the resilience of Port access routes, vulnerable Port assets, and the inland areas they protect as the first line of defense against flooding. This can be achieved through the development of a plan for increasing

the height and area protected by the Port levees or implementing alternative protection strategies.

- The City and AMPORTS should begin planning for the renewal of the Port lease by discussing roles and responsibilities for sea level rise protection. The City should consider adding specific maintenance measures to the lease.

- Develop a contingency plan for using other port facilities within or outside of the region in the event of temporary or permanent disruption at the Port of Benicia. Although AMPORTS already has some ability to shift vehicles during storm events, more frequent flooding in the future may require an enhanced plan.

- Work with other local marine companies or government agencies to commission a study on the potential impact of climate change on dredging needs, considering both sea level rise (which may reduce dredging needs) and increased runoff (which may increase dredging needs). If necessary, AMPORTS should begin factoring in more frequent dredging when budget planning.

- Continue to investigate the feasibility of using dredged materials to increase the Port's levee heights. Coordinate with BCDC on developing a protocol for this practice.

- Maintain all levees that front the Port property, and the existing walls on the east edge of the property. AMPORTS already periodically increases the height of its levees. Assess the need for repairs or height increases on a regular basis (e.g., annually). Height increases should be based on observed storm impacts and measured sea level rise/local subsidence or refined sea level rise projections.

- Invest in increased floodproofing when performing routine maintenance processes and upgrading assets at the end of their useful lives.

- Ensure that all storm drains and water flow pathways surrounding buildings are cleared of any debris that may block water from correctly flowing to drains.

- Develop internal guidance on how to consider sea level rise and storm events in the process for developing, planning, and funding capital investments. This guidance should encourage capital investments and new infrastructure to be sufficiently hardened against future changes in climate. In most cases, adaptation measures at the Port can be deferred and combined with scheduled maintenance or replacement.

7.3 FUNDING SOURCES FOR ADAPTATION STRATEGIES

At this point, specific funding sources for hardening Port infrastructure against the impacts of sea level rise have not been identified. For energy-efficiency programs, a number of funding sources could help reduce energy costs and prepare for increased temperatures.

- Align adaptation projects with mitigation projects, such as installing solar power to both reduce greenhouse gas emissions and increase resilience to power outages. This can achieve multiple goals for a given amount of funding.
- Bay Area Joint Policy Committee (program criteria still under development)
- Savings by Design
    - Encourages high-performance new building designs and construction for commercial buildings. Offers incentives for customized new construction projects that exceed California's Title 24 energy efficiency standards.
- Customized Retrofit Incentives
- Business Rebates
- On-Bill Financing
    - Offers government entities 0%, no-fee loans of up to $250,000 (or $1 million under certain conditions), with terms of up to 10 years for installation of qualified energy-efficiency measures under specified utility incentive programs.
    - Loans are then paid back on the monthly utility bill.
    - In some cases, the monthly energy savings may be equal to or greater than the monthly payment. This program also offers commercial customers financing of $100,000 with terms of up to five years.
- Automated Demand Response (DR) Program
    - Designed to enable customers to contribute to energy load reduction during times of peak demand.
    - Offers financial incentives for load reduction during times of peak demand. Participation is open to customers enrolled in a qualifying DR or time-varying pricing programs.
    - Auto-DR uses communication and control technology to automatically implement the customer's chosen preprogrammed load reductions, providing a fast and reliable way to respond to peak events while still leaving the customer in complete control.
    - Incentives range from $125 to $400/kW of reduction capability, depending on level of automation and utility company.

- Eligible equipment includes: energy management systems and software, wired and wireless controls for lighting, HVAC, thermostats, motors, pumps and other equipment capable of receiving curtailment signals.

- Base Interruptible Program
  - The Base Interruptible Program provides incentives to reduce facility loads to below a level that is pre-selected by the customer (i.e., firm service level, or FSL).
  - The program provides 30 minutes' advance notice, and pays between $8.00/kW to $9.00/kW per month in incentives, where payments are provided even in the absence of events called.
  - Failure to reduce load down to or below your FSL during an event will result in a charge of $6.00/kWh for any energy use above the FSL.
  - Maximum of one event per day and four hours per event. The program will not exceed 10 events per month, or 120 hours per year.

- Demand Bidding Program
  - Low-risk demand response program that provides incentives to reduce electric loads during program events.
  - Allows customers to submit load reduction bids on an hourly basis for any event without a financial penalty. Demand bidding program events usually take place from noon to 8:00 p.m. and can occur on any weekday excluding holidays.
  - There is no penalty for failure to reduce electric load during an event.

- Property Assessed Clean Energy (PACE) Programs
  - Offers financial incentives and rebates to businesses and individuals around the State of California for participating in various programs that promote clean energy technologies and practices.
- Public-Private Partnerships
  - A public–private partnership (PPP or 3P or P3) is a relationship between a government entity and one or more private sector companies. A PPP usually involves a contract between a public sector authority and a private party, in which the private party provides a public service or assumes substantial financial, technical and operational risk in the project. These partnership allow cities to take more risk and innovate.

- CDP (formerly the Carbon Disclosure Project) is currently working on a model to increase these types of partnerships to advance implementation of adaptation efforts.
- The Rockefeller Foundation is currently implementing the 100 Resilient Cities campaign. The Foundation provided funding for 100 cities around the world to develop resilience strategies.

8. CLIMATE CHANGE ADAPTATION STRATEGIES FOR BUSINESSES AND HOMEOWNERS

This plan focuses on adaptation strategies that can be undertaken by the City of Benicia; however, individual businesses and homeowners will also have to take action to prepare for a changing climate. The following strategies are examples of the types of actions that could be taken. A public outreach plan would need to be developed and implemented to inform the community and businesses of available strategies and how best to prepare. Costs would vary depending on the specifics of implementation.

8.1 EXTREME TEMPERATURES

- Install battery backup systems for use during power outages.
- Participate in DR programs, such as "Flex Alert," that incentivize businesses to conserve electricity and shift demand from peak to off-peak hours.
- Develop a plan for extreme heat days including assurance of adequate water, shade, rest breaks and training on heat risks.
- When conducting regular maintenance, evaluate the potential life cycle costs of increasing resilience.
- Review the operating temperature ranges of equipment and replace, as necessary, at the end of their useful life with more resilient designs.
- Install solar-powered or diesel generators.
- Invest in HVAC optimization strategies.
- Install equipment that can participate in DR programs automatically.
- Install cool roofing and reflective roofing using light-colored or cooler materials.
- Employ building insulation strategies via roof deck insulation, wall insulation, high performance windows, and building orientation.
- Shade building with trees.
- Improve access to air conditioning units to protect workers and the public from heat stress.
- Invest in alternatives to active cooling systems such as solar-powered AC and fans, and cold water systems.
- Follow industry indoor temperature guidelines and Heat-Health Alert Warnings.

8.2 SEA LEVEL RISE, STORM SURGE, AND FLOODING

- Develop a continuity of operations plan that includes information on climate change and the potential impacts (and appropriate response to) sea level rise and extreme weather events.
- Invest in increased floodproofing when performing routine maintenance.
- Ensure that all storm drains and water flow pathways surrounding buildings are cleared of any debris that may block water from correctly flowing to drains.

9. MOVING FORWARD

This plan represents an important first step in preparing the City of Benicia for the impacts of climate change, but this is only the beginning. The City has important work ahead to begin implementation of the strategies in this plan, monitor their effectiveness, share lessons learned with nearby communities, and update this plan as needed. The City will be responsible for updating the plan, at a cost to be determined based on specific needs.

- Although 11 strategies are highlighted as priorities in this plan, they are not the only steps that Benicia needs to take to become a more resilient city. Appendix B: Compendium of Adaptation Strategies presents a broader set of adaptation strategies to address sea level rise, storm surge, and extreme temperatures. The strategies are organized by geographic area and vulnerability to facilitate easy review and use by the City. The strategies range from:

- Emergency response planning
- Code changes to ensure future construction is resilient
- Hardening of the shoreline in specific locations
- Post-flood responses
- Protection of natural habitats, parks, and trails
- Special consideration for communities of concern
- Protection of key economic centers and residences
- Collaboration with partner agencies
- Reduction of urban heat islands
- Increases in energy efficiency
- Additional research and monitoring needed to develop additional strategies

When implemented together, these actions will create a complete strategy for resiliency that can be revisited and updated. As feasible, the City should mainstream the policy and management-based strategies into everyday practice, but it is understood these will take time to fully integrate.

As the City implements this adaptation plan, it will also continue to collaborate with local, regional, state, and federal agencies that are on the forefront of this work. Coordinated action is necessary to tackle the large barriers that remain, including the lack of funding to implement priority strategies.

It is also understood that the funding and staffing to coordinate and implement adaptation strategies citywide is a challenge that must be addressed if plan implementation is to move forward.

Climate Change Adaptation Plan

Appendix A

Evaluation Criteria

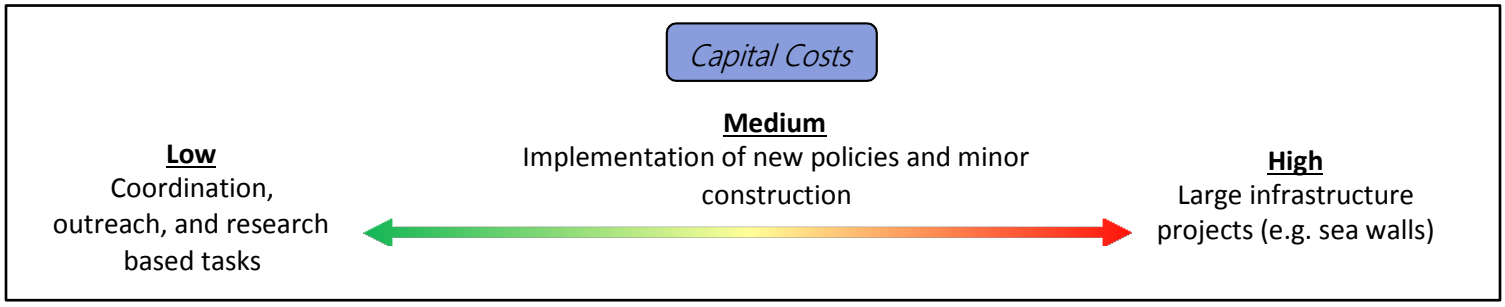
THE CITY OF BENICIA CALIFORNIA

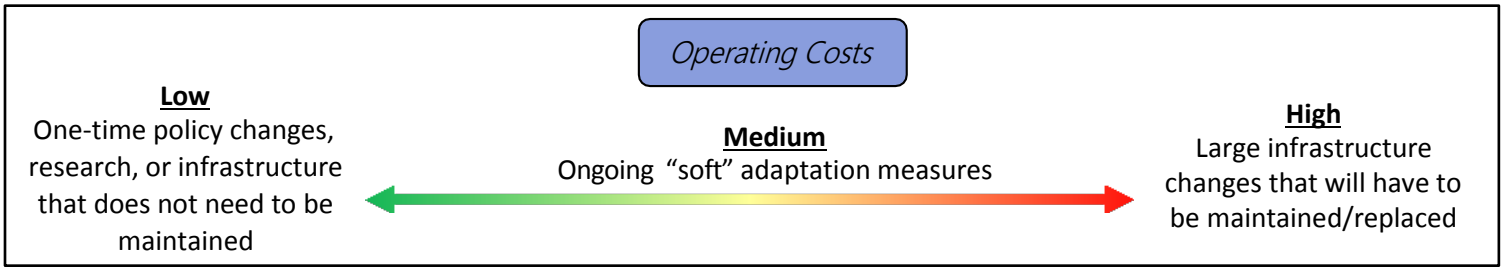
APPENDIX A: EVALUATION CRITERIA

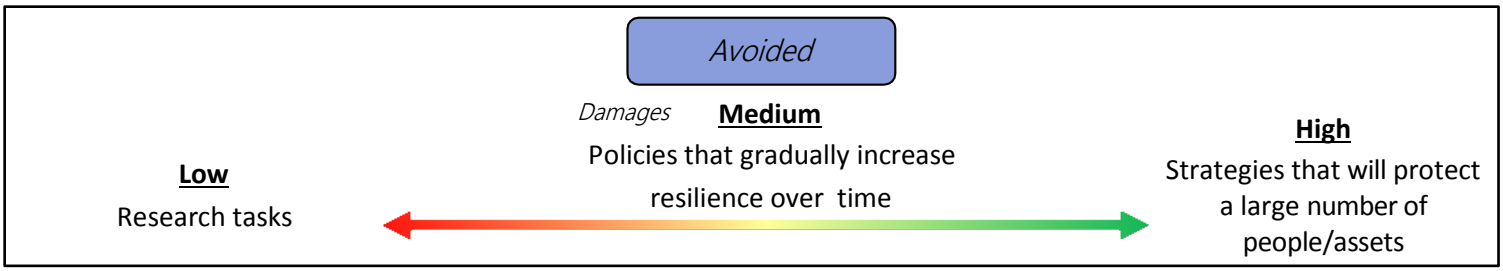
Evaluation criteria are an essential tool that the City can use to select and prioritize action to adapt to a changing climate. BCDC and the Adapting to Rising Tides project provided example criteria and organized the criteria into four assessment frames: Society and Equity, Economy, Environment, and Governance. The five evaluation categories below were developed with these frames in mind and with input from City staff and department heads.

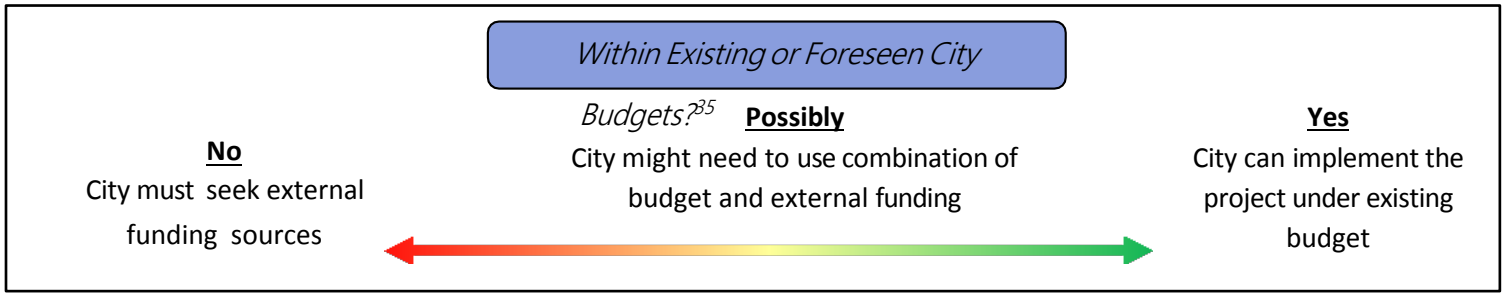
EVALUATION CATEGORY 1: SUPPORTING COST-EFFECTIVE RESILIENCE MEASURES AND A THRIVING ECONOMY

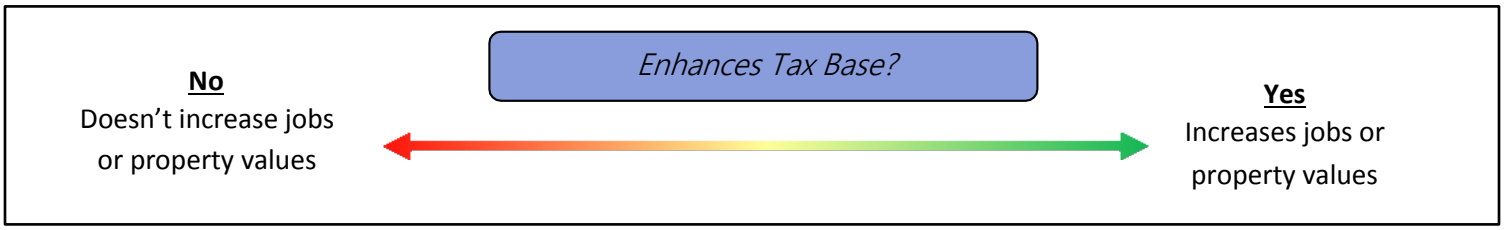
Consideration of the economic feasibility of adaptation strategies is crucial for the City of Benicia, which often implements programs and projects with tight budgetary limitations and for its residents and businesses who could experience lost revenues or cleanup costs related to climate change events. By characterizing the monetary costs and benefits of each adaptation strategy, the City can rank strategies on a scale of low-cost, high-benefit (more desirable) to high-cost, low benefit (less desirable). The evaluation subcriteria for adaptation strategies in this category are comprised of capital costs, operating costs, avoided damages, whether a strategy is within existing of foreseen city budgets, and whether a strategy will enhance the tax base. Each criterion is described in greater detail below:











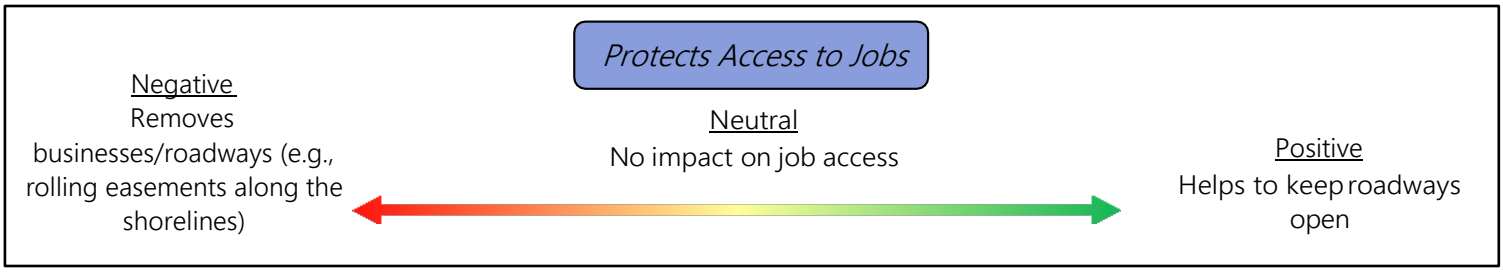
EVALUATION CATEGORY 2: PROTECTING POPULATIONS OF CONCERN AND ACCESS TO THE OUTDOORS

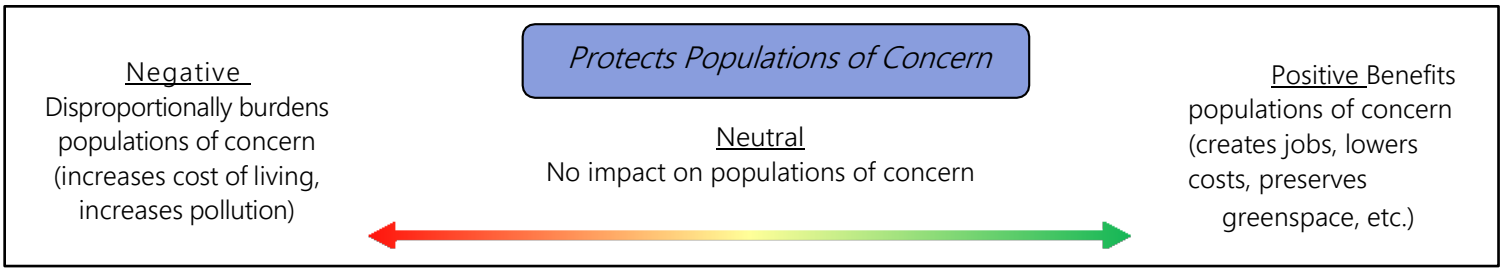
The impacts of climate change are expected to unequally burden those who can least afford to deal with its consequences. Adaptation actions that enhance the climate resilience of populations of concern are crucial in developing a fair and equitable adaptation plan. The City of Benicia consulted with public health officials in Solano County and the Bay Area to define and identify populations of concern in Benicia. Benicia worked to identify a definition that made sense based on the demographics of its residents. After consultation, the team developed the following definition:

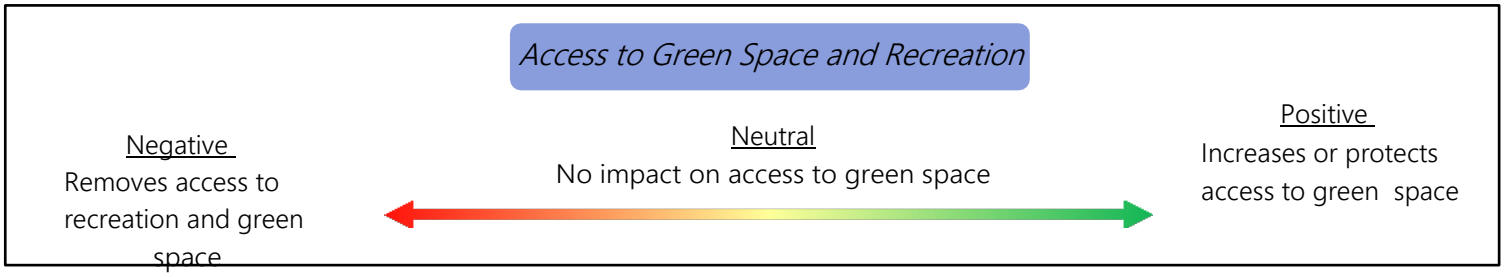
Populations of concern include elderly residents (primarily located in Rancho Benicia), low-income families, children, populations with limited English proficiency, those with pre-existing health conditions like asthma, residents without access to vehicles, and those who work or live near hazardous clean-up sites.

[1] This criteria was not assessed for all adaptation strategies, but should be considered by the City before selecting any final adaptation strategies for implementation. Projects with implementation and operating costs outside of city budgets can still be pursued, though likely through external funding sources such as grants.

The evaluation subcriteria for adaptation strategies in this category consist of protecting access to jobs, protecting populations of concern, and maintaining access to green space and recreation, and are described in greater detail below:

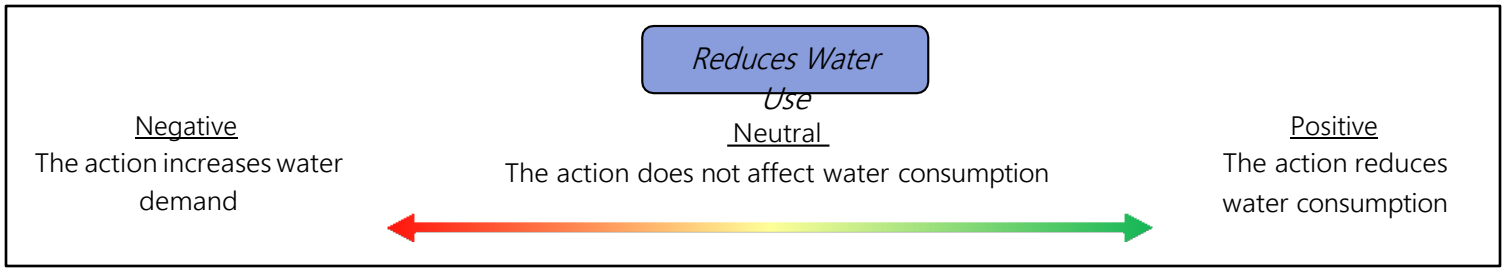


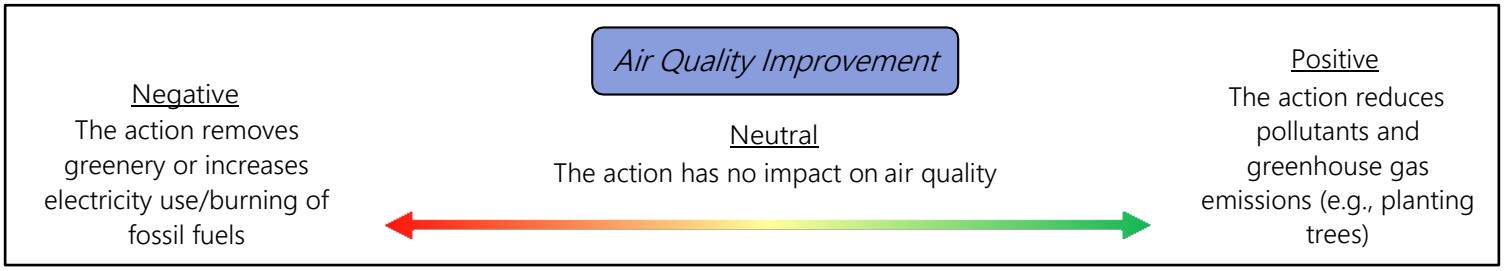


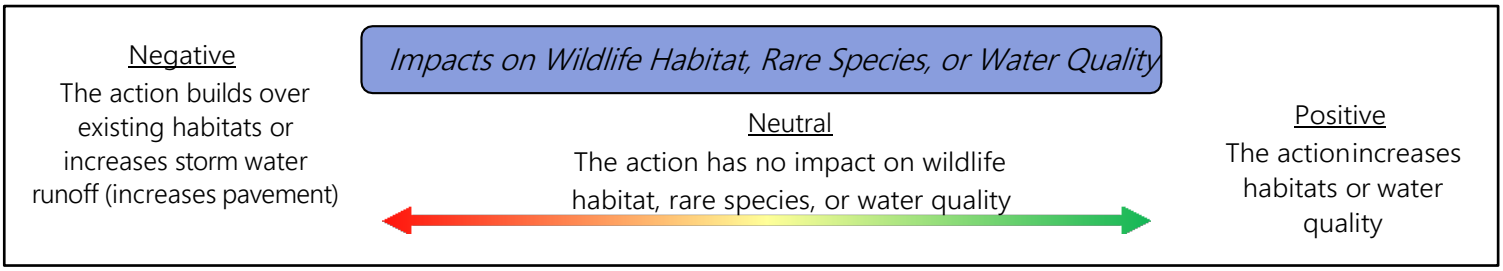


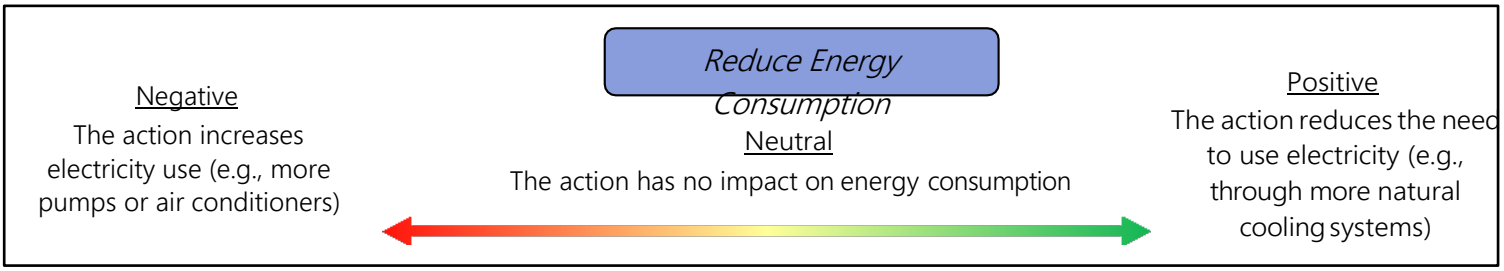
EVALUATION CATEGORY 3: INCREASING RESOURCE EFFICIENCY AND MAINTAINING A HEALTHY ENVIRONMENT

Adaptation strategies that reduce water and energy consumption, as well as air pollution and habitat degradation, can enhance environmental services on which the residents and businesses of Benicia depend. The evaluation subcriteria for adaptation strategies in this category are comprised of impacts on wildlife habitat, rare species, or water quality; reduction of water use; potential for air quality improvement; and reduction of energy consumption. Each criterion is described in greater detail below:









EVALUATION CATEGORY 4: OVERCOMING BARRIERS AND ALIGNING WITH EXISTING POLICIES

Climate adaptation is still a new and emerging field of work. For this reason, local, state, and federal policies may have not been designed to accommodate the types of strategies currently under consideration, but every level of government is working to overcome these barriers. To better understand the regulatory barriers, the City worked with the UC Berkeley School of Law to assess legal issues that could impede planning for climate change and the implementation of adaptation strategies. The evaluation subcriteria for adaptation actions in this category consist of political

decision-maker feasibility, community support, opportunity for community involvement, and consistency with city plans, and are described in greater detail below:

Political Decision-Maker Feasibility

Low
High-cost measures or policies that impact land owners (e.g., rolling easements) and that are inconsistent with existing priorities

Medium
Policy changes that aren't likely to be too politically charged

High
Low cost actions that are quick and easy to implement and consistent with existing City priorities

Opportunity for community involvement

Low
Public agency coordination and research. Things that are more likely to evaluated internally

Medium
Policy decisions and construction projects that would undergo community review before approval

High
Direct interaction with the community through outreach and other on-the-ground activities

Community Support[6]

Low
Policies without much community support

Medium
Policies with equal levels of support and opposition within the community

High
Policies supported by local community members

Consistency with City Plans/Policies

Low
Strategy would require development of new city policies

Medium
Strategy may require modifying small aspects if City plans and policies

High
Strategy is consistent and works well with existing City plans and policies

Is the Strategy Legally Mandated?

No
Strategy is not required under current law

Yes
Strategy is required under current law

Legal or Regulatory Barriers[9]

This qualitative criterion seeks to highlight any regulatory barriers to implementation.

EVALUATION CATEGORY 5: ADDITIONAL CONSIDERATIONS

For each adaptation strategy, Benicia defined additional considerations that did not fit into the above four categories. The evaluation criteria for adaptation actions in this category comprise less-subjective criteria such as the time period required for implementation, implementing agency, the scale of the project, opportunity for integration into city plans, other co-benefits that are not covered in the existing evaluation criteria, the level of urgency (i.e. how soon Benicia should begin implementing an action to provide maximal benefit), and adaptability over time/flexibility, and are described in greater detail below:

Implementation Time Period

0- 5 Years
Strategies that collect information, gather resources, or impact large investments (e.g. policy changes)

5- 30 Years
Strategies with less pressing information needs (e.g. community engagement projects)

30+ Years
Large infrastructure projects or long-term policies

Implementing Agency

This qualitative criterion identifies which agency should take the lead in implementing the strategy.

Scale

Asset	System	Community
Helps just one location (e.g., flood proofing a single building)	Helps to protect multiple assets in the same sector (e.g., all roadways)	Helps to protect many people and types of assets

Opportunity for Integration into City Plan

This qualitative criterion identifies any opportunities to align a strategy with existing City plans and goals.

Co-Benefits

This criterion identifies any benefits not captured by the above evaluation criteria, such as reducing greenhouse gas emissions, increasing interagency collaboration, health benefits, and positioning the City for future grant funding.

Level of Urgency

No	Medium	High
Non-priority strategies whose implementation can wait until late-century	Strategy can be implemented by midcentury and still deliver benefits	Strategy would provide immediate benefits

Can Benicia Revise the Strategy Over Time?

No	Partially	Yes
Hard changes in infrastructure that do not have plans for phased adaptation	Policies that impact the construction of many things over time (e.g., zoning, building codes)	Plans, outreach, and research based strategies

Climate Change Adaptation Plan

Appendix B

Compendium of Adaptation Strategies

THE CITY OF BENICIA CALIFORNIA

	Benicia: Sea Level Rise Adaptation Options (V5, 10/10/16). Color Coding as follows: GREEN = Favorable; YELLOW = Moderate; RED = Unfavorable.			Descriptive (not criteria)		General Criteria	
Ref #	Strategy Summary	Detailed Adaptation Measures	Vulnerabilities Addressed	Time period for implementation (0-5 years, 5-30 years, 30+ years)	Scale (community, system, asset)	Level of Urgency (low, med, high)	Adaptable Over Time (yes, partially, no)
	Geographic Areas						
1	***Benicia State Park***						
1.3.3	Reduce erosion and land loss impacts from sea level rise and storm events to natural, non-wetland shorelines (e.g., sandy	Monitor erosion over time; if erosion is an issue, utilize soft structures to limit bluff erosion.	Surrounding natural bluff features are made of erosive material subject to wave action as well as erosion due to overland flow. As sea level rises, waves may become larger and act higher up on the bluffs,	5-30 years	System	Medium	Yes
2	***West L and West 14th Street to West 9th Street***						
2.1	Reduce erosion and land loss impacts from sea level rise and storm events to natural, non-wetland shorelines (e.g., bluffs)	Monitor bluff erosion over time. If erosion is an issue, work with residents to install structural improvements (e.g., increase armoring), in front of their properties. At 12th St and 9th Street Park, the City should implement similar protection measures if erosion rates accelerate.	Surrounding natural bluff features are made of erosive material subject to wave action as well as erosion due to overland flow. As sea level rises, waves may become larger and act higher up on the bluffs, increasing the bluffs' susceptibility to erosion.	5-30 years	Community	Low	Yes
2.2.1	Track the condition of the shoreline structures and perform maintenance to prevent premature damage	While not immediately at risk, these areas should regularly be reassessed for vulnerability and the need for upgrades over time as sea level rise projections are updated. The City should work with residents to plan for increasing revetments on their property may offer additional protection by placing additional armoring sized for increasing wave conditions. The revetment height can be increased, and additional toe protection can be added as needed. Sea walls can be raised vertically, or expanded horizontally to prevent flanking.	Isolated sea walls (privately owned) and engineered revetments harden the shoreline, protecting it from waves and strong currents that could cause erosion and land loss. Revetments and seawalls are primarily designed to protect the shoreline, but they are susceptible to damage from strong currents and wave conditions that occur beyond the "design" event. As sea level rises, wave heights and velocities may increase, exposing the revetments and sea walls to conditions beyond those for which they were designed. Additionally, increased overtopping could result in a loss of foundation material and undercutting of the toe, potentially causing the entire structure to become unstable.	5-30 years	Community	Medium	Partially
2.2.2		Increase maintenance and inspection schedule for engineered shoreline protection features in this area.		5-30 years	System	Low	Yes

	Benicia: Sea Level Rise Adaptation	Economy				Environment				Equity			Governance	
Ref #	Strategy Summary	Capital Costs (low, med, high)	Operating Costs (low, med, high)	Avoided Damages (low, med, high)	Enhances Tax Base (yes, no)	Impacts on Wildlife Habitat, Rare Species, or Water Quality (positive, neutral, negative)	Reduce Water Use (positive, neutral, negative)	Air Quality Improvement Potential (positive, neutral, negative)	Reduce Energy Use (positive, neutral, negative)	Protect Access to Jobs (positive, neutral, negative)	Protection of Vulnerable Populations (positive, neutral, negative)	Access to Green Space and Recreational Areas (positive, neutral, negative)	Political Decision-Maker Feasibility (low, med, high)	Opportunity for Community Involvement (low, med, high)
	Geographic Areas													
1	***Benicia State Park***													
1.3.3	Reduce erosion and land loss impacts from sea level rise and storm events to natural, non-wetland shorelines (e.g.,	Medium	Medium	Medium	No	Positive	Neutral	Neutral	Neutral	Neutral	Positive	Positive	High	Low
2	***West L and West 14th Street to West 9th Street***													
2.1	Reduce erosion and land loss impacts from sea level rise and storm events to natural, non-wetland shorelines (e.g., bluffs)	Low	Medium	High	No	Positive	Neutral	Neutral	Neutral	Positive	Positive	Positive	High	High
2.2.1	Track the condition of the shoreline structures and perform maintenance to prevent premature damage	Medium	Low	High	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low
2.2.2		Low	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low

	Benicia: Sea Level Rise Adaptation Options (V5, 10/10/16). Color Coding as follows: GREEN = Favorable; YELLOW = Moderate; RED = Unfavorable.			Descriptive (not criteria)		General Criteria	
Ref #	Strategy Summary	Detailed Adaptation Measures	Vulnerabilities Addressed	Time period for implementation (0-5 years, 5-30 years, 30+ years)	Scale (community, system, asset)	Level of Urgency (low, med, high)	Adaptable Over Time (yes, partially, no)
3	***West 9th Street to Gull Point Court***						
3.1	Reduce erosion and land loss impacts from sea level rise and storm events to natural, non-wetland shorelines (e.g., bluffs)	Monitor bluff erosion over time. If erosion is an issue, work with residents to install structural improvements (e.g., increase armoring), in front of their properties. At 12th St and 9th Street Park, the City should implement similar protection measures if erosion rates accelerate.	Surrounding natural bluff features are made of erosive material subject to wave action as well as erosion due to overland flow. As sea level rises, waves may become larger and act higher up on the bluffs, increasing the bluffs susceptibility to erosion.	5-30 years		Low	Yes
3.2.1	Track the condition of the shoreline structures and perform maintenance to prevent premature damage	Isolated seawall and revetments maintained and owned by home owners should be incorporated into an overall bluff protection strategy to provide a uniform protections system if space is available (varies from property to property). The uniform system could be structural (e.g., enhanced revetments and seawalls) or non-structural (e.g., increased vegetation). Where little to no room to incorporate a shore protection system exists and elevations are low, managed retreat (i.e., removing the properties from active use) should be considered.	Isolated sea walls and engineered revetments harden the shoreline, protecting it from waves and strong currents that could cause erosion and land loss; however, residences do abut the shoreline. Revetments and seawalls are primarily designed to protect the shoreline, but they are susceptible to damage from strong currents and wave conditions that occur beyond the "design" event. As sea level rises, wave heights and velocities may increase, exposing the revetments and sea walls to conditions beyond those for which they were designed. Additionally, increased overtopping could result in a loss of foundation material and undercutting of the toe, potentially causing the entire structure to become unstable.	5-30 years	System	Medium	Partially
3.2.2		Increase maintenance and inspection schedule for engineered shoreline protection features in this area.		5-30 years	System	Medium	Yes
4	***Gull Point Court to West Kuhland Alley***						
4.1.1	Track the condition of engineered revetment to prevent premature damage	While not immediately at risk, this area should regularly be reassessed for vulnerability and the need for upgrades over time as revised sea level rise projections are produced. The City should work with residents to plan for improving revetments on their property such as by increasing the armoring size. The revetment height can be increased, and additional toe protection can be added as needed. Sea walls can be raised vertically, or expanded horizontally to prevent flanking. Where elevations are low managed retreat should be considered.	Engineered revetments harden the shoreline, protecting it from waves and strong currents that could cause erosion and land loss. Revetments are primarily designed to protect the shoreline, but they are susceptible to damage from strong currents and wave conditions that occur beyond the "design" event. As sea level rises, wave heights and velocities may increase, exposing the revetments to conditions beyond those for which they were designed. Additionally, increased overtopping could result in a loss of foundation material and undercutting of the toe, potentially causing the entire structure to become unstable.	5-30 years	System	Medium	Partially
4.1.2		Increase maintenance and inspection schedule for revetments in this area.		5-30 years	System	Medium	Yes
5	***West Kuhland Alley to East B Street***						
5.1	Monitor erosion over time and use the incoming information to inform adaptation plans in the future	Evaluate areas of existing erosion and develop structural or non-structural shoreline protection. In low lying areas, consider a combination of managed retreat and structural or non-structural protection of upland areas.	Portions of unprotected shoreline are exposed to any changes in sea levels and storm surges. While isolated sea walls and non-engineered slope protection exists in some areas, this system of defense is not comprehensive.	5-30 years	System	Medium	Partially

	Benicia: Sea Level Rise Adaptation	Economy				Environment				Equity			Governance	
Ref #	Strategy Summary	Capital Costs (low, med, high)	Operating Costs (low, med, high)	Avoided Damages (low, med, high)	Enhances Tax Base (yes, no)	Impacts on Wildlife Habitat, Rare Species, or Water Quality (positive, neutral, negative)	Reduce Water Use (positive, neutral, negative)	Air Quality Improvement Potential (positive, neutral, negative)	Reduce Energy Use (positive, neutral, negative)	Protect Access to Jobs (positive, neutral, negative)	Protection of Vulnerable Populations (positive, neutral, negative)	Access to Green Space and Recreational Areas (positive, neutral, negative)	Political Decision-Maker Feasibility (low, med, high)	Opportunity for Community Involvement (low, med, high)
3	***West 9th Street to Gull Point Court***													
3.1	Reduce erosion and land loss impacts from sea level rise and storm events to natural, non-wetland shorelines (e.g., bluffs)	Low	Medium	High	No	Positive	Neutral	Neutral	Neutral	Positive	Positive	Positive	High	High
3.2.1	Track the condition of the shoreline structures and perform maintenance to prevent premature damage	Medium	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low
3.2.2		Low	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low
4	***Gull Point Court to West Kuhland Alley***													
4.1.1	Track the condition of engineered revetment to prevent premature damage	Medium	Low	High	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low
4.1.2		Low	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low
5	***West Kuhland Alley to East B Street***													
5.1	Monitor erosion over time and use the incoming information to inform adaptation plans in the future	Medium	Low	High	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low

	Benicia: Sea Level Rise Adaptation Options (V5, 10/10/16). Color Coding as follows: GREEN = Favorable; YELLOW = Moderate; RED = Unfavorable.			Descriptive (not criteria)		General Criteria	
Ref #	**Strategy Summary**	**Detailed Adaptation Measures**	**Vulnerabilities Addressed**	**Time period for implementation (0-5 years, 5-30 years, 30+ years)**	**Scale (community, system, asset)**	**Level of Urgency (low, med, high)**	**Adaptable Over Time (yes, partially, no)**
6	***Along First Street from East B Street to the peninsula and the waterfront***						
6.1	Implement the Waterfront Master Plan, which provides ideas for protective measures (e.g., elevated greenspace) along this section.	The City should consider implementing sea level rise and storm surge protection measures identified in the Waterfront Master Plan (e.g., sea wall, enhanced vegetation, rain garden, sewer lift).	During storm events, there is already significant flooding in this area, despite the existing sea wall and engineered revetments.	5-30 years	Community	High	Yes
6.2	Enhance capacity of alternate routes/modes to accommodate re-routed commuter traffic if significant roadways are disrupted (e.g., E 2nd St)	Identify and invest in non-motorized transportation corridors (bike and pedestrian) that will provide alternatives if roadways are disrupted (e.g., E 2nd St).	Alternate routes provide some adaptive capacity; however, by the end of the century, many of the neighboring roads could also be affected by sea level rise. This will limit economic activity and impact residents.	5-30 years	System	High	No
6.3	Establish mechanisms to protect the Bay Trail against sea level rise and storm surge impacts	Prioritize resurfacing vulnerable trail segments with erosion-resistant materials (only applicable along the waterfront area, which will be remedied with the implementation of the Waterfront Master Plan).	The Bay Trail provides critical recreation and transportation access to Benicia residents. In portions of the Benicia State Recreation Area, it is an unpaved trail which makes it more vulnerable to damage from flooding. Portions of the trail are projected to be flooded from SLR and storm surge.	5-30 years	System	Medium	Yes
6.4	Continue maintenance of access to shoreline recreation areas	Prioritize maintenance and repair of barrier-free access to the shoreline and recreation facilities in order to minimize re-routing or closure (i.e., Implement the boardwalk in the Waterfront Master Plan; maintain coastal sections of the Bay Trail with regular maintenance; maintain the trails in the Benicia state park).	The community may face loss of aesthetics and opportunities for outdoor recreation, which may diminish the value of Benicia as a desirable place to live.	0-5 years	System	Medium	Yes
7	***Benicia Marina/Harbor***						
7.1	Increase access to communities that could be isolated during disasters (e.g. Rancho Benicia)	Develop alternate access plans for Rancho Benicia (e.g., connect E G St to Redwood St). The only existing access road is E H Street.	Alternate routes provide some adaptive capacity; however, by the end of the century, many of the neighboring roads could also be affected by sea level rise. This will limit economic activity and impact residents.	0-5 years	Asset	High	Yes
7.2	Conduct routine maintenance and integrate upgrades, as appropriate	As part of routine maintenance and rehabilitation projects, upgrade the waterside and shoreside elements as needed to maintain the Marina throughout its useful life. Most impacts to the Marina will occur beyond the useful life of the current infrastructure so there is no need to proactively implement adaptation measures outside of routine maintenance practices.	Waterside assets are designed to move and function under storm events, however, landside infrastructure is not designed for flooding.	5-30 years	Asset	Low	Yes
7.3	Repair the Marina breakwater	The City should work with the Marina to repair and elevate existing Marina breakwater to provide continued protection from current and future storms.	Existing break wall is in a state of disrepair.	0-5 years	System	High	Partially
7.4.1	Establish a phased plan for protecting or retreating from Portside Village	Increase ground floor flood proofing to prevent damage during storm surge events and improve drainage to remove water quickly.	Portside village has experienced settling and damage from flooding. Although there have been repairs, all parties acknowledge that the repairs to the drainage system are insufficient for addressing future changes in sea levels.	0-5 years	Asset	High	Yes
7.4.2		Discuss options for not renewing the lease on the land and the eventual conversion of the properties to natural areas.		5-30 years	System	High	Yes
7.4.3		Construct a seawall to protect the development and infrastructure inland of Portside Village.		30+ years	Community	High	Partially

	Benicia: Sea Level Rise Adaptation	Economy				Environment				Equity			Governance	
Ref #	Strategy Summary	Capital Costs (low, med, high)	Operating Costs (low, med, high)	Avoided Damages (low, med, high)	Enhances Tax Base (yes, no)	Impacts on Wildlife Habitat, Rare Species, or Water Quality (positive, neutral, negative)	Reduce Water Use (positive, neutral, negative)	Air Quality Improvement Potential (positive, neutral, negative)	Reduce Energy Use (positive, neutral, negative)	Protect Access to Jobs (positive, neutral, negative)	Protection of Vulnerable Populations (positive, neutral, negative)	Access to Green Space and Recreational Areas (positive, neutral, negative)	Political Decision-Maker Feasibility (low, med, high)	Opportunity for Community Involvement (low, med, high)
6	***Along First Street from East B Street to the peninsula and the waterfront***													
6.1	Implement the Waterfront Master Plan, which provides ideas for protective measures (e.g., elevated greenspace) along this section.	High	Low	High	Yes	Positive	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low
6.2	Enhance capacity of alternate routes/modes to accommodate re-routed commuter traffic if significant roadways are disrupted (e.g., E 2nd St)	High	Medium	Low	Yes	Neutral	Neutral	Positive	Positive	Positive	Positive	Positive	Medium	Medium
6.3	Establish mechanisms to protect the Bay Trail against sea level rise and storm surge impacts	Medium	Medium	Medium	Yes	Positive	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	Medium	Low
6.4	Continue maintenance of access to shoreline recreation areas	Medium	Low	Medium	Yes	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	Positive	High	Low
7	***Benicia Marina/Harbor***													
7.1	Increase access to communities that could be isolated during disasters (e.g. Rancho Benicia)	Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Positive	Positive	Positive	Medium	Medium
7.2	Conduct routine maintenance and integrate upgrades, as appropriate	Low	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Positive	Positive	Positive	High	Low
7.3	Repair the Marina breakwater	High	Medium	High	No	Neutral	Neutral	Neutral	Neutral	Positive	Positive	Positive	High	Low
7.4.1	Establish a phased plan for protecting or retreating from Portside Village	Medium	Medium	Medium	Yes	Neutral	Neutral	Neutral	Neutral	Positive	Positive	Neutral	Medium	Medium
7.4.2		High	Low	Medium	No	Positive	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	Low	Medium
7.4.3		High	Medium	High	No	Neutral	Neutral	Neutral	Neutral	Positive	Positive	Neutral	Medium	High

	Benicia: Sea Level Rise Adaptation Options (V5, 10/10/16). Color Coding as follows: GREEN = Favorable; YELLOW = Moderate; RED = Unfavorable.			Descriptive (not criteria)		General Criteria	
Ref #	**Strategy Summary**	**Detailed Adaptation Measures**	**Vulnerabilities Addressed**	**Time period for implementation (0-5 years, 5-30 years, 30+ years)**	**Scale (community, system, asset)**	**Level of Urgency (low, med, high)**	**Adaptable Over Time (yes, partially, no)**
8	***Turnbull Park to Amports***						
8.1	Increase the frequency of review of new scientific data in the WWTP Master Plan	Set shorter review cycles for updating the climate change information in the WWTP Master Plan and the Standard Operating Protocol. For example, decrease the cycle from 5 years to three years.	Preliminary actions have been taken to prepare the WWTP for sea level rise (e.g., integrating it as a topic in the system management plan); however, review of new information and updates are infrequent.	0-5 years	System	High	Yes
8.2	Update existing operations, maintenance, and emergency response plans and procedures for wastewater infrastructure that may be inadequate to address contingencies associated with storm events	At the WWTP, prepare for recovery from flooding by stockpiling response materials and storing them outside of flood prone areas, maintaining turn-key agreements for equipment rental (and ensuring the contracts provide priority to the WWTP after an event), and pre-positioning emergency power generation capacity, portable pumps, and debris removal equipment.		0-5 years	System	High	Yes
8.3	Collaborate with other WWTP on planning for climate change	Develop a climate change working group with other waste water treatment plants in the region (and potentially further afield with agencies that have been working on this topic such as King County, WA) to discuss actions for addressing sea level rise and storm surge.		5-30 years	System	Low	Yes
8.4	Increase WWTP redundancy and remote operation abilities	Conduct a study on the costs and benefits of moving to alternative wastewater treatment strategies such as distributed wastewater treatment networks.	Some elements of the WWTP have built-in system redundancies. However, this is not consistent across all internal systems, and reliance on those redundancies would likely limit the operating capacity of the plant.	5-30 years	System	High	Partially
8.5	Reduce the vulnerability of the WWTP stormwater outfall through pumps or changing elevations	Conduct additional studies on the sea level at which the current WWTP outfall would perform sub optimally. If necessary, determine the timeline and strategy for increasing pumping.	The WWTP outfall is highly sensitive to changes in sea level as it could affect the ability of the outfall to discharge treated wastewater, requiring additional pumping to maintain existing performance.	5-30 years	Asset	Medium	Yes
8.6	Repair cracked sewage pipes, increase capacity, and monitor total dissolved solids levels to ensure sufficient capacity at all times	Monitor changes in the water table and changes in the levels of total dissolved solids in the WWTP influent. In both cases, the infiltration is likely to be the result of aging and cracked pipes. If changes are identified, locate and repair the cracked pipes before it impacts overall system capacity. If pipes cannot be located or replaced, increase wet weather system capacity to handle increased load.	If the water table were to cover the sewer pipelines, there could be significant water infiltration into the sewage system. This additional load could impact the WWTP. The wet weather relief system provides storage during rainfall and coastal flooding events to reduce excess load at the WWTP and currently has some excess capacity; however, this capacity may be undermined with changes in groundwater levels. Flooding within the facility would result in high repair costs and the release of untreated water would result in significant fines.	5-30 years	System	Medium	Yes
8.7	Flood proof the main WWTP electrical systems to ensure continuous operation during storm events	Increase flood proofing and/or the capacity of pumps (stormwater pumps and sump pumps) to decrease the likelihood of storm events shutting down the electrical components of the plant. Establish plans to deliver fuel to backup power generation systems and maintain existing contracts for emergency generator delivery. This action is only necessary if comprehensive measures (e.g., enhanced flood walls) are not implemented.	The WWTP main electrical systems, which are key to the plants continued operation, are located underground and are highly sensitive to even low levels of flooding. Equipment with electrical components such as motors, instrumentation, and motor control centers are particularly sensitive to storm events or tidal inundation, and would cease to operate if they were to get wet. The below ground electrical vaults also have sump pumps to remove ground water; however, these are small pumps made to remove only small volumes of water during infrequent, short duration flooding events. These pumps do not have significant capacity for frequent and heavy intensity events.	0-5 years	System	High	Partially

	Benicia: Sea Level Rise Adaptation	Economy				Environment				Equity			Governance	
Ref #	Strategy Summary	Capital Costs (low, med, high)	Operating Costs (low, med, high)	Avoided Damages (low, med, high)	Enhances Tax Base (yes, no)	Impacts on Wildlife Habitat, Rare Species, or Water Quality (positive, neutral, negative)	Reduce Water Use (positive, neutral, negative)	Air Quality Improvement Potential (positive, neutral, negative)	Reduce Energy Use (positive, neutral, negative)	Protect Access to Jobs (positive, neutral, negative)	Protection of Vulnerable Populations (positive, neutral, negative)	Access to Green Space and Recreational Areas (positive, neutral, negative)	Political Decision-Maker Feasibility (low, med, high)	Opportunity for Community Involvement (low, med, high)
8	***Turnbull Park to Amports***													
8.1	Increase the frequency of review of new scientific data in the WWTP Master Plan	Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low
8.2	Update existing operations, maintenance, and emergency response plans and procedures for wastewater infrastructure that may be inadequate to address contingencies associated with storm events	Low	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low
8.3	Collaborate with other WWTP on planning for climate change	Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low
8.4	Increase WWTP redundancy and remote operation abilities	Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low
8.5	Reduce the vulnerability of the WWTP stormwater outfall through pumps or changing elevations	Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low
8.6	Repair cracked sewage pipes, increase capacity, and monitor total dissolved solids levels to ensure sufficient capacity at all times	Medium	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low
8.7	Flood proof the main WWTP electrical systems to ensure continuous operation during storm events	High	Low	High	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low

	Benicia: Sea Level Rise Adaptation Options (V5, 10/10/16). Color Coding as follows: GREEN = Favorable; YELLOW = Moderate; RED = Unfavorable.			Descriptive (not criteria)		General Criteria	
Ref #	**Strategy Summary**	**Detailed Adaptation Measures**	**Vulnerabilities Addressed**	**Time period for implementation (0-5 years, 5-30 years, 30+ years)**	**Scale (community, system, asset)**	**Level of Urgency (low, med, high)**	**Adaptable Over Time (yes, partially, no)**
8.8	Expand the WWTP flood wall protection	At the WWTP, the City should monitor increases in sea levels and regularly assess the need to increase the height of the existing flood walls and continue the protection structure around the WWTP to prevent landside flooding (i.e., up E 5th St).	The WWTP is surrounded by flood walls that rise to an elevation of six feet above grade. In the 24 inch total water level scenario, this is sufficient to protect the WWTP from flooding. However, by the end-of-century, 60 inch sea level rise scenario, water would encroach high enough up bordering East 5th Street to circumvent the wall and flood over half of the WWTP property from the west.	5-30 years	System	Low	Yes
8.9.1	Increase redundancy and remote operation abilities at the WWTP	Add redundancy or increase capacity to re-route around compromised wastewater system components.	Some elements of the WWTP have built-in system redundancies. However, this is not consistent across all internal systems, and reliance on those redundancies would likely limit the operating capacity of the plant.	5-30 years	System	High	Yes
8.9.2		Reduce the vulnerability of components by improving the ability to operate remotely, reducing the complexity, ensuring access to backup power or portable pumps, or by redesigning (e.g., restrict pump station design capacity to be operable with portable pumps). Require shut-off, overflow, and re-routing mechanisms to be designed and installed to function during an emergency.		0-5 years	System	Medium	Partially
8.10	Construct a living levee	Work with the US Fish and Wildlife Service and the California Department of Fish and Wildlife to monitor wetlands for loss of habitat, construct a living levee along the waterfront to maintain the natural habitat and protect inland infrastructure.	Inland migration of wetlands is constrained by development which limits the ability of the wetlands to naturally respond and adjust to rising sea levels.	30+ years	Community	Medium	Yes
9	***Amports***						
9.1	Identify and protect infrastructure located under the wharves at the Port of Benicia that may be increasingly vulnerable to high water levels and wave erosion during storm events, which can disrupt asset function, cause scour, require additional maintenance, and potentially shorten asset life span	Encourage Amports to conduct analyses of critical infrastructure to identify the potential for increased erosion, scour and wear due to increased tide and wave energy. This should build off of the existing Climate Change Vulnerability Report information.	While erosion can weaken supports, most channels and waterways are built to withstand erosion. However, increased erosion rates may not be adequately planned for and could thus affect port support structures. The port's levee system is also subject to erosion from wind/wave forces. The waterside structures are designed to deal with a known range of water level variation with an anticipated maximum. As that maximum increases, the function of the facility can be affected.	0-5 years	Asset	Medium	Partially
9.2.1	Determine water access locations and pump needs	Encourage Amports to assess water flow paths on the Port property in order to determine "weak links" and locations for increased protection from sea level rise and storm surge. This action will identify critical low points or holes in the levee system that should be targeted for adaptation. Follow the process established in the Adapting to Rising Tides second transportation study.	The landside portion of the port requires protection to keep from flooding during extreme high tides and waves. Damage to the rail lines, roadways, structures, and paved areas would affect operations. Existing storm pumps and back-up generators reduce vulnerability but they may be undersized for future needs.	0-5 years	Asset	High	Yes
9.2.2		Encourage Amports to evaluate the need for increasing the capacity of the storm pumps and on-site generators in order to minimize flooding and maintain operations. The current pumps are used during heavy rain events and may be undersized for additional load from sea level rise and increased storm surge.		0-5 years	Asset	High	Yes

	Benicia: Sea Level Rise Adaptation	Economy				Environment				Equity			Governance	
Ref #	Strategy Summary	Capital Costs (low, med, high)	Operating Costs (low, med, high)	Avoided Damages (low, med, high)	Enhances Tax Base (yes, no)	Impacts on Wildlife Habitat, Rare Species, or Water Quality (positive, neutral, negative)	Reduce Water Use (positive, neutral, negative)	Air Quality Improvement Potential (positive, neutral, negative)	Reduce Energy Use (positive, neutral, negative)	Protect Access to Jobs (positive, neutral, negative)	Protection of Vulnerable Populations (positive, neutral, negative)	Access to Green Space and Recreational Areas (positive, neutral, negative)	Political Decision-Maker Feasibility (low, med, high)	Opportunity for Community Involvement (low, med, high)
8.8	Expand the WWTP flood wall protection	High	Low	High	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low
8.9.1	Increase redundancy and remote operation abilities at the WWTP	High	Low	High	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Medium	Low
8.9.2		Medium	Low	High	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low
8.10	Construct a living levee	High	Medium	Medium	No	Positive	Neutral	Neutral	Neutral	Positive	Positive	Positive	Medium	Medium
9	***Amports***													
9.1	Identify and protect infrastructure located under the wharves at the Port of Benicia that may be increasingly vulnerable to high water levels and wave erosion during storm events, which can disrupt asset function, cause scour, require additional maintenance, and potentially shorten asset life span	Medium	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Medium	Low
9.2.1	Determine water access locations and pump needs	Medium	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low
9.2.2		Medium	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low

	Benicia: Sea Level Rise Adaptation Options (V5, 10/10/16). Color Coding as follows: GREEN = Favorable; YELLOW = Moderate; RED = Unfavorable.			Descriptive (not criteria)		General Criteria	
Ref #	**Strategy Summary**	**Detailed Adaptation Measures**	**Vulnerabilities Addressed**	**Time period for implementation (0-5 years, 5-30 years, 30+ years)**	**Scale (community, system, asset)**	**Level of Urgency (low, med, high)**	**Adaptable Over Time (yes, partially, no)**
9.3.1	Evaluate opportunities to improve resilience based on past disruptions and damage to perishable goods	Encourage Amports to conduct an economic analysis of the consequences of perishable goods not being delivered, using past disruptions at the Port of Benicia to inform understanding of the types of products that would perish if delivery is delayed and the length of time within which a delivery would have to be made. This process should also improve understanding of the critical partners, timelines, and pathways for perishable goods movement.	Higher sea levels increase the risk of the port's drainage systems being overwhelmed by heavy precipitation and contribute to surface flooding. The port's drainage system is already stressed during precipitation events due to flooding along Sulphur Springs Creek.	0-5 years	Asset	Medium	Partially
9.3.2		Encourage Amports to ensure the COOP plan includes information on climate change and the potential impacts (and appropriate response to) sea level rise and extreme weather events.		0-5 years	Asset	High	Yes
9.4.1	Coordinate with Amports on access to land surrounding port facilities and services to help provide protection against flooding	Support partnership among the City and Amports to engage in collaborative multi-objective planning to improve the resilience of vulnerable port assets, and the inland areas they protect as the first line of defense against flooding. This can be achieved through the development of a plan for increasing the Port levees or implementing alternative protection strategies, that outlines roles and responsibilities for implementation.	The leased structure of the port land will require coordination between the City and AMPORTS to determine an appropriate path towards resiliency.	0-5 years	Asset	High	Yes
9.4.2		Begin planning for the renewal of the Port lease by discussing roles and responsibilities for sea level rise protection.		5-30 years	Asset	High	Yes
9.5	Update or develop plans with other port facilities to redirect cargo if the Port of Benicia is temporarily or permanently disrupted	Encourage Amports to develop contingency plans for using other port facilities within or outside of the region in the event of temporary or permanent disruption at the Port of Benicia.	The port is the sole access point for several products to Northern California (e.g., specific auto manufacturers).	5-30 years	Asset	High	Yes
9.6.1	Adjust dredging practices to account for sea level rise	Encourage Amports to commission study to determine potential impact of climate change on dredging needs looking at both SLR (which may reduce dredging needs) and increased runoff (which may increase dredging needs). If necessary, begin factoring in more frequent dredging when budget planning.	The Port of Benicia currently has to dredge its ship channels to maintain their depth. Sea level rise may increase the natural depth of the channel, which would reduce dredging maintenance requirements. However, changes in rates of coastal erosion and deposition can lead to changes in sedimentation rates.	5-30 years	Asset	High	Yes
9.6.2		Encourage Amports to investigate the feasibility of using dredged materials to increase their own levee heights. Coordinate with BCDC on developing a protocol for this practice.		0-5 years	Asset	High	Yes
9.7	Maintain levees to current standards and expand coverage	Work with AMPORTS to maintain all levees that front the Port property and the existing walls on the East edge of the property and along the dock access road. Assess the need for repairs or height increases on a regular basis (e.g., annually). Height increases should be based on observed storm impacts and measured sea level rise/local subsidence or refined sea level rise projections. Consider adding specific maintenance measures in lease when renegotiated with Amports.	The port's levee system currently offers an increased level of protection from coastal flooding; however, the Port still floods periodically and this is likely to increase in the future, particularly is the levees are not maintained.	30+ years	Asset	High	Yes
9.8	Prevent corrosion and damage from flooding	Invest in increased flood proofing when performing routine maintenance processes.	Damages from flooding can completely destroy electrical equipment, preventing normal port operations. Saltwater can increase metal corrosion. Even the water pumps designed to remove flood water are sensitive to inundation.	30+ years	Asset	High	Yes

	Benicia: Sea Level Rise Adaptation	Economy				Environment				Equity			Governance	
Ref #	Strategy Summary	Capital Costs (low, med, high)	Operating Costs (low, med, high)	Avoided Damages (low, med, high)	Enhances Tax Base (yes, no)	Impacts on Wildlife Habitat, Rare Species, or Water Quality (positive, neutral, negative)	Reduce Water Use (positive, neutral, negative)	Air Quality Improvement Potential (positive, neutral, negative)	Reduce Energy Use (positive, neutral, negative)	Protect Access to Jobs (positive, neutral, negative)	Protection of Vulnerable Populations (positive, neutral, negative)	Access to Green Space and Recreational Areas (positive, neutral, negative)	Political Decision-Maker Feasibility (low, med, high)	Opportunity for Community Involvement (low, med, high)
9.3.1	Evaluate opportunities to improve resilience based on past disruptions and damage to perishable goods	Medium	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Medium	Low
9.3.2		Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	Neutral	High	Low
9.4.1	Coordinate with Amports on access to land surrounding port facilities and services to help provide protection against flooding	Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	Neutral	High	Low
9.4.2		Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	Neutral	High	Low
9.5	Update or develop plans with other port facilities to redirect cargo if the Port of Benicia is temporarily or permanently disrupted	Medium	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low
9.6.1	Adjust dredging practices to account for sea level rise	Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Medium	Low
9.6.2		Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Medium	Low
9.7	Maintain levees to current standards and expand coverage	High	Medium	High	Yes	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low
9.8	Prevent corrosion and damage from flooding	Medium	Medium	Medium	Yes	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low

	Benicia: Sea Level Rise Adaptation Options (V5, 10/10/16). Color Coding as follows: GREEN = Favorable; YELLOW = Moderate; RED = Unfavorable.			Descriptive (not criteria)		General Criteria	
Ref #	**Strategy Summary**	**Detailed Adaptation Measures**	**Vulnerabilities Addressed**	**Time period for implementation (0-5 years, 5-30 years, 30+ years)**	**Scale (community, system, asset)**	**Level of Urgency (low, med, high)**	**Adaptable Over Time (yes, partially, no)**
10	***Sulphur Springs***						
10.1	Identify opportunities to relocate infrastructure that borders Sulphur Springs	In collaboration with local property owners (e.g., Valero), identify opportunities to locate and relocate infrastructure (e.g., Valero WWTP) and impervious surfaces away from Sulphur Springs in order to expand the natural flood plain. Use the flooding maps in the Climate Change Vulnerability Report to identify additional infrastructure.	Sulphur springs is not regularly cleared of vegetation that impedes the ability of water to flow out into the Bay. It also no longer has a tidal gate to prevent Bay water from traveling upstream.	5-30 years	Community	High	Yes
10.2.1	Implement stream restoration projects to accommodate tidal action, or managed stream restoration with new tide gate	Expand vegetation control practices at Sulphur Springs Creek and increase the stream depth (or embankment height) in order to minimize flooding issues. Modifications to the creek would require a partnership between the City, Caltrans, UPRR, other private parties (including Valero) as well as working closely with environmental permitting agencies, including USFWS, CDFW, and SFRWQCB.		0-5 years	Community	High	Yes
10.2.3		The City should conduct a hydrodynamic analysis to determine if re-installing a tidal gate (passive or otherwise) at Sulphur Springs would decrease the likelihood of flooding. Modifications to the creek would require a partnership between the City, Caltrans, UPRR, other private parties (including Valero) as well as working closely with environmental permitting agencies, including USFWS, CDFW, and SFRWQCB.		0-5 years	Community	High	Yes
11	***Amports to I-680***						
11.1.1	Elevate existing infrastructure or construct natural solutions to prevent erosion and protect inland infrastructure	Raise Industrial Way or the Union Pacific train tracks to serve as a levee and protect inland businesses. If the protection is implemented at Industrial Way then the Union Pacific tracks may need to be realigned to avoid regular flooding.	Unprotected shoreline with isolated sea walls and non-engineered slope protection is subject to flooding. The train tracks and Industrial Way offer some protection before water reaches the Industrial Park but this is insufficient for future sea levels and storm surges.	30+ years	System	Low	No
11.1.2		In collaboration with US Army Corps of Engineers, BCDC, CA Fish and Wildlife, and US Fish and Wildlife rehabilitate the marshland in front of the Benicia Industrial Park to serve as a horizontal living levee that can keep up with changes in sea levels and storm surges and protect inland infrastructure.		5-30 years	Community	Medium	Yes
12	**OVERARCHING**						
	Informational Vulnerability						
12.1.1	Research effects of sea level rise on groundwater levels and salinity intrusion	Coordinate with regional, state, and federal agencies, academic researchers, and the private sector to improve the region's understanding of how sea level rise will affect groundwater levels. Advocate for state research funding (e.g., PEER) be used to support this research.	It is unknown how sea level rise will impact the Benicia water table and level and groundwater salinity. Nearest monitoring station is Hayward.	5-30 years	Community	Low	Yes
12.1.2		Work with USGS, regional, state, and federal agencies, academic researchers, and the private sector to measure groundwater levels and salinity intrusion, and make the data publically available through a centralized database (preferably as part of the existing USGS system). Consult USGS on preferred subsidence monitoring methods. Elevations, and elevation changes, have been measured using Interferometric Synthetic Aperture Radar (InSAR), Continuous GPS (CGPS) measurements, campaign Global Positioning System (GPS) surveying, and spirit-leveling surveying.		5-30 years	Community	Low	Yes

	Benicia: Sea Level Rise Adaptation	Economy				Environment				Equity			Governance	
Ref #	Strategy Summary	Capital Costs (low, med, high)	Operating Costs (low, med, high)	Avoided Damages (low, med, high)	Enhances Tax Base (yes, no)	Impacts on Wildlife Habitat, Rare Species, or Water Quality (positive, neutral, negative)	Reduce Water Use (positive, neutral, negative)	Air Quality Improvement Potential (positive, neutral, negative)	Reduce Energy Use (positive, neutral, negative)	Protect Access to Jobs (positive, neutral, negative)	Protection of Vulnerable Populations (positive, neutral, negative)	Access to Green Space and Recreational Areas (positive, neutral, negative)	Political Decision-Maker Feasibility (low, med, high)	Opportunity for Community Involvement (low, med, high)
10	***Sulphur Springs***													
10.1	Identify opportunities to relocate infrastructure that borders Sulphur Springs	Low	Low	High	No	Positive	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	High	Low
10.2.1	Implement stream restoration projects to accommodate tidal action, or managed stream restoration with new tide gate	Low	Low	Medium	No	Positive	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low
10.2.3		Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low
11	***Amports to I-680***													
11.1.1	Elevate existing infrastructure or construct natural solutions to prevent erosion and protect inland infrastructure	High	Low	High	No	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	Neutral	High	Low
11.1.2		Low	Low	High	No	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	Positive	High	Low
12	**OVERARCHING**													
	Informational Vulnerability													
12.1.1	Research effects of sea level rise on groundwater levels and salinity intrusion	Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low
12.1.2		Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low

	Benicia: Sea Level Rise Adaptation Options (V5, 10/10/16). Color Coding as follows: GREEN = Favorable; YELLOW = Moderate; RED = Unfavorable.			Descriptive (not criteria)		General Criteria	
Ref #	Strategy Summary	Detailed Adaptation Measures	Vulnerabilities Addressed	Time period for implementation (0-5 years, 5-30 years, 30+ years)	Scale (community, system, asset)	Level of Urgency (low, med, high)	Adaptable Over Time (yes, partially, no)
12.2	Gather and track information on the impacts of weather events	The City should develop a database for tracking the cost of extreme weather events (e.g., cost of labor to respond, cost of repairs, duration of impact, location of impacts, severity of impact, date and time of event) on the City. Consider integrating with asset management systems or create a new centralized and coordinated database.	There is not a consistent and consolidated method for tracking the impact of weather events on Benicia.	0-5 years	Community	High	Yes
12.3	Track and comment on FEMA flood map revisions	Continue existing practice of engaging with regional and federal agencies to ensure the timely update and review of flood maps and access to data, studies, and models to help the region better understand future risks from sea level rise. Discuss the possibility of including sea level rise risk in the next round of FEMA flood map revisions.	Current flood maps do not take into account sea level rise; however, preparing for today's storm events will enhance preparedness for future sea level rise.	0-5 years	Community	High	Yes
12.4.1	Identify how impacts to neighboring cities shorelines could compromise the function of assets in Benicia	Support a regional evaluation of transportation and utility networks that are vulnerable to sea level rise to determine hot spots or weak links that would cause significant disruption to the regional economy and quality of life.	The physical interaction between Benicia's shorelines and those of neighboring cities is unknown which could impact networked resources such as utilities or transportation.	0-5 years	System	High	Yes
12.4.2		Support a regional evaluation of structural shorelines and determine how they are connected/interconnected to natural shorelines in providing flood risk reduction benefits.		0-5 years	Community	High	Yes
12.5.1	Identify how sea level rise may increase the risk of liquefaction during an earthquake and increase vulnerability	Support a regional study on the impacts of groundwater elevations on the potential for increased liquefaction potential during earthquakes. Study would likely be led by ABAG.	Sea level rise and changes in groundwater may increase the potential for liquefaction, and thus the potential for damage to infrastructure during an earthquake.	0-5 years	Community	High	Yes
12.5.2		Update the local hazard mitigation plan to include an overview of critical infrastructure and land uses in areas exposed to sea level rise (see Vulnerability Report for more information) and liquefaction (see ABAG online maps) to identify strategies that can improve resilience to both hazards. Use a GIS overlay to identify locations and work with ABAG to develop strategies.		0-5 years	Community	High	Yes

	Benicia: Sea Level Rise Adaptation	Economy				Environment				Equity			Governance	
Ref #	Strategy Summary	Capital Costs (low, med, high)	Operating Costs (low, med, high)	Avoided Damages (low, med, high)	Enhances Tax Base (yes, no)	Impacts on Wildlife Habitat, Rare Species, or Water Quality (positive, neutral, negative)	Reduce Water Use (positive, neutral, negative)	Air Quality Improvement Potential (positive, neutral, negative)	Reduce Energy Use (positive, neutral, negative)	Protect Access to Jobs (positive, neutral, negative)	Protection of Vulnerable Populations (positive, neutral, negative)	Access to Green Space and Recreational Areas (positive, neutral, negative)	Political Decision-Maker Feasibility (low, med, high)	Opportunity for Community Involvement (low, med, high)
12.2	Gather and track information on the impacts of weather events	Medium	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low
12.3	Track and comment on FEMA flood map revisions	Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low
12.4.1	Identify how impacts to neighboring cities shorelines could compromise the function of assets in Benicia	Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Positive	Positive	Neutral	High	Medium
12.4.2		Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Medium
12.5.1	Identify how sea level rise may increase the risk of liquefaction during an earthquake and increase vulnerability	Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low
12.5.2		Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low

	Benicia: Sea Level Rise Adaptation Options (V5, 10/10/16). Color Coding as follows: GREEN = Favorable; YELLOW = Moderate; RED = Unfavorable.			Descriptive (not criteria)		General Criteria	
Ref #	**Strategy Summary**	**Detailed Adaptation Measures**	**Vulnerabilities Addressed**	**Time period for implementation (0-5 years, 5-30 years, 30+ years)**	**Scale (community, system, asset)**	**Level of Urgency (low, med, high)**	**Adaptable Over Time (yes, partially, no)**
12.5.3.1	Coordinate with non-profit, community, and faith based groups to ensure availability and accuracy of information	Develop and maintain a centralized database of non-profit, community, and faith-based organizations, equipment and service providers, and others that can communicate with communities at risk. This may be accomplished through a survey and periodic meetings with these groups.	While there is a general understanding of the types of vulnerable populations that reside in Benicia, there is no consolidated list or database of their locations. This limits the ability to help prepare these communities for future impacts and to communicate with them during an extreme weather event.	5-30 years	Community	Low	Yes
12.5.3.2		Develop and maintain a voluntary database that includes specific needs within each community related to emergency response. Begin with information from the community-groups and, if needed, conduct a community-wide survey.		5-30 years	Community	Low	Yes
12.6	Develop plans to protect populations that are particularly vulnerable to sea level rise and storm surge	Assess how sea level rise and storm events will affect vulnerable populations once locations of residents are established.	A variety of socioeconomic factors affect the sensitivity of a community. For example, economic status, level of education, health and physical mobility, ownership of a home or car, and proficiency in English can all affect a resident's sensitivity to climate change. Within Benicia, some the older neighborhoods (some with structures dating back to the 1850's) have a higher concentration of sensitive residents. These demographics will need to be taken under consideration when developing emergency response plans and in providing general assistance to residents to adapt their personal homes to become more resilient to climate change.	5-30 years	Community	Low	Yes
12.7	Monitor land subsidence to understand the combined impact of subsidence and sea level rise	Work with the US Geological Survey (USGS) to develop a subsidence monitoring program to provide an understanding of the combined impacts of subsidence and sea level rise/storm surge. Consult USGS on preferred subsidence monitoring methods. Elevations, and elevation changes, have been measured using Interferometric Synthetic Aperture Radar (InSAR), Continuous GPS (CGPS) measurements, campaign Global Positioning System (GPS) surveying, and spirit-leveling surveying.	The bottom of East 2nd Street and East B Street may become especially vulnerable to sea level rise and storm surge as they continue to settle. Settlement is not being measured.	5-30 years	System	High	Yes
12.8	Increase accessibility and coordination of information about the location and condition of stormwater infrastructure that is needed for site- and asset-specific vulnerability and risk assessments	Track inland flooding events, their cause (e.g., specific system blockages, highly impermeable areas), duration, and extent in order to have a rich database from which to develop maintenance and intervention plans. Although inland flooding was not a focus of this study, it should be further studied in the future.	There is very limited information on the complete stormwater system, its weak points, and historic flooding events.	0-5 years	System	High	Yes
12.9	Determine locations of stormwater system with insufficient capacity	Conduct a comprehensive assessment of stormwater and flood control system components that have insufficient capacity to accommodate sea level and groundwater rise, (e.g., existing pipe and channel sizes are known to be undersized in the Marina, and the outfall elevations are known to be low at the end of E 2nd St. and E 5th St.)	The stormwater system is gravity-driven and has been noted to be under sized for present demand, plus the outfalls are low-lying and currently back-up during storm events. As sea levels rise, there will be less of a gradient between the source of the stormwater and its eventual destination, and some of the outfalls could be below sea level during high tide or a storm event. This means that Carquinez Strait water could enter the stormwater systems and travel up creeks, channels, and pipes. If elevated Carquinez Strait levels coincide with a precipitation event, the presence of Bay water in stormwater infrastructure could reduce the system's capacity to store and convey stormwater, which could result in stormwater backing up and causing inland flooding.	0-5 years	System	Medium	Yes
12.10	Determine locations for opportunistic installation of LID infrastructure	Conduct watershed analyses to identify opportunity sites for green infrastructure or low impact development (LID) techniques to improve stormwater and flood control system capacity to accommodate sea level and groundwater rise		0-5 years	System	Medium	Yes

	Benicia: Sea Level Rise Adaptation	Economy				Environment				Equity			Governance	
Ref #	Strategy Summary	Capital Costs (low, med, high)	Operating Costs (low, med, high)	Avoided Damages (low, med, high)	Enhances Tax Base (yes, no)	Impacts on Wildlife Habitat, Rare Species, or Water Quality (positive, neutral, negative)	Reduce Water Use (positive, neutral, negative)	Air Quality Improvement Potential (positive, neutral, negative)	Reduce Energy Use (positive, neutral, negative)	Protect Access to Jobs (positive, neutral, negative)	Protection of Vulnerable Populations (positive, neutral, negative)	Access to Green Space and Recreational Areas (positive, neutral, negative)	Political Decision-Maker Feasibility (low, med, high)	Opportunity for Community Involvement (low, med, high)
12.5.3.1	Coordinate with non-profit, community, and faith based groups to ensure availability and accuracy of information	Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	High	High
12.5.3.2		Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	High	High
12.6	Develop plans to protect populations that are particularly vulnerable to sea level rise and storm surge	Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	High	High
12.7	Monitor land subsidence to understand the combined impact of subsidence and sea level rise	Low	Medium	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low
12.8	Increase accessibility and coordination of information about the location and condition of stormwater infrastructure that is needed for site- and asset-specific vulnerability and risk assessments	Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low
12.9	Determine locations of stormwater system with insufficient capacity	Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low
12.10	Determine locations for opportunistic installation of LID infrastructure	Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low

	Benicia: Sea Level Rise Adaptation Options (V5, 10/10/16). Color Coding as follows: GREEN = Favorable; YELLOW = Moderate; RED = Unfavorable.			Descriptive (not criteria)		General Criteria	
Ref #	**Strategy Summary**	**Detailed Adaptation Measures**	**Vulnerabilities Addressed**	**Time period for implementation (0-5 years, 5-30 years, 30+ years)**	**Scale (community, system, asset)**	**Level of Urgency (low, med, high)**	**Adaptable Over Time (yes, partially, no)**
12.11.1	Support research on how marsh habitats will respond to accelerating sea level rise and how these habitats will be affected by shoreline adaptation responses	Support a regional research agenda to advance the understanding of how marshes will respond to accelerating sea level rise in light of declining sediment supply and limited space to migrate inland.	Although there are tools for understanding the range of potential responses of the Benicia marshes to sea level rise, there is not a conclusive assessment of future impacts.	5-30 years	System	Medium	Yes
12.11.2		Work with regional agencies to research and test restoration and management actions that will improve marshes resilience to sea level rise.		5-30 years	System	Medium	Yes
12.12	Track changes in tidal marsh habitat and factor sea level rise into marsh management	Establish a monitoring program to obtain baseline information to track changes in tidal marsh habitat and identify when it is approaching key thresholds, e.g., measure vertical accretion, observe changes in vegetation and indicator species, document marsh edge erosion (photo-points/surveys).		5-30 years	System	Medium	Yes
12.13.1	Increase accessibility and coordination of information about the location and condition of energy infrastructure that may be vulnerable	Continue conversations with PG&E regarding the location of infrastructure that may be vulnerable to sea level rise and storm surge.	There is limited information on the location of utility infrastructure due to the sensitive nature of disclosing this information.	0-5 years	System	Medium	Yes
12.13.2		Collaborate with PG&E to determine upstream vulnerabilities in the electric supply system that may be vulnerable to climate change and may impact Benicia.	Although utility infrastructure within the project area is not anticipated to be impacted by sea level rise and storm surge, damage in neighboring areas could impact Benicia.	0-5 years	Community	Medium	Yes
	Management Control Vulnerability						
12.14	Develop coordinated information for contaminated lands and hazardous material sites, for use during emergency and adaptation planning and for setting remediation, monitoring, and enforcement priorities to reduce risks	Develop and keep current a centralized information system that has key emergency and adaptation planning information about contaminated lands and hazardous materials sites. Discuss individual site plans for preparing for sea level and groundwater level rise and require that hazardous materials are stored above projected flood levels or are protected from flood damage. The storage levels should take into account rising sea levels and increased storm surges. Consider increasing the required elevations by 12 to 24 inches to account for these changes.	Information on hazardous material sites has not been updated in the General Plan since initial adoption. There is limited understanding of the current locations and status of hazardous material sites.	5-30 years	Community	Low	Yes

	Benicia: Sea Level Rise Adaptation	Economy				Environment				Equity			Governance	
Ref #	Strategy Summary	Capital Costs (low, med, high)	Operating Costs (low, med, high)	Avoided Damages (low, med, high)	Enhances Tax Base (yes, no)	Impacts on Wildlife Habitat, Rare Species, or Water Quality (positive, neutral, negative)	Reduce Water Use (positive, neutral, negative)	Air Quality Improvement Potential (positive, neutral, negative)	Reduce Energy Use (positive, neutral, negative)	Protect Access to Jobs (positive, neutral, negative)	Protection of Vulnerable Populations (positive, neutral, negative)	Access to Green Space and Recreational Areas (positive, neutral, negative)	Political Decision-Maker Feasibility (low, med, high)	Opportunity for Community Involvement (low, med, high)
12.11.1	Support research on how marsh habitats will respond to accelerating sea level rise and how these habitats will be affected by shoreline adaptation responses	Low	Low	Low	No	Positive	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low
12.11.2		Low	Low	Low	No	Positive	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low
12.12	Track changes in tidal marsh habitat and factor sea level rise into marsh management	Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low
12.13.1	Increase accessibility and coordination of information about the location and condition of energy infrastructure that may be vulnerable	Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low
12.13.2		Low	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low
	Management Control Vulnerability													
12.14	Develop coordinated information for contaminated lands and hazardous material sites, for use during emergency and adaptation planning and for setting remediation, monitoring, and enforcement priorities to reduce risks	Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low

	Benicia: Sea Level Rise Adaptation Options (V5, 10/10/16). Color Coding as follows: GREEN = Favorable; YELLOW = Moderate; RED = Unfavorable.			Descriptive (not criteria)		General Criteria	
Ref #	**Strategy Summary**	**Detailed Adaptation Measures**	**Vulnerabilities Addressed**	**Time period for implementation (0-5 years, 5-30 years, 30+ years)**	**Scale (community, system, asset)**	**Level of Urgency (low, med, high)**	**Adaptable Over Time (yes, partially, no)**
12.15.1	Incorporate consideration of sea level rise into the capital investment planning, design, and funding of infrastructure	Develop internal guidance to require or encourage the consideration of sea level rise and storm events in the City's process for developing, planning, and funding capital investments. This guidance should encourage capital investments and new infrastructure away from areas projected to be impacted by climate change, unless sufficient adaptation measures are put in place. Formally integrate this consideration into the strategic planning process (potentially through a new goal) and capital investment planning process. Examples include the San Francisco Sea Level Rise Guidance, especially the easy to follow checklist for projects.	Planning, programming, construction, and other City functions operate under a false assumption of climate stationary which exposes investments to future changes in climate.	0-5 years	Community	High	Yes
12.15.2		Incorporate Vulnerability Report findings in a City-wide (or individual department) asset management systems. Use flags in the system to ensure that when repairs and major rehabilitations a scheduled to occur, they take into account projected vulnerabilities to sea level rise and storm surge. By simply reminding maintenance staff of vulnerabilities, they may be able to increase the resilience of the asset during routine maintenance. Also ensure that all fields in the asset management system that may inform vulnerability to climate change (e.g., age, elevation, construction materials, pipe diameters, maintenance schedules/cost) are kept up to date.		0-5 years	Community	High	Yes
12.16.1	Incorporate consideration of sea level rise into plans, policies, and practices that guide community development, land use planning, emergency planning, and capital investments	Qualify for and maintain the highest feasible rating under the Community Rating System of the National Flood Insurance Program to reduce flood risks and the cost of private property insurance.		5-30 years	Community	Medium	Yes
12.16.2		Prepare, adopt, implement, and update a comprehensive recovery plan (either as a stand-alone document or as part of the Emergency Operations Plan) to direct how and where state or federal disaster recovery funds are used to rebuild resilient communities after storm events. Include benefit-cost guidance based on the existing FEMA framework for conducting such analyses. The plan should focus on determining when to rebuild assets to a higher standard so they can withstand future events of similar or greater intensity.		0-5 years	Community	High	Yes
12.16.3		The City should limit future development in areas projected to be impacted by sea level rise (see exposure maps in the Vulnerability Report. Recommend using the 24 inch total water level for this purpose) by revising the zoning code to prohibit new construction without sufficient flood protection.		0-5 years	Community	High	Yes
12.16.4		Evaluate the feasibility of applying adaptive management to Land Use Planning and decision making. The Department of Interior (DOI) has an adaptive management guide that may serve as a reference.		5-30 years	Community	Medium	Yes
12.16.5		Improve coordination among agency departments or divisions to ensure consistent regulatory and planning approaches to sea level rise adaptation, and to reduce programmatic or legislative barriers to assessing and addressing future risks. This could be completed through the creation of an internal working group that regularly meets to discuss actions and progress.		5-30 years	Community	Medium	Yes
12.16.6		Develop incentives for cluster development in low-risk areas (see maps in the Vulnerability Report to define areas) potentially using density bonuses, reduced impact fees, tax incentives and streamlined permitting.		5-30 years	Community	Medium	Partially
12.16.7		Create a voluntary transfer of development rights program to allow property owners to sell development rights in high-risk areas in exchange for rights in low-risk areas (see maps in the Vulnerability Report to define areas).		5-30 years	Community	Low	Partially
12.16.8		Use rolling easements to establish a boundary that moves inward as sea level rises along the shoreline. Establish the easements soon enough to acquire areas for inland migration of marshes and to avoid shoreline armoring that would foreclose the option of implementing natural solutions to sea level rise. See 2011 EPA report on Rolling Easements for information on the types of easements and strategies for implementation.		30+ years	Community	Low	Partially

	Benicia: Sea Level Rise Adaptation	Economy				Environment				Equity			Governance	
Ref #	Strategy Summary	Capital Costs (low, med, high)	Operating Costs (low, med, high)	Avoided Damages (low, med, high)	Enhances Tax Base (yes, no)	Impacts on Wildlife Habitat, Rare Species, or Water Quality (positive, neutral, negative)	Reduce Water Use (positive, neutral, negative)	Air Quality Improvement Potential (positive, neutral, negative)	Reduce Energy Use (positive, neutral, negative)	Protect Access to Jobs (positive, neutral, negative)	Protection of Vulnerable Populations (positive, neutral, negative)	Access to Green Space and Recreational Areas (positive, neutral, negative)	Political Decision-Maker Feasibility (low, med, high)	Opportunity for Community Involvement (low, med, high)
12.15.1	Incorporate consideration of sea level rise into the capital investment planning, design, and funding of infrastructure	Low	Low	High	No	Neutral	Neutral	Neutral	Neutral	Positive	Positive	Neutral	High	Medium
12.15.2		Low	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Medium	Medium
12.16.1	Incorporate consideration of sea level rise into plans, policies, and practices that guide community development, land use planning, emergency planning, and capital investments	Medium	Low	Medium	Yes	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low
12.16.2		Low	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	High
12.16.3		Low	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	Neutral	Low	Medium
12.16.4		Low	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Medium
12.16.5		Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low
12.16.6		Medium	Medium	Medium	Yes	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Medium	Low
12.16.7		Medium	Medium	Medium	Yes	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Low	Low
12.16.8		Low	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	Low	Medium

	Benicia: Sea Level Rise Adaptation Options (V5, 10/10/16). Color Coding as follows: GREEN = Favorable; YELLOW = Moderate; RED = Unfavorable.			Descriptive (not criteria)		General Criteria	
Ref #	Strategy Summary	Detailed Adaptation Measures	Vulnerabilities Addressed	Time period for implementation (0-5 years, 5-30 years, 30+ years)	Scale (community, system, asset)	Level of Urgency (low, med, high)	Adaptable Over Time (yes, partially, no)
12.17.1	Collaborate on identifying regional approaches to sea level rise adaptation	Collaborate with county and regional agencies to discuss and analyze approaches to improve the resilience of current vulnerable communities and how to plan future growth to avoid placing more of the region's population at risk (i.e., provide input on housing distributions in Plan Bay Area). Regional planning efforts occur every 4 years.	There is limited regional collaboration on addressing climate change.	5-30 years	Community	Low	Yes
12.17.2		Improve coordination with communities in the region on policies targeted at improving Bay Area resilience to climate change. This should include local neighbors (e.g., Vallejo) and regional leaders (e.g., Berkeley). This collaboration may create cost savings and increase public acceptance.		5-30 years	Community	Low	Yes
12.18	Continue to educate the public on the need to adapt	Continue to outreach to the community in order to educate a broad audience including facility owners, asset managers, private business owners, and the general public on the risks, costs, and benefits of hazard reduction strategies in comparison to relocation of vulnerable land uses. This may be done through community art exhibits, community meetings, or collaboration with the Benicia Herald.	The public does not fully understand how they will be impacted by sea level rise and climate change.	5-30 years	Community	Low	Yes
12.19	Facilitate partnerships between government agencies and community-based organizations to address climate change impacts	Establish a small grant program to fund community and faith-based groups to engage with the public and vulnerable populations on the topic of climate change adaptation. For example, provide mini-grants to allow these groups to participate in the implementation of this adaptation plan or in conducting additional public education on local climate impacts and emergency response in multiple languages. The MTC Community Based Organization grant program may serve as an example.	Climate change will directly impact Benicia residents and their personal property. Currently, there is no established protocol for communicating with the public about these risks and potential solutions.	5-30 years	Community	Low	Yes

	Benicia: Sea Level Rise Adaptation	Economy				Environment				Equity			Governance	
Ref #	Strategy Summary	Capital Costs (low, med, high)	Operating Costs (low, med, high)	Avoided Damages (low, med, high)	Enhances Tax Base (yes, no)	Impacts on Wildlife Habitat, Rare Species, or Water Quality (positive, neutral, negative)	Reduce Water Use (positive, neutral, negative)	Air Quality Improvement Potential (positive, neutral, negative)	Reduce Energy Use (positive, neutral, negative)	Protect Access to Jobs (positive, neutral, negative)	Protection of Vulnerable Populations (positive, neutral, negative)	Access to Green Space and Recreational Areas (positive, neutral, negative)	Political Decision-Maker Feasibility (low, med, high)	Opportunity for Community Involvement (low, med, high)
12.17.1	Collaborate on identifying regional approaches to sea level rise adaptation	Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	High	Medium
12.17.2		Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	High	Medium
12.18	Continue to educate the public on the need to adapt	Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	High	High
12.19	Facilitate partnerships between government agencies and community-based organizations to address climate change impacts	Low	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Positive	Positive	Neutral	High	High

	Benicia: Sea Level Rise Adaptation Options (V5, 10/10/16). Color Coding as follows: GREEN = Favorable; YELLOW = Moderate; RED = Unfavorable.			Descriptive (not criteria)		General Criteria	
Ref #	Strategy Summary	Detailed Adaptation Measures	Vulnerabilities Addressed	Time period for implementation (0-5 years, 5-30 years, 30+ years)	Scale (community, system, asset)	Level of Urgency (low, med, high)	Adaptable Over Time (yes, partially, no)
12.20.1	Foster strong social networks and community planning among residents to enhance neighborhood resilience to flooding impacts	Provide expanded Benicia Emergency Response Team (BERT) trainings, refresher classes, and annual exercises that include flooding preparedness and response.	A neighborhood with a strong social network that is tied together by individual relationships will have a lower overall sensitivity and higher adaptive capacity than a neighborhood where residents either do not know each other, or are not invested in the overall community good. The Benicia Citizens Corps and Emergency Response Team, the Benicia Chamber of Commerce, the Benicia Industrial Park Association, and the Benicia Main Street Program serve as organizing bodies that increase the adaptive capacity of the City of Benicia.	5-30 years	Community	Medium	Yes
12.20.2		Provide technical assistance to neighborhoods to support the development and maintenance of disaster plans, including storm evacuation procedures and shelter-in-place guidelines. This may include a sample plan, outreach, and meeting facilitation.		5-30 years	Community	Low	Yes
12.20.3		City of Benicia should develop a "Maintain-a-Drain" program that encourages neighborhoods to keep storm drains free of debris, reducing potential flood risks. The City of Oakland program can serve as an example.		5-30 years	Community	High	Yes
12.21.1	Update local plans and resources to address contingencies and secondary impacts associated with sea level rise	City of Benicia Fire Department should update the Emergency Operations Plan to address sea level rise and storm event contingencies and secondary impacts that are broad-scale (e.g., county or Bay Area-wide) and/or severe (e.g., long lasting and/or deep inundation). Include specifics on communication protocols with local community or faith-based organizations, and facilities that serve communities and can be activated during a flood or storm event. Work with those groups to establish a protocol that works well for them. Also include a contingency plan and procedures to address the need for short-term sheltering and long-term housing for displaced residents, with particular attention to vulnerable populations. In the past, the City has used hotels but this may not be a preferred solution if flooding becomes more common.	Existing emergency response procedures do not take climate change impacts into account.	5-30 years	Community	High	Yes
12.21.2		City of Benicia Fire Department and CAP Coordinator to review and update the Local Hazard Mitigation Plan to include sea level rise and other climate change impacts and ensure eligibility for state and federal emergency funds. Summarize the vulnerabilities identified in the Climate Change Vulnerability Report and include a summary of the adaptation measures selected for action.		5-30 years	Community	High	Yes
12.21.3		Coordinate emergency plans and information sharing among individual facilities/businesses, neighborhoods, utilities, cities, counties and regional and state authorities, including establishing protocols for responding to NOAA weather forecasts (e.g., when to close, shelter-in-place, or evacuate). Develop policies or incentives to encourage/require emergency response plans and procedures to consider power, water, and food necessary to maintain the function of key community services during a flood emergency. For private businesses, the city could encourage inclusion by drafting example plans and holding scenario planning workshops to identify holes in current plans and solutions for filling them. This may be coordinated with the Benicia Industry Associations.		5-30 years	Community	Medium	Yes

	Benicia: Sea Level Rise Adaptation	Economy				Environment				Equity			Governance	
Ref #	Strategy Summary	Capital Costs (low, med, high)	Operating Costs (low, med, high)	Avoided Damages (low, med, high)	Enhances Tax Base (yes, no)	Impacts on Wildlife Habitat, Rare Species, or Water Quality (positive, neutral, negative)	Reduce Water Use (positive, neutral, negative)	Air Quality Improvement Potential (positive, neutral, negative)	Reduce Energy Use (positive, neutral, negative)	Protect Access to Jobs (positive, neutral, negative)	Protection of Vulnerable Populations (positive, neutral, negative)	Access to Green Space and Recreational Areas (positive, neutral, negative)	Political Decision-Maker Feasibility (low, med, high)	Opportunity for Community Involvement (low, med, high)
12.20.1	Foster strong social networks and community planning among residents to enhance neighborhood resilience to flooding impacts	Low	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Positive	Positive	Neutral	High	Medium
12.20.2		Low	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	High	High
12.20.3		Low	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	High
12.21.1	Update local plans and resources to address contingencies and secondary impacts associated with sea level rise	Low	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	Neutral	High	Low
12.21.2		Low	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low
12.21.3		Low	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	High	Medium

	Benicia: Sea Level Rise Adaptation Options (V5, 10/10/16). Color Coding as follows: GREEN = Favorable; YELLOW = Moderate; RED = Unfavorable.			Descriptive (not criteria)		General Criteria	
Ref #	Strategy Summary	Detailed Adaptation Measures	Vulnerabilities Addressed	Time period for implementation (0-5 years, 5-30 years, 30+ years)	Scale (community, system, asset)	Level of Urgency (low, med, high)	Adaptable Over Time (yes, partially, no)
12.22	Require COOP plans to address power, water, food, and community services	Require individual City Departments to draft continuity of operation plans to ensure the continued ability to provide services during storm events (e.g., develop telecommuting options).	Continuity of Operations plans and telecommuting programs are not universal in the private or public sector, despite their ability to ability to ensure smooth and continued business operation during extreme weather events and other disasters.	5-30 years	Community	Medium	Yes
12.23	Develop a land buyout program	Prioritize buyout of properties that are damaged or at high risk of damage from sea level rise or storm events. This may (1) be instituted reactively over time as properties are damaged, or (2) proactively for businesses and residences that fall within the 24 inch sea level rise flooding area (as identified in the vulnerability report). For a model program, see the NY Rising Buyout and Acquisition Program that was implemented after Superstorm Sandy.	Residences and businesses along the shoreline have not been constructed to withstand frequent flooding events.	5-30 years	Community	Low	Partially
12.24.1	Increase disclosure of risks, require new developments to minimize vulnerabilities, and incentivize existing developments to do the same	Work with state legislators to develop requirements for real estate agents and lessors of residential and commercial properties to disclose the risk of sea level rise. This would be added to existing disclosure forms.	Most buildings are constructed of water and heat sensitive materials such as wood and plaster. With climate change, they may become uninhabitable due to deterioration and/or the growth of mold.	5-30 years	Community	High	Yes
12.24.2		Work with building industry to develop and distribute guidelines for reducing damages by designing or retrofitting structures to accommodate saltwater exposure and periodic low levels of flooding.		5-30 years	Community	Medium	Partially
12.24.3		Provide incentives or require that entrances, windows and foundations be raised above future flood elevations for all new construction or substantial reconstruction in areas likely to be at risk from sea level rise. The new Federal Flood Risk Management Standard may serve as an example.		5-30 years	Community	High	Partially
12.24.4		Continue to provide flood protection assistance to community residents, e.g., technical advice and materials such as sand bags and plastic sheeting, and ensure vulnerable populations have access to these materials at low or no cost.		0-5 years	Community	High	Yes
12.24.5		Encourage owners of property in floodplains to purchase flood insurance and educate the public that most homeowner insurance policies do not cover a property that is flood damaged. This could be achieved through a social marketing campaign and informational sessions, and should build upon the work that is currently underway as part of the FEMA map update process.		0-5 years	Community	High	Yes
12.24.6		Participate in and seek to qualify for the highest feasible rating of the Community Rating System of the National Flood Insurance Program to reduce flood risks and private property insurance costs.		0-5 years	Community	High	Yes
12.24.7		Encourage residents and landowners to use hazardous waste disposal and drop off locations to reduce the amount of potentially hazardous materials released during a flood event. This could be achieved through additional mailers/fliers, and other forms of marketing.		0-5 years	Community	High	Yes

	Benicia: Sea Level Rise Adaptation	Economy				Environment				Equity			Governance	
Ref #	Strategy Summary	Capital Costs (low, med, high)	Operating Costs (low, med, high)	Avoided Damages (low, med, high)	Enhances Tax Base (yes, no)	Impacts on Wildlife Habitat, Rare Species, or Water Quality (positive, neutral, negative)	Reduce Water Use (positive, neutral, negative)	Air Quality Improvement Potential (positive, neutral, negative)	Reduce Energy Use (positive, neutral, negative)	Protect Access to Jobs (positive, neutral, negative)	Protection of Vulnerable Populations (positive, neutral, negative)	Access to Green Space and Recreational Areas (positive, neutral, negative)	Political Decision-Maker Feasibility (low, med, high)	Opportunity for Community Involvement (low, med, high)
12.22	Require COOP plans to address power, water, food, and community services	Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	Neutral	Low	Low
12.23	Develop a land buyout program	Medium	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	Low	Low
12.24.1	Increase disclosure of risks, require new developments to minimize vulnerabilities, and incentivize existing developments to do the same	Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Medium	Medium
12.24.2		Low	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Medium	Low
12.24.3		Low	Low	Medium	Yes	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low
12.24.4		Low	Low	Medium	Yes	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	High	High
12.24.5		Low	Medium	Medium	Yes	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	Medium	Medium
12.24.6		Medium	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	High	Low
12.24.7		Low	Low	Low	No	Positive	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	High

	Benicia: Sea Level Rise Adaptation Options (V5, 10/10/16). Color Coding as follows: GREEN = Favorable; YELLOW = Moderate; RED = Unfavorable.			Descriptive (not criteria)		General Criteria	
Ref #	**Strategy Summary**	**Detailed Adaptation Measures**	**Vulnerabilities Addressed**	**Time period for implementation (0-5 years, 5-30 years, 30+ years)**	**Scale (community, system, asset)**	**Level of Urgency (low, med, high)**	**Adaptable Over Time (yes, partially, no)**
12.25	Revise the building and zoning codes to increase flood protection	The City should revise the existing building code Provisions for Flood Hazard Reduction (Chapter 15.48) and ensure that waterproof materials (e.g., waterproof shutters, shield or doors and salt-resistant materials) be used in the construction of new infrastructure and in the repair or protection of existing infrastructure that are located within projected sea level rise areas (see Vulnerability Report maps; recommend the 24 inch total water level map be used for this purpose).	Essential mechanical and electrical equipment (e.g., HVAC, elevator controls) in buildings are highly water and salt sensitive and are often located below-grade or on the ground floor. Rising sea levels, increased storm surge, and rising groundwater levels may damage equipment that has not been flood proofed and areas with existing small pumps may be overwhelmed by future water levels. Additionally, the City already provides sandbags before storms; however, application by residences and businesses is not consistent,	0-5 years	Community	High	Yes
12.26.1	Develop plans to protect habitable space located below-grade	Create incentives for property owners to repurpose below-grade space to less vulnerable or temporary uses.	Below grade space is especially vulnerable to sea level rise, storm surge, and groundwater rise.	0-5 years	Asset	High	Yes
12.26.2		Develop and enforce policies for repair and reconstruction to eliminate below-grade habitable space that is damaged by sea level and groundwater rise.		5-30 years	Community	High	Yes
12.27	Develop plans to protect historic structures	Develop individual hazard management plans for historic structures that take climate change impacts into account. If necessary, consider moving the structure to a safer location. Note: these structures were not specifically assessed in this study.	Benicia has eight properties listed in the National Register of Historical Places , and many more old structures that add to the character of the City. These unique structures cannot easily be moved, and, due to their age and construction materials, are more likely to be sensitive to flooding.	0-5 years	Asset	High	Yes
12.28	Encourage regional transit planning for sea level rise	Work with adjacent communities to develop and jointly implement transit adaptation strategies that address changes in transportation system condition and use due to sea level rise and storm events.	Planning transportation requires significant interagency coordination, between different levels of government (local, county, regional, state, federal), and different types of agencies (funding, operating, regulatory). The necessity of coordination will only increase with sea level rise affects.	5-30 years	Community	High	Yes
12.29	Increase Public Works training for flood response	Increase training on storm surge response (e.g., provide training on proper sandbag use) for City Public Works maintenance staff.	Maintenance staff are not specifically trained on how to prepare local roadways before a storm event to minimize damage and flooding.	0-5 years	Community	High	Yes
12.30.1	Establish mechanisms to protect the Bay Trail against sea level rise and storm surge impacts	Work with the Bay Trail to develop and maintain a Bay Trail asset management database that includes ownership, location, elevation, condition, and management status.	The Bay Trail provides critical recreation and transportation access to Benicia residents. In portions of the Benicia State Recreation Area, it is an unpaved trail which makes it more vulnerable to damage from flooding. Portions of the trail are projected to be flooded from SLR and storm surge.	0-5 years	Asset	Medium	Yes
12.30.2		Establish agreements among shoreline managers to maintain, repair, and upgrade shoreline levees in a manner that best preserves the Bay Trail and connected shoreline access.		0-5 years	System	High	Yes
12.31.1	Update existing the Stormwater Master Plan, and emergency response plans and procedures for stormwater infrastructure that may be inadequate to address contingencies associated with storm events	When revising the stormwater master plan, include a section on sea level rise vulnerabilities (as identified in the Climate Change Vulnerability Report) and summarize adaptation measures recommended for implementation (from this list).	Existing operations and recovery plans do not take the increased frequency of flooding events due to sea level rise and storm surge into account.	0-5 years	System	High	Yes

	Benicia: Sea Level Rise Adaptation	Economy				Environment				Equity			Governance	
Ref #	Strategy Summary	Capital Costs (low, med, high)	Operating Costs (low, med, high)	Avoided Damages (low, med, high)	Enhances Tax Base (yes, no)	Impacts on Wildlife Habitat, Rare Species, or Water Quality (positive, neutral, negative)	Reduce Water Use (positive, neutral, negative)	Air Quality Improvement Potential (positive, neutral, negative)	Reduce Energy Use (positive, neutral, negative)	Protect Access to Jobs (positive, neutral, negative)	Protection of Vulnerable Populations (positive, neutral, negative)	Access to Green Space and Recreational Areas (positive, neutral, negative)	Political Decision-Maker Feasibility (low, med, high)	Opportunity for Community Involvement (low, med, high)
12.25	Revise the building and zoning codes to increase flood protection	Low	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Low	Low
12.26.1	Develop plans to protect habitable space located below-grade	Medium	Medium	Medium	Yes	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	Neutral	Medium	Medium
12.26.2		Medium	Medium	Medium	Yes	Neutral	Neutral	Neutral	Neutral	Positive	Positive	Neutral	Medium	Low
12.27	Develop plans to protect historic structures	Medium	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	Medium	Medium
12.28	Encourage regional transit planning for sea level rise	Low	Medium	Medium	No	Neutral	Neutral	Neutral	Neutral	Positive	Positive	Neutral	Medium	Low
12.29	Increase Public Works training for flood response	Low	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	High	Medium
12.30.1	Establish mechanisms to protect the Bay Trail against sea level rise and storm surge impacts	Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	High	Low
12.30.2		Medium	Medium	Medium	Yes	Positive	Neutral	Neutral	Neutral	Neutral	Positive	Positive	Medium	Low
12.31.1	Update existing the Stormwater Master Plan, and emergency response plans and procedures for stormwater infrastructure that may be inadequate to address contingencies associated with storm events	Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low

	Benicia: Sea Level Rise Adaptation Options (V5, 10/10/16). Color Coding as follows: GREEN = Favorable; YELLOW = Moderate; RED = Unfavorable.			Descriptive (not criteria)		General Criteria	
Ref #	Strategy Summary	Detailed Adaptation Measures	Vulnerabilities Addressed	Time period for implementation (0-5 years, 5-30 years, 30+ years)	Scale (community, system, asset)	Level of Urgency (low, med, high)	Adaptable Over Time (yes, partially, no)
12.32.1	Pursue additional funding to address stormwater infrastructure issues that would be exacerbated with sea level rise	Assess existing funding and, if necessary, pursue Bay Area Integrated Regional Water Management Plan (IRWMP) and other state/federal funding for repair or improvement of stormwater management and flood control infrastructure. Key locations for repairs and upgrades include low-lying stormwater outfalls, and the downtown/waterfront and directly west of there (see the Existing Conditions report for more information on current flooding locations).	There is insufficient funding to maintain and upgrade the stormwater system .	0-5 years	System	High	Yes
12.32.2		Conduct public outreach to educate property owners about the importance of stormwater management and flood control so they support bond initiatives and increases in assessments for infrastructure repair and improvement.		5-30 years	Community	Medium	Yes
12.32.3		Investigate and pursue alternative funding mechanisms, e.g., taxes, fee-based mechanism, assessment districts, or leveraging private sector resources.		5-30 years	System	Medium	Yes
12.33.1	Implement approaches to increase the capacity of stormwater and flood control infrastructure to accommodate sea level and groundwater rise	Conduct an outreach and education campaign to encourage existing developments to install on-site stormwater capture and retention, low impact development (LID), and green infrastructure. Consider offering incentives for installation.	The stormwater system is gravity-driven and has been noted to be under sized for present demand, plus the outfalls are low-lying and currently back-up during storm events. As sea levels rise, there will be less of a gradient between the source of the stormwater and its eventual destination, and some of the outfalls could be below sea level during high tide or a storm event. This means that Carquinez Strait water could enter the stormwater systems and travel up creeks, channels, and pipes. If elevated Carquinez Strait levels coincide with a precipitation event, the presence of Bay water in stormwater infrastructure could reduce the system's capacity to store and convey stormwater, which could result in stormwater backing up and causing inland flooding.	0-5 years	System	High	Yes
12.33.2		Enforce stormwater management, and discharge control ordinances, following the RWQCB Best Management Practices (BMPs), to keep watercourses free of obstructions and protect drainage facilities		0-5 years	System	High	Yes
12.33.3		The City should continue regular maintenance of stormwater infrastructure, such as keeping storm drains clear of debris and trash and invest in routine upgrades (e.g., under or cross drains, backflow or flex valves, perimeter walls or pile/column foundations), and using low impact development (LID) techniques. Such maintenance is required in the NPDES permits. Conduct emergency cleanings prior to forecast storm events.		0-5 years	System	High	Yes
12.33.4		Require new developments and redevelopments to reduce and manage stormwater through on-site capture and retention, low impact development (LID), green infrastructure, and other means. Currently, these strategies are only recommended.		0-5 years	System	High	Yes
12.34	Limit construction in areas not currently served by utilities	Avoid new development and substantial redevelopments that will require expanding the capacity of utilities and infrastructure in areas at risk (see 24 inch total water level map). Accomplish by changing the zoning code to disallow new parcels (e.g., Yuba) to be developed along the shoreline.	Stormwater drainage issues are exacerbated by non-porous development which decrease the absorption of stormwater into the ground.	5-30 years	Community	High	Yes

	Benicia: Sea Level Rise Adaptation	Economy				Environment				Equity			Governance	
Ref #	Strategy Summary	Capital Costs (low, med, high)	Operating Costs (low, med, high)	Avoided Damages (low, med, high)	Enhances Tax Base (yes, no)	Impacts on Wildlife Habitat, Rare Species, or Water Quality (positive, neutral, negative)	Reduce Water Use (positive, neutral, negative)	Air Quality Improvement Potential (positive, neutral, negative)	Reduce Energy Use (positive, neutral, negative)	Protect Access to Jobs (positive, neutral, negative)	Protection of Vulnerable Populations (positive, neutral, negative)	Access to Green Space and Recreational Areas (positive, neutral, negative)	Political Decision-Maker Feasibility (low, med, high)	Opportunity for Community Involvement (low, med, high)
12.32.1	Pursue additional funding to address stormwater infrastructure issues that would be exacerbated with sea level rise	Low	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low
12.32.2		Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	High
12.32.3		Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Medium	Low
12.33.1	Implement approaches to increase the capacity of stormwater and flood control infrastructure to accommodate sea level and groundwater rise	Medium	Low	Medium	No	Neutral	Positive	Neutral	Neutral	Neutral	Positive	Neutral	Medium	Medium
12.33.2		Low	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Medium	Low
12.33.3		Low	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low
12.33.4		Low	Low	Medium	Yes	Positive	Neutral	Neutral	Positive	Neutral	Neutral	Neutral	Medium	Low
12.34	Limit construction in areas not currently served by utilities	Low	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Low	Low

	Benicia: Sea Level Rise Adaptation Options (V5, 10/10/16). Color Coding as follows: GREEN = Favorable; YELLOW = Moderate; RED = Unfavorable.			Descriptive (not criteria)		General Criteria	
Ref #	**Strategy Summary**	**Detailed Adaptation Measures**	**Vulnerabilities Addressed**	**Time period for implementation (0-5 years, 5-30 years, 30+ years)**	**Scale (community, system, asset)**	**Level of Urgency (low, med, high)**	**Adaptable Over Time (yes, partially, no)**
12.35	Support research on how marsh habitats will respond to accelerating sea level rise and how these habitats will be affected by shoreline adaptation responses	Collaborate with BCDC to develop and implement a Regional Sediment Management Plan for the Bay.	Although there are tools for understanding the range of potential responses of the Benicia marshes to sea level rise, there is not a conclusive assessment of future impacts.	5-30 years	System	Medium	Yes
12.36	Facilitate shoreline decision making	Improve communication and coordination between those that own and manage the shoreline (e.g.., US Army Corps, US FWS, CA FWS, BCDC, private land, the City, CA State Parks) and those that own and manage the assets that are protected by these shorelines (e.g., private residences and businesses). Expand or form partnerships among these groups to facilitate decision-making regarding shoreline improvements and new investments.	Shoreline owners and the owners of land and structured behind the shoreline are frequently different parties. Limited communication can hurt the ability to develop and implement comprehensive adaptation strategies.	0-5 years	Community	Medium	Yes
12.37	Encourage development of a regional permit authorization program	Encourage BCDC to develop and implement a regional permit authorization program to expedite the ongoing maintenance, minor repair, or upgrade of structural shorelines.	There is limited funding for maintaining structural shorelines.	5-30 years	System	Medium	Yes
12.38	Increase setbacks to protect habitat	Develop City policies, public guidance and/or incentives for private developers to encourage setbacks and buffers adjacent to tidal marshes that protect sensitive species (e.g., Benicia state park, marshland abutting the BIP, Sulphur Springs, the downtown waterfront area) and allow appropriate types of public access and recreation uses. Setback policies can be codified in City zoning, guidance can be distributed to coastal landowners, and incentives could take the form of density bonuses, streamlined permitting, or reduced development fees.	Downshifts and loss of marsh habitat would affect plants and animals including several State-listed or federally threatened and endangered species that rely on tidal marsh for breeding, foraging, and high tide refugia.	0-5 years	System	Medium	Yes
12.39	Track changes in tidal marsh habitat and factor sea level rise into marsh management	Factor sea level rise into design of new tidal marsh restorations, e.g., consider marsh future capacity to build upward and move landward with higher water levels.	Although there are tools for understanding the range of potential responses of the Benicia marshes to sea level rise, there is not a conclusive assessment of future impacts.	5-30 years	System	Medium	Yes
12.40.1	Encourage the CPUC to require CA utilities to review and update existing operations, maintenance, and emergency response plans and procedures that may be inadequate to address contingencies associated with storm events	Encourage CPUC to require the development of standardized procedures across jurisdictions for shutting down substations in advance of flooding, and for the restoration of power afterwards.	Substations can be shut down to prevent major damage from floodwaters such as corrosion to transformers, capacitors, switches and other equipment. The proper shutdown of power plants takes time, however, which adds to the sensitivity.	0-5 years	Asset	Medium	Yes
12.40.2		For electricity transmission and telecommunications assets, encourage CPUC to require the development of a load transfer and re-routing plan for networked systems to maintain service when part of the system is jeopardized.		0-5 years	Asset	Medium	Yes
12.40.3		Encourage CPUC to require utilities to prepare for recovery from flooding by stockpiling materials, establishing turn-key agreements for equipment rental, and pre-positioning emergency power generation capacity, portable pumps, and debris removal equipment.		0-5 years	System	Medium	Yes

	Benicia: Sea Level Rise Adaptation	Economy				Environment				Equity			Governance	
Ref #	Strategy Summary	Capital Costs (low, med, high)	Operating Costs (low, med, high)	Avoided Damages (low, med, high)	Enhances Tax Base (yes, no)	Impacts on Wildlife Habitat, Rare Species, or Water Quality (positive, neutral, negative)	Reduce Water Use (positive, neutral, negative)	Air Quality Improvement Potential (positive, neutral, negative)	Reduce Energy Use (positive, neutral, negative)	Protect Access to Jobs (positive, neutral, negative)	Protection of Vulnerable Populations (positive, neutral, negative)	Access to Green Space and Recreational Areas (positive, neutral, negative)	Political Decision-Maker Feasibility (low, med, high)	Opportunity for Community Involvement (low, med, high)
12.35	Support research on how marsh habitats will respond to accelerating sea level rise and how these habitats will be affected by shoreline adaptation responses	Low	Low	Low	No	Positive	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low
12.36	Facilitate shoreline decision making	Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	High
12.37	Encourage development of a regional permit authorization program	Low	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low
12.38	Increase setbacks to protect habitat	Low	Low	Medium	No	Positive	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	Low	Low
12.39	Track changes in tidal marsh habitat and factor sea level rise into marsh management	Medium	Low	Medium	No	Positive	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	High	Low
12.40.1	Encourage the CPUC to require CA utilities to review and update existing operations, maintenance, and emergency response plans and procedures that may be inadequate to address contingencies associated with storm events	Low	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Medium	Low
12.40.2		Low	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Medium	Low
12.40.3		Low	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Medium	Low

	Benicia: Sea Level Rise Adaptation Options (V5, 10/10/16). Color Coding as follows: GREEN = Favorable; YELLOW = Moderate; RED = Unfavorable.			Descriptive (not criteria)		General Criteria	
Ref #	**Strategy Summary**	**Detailed Adaptation Measures**	**Vulnerabilities Addressed**	**Time period for implementation (0-5 years, 5-30 years, 30+ years)**	**Scale (community, system, asset)**	**Level of Urgency (low, med, high)**	**Adaptable Over Time (yes, partially, no)**
12.41	Encourage PG&E to update standards for new construction	Review and update standards, codes, and regulations for the construction and placement of utility infrastructure to avoid or address sea level rise, storm events, and elevated groundwater levels.	Electrical components and pipes that are exposed to sea water are susceptible to damage or destruction due to the corrosive nature of salt water.	0-5 years	System	Medium	Yes
12.42	Identify pipelines, cables, and utility poles that are exposed to storm events and address vulnerabilities to scour, erosion, and high winds	Encourage PG&E to inspect underground infrastructure, particularly after storm events and extreme tides, and improve cover as necessary to ensure it is sufficient to withstand scour and flooding.	Waves and storm surge generally do not damage either aboveground or belowground pipelines (e.g., natural gas); however, damage can occur from changes in water tables or soil stability due to sea level rise and from wave action and storm surge, particularly for submerged or low-elevation pipelines.	0-5 years	System	Medium	Yes
	Physical and Functional Vulnerability						
12.43	Develop coordinated information for contaminated lands and hazardous material sites, for use during emergency and adaptation planning and for setting remediation, monitoring, and enforcement priorities to reduce risks	Prioritize the remediation of contaminated sites based on the timing of exposure to sea level rise, storm events (see maps in the Vulnerability Report), and elevated groundwater, degree of vulnerability, and extent of the consequences.	Information on hazardous material sites has not been updated in the General Plan since initial adoption. There is limited understanding of the current locations and status of hazardous material sites.	5-30 years	Community	Medium	Yes
12.44	Implement approaches to increase the capacity of stormwater and flood control infrastructure to accommodate sea level and groundwater rise	The Public Works Department should consider increasing stormwater system capacity and improving operations by increasing pipe size, installing backflow prevention devices, elevating outfalls, installing forced mains, installing new pump stations, or increasing existing pump station capacity.	The stormwater system is gravity-driven and has been noted to be under sized for present demand, plus the outfalls are low-lying and currently back-up during storm events. As sea levels rise, there will be less of a gradient between the source of the stormwater and its eventual destination, and some of the outfalls could be below sea level during high tide or a storm event. This means that Carquinez Strait water could enter the stormwater systems and travel up creeks, channels, and pipes. If elevated Carquinez Strait levels coincide with a precipitation event, the presence of Bay water in stormwater infrastructure could reduce the system's capacity to store and convey stormwater, which could result in stormwater backing up and causing inland flooding.	0-5 years	System	High	Partially
12.45	Encourage PG&E to increase inspection and maintenance of existing structures	Encourage PG&E to increase their inspection and maintenance of infrastructure that is sensitive to water or salt in areas at risk from sea level rise, storm events, or elevated groundwater levels.	Electrical components and pipes that are exposed to sea water are susceptible to damage or destruction due to the corrosive nature of salt water.	0-5 years	System	Medium	Yes

	Benicia: Sea Level Rise Adaptation	Economy				Environment				Equity			Governance	
Ref #	Strategy Summary	Capital Costs (low, med, high)	Operating Costs (low, med, high)	Avoided Damages (low, med, high)	Enhances Tax Base (yes, no)	Impacts on Wildlife Habitat, Rare Species, or Water Quality (positive, neutral, negative)	Reduce Water Use (positive, neutral, negative)	Air Quality Improvement Potential (positive, neutral, negative)	Reduce Energy Use (positive, neutral, negative)	Protect Access to Jobs (positive, neutral, negative)	Protection of Vulnerable Populations (positive, neutral, negative)	Access to Green Space and Recreational Areas (positive, neutral, negative)	Political Decision-Maker Feasibility (low, med, high)	Opportunity for Community Involvement (low, med, high)
12.41	Encourage PG&E to update standards for new construction	Low	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Medium	Low
12.42	Identify pipelines, cables, and utility poles that are exposed to storm events and address vulnerabilities to scour, erosion, and high winds	Low	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Medium	Low
	Physical and Functional Vulnerability													
12.43	Develop coordinated information for contaminated lands and hazardous material sites, for use during emergency and adaptation planning and for setting remediation, monitoring, and enforcement priorities to reduce risks	Low	Low	Medium	No	Positive	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Medium	Low
12.44	Implement approaches to increase the capacity of stormwater and flood control infrastructure to accommodate sea level and groundwater rise	High	Medium	High	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Medium	Low
12.45	Encourage PG&E to increase inspection and maintenance of existing structures	Medium	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Medium	Low

	Benicia: Temp. Adapt. Options (v5, 10/10/16).			Descriptive (not criteria)		General Criteria	
Ref #	**Strategy Summary**	**Detailed Adaptation Measures**	**Vulnerabilities Addressed**	**Time period for implementation (0-5 years, 5-30 years, 30+ years)**	**Scale (community, system, asset)**	**Level of Urgency (low, med, high)**	**Adaptable Over Time (yes, partially, no)**
	OVERARCHING						
	Informational Vulnerability						
1.1	Track information on the impacts of high heat days on the City	Establish internal metrics and processes for tracking the negative impacts of high heat days on the City. Focus on the costs of repairs, social services, labor, and the number of people or businesses impacted by the event. When possible, monetize the impacts and store this information in a format that is compatible with asset management databases that contain data on the age, condition, expected useful life, replacement cost, rehabilitation schedule and costs, location, and elevation of assets.	There is insufficient data on the historic impact of high heat days on the city. This information would assist in understanding vulnerabilities and in developing a case for investment.	0-5 years	Community	**High**	**Yes**
1.2	Identify and monitor temperature hot-spots	Identify data sources and best practices for developing heat hot-spot maps that can help inform where to target adaptation actions. Partner with a University to develop these maps.		30+ years	Community	**High**	**No**
1.3.1	Coordinate with non-profit, community, and faith based groups to ensure availability and accuracy of information	Develop and maintain a centralized database of non-profit, community, and faith-based organizations, equipment and service providers, and others that can communicate with communities at risk.	There is no database of the locations of vulnerable populations. This limits the ability of emergency responders to target their response to those that may need it most.	0-5 years	Community	**High**	**Yes**
1.3.2		Develop and maintain a voluntary database that includes specific needs within each community related to emergency response.		0-5 years	Community	**High**	**Yes**
1.4.1	Increase awareness of vector-borne diseases	Develop and distribute culturally appropriate and accessible materials about vector-borne disease prevention.	Increased temperatures have the potential to cause negative impacts on human health. In addition to direct impacts, increased temperatures can increase the risk of vector-borne diseases (e.g., Valley fever).	0-5 years	Community	**Medium**	**Yes**
1.4.2		Expand the capacity to educate health care providers to recognize and report patterns of vector-borne disease illnesses and injuries, and to inform the public about preventive actions.		0-5 years	Community	**Medium**	**Yes**
1.4.3		Work with healthcare providers to develop a response plan for emerging vector-borne diseases, including increased capacity for health services that are triggered by certain case thresholds.		5-30 years	Community	**Medium**	**Yes**

Color Coding as follows: GREEN = Favorable; YELLOW = Moderate; RED = Unfavorable.

	Benicia: Temp. Adapt. Options (v5, 10/10/16).	Economy				Environment				Equity			Governance	
Ref #	Strategy Summary	Capital Costs/Upfront Costs (low, med, high)	Operating Costs/Ongoing Costs (low, med, high)	Avoided Damages (low, med, high)	Enhances Tax Base (yes, no)	Impacts on Wildlife Habitat, Rare Species, or Water Quality (positive, neutral, negative)	Reduce Water Use (positive, neutral, negative)	Air Quality Improvement Potential (positive, neutral, negative)	Reduce Energy Use (positive, natural, negative)	Protect Access to Jobs (positive, neutral, negative)	Protection of Vulnerable Populations (positive, neutral, negative)	Access to Green Space and Recreational Areas (positive, neutral, negative)	Political Decision-Maker Feasibility (low, med, high)	Opportunity for Community Involvement (low, med, high)
	OVERARCHING													
	Informational Vulnerability													
1.1	Track information on the impacts of high heat days on the City	Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	High	Medium
1.2	Identify and monitor temperature hot-spots	Medium	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	High	Low
1.3.1	Coordinate with non-profit, community, and faith based groups to ensure availability and accuracy of information	Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	Medium	High
1.3.2		Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	High	High
1.4.1	Increase awareness of vector-borne diseases	Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	Medium	High
1.4.2		Low	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	Medium	Low
1.4.3		Low	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	Low	Low

Color Coding as follows: GREEN = Favorable; YELLOW = Moderate; RED = Unfavorable.

	Benicia: Temp. Adapt. Options (v5, 10/10/16).			Descriptive (not criteria)		General Criteria	
Ref #	**Strategy Summary**	**Detailed Adaptation Measures**	**Vulnerabilities Addressed**	**Time period for implementation (0-5 years, 5-30 years, 30+ years)**	**Scale (community, system, asset)**	**Level of Urgency (low, med, high)**	**Adaptable Over Time (yes, partially, no)**
	Management Control Vulnerability						
1.5.1	Facilitate partnerships between government agencies and community-based organizations to address climate change impacts	Conduct community-led campaigns to build public support for community groups and leaders to participate in collaborative efforts to address current and future climate stressors, including extreme heat. Campaigns should develop and market strategies and recommendations for staying cool at home and work. Coordinate outreach to public and partners, with consistent messaging, information, and instructions via public broadcast, websites, email, and social media.	A neighborhood with a strong social network that is tied together by individual relationships will be less vulnerable than a neighborhood where residents either do not know each other, or are not invested in the overall community good.	5-30 years	Community	**High**	**Yes**
1.5.2		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 community-level climate adaptation plans or conducting public education on local climate impacts and emergency response in multiple languages.		5-30 years	Community	**High**	**Yes**
1.5.3		Create and implement a framework that government agencies, organizations and community partners can use to engage in open, transparent, and well publicized planning and decision making processes.		0-5 years	Community	**High**	**Yes**
1.6	Integrate heat events into the emergency communication protocol	The City should develop and maintain an emergency communication protocol for city, county, regional, and state agencies, local community or faith-based organizations, and facilities that serve communities and can be activated during an extreme heat event or loss of power. Explore the creation of a new online Emergency Notification Contact System.		0-5 years	Community	**High**	**Yes**
1.7	Review the Local Hazard Mitigation Plan for potential incorporation and/or refinement of health impacts related to heat event projections	Update the Local Hazard Mitigation Plan to include information on increasing temperatures and emerging climate change research for potential health impacts. Consider developing a contingency plan for excessive heat emergencies.	The current Local Hazard Mitigation plan does not address the appropriate response to high heat days.	0-5 years	Community	**High**	**Yes**

Color Coding as follows: GREEN = Favorable; YELLOW = Moderate; RED = Unfavorable.

	Benicia: Temp. Adapt. Options (v5, 10/10/16).	Economy				Environment				Equity			Governance	
Ref #	Strategy Summary	Capital Costs/Upfront Costs (low, med, high)	Operating Costs/Ongoing Costs (low, med, high)	Avoided Damages (low, med, high)	Enhances Tax Base (yes, no)	Impacts on Wildlife Habitat, Rare Species, or Water Quality (positive, neutral, negative)	Reduce Water Use (positive, neutral, negative)	Air Quality Improvement Potential (positive, neutral, negative)	Reduce Energy Use (positive, natural, negative)	Protect Access to Jobs (positive, neutral, negative)	Protection of Vulnerable Populations (positive, neutral, negative)	Access to Green Space and Recreational Areas (positive, neutral, negative)	Political Decision-Maker Feasibility (low, med, high)	Opportunity for Community Involvement (low, med, high)
	Management Control Vulnerability													
1.5.1	Facilitate partnerships between government agencies and community-based organizations to address climate change impacts	Medium	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	High	High
1.5.2		Medium	Medium	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	Medium	High
1.5.3		Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	Medium	High
1.6	Integrate heat events into the emergency communication protocol	Low	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	High	High
1.7	Review the Local Hazard Mitigation Plan for potential incorporation and/or refinement of health impacts related to heat event projections	Medium	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	High	Medium

Color Coding as follows: GREEN = Favorable; YELLOW = Moderate; RED = Unfavorable.

	Benicia: Temp. Adapt. Options (v5, 10/10/16).			Descriptive (not criteria)		General Criteria	
Ref #	**Strategy Summary**	**Detailed Adaptation Measures**	**Vulnerabilities Addressed**	**Time period for implementation (0-5 years, 5-30 years, 30+ years)**	**Scale (community, system, asset)**	**Level of Urgency (low, med, high)**	**Adaptable Over Time (yes, partially, no)**
1.8	Update the Benicia Emergency Operation Plan to include extreme heat	The City should revise the Benicia Emergency Operations Plan to include an Extreme Heat Response Plan. This should designate public cooling shelters, cancellation policies for outdoor activities and events, post-season reviews of program performance by partners, and public input on ways to improve the program. Identify program partners and vulnerable populations, as well as clear criteria that define extreme heat events and help to evaluate weather forecasts and conditions so preparation can begin prior to the extreme temperatures. If useful, include in-person assessments for vulnerable persons. Train staff in shelter operations, such as Red Cross trainings, to handle extreme temperature events. San Francisco and Philadelphia have these types of plans.	The current local Benicia Emergency Operation Plan does not address the appropriate response to high heat days. This creates the possibility of underutilized city services during heat events.	0-5 years	Community	**High**	**Yes**
1.9	Launch extreme heat pilot program	Launch a pilot program to identify and test strategies for protecting vulnerable neighborhoods from extreme heat health impacts. Integrate results into the Benicia Emergency Operation Plan.		0-5 years	Community	**Medium**	**Partially**
1.10	Pursue additional funding for implementing extreme heat adaptation	Pursue assistance from state agencies in responding to high heat days, such as emergency management grants, planning assistance and guidance, mutual aid agreements, mitigation and post-disaster recovery.	There are no dedicated funding streams for implementing extreme heat adaptation strategies	5-30 years	Community	**Medium**	**Yes**
1.11	Update capital improvement planning process to consider extreme heat events	Require an evaluation of extreme heat events in planning capital improvements and infrastructure investments, including an evaluation of whether an alternative design would reduce future risks and lifecycle costs.	It is not standard practice to consider extreme heat when prioritizing or developing projects as part of the capital improvement planning process.	5-30 years	Asset	**High**	**Yes**
1.12	Train public safety officers to recognize heat-related illness	Ensure that public safety staff are properly trained to recognize and respond to physical and behavioral signs of heat-related illness.	Due to the coastal breezes, Benicia has limited experience responding to extreme heat events. This limits the preparedness for future events.	0-5 years	Community	**Medium**	**Partially**

Color Coding as follows: GREEN = Favorable; YELLOW = Moderate; RED = Unfavorable.

	Benicia: Temp. Adapt. Options (v5, 10/10/16).	Economy				Environment				Equity			Governance	
Ref #	Strategy Summary	Capital Costs/Upfront Costs (low, med, high)	Operating Costs/Ongoing Costs (low, med, high)	Avoided Damages (low, med, high)	Enhances Tax Base (yes, no)	Impacts on Wildlife Habitat, Rare Species, or Water Quality (positive, neutral, negative)	Reduce Water Use (positive, neutral, negative)	Air Quality Improvement Potential (positive, neutral, negative)	Reduce Energy Use (positive, natural, negative)	Protect Access to Jobs (positive, neutral, negative)	Protection of Vulnerable Populations (positive, neutral, negative)	Access to Green Space and Recreational Areas (positive, neutral, negative)	Political Decision-Maker Feasibility (low, med, high)	Opportunity for Community Involvement (low, med, high)
1.8	Update the Benicia Emergency Operation Plan to include extreme heat	Low	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	High	Medium
1.9	Launch extreme heat pilot program	Medium	Medium	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	Medium	High
1.10	Pursue additional funding for implementing extreme heat adaptation	Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	High	Low
1.11	Update capital improvement planning process to consider extreme heat events	Medium	Medium	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	Medium	Low
1.12	Train public safety officers to recognize heat-related illness	Medium	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	Medium	Low

Color Coding as follows: GREEN = Favorable; YELLOW = Moderate; RED = Unfavorable.

	Benicia: Temp. Adapt. Options (v5, 10/10/16).			Descriptive (not criteria)		General Criteria	
Ref #	**Strategy Summary**	**Detailed Adaptation Measures**	**Vulnerabilities Addressed**	**Time period for implementation (0-5 years, 5-30 years, 30+ years)**	**Scale (community, system, asset)**	**Level of Urgency (low, med, high)**	**Adaptable Over Time (yes, partially, no)**
1.13.1	Implement measures to protect workers at risk of extreme heat	Review current OSHA standards and consider developing new thresholds for changes in work hours for outdoor employees at risk of extreme heat.	Outdoor workers and athletes are particularly vulnerable to heat events due to their outdoor physical exertion.	5-30 years	Community	**High**	**Yes**
1.13.2		Augment training of employers and workers in industries with outdoor work, including assurance of adequate water, shade, rest breaks and training on heat risks.		0-5 years	Community	**Medium**	**Yes**
	Physical and Functional Vulnerability						
1.14	Increase outdoor heat safety	Install water and ice distribution stations, as well as pop-up tents, sprinklers, hoses, fans, and other water-cooling devices in outdoor areas. Expand hours of operation for pools. Investigate re-opening the local movie theatre.	There are limited locations for residents to visit to cool down during hot days.	0-5 years	Community	**Medium**	**Yes**
2	**COMMUNITY ASSETS**						
	Management Control Vulnerability						
2.1	Obtain healthcare professional feedback and input on adaptation strategies	Convene key healthcare agencies and partners representing the health care sector to review this suite of strategies, assess additional risks to the health sector and identify any new or modified strategies necessary to become more heat prepared and resilient.	Heat-related illnesses can include heat cramps, heat exhaustion, and heat stroke. The elderly and the very young, in addition to those predisposed to medical conditions, are the most likely to be affected by heat-related illnesses. Other vulnerable populations include those that have to or choose to physically exert themselves on high heat days (e.g., indoor and outdoor workers, athletes).	5-30 years	Community	**Medium**	**Yes**
2.2	Coordinate with other communities to identify ways to improve planning for resilience of communities	Collaborate with communities in the region to discuss and analyze approaches to improve the resilience of current vulnerable communities and how to plan future growth to avoid placing more of the region's population at risk.	There is no consistent approach to responding to heat impacts and implementing preventative measures	0-5 years	Community	**High**	**Yes**

Color Coding as follows: GREEN = Favorable; YELLOW = Moderate; RED = Unfavorable.

	Benicia: Temp. Adapt. Options (v5, 10/10/16).	Economy				Environment				Equity			Governance	
Ref #	Strategy Summary	Capital Costs/Upfront Costs (low, med, high)	Operating Costs/Ongoing Costs (low, med, high)	Avoided Damages (low, med, high)	Enhances Tax Base (yes, no)	Impacts on Wildlife Habitat, Rare Species, or Water Quality (positive, neutral, negative)	Reduce Water Use (positive, neutral, negative)	Air Quality Improvement Potential (positive, neutral, negative)	Reduce Energy Use (positive, natural, negative)	Protect Access to Jobs (positive, neutral, negative)	Protection of Vulnerable Populations (positive, neutral, negative)	Access to Green Space and Recreational Areas (positive, neutral, negative)	Political Decision-Maker Feasibility (low, med, high)	Opportunity for Community Involvement (low, med, high)
1.13.1	Implement measures to protect workers at risk of extreme heat	Low	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Positive	Positive	Neutral	Medium	High
1.13.2		Low	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Positive	Positive	Neutral	Medium	High
	Physical and Functional Vulnerability													
1.14	Increase outdoor heat safety	Medium	Medium	Medium	No	Neutral	Negative	Neutral	Negative	Neutral	Positive	Positive	Medium	High
2	COMMUNITY ASSETS													
	Management Control Vulnerability													
2.1	Obtain healthcare professional feedback and input on adaptation strategies	Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	Medium	Low
2.2	Coordinate with other communities to identify ways to improve planning for resilience of communities	Low	Low	Low	Yes	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	High	Medium

Color Coding as follows: GREEN = Favorable; YELLOW = Moderate; RED = Unfavorable.

	Benicia: Temp. Adapt. Options (v5, 10/10/16).			Descriptive (not criteria)		General Criteria	
Ref #	**Strategy Summary**	**Detailed Adaptation Measures**	**Vulnerabilities Addressed**	**Time period for implementation (0-5 years, 5-30 years, 30+ years)**	**Scale (community, system, asset)**	**Level of Urgency (low, med, high)**	**Adaptable Over Time (yes, partially, no)**
	Physical and Functional Vulnerability						
2.3.1	Build the resilience of facilities that provide key community services so that they can maintain operations if connections to services such as power, clean water, and safe food supplies are disrupted	Conduct vulnerability and risk assessments of individual facilities that provide key community services and develop site-specific strategies to reduce service disruptions or closures.	A variety of socioeconomic factors affect the sensitivity of a community. For example, economic status, level of education, health and physical mobility, ownership of a home or car, and proficiency in English can all affect a resident's sensitivity to climate change. This will need to be taken under consideration when developing emergency response plans and when providing general assistance to residents to adapt their personal homes to become more resilient to climate change.	0-5 years	Asset	**High**	**Partially**
2.3.2		Develop policies or incentives to encourage/require facilities providing key community services to implement changes to facility structures or operations that would reduce potential for disruption or closure due to extreme heat events.		5-30 years	Community	**High**	**Yes**
2.3.3		Increase the use of solar panels to power fuel pumping stations for emergency vehicles in order to ensure there is a continuous ability to respond to heat events.		0-5 years	System	**Medium**	**Partially**
2.3.4		Support regulatory efficiency programs (e.g., low-flow plumbing fixtures, Water Sense Program for appliances), as well as efforts to minimize water consumption in fountains, parks and other landscaped publicly owned or managed properties while still maintaining thriving vegetation.		0-5 years	Community	**Medium**	**Yes**
2.4	Examine and expand the use of cool, porous, or sustainable materials	Develop standard specifications for cool, porous or sustainable pavements that can be used to reduce urban heat island effects, and consider updating the Building Standards Code to include any standard specifications for cool or sustainable pavements.		0-5 years	Community	**High**	**Yes**

Color Coding as follows: GREEN = Favorable; YELLOW = Moderate; RED = Unfavorable.

	Benicia: Temp. Adapt. Options (v5, 10/10/16).	Economy				Environment				Equity			Governance	
Ref #	Strategy Summary	Capital Costs/Upfront Costs (low, med, high)	Operating Costs/Ongoing Costs (low, med, high)	Avoided Damages (low, med, high)	Enhances Tax Base (yes, no)	Impacts on Wildlife Habitat, Rare Species, or Water Quality (positive, neutral, negative)	Reduce Water Use (positive, neutral, negative)	Air Quality Improvement Potential (positive, neutral, negative)	Reduce Energy Use (positive, natural, negative)	Protect Access to Jobs (positive, neutral, negative)	Protection of Vulnerable Populations (positive, neutral, negative)	Access to Green Space and Recreational Areas (positive, neutral, negative)	Political Decision-Maker Feasibility (low, med, high)	Opportunity for Community Involvement (low, med, high)
	Physical and Functional Vulnerability													
2.3.1	Build the resilience of facilities that provide key community services so that they can maintain operations if connections to services such as power, clean water, and safe food supplies are disrupted	Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	Medium	Medium
2.3.2		Medium	Medium	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	Medium	Low
2.3.3		Medium	Low	Medium	Yes	Neutral	Positive	Positive	Neutral	Neutral	Positive	Neutral	Medium	Low
2.3.4		Low	Low	Low	No	Neutral	Positive	Neutral	Positive	Neutral	Positive	Neutral	High	Medium
2.4	Examine and expand the use of cool, porous, or sustainable materials	Medium	Low	Medium	No	Positive	Neutral	Neutral	Positive	Neutral	Positive	Neutral	Medium	Medium

Color Coding as follows: GREEN = Favorable; YELLOW = Moderate; RED = Unfavorable.

	Benicia: Temp. Adapt. Options (v5, 10/10/16).			Descriptive (not criteria)		General Criteria	
Ref #	**Strategy Summary**	**Detailed Adaptation Measures**	**Vulnerabilities Addressed**	**Time period for implementation (0-5 years, 5-30 years, 30+ years)**	**Scale (community, system, asset)**	**Level of Urgency (low, med, high)**	**Adaptable Over Time (yes, partially, no)**
2.4.1	The City (Parks & Community Services Department) should promote and expand urban greening and the use of green infrastructure as part of cooling strategies in public and private spaces.	Increase tree canopy cover percentage, especially for high-risk areas, and especially for areas with highest urban heat island contribution: large parking lots, arterial roads, dark roofs on buildings. Avoid trees that produce abundance of allergens or Volatile Organic Compounds or require excessive water. Avoid conflicts with photovoltaic systems when siting trees. Consider greening areas near vulnerable populations to ensure that urban heat island and aesthetic benefits accrue to populations most in need. Use trees to provide shade at places where people recreate. This could be a cost effective solution for parking lots, parks, walking and bike paths, and tracks. Work with community groups like Friends of the Urban Forest.	Temperatures are commonly higher in urban, paved areas due to the urban heat island effect, whereby the pavement and buildings in an urbanized area absorb sunlight and heat. This effect may become more pronounced in built up areas such as downtown and the Benicia Industrial Park.	5-30 years	Community	**High**	**Partially**
2.4.2		Use alternative vegetative solutions to alleviate urban heat island: for example, green walls and green roofs where trees are not possible. These solutions are more costly than trees, but still provide significant benefit. Increase funding for green roof incentives (such as green roofs, tax incentives, or expedited permitting), assist builders with financing upfront costs, change building, tax, or zoning codes.		5-30 years	Community	**High**	**Partially**
2.4.3		Where possible, restore natural geomorphic and hydrologic features to remove failing culverted and channelized streams in urban areas. Exposed water flow can increase evaporation and decrease the local temperature.		5-30 years	Community	**Medium**	**No**
2.4.4		Build upon current efforts to educate the general public on best practices to green urban residential areas. Implement public educational programs such as demonstration projects, informational programs (online resource centers), and outreach efforts (such as tours of demonstration projects). Incorporate green roofs into local government buildings as the example buildings.		0-5 years	Community	**High**	**Yes**

Color Coding as follows: GREEN = Favorable; YELLOW = Moderate; RED = Unfavorable.

	Benicia: Temp. Adapt. Options (v5, 10/10/16).	Economy				Environment				Equity			Governance	
Ref #	Strategy Summary	Capital Costs/Upfront Costs (low, med, high)	Operating Costs/Ongoing Costs (low, med, high)	Avoided Damages (low, med, high)	Enhances Tax Base (yes, no)	Impacts on Wildlife Habitat, Rare Species, or Water Quality (positive, neutral, negative)	Reduce Water Use (positive, neutral, negative)	Air Quality Improvement Potential (positive, neutral, negative)	Reduce Energy Use (positive, natural, negative)	Protect Access to Jobs (positive, neutral, negative)	Protection of Vulnerable Populations (positive, neutral, negative)	Access to Green Space and Recreational Areas (positive, neutral, negative)	Political Decision-Maker Feasibility (low, med, high)	Opportunity for Community Involvement (low, med, high)
2.4.1	The City (Parks & Community Services Department) should promote and expand urban greening and the use of green infrastructure as part of cooling strategies in public and private spaces.	Medium	Medium	Medium	Yes	Positive	Negative	Positive	Positive	Neutral	Positive	Positive	Medium	High
2.4.2		Medium	Low	Medium	No	Positive	Neutral	Positive	Positive	Neutral	Positive	Positive	Medium	High
2.4.3		High	Medium	Medium	No	Positive	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	Medium	Medium
2.4.4		Medium	Medium	Medium	No	Positive	Neutral	Positive	Positive	Neutral	Positive	Positive	High	High

Color Coding as follows: GREEN = Favorable; YELLOW = Moderate; RED = Unfavorable.

	Benicia: Temp. Adapt. Options (v5, 10/10/16).			Descriptive (not criteria)		General Criteria	
Ref #	**Strategy Summary**	**Detailed Adaptation Measures**	**Vulnerabilities Addressed**	**Time period for implementation (0-5 years, 5-30 years, 30+ years)**	**Scale (community, system, asset)**	**Level of Urgency (low, med, high)**	**Adaptable Over Time (yes, partially, no)**
2.5	Update local regulations, building codes, and practices to promote and support green buildings	The City should review and incorporate changes as appropriate, to regulations, codes and industry practices for buildings, land use and design elements to identify opportunities to accelerate the adoption of cooling strategies for both indoor and outdoor environments, such as updating the City green building codes (see Philadelphia's Green Roofs building code for an example), advocating to the California Energy Commission for increased building energy efficiency standards, and local land-use cooling strategies (e.g., implementing a program to reduce urban heat island effect).	Buildings themselves can be affected by high temperatures–paint is more likely to become brittle and chip, business equipment filters and sealants may need to be replaced more frequently, and concrete pavement may crack if there are an insufficient number of expansion joints. However, none of the community facility and service asset owners identified high heat as a concern for continued operation.	0-5 years	Community	**High**	**Yes**
2.6.1	Review and improve access to and use of air conditioning and other indoor cooling strategies	Improve the availability of air conditioning to vulnerable populations who do not currently have access.	Due to the age of buildings within the Project Area (some being constructed as early as the 1850's with a second boom in construction following the 1950's), as well as the current coastal breeze, the vast majority do not have air conditioning units. This lack of universal cooling systems increases the sensitivity of the public and businesses to high heat conditions.	0-5 years	Community	**High**	**Yes**
2.6.2		Work with utilities to review the adequacy of programs designed to help vulnerable populations stay cool during heat waves, with attention to ways to offset the economic impacts on seniors and low income groups.		0-5 years	Community	**High**	**Yes**
2.6.3		Coordinate with the Flex Alert program and PG&E/MCE to create a unified message appropriate for extreme heat events.		0-5 years	Community	**High**	**Yes**
2.6.4		Identify alternatives to grid-powered air conditioners for cooling, such as propane air conditioners, fans and cold water systems, and educate residents and business owners on these technologies.		0-5 years	Community	**High**	**Yes**
	TRANSPORTATION						
	Physical and Functional Vulnerability						
2.7	Update pavement binder requirements	Review the pavement binder mix specifications and determine if the upper temperature threshold is within the range of projected future temperatures. If not, revise the specifications to ensure that roadway surfaces will be stable under future conditions. Coordinate with Caltrans.	Sustained high temperatures can cause asphalt pavement to soften, resulting in rutting and shoving. Asphalt binder is designed to withstand temperatures up to a certain threshold. Pavement binder may exhibit sensitivity beginning at 108°F, particularly if combined with truck traffic. Incremental temperature increases up until that point is not likely to cause much damage. Higher temperature threshold asphalt mixes are available at increased costs.	0-5 years	System	**High**	**Partially**
2.8	Revise pavement design to minimize heaving	Review maximum joint spacing specifications and consider revising to shorten the distance based on engineering calculations of potential for damage during future high heat days.	Concrete pavement can heave at the joints if they are spaced too far apart. When high heat is accompanied by drought conditions, asphalt concrete pavement can crack, making it more vulnerable to water damage when it does rain.	0-5 years	System	**High**	**Partially**

Color Coding as follows: GREEN = Favorable; YELLOW = Moderate; RED = Unfavorable.

	Benicia: Temp. Adapt. Options (v5, 10/10/16).	Economy				Environment				Equity			Governance	
Ref #	Strategy Summary	Capital Costs/Upfront Costs (low, med, high)	Operating Costs/Ongoing Costs (low, med, high)	Avoided Damages (low, med, high)	Enhances Tax Base (yes, no)	Impacts on Wildlife Habitat, Rare Species, or Water Quality (positive, neutral, negative)	Reduce Water Use (positive, neutral, negative)	Air Quality Improvement Potential (positive, neutral, negative)	Reduce Energy Use (positive, natural, negative)	Protect Access to Jobs (positive, neutral, negative)	Protection of Vulnerable Populations (positive, neutral, negative)	Access to Green Space and Recreational Areas (positive, neutral, negative)	Political Decision-Maker Feasibility (low, med, high)	Opportunity for Community Involvement (low, med, high)
2.5	Update local regulations, building codes, and practices to promote and support green buildings	Medium	Medium	Medium	No	Neutral	Positive	Positive	Positive	Neutral	Positive	Positive	Medium	Medium
2.6.1	Review and improve access to and use of air conditioning and other indoor cooling strategies	Medium	Medium	Medium	No	Neutral	Neutral	Neutral	Negative	Neutral	Positive	Neutral	High	High
2.6.2		Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	High	High
2.6.3		Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	High	High
2.6.4		Medium	Low	Medium	No	Neutral	Neutral	Neutral	Negative	Neutral	Positive	Neutral	High	High
	TRANSPORTATION													
	Physical and Functional Vulnerability													
2.7	Update pavement binder requirements	Low	Medium	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	Medium	Low
2.8	Revise pavement design to minimize heaving	Low	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	Medium	Low

Color Coding as follows: GREEN = Favorable; YELLOW = Moderate; RED = Unfavorable.

	Benicia: Temp. Adapt. Options (v5, 10/10/16).			Descriptive (not criteria)		General Criteria	
Ref #	**Strategy Summary**	**Detailed Adaptation Measures**	**Vulnerabilities Addressed**	**Time period for implementation (0-5 years, 5-30 years, 30+ years)**	**Scale (community, system, asset)**	**Level of Urgency (low, med, high)**	**Adaptable Over Time (yes, partially, no)**
3	**Port of Benicia**						
	Informational Vulnerability						
3.1	Enhance accessibility and coordination of detailed infrastructure information for the Port of Benicia for vulnerability and risk assessments	Continue collaborations between the Port and the City on climate change issues, including the sharing of asset condition information and plans for upgrades/maintenance to port facilities. Enhance information sharing on the vulnerability of port assets to extreme heat conditions.	The existing lease structure of the Port land will require increased information and collaboration between the city and the port in order to minimize climate change impacts	0-5 years	Asset	**High**	**Yes**
3.2	Minimize the loss of temperature sensitive cargo	Determine the current processes for receiving and storing temperature sensitive cargo at the port. If necessary, develop new protocols for preventing spoilage.	It is unknown if the Port of Benicia processes any temperature sensitive cargo that may spoil if exposed to higher temperatures.	0-5 years	System	**Medium**	**Yes**
	Physical and Functional Vulnerability						
3.3	Ensure the use of heat resistant materials during routine maintenance	When conducting regular maintenance of paved surfaces, evaluate the potential life cycle costs of changing the pavement binder or the use of cool pavements.	The Port of Benicia has a significant paved area for storage of import cargo. Higher temperatures and extreme heat can cause these paved surfaces to deteriorate more quickly.	30+ years	System	**High**	**Yes**
3.4	Review equipment design to ensure operability during extreme temperatures	Review the operating temperature ranges for assets at the Port and replace assets, as necessary, at the end of their useful life with more resilient designs.	Structures made from metals, such as handling cranes and warehouses, are sensitive to temperature; increased temperature and more extreme heat events can necessitate design for higher maximum temperatures in replacement or new construction of these structures. Most cranes are designed for the normal range of temperatures encountered at sea world-wide (14°F to 95°F). However, cranes can be designed to withstand temperature extremes, such as up to +113°F.	5-30 years	System	**High**	**Yes**

Color Coding as follows: GREEN = Favorable; YELLOW = Moderate; RED = Unfavorable.

	Benicia: Temp. Adapt. Options (v5, 10/10/16).	Economy				Environment				Equity			Governance	
Ref #	Strategy Summary	Capital Costs/Upfront Costs (low, med, high)	Operating Costs/Ongoing Costs (low, med, high)	Avoided Damages (low, med, high)	Enhances Tax Base (yes, no)	Impacts on Wildlife Habitat, Rare Species, or Water Quality (positive, neutral, negative)	Reduce Water Use (positive, neutral, negative)	Air Quality Improvement Potential (positive, neutral, negative)	Reduce Energy Use (positive, natural, negative)	Protect Access to Jobs (positive, neutral, negative)	Protection of Vulnerable Populations (positive, neutral, negative)	Access to Green Space and Recreational Areas (positive, neutral, negative)	Political Decision-Maker Feasibility (low, med, high)	Opportunity for Community Involvement (low, med, high)
3	Port of Benicia													
	Informational Vulnerability													
3.1	Enhance accessibility and coordination of detailed infrastructure information for the Port of Benicia for vulnerability and risk assessments	Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low
3.2	Minimize the loss of temperature sensitive cargo	Low	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low
	Physical and Functional Vulnerability													
3.3	Ensure the use of heat resistant materials during routine maintenance	Medium	Low	Medium	No	Neutral	Neutral	Neutral	Positive	Neutral	Neutral	Neutral	High	Low
3.4	Review equipment design to ensure operability during extreme temperatures	Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	High	Low

Color Coding as follows: GREEN = Favorable; YELLOW = Moderate; RED = Unfavorable.

	Benicia: Temp. Adapt. Options (v5, 10/10/16).			Descriptive (not criteria)		General Criteria	
Ref #	**Strategy Summary**	**Detailed Adaptation Measures**	**Vulnerabilities Addressed**	**Time period for implementation (0-5 years, 5-30 years, 30+ years)**	**Scale (community, system, asset)**	**Level of Urgency (low, med, high)**	**Adaptable Over Time (yes, partially, no)**
4	**Natural Habitats**						
	Informational Vulnerability						
4.1	Develop a deeper understanding of the impact of changing temperatures on natural areas	Work with state and regional agencies to study the impacts of increased temperatures on natural vegetation health, invasive species, and local and migratory animals. Determine resilient species for restoration projects.	It is unknown how specific species will respond to changes in temperature and how that will change the overall health of the natural habitats.	5-30 years	Community	**Medium**	**Yes**
	Management Control Vulnerability						
4.2.1	Increase coordination and shared objectives among shoreline owners to facilitate planning and implementing improvements or changes to shorelines	Develop agreements among park managers and park landowners that articulate shared objectives, decision-making, and funding responsibilities for extreme heat event adaptation planning and response.		0-5 years	Community	**Medium**	**Yes**
4.2.2		Expand or form partnerships among agencies, organizations, and community members to facilitate decision-making regarding park improvements and new investments in light of extreme heat events.		5-30 years	System	**Medium**	**Yes**
	Physical and Functional Vulnerability						
4.3	Revise natural area practices to ensure biodiversity is retained under higher temperatures	Revise existing processes to focus acquisition, restoration and management of the City's natural areas inventory to ensure species of concern and overall biodiversity are retained, even with increasing heat events.	It is unknown how specific species will respond to changes in temperature and how that will change the overall health of the natural habitats.	30+ years	System	**High**	**Yes**
5	**Utilities**						
	Informational Vulnerability						
5.1	Continue conversations with PG&E on the location and condition of energy infrastructure that may be vulnerable	Continue conversations with PG&E regarding the location of infrastructure that may be vulnerable to extreme temperatures.	There is limited information on the location of utility infrastructure due to the sensitive nature of disclosing this information.	5-30 years	System	**High**	**Yes**
5.2	Encourage the CPUC to require that reserve margins are sufficient for future extreme temperature event demands	Encourage CPUC to revise peak load planning process to rely on projections of future temperatures rather than using historic temperature data, and to review established energy reserve margins to ensure they are sufficient for meeting future demands with higher summer temperatures.	Current energy reserves provide a buffer to ensure continuous availability of power; however, projections of need for energy reserves is based on historic temperatures and demand rather than future projections of temperature.	0-5 years	System	**Medium**	**Yes**
	Management Control Vulnerability						
5.3	Encourage PG&E to update energy assurance/resiliency plans	Encourage PG&E to review CalEPA guidance on integrating smart energy investments in energy and safety elements of energy assurance/resiliency plans, and hazard mitigation plans.	Current City plans do not discuss the potential impact of climate change on energy systems.	0-5 years	System	**High**	**Yes**

Color Coding as follows: GREEN = Favorable; YELLOW = Moderate; RED = Unfavorable.

	Benicia: Temp. Adapt. Options (v5, 10/10/16).	Economy				Environment				Equity			Governance	
Ref #	Strategy Summary	Capital Costs/Upfront Costs (low, med, high)	Operating Costs/Ongoing Costs (low, med, high)	Avoided Damages (low, med, high)	Enhances Tax Base (yes, no)	Impacts on Wildlife Habitat, Rare Species, or Water Quality (positive, neutral, negative)	Reduce Water Use (positive, neutral, negative)	Air Quality Improvement Potential (positive, neutral, negative)	Reduce Energy Use (positive, natural, negative)	Protect Access to Jobs (positive, neutral, negative)	Protection of Vulnerable Populations (positive, neutral, negative)	Access to Green Space and Recreational Areas (positive, neutral, negative)	Political Decision-Maker Feasibility (low, med, high)	Opportunity for Community Involvement (low, med, high)
4	Natural Habitats													
	Informational Vulnerability													
4.1	Develop a deeper understanding of the impact of changing temperatures on natural areas	Low	Low	Low	No	Positive	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	High	Medium
	Management Control Vulnerability													
4.2.1	Increase coordination and shared objectives among shoreline owners to facilitate planning and implementing improvements or changes to shorelines	Low	Low	Low	No	Positive	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	High	Low
4.2.2		Low	Low	Low	No	Positive	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	High	Low
	Physical and Functional Vulnerability													
4.3	Revise natural area practices to ensure biodiversity is retained under higher temperatures	Low	Low	Low	No	Positive	Neutral	Positive	Neutral	Neutral	Neutral	Positive	Medium	Medium
5	Utilities													
	Informational Vulnerability													
5.1	Continue conversations with PG&E on the location and condition of energy infrastructure that may be vulnerable	Low	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	High	Low
5.2	Encourage the CPUC to require that reserve margins are sufficient for future extreme temperature event demands	Low	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	High	Low
	Management Control Vulnerability													
5.3	Encourage PG&E to update energy assurance/resiliency plans	Low	Low	Low	No	Neutral	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	High	Low

Color Coding as follows: GREEN = Favorable; YELLOW = Moderate; RED = Unfavorable.

	Benicia: Temp. Adapt. Options (v5, 10/10/16).			Descriptive (not criteria)		General Criteria	
Ref #	**Strategy Summary**	**Detailed Adaptation Measures**	**Vulnerabilities Addressed**	**Time period for implementation (0-5 years, 5-30 years, 30+ years)**	**Scale (community, system, asset)**	**Level of Urgency (low, med, high)**	**Adaptable Over Time (yes, partially, no)**
	Physical and Functional Vulnerability						
5.4.1	Work with utilities to protect energy systems	Work with utilities and fuel providers to protect energy supplies (e.g., diesel for backup generators, propane, battery powered) to cooling centers and other essential services, wherever possible.	Thermal expansion of transmission and distribution power lines causes line sag, decreasing the amount of power that can be securely transported through lines. Older substations may be damaged by extreme high temperatures.	0-5 years	Community	**High**	**Yes**
5.4.2		Encourage PG&E to accelerate the installation of smart grid technology (e.g., Intelligent Switches) and substation upgrades that can reduce response time during power outages.		5-30 years	System	**Medium**	**Yes**
5.5.1	Reduce energy consumption during high heat events	Encourage PG&E/MCE to continue programs to mitigate peak demand and increase energy efficiency (e.g., PG&E's .Smart Rate, Peak Day Pricing, SmartAC)	Increased temperatures increase electricity demand, which can overburden the network. This can result in brownouts and rolling blackouts.	5-30 years	System	**High**	**Yes**
5.5.2		The City should continue to implement City sponsored energy efficiency programs. For example, the Business Resource Incentive Program and the Benicia Home Efficiency Program that can help businesses and residents conserve energy, upgrade to efficient equipment, and install proper insulation to prevent the need for excess use of air conditioning as temperatures rise.		0-5 years	Community	**High**	**Yes**
5.5.3		The City should continue to assist in advertising and promoting external energy efficiency programs. For example, BayREN, MCE and PG&E incentives, Energy Upgrade California, and PACE.		0-5 years	Community	**High**	**Yes**
	NOTES: **1. No specific vulnerabilities to extreme temperatures have been identified for stormwater, wastewater, or specific geographic regions.** **2. Color Coding as follows: GREEN = Favorable; YELLOW = Moderate; RED = Unfavorable.**						

	Benicia: Temp. Adapt. Options (v5, 10/10/16).	Economy				Environment				Equity			Governance	
Ref #	Strategy Summary	Capital Costs/Upfront Costs (low, med, high)	Operating Costs/Ongoing Costs (low, med, high)	Avoided Damages (low, med, high)	Enhances Tax Base (yes, no)	Impacts on Wildlife Habitat, Rare Species, or Water Quality (positive, neutral, negative)	Reduce Water Use (positive, neutral, negative)	Air Quality Improvement Potential (positive, neutral, negative)	Reduce Energy Use (positive, natural, negative)	Protect Access to Jobs (positive, neutral, negative)	Protection of Vulnerable Populations (positive, neutral, negative)	Access to Green Space and Recreational Areas (positive, neutral, negative)	Political Decision-Maker Feasibility (low, med, high)	Opportunity for Community Involvement (low, med, high)
	Physical and Functional Vulnerability													
5.4.1	Work with utilities to protect energy systems	Low	Low	Medium	No	Neutral	Neutral	Neutral	Neutral	Positive	Positive	Neutral	High	Low
5.4.2		Low	Low	Medium	No	Neutral	Positive	Positive	Positive	Neutral	Positive	Neutral	High	Low
5.5.1	Reduce energy consumption during high heat events	Low	Low	Low	No	Neutral	Positive	Positive	Positive	Neutral	Positive	Neutral	High	Low
5.5.2		Low	Medium	Medium	Yes	Neutral	Neutral	Positive	Positive	Neutral	Positive	Neutral	High	Medium
5.5.3		Low	Low	Medium	No	Neutral	Neutral	Positive	Positive	Neutral	Positive	Neutral	High	Medium
	NOTES: **1. No specific vulnerabilities to extreme temperatures have been identified for stormwater, wastewater, or specific**													

Color Coding as follows: GREEN = Favorable; YELLOW = Moderate; RED = Unfavorable.

Climate Change Adaptation Plan

Appendix C

UC Berkeley Legal Report

THE CITY OF BENICIA CALIFORNIA

APPENDIX C: UC BERKELEY LEGAL REPORT

TO: Alex Porteshawver; Steven Weissman

FROM: Subin Varghese; Cassy Havens

DATE: May 13, 2015

SUBJECT: Legal Research Regarding Benicia's Climate Change Adaptation Strategies

I. Introduction
II. Possible Legal Issues
   a. Public Trust Doctrine
   b. Landlord Obligations & Liability Issues (including Benicia Port)
   c. Takings
III. Analysis of Benicia Adaptation Strategies
   a. Assess primary legal issues triggered by implementing priority adaptation measures
IV. Conclusion

I. Introduction

The City of Benicia is proactively planning for possible sea level rise (SLR) and flooding impacts in the future. As part of this process, the City completed a Vulnerability Assessment and developed adaptation strategies that the City may implement to reduce projected risks to public infrastructure and private property within the city. The University of California, Berkeley School of Law was selected to assist the City with preliminary research and to identify potential legal issues associated with implementing priority strategies selected by City Department Heads. Below is an overview of those issues. Our analysis and recommendations are not legal advice and should not be construed as such; as law students, the primary interest in this project is to develop a base of information the City can build on as it moves forward with implementation of the Adaptation Plan. Finally, legal citations including pin cites were provided as time allowed; some of these citations may not be accurate.

II. Possible Legal Issues

A. Public Trust Doctrine

In the United States, lands covered by tide waters are owned and held in trust for the public by the respective states within which they are found.[2] "Tide waters" has a broad meaning, and also includes navigable waters not subject to tides, such as lakes, streams, and creeks.[3] The Supreme Court of the United States differentiated the title a state holds in lands and its title to soils under tide water: "It is a title held in trust for the people of the state, that they may enjoy the navigation of the waters, carry on commerce over them, and have liberty of fishing therein, freed from the obstruction or interference of private parties."[4] In recent years, the public trust doctrine has been expanded to include not only protection of navigable waters, by recreational activities.

The California Supreme Court identified public trust covers lands "lying between the lines of ordinary high and low tide, as well as that within a bay or harbor and permanently covered by its waters."[5] The public trust covers the entire beach from Oregon to Mexico, and the shores of "every bay, inlet, estuary, and navigable stream."[6]

A public easement and servitude exists over public trust lands for the purposes of navigation and fishery.[7] Additional uses covered by the public trust doctrine include "the right to fish, hunt, bathe, swim, to use for boating and general recreation purposes."[8]

<u>Grant of public trust lands to the City of Benicia</u>

The Benicia Arsenal (former military base) was deactivated in 1963 and the Defense Department transferred ownership to the City of Benicia in 1965; some of that land was eventually given to Benicia Industries, Inc. to develop the Industrial Park and operate the Port. Some historic sites in the Arsenal are still owned by the City (Clock Tower, Commanding Officer's Quarters, Camel Barns, and the future Industrial Park Bus Hub parcel). Beginning in 1964, the State of California granted the City of Benicia title and interest to public trust lands within the Arsenal's waterfront to be managed according to the terms of the grant and consistent with the public trust doctrine. The City is still

---

[2] *Illinois Cent. R. Co. v. State of Illinois*, 146 U.S. 387, 435 (1892).
[3] *See Id.* at 452.
[4] *Id.*
[5] *People ex inf. Webb v. California Fish Co.*, 166 Cal. 576, 584 (1913)
[6] *Id.* at 591.
[7] *Id.* at 584.
[8] *Marks v. Whitney*, 6 Cal.3d 251, 259 (1971)

responsible for ensuring the lands are used consistent with the public trust doctrine and reporting revenues generated from trust land uses to the State Lands Commission (SLC) on an annual basis.

Changes to Coastlines and Public Trust Lands

Coastlines and public trust property lines can be changed by different processes. Accretion is the "gradual addition to land of particles deposited by imperceptible degrees, and alluvion is the result of this process."[9] The accretion can occur due to natural or artificial causes. Avulsion occurs when a "river or stream, navigable or not navigable, carries away, by sudden violence, a considerable and distinguishable part of a bank, and bears it to the opposite bank, or to another part of the same bank."[10] Especially relevant to sea level rise is the process of erosion or submergence, which is "accretion in reverse."[11] The Supreme Court of the United States explained that the basic principle of property bordering a body of water is that "every proprietor whose land is thus bounded, is subject to loss, by the same means which may add to his territory and as he is without remedy for his loss, in this way, he cannot be held accountable for his gain."[12]

Accretion & Alluvion

Accretion, and the accumulation into alluvion, is not necessarily an issue that will come up as the sea level rises, since it deals with an increase in land by small degrees. In California, whether the accretion is natural or artificial determines who owns it. The general California rule for accretions is very simple: if the accretion is natural, the private landowners own it, and if it is artificial it belongs to the state.[13] However, the California rule narrowly construes what is meant by artificial.[14] Accretion is artificial if "directly caused by human activities in the immediate vicinity of the accreted land," such as from local dredging and construction of wing dams and levees.[15] Accretion is not considered artificial if the human activities occurred far away and long ago, such as accretion due to historic hydraulic mining.[16] The court also noted that historically, the presumption is to give ownership of accretions to the owner of the land adjoining, since these owners are "often losers by the breaking in of the sea, or at charges to keep it out" so this possible gain is "reciprocal consideration for such possible charge or loss."[17]

In *Lovelace*, the court held that the land in question formed from human activities, but since they occurred so long ago, and so far away, it could not be considered artificial accretion.[18] Both the state and private landowners claimed ownership over twelve acres that had formed between the Sacramento River and the landowners' property.[19] The only issue disputed by the parties was whether hydraulic mining operations at rivers connected to the Sacramento River back before 1884 constitutes artificial or natural accretions.[20] California developed its own separate artificial accretion rule, to

---

[9] Cal. Civ. Code § 1014
[10] Cal. Civ. Code § 1015.
[11] *Municipal Liquidators, Inc. v. Tench*, 153 So.2d 728, 730. (Fla. Dist. Ct. App. 1963).
[12] *Mayor, Aldermen and Inhabitants of City of New Orleans v. U.S.,* 35 U.S. 662, 717 (1836).
[13] *State of Cal. Ex rel. State Lands Com. v. Superior Court*, 11 Cal.4th 50, 56 (1995) ("*Lovelace*").
[14] *Id.*
[15] *Id.*
[16] *Id.*
[17] *Id.* at 65.
[18] *See* 11 Cal.4th at 77.
[19] *Id.* at 56-56.
[20] *Id.* at 57-58.

prevent granting away of a material portion of tidelands that may later be covered by artificial accretions from construction of a wharf or pier or breakwater.[21] However in this case, the artificial accretion exception to the common law rule does not cover human activities "far from the site of accretion," since the connection between the mining and the accretion miles downstream is "too attenuated."[22]

Since the accretion caused by mining activities several miles away and over a time period many years in the past was too attenuated to qualify as artificial accretion, any accretion that may be caused by climate change would likely not be considered artificial. In that case, any accretions would be considered natural and belong to the littoral landowners.

Avulsion

Avulsion may be relevant if increased storm intensity due to climate change causes sudden changes in the banks of rivers, streams, creeks, or straights. Where accretion deals with a slow, gradual increase in land by small degrees, avulsion occurs in a quick, sudden act. If a distinguishable part of a bank is carried away by a sudden act to another bank, the owner of the original bank may reclaim it within a year after the owner of the subsequent property takes possession of it.[23] This rule applies whether or not the river (or other water body) is navigable.[24]

In *Beach Colony II v. California Coastal Commission*, the court ruled that owners of lands which border on wetlands within the California Coastal Zone "may restore their property to its original contours after its lands have been violently torn or washed away."[25] It further held that encroaching waters which overflow to cover previously uncovered land due to the physical damage caused by the violent event, "do not automatically transform the lands encroached upon" into a wetland.[26]

Therefore, if increased storms or events of "sudden violence" cause considerable and distinguishable parts of a river or stream bank to move to a different bank, the original owner may have the right to reclaim it as long as it's done within a year of the subsequent owner taking possession of it. This may be an issue that applies to Benicia, since there are lands along the strait subject to avulsion.

Submergence & Erosion

What happens to privately owned land that is gradually submerged by rising water due to climate change? Unfortunately, case law is lacking and statutes do not specifically address this issue in California. Where the change is gradual and imperceptible, the rule is that the "boundaries shift with the shifting of the channel or shore."[27] Under the doctrine of submergence, title to land which is gradually submerged by the rise in water level reverts to the sovereign "in order to guarantee full public enjoyment of the watercourse."[28] Every property owner, whose land is bounded by water, is "subject to loss, by the same means which may add to his territory."[29] When a sea, lake, or navigable

---

[21] *See Id.* at 70.
[22] *Id.* at 77-78.
[23] Cal. Civ. Code § 1015.
[24] *Id.*
[25] 151 Cal. App. 3d 1107, 1109 (4th District 1984)
[26] *Id.*
[27] *Raglan v. Johnston Rock Co.*, 50 Cal. App. 2d 705, 708 (3rd District, 1942)
[28] *101 Ranch v. U.S.*, 905 F.2d 180, 183 (8th Cir. 1990).
[29] 35 U.S. at 717.

stream "gradually and imperceptibly encroaches upon the land" the owner loses the land and ownership returns to the state (or City or other trustee).[30]

In *Raglan*, the court found that when a stream is the boundary between properties it shifts along with gradual and imperceptible changes.[31] At issue in this matter was to determine what property owner should receive the value of gravel removed from their border creek.[32] Although the stream was non-navigable, and the boundary had been set in the middle of the stream in the property deeds, the stream in fact moved from season to season, and thus the boundary also moved.[33]

In *101 Ranch*, the court ruled that property owners next to a lake were subject to both the doctrine of submergence and reliction.[34] Under the doctrine of reliction, or accretion, the landowner gains title to lands "uncovered by gradual recession of the water."[35] Under the doctrine of submergence, title to land "which becomes submerged by the gradual rise in water level" reverts to the state.[36] Plaintiff's quitclaim deed, conveying rights to zones within the navigable waterway, really only conveyed "such rights as it was entitled to have as a riparian owner upon public waters," meaning the deed only transferred rights to lands not covered by water, since the state always retains title to submerged lands.[37]

In *Municipal Liquidators*, the Florida appellate court found that the loss of land was due to submergence and not avulsion due to the presumption of erosion or submergence and the inability of the landowner to meet its burden of proof for avulsion.[38] If the court had found the land was lost due to avulsion, the property owners could have re-established their old boundary lines out to the bulkhead in the bay. The law presumes, unless plaintiff can establish evidence to the contrary that changes to the land occurred by accretion or submergence, and not by a sudden, violent force.[39] The landowner who tries to claim land under the water has the "burden of showing that it caved off suddenly," by showing a sudden change, or by a preponderance of the evidence by showing that the "changes were violent and subject to being perceived" while they were happening.[40]

---

[30] 153 So.2d at 730.
[31] 50 Cal. App. 2d at 708.
[32] *Id.* at 707.
[33] *See Id.* at 708-09.
[34] 905 F.2d at 184.
[35] *Id.* at 183.
[36] *Id.*
[37] *See Id.* at 185.
[38] *See* 153 So.2d at 731.
[39] *See Id.*
[40] *Id.*

Below is a chart explaining four different cases dealing with different types of water bodies.

Case	Body of Water	Holding
City of New Orleans	River & Gulf	Property owner bordering body of water can gain land through accretion, and lose it by submergence, without remedy.
Raglan	Stream	Boundary of property fixed to stream moves when the stream moves.
101 Ranch	Lake	Even non-tidal bodies of water are subject to the public trust doctrine, and public trust land cannot be deeded away by private parties.
Municipal Liquidators	Bay	In the event of erosion or submergence land reverts to the State, erosion is presumed over avulsion, and the burden of proof is on the party alleging avulsion.

Given the general rules and principles established by the Supreme Court of the United States in City of New Orleans, property owners bounded by water may gain or lose land as a matter of course, and the principle from *101 Ranch*, land slowly covered/submerged due to sea level rise will likely transfer to the state.

B. Landlord Obligations & Liability Issues

A lease is "a conveyance of an estate in real property" and also a contract between the lessor and the lessee for the "possession and use of the property in consideration of rent."[41] There are two sets of rights and obligations: the first is based on the relation of landlord and tenant, and the second "comprising those growing out of the express stipulations of the lease."[42] The lessee has a "present possessory interest in the premises" and a right during the lease to the "full use and enjoyment of the leased property," limited by a restriction not to commit waste, and by the lease terms.[43] In addition, tenants are limited to remedies specified in the lease, and it is not assumed that the lessor will make repairs.[44]

<u>Duties, Obligations, and Liability Issues</u>

Landlords are often responsible for making repairs or taking preventative actions to allow tenants the full use of its land and could be subject to liability for failing to take those actions. However, according to the existing Master Lease between the City and AMPORTS (formerly known as Benicia Industries, Inc.), "assumes the obligations of repair and maintenance of the Premises and all structures or other improvements…."[45] AMPORTS must make repairs and improvements consistent

[41] *Avalon Pacific-Santa Ana, LLP v. HD Supply Repair & Remodel, LLC*, 192 Cal. App. 4th 1183, 1190 (4th District, 2011).
[42] *Id.*
[43] *Id.* at 1190-91.
[44] *Sheets v. Selden*, 74 U.S. 416, 417 (1868).
[45] Lease of Tide and Submerged Lands, p.5-6 (1965).

with the uses and conditions in the lease and in compliance with all laws, etc. including the public trust doctrine.[46]

Hazardous Materials

Disputes over responsibility for hazardous materials abatement between landlords and tenants of commercial properties require courts to construe relevant lease terms, and presume the intent of the parties to the agreement.[47] In addition to reviewing the agreement, the property owner has a duty to comply with all laws and orders, and as lessor, "remains subject to that duty unless it is assumed by the lessee."[48] There are two primary ways a lessee can assume this duty: by voluntarily putting the premises to different uses than those before the creation of his tenancy, or by negotiations between the parties to the lease.[49]

In *Brown*, the California Supreme Court held that the lessee had assumed responsibility for repairs according to a county order.[50] The parties entered into a long-term (15 year) lease and were both sophisticated business partners with substantial experience in leasing commercial property.[51] The following provisions led the Court to its decision:

1. A lease provision indicated that lessee should consult with a professional to evaluate the building's condition, especially to determine if there was asbestos or other hazardous materials present.[52]
2. The lessees were responsible for property taxes, liability insurance, and compliance with all applicable statutes and orders relating to the premises.[53]
3. A lease clause required the lessee to indemnify and hold harmless the lessor "against any claim arising from the use of the property" during the lease.[54]
4. The lessees agreed to a "virtually global" duty of repair, which combined with the other terms, strongly suggested that the parties intended to transfer almost all of the responsibilities of property ownership to the lessee.[55]

Port Lease – AMPORTS and City of Benicia

The City entered into a 66 year lease with Benicia Industries, Inc. (now AMPORTS). The lease is similar to the lease at issue in *Brown*. Like in *Brown*, where the court ruled the lessee was responsible for asbestos abatement due to the long-term nature of the lease (15 years), here the lease is even longer (66 years).[56] Also similar to *Brown*, AMPORTS has assumed all obligations to repair, maintain, and improve the property.[57] In addition, AMPORTS is also required to comply with applicable statutes and regulations and insure the property with liability insurance, just as in *Brown*.[58] Finally, similar to

---

[46] *Id.*
[47] *Brown v. Green*, 8 Cal.4th 812, 816 (1994).
[48] *Glenn R. Sewell Sheet Metal, Inc. v. Loverde*, 70 Cal.2d 666, 672 (1969).
[49] *Id.* at 672-74.
[50] *Id.* at 812.
[51] *Id.* at 817.
[52] *Id.* at 818.
[53] *Id.* at 819.
[54] *Id.* at 820.
[55] *Id.* at 826.
[56] See 8 Cal.4th at 819; Port Lease ¶ 2.
[57] See 8 Cal.4th at 826; Port Lease ¶ 6.
[58] *See* 8 Cal.4th at 819; Port Lease ¶¶ 6, 8.

Brown, AMPORTS also agreed to indemnify and save harmless the City against any and all claims of liability arising from the premises.[59]

Although *Brown* dealt with asbestos abatement via county order, the lease terms are similar and a court would likely assess the AMPORTS lease similar to how it did in *Brown*. A court would likely find that the parties intended to transfer all responsibilities of property ownership to the lessee for the term of the lease, and find the lessee responsible for any necessary adaptations required by law. In the context of sea level rise and flooding, AMPORTS would be responsible for any adaptations or actions required by law or regulation.[60]

D. Direct and Inverse Condemnation

State and local governments have the power, known as the right of "eminent domain," to take private property for public use. Both the United States Constitution and California Constitution place limits on this power. Under the Fifth Amendment to the U.S. Constitution, private property may not "be taken for public use, without just compensation."[61] The California Constitution similarly asserts the eminent domain power and limiting requirement that "just compensation" is paid to the owner.[62]

The process of utilizing the power of eminent domain and providing just compensation is known as "condemnation." When the government asserts eminent domain, it proactively engages in what is referred to as "direct condemnation" as opposed to "inverse condemnation." In a direct condemnation, the government condemns land and compensates the property owner for the value of the land. On the other hand, an inverse condemnation can result from a loss of property or the value of property, where the government had not initiated condemnation and compensation, e.g., was never asserting eminent domain or that it was taking land in the first place.

Three are generally two types of inverse condemnation: a "physical taking" resulting from an invasion or damage to property by the government,[63] and a "regulatory taking" resulting from a loss in value or use of property due to government regulations.[64] If the government requires land or money from a property owner to offset an impact of that property's use, e.g. an "exaction," it will constitute a taking if does not meets standards articulated by the U.S. Supreme Court. Physical takings, regulatory takings, and exactions are each discussed below in greater detail, as well as their relation to adaptation strategies.

<u>Inverse Condemnation by Physical Taking</u>

Inverse condemnation departs from the law of eminent domain when it deals with unintended physical damage to property; these cases are "based primarily on principles of tort and property law."[65] It is proper to impose liability in inverse condemnation for unintended physical damage when the damage follows from a public entity's "maintenance and use of a public

---

[59] *See* 8 Cal.4th at 820; Port Lease ¶ 9.
[60] See AB 691, State lands: granted trust lands: sea level rise. *Available online*: http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140AB691.
[61] US Const., Amend. V.
[62] Cal. Const., Art. I, §19.
[63] See, e.g, Loretto.
[64] See, e.g., Lucas [cite (total deprivation of economic use)]; Penn Central [cite (partial deprivation of economic use)].
[65] 202 Cal. App. 3d at 1165.

improvement" such as a flood wall.[66] If a public entity fails to construct or maintain the improvement properly, it is taking a calculated risk that damage to private property may occur.[67] If damage then results, it is proper to "require the entity that took this risk to bear the loss."[68] Public entities are also liable for damage caused to property owned by another public entity.[69]

Applicability to Climate Change Efforts

Actions taken by the City or state may result in liability for inverse condemnation actions if plaintiffs prove certain elements. There is also a question of whether the failure to make improvements on its own property may result in inverse condemnation liability to damage caused to other property owners. A standard of reasonableness is balanced with a proportional assessment of damages, limited to the amount of damage caused by its actions. California has specific rules and policies for inverse condemnation actions in the context of flood and water damages caused by a public entity.

1. General Inverse Condemnation, and Failure to Make Modifications

The plaintiff must prove that the defendant "substantially participated in the planning, approval, construction, or operation of a public project or improvement which proximately caused injury to plaintiff's property."[70] In inverse condemnation cases involving land subsidence onto adjacent property, "liability resulted from affirmative actions the entity undertook" as part of a project.[71]

In *Wildensten*, the court found the park district was not liable for inverse condemnation. The district merely owned undeveloped land and refused to stabilize it to prevent landslides onto an adjacent landowner's property.[72] The court also stated that mere ownership of raw land "which threatens adjoining private property with landslide" did not amount to "substantial participation" in a public project or improvement, and thus cannot form a basis for an inverse condemnation claim.[73] There was also no duty by the park district to correct potential hazardous conditions on its property, and in fact Government Code § 831.25 provides immunity to public agencies for tort damages to adjacent private property resulting from land failure if the "failure was caused by a natural condition of unimproved land."[74]

In practice, it is hard for plaintiffs to prove the elements required to win an inverse condemnation claim. Courts are extremely deferential to local governments and government actors. The City should continue to take all reasonable efforts to improve areas and build project utilizing the best available technical and engineering practices and information so that such efforts or projects do not fail and cause possibly liability.

---

[66] *Id.*
[67] *Id.*
[68] *Id.*
[69] *See Id.*
[70] Wildensten v. East Bay Regional Park Dist., 231 Cal. App. 3d 976, 979-80 (1st District, 1991).
[71] *Id.* at 980-81.
[72] 231 Cal. App. 3d at 979.
[73] *Id.* at 980.
[74] See *Id.* at 981-82.

2. Inverse Condemnation in Context of Flood Control Projects

Would the city be liable under the law of inverse condemnation if its flood control efforts fail and damage private property? When a public entity's design, construction, or maintenance of a flood control project poses an unreasonable risk of harm to property historically subject to flooding and causes substantial damage to it, the property owners may recover damages for inverse condemnation.[75] If the public entity acted unreasonably, the entity must reimburse damaged property owners for damage that is more than their "proper share to the public undertaking."[76] Several factors should be used in assessing public entity liability:

a. The overall public purpose being served by the improvement project;
b. The degree to which the plaintiff's loss is offset by reciprocal benefits;
c. The availability to the public entity of feasible alternatives with lower risks;
d. The severity of the plaintiff's damage in relation to risk-bearing capabilities;
e. The extent to which damage of the kind the plaintiff sustained is generally considered as a normal risk of land ownership; and
f. The degree to which similar damage is distributed at large over other beneficiaries of the project or is peculiar only to the plaintiff.[77]

In addition, the reasonableness rule described above also applies to cases where a public entity diverts and re-channels water under a flood control system of dikes and levees, which then fails in a severe rainstorm, causing damage to properties historically subject to flooding.[78]

In *Bunch*, the court ruled the water district was not liable for flood damage to plaintiff's property since its conduct in maintaining dikes and levees was not unreasonable.[79] The area where plaintiff owned property had been subject to flooding since before 1948, when a private developer first constructed flood control facilities along the alluvial plain.[80] The facilities failed during a major storm in 1976, and the water district undertook repairs and started a flood control study.[81] In 1979, the "most severe tropical storm in the recorded history of that region" caused floods that overtopped the dike and levee, causing damage to many cities in the area.[82] The court considered the water district's limited budget and allocation of funds as relevant evidence showing it was reasonable in its actions.[83] The trial court had also considered "substantial expert testimony as to the reasonableness of the district's flood control measures" and remedial action taken after the first major storm to cause damage.[84]

Recently, several cities near Chicago were sued by homeowners and insurance companies due to damage caused by flooding and storm surge. Most of the cases were settled, but one made it to the Appellate Division who issued an unpublished opinion affirming that the City of Chicago Heights was

---

[75] See Belair v. Riverside County Flood Control Dist., 47 Cal.3d 550, 564-67 (1988).
[76] *Id.* at 566.
[77] *Locklin v. City of Lafayette*, 7 Cal. 4th 327, 368-69 (1994).
[78] *Bunch v. Coachella Valley Water Dist.*, 15 Cal. 4th 432, 447 (1997).

[79] *Id.* at 436.
[80] *Id.* at 437.
[81] *Id.* at 437-38.
[82] *Id.* at 438.
[83] *Id.* at 451-52.
[84] *Id.* at 452.

not liable for damages caused by the flooding.[85] The city was shielded from liability under a state Tort Immunity Act,[86] which protects "local public entities and public employees from liability resulting from the operation of government."[87] Specifically, discretionary acts by public employees are immune from liability for injuries resulting from the act or omission in determining policy.[88] Additionally, the court found that the plaintiffs did not meet the burden of proof for showing res ipsa loquitur negligence on the part of the city.[89] The doctrine of res ipsa loquitur requires plaintiffs to show that the "(1) the occurrence is one that ordinarily does not occur in the absence of negligence; and (2) the defendant had exclusive control of the instrumentality that caused the injury."[90] Key to this court's decision was a section of the municipal code that placed the "responsibility for the installation, connection and maintenance of sewer lines that connect to the City's system upon the City's residents and business," eliminating the "exclusive control" argument.[91]

When planning flood control measures and projects, based on the development of case law, the reasonableness of the actions as well as the *Locklin* factors should be carefully considered. In addition, the City's municipal code regarding maintenance of sewer lines and connections should be reviewed to see if the language is in line with that in the City of Chicago Heights.

3. Construction of breakwater causing erosion damage

The City may consider the construction or expansion of a breakwater. A number of California cases have addressed erosion damage caused by the construction of a breakwater. Cases distinguish breakwaters constructed by private parties from those built by public entities. A littoral owner may build a groin/sea wall for protection, but only if the purpose of improving his or her property by causing a beach to form by accretion, does not cause injury to another owner.[92] A littoral owner has no similar right against a state or city exercising their power to improve tidelands in aid of navigation, even if the improvement just checks the flow of sand to the land.[93] Littoral owner has a right to uninterrupted flow of sand to his land by the ocean currents in their natural state against an individual, but not against the state.[94] "Littoral rights are always subordinate to the state's right to improve navigation."[95]

In *Katenkamp*, the court ruled that a private owner is allowed to combat the "common enemy" of the sea, but could not construct a wall or groin just to create a beach on its land if it damages another's property.[96] The defendant, who had a rocky shore, constructed walls/groins on its property so that sandy water would be carried onto its land from his neighbor's sandy beach.[97]

---

[85] Nichols v. City of Chicago Heights, 2015 IL App (1st) 122994-U.

[86] California has a similar statute, the Government Tort Claims Act, G.C. § 815.
[87] *Id.* at 11.
[88] *Id.*
[89] *Id.* at 15.
[90] *Id.*
[91] *See Id.* at 3.
[92] *Katenkamp v. Union Realty Co.*, 6 Cal.2d 765, 774 (1936).
[93] *Miramar Co. v. Santa Barbara*, 23 Cal.2d 170, 173 (1943).
[94] *Id.* at 173.
[95] *Id.* at 176.
[96] 6 Cal.2d at 774.
[97] *Id.* at 768.

In *Miramar*, the court ruled that erosion of plaintiff's beach did not constitute a taking or damaging of private property for public use.[98] The City of Santa Barbara had constructed a permanent breakwater 3 miles from plaintiff's land extending from the shore bank to "approximately 2,500 feet into the Pacific Ocean."[99] This construction blocked the natural flow of sandy water to plaintiff's beach, causing the sand to denude and the high tide line to advance.[100] Although plaintiff claimed the loss of sandy water led to the loss of its beach and ruined its business as a beach resort, (plaintiff claimed $750,000 in damages) the court found there was no taking or damage of private property for public use.[101] The court based its decision on the principle that the "littoral rights of an upland owner who owns no title to tide lands adjoining his property are subject to termination by whatever disposition of the tide lands the state chooses to make."[102]

As long as any breakwaters or sea walls are constructed for the purpose of controlling navigation or exercising other public trust rights, a court would likely not impose liability if private property were subsequently damaged as an incidental consequence. States have the right to improve their navigable waters.

Inverse Condemnation by Regulatory Taking

The second type of inverse condemnation is a regulatory taking. A regulatory taking can result from a government regulation, where the government had not initiated condemnation and compensation, but instead passed a regulation that resulted in a loss of the property or value of property. Generally, there are two types of regulatory takings: 1) a taking caused by a regulation that diminishes all economic value of property,[103] and 2) a taking caused by regulation that diminishes some use of property deemed to have gone "too far."[104]

Total Deprivation of Economic Use

Government action that completely deprives an owner of the economic use of property is considered a taking that requires just compensation under federal and state law. In *Lucas v. South Carolina Coastal Council*, the U.S. Supreme Court held that the total deprivation of a property's economic value is "the equivalent of a physical appropriation."[105] Two years after Lucas purchased land for $975,000 to build single-family homes, a South Carolina statute regulating coastal areas had the effect of preventing Lucas from building the homes. Key to the Court's reasoning that this action caused a total deprivation, was the finding that at the time the land was purchased, the land was zoned for residential use and no other regulations restricted this use. There was no question of the police power to enact the statute and limit development on the land, or the reasonableness of concluding that harm could be caused to the coast by construction in this area. Rather, the issue boiled down to the property rights associated with this parcel of land, including the pre-existing expectation and ability to build habitable dwellings. It was this property right that gave the land economic value before the South Carolina statute was enacted and which made the land essentially

[98] 23 Cal.2d at 176.
[99] *Id.* at 171, 176.
[100] *Id.*
[101] *See Id.* at 172, 176.
[102] *Id.* at 174.
[103] Cite Lucas
[104] *See generally Penn Coal* and *Penn Central*.
[105] Lucas v. S. Carolina Coastal Council, 505 U.S. 1003, 1017, (1992).

"valueless" after the act's passage. Causing the total loss of the property's value was equivalent to taking the property and required just compensation.

Considering potential adaptation strategies that could be implemented in Benicia, one takeaway is that coastal-zone construction bans as a climate change response may face similar legal barriers unless property owners are compensated for their economic losses. The *Lucas* rule suggests there is strategic value in approaching coastal regulations in a way that does not change property expectations, but instead falls within existing expectations and legal restrictions such as existing coastal permit requirements, exercise of its police powers consistent with the public trust doctrine or floodplain-related regulations. For example, the City could establish regulations related to FEMA floodplain maps and insurance requirements or identify parcels vulnerable to SLR and require certain modifications be made at the time of purchase, sale, or lease; it could also require that owners and lessees acknowledge the possible risk of SLR and coastal flooding. Possibilities might include floodplain-regulations based on maps or the distance of a property from the strait. The key is favoring strategies which link into restrictions already on or foreseeable on the land. The *Lucas* Court noted that a state "may resist compensation only if the logically antecedent inquiry into the nature of the owner's estate shows *the proscribed use interests were not part of his title to begin with*."[106] In the absence of laws that already limited development in flood-prone or SLR vulnerable areas, a total ban on construction would likely be a *Lucas*-type inverse condemnation by regulatory taking.

Partial Deprivation of Economic Use

Even if government action does not totally diminish the economic use of property, if it partially deprives property's economic use, it may still constitute an inverse condemnation taking if it goes "too far."[107] That rule, first articulated in 1922 by the U.S. Supreme Court in *Penn Coal*, was elaborated on in *Penn Central Transportation Company v. City of New York*. There, the Supreme Court held that a limitation on construction was not a regulatory taking because it did not interfere with the property's current use and did not entirely prohibit further development on the property.[108] At issue was the application of New York City's Landmarks Preservation Law, which restricted development of historic landmarks, to the Grand Central Terminal.[109] Penn Central Transportation Co., the owners of the Terminal, wanted to construct either a 53-story or 55-story building atop the Terminal.[110] Within its authority under the Landmarks Law, the Landmarks Commission denied both proposals.[111] The owners did not submit any other plans and instead filed a lawsuit claiming that the denials were a Fifth Amendment taking requiring just compensation.[112]

The Supreme Court reviewed its Fifth Amendment Takings case law, which, at its core, is "'designed to bar Government from forcing some people alone to bear public burdens which, in all fairness and justice, should be borne by the public as a whole.'"[113] Determining when a takings has occurred, the Court stated, has no "set formula" and "depends largely upon the particular

---

[106] Lucas (emphasis added)
[107] *Pennsylvania Coal Co. v. Mahon*, 260 U.S. 393, 415 (1922) ("The general rule at least is that while property may be regulated to a certain extent, if regulation goes too far it will be recognized as a taking.").
[108] *Penn Cent. Transp. Co. v. City of New York*, 438 U.S. 104, 138 (1978).
[109] *Id.* at 107.
[110] *Id.* at 116-17.
[111] *Id.* at 117.
[112] *Id.* at 118-19.
[113] *Id.* at 123 (quoting *Armstrong v. United States*, 364 U.S. 40, 49 (1960)).

circumstances" in each case.[114] Still, the Court identified "several factors that have particular significance": "[t]he economic impact of the regulation," interference with "investment-backed expectations," and "the character of the governmental action."[115] The Court undertakes this analysis by considering the "parcel as a whole" not the infringement of property rights in discrete segments.[116]

Applying this standard, the Court reasoned, first, that the NYC law did not "interfere in any way with the present uses of the Terminal," because it could continue to be used as it had for the past several decades.[117] Second, because the owners did not submit proposals for a smaller building, it could not be said that the law absolutely prevented construction above the Terminal.[118] Furthermore, the law did not entirely deny airspace development rights, because the owners were allowed to transfer their airspace building rights to other properties.[119]

Outside of adaptation strategies such as absolute development bans that might raise questions of a total deprivation of property value, most climate change responses are more likely to raise questions of whether they partially deprive property of economic use enough to constitute a taking, if they raise takings issues at all. While takings jurisprudence does not equate any diminution in property rights or value to a taking of property requiring just compensation, the ad hoc *Penn Central* test still leaves significant uncertainty as to what level or type of action amounts to a taking. Various researchers have begun to assess local government abilities to implement climate change adaptation strategies in the context of regulatory takings claims and suggest possible approaches. One strategy, advocated by Dartmouth Environmental Policy Professor Chad McGuire, is to avoid government action in its role as a regulator, and instead focus on its role as owner of public property or trustee of public property.[120]

There is value associated with governmental actions that go beyond traditional regulation, such as actions governments can take as property owners or trustees of public rights.[121] For example, in most states, the state government owns submerged coastal lands (the wet beach) up to a mean high tide line. Attempts by a private landowner with rights to the dry beach landward to protect her property by armoring it, e.g. building a sea wall to prevent the sea's encroachment due to sea level rise, could be seen as infringing the public ownership of land that would otherwise become submerged. Both parties would thus be in a context of competing property interests, and if the government sought to achieve policy that accommodated these interests, it would be acting in its role as a property owner, rather than as regulator, and arguably not be exposed to regulatory takings claims.[122] Similarly, under the public trust doctrine, states (or other trustees) have an obligation to protect public interests in the coastal zone. Actions toward that end are grounded in property law and thus arguably do not constitute a regulatory taking.[123]

For example, in *Stop the Beach Renourishment v. Florida Dept. of Environmental Protection*, the Supreme Court found that Florida's restoration of an eroded beach, which increased the distance

---

[114] *Id.* at 124 (internal quotations and citations omitted).
[115] *Id.*
[116] *Id.* at 130-31.
[117] *Id.* at 136.
[118] *Id.* at 137.
[119] *Id.*
[120] See McGuire, et al.
[121] *See Id.* at 163-66.
[122] *See Id.* at 164-65.
[123] *See Id.* at 165-66.

between a landowner's property and the water, did not amount to a taking, in part because the doctrine of avulsion permitted the state to reclaim the beach on behalf of the public.[124] The Court placed a particular emphasis on state common law and principles of property law, relying on its holding and reasoning in previous cases such as *Lucas*. Therefore, the City (or the State) could consider implementing adaptation strategies relying on its role as a property owner, protecting public access, natural resources, and implementing projects consistent with the public trust doctrine. In this way, the actions have a greater likely hood of withstanding regulatory takings challenges.

Exactions

As mentioned, both physical takings and regulatory takings can amount to an exaction if the government imposes conditions on a property to address adverse impacts of that development, such as traffic or infrastructure needs, if those government actions result in a physical taking of land, require something built on the property, or require an in lieu of impact fee. Courts will allow these actions only when a higher standard is met: there must be an "essential nexus" to the government's purpose and power[125] and the physical or monetary exaction must be in "rough proportionality" to the impact the government is alleging.[126]

In *Nollan v. California Coastal Commission*, the Coastal Commission approved a permit but required the developer to address adverse impacts of the proposed development by requiring a public easement on the landowner's property.[127] The Nollans wanted to demolish their current small residence on the property (used primarily as a rental property) and build a larger home (originally the residence was about 500 square feet and they wanted to expand it to a 3-bedroom house).[128] Alleged adverse impacts included blocking the ocean view and preventing the public from recognizing that the beach was nearby and accessible.[129] The U.S. Supreme Court found that preventing the construction of the house lacked an "essential nexus" to the alleged impact. If the issue was the public's view of the ocean, then reasonable conditions might have included height restrictions, a ban on fences, or requiring a viewing spot.[130] Instead, the Court noted, "the condition substituted for the prohibition utterly fails to further the end advanced as the justification for the prohibition."[131] Furthermore, "unless the permit condition serves the same governmental purpose as the development ban, the building restriction is not a valid regulation of land use but 'an out-and-out plan of extortion.'"[132]

In *Dolan v. City of Tigard*, reviewing the permit condition requiring the applicant to build a bike path, the U.S. Supreme Court held that there must be "rough proportionality" between what was being taken from the property owner and the impact of the project without the bike path.[133] In remanding the case, the Court did not require a precise mathematical calculation, but indicated that some sort of individualized determination is necessary.[134] There, the landowner applied for a permit to

---

[124] 560 U.S. at 702.
[125] *Nollan v. California Coastal Comm'n*, 483 U.S. 825, 837 (1987).
[126] *Dollan v. City of Tigard*, 512 U.S. 374, 391 (1994).
[127] Nollan 483 U.S. at 837.
[128] *Id.* at 828.
[129] *Id.*
[130] *Id.* at 837.
[131] *Id.*
[132] *Id.*
[133] Dolan v. City of Tigard, 512 U.S. 374, 391 (1994).
[134] *Id.*

redevelop her property, including doubling the size of her store and paving a parking lot.[135] Because the land was within the 100-year floodplain, and allegedly would cause more traffic, the city required the landowner to dedicate a portion of her land for a storm drainage system and an additional segment for a pedestrian/bike path.[136] While the Court found that the requirements met the *Nollan* essential nexus test, the city did "not met its burden of demonstrating that the additional number of vehicle and bicycle trips generated by petitioner's development reasonably relate to the city's requirement for a dedication of the pedestrian/bicycle pathway easement."[137]

In the context of adaptation strategies, it is important to recognize that exactions must meet the higher *Nollan/Dolan* essential nexus and rough proportionality standard in order to be permissible. However, the *Nollan/Dolan* test only applies to individual adjudicative permit approvals not to generally applicable legislative zoning decisions.[138] Therefore, these types of challenges may be avoided by developing generally applicable plans and policies, rather than relying on ad hoc permitting decisions. In addition, as discussed earlier, to the extent possible, a municipality can avoid regulating private property by taking adaptive measures on land it owns (such as trust lands). However, those strategies may be limited. When addressing climate change impacts requires regulating private property, broad policies reasonably regulating all property under a comprehensive scheme will likely prove more defensible than appropriating land or fees from individual landowners.

III. Analysis of Benicia Adaptation Strategies

The City of Benicia has conducted a vulnerability assessment and is developing an adaptation plan. Below are sixteen draft adaptation strategies proposed during the process, which were presented to our team for analysis since they were chosen as priority strategies for near-term implementation. The following analysis is not legal advice and shall not be construed as such; it is an academic analysis of potential legal issues the City could encounter when implementing adaptation strategies. This is also not meant to be an exhaustive analysis of potential legal issues and barriers. There are numerous other areas of law not discussed here that the City will have to address before moving forward.

<u>Revising zoning to limit development in areas that may be subject to flooding from sea level rise</u>

This action needs to be consistent with the General Plan. The City will also be held to the reasonableness standard established in *Euclid*. The City may also consider possible regulatory taking issues and its ability to pass regulations consistent with the public trust doctrine. The City of Benicia was granted "certain salt marsh, tide, and submerged lands" along the waterfront at the southwest line of "D" Street at the intersection between East Seventh and East Eighth Street. Some of the trust lands were leased to Benicia Industries, Inc. to create the Benicia Industrial Park and Port; the City still retains title to trust lands in the Marina. The current zoning map (April 2012) indicates that portions of this parcel are zoned open space, limited industrial, and water related industrial. The City could assess zoning restrictions and requirements currently in place and update those to reflect sea level rise vulnerabilities without relying on its role as trustee of public trust lands; however, as discussed earlier, legal challenges may be minimized by relying on the language in Chapter 1030 (Parcel A) granting the City certain trust lands. That chapter states:

> The city and its lessees shall use the land for "the establishment, improvement and conduct of a harbor, and for the construction, reconstruction, repair, maintenance, and operation of wharfs,

[135] *Id.* at 379.
[136] *Id.*
[137] *Id.* at 395.
[138] *Action Apartment Ass'n v. City of Santa Monica*, 166 Cal. App. 4th 456 (2008)

docks, piers, slips, quays, and other works, buildings, facilities, utilities, structures, and appliances incidental, necessary, or convenient for the promotion and accommodation of commerce and navigation."

These uses must be consistent with the protection, restoration, and enhancement of resources, balanced with other public trust uses (recreation, public access, commerce, navigation, and shipping) which will contribute to the long-term economic vitality of the Strait. If the City were to consider amending its code and requirements to address sea level rise, it may choose to cite its responsibility to protect and restore that area to preserve public access and navigation related economic uses. In addition, AB 691(State lands: granted trust lands: sea level rise) says that "addressing the impacts of sea level rise for all of its legislatively granted public trust lands shall be among the management priorities of a local trustee …" The bill would "require a local trustee whose gross public trust revenues average over $250,000 annually between January 1, 2009, and January 1, 2014, to prepare and submit to the commission, no later than July 1, 2019, except as provided, an assessment of how it proposes to address sea level rise. The bill would permit, but not require, a local trustee whose gross public trust revenues are $250,000 or less to prepare and submit to the commission an assessment." This bill provides additional support to the City if it were to move forward with modifying the zoning code to reflect sea level rise concerns since it is required by law to consider these impacts.

Recommendation: Conduct additional legal research on ability to modify zoning code; identify sections of code that can be updated.

<u>Use rolling easements to establish a boundary that moves inward as sea level rises along the shoreline</u>

The public trust doctrine governs lands covered by tide waters, and the state owns title to these lands. As indicated previously in this report, the state retains title to lands that become submerged gradually over time. There could be some issues with landowners who claim the change in sea level is due to avulsion, and not submergence, but in these cases the burden is on the landowner to prove there was a violent and perceptible change to the sea level. In cases where land is lost because it is inundated by water, the presumption is that it occurred through submergence. When a sea, lake, or navigable stream "gradually and imperceptibly encroaches upon the land" the owner loses the land and ownership returns to the state. In *Municipal Liquidators* and *101 Ranch* there were no claims by landowners that there had been a taking; the reasoning used in these cases, and the other public trust doctrine cases does not even acknowledge or mention the possibility that natural encroachment of water could result in a taking by the government.

Recommendation: This strategy requires more specific guidelines about when, and how these easements will be confirmed as sea level rises. The City would need to coordinate with other relevant offices and departments, such as the County Recorder, BCDC, and others to confirm the changes in boundary lines. In addition, any ordinance or amendment to the City's Zoning Code would need to be consistent with the Benicia Waterfront Special Area Plan and General Plan.

<u>Create a voluntary transfer of development rights program to allow property owners to sell development rights in high-risk areas in exchange for rights in low-risk areas</u>

There do not appear to be any legal issues implicated by this program since it would be a voluntary transfer of development rights from private property owners to the City. However, if the program worked to force developers to transfer their rights or forfeit them this may be considered a regulatory taking.

This strategy requires more specific guidelines and research about how this program would be implemented, and what prices would be charged for this development rights transfer. It may require regulations or ordinances to be enacted to allow the transfer of contracts and agreements already in place. If a similar program has been implemented elsewhere, that may be a good resource to consider; unfortunately none were readily available to compare.

Recommendation: Try to find a similar program elsewhere as a starting point, and see if there were any legal issues that came up after or during implementation.

Prioritize buyout of properties with certain land uses that are damaged or at high risk of damage from sea level rise or storm events

The City should consider whether this would be considered a taking. As long as compensation is made for the property lost, it would not be considered a taking.

The level of risk required to trigger these buyouts may be problematic to assign (does it have to be practically certain, or more than likely?) since it may prompt landowners with smaller risks to seek buyout of their property before the risk is substantial. It may be better to have clear, bright line rules in place about when properties are bought, and what valuation mechanism should be used, since a property that is already damaged may cost less money than one with future risk.

Recommendation: Research and compare policies in other cities that buyout damaged properties due to sea level rise or storm events.

Require facilities that generate, transport, and/or store hazardous materials to consider vulnerability and risks of sea level rise, storm events, and elevated groundwater in emergency plans, facility operations plans, and capital improvement plans

We do not foresee any legal issues related to the doctrinal areas we have discussed. Given that this would not take any property or reduce the economic use of land, it does not appear to be a takings issue. In a landlord-tenant relationship, the responsibility for handling hazardous material depends on the lease terms. That party would also be responsible for complying with all laws and regulations including any conditions imposed through existing permits.

Recommendation: Identify hazardous materials sites and reach out to property owners and identify ways to incorporate climate change risks into operational and capital improvement plans.

Develop and implement requirements for real estate agents and lessors of residential and commercial properties to disclose the risk of sea level rise

There may be some legal issues associated with existing real estate disclosure laws, but these issues were not researched as part of this project. There do not appear to be any legal issues for the City in enacting these requirements since they only work to provide informational disclosures to property owners and lessees. However, this may be politically difficult to move forward in Benicia due to perceived or actual property value losses. The City attempted to move forward with residential and commercial energy conservation ordinances (RECO/CECO) but they were stalled because of the mandatory reporting requirements. This measure will likely receive similar feedback.

Recommendation: Research real estate disclosure laws and contact local real estate agents for perspective on issues relating to "perceived" value of property. The City may choose to develop disclosure standards with other nearby jurisdictions to create consistency and a regional model.

Review and update standards, codes, and regulations for the construction and placement of new facilities and infrastructure to avoid or address sea level rise, and storm events

The City should consider whether the codes and regulations diminish the economic use of a landowner's property and amount to a taking. The city may consider regulating in a comprehensive "legislative" manner. Any new codes, standards, etc. would have to be consistent with State law and the City's General Plan.

Recommendation: Identify standards, codes, regulations that could be updated to reflect sea level rise and storm surge vulnerabilities and mechanisms to reduce that vulnerability.

Review existing municipal building code Provisions for Flood Hazard Reduction (Chapter 15.48) and ensure that waterproof materials be used in the construction of new infrastructure and in the repair or protection of existing infrastructure. Consider revising the code to stricter standards that account for potential sea level rise

The City could identify code sections to improve, specifically the provisions related to flood hazard reduction. The City would need to first consult with state law to determine its ability to pass more stringent local ordinances that require the use of certain materials that would prevent damage due to sea level rise. The state constitution (article 11, section 11) grants cities and counties the police power authority to protect the public health, safety and welfare. Pursuant to that authority, a city or county may regulate the use of property. They may regulate property for purposes such as abating nuisances, enforcing building and health codes, zoning and planning, and environmental protection. However, the City needs to make sure it does not go "too far" and diminish the use of the private property as if it physically took the land. The City would need to draft any new code or regulation so that the property could still be put to productive economic use and not lose its value. Also, any changes should not require the private property owner to provide a public benefit, e.g. protect a portion of the city from rising waters. Finally, the regulation must be imposed fairly and reasonably and not impose an unfair burden on the affected property owners; keep in mind that courts tend to apply the city's police powers very broadly and defer to the local government as it develops or updates its local codes.

Recommendation: Draft proposed language for stricter standards, review how it compares to the current municipal building code and what duty and obligation it imposes on construction projects and private property owners.

Prohibit below-grade habitable space in new development that will be exposed to sea level rise, storm events, and elevated groundwater

Prohibiting the use of property and development structures in this way could raise regulatory takings issues. This would require a look at the specific implementation of this strategy, and evaluating the *Penn Central* factors of the economic impact of the regulation, any investment-backed expectations, and the character of the government action. If a property owner had paid for a parcel of land with the expectation that using it for habitable space gave it certain value, it may more likely constitute a takings.[139] However, this must be balanced with the City's police powers and desire to protect public health and welfare as well as its statutory obligation to preserve and protect those public trust lands granted to it.

[139] See Lucas.

Recommendation: Draft proposed language for new standards, review how it compares to the current municipal building code and what duty and obligation it imposes on construction projects and private property owners.

Develop and enforce policies for repair and reconstruction to eliminate below-grade habitable space that is vulnerable to sea level rise.

The City could require certain repair or renovation of properties located within areas vulnerable to sea level rise at certain planning thresholds, e.g. 2030, 2050, and 2100. These could be standalone requirements (zoning) are triggered by minor or major renovations as defined by the City in its building code and consistent with the state building code as well as the City's authority. The City would need to assess its legal and regulatory authority to change the building code and identify potential takings issues.

Recommendation: Draft proposed language for stricter standards, review how it compares to the current building code and what duty and obligation it imposes on construction projects and private property owners.

Consider the feasibility of using dredged material from the Port of Benicia shipping channel for local levees and sea walls

Any beneficial reuse of dredged materials must first be consistent with the public trust doctrine since the local dredged material would like be connected to public trust lands either owned by the City or the State. Second, BCDC regulates filling, dredging, and changes in use in the San Francisco Bay and reusing dredged materials would require a permit from BCDC (possibly also from the Army Corps of Engineers) and the City (per the Benicia Special Area Plan, adopted May 1977). Permits should be issued by the City only on the basis of specific findings that the work and uses are consistent with the zoning and the City's General Plan, as amended by the Special Area Plan. Permits should be issued by the Bay Commission only on the basis of specific findings that the work and uses are consistent with the Bay Plan (as amended by the Special Area Plan), the McAteer-Petris Act, and the public trust. If the Port of Benicia wanted to reuse its dredged materials locally for levees, sea walls, or other protection, it would have to go through the Joint Aquatic Resources Permit Application (JARPA) process. JARPA is a permit application form that consolidates federal, state, and local permits and simplifies the permit process for applicants proposing construction, fill placement, public access impingement, and other development activities in or near aquatic environments and wetlands in the San Francisco Bay Area. The dredged material would also likely need to be tested to determine if it was acceptable to use as fill.

Recommendation: Consult with AMPORTS, BCDC, and the Army Corps of Engineers early in project development to assess feasibility of moving forward with this type of beneficial reuse.

Investigate and pursue alternative funding mechanisms for improvements to stormwater infrastructure, e.g., taxes, fee-based mechanism, assessment districts, or leveraging private sector resources

The City would need to conduct a comprehensive financial assessment and determine the best options for funding improvements that allow it to better deal with storm surge and flooding. Some options may include:

1. Improvement District,
2. Bond issuances,

3. Mello-Roos Tax Districts or other special district financing options,

4. Corporate sponsorships and financing agreements, and

5. Grants

Recommendation: Review financing options and proposed improvements and determine best option for financing upgrades.

Avoid new development and substantial redevelopments that will require expanding the capacity of utilities and infrastructure in areas at risk

More specificity is needed on how the developments would be avoided. Legal barriers are likely to be avoided if this is achieved through comprehensive plans such as general plan amendments or zoning code changes. If a particular development is planned in an at risk area, the city may require an impact fee or plan modification to protect the project against potential sea level rise or storm surge risks.

Recommendation: Identify vacant parcels or potential redevelopment areas that are currently or will be susceptible to flooding and sea level rise. Identify potential zoning code changes needed or permit conditions to protect existing and new development.

Identify opportunities to locate and relocate infrastructure and impervious areas away from Sulphur Springs and expand the natural floodplain

This will require coordination with many different local and state agencies and property owners including the State Lands Commission, BCDC, the City, RWQCB, and AMPORTS. BCDC regulates filling, dredging, and changes in use in San Francisco Bay and requires that maximum feasible public access for shoreline development projects within 100 feet of the mean high tide line. The creek is coastally connected and floods during high tide events. If any of the involved parties proposed dredging the creek to reduce flooding impacts on nearby privately owned parcels in the industrial park, BCDC would need to issue a permit and the applicant would have to go through the JARPA process.

In addition, if the City or other permit applicant, e.g. AMPORTS proposed to expand the floodplain to adjacent land, it would have to identify if it would amount to direct condemnation requiring the City to compensate those land owners or other permit applicant to enter into an agreement with those landowners. If private land is lost by the natural, imperceptible expansion of the floodplain due to sea level rise, courts would likely find this is covered by submergence, and title to the land would revert to the state as discussed above.

Recommendation: Determine the level of expansion of the floodplain, the rate at which land was lost and specific infrastructure for relocation.

Review and incorporate changes as appropriate, to regulations, codes and industry practices for buildings, land use and design elements to identify opportunities to accelerate the adoption of cooling strategies for both indoor and outdoor environments, such as updating green building codes, energy efficiency standards, indoor air quality improvements, and land-use cooling strategies (reducing urban heat island effect)

Municipal building codes must be consistent with the state unless findings are made about local conditions that allow for deviation. They should be drafted so that implementation does not result in diminished economic use of property. If regulations or codes go so far as causing a partial deprivation

of a property's economic use, there could be a *Penn Central*-type regulatory takings issue. This would be a case-by-case specific determination.

Recommendation: Review existing building codes and ordinances and determine if they can be updated or if new ordinances need to be (or could be) passed to facilitate these improvements.

Removing marshes (or parts of marshes) to harden the shoreline (by building a levee or seawall), e.g. reducing the size of marshes/wetlands in order to build hardened shoreline protection features

Adaptation strategies fall in several categories including protect, retreat, accommodate, and hybrid approaches. Hardened shoreline protection falls under the protect category, but is often seen as a last resort. If this option is pursued, the protection must be integrated with natural features that enhance the Bay ecosystem, e.g. including additional marsh or wetlands in the project design (BCDC Sea Level Rise Policies Fact Sheet). If possible, any hardened shoreline protection should avoid removal of existing wetlands, marshes, and other natural areas when possible. These protections must also be designed to maintain public access to natural resources and the coast. If this type of project were pursued by the City or other private landowner, the developer would need to obtain all necessary permits from the City and BCDC among others. The project, depending on its location, would have to be consistent with the Benicia Special Area Plan, General Plan, and with the McAteer-Petris Act of 1965. Depending on where the proposed sea wall, levee, etc. is located, the City will have to assess whether building a structure amounts to "taking" of any nearby property or economic value. Specific development agreements may also have to be negotiated and environmental review may also have to be completed and the impacts to nearby natural resources and habitats will have to be addressed.

Recommendation: Identify areas where hardened shoreline protection is the preferred approach to protect key city assets and facilities from seal level rise and flooding. Identify if those areas are connected to existing marshes or wetlands and identify if public access will be impacted. Develop alternate strategies if needed and consult with regulatory agencies, e.g. BCDC, early in project development.

IV. Conclusion

This memo has outlined a range of potential issues the City may choose to consider as it moves forward with implementation of the Adaptation Plan. Further research and legal analysis is needed, but the information can assist the City in developing appropriate methods to increase resiliency and help resident and business prepare for SLR and flooding impacts.

Climate Change Adaptation Plan

Appendix D

AMPORTS Energy Efficiency/ Renewable Energy Case Study

THE CITY OF BENICIA CALIFORNIA

APPENDIX D: AMPORTS ENERGY EFFICIENCY/ RENEWABLE ENERGY CASE STUDY

As part of the larger effort to assess site-specific vulnerabilities, risks, and mitigation/adaptation opportunities, AMPORTS participated in Benicia's Business Resource Incentive Program (BRIP), a comprehensive sustainability program that provides no-cost assessments, resource conserving recommendations, and funding (grants and loans) to make those upgrades at businesses in the city's industrial park. Carbon Lighthouse, a consultant assisting the City to implement BRIP, completed a preliminary energy efficiency and solar feasibility analysis at the AMPORTS facility. The analysis included a complete site walkthrough and interviews with facility staff to identify, evaluate, and estimate the costs and benefits of a potential energy project for AMPORTS.

Carbon Lighthouse identified three project opportunities as follows:

Project Opportunity	Project Cost	IRR	Payback (years)	Lifetime Savings*	CO_2 savings (tons/year)
Lighting	$105,000	21%	4.7	$329,000	37
Solar	$2,812,000	9.9%		$10,196,000	314
Combined Project	$2,917,000	9.9%		$10,525,000	351

*Indicates an annual utility cost increase of 5.2%

PROJECT OVERVIEW

Below is an overview of Carbon Lighthouse's findings and recommended upgrades.

Lighting

Upgrade opportunities were identified for the parking lot light pole fixtures and building exterior lighting. Additionally, cost and maintenance improvements were identified for the ballasts used for interior fluorescent lighting at buildings. The AMPORTS facility uses mostly T8 fluorescent lighting controlled by motion sensors in its building interiors. AMPORTS staff indicated that maintenance for these lamps is an issue because of premature lamp burnout caused by frequent on/off switching. The facility also uses high wattage metal halide lamps in the parking lots.

Proposed upgrades include: changing T8 lighting ballasts to instant start ballasts and upgrading parking lot lights to high output LEDs.

Solar

Installing a solar photovoltaic (PV) system will reduce energy consumption and greenhouse gas emissions. Carbon Lighthouse determined that it was not feasible to add solar PV arrays to the building roofs due to the roofs' age and construction; however, there is an opportunity to add

ground-mounted solar PV to the vacant parking lot adjacent to 700 Bayshore Road.[140] The solar analysis was conducted assuming an estimated blended[141] utility rate of $0.17/kWh. Local incentives and tax credits as well as the cost of improving the distribution infrastructure to allow for utility interconnection to the sites were also included in the analysis. Financial returns will vary greatly depending on AMPORTS's ability to monetize tax benefits and the decision to opt in or out of utility (Pacific Gas & Electric or Marin Clean Energy) incentive programs.

Proposed solar project includes: installing a 592 kW array on the vacant parking lot adjacent to 700 Bayshore Road.

Combined

Carbon Lighthouse also evaluated a combined lighting and solar project (same project scopes as listed above). Combining the lighting and solar project would reduce the payback to 9.2 years from 9.9 years (stand-alone solar project) because the annual energy cost savings attributed to lighting upgrades are bundled with savings achieved by using solar versus grid energy.

AMPORTS Feedback

After reviewing the Preliminary Energy Assessment prepared by Carbon Lighthouse, AMPORTS indicated the lighting project looks viable, and wants to pursue it further. The high upfront cost ($2.8M) for the solar PV system and combined project ($2.9M) present a bigger challenge. General Manager Randy Scott indicated that even if AMPORTS could identify financing through the City's BRIP or PACE programs or through another financial institution, it may be difficult to get board approval for these projects. Mr. Scott did forward the initial assessment with detailed financial analysis to AMPORTS's engineers for further analysis and to discuss if internal support is possible to move forward with the project.

[140] City staff recommends that this project be evaluated in conjunction with the feasibility study for the recycled water project and the prospective Bay Trail/Ridge Trail/Delta Trail alignment. This will ensure a consistent waterfront planning effort.

[141] Blended utility rate reflects the average price per kWh based on AMPORTS's rate schedule and use.

Figure D-1: Proposed 592 kW solar array

AMPORTS CLEAN ENERGY FEASIBILITY STUDY SUMMARY

In addition to completing the Business Resource Incentive Program (BRIP) assessment with Carbon Lighthouse (discussed above), AMPORTS agreed to work with OpTerra Energy Service to explore the possibility of a clean energy project.

Process Overview

OpTerra and City Staff met with AMPORTS at its administrative offices and discussed opportunities for the installation of solar photovoltaic (PV) systems on AMPORTS property as well as some energy efficiency upgrades to Port equipment. After initial discussions, the group toured a variety of potential locations owned by AMPORTS with ample space for the development of solar. When evaluation the sites, OpTerra considered the following factors:

- Proximity to potential electrical infrastructure tie-in locations
- Robustness of existing electrical infrastructure
- Location of existing utility easements and transportation (freeway) corridors
- Acreage of potential sites and adjacency to additional potential sites
- Slope and aspect of potential sites
- Accessibility of potential sites
- Potential for existence of abandoned military ordinance on potential sites.

After completing the site visit, OpTerra modeled various solar layouts and presented this information to Randy Scott. OpTerra was required to sign a non-disclosure agreement (NDA) with AMPORTS due to the sensitive nature of some of the parcels under consideration. AMPORTS also authorized PG&E to send Port-wide consumption and billing data to OpTerra so they could assess all opportunities to improve efficiency and increase renewable energy generation.

After analyzing the PG&E data and assessing available solar sites, OpTerra met with Mr. Scott to discuss potential opportunities and presented the following:

- A rough schematic of a solar PV layout at one potential site
- A rough order-of-magnitude financial pro forma
- An overview of potential funding mechanisms
- Potential next steps

OpTerra also explained a discrepancy in the PG&E data, which will delay the full-analysis (the annual PG&E expenditure as indicated by Mr. Scott exceeds the cumulative bill amounts provided by the utility). OpTerra will need to follow-up with PG&E to clarify this discrepancy.

Next Steps

AMPORTS and OpTerra agreed that it may be possible to move forward with a design-build clean energy project. OpTerra plans to draft a contract for AMPORT's review and determine cost and appropriate financing mechanism(s), which may include a BRIP grant or loan, on-bill financing, PACE, or other private funding.

Climate Change Adaptation Plan

Appendix E

Vulnerability Assessment

THE CITY OF BENICIA CALIFORNIA

Benicia Climate Change Vulnerability and Adaptation Plan

Vulnerability Assessment

Prepared for:

The City of Benicia

Prepared by:

With Contributions from:

PlaceWorks

Moffat & Nichol

Date: April 2015

Table of Contents

1 Introduction 1

1.1 Project Background 1

1.2 Project Scope 2

General Project Approach 2

Project Area 4

1.3 Sectors for Study: Assets and Areas 6

1.4 Overview of This Report 7

2 Introduction to Vulnerability 10

2.1 Exposure 10

2.2 Sensitivity 11

2.3 Adaptive Capacity 12

2.4 Moving Beyond Vulnerability to Risk 13

Uncertainty 13

Consequence 14

3 Overview of Existing Conditions and Current Hazards 15

3.1 Earthquake 15

3.2 Wildfires 16

3.3 Flooding/Storm Surge 16

3.4 Temperature 16

3.5 Drought 17

4 Overview of Future Climate Change Hazards 17

4.1 Extreme Temperature 18

4.2 Sea Level Rise and Storm Surge 18

5 Vulnerability Assessment Approach 23

5.1 Exposure -- Quantitative Analysis 23

5.2 Sensitivity and Adaptive Capacity -- Qualitative Assessment 23

Definition of Sensitivity and Adaptive Capacity 24

6 Key Sector Level Vulnerabilities 25

6.1 Community Facilities and Services 25

Extreme Temperature 27

Sea Level Rise/Storm Surge 30

6.2 Transportation 34

Extreme Temperature 36
Sea Level Rise/Storm Surge 37
6.3 Port of Benicia 39
Extreme Temperature 40
Sea Level Rise/Storm Surge 41
6.4 Wastewater 43
Extreme Temperature 45
Sea Level Rise/Storm Surge 45
6.5 Stormwater 48
Extreme Temperature 49
Sea Level Rise/Storm Surge 49
6.6 Natural Areas/Shoreline Protection 51
Extreme Temperature 52
Sea Level Rise/Storm Surge 52
6.7 Energy and Pipeline Infrastructure 63
Extreme Temperature 64
Sea Level Rise and Storm Surge 66
7 Next Steps 68
Attachment A: Individual Asset Profile Sheets 69
Benicia Wastewater Treatment Plant 69
Turnbull Park 72
Portside Village Townhomes 74
Port of Benicia 77
Downtown Commercial Area 79
Benicia Industrial Park 81
Police Station 83
Fire Station 84
Benicia Community Center 85
City Hall 87
Fitzgerald Field 89
Benicia Marina Harbor 90
Transportation Assets 92
Stormwater Outfalls 94

Benicia State Recreation Area 96
Liberty High School 98
Attachment B: Vulnerability and Risk Survey 100

Table of Tables

Table 1: Select Community Assets and Areas for Vulnerability Assessment 7
Table 2: Range of Projected Changes in Temperature 18
Table 3: Community Services and Facilities Key Vulnerabilities 26
Table 4: Community Facilities and Services Exposure to Sea Level Rise based Flooding 30
Table 5: Project Area Exposure to Sea Level Rise 31
Table 6: Transportation Key Vulnerabilities 36
Table 7: Transportation Exposure to Sea Level Rise 38
Table 8: Port of Benicia Key Vulnerabilities 40
Table 9: Key Wastewater Treatment Plant Vulnerabilities 44
Table 10: Stormwater System Key Vulnerabilities 48
Table 11: Natural Areas and Shoreline Protection Key Vulnerabilities 51
Table 12: Energy Infrastructure Key Vulnerabilities 64
Table 13: 2012 Cost per Outage Event Estimates by Region and Customer 67

Table of Figures

Figure 1: Adapting to Rising Tides Planning Process 2
Figure 2: Project Area Map 5
Figure 3: Combining the Elements of Vulnerability. 10
Figure 4: 24 Inch Total Water Level 21
Figure 5: 60 Inch Total Water Level 22
Figure 6: WWTP Flooding under 60 Inch Total Water Level 45
Figure 7: Current Benicia State Park Marsh Conditions 54
Figure 8: Benicia State Park in 2050 55
Figure 9: Benicia State Park in 2100 56
Figure 10: Benicia Industrial Park Current Marsh Conditions 57
Figure 11: Benicia Industrial Area in 2050 58
Figure 12: Benicia Industrial Area in 2100 59
Figure 13: Benicia Marina Current Marsh Conditions 60
Figure 14: Benicia Marina in 2050 61
Figure 15: Benicia Marina in 2100 62

1 Introduction

1.1 Project Background

The City of Benicia is a waterfront community in the San Francisco Bay Area. As one of California's early capitals, it is full of history--home to the first West Coast U.S. Army post, a railroad car ferry, and numerous other historic sites. Today, Benicia is home to a thriving arts community, beautiful weather and scenic vistas, and a downtown full of charming boutiques and antique shops.

In order to maintain its high quality of life, prosperous businesses, productive ecosystems, and vibrant neighborhoods, Benicia is proactively planning for the challenges that a changing climate may bring. To do so, Benicia is conducting a Climate Change Vulnerability Assessment and creating an Adaptation Plan that will identify adaptation measures that are sustainable, equitable, economically viable, cost effective, and where feasible, able to be integrated into existing and future City plans. This plan will help Benicia prepare for and become a more resilient city that can manage the risks of today, as well as those of tomorrow.

Building on the ART Project

The City of Benicia project is modeled after the San Francisco Bay Conservation and Development Commission's (BCDC) Adapting to Rising Tides (ART) project. During the ART project, BCDC, with support from the National Oceanic and Atmospheric Administration Coastal Services Center (NOAA CSC), undertook a detailed sea level rise vulnerability assessment project in Alameda County.

The ART project developed and piloted a process for conducting vulnerability assessments by bringing together a broad suite of stakeholders and experts to collectively gain a better understanding of how climate change will affect the ecosystems, infrastructure, and economy of Alameda County.

The City of Benicia is using the tools and framework developed for the ART project as much as feasible. Due to the differing scales of analysis (city vs. region) and project timeline, the tools have been customized for a local planning effort.

For more information on the ART project, please see http://www.adaptingtorisingtides.org/.

This document provides an overview of the vulnerability assessment findings and builds on the prior Existing Conditions Report. Adaptation strategies will be explained in a subsequent report.

This work is funded through the California Coastal Conservancy's Climate Ready Grant Program (Round 1). The grant program seeks to help California's coastal communities act now to prepare for climate change effects. The City of Benicia is using its grant to build upon prior and ongoing sustainability efforts within the City, such as Climate Action Plan (CAP) implementation. The City is committed to reducing greenhouse gas (GHG) emissions by implementing CAP strategies such as increasing renewable energy and making City facilities more efficient. Now, the City is examining ways to prepare for a future climate that is different from that of today.

1.2 Project Scope

General Project Approach

This project is following the Adapting to Rising Tides Planning Process (see Figure 1) developed by the Bay Conservation Development Commission (BCDC), and includes the following phases:

Figure 1: Adapting to Rising Tides Planning Process, http://www.adaptingtorisingtides.org/wp-content/uploads/2012/09/CH-1-Intro.pdf

- **Scope and Organize (completed).** The scoping process was completed in September 2014, and included three primary activities.

  First, two Advisory Groups were convened to provide input throughout the project. The Technical Advisory Committee (TAC) consists of local, regional, and state public agencies that own, operate, or otherwise contribute to the planning and funding of infrastructure in Benicia. The Community Advisory Group (CAG) consists of members of the public with a vested interest in the project (e.g., homeowners, business owners, community group representatives, and City commissioners). The project team held two kick-off meetings, each 3 hours long with the TAC and CAG. Both groups learned about project objectives, identified existing conditions, and helped brainstorm project goals. The TAC provided more technical information related to existing assets and infrastructure, e.g. Pacific Gas & Electric Company discussed its critical infrastructure in the project area.

Benicia Climate Adaptation Goals

These goals were developed with input from the Advisory Groups. They currently serve as aspirational goals, the implementation of which will extend beyond the life of this project.

1. Protect the beauty and functionality of the many assets that support Benicia's high quality of life, including historic districts and buildings, the shoreline, wetlands, marshes and shoreline recreational features.
2. Support all of Benicia's residents and businesses where they live and work in the face of climate change vulnerability, and help them to plan for and recover quickly from climate-related emergencies.
3. Incorporate planning for climate change, vulnerability and adaptation in all City functions, including planning, public works, parks and recreation, and emergency preparedness.
4. Revise local land use plans, development regulations and building codes to aid and protect future development projects in the face of climate change.
5. Serve as a regional leader and model in planning for climate change and adaptation, and cooperate with regional agencies and neighboring jurisdictions in planning for regional readiness and resilience.
6. Educate the public on the need for personal disaster preparedness, adaptation and investment in resilient infrastructure.
7. Use public art to illustrate issues and educate the public regarding climate change, vulnerability and adaptation.

Second, Benicia climate change projections were created using downscaled (i.e., a strategy for generating locally relevant data from global climate models) climate change from publicly accessible data sets and tools. Climate scenarios were developed for sea level rise and storm surge (total water levels), precipitation, and changing temperatures. Based on the severity of the climate change variables, sea level rise and extreme temperatures were selected for evaluation in the vulnerability assessment. A summary is contained in Section 4 of this report, and a more detailed overview is included in the separate Task 2 Summary Report.

Third, the TAC and CAG provided input on the selection of community assets and geographic areas for analysis in this study. The project team selected a diverse range of assets to 1) cover different types of infrastructure and community assets found within the Project Area, and 2) to serve as representative assets that can provide insight on other vulnerable assets within the Project Area that were not selected for further analysis (e.g., not *all* roads were assessed, only select roads in key locations). A summary of the assets can be found in Section 1.3.

- **Assess (completed).** The City of Benicia is already vulnerable to current hazards such as flooding, earthquakes, and wildfires. It is important to understand how infrastructure has been affected in the past and how asset managers might deal with the same or exacerbated future events. A summary of this information is contained in Section 3 of this report, and a more detailed overview is included in the Existing Conditions and Stressors Report completed previously for this project.

- **Define (subject of this report)**. This report discusses how sea level rise, storm surge, and changes in temperature will impact Benicia. It discusses potential vulnerabilities in the following sectors: Community Facilities and Services, Transportation, Port of Benicia, Wastewater, Stormwater, Natural Areas/Shoreline Protection, and Energy and Pipeline Infrastructure.

- **Plan (to be completed by June 2015).** The next step after this report is to develop adaptation strategies that could increase the City of Benicia's resilience to sea level rise, storm surge, and extreme temperatures. These options will undergo a qualitative evaluation to determine their impacts on economy, the environment, social equity, and a high-level benefit-cost assessment to determine priority actions. The top adaptation strategies will be documented in a report that will include opportunities to integrate them into existing City plans.

- **Implement and Monitor (following this project)**. Although outside the scope of this project, implementing and monitoring climate change and adaptation strategies will be vital steps in the climate change resiliency process. The City of Benicia Adaptation Plan will include a monitoring plan to help the City advance this work.

Project Area

The City of Benicia is located on the north bank of the Carquinez Strait and the north side of Suisun Bay in Solano County. The Project Area is located along the City's shoreline, extending from the Benicia State Park in the west to the City's eastern extent, just past the east end of the Benicia Industrial Park (see Figure 1). The Project Area near the shoreline is relatively flat and then slopes upward in general as one proceeds further from the shoreline. The Project Area has a strong and relatively persistent breeze. The shoreline area encompasses a variety of land uses, including natural areas (e.g., marshes, wetlands, parks, beaches), park areas (some of which contain natural habitats), industrial/commercial developments, a port, and residential areas.

Figure 2: Project Area Map

1.3 Sectors for Study: Assets and Areas

The project team (ICF International, PlaceWorks, and Moffatt & Nichol) considered input from local, regional, and state public agencies, as well as community members, when identifying key assets and areas for study. These groups highlighted assets and area that they believe are highly critical to the community's function, and may be vulnerable to climate-related hazards. Based on that process, the following sectors were selected for study:

- **Community Land Use:** Community land use includes the buildings and infrastructure that make up Benicia's neighborhoods and commercial centers. This infrastructure supports the social and economic structure of the City.
- **Transportation:** The network of local roads, freeways, transit, bike and pedestrian paths, and rail lines that transport people and goods within the City and between the City and other locations.
- **Port of Benicia:** The Port of Benicia is privately owned and operated by AMPORTS; however, the underlying land is owned by the City of Benicia. The port is an international trading hub.
- **Wastewater:** The Benicia wastewater treatments plant treats residential, commercial, and industrial sewage from the City before discharging it into the Carquinez Strait.
- **Stormwater:** The stormwater system transports rainfall runoff into the Bay.
- **Natural Habitats:** The Benicia shoreline contains several areas with natural features, such as wetlands and marshes.
- **Energy Infrastructure:** Pacific Gas & Electric (PG&E) provides electricity and natural gas to the City of Benicia.

Additional considerations that led to the individual asset selection included 1) ensuring adequate coverage of the wide range of the types of infrastructure and community assets found within the Project Area, and 2) representative assets that can provide insight regarding other vulnerable assets within the Project Area that were not selected for further analysis. For example, there are many local streets within the Benicia Project Area; these streets all have fairly similar characteristics in terms of their construction materials, governance, and maintenance regimens. For this reason, it makes sense to analyze a few roads, determine their vulnerability, and apply the learning from that process to the other local roads. The specific community assets and areas advanced for inclusion in this vulnerability assessment are documented in Table 1.

This assessment is not comprehensive of all city services (e.g., the library) or private properties (e.g., Valero). Some private businesses (e.g., Union Pacific) were asked to participate but choose not to, while others have participated in a limited review of key documents (e.g., Valero). It is unknown whether these businesses are undertaking internal climate change vulnerability assessments.

Table 1: Select Community Assets and Areas for Vulnerability Assessment

Sector	Assets
Community Land Use	• Downtown commercial areas • Portside Village townhomes • Benicia Industrial Park • Benicia Public Schools • Police Station (200 East L Street) • Fire Station (150 Military West) • Benicia Community Center (370 E L St) • City Hall • Fitzgerald Field • Benicia Marina
Transportation	• East 2nd Street/East B Street • East 5th Street • Bayshore Road • Industrial Way • Bay Trail*
Port of Benicia	• Port property at large • Engineered shoreline protection structures
Wastewater	• Benicia Wastewater Treatment Plant (WWTP), including flood walls

Stormwater	• Stormwater outfalls at:
	  o East 2nd Street*
	  o East 5th Street*

Natural Habitats	• Benicia State Park (marsh and estuary) • Marsh in front of Benicia Industrial Park • Marsh in front of Benicia Marina
Energy Infrastructure	• PG&E infrastructure

**Vulnerability assessment results for these assets are limited due to insufficient data or no participation from the asset owners/managers. Results tend to be more generalized based on the professional opinion of the ICF Team.*

1.4 Overview of This Report

This vulnerability assessment discusses some of the ways that climate change could affect Benicia's community assets and areas, and what the consequences of those effects might be on the community. This assessment specifically focuses on potential changes in temperature, sea level rise, and storm surge, including their effect on local drainage. Changes in precipitation are not covered in this report because they are projected to be minimal for the Project Area (see the Task 2 Summary Report for additional information).

As previously discussed, this report covers the sectors and assets identified in Table 1, which were suggested as key sectors/assets during the Advisory Group workshops. Other assets and sectors in Benicia could also be affected by climate change, but they are not the focus of this report because they 1) are significantly similar to one or more of the selected assets, 2) their owner did not agree to participate in this project, or 3) they were not identified by the Advisory Groups or the City of Benicia for inclusion in this assessment (e.g., garbage collection/recycling).

The vulnerability assessment was conducted by evaluating the three components of vulnerability: exposure, sensitivity, and adaptive capacity. To evaluate components, the ICF Team first identified how the climate in Benicia might change (exposure), and then evaluated the assets' sensitivities to future climate events (sensitivity), and their ability to adapt to those changes in climate (adaptive capacity). The evaluation of sensitivity and adaptive capacity depended largely on input from the asset managers through participation in the workshop and through responses to a survey; expert judgment of the consultant team was used to fill in remaining gaps. Detailed information on the vulnerability assessment approach can be found in Section 5.

Key Terms and Concepts

Climate change: Long term changes to the global or regional "average weather" attributed to anthropogenic emissions.

Climate stressor: Parameters used to measure and describe climate. For example: temperature, precipitation, wind, storm surge, waves, and relative sea level change.

Climate impact: The effect that climate has on infrastructure and natural areas.

Asset: Asset refers to any piece of built infrastructure, natural area, or community facility under consideration in this assessment.

Asset sector: A collection of similar assets. For the purposes of this report – community facilities and services; transportation; Port of Benicia; natural habitats; stormwater; wastewater; energy infrastructure.

Vulnerability: The degree to which a system is exposed to, sensitive to, and unable to cope with or adapt to the adverse effects of change, including climate variability and extremes.

Adaptation: Adjustments in natural or human systems that occur in response to already experienced or expected climate changes and their impacts.

The goal of this vulnerability assessment is to identify the potential vulnerabilities associated with each asset. No judgment is made on the relative vulnerabilities of the assets or the overall extent to which they are vulnerable. No rankings or scores are assigned that would indicate that some assets are more vulnerable than others. This approach was taken because the BCDC Adapting to Rising Tides project determined that vulnerability rankings and scores can be misleading when trying to compare assets that are distinctly different. Additionally, scores can provide a false sense of confidence in an analysis that likely has many data gaps and/or qualitative judgments.

This report follows the following format:

- An introduction to vulnerability assessment terminology
- An overview of historical/current natural hazards and information on the existing conditions of community assets. Understanding the existing condition of community assets and areas, as well as how they have been affected by past extreme weather events, provides insight to how the community asset or area could respond to future climate changes.
- An overview of future climate change stressors (i.e., sea level rise, storm surges, extreme temperatures)
- An overview of the vulnerability assessment methodology
- A summary of the key sector level vulnerability and consequence findings
- A summary of immediate next steps
- An appendix of asset specific vulnerabilities

To assist other local communities in conducting similar assessments, this report also includes "Tips for Success" boxes throughout the report that recommend best practices from the Benicia experience.

2 Introduction to Vulnerability

Vulnerability has a very specific definition for climate change assessments. The Intergovernmental Panel on Climate Change (IPCC), an internationally accepted authority on climate change, defines climate vulnerability as "the degree to which a system, whether it be communities, ecosystems, infrastructure assets, or others, is susceptible to and unable to cope with the effects of climate change," and consists of three main concepts[1]:

Exposure

The nature and degree to which an asset is exposed to significant climatic variations

Positively correlated with vulnerability

Sensitivity

The degree to which an asset is affected, either adversely or beneficially, by climate-related stimuli

Positively correlated with vulnerability

Adaptive capacity

The ability of a system (or asset) to adjust to climate change to moderate potential damages, to take advantage of opportunities, or to cope with the consequences

Negatively correlated with vulnerability

The greater the exposure and sensitivity of an asset or community, the greater the vulnerability and the greater the adaptive capacity of an asset or community, the lower the vulnerability. This relationship between adaptive capacity, sensitivity, and exposure can be seen in Figure 3. Low adaptive capacity combined with significant sensitivity and exposure will result in a vulnerable asset, while high adaptive capacity can counteract some sensitivity and exposure to result in a less vulnerable asset. The following sections dive deeper into each of the three components of vulnerability.

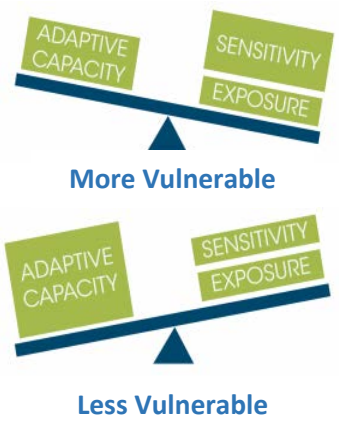


Figure 3: Combining the Elements of Vulnerability.

2.1 Exposure

Exposure measures the nature and degree to which an asset is exposed to significant climatic variations.[1] For example, parts of the Benicia Marina and Port Area are projected to be exposed to daily inundation (i.e., either permanently under water or within the daily tidal zones) from sea level rise by 2100 (storm surge will impact the area in the near term) because of their coastal location and lack of a shoreline protection system. Meanwhile, City Hall is not projected to be exposed to sea level rise or storm surge due to its inland location and higher elevation.

As another example, the entire City of Benicia is projected to be exposed to higher temperatures by 2050 due to climate change. Exposure to temperature increases tends to be more uniform within a small geographic area, because all assets tend to have similar exposure. Exposure to sea level rise and

[1] Definitions adapted from the IPCC in the U.S. Department of Transportation, Impacts of Climate Change and Variability on Transportation Systems and Infrastructure: The Gulf Coast Study, Phase 2, Task 3.1, Screening for Vulnerability Report. Accessible at: http://www.fhwa.dot.gov/environment/climate_change/adaptation/ongoing_and_current_research/gulf_coast_study/phase2_task3/task_3.1/index.cfm

storm surge is more variable within a city, because asset location, land elevation, height of structure, and other features can greatly influence if, and to what degree, an asset is exposed.

2.2 Sensitivity

Sensitivity is the degree to which an asset is affected, either adversely or beneficially, by climate-related stimuli.[1] For example, a building is sensitive to flooding if it is not waterproofed. It is more sensitive if there is electrical equipment on the ground floor. But sensitivities can result from more than only the physical characteristics of a structure. By following the guidance in the Adapting to Rising Tides Report, sensitivities have been identified across the following subject areas:

- **Physical and Functional Sensitivities:** Describes existing conditions or design features that make a community asset more sensitive to temperature and sea level rise. These features may include:
  - **Outdoor equipment** may not have been designed to withstand high heat conditions.
  - High heat may lead to **unsafe working conditions.**
  - Infrastructure that is **at or below grade** may be more likely to flood.
  - Elements that are **water sensitive** such as electrical or mechanical equipment may short out or corrode if exposed to water.
  - Some assets (e.g., grass and vegetation) can withstand freshwater flooding but may be sensitive to **salt water** flooding.
  - Coastal areas can be sensitive to **erosion** if they are not engineered to withstand coastal forces.
  - Additional coastal areas may be exposed to **liquefaction** (i.e., when the soil behaves as a liquid) during earthquakes due to increased groundwater intrusion.
  - **Dependence on other systems** for operation such as access to roads, rail tracks, or utilities may increase sensitivity.
- **Management Sensitivities:** Describes governance and management challenges. These challenges may include:
  - Community assets where **multiple agencies** are responsible for asset governance. This coordination may require a longer lead time to implement adaptation strategies.
  - **Management approaches** where the previous way of conducting business could no longer be sufficient. For example, planning horizons of 5 to 10 years are likely insufficient for capturing the long-term investments needed to adapt to sea level rise. Additionally, the regular management routines may be insufficient to deal with exacerbated flooding issues.

Tips for Success – Early Identification of Elements of Sensitivity

It is easy to jump to conclusions about the physical impacts that climate change will have on infrastructure and to forget about other sensitivities. By establishing sensitivity foci *before* diving into the vulnerability assessment, we were able to ensure that all aspects of sensitivity were evaluated.

- The lack of flexibility in available **funding sources** creates financing issues. Even though existing funding sources can be used for resilience projects, the budgets tend to be stretched thin (e.g., funding for State Parks can be used to raise wetlands through sea level rise but many parks are closing due to insufficient funding).

- **Informational Sensitivities:** Describes challenges to obtaining the information necessary to sufficiently understand vulnerability and risk. As discovered in the ART project, "these challenges were not only barriers to fully understanding the issues, but were themselves causes of vulnerability and risk."[2] There are three types of informational sensitivities:
  - In some cases, the information needed is **unavailable** or functionally out of date.
  - At other times, the information is **inaccessible** because it is privately held.
  - Sometimes, there is confusion over the availability of data due to **inadequate coordination** and/or inconsistencies in data formats that cannot be overcome (e.g., new staff may not be aware of the existence of older data sets such as historic maintenance and flooding remediation project details).

2.3 Adaptive Capacity

Adaptive capacity measures the ability of a system (or asset) to adjust to climate change by moderating potential damages, taking advantage of opportunities, or coping with the consequences.[2] For example, the City's Wastewater Treatment Plant (WWTP) has multiple positive and negative factors contributing to its overall adaptive capacity. Like many other cities, it is the only treatment plant that serves Benicia and so, there is a great need to adapt to changing conditions. The WWTP does have on-site pumps and an existing seawall that can help to constrain inundation and to remove water during a storm event which increases the overall adaptive capacity.

Determining the adaptive capacity of a system involves asking questions such as:

- Are there barriers to a system's ability to accommodate change in climate?
- What is the cost to repair the asset in the event of damage?
- Are plans already in place to respond to extreme weather events?
- Is there redundancy within the network of assets to support the City if one asset fails?
- Can the existing ventilation/cooling system handle the projected increase in temperature?
- Are other agencies and/or jurisdictions involved in the operation, design, or oversight of the infrastructure making it difficult to coordinate an emergency response?
- To what extent do climate change impacts and adaptation activities affect other sectors?

Adaptive capacity can be evaluated based on answers to these questions, using key metrics such as current condition of infrastructure assets and extent of backup, redundant or alternative assets.

[2] BCDC. Adapting to Rising Tides, Vulnerability and Risk Assessment Report. Chapter 3: Vulnerability and Risk Classification. Available at: http://www.adaptingtorisingtides.org/vulnerability-and-risk-assessment-report/

2.4 Moving Beyond Vulnerability to Risk

Vulnerability is an indication of how a specific asset could be affected under future climate scenarios. Risk illustrates how probable the occurrence (or *likelihood)* of an event is, as well as the *consequence* of that event occurring (that is, how bad the damage from that event would be).[3] The IPCC states that all of their climate projections are "equally likely" future scenarios and so, while all scenarios show an upward trend in global greenhouse gas emissions and measurable changes in climate, it is uncertain whether the lower emissions scenarios or the higher emissions scenarios will come to pass. For that reason, this report considers *uncertainty* instead of likelihood/probability. Our treatment of characterizing uncertainty and consequence are discussed in the sections that follow.

Uncertainty

The climate scenarios described in this report are all plausible and bound our current understanding of potential future global greenhouse gas emissions and the resulting climate change, but no specific scenario is certain to occur. There are three main sources of uncertainty in climate model simulations:

1. Natural variability (the unpredictable nature of the climate system)
2. Model uncertainty (the ability to accurately model the Earth's many complex processes)
3. Scenario uncertainty (the ability to project future societal choices such as energy use)

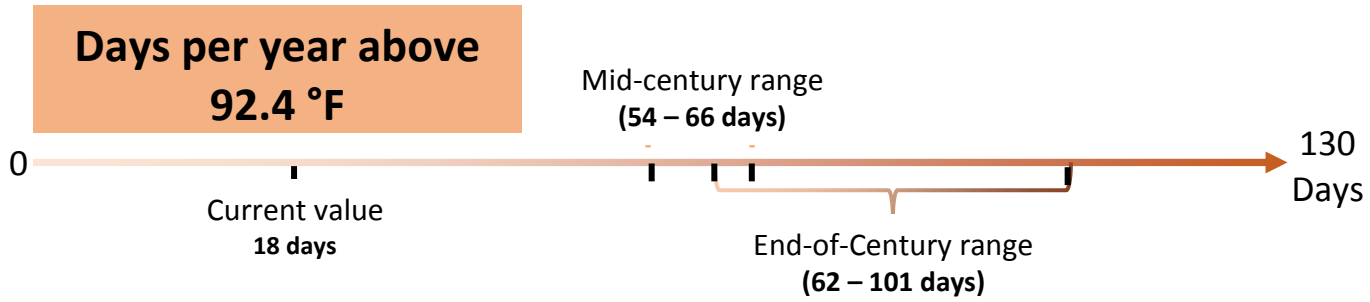
The relative contribution of each uncertainty component to the climate model simulation's overall uncertainty varies with time. In the near term, scenario uncertainty is relatively minimal and model uncertainty and natural variability are the dominant contributors to near-term and mid-century uncertainty. Over the longer term, scenario uncertainty describes a larger portion of the total uncertainty. While the City of Benicia is actively working to reduce their emissions, their contribution to global emissions is very small compared to the emissions of the entire United States, China, and India. Therefore, despite the strong local commitment to emissions reductions, the global uncertainty in emissions policies and energy choices results in a wide range of potential emissions futures.

The three elements of uncertainty are mitigated by averaging across different data sets and presenting the outcomes as a plausible range of future conditions. Natural variability is addressed by averaging over 20 years of climate projections (e.g., 2046-2065). This averaging smoothes over some of the annual variability that may arise. Model uncertainty is addressed by averaging across 19 climate models and scenario uncertainty is addressed by using two, equally likely, future emission scenarios which represent differences in how society may change in the future. These emission scenarios bound the high and low range of the climate change projections. Neither end of the projection range is considered more likely to occur than the other.

In the near term, it is easier to predict emission levels because they will likely be similar to today's rate of emissions production given the limited time for the global society to evolve. However, it is very difficult to project emission levels out 50 to 90 years into the future because it is not known how our global society will evolve over time (e.g., population growth, economic growth, energy use, development of significant technological advancements, political action mitigating emissions). Thus, the range of plausible future emissions expands over future time, along with the plausible range of climate

[3] Definitions for risk, likelihood, and consequence are adapted from the International Panel on Climate Change (IPCC)'s Fifth Assessment Report. Please see "WGII AR5 Glossary" at http://ipcc-wg2.gov/AR5/images/uploads/WGIIAR5-Glossary_FGD.pdf.

responses. The figure below, shows projected increases in the number of days per year above 92.4 °F (historically, 95% of days in Benicia have been below this temperature). As can be seen, there is less uncertainty across the plausible mid-century projections (a range of 12 days) compared to the end-of-century projections (a range of nearly 40 days). Additionally, the general trend towards an increased number of hot days is clear, despite the uncertainty surrounding the specific projections.



Because the range of projections grows with future time, the City of Benicia will place an emphasis on addressing near-term vulnerabilities since there is greater certainty that they will occur.

Consequence

Consequence represents the effects on natural and human systems.[3] In other words, it encompasses the effect that climate change-related damage would have on the greater community.[3] Consequence is qualitatively assessed in this report, using determining questions such as:

- If this asset is damaged due to climate change, what would be the potential economic affects?
- What is the estimated scale of the effect, such as the size of the population or land area affected?
- Is the asset considered critical to the City's mission?

The consequence findings in this report are classified in the following manner:

- **Economy** – For example, sea level rise threatens to inundate parts of the Benicia Industrial Park which could threaten jobs, and economic output due to disrupted businesses.
- **Environment** – For example, sea level rise threatens to inundate the Benicia State Park, which could negatively affect wildlife and reduce recreation areas.
- **Equity** – For example, increases in very hot days can disproportionally affect the elderly and the very young, whom are more vulnerable to heat-related illness.
- **Governance** – For example, advancing sea levels may require increased coordination between the City, BCDC, the Army Corps of Engineers, private entities and other parties.

The cost of adapting versus not adapting is not included in the consequences because it requires a more detailed assessment which cannot be completed until adaptation solutions are developed. This information will be included in the upcoming adaptation report. This structure also matches the Adapting to Rising Tides (ART) process which this project is using as a template.

3 Overview of Existing Conditions and Current Hazards

This section summarizes some of the most pertinent findings from the Existing Conditions and Stressors report. The Existing Conditions report was developed through a literature review of City documents and academic literature on the impacts of extreme weather events on infrastructure, as well as workshop sessions with the Technical Advisory Council and Community Advisory Group.

In order to develop robust adaptation measures that deal with some of the consequences mentioned in the previous section, it is important to first identify existing stressors that affect Benicia's infrastructure today. Existing stressors affecting Benicia include earthquakes, storm surge, flooding, wildfires, landslides, extreme temperatures, and drought. Some of these existing stressors could be exacerbated by climate change, such as flooding and extremer temperatures.

Tips for Success – Holding an Effective Data Gathering Workshop

- Holding an in-person meeting to discuss existing conditions was an effective way to establish the existing conditions.
- Divide technical experts and community members while gathering politically sensitive information.
- Focus invitations on staff who operate and manage important assets on a day-to-day basis.
- Ask people to provide web links or PDFs of management or emergency operation plans that provide insight on operations.
- Discuss existing conditions before discussing climate change in order to focus the conversation on existing impacts.
- Ask for examples of how infrastructure has been

3.1 Earthquake

Unlike the other existing stressors, the frequency and severity of earthquake magnitude are not affected by climate change. However, earthquakes can cause liquefaction, which occur when saturated or partially saturated soils lose stiffness and behave like a liquid. Rising groundwater levels due to sea level rise can increase the likelihood of liquefaction in the event of an earthquake. Earthquakes are thus included in this report because the consequences of earthquakes may be greater with sea level rise due to the potential for expansion of liquefaction areas.

Although other faults run closer to Benicia, the Hayward Fault poses the largest threat because it has the greatest likelihood of a sizable earthquake (e.g., a 7 or over on the Richter scale) in the next 30 years. If an earthquake were to occur, the Benicia shoreline could not only experience ground shaking but could also experience additional damage due to its susceptibility to liquefaction[4]. The last major earthquake centered in Solano County, a magnitude 6.5, occurred on the Concord/Green Valley fault in 1892. Currently, the following area in Benicia is exposed to earthquake impacts[5]:

- 25 acres vulnerable to earthquake faulting, mostly along the coastline

Examples of Existing Conditions

- **Transportation** –7 miles of railway in Benicia are located in potential earthquake and liquefaction susceptibility zones. Historic flooding has affected East 2nd St and East 5th St.
- **Shoreline Protection** – Shoreline protection structures such as levees are negatively impacted by coastal flooding, which lead to erosion and structural damage.

[4] Tables of land and infrastructure in Benicia vulnerable to various natural hazards are included in the "Annex to 2010 Association of Bay Area Governments Local Hazard Mitigation Plan: *Taming Natural Disasters".* Accessible at: http://resilience.abag.ca.gov/wp-content/documents/2010LHMP/Benicia-Annex-2011.pdf

[5] Statistics are from the City of Benicia "Annex to 2010 Association of Bay Area Governments Local Hazard Mitigation Plan: *Taming Natural Disasters".* Accessible at: http://resilience.abag.ca.gov/wp-content/documents/2010LHMP/Benicia-Annex-2011.pdf

- 1,320 acres classified as having severe earthquake shaking potential
- 833 acres vulnerable to liquefaction due to loose soils

The most severe shaking severity is projected to occur in coastal areas in the southern and eastern parts of Benicia, essentially overlapping the entirety of the project area.

3.2 Wildfires

Wildfire risks in Benicia are greatest in the inland grassy hills, which are outside of this project's study area. In total, 316 acres in Benicia are subject to high, very high, or extreme wildfire threat[6], and wildfires can also impair air quality in Benicia. However, the coastal regions have historically only been minimally affected by wildfires.

3.3 Flooding/Storm Surge

The Project Area has historically been affected by flooding due to its location on low-lying land adjacent to the shoreline without any significant grade to assist with drainage. The stormwater system in Benicia is gravity fed, and during storm events, undersized drainage pipes can become surcharged, leading to water backing up and flooding portions of the City. Flooding can occur both in areas that are hydrologically connected to the Bay as well as in low-lying areas that are not hydrologically connected to the Bay due to rainwater pooling in areas without drainage systems. This vulnerability assessment identifies assets that are currently affected by flooding and distinguishes between current drainage issues and those that could be exacerbated by climate change.

Examples of Flooding

1997 - The El Nino season in 1997 resulted in extreme coastal and inland flooding due to a combination of heavy rains, high tides, and undersized stormwater drainage systems.

2005 - A 40-year storm event coupled with extreme high tides with heavy rain. This led to coastal water overtopping local flood protection structures and flooding downtown, residential communities, and other portions of the City.

Current flooding occurs when rainfall events coincide with high tide and when storm conditions cause the stormwater outfalls to be blocked. Coastal areas in Benicia are vulnerable to flooding from storm surges, which are rises in water generated by a storm above and beyond the predicted tide. It is this combination of storm surge and precipitation that has historically resulted in flooding along East B, East 2nd and East 5th Streets, the Port of Benicia, and some natural shoreline areas.

3.4 Temperature

Currently, temperature extremes (high and low) have limited to no impact on the City of Benicia. Temperatures over 99° F only occur approximately four times per year, with the hottest temperature of the year, on average, reaching 102° F. Even when high temperatures occur, the coastal breezes moderate the temperature, reducing the "real feel" and limiting the negative impacts to human health (e.g., heat cramps, heat stroke).

[6] City of Benicia "Annex to 2010 Association of Bay Area Governments Local Hazard Mitigation Plan: *Taming Natural Disasters".* Accessible at: http://resilience.abag.ca.gov/wp-content/documents/2010LHMP/Benicia-Annex-2011.pdf

While the City of Benicia Emergency Operations Plan[7] indicates the steps for declaring a local emergency, and preparing and operating emergency healthcare services and shelters, it does not specifically identify temperature as a potential cause for activation. The Plan specifically states that the local state of emergency list is not comprehensive and that other causes of emergencies may exist. The extent to which private businesses have operational plans that address the proper response on high heat days is unknown.

Air conditioning in residences and commercial buildings is limited. In the event of high heat days, residents may have to seek out locations with air conditioning such as the library, schools, or the community center. Members of the CAG expressed concern that the only movie theatre in the City is closed, removing an obvious air conditioned location that residents could visit on high heat days.

3.5 Drought

California is currently in the midst of one of the worst droughts on record. Drought conditions occur when there are decreased levels of precipitation for an extended period of time. Droughts can be exacerbated by increased ambient temperatures which increase evaporation, melt the snowpack (or prevent precipitation from falling as snow), and generally results in increased human water consumption. Although the drought is a serious issue for the state and the City of Benicia, it is best addressed outside of this vulnerability assessment since drought conditions are a statewide phenomenon that will require additional stakeholders and partnerships to address.

Although this is a statewide issue, the City of Benicia has already conserved 22.6% of water between March 2014 and February 2015 compared to the same time in 2013. It continues to work toward the April 2015 state-mandated 25% reduction goal by encouraging residents and businesses to conserve water by providing rebates and incentives for more efficient appliances and fixtures and replacement of grass with native and lower water plantings and by investigating opportunities to treat and recycle wastewater for large industrial users in the City.

4 Overview of Future Climate Change Hazards

While a range of climate change impacts are projected to occur in Benicia, the scope of this project focuses on two hazards most certain to have significant negative effects on the City. While climate change could result in changes in the frequency and duration of drought, wildfires, precipitation events, extreme temperature events, sea level rise, and storm surge, this study focuses on extreme temperature and sea level rise/storm surge. Based on available climate change data, temperature and sea level rise are two stressors in Benicia that are projected to clearly deviate substantially from current

Tips for Success – Climate Change and Temperature Tools

There are two main temperature tools that could be used to obtain localized temperature projections:

1. CalAdapt – Provides California annual projections for six temperature variables (http://cal-adapt.org/temperature/heat/)
2. CMIP Climate Data Processing Tool – Averages data from multiple models and emission scenario (if desired) across 26 temperature variables. Allows user to select size of geographic area and range of years to average across (not yet posted on US DOT's website)

[7]City of Benicia, California Emergency Operation Plan. January 2007. Accessible at http://www.ci.benicia.ca.us/vertical/Sites/%7B3436CBED-6A58-4FEF-BFDF-5F9331215932%7D/uploads/%7BFFAF7365-1029-485A-B5FF-8ECD7951574C%7D.PDF

conditions. Additional information on the selection of these two stressors can be found in the Task 2 Summary Report (an overview of input received from the TAC and CAG during the project kick-off meetings).

The following sections discuss how temperature and sea level rise projections were developed. They provide insight on the *exposure* aspect of vulnerability, while Section 5 provides an overview of the sensitivity and adaptive capacity methodology.

4.1 Extreme Temperature

Temperature projections are derived from the World Climate Research Programme's Fifth Coupled Model Intercomparison Project (CMIP5). CMIP5 averages the projections of many climate models under different future greenhouse gas emissions scenarios. ICF used the CMIP Climate Data Processing Tool, soon to be available on the US Department of Transportation (DOT) website, to process the model outputs into variables that are more useful for planning and engineering. This tool provides more robust information than the California Energy Commission, CalAdapt tool, which is frequently cited as a valuable resource. Key data points are shown in Table 2, while the full data set and additional information on the methods used to derive the data are available in the Task 2 Summary Report.

Table 2: Range of Projected Changes in Temperature

Variable	Baseline (1950-1999) *Observed Value*	Mid-century (2046-2065) *Modeled Value*	End-of-century (2080-2099) *Modeled Value*
Average Annual Mean Temperature	59 °F	62 – 63 °F	63 – 67 °F
Hottest Temperature of the Year	102 °F	107 – 108 °F	108 – 112 °F
Average Number of Days per Year above 92.4°F **(95% of days in Benicia have historically fallen below this temperature)**	18 days	54 – 66 days	62 – 101 days
Maximum Number of Consecutive Days per Year above 92.4°F	5 days	12 – 15 days	13 – 32 days
Average Summer Temperatures	84 ° F	88 – 89 ° F	89 – 93 ° F
Highest 4-Day Average Summer Temperature	98 ° F	102 – 104 ° F	103 – 107 ° F

4.2 Sea Level Rise and Storm Surge

The California Ocean Protection Council (OPC) released sea level rise planning guidance in 2013, which includes the scientific findings of the National Research Council (NRC) Sea-Level Rise for the Coasts of California, Oregon, and Washington study. This guidance has been adopted by many California agencies including the San Francisco Bay Conservation and Development Commission, and the California Coastal Conservancy. The OPC guidance recommends assessing 5 to 24 inches of sea level rise by mid-century and 17 to 66 inches by the end-of-century. In order to utilize publicly available sea level rise mapping tools (see callout box, below), Benicia has rounded these recommendations to develop the following three sea level rise scenarios:

- 12 inches (low, mid-century projection)
- 24 inches (high, mid-century projection and the low end-of-century projection)
- 60 inches (high end-of-century projection)

In order to determine the effect of storms on coastal flooding, a FEMA study of average water level depths during storm events of various return intervals (e.g., 1 yr., 2 yr., 5 yr., 10 yr., 25 yr., 100 yr.) within the San Francisco Bay was used to identify current flood levels[8]. To combine the sea level rise mapping data and the storm depth data, ICF used the same approach as BCDC used for the ART project, called "total water level". Total water level allows for the simultaneous consideration of changes in short-term, storm-related flooding as well as long-term permanent inundation due to sea level rise. This approach does have limitations—it does not specifically model storms and the wave run-up processes that occur in the San Francisco Bay; however, the narrow waterway of the Carquinez Strait does not allow for significant wave development, so the total water level approach may be more appropriate in Benicia than in other coastal communities that abut large expanses of open water. The newly released Our Coast Our Future (OCOF) tool does model storm surge in the San Francisco Bay Area; however, this model was not used in this analysis for three reasons: (1) it was released after the start of the project; (2) the inland extent of the OCOF modeling is substantially similar to the total water level mapping; and (3) the ICF Project Team identified limitations to the inland extent of the OCOF modeling that are specific to Benicia and limit the accuracy of the results.

The inundation scenarios represented by the total water level's combination of sea level rise and high tide are identified in the map legends in Figure 4 and Figure 5. The legend indicates that the water level at 60 inches of sea level rise, combined with the daily high tide, is equivalent to the water level at 24 inches of sea level rise, coupled with the 25-year high tide (i.e., a tide/storm event that, on average, has occurred once every 25 years; on an annual basis, this event has a 4% chance of occurrence any given year). In other words, 60 inches of flooding is possible even before sea levels rise 60 inches, due to infrequent, although possible, high tide storm surge events. Water level scenarios with a high sea level rise and more frequent high tide event (such as the 60 inch plus daily high tide scenario) could force communities to change the way they use a given area due to daily flooding events, whereas scenarios with less sea level rise and a less common high tide (such as the 24 inches plus 25-year high tide scenario) do not necessarily demand a change in use, as flooding is less common.

[8] FEMA CCAMP San Francisco Bay Area Coastal Study, http://www.r9map.org/Pages/San-Francisco-Coastal-Bay-Study.aspx

Tips for Success – Sea Level Rise Tools

There are several sea level rise tools that can be used to obtain localized maps:

1. **NOAA Digital Coast Sea Level Rise Viewer** - utilized for this project due to the clear maps, the commitment to maintaining and updating the data, and the opportunity for replication by using a nationally available tool. Can map up to six feet of sea level rise. (http://coast.noaa.gov/digitalcoast/tools/slr/)
2. **Surging Seas** - utilized for this project for the socioeconomic impact analysis. Did not use as main source of mapping because it was difficult to see the difference between flooded areas and areas that are low-lying but protected by levees or natural features. Allows for mapping up to 10 feet of sea level rise. (http://sealevel.climatecentral.org/)
3. **Our Coast Our Future** - Excellent tool for Bay Area specific sea level rise modeling and mapping. Recommended for use in areas abutting significant open water where wind and waves will impact the inland flooding extent. Not utilized in this project due to localized shortcomings on the inland extent of the modeled area. (http://data.prbo.org/apps/ocof/index.php?page=flood-map)
4. **Future San Francisco Bay Tidal Marshes** - utilized for determining the response of natural areas to sea level rise and sedimentation. Not appropriate for mapping outside of natural areas. (http://data.prbo.org/apps/sfbslr/)

The following maps display the 24-inch and 60-inch sea level rise scenarios for Benicia, with markers for the location of assets analyzed in this vulnerability assessment. Red markers indicate that the asset is within the sea level rise inundation area, while black markers indicate that the asset is not projected to be affected by daily inundation. For identification of the individual markers, please see Attachment A: Individual Asset Profile Sheets.

The areas projected to be affected by sea level rise are indicated by two main colors on the map—blue and green. The blue represents areas that are anticipated to be flooded while the green displays areas that would be "below sea level" but that are protected from flooding by topographical features or man-made shoreline protection systems. However, it should be noted that the elevation data used in the mapping may omit fine features affecting connectivity (e.g. seawalls, ditches), meaning that the sea level rise maps may overstate the extent of flooding. For example, the Benicia WWTP is protected by a flood wall that is not represented in the sea level rise model. In general, the mapping assumes that existing levees are in good condition and will be maintained at their current elevation into the future.

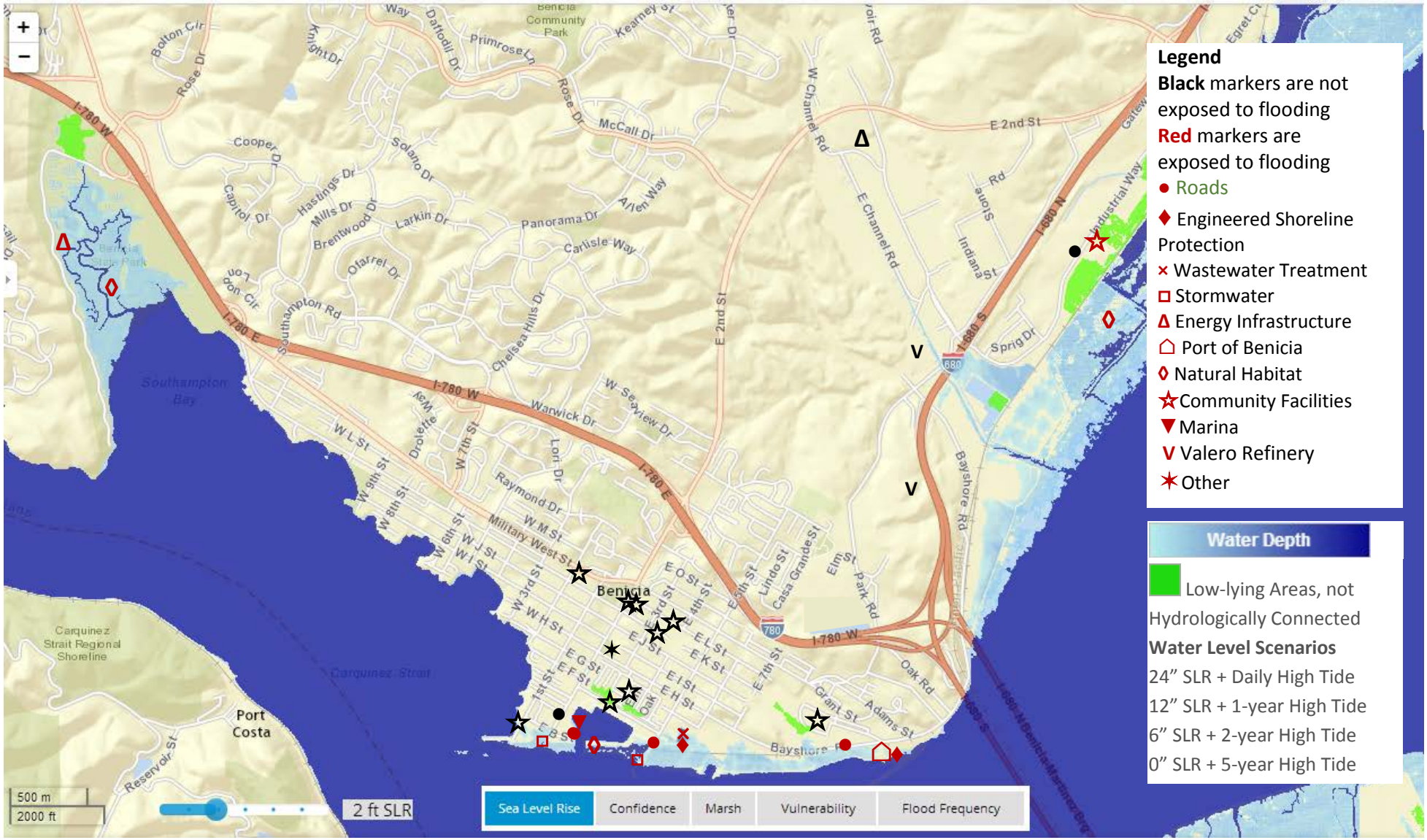


Figure 4: 24 Inch Total Water Level

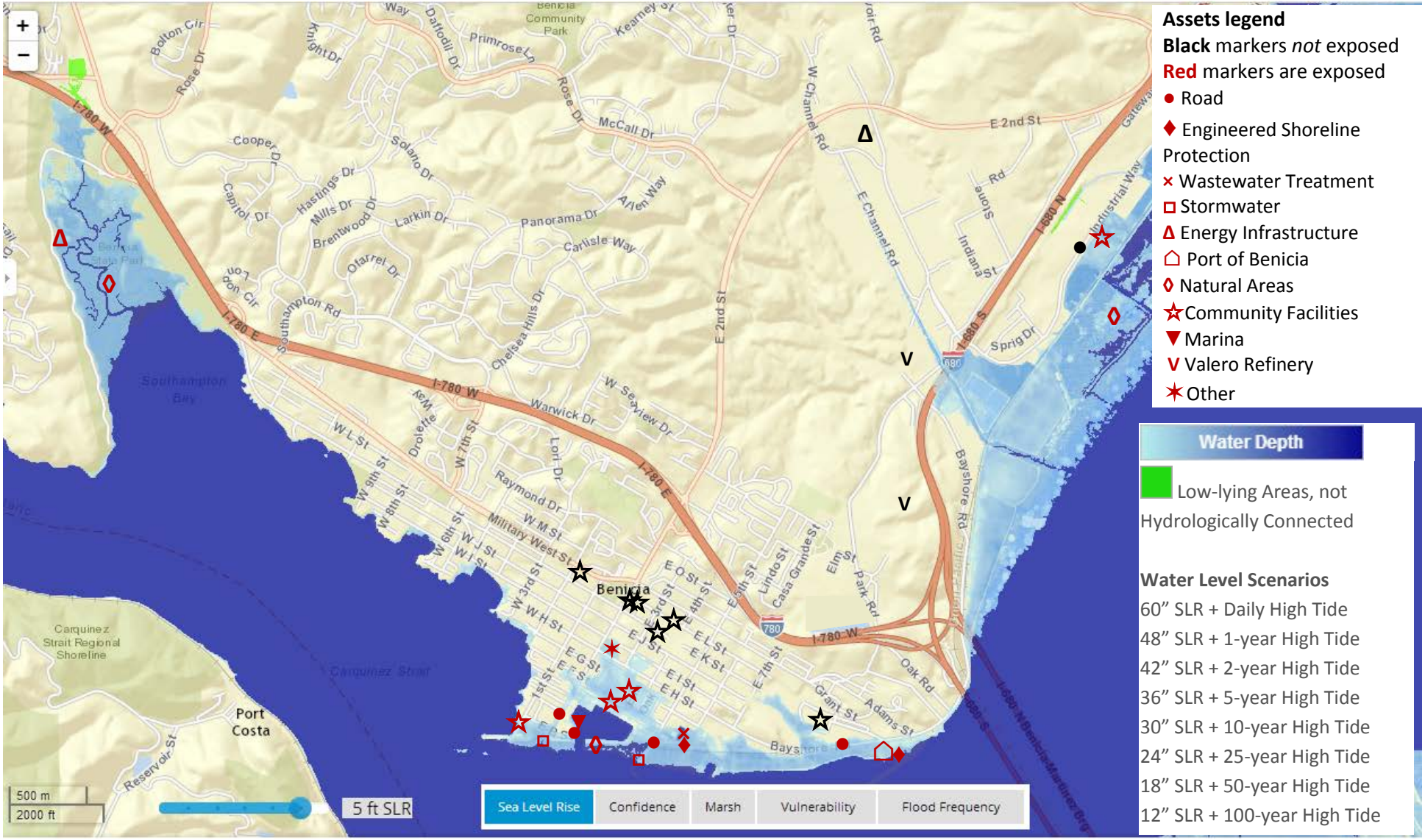


Figure 5: 60 Inch Total Water Level

5 Vulnerability Assessment Approach

This assessment approach relies on both qualitative and quantitative data as described in the following sections.

The vulnerability assessment is not a detailed engineering assessment nor does it pose solutions to the problems caused by sea level rise and high temperatures (adaptation options will be considered in a subsequent report). Engineering considerations, such as feasibility and cost estimates, will come under consideration in the development of adaptation measures.

5.1 Exposure -- Quantitative Analysis

The ICF Team conducted a quantitative analysis of exposure for the community areas and assets (as identified in Table 1) using the sea level rise and temperature data summarized in Section 4. In addition, specialized tools were used to conduct a more refined analysis of the sensitivity of marshes to sea level rise, and another sea level rise mapping tool was used to determine the socioeconomic exposure to sea level rise. Fortunately, these tools are free for public use:

- The Point Blue Conservation Science Future San Francisco Bay Tidal Marshes Tool[9] was used to determine how Benicia marshes could respond to sea level rise (see Section 6.6 for more information)
- The Climate Central Surging Seas Tool[10] was used to determine the socioeconomic exposure to sea level rise (see Section 6.1 for more information)

5.2 Sensitivity and Adaptive Capacity -- Qualitative Assessment

Asset owners and managers who interact with infrastructure on a day-to-day basis are a critical data source for sensitivity and adaptive capacity information. Collecting their input is integral to determining the sensitivity and adaptive capacity of an asset because this information is not always recorded in any traditional reports. In order to gather this information, the ICF team administered an online survey of asset owners and managers. The questions were provided by BCDC and modified by the ICF Team to include questions related to the effects of extreme temperatures.

The survey consisted of questions about the sensitivity and adaptive capacity of the particular assets operated, managed, or owned by the respondent. The survey also asked for input on the potential consequences to the asset, or to the larger system or community that relies on the asset, if impacts were to occur. Lastly, the survey included a section focused on the potential for equity issues, such as disproportionate burden on vulnerable populations if an impact were to occur. A copy of the survey questions can be found in Attachment B: Vulnerability and Risk Survey.

To help facilitate the survey, ICF and City of Benicia staff exchanged emails and held calls with select survey respondents to provide clarification and guidance on responding to the survey.

[9] Point Blue Conservation Science. Future San Francisco Bay Tidal Marshes: a Climate-Smart Planning Tool. Accessible at http://data.prbo.org/apps/sfbslr/.
[10] Climate Central. Surging Seas. Accessible at http://sealevel.climatecentral.org/.

The vast majority of the assets assessed are owned and managed by the City of Benicia. Eleven additional people (a mix of private industries, local, state, and federal agencies) were asked to participate; of these eleven, six responded to the survey.

In addition to the survey, the ICF team reviewed a variety of literature sources, including:

- Other vulnerability reports (e.g., Adapting to Rising Tides, U.S. DOT Gulf Coast Study Phase 2[11])
- Professional literature on the effect of weather events on various types of infrastructure
- Benicia specific asset management or operating plans

These resources, as well as the ICF Team's professional knowledge, were used to complete the vulnerability assessment.

Tips for Success – Designing Effective Surveys

These tips cover elements of the survey design and implementation process that were effective as well as elements that the Project Team would change before undertaking a similar effort. In both cases, these tips should not be viewed as established best practices since they have not been sufficiently tested; they are simply the Project Team's thoughts on how to improve the survey response.

- **It's All in the Details –** Useful vulnerability assessments dive into the details. Be sure to balance the need for specifics with the users time.
- **Brevity is Key –** Ask fewer questions that allow for more narrative feedback in order to not overwhelm the respondent. Also, limit the amount of technical terminology unless it is well defined.
- **Be Specific –** Include examples in the questions that help elucidate the type of information desired.
- **The Right Person –** Confirm the identified contact is the correct person to be responding and enable them to skip questions or answer "I don't know" (which is also useful information!) if needed.
- **Format –** Online surveys allow the results to be easily consolidated. Google Forms provided skip-page functionality so asset owners only saw questions relevant to their asset. Users could also save and edit their responses at a future date.
- **Reminders –** Send frequent reminders of the survey and don't expect to receive responses until a week after the close date. Prepare a back-up plan in case survey responses are not submitted.
- **Education/Background – Provide** background information throughout the survey to educate the respondent on climate change vulnerability terms and data. This will also help them to understand the purpose of their responses. It is also useful to provide a PDF version of the survey so respondents can prepare their responses before entering them online.
- **Interviews –** Time and budget permitting, conducting individual interviews may be a more effective information gathering process than a survey. The questions can be customized and the interviewer can guide and probe to determine the underlying cause of specific vulnerabilities.

Definition of Sensitivity and Adaptive Capacity

There is frequently overlap between sensitivity and adaptive capacity. For the purposes of this assessment, adaptive capacity broadly encompasses:

- **Ability to quickly repair damage** – this may be due to the likely costs being low or the asset being prioritized for repair in the event of an emergency.
- **Redundancy** – if ability of alternative assets to replace some or all of the functionality of the damaged asset

Individual sectors may have additional and unique indicators of adaptive capacity; these will be found in the adaptive capacity sections of the report.

[11] U.S. Department of Transportation. 2008-2014. Accessible at https://www.fhwa.dot.gov/environment/climate_change/adaptation/ongoing_and_current_research/gulf_coast_study/.

6 Key Sector Level Vulnerabilities

This section summarizes the key vulnerabilities and consequences identified within each sector. For each asset sector, a summary of the exposure, sensitivities, adaptive capacity, and the potential consequences of the climate change effects is presented. This section provides a high level overview of cross-cutting vulnerabilities identified at the systematic level rather than a detailed assessment of the vulnerability of each individual asset.

Specifics on the vulnerability of individual assets in each sector are presented in Attachment A: Individual Asset Profile Sheets. The asset profile sheets classify the vulnerabilities and risks based on characteristics that will help to 1) prioritize management issues, 2) guide the development of adaptation strategies, and 3) highlight where improved coordination is needed in order to implement adaptation strategies (e.g., between public agencies, between the public and private sectors). These asset profiles will be supplemented with additional information during the subsequent adaptation measure development phase in order to clarify and refine the appropriate adaptation response.

Tips for Success – Vulnerability Assessment Process

- Don't just depend on survey responses; use a variety of resources to identify sensitivities (e.g., other vulnerability reports, asset specific design standards and literature).
- If possible, conduct site visits to better understand the elements that may be impacted by climate change.
- Leave time for review – the potential sensitivities identified in the literature should be vetted with the asset owners/managers to determine their applicability. Reviews can be conducted via email or in a workshop setting.

It needs to be emphasized that within every sector there is variation in the vulnerability between different assets (e.g., no two roads have the exact same vulnerability due to variations in location, maintenance, and use). A review of the individual asset profiles needs to be conducted before reaching any asset-specific vulnerability conclusions.

Exposure to high heat is not covered in the sections below because exposure is consistent across all assets since temperature is not expected to vary across the Project Area. The one exception is stormwater. Since the stormwater assets are buried underground, they are buffered from changes in air temperature. Assets could be exposed to more frequent extreme temperatures as well as higher average temperatures throughout the century as presented in Table 2.

6.1 Community Facilities and Services

The Community Facilities and Services sector consists of the job centers, residences, schools, emergency facilities, recreation areas, and public buildings that together support and define neighborhoods. This assessment of community facilities and services considers the vulnerability and risk to people in a number of areas: where they live and work; the property they may own or rely on; and the key services and facilities that support and maintain the social and economic interactions that tie communities together.

The particular community facilities and services included in this vulnerability assessment are:

- Commercial Centers:
    - Downtown commercial areas

    - Benicia Industrial Park
    - Benicia Arsenal[12]
- Residential Neighborhoods:
    - Portside Village townhomes
    - Rancho Benicia mobile home park[7]
- Community Buildings and Services
    - Benicia Public Schools
    - Police Station (200 East L Street)
    - Fire Station (150 Military West)
    - Benicia Community Center (370 E L Street)
    - City Hall (250 E L Street)
- Recreation Areas
    - Fitzgerald Field
    - Benicia Marina

Understanding the overarching vulnerability and risk across such a broad and varied range of assets is necessary for planning purposes but also challenging to communicate. A high level summary of the vulnerability findings is presented in Table 3. This table is meant to be informative and serve as a jumping-off point for discussion rather than a definitive assessment of all assets within this sector.

The findings presented in this section and in the individual asset profiles (see Attachment A: Individual Asset Profile Sheets) will be used to inform the subsequent development of cross-sectorial adaptation strategies in order to develop community-wide resilience.

Table 3: Community Services and Facilities Key Vulnerabilities

Exposure
• The number of high heat days (over 92.4°F) is projected to increase by 36-48 days by mid-century and 44-83 by end-of-century • The average summer temperature is projected to increase by 4-5°F by mid-century and 5-9°F by end-of-century • 515 homes are projected to be in the 2100 sea level rise inundation zone • Commercial centers (e.g., downtown 1st street, the port, portions of the Benicia Industrial Park) are projected to be inundated on a daily basis by the end of the century; however, they will be impacted by storm events within the mid-century time frame • City services (e.g., fire, police, community center) are not projected to be exposed to sea level rise and storm surge

[12] ICF did not receive a completed survey response for this asset. All vulnerability information provided on this asset is derived from the ICF Team's professional experience.

Sensitivity
Physical/Functional Sensitivities • Essential mechanical and electrical equipment in buildings are highly water and salt sensitive and are often located below-grade or on the ground floor. • Most buildings are constructed of water and heat sensitive materials such as wood and plaster. **Management Sensitivities** • Certain populations are especially sensitive to heat events and flooding. This includes children, the elderly, people without vehicles, those with pre-existing medical needs, renters, and those below the poverty line. • Communities of residents and businesses are informal networks that are easily severed during extreme weather events. Areas with strong social networks and may be less sensitive to extreme weather events. • Many emergency plans do not account for the impacts of sea level rise and extreme heat events. **Information Sensitivities** • Information on the location of residents with specific needs is not tracked and accessible for response during extreme weather events.
Adaptive Capacity (Select examples)
• **Redundancy:** Existing fire and police stations in Benicia can serve as back-up support in the event of weather-related emergency. • **Planned response:** While called by different names, a Continuity of Operations Plan specifies actions to take to preserve worker and workplace safety in the event of any number of scenarios. This plan would likely recommend temperatures at which it is unsafe to continue work or at which additional breaks are required, as well as instructions on shutting down and protecting equipment in the event of dangerous temperatures or flooding. • **Cooling centers:** The Benicia Community Center is one example of a location that could be used as a public cooling center which, during high heat events, could shelter and cool residents. A general protocol for implementing shelters is outlined in the Benicia Emergency Operations Plan[13], although the plan does not specifically indicate procedures for heat events. (See individual asset profiles for information on back-up cooling centers.)

Extreme Temperature

Sensitivity

The following characteristics affect the sensitivity of Community Facilities and Services, as well as residents, to extreme temperatures:

- **Lack of acclimatization to high temperatures:** High temperatures can be more damaging than most people realize. Even though heat-related deaths are largely preventable, many people are injured or even die from heat every year. A 10-day heatwave in California in 2006 resulted in more than 650 heat-related deaths[14]. Benicia historically has had a moderate climate influenced

[13] City of Benicia, California Emergency Operations Plan. 2007. Accessible at http://www.ci.benicia.ca.us/vertical/Sites/%7B3436CBED-6A58-4FEF-BFDF-5F9331215932%7D/uploads/%7BFFAF7365-1029-485A-B5FF-8ECD7951574C%7D.PDF.

[14] Data from the California Heat Adaptation Workgroup report, "Preparing California for Extreme Heat". Accessible at: http://www.climatechange.ca.gov/climate_action_team/reports/Preparing_California_for_Extreme_Heat.pdf

by cooling winds off the Bay. Unfortunately, this means that residents are not acclimatized to high heat conditions and are therefore more sensitive to heat and more likely to be affected by high temperatures.

- **Vulnerable populations:** Heat-related illnesses can include heat cramps, heat exhaustion, and heat stroke. The elderly and the very young, in addition to those predisposed to medical conditions, are the most likely to be affected by heat-related illnesses. Other vulnerable populations include those that have to or choose to physically exert themselves on high heat days (e.g., indoor and outdoor workers, athletes).
- **Air conditioning:** Due to the age of buildings within the Project Area (some being constructed as early as the 1850's with a second boom in construction following the 1950's), as well as the current coastal breeze, the vast majority do not have air conditioning units. This lack of universal cooling systems increases the sensitivity of the public and businesses to high heat conditions.
- **Urban heat island:** Temperatures are commonly higher in urban, paved areas due to the urban heat island effect, whereby the pavement and buildings in an urbanized area absorb sunlight and heat. This effect may become more pronounced in built up areas such as downtown and the Benicia Industrial Park.
- **Building materials:** Buildings themselves can be affected by high temperatures–paint is more likely to become brittle and chip, business equipment filters and sealants may need to be replaced more frequently, and concrete pavement may crack if there are an insufficient number of expansion joints. However, none of the community facility and service asset owners identified high heat as a concern for continued operation.
- **Socioeconomic factors**: A variety of socioeconomic factors affect the sensitivity of a community. For example, economic status, level of education, health and physical mobility, ownership of a home or car, and proficiency in English can all affect a resident's sensitivity to climate change. Within Benicia, some the older neighborhoods (some with structures dating back to the 1850's) have a higher concentration of sensitive residents. This will need to be taken under consideration when developing emergency response plans and when providing general assistance to residents to adapt their personal homes to become more resilient to climate change.
- **Renters:** Individuals that rent housing and businesses buildings may be particularly sensitive, as they may not be able to influence the owners to improve the property to better withstand high temperatures, for example by installing air conditioning units.
- **Local Breezes:** Benicia is fortunate to be located in a breezy, coastal location, which decreases the "real feel" of the temperature, reducing the sensitivity of the area. While the effects of climate change on these wind patterns is unknown, if they continue into the future, then they will decrease the effects of high heat days within the Project Area.

Adaptive Capacity

The following measures affect the adaptive capacity of Community Facilities and Services, as well as residents, to extreme temperatures:

- **Back-up facilities:** Existing fire and police stations outside of the Project Area can serve as back-up support in the event of weather-related emergency.

- **Continuity of Operation Plans:** While called by different names, a plan of this sort specifies actions to take to preserve worker and workplace safety in the event of any number of scenarios. This plan would likely recommend temperatures at which it is unsafe to continue work or at which additional breaks are required, as well as instructions on shutting down and protecting equipment in the event of dangerous temperatures.
- **Cooling centers:** The Benicia Community Center is one example of a location that could be used as a public cooling center which, during high heat events, could shelter and cool residents. A general protocol for implementing shelters is outlined in the Benicia Emergency Operations Plan[15], although the plan does not specifically indicate procedures for heat events. (See individual asset profiles for information on back-up cooling centers.)
- **Community groups:** A neighborhood with a strong social network that is tied together by individual relationships will have a lower overall sensitivity and higher adaptive capacity than a neighborhood where residents either do not know each other, or are not invested in the overall community good. Although the Benicia Citizens Corps and Emergency Response Team (BERT), whose mission is to "recruit, train and coordinate volunteers wishing to prepare themselves, their families, their neighborhoods and their businesses to be self-sufficient in the aftermath of future disasters and other emergencies affecting Benicia," currently do not address high heat or flooding, their existence still increases the adaptive capacity of the City of Benicia.
- **Business associations:** The Benicia Chamber of Commerce, Benicia Industrial Park Association, and the Benicia Main Street Program offer adaptive capacity by increasing coordination, communication, and assistance to businesses.
- **Funding flexibility:** The City of Benicia Capital Improvement Plan may have the ability to prioritize funding for resiliency projects. This increases the adaptive capacity of the community.

Consequence

The potential consequences of high heat affecting Community Facilities and Services, as well as residents, include:

- **Decreased economic activity:** High heat may decrease leisure shopping as people try to stay indoors. However, if people do not have air conditioning at home, then they may seek out air conditioned businesses in order to cool themselves.
- **Loss of heat sensitive inventory:** Stores may have to dispose of portions of their inventory if it is exposed to high temperatures for too long. For example, produce may spoil faster under high temperatures. This could represent a large economic loss to the business owner.
- **Decreased air quality:** Increased temperatures can also "cook up" local pollution levels (e.g., ground level ozone and secondary air pollutants), which disproportionately affect the very young, the elderly, and those with existing cardiopulmonary issues.
- **Heat stroke:** High temperatures increase the risk of heat-related illness, such as heat stroke and heat cramps.

[15] City of Benicia, California Emergency Operations Plan. 2007. Accessible at http://www.ci.benicia.ca.us/vertical/Sites/%7B3436CBED-6A58-4FEF-BFDF-5F9331215932%7D/uploads/%7BFFAF7365-1029-485A-B5FF-8ECD7951574C%7D.PDF.

- **Infectious disease:** Warming temperatures open up new regions (such as California) to the effects of insect carried infectious diseases such as Lyme disease and Valley Fever.

Sea Level Rise/Storm Surge

Exposure

A number of Community Facilities and Service assets within the Project Area are projected to be exposed to sea level rise within the next century. Although there is uncertainty in the exact timing of daily inundation, assets are projected to be exposed to daily or at least frequent inundation within the time frames identified in Table 4.

Table 4: Community Facilities and Services Exposure to Sea Level Rise based Flooding

Asset	Currently Floods during Heavy Rain Events due to Inadequate Drainage	12 Inch Total Water Level (daily inundation at mid-century)	24 Inch Total Water Level (daily inundation at late mid-century to early end-of-century)	60Inch Total Water Level (daily inundation at end-of-century)	Not Projected to be Inundated this century
Benicia Marina (landside infrastructure)	X	X	X	X	
Downtown Commercial Area				X	
Portside Village Townhomes	X			X	
Rancho Benicia Townhomes	X*			X	
Benicia Industrial Park				X	
Fitzgerald Field	X			X	
Benicia Public Schools					X
Police Station					X
Fire Station					X
Benicia Community Center					X
City of Benicia Buildings					X

**Rancho Benicia has historically flooded but it has not flooded in the last six years due to the new ability to divert flood water away and the 1997 Marina Storm Drain Project (although those pumps are now considered undersized).*

The historic records of flooding within the downtown area indicate that sea level rise is only a part of the flood risk story. Benicia's gravity-fed stormwater system has low-lying outfalls that are submerged during extreme high tides and storm events. When stormwater outfalls are submerged, inland rainfall is not able to drain into the Carquinez Strait. Stormwater backs up onto community streets and public spaces, where the water remains until the tides subside and the water can drain. Due to improvements in the last decade, the City of Benicia is now able to divert some flood water away from downtown and Rancho Benicia by storing the water on Fitzgerald Field (a retention pond area); however, during the most extreme rain storms, this measure is not sufficient to divert all flood water from downtown (it has been sufficient for preventing flooding at Rancho Benicia). For this reason, it is indicated in Table 4 that

the greater downtown area is known to flood during rain events due to inadequate drainage and that this issue will continue unless the drainage system is improved; however, with the exception of the Marina's landside infrastructure, these properties are not anticipated to be directly flooded from the coast due to sea level rise and storm surge until the end of the century. As the sea rises, the stormwater outfalls could be submerged more frequently, which would result in more frequent inundation from smaller rainfall events long before the end-of-century daily inundation occurs. This means that the annual flooding of Fitzgerald Field and some neighboring areas (e.g., Rancho Benicia, downtown) may increase from an annual occurrence to a regular impact. This increase in tidal flooding events is already evident during King Tide events. Options to reduce or eliminate the occurrence of more frequent flooding due to the storm drain outfalls will be developed during the subsequent adaptation scoping process.

As demonstrated in Table 4, residential and commercial areas are projected to be exposed to sea level rise, while community services (e.g., fire and police buildings) are not projected to be exposed to sea level rise impacts. For this reason, the sensitivity, adaptive capacity, and consequence sections focus on residents and businesses.

In addition to assessing the exposure of these key assets, the ICF team conducted a Project Area-wide analysis of the population, homes, property value, and total land exposed to sea level rise, using the Surging Seas Tool, developed by Climate Central. This tool overlays sea level rise mapping data with current U.S. Census data to provide projected socioeconomic impacts of sea level rise. The tool does not project future changes in population, land use, or property values. This analysis provides the residential and commercial impacts summarized in Table 5.

Table 5: Project Area Exposure to Sea Level Rise

	12" Total Water Level (daily inundation at mid-century)	24" Total Water Level (daily inundation at late mid-century to early end-of-century)	60" Total Water Level (daily inundation at end-of-century)
Population	75	115	836
Property Value (Millions)	$31	$64	$213
Homes	41	62	515
Land (Acres, not including saltwater marsh)	50	118	402

Source: Climate Central Surging Seas Tool, http://sealevel.climatecentral.org/

Sensitivity

The following characteristics affect the sensitivity of Community Facilities and Services, as well as residents, to sea level rise and flooding:

- **Construction Materials:** In general, most buildings are not designed or constructed to withstand flooding or rising groundwater.
  - **Drywall/Plaster:** Buildings with drywall are particularly sensitive because drywall wicks water upward, meaning damage can occur well above the actual level of flooding. In addition, drywall and other materials, such as plaster, can become fragile if exposed to water for long periods of time, and even if dried, they cannot easily be decontaminated and generally must be demolished and replaced.
  - **Wood:** Wood may not suffer structural damage from flooding, but mold and other organisms can flourish in the wet, post-flood environment.
- **Underground features:** Higher groundwater levels that may result from rising sea level could affect buildings that have underground components such as electrical and mechanical systems.
- **Ground floor mechanical and electrical systems:** Buildings with mechanical and electrical equipment on the ground floor (e.g., HVAC units, elevator controls) are more sensitive to flooding.
- **Salt sensitive components:** Vegetation at parks and surrounding structures may survive freshwater flooding but will likely die if inundated with saltwater.
- **Socioeconomic factors:** A variety of socioeconomic factors affect the sensitivity of a community. For example, economic status, level of education, health and physical mobility, ownership of a home or car, and proficiency in English can all affect a resident's sensitivity to climate change. Within Benicia, some the older neighborhoods (some with structures dating back to the 1850's) have a higher concentration of sensitive residents. These demographics will need to be taken under consideration when developing emergency response plans and in providing general assistance to residents to adapt their personal homes to become more resilient to climate change.
- **Historical Landmarks:** Benicia has eight properties listed in the National Register of Historical Places[16], and many more old structures that add to the character of the City. These unique structures cannot easily be moved, and, due to their age and construction materials, are more likely to be sensitive to flooding.

Spotlight – Benicia Marina

- Fixed structures such as the entrance jetties, the harbormaster's office, fueling tanks, boat launch ramp, and parking are sensitive to sea level rise
- Wave protection structures will require improvements to continue to provide the same level of protection
- Access from the landside may be impacted by rising sea levels as improvements to the shoreline will change access to the berths
- Landside support facilities are presently subject to periodic flooding from extreme storm events
- The floating dock has high adaptive capacity since, to a certain degree, it can rise with the seas

[16] National Park Service. List of Properties on the National Register. 2014. Accessible at: http://www.nps.gov/nr/research/.

- **Renters:** Individuals who rent housing and businesses that rent buildings may be particularly sensitive because they may not be able to influence the owners to improve the property to better withstand flooding, or to respond to a flood event, for example by quickly drying and replacing damaged materials. Residential renters may also lack insurance that could provide assistance with replacing damaged personal items or providing an alternative place to live.
- **Sandbags:** Stockpiling sandbags allows residents, business owners, and property managers to protect properties from temporary flooding events, thus reducing their sensitivity. Again, this is not a long-term solution, but sandbags can provide relief until a more permanent solution is developed.
- **Water pumps:** Schools and City facilities (e.g., police and fire stations) have small pumps to clear some flood water. These pumps are not sized to manage large flooding events or groundwater issues but do reduce sensitivity.
- **Shoreline protection:** If the existing shoreline protection system—shoreline protection structures (e.g., levees, flood walls) and natural shoreline areas (e.g., marshes)—is maintained, it will reduce sensitivity by attenuating the effects of storm surge and sea level rise.

Spotlight – Benicia Industrial Park (BIP)

- Existing flooding currently occurs in parts of the BIP which will only become more frequent with time.
- Due to the large area and varied terrain of the BIP, some areas will be more sensitive than others (e.g. those fronting the Bay which are presently flooded by extreme high tides and waves)
- The adaptive capacity is moderate as there is some space along the waterfront for improvements to be made though it is restrained by existing roadways, railway and competing uses for the waterfront land.

Adaptive Capacity

The following measures affect the adaptive capacity of Community Facilities and Services, as well as residents, to sea level rise and flooding:

- **Socioeconomic factors:** The ability to move to new areas and afford temporary housing situations (e.g., hotels) increases adaptive capacity. While this is not a long-term solution to flooding, it can provide temporary relief.
- **Continuity of Operation Plans:** While not always called the same thing, these plans dictate the appropriate response to flood events. Benicia public schools have long-term improvement plans and emergency management plans that identify where classes would take place if a particular site becomes compromised.
- **Telecommuting policy:** While telecommuting is not appropriate to all types of jobs, permitting and enabling telecommuting can enable employees to continue working in the event of workplace flooding.
- **Community groups:** A neighborhood with a strong social network that is tied together by individual relationships will have a lower overall sensitivity and higher adaptive capacity than a neighborhood where residents either do not know each other, or are not invested in the overall community good. The Benicia Citizens Corps and Emergency Response Team, whose mission is to "recruit, train and coordinate volunteers wishing to prepare themselves, their families, their

neighborhoods and their businesses to be self-sufficient in the aftermath of future disasters and other emergencies affecting Benicia, "increases the adaptive capacity of the City of Benicia.

- **Business groups:** For businesses, the collaborative Benicia Chamber of Commerce, Benicia Industrial Park Association, and the Benicia Main Street Program offer adaptive capacity by increasing coordination, communication, and assistance to businesses.
- **Funding flexibility:** The City of Benicia Capital Improvement Plan may have the ability to prioritize funding for resiliency projects that are linked to Council approved priorities. This increases the adaptive capacity of the community.

Consequence

The potential overarching consequences of sea level rise and flooding affecting Community Facilities and Services, as well as residents, include:

- **Reduced sales and property tax:** Damage to businesses would affect sales and damage to residential and commercial properties could reduce property values and therefore reduce property tax revenue for the City of Benicia.
- **Increased insurance rates:** As flooding becomes more common over time, the rates for flood insurance could increase. This would have a larger effect on low-income communities.
- **Loss of businesses and residents:** Damages to businesses could result in long lasting or permanent closure, limiting Benicia resident access to goods and reducing the quality of life within the City. Damage to homes may cause residents to leave Benicia altogether.
- **Unsafe environments:** Mold-damaged homes and businesses could create unsafe living and working environments.
- **Loss of childcare:** School closures would affect parents' ability to work due to increased childcare demands.
- **Loss of recreation:** The flooding of Fitzgerald Field affects the ability of residents to play recreational baseball.
- **Loss of personal belongings:** Flooding can damage or destroy sensitive personal information and family heirlooms. These possessions may be irreplaceable.

6.2 Transportation

The Benicia Project Area is served by a network of local roadways, recreational trails, select bus routes, connections to major freeways, and rail lines. The transportation focus of the vulnerability assessment is on a subset of the local roads and recreational trails within the Project Area. These roads were selected based on their previous flooding damage as well as the access they provide to essential services and places of employment in the City of Benicia. They are not comprehensive of all roads that have historically flooded or will flood in the future. The assets include:

- **East B Street and East 2nd Street** – serve a residential neighborhood and provide spillover parking for 1st Street (a commercial district). Also provide access to the waterfront and commercial areas.
- **East 5th Street** – serves residential neighborhoods and provides access to the WWTP.

- **Bayshore Road** – provides access to the Port of Benicia and continues along Sulphur Springs Creek.
- **Industrial Way** – provides access to the Benicia Industrial Park, follows along Sulphur Springs Creek and abuts the natural marsh along the Suisun Bay.
- **Bay Trail** – a recreational biking and walking trail that circumnavigates the Bay on paved and unpaved paths and roads.

The sensitivity of the roadways to extreme heat and sea level rise is fairly consistent across the selected assets. This indicates that the findings are also applicable to other roadways within the City that may be exposed to climate change impacts. Likewise, the findings for the Bay Trail are representative of the potential affects to other coastal trails.

Although the Union Pacific (UP) railroad tracks were not fully assessed for their vulnerability, they were assessed for their exposure to sea level rise. It is projected that portions of the track near Sulphur Springs may be exposed to daily inundated with 24 inches of sea level rise (high range of the mid-century projections). Under the high range of the end-of-century sea level rise projections (60 inches), significant portions of the tracks that pass to the East of the Benicia Industrial Park, and adjacent to the port will be inundated on a daily basis.

A high level summary of the vulnerability findings is presented in Table 6. This table is meant to be informative and serve as a jumping-off point for discussion rather than a definitive assessment of all assets within this sector.

Table 6: Transportation Key Vulnerabilities

Exposure
• The number of high heat days (over 92.4°F) is projected to increase by 36-48 days by mid-century and 44-83 by end-of century • The average summer temperature is projected to increase by 4-5°F by mid-century and 5-9°F by end-of-century • Many of the transportation assets currently flood during extreme high tide events (in part due to local drainage issues) • All transportation assets covered by this assessment are projected to be partially exposed to daily inundation by mid-century
Sensitivity
Physical/Functional Sensitivities • Roadways located at grade, making them susceptible to flooding • Ancillary support (e.g., stop lights) may be sensitive to salt water flooding • Asphalt mix may soften and rut in extreme temperatures • Closed roadways could interfere with emergency response/evacuation procedures **Management Sensitivities** • The number of agencies involved in allocating funding for roadway repairs and improvements could complicate the planning and implementation process moving forward; however, they may also bring additional funding and support • There is a lack of financing to plan for the impacts of sea level rise and high heat events on transportation assets • Planning needs to be coordinated between transportation agencies and the surrounding land owners and stakeholders • Roadway repair workers are sensitive to high heat work environments and may require additional breaks until temperatures cool **Information Sensitivities** • There is a lack of detailed, easily accessible transportation data (e.g., cost, elevations, construction date, settlement measurements)
Adaptive Capacity (Select examples)
• **Redundancy:** Through traffic may be able to use alternate routes, but access to specific residences and businesses is dependent on the operability of specific roads • **Routine Repair:** Existing routine repair schedules and Public Works Maintenance Crews can be quickly dispatched to respond to physical damage • **Lifespan and Cost:** The relatively short lifespan and low cost of roadway overlays provides opportunities for rehabilitation projects to include adaptive measures. However, significant structural changes (e.g., raising the roadway) would significantly increase costs.

Extreme Temperature

Sensitivity

The following characteristics affect the sensitivity of transportation assets to extreme temperatures:

- **Asphalt mix:** Sustained high temperatures can cause asphalt pavement to soften, resulting in rutting and shoving. Asphalt binder is designed to withstand temperatures up to a certain

threshold. Pavement binder may exhibit sensitivity beginning at 108°F, particularly if combined with truck traffic. Incremental temperature increases up until that point is not likely to cause much damage. Higher temperature threshold asphalt mixes are available at increased costs.

- **Concrete joints:** Concrete pavement can heave at the joints if they are spaced too far apart. When high heat is accompanied by drought conditions, asphalt concrete pavement can crack, making it more vulnerable to water damage when it does rain.
- **Worker and equipment safety:** Health and safety risk as well as possible engine and equipment heat stress begins at around 85°F, but the situation becomes more critical at 105-110°F. Restrictions limiting the number of hours that road crew maintenance can work begin at 85°F. At 110°F, operations are generally halted.

Adaptive Capacity

The adaptive capacity of transportation assets is affected by:

- **Routine pavement repair:** Benicia's established Public Works Maintenance Crews can be utilized to quickly repair roadway damage after it occurs.
- **Asphalt lifespan:** The short lifespan of concrete paving provides opportunities for adopting a new asphalt mix before temperatures significantly increase. This action would have to be coordinated with other transportation agencies.
- **Asphalt cost:** Repaving roads and repairing potholes is a relatively low-cost repair; however, as impacts become more frequent, these costs can add up.

Consequence

Consequences of high temperatures affecting transportation could include:

- **Increased roadway repairs**: Increased roadway repairs would lead to temporary, localized increases in dust and air pollution. Repairs could also require detours, increasing traffic and decreasing access to the Project Area. However, most roadway repairs can be conducted at night to minimize these affects.
- **Higher construction costs**: More frequent repairs and transitions to less temperature sensitive materials could increase the cost of construction and roadway repairs.

Sea Level Rise/Storm Surge

Exposure

Similar to Community Facilities and Services, Transportation assets are affected by flooding during simultaneous rainfall and high tide events. These impacts could become more common with sea level rise, increasing the frequency and severity of roadway flooding. However, as can be seen in Table 7, most of these roadways are not projected to be impacted by flooding from the coast (without a simultaneous rainfall event) until there is 24 to 60 inches of sea level rise/storm surge. At that point, most roadways in the project area could be at least partially inundated on a daily basis by the middle of the century. The Bay Trail, which runs along the coast in several locations, will likely be affected even sooner. As the seas continue to rise, the inland extent of the flooded roadway could increase.

Table 7: Transportation Exposure to Sea Level Rise

Asset	Currently Floods during Heavy Rain Events due to Inadequate Drainage	12 Inch Total Water Level (daily inundation at mid-century)	24 Inch Total Water Level (daily inundation at late mid-century to early end-of-century)	60 Inch Total Water Level (daily inundation at end-of-century)
East 2nd St./East B St.	**X**		**X***	**X**
East 5th St.	**X**		**X**	**X**
Bayshore Road			**X**	**X**
Industrial Way			**X**	**X**
Bay Trail	**X**	**X**	**X**	**X**
Union Pacific	**Unknown**		**X**	**X**

** Implementation of the Waterfront Master Plan may reduce flooding in this area due to the construction of an 18 inch elevated green/seawall. However, full engineering design of this strategy has not yet been completed.*

Sensitivity

The following factors may affect the sensitivity of the transportation network to sea level rise and storm surge:

- **Elevation:** All of the roadways under analysis are at grade (i.e., at ground level) and are constructed of asphalt.
- **Level of flooding:** According to the ART project, a road becomes impassable when covered in one foot of water.
- **Unpaved trails:** Portions of the Bay Trail are unpaved. While unpaved trails are more susceptible to damage during flooding events, they are also less costly to repair.
- **Ancillary support:** Signals and stoplights may be shorted out if their electrical equipment is not adequately protected from floods.
- **Existing pavement cracks**: Existing cracks in pavement can allow flood water to leak in under the pavement and damage the subgrade, which is very sensitive to moisture levels. This could accelerate the deterioration of the roadway.
- **Pavement design:** The sensitivity of pavements depends on the type of pavement design. Thin bituminous pavements are more sensitive to water than other types since because if moisture breaches the subgrade from the pavement shoulder, it can deform the subgrade which is then subjected to high stress loads during traffic. In thick bituminous pavements, the thicker pavement layers help prevent the transmission of stress to the subgrade—the pavement is therefore less sensitive to moisture in the subgrade. However, over time, changes in temperatures and high traffic loads can result in cracking damage in even thicker pavements, which can then be susceptible to accelerated damage from flooding events.
- **Liquefaction:** Roads may be more sensitive to liquefaction (i.e., soils that will behave like a liquid during an earthquake) with increased groundwater levels.

- **Combined stressors:** Flooding works in concert with other variables, such as temperature changes and traffic loading, to shorten the working life of pavement.

Adaptive Capacity

The following attributes may affect the adaptive capacity of the road network to sea level rise and storm surge:

- **Alternate routes:** Alternate routes provide some adaptive capacity; however, by the end of the century, many of the neighboring roads could also be affected by sea level rise. For this reason, area-wide adaptation strategies should be considered.
- **Routine pavement repair:** Benicia's Public Works Maintenance Crews can be utilized to quickly repair roadway damage after it occurs (once the water has subsided). However, the more frequently the roadway floods, the more the integrity of the subbase will be undermined and there will be increased occurrence of cracks and potholes. Additionally, Public Works will not repair the surface of lightly damaged roads when an underlying issue is not being addressed. For example, current flooding on East B Street is due to a clogged stormwater outfall at the base of the road, Public Works will not repair the street until the underlying issue of the clogged storm drain, which leads to the flooding, is repaired.
- **Storm preparation:** Public Works Maintenance Crews use barricades to close roads and set up sandbags in advance of storms to prevent water from spreading. This activity is undertaken without any formal training.

Consequence

Sea level rise effects to the transportation network may have the following consequences for the surrounding communities:

- **Disruptions:** More frequent and serious disruptions to traffic flow could have economic and social consequences. The disruption of truck access to the port, disruption of access to Benicia Industrial Park businesses and access to the Marina could affect the City's economic development, as well as people's access to their homes, places of employment, and shopping locations. There may also be disruptions to the access road to the waste water treatment plant.
- **Maintenance costs:** Some of the common damage from moisture includes surface defects, surface deformations, and cracking. Repairing this damage could increase City maintenance costs.
- **Safety**: Flooded residential roadways may affect the ability of emergency personnel to evacuate those in need, particularly the elderly and low-income households.
- **Public agency coordination**: Planning transportation requires significant interagency coordination, between different levels of government (local, county, regional, state, federal), and different types of agencies (funding, operating, regulatory). The necessity of coordination will only increase with sea level rise affects.

6.3 Port of Benicia

The Port of Benicia is privately owned and operated by Amports; however, the underlying land is owned by the City of Benicia. AMPORTS' lease on the land will sunset in 2032 and until that time, Amports is responsible for all maintenance and upgrades to the property. The port spans 645 acres within the

4,000-acre Benicia Industrial Park, with 140,000 square feet of vehicle processing buildings and a 38-foot deep shipping channel. The 2,400-foot long deep-water pier has the capacity to berth 3 ships, while on-terminal rail access from Union Pacific can potentially utilize 170 railcars. The Port of Benicia is a trading hub with Japan, South Korea, and Australia, and handles general cargo. The port is the Northern California hub for domestic distribution of Ford and Chrysler, and Toyota delivers to Northern California solely through the Port of Benicia. The port also exports oil from the Valero Benicia Refinery.

A high level summary of the vulnerability findings is presented in Table 8. This table is meant to be informative and serve as a jumping-off point for discussion rather than a definitive assessment of all vulnerabilities within the port.

Table 8: Port of Benicia Key Vulnerabilities

Exposure
• The number of high heat days (over 92.4°F) is projected to increase by 36-48 days by mid-century and 44-83 days by end-of century • The average summer temperature is projected to increase by 4-5°F by mid-century and 5-9°F by end of century • Currently protected from flooding by levees; however, water traveling up Sulphur Springs Creek may flood the port property
Sensitivity (select examples)
Physical/Functional Sensitivities • Mechanical equipment is sensitive to flooding and high heat conditions • Paved areas sensitive to high heat and flooding • Shoreline protection, back-up power, and sump pumps reduce the properties sensitivity **Management Sensitivities** • The port is surrounded by other assets with which it will have to coordinate to address flooding issues. These include the Valero refinery, Union Pacific, local roads, and Sulphur Springs Creek • The port is privately owned but the land is leased from the City, which will require coordination on adaptation strategies. According to the lease, Amports is responsible for all property maintenance and upgrades. • Temperature sensitive cargo is sensitive to extreme heat days • Port employees are sensitive to high heat work environments and may require additional breaks until temperatures cool **Information Sensitivities** • Additional information is needed on the temperature design thresholds of port equipment
Adaptive Capacity
• **Redundancy:** The port has some excess storage capacity that could be used in the event of flooding within their standard storage areas • **Planned response:** The port has protocols in place to manage flooding events, thus providing for a faster response and reopening of the property

Extreme Temperature

Sensitivity

The following components of the Port of Benicia may be sensitive to high temperatures:

- **Paved surfaces:** The Port of Benicia has a significant paved area for storage of import cargo. Higher temperatures and extreme heat can cause these paved surfaces to deteriorate more quickly.
- **Metal equipment:** Structures made from metals, such as handling cranes and warehouses, are sensitive to temperature; increased temperature and more extreme heat events can necessitate design for higher maximum temperatures in replacement or new construction of these structures. Most cranes are designed for the normal range of temperatures encountered at sea world-wide (14°F to 95°F). However, cranes can be designed to withstand temperature extremes, such as up to +113°F.
- **Worker safety:** Temperatures over 90°F can cause heat exhaustion for workers and overheating of equipment. Heat exhaustion is likely at 105°F.
- **Temperature sensitive cargo:** It is unknown if the Port of Benicia processes any temperature sensitive cargo that may spoil if exposed to higher temperatures.
- **Air conditioning/refrigeration:** Air conditioning and refrigeration increase worker safety and protect goods from spoilage, thus reducing sensitivity.

Adaptive Capacity

The effects of exposure and sensitivity of the port to high temperatures may be balanced by the following adaptive capacity measure:

- **Continuity of Operations Plan:** A plan that specifies the appropriate response to high temperatures would allow the port to properly shut down and protect sensitive equipment.

Consequence

If the port were to be affected by high temperatures, the following consequences would impact the port and the City of Benicia:

- **Loss of business:** Business may shift to other ports of call if there are issues at the port. This could reduce economic prosperity and potentially lead to a loss of jobs within Benicia.
- **Higher operating costs:** Higher temperatures could result in higher energy consumption and increased costs for refrigerated warehouses or "reefer slots" (electrical plug-ins for containers with on-board cooling units). Electricity outage during extreme heat events can spoil refrigerated goods.
- **Coordination:** The leased structure of the port land will require coordination between the City and AMPORTS to determine an appropriate path towards resiliency.

Sea Level Rise/Storm Surge

Exposure

The very nature of a seaport requires its placement in a low-lying, coastal location. However, the port's landside areas need not be exposed to sea level rise. The Port of Benicia has invested in a levee system to protect it from coastal storms. These levees are identified in the sea level rise maps; however, the vertical accuracy and horizontal extent of the levees in the sea level rise mapping tool may not be an exact match for what is on the ground. Detailed engineering field work, mapping, and modeling would need to be conducted to determine weak spots in the levee network.

The sea level rise mapping conducted for this study indicates that the levee system would begin to be overtopped in the 24 inch total water level scenario with complete overtopping in the 60 inch total

water level scenario. This roughly corresponds with the port's records of coastal flooding occurring approximately three times over the past 30 years.

Behind the levees is a large, flat, paved cargo storage area. Once flood water enters this area, it could immediately begin to spread and inundate large swaths of the storage area.

To the west of the Port of Benicia property is a non-occupied parcel of land, frequently referred to as the Yuba parcel. While this property is currently outside of the Port's boundaries (as indicated in the Bay Plan), parts of the parcel used to function as part of the port. Even today, this property is subject to regular tidal flooding; with most of the area south of the abandoned rail corridor inundated at under 24 inch total water levels.

Sensitivity

The Port of Benicia may be sensitive to sea level rise and storm surge for the following reasons:

- **Changing water level:** The waterside structures are designed to deal with a known range of water level variation with an anticipated maximum. As that maximum increases, the function of the facility can be affected.
- **Pavement condition and materials:** The same way that asphalt roads are sensitive to water (increased deterioration), the low lying, flat, asphalt area used for the storage of cargo is highly sensitive to rising sea levels.
- **Landside access:** The landside portion of the port requires protection to keep from flooding during extreme high tides and waves. Damage to the rail lines and/or roadway would affect operations.
- **Erosion**: While erosion can weaken supports, most channels and waterways are built to withstand erosion. However, increased erosion rates may not be adequately planned for and could thus affect port support structures. The port's levee system is also subject to erosion from wind/wave forces.
- **Electrical equipment:** Damages from flooding can completely destroy electrical equipment, preventing normal port operations. Saltwater can increase metal corrosion. Even the water pumps designed to remove flood water are sensitive to inundation.
- **Drainage system**: Higher sea levels increase the risk of the port's drainage systems being overwhelmed by heavy precipitation and contribute to surface flooding. The port's drainage system is already stressed during precipitation events due to flooding along Sulphur Springs Creek.
- **Dredging:** The Port of Benicia currently has to dredge its ship channels to maintain their depth. Sea level rise may increase the natural depth of the channel, which would reduce dredging maintenance requirements. However, changes in rates of coastal erosion and deposition can lead to changes in sedimentation rates.
- **Liquefaction:** The port area is already susceptible to earthquake induced liquefaction (i.e., the soils behave as a liquid rather than a solid). Increased groundwater intrusion may increase this sensitivity.
- **Equipment Type**: Some equipment is more sensitive to saltwater exposure. For example, some studies report that engines that run on diesel are more resilient against saltwater exposure than electricity-powered engines.[17]

[17] Smythe, T. 2013. Assessing the Impacts of Hurricane Sandy on the Port of New York and New Jersey's Maritime Responders and Response Infrastructure. Quick Response Report No. 238: Final Report to the University of Colorado Natural Hazards Center.

- **Levees:** The port's levee system offers an increased level of protection from coastal flooding, reducing the sensitivity.
- **Back-up generators:** The port maintains emergency generators that can be utilized in the event of a power outage.
- **Storm pumps:** The port has storm pumps on top of its levees that can remove water that collects behind the levees. Diesel back-up generators can also power these storm pumps.
- **Coordination:** The leased structure of the port land will require coordination between the City and AMPORTS to determine an appropriate path towards resiliency.

Adaptive Capacity

The port has already begun to balance its sensitivities with the following sea level rise and storm surge adaptive capacity measures:

- **Excess capacity:** The port has excess storage capacity that can be used to shift cargo to locations that are not affected by flood waters. This is a temporary solution for short term flooding events rather than a permanent storage option.

Consequence

If the port were to be affected by sea level rise and storm surge, the following consequences may come to bear on the port and the City:

- **Temporary closure:** Past flooding events have resulted in short duration (approximately one day) closures of the port.
- **Loss of business:** Business may shift to other ports of call if there are issues at the port. This could reduce economic prosperity and potentially lead to a loss of jobs within Benicia.

6.4 Wastewater

The City of Benicia Wastewater Treatment Plant (WWTP) provides secondary treatment of residential, commercial, and industrial sewage in the city (except process waste from the Valero Benicia Refinery) before discharging it in the Carquinez Strait.

The WWTP on East 5th Street was built in 1958 and has been upgraded and expanded several times. In 2000, the City completed a $20 million upgrade of the WWTP. Since 2000, the City has implemented extensive infiltration/inflow rehabilitation improvements at critical locations in the collection system to limit the amount of stormwater that enters the system, thus reducing the quantity of water that needs to be processed during storm events. In 2005 the City completed a $15 million wet weather upgrade of the treatment plant and collection system.

The plant is maintained and operated by the Public Works' Wastewater Operations Division. The plant has a permitted dry weather capacity of 4.5 million gallons per day and a short-term hydraulic capacity of 24 million gallons per day.

The sewer system is managed by the City of Benicia Public Works Department. The collection system consists of 24 lift stations (used for lifting wastewater from a lower to a higher elevation), approximately 150 miles of sewer pipelines, a 3-mile wet weather relief (interceptor) pipeline, and 6 wet weather control structures (the wet weather system provides storage to ensure the WWTP is not overwhelmed during a rain storm). The treated water discharge system consists of a 1,100-foot long outfall pipeline

and a 150-foot long outfall diffuser pipeline that discharges into the Carquinez Strait. The system's design and construction standards follow the department's Engineering Design Standards and Standard Plans[18] developed in December 1992 with adopted revisions.

The Valero refinery also operates a wastewater treatment plant in the City of Benicia; it specifically processes water used and collected on the Valero property. Although the Valero property was not comprehensively assessed for vulnerability, several stakeholders have expressed concern over the location of the Valero WWTP pools. These pools are located directly east of the Sulphur Springs creek and are thus vulnerable to water backing up the creek due to sea level rise or a storm event. According to the NOAA sea level rise mapping tool, these pools could be very close to flooding with 24 inches of increased total water levels and would be fully inundated under 36 inches of increased total water levels. It is currently unknown if these pools are surrounded by flood walls or any other type of barrier that would minimize the potential for flooding. If the pools were to be flooded, they could release contaminants into the surrounding area and into the Carquinez Strait.

A high level summary of the City of Benicia WWTP vulnerability findings is presented in Table 9. This table is meant to be informative and serve as a jumping-off point for discussion rather than a definitive assessment of all assets within this sector.

Table 9: Key Wastewater Treatment Plant Vulnerabilities

Exposure
• The number of high heat days (over 92.4°F) is projected to increase by 36-48 days by mid-century and 44-83 days by end-of century • The average summer temperature is projected to increase by 4-5°F by mid-century and 5-9°F by end of century • Flood walls will likely protect the WWTP from mid-century flooding but water is projected to travel up East 5th Street and circumnavigate the flood walls, resulting in daily inundation by the end of the century and earlier during extreme storm events (e.g. 50 to 100 year flood)
Sensitivity (select examples)
Physical/Functional Sensitivities • No heat sensitive elements have been identified at the WWTP • Mechanical equipment is sensitive to flooding. Existing pumps offer some capacity to remove water but they may be undersized for future events • The floodwall provides protection from shore side flooding but does not protect against landside water intrusion • The WWTP outfall may not operate properly with additional sea level rise • The wet weather relief system provides storage during rainfall and coastal flooding events to reduce excess load at the WWTP • The WWTP is a large, expensive, and complex system with little to no redundancy within each system

[18] City of Benicia, Public Works Department, Engineering Design Standards and Standard Plans. December 1992. Accessible at: http://www.ci.benicia.ca.us/vertical/sites/%7B3436CBED-6A58-4FEF-BFDF-5F9331215932%7D/uploads/%7B281B84C5-B8BA-4E49-B363-DFA95B5DB02F%7D.PDF

• Rising sea levels could cause rise in groundwater levels around ageing sewer pipes resulting in groundwater intrusion into the pipes and thus loss in sewer pipe capacity **Management Sensitivities** • The existing commitment to monitoring sea level rise (reviewing literature at least every 5 years) and planning to adapt reduces the sensitivity of the WWTP **Information Sensitivities** • There is a need for additional information on the rate of change in groundwater levels and the impact it would have on increased total dissolved solids and flow to the WWTP
Adaptive Capacity
• **Redundancy:** There are no other WWTPs that serve the City of Benicia • **Planned response:** The WWTP holds supply contracts with multiple companies, which helps to ensure the availability of treatment chemicals after an extreme weather event • **Expansion:** The WWTP is geographically constrained, which limits the adaptive measures that could be used to protect the property • **Pumps:** The WWTP has small pumps to remove flood water during storm events

Extreme Temperature

The Vulnerability Survey responses revealed no WWTP sensitivities to temperature extremes. This may not be the case at other WWTP that use different processes (e.g., aerobic ponds).

Sea Level Rise/Storm Surge

Exposure

On the exposure maps, the WWTP appears to be inundated in the 24 inch and 60 inch total water level maps; however, these maps do not account for a sheet piling sea wall constructed as part of the 1998 plant improvements. The wall runs along the south facing edge of the plant, and the engineering drawings indicate a top sea wall elevation of at least 6 feet above ground level. In the 24 inch total water level scenario, this is sufficient to protect the WWTP from flooding. However, by the end-of-century, 60 inch sea level rise scenario, water would encroach high enough up bordering East 5th Street to circumvent the wall and flood over half of the WWTP property from the west. The Waste Water System Master Plan acknowledges the risks of sea level rise and staff is actively engaged in monitoring and updating the sea level rise data and planning element.

Figure 6: WWTP Flooding under 60 Inch Total Water Level

Sensitivity

The following attributes may affect (positively or negatively) the sensitivity of the WWTP to sea level rise:

- **Outfall**: The outfall is highly sensitive to changes in sea level as it could affect the ability of the outfall to discharge treated wastewater, requiring additional pumping to maintain existing performance.
- **Rising groundwater**: If the water table were to cover the sewer pipelines, there could be significant water infiltration into the sewage system. This additional load could impact the WWTP. Additionally, if the groundwater contains salts, then the increased total dissolved solids in the sewage could put additional stress on the system and may hinder sludge settling and overall plant performance.
- **Electrical equipment:** The WWTP main electrical systems, which are key to the plants continued operation, are located underground and are highly sensitive to even low levels of flooding. Equipment with electrical components such as motors, instrumentation, and motor control centers are particularly sensitive to storm events or tidal inundation, and would cease to operate if they were to get wet.
- **Seawalls:** The WWTP is surrounded by flood walls that rise to an elevation of six feet above grade. This elevation will protect the plant from near-term sea level rise scenarios, thus reducing the sensitivity.
- **Pumps:** The WWTP has two storm water pump stations that remove water from the plant headworks for treatment. The below ground electrical vaults also have sump pumps to remove ground water. However, these are small pumps made to remove only small volumes of water during infrequent, short duration flooding events. These pumps do not have significant capacity for frequent and heavy intensity events.
- **Design:** The WWTP was designed to withstand a 20 year storm event which will likely protect the WWTP from the mid-century 12-24 inches of sea level rise.
- **Wet weather relief:** The wet weather relief system provides storage during rainfall and coastal flooding events to reduce excess load at the WWTP. Increased loads can be caused by infiltration into deteriorating sewer lines.
- **Redundancy:** Some elements of the WWTP have built-in system redundancies. However, this is not consistent across all internal systems, and reliance on those redundancies would likely limit the operating capacity of the plant.
- **Planning:** The WWTP System Plan acknowledges the risk posed by sea level rise and requires staff to consider sea level rise and adaptive measures in future planning for major asset rehabilitation and design of WWTP improvements. Additionally, the System Plan requires new sea level rise projections to be reviewed every five years and the City should keep up-to date records on facility elevations and measurements of total dissolved solids in the WWTP influent.

Adaptive Capacity

The WWTP has a number of adaptive capacity measures in place to help reduce the impacts of sea level rise. However, other aspects of the WWTP design limit the adaptive capacity of the plant.

- **Limited room for expansion:** The expansion of the existing system is limited by the available land area and competing uses.

- **Redundancy:** No other WWTP services the City of Benicia.
- **Power:** The WWTP relies upon electricity to operate, which could be interrupted due to flooding or storm events. While backup power is available from portable or on-site generators, these units require fuel resupply to operate beyond a short period.
- **Back-up supplies**: If the on-site generators fail, there are two local companies that can bring portable generators to the plant. There is an existing plan for this procedure. Additionally, the WWTP uses various chemicals to treat the wastewater. In the event that the primary vendor is unable to meet their needs the WWTP has another vendor they could use.
- **Treatment Capacity:** The treatment plant can handle some additional wet weather capacity, but excessive flooding may overwhelm the system, resulting in operational failures, overflows, and backups. Changes to the treatment plant would require expensive modifications to the treatment plant as well as permitting.

Consequence

If the WWTP were to be affected by sea level rise and storm surge, the following consequences may affect the City:

- **Replacement and repair costs**: In general, wastewater treatment components have moderate to high capital replacement costs (e.g., sewer lines, sewer lifts, pump stations, stop gates, interceptors, outfall flow regulator, all electrical and mechanical components, filters), moderate to high operating and maintenance costs (e.g., treatment chemicals, power, staff), and, depending on the extent of the impact, would require significant financial resources to be returned to full function after damage.
- **Fines**: If the WWTP violates its discharge permit (e.g., if groundwater rise or coastal flooding overwhelmed the WWTP and led to the release of untreated sewage), they City could be fined. Fines vary depending on severity and duration of violation, ranging from several thousand to millions of dollars. The Bay Area Air Quality Management District may also levy similar fines.
- **Local Economy**: Failure of the wastewater system could not only affect residential communities and commercial enterprises, but also would adversely affect industrial facilities that require sewer service to operate. The overall economic consequences due to loss of industrial production and employment disruption could be quite significant depending on the duration and extent of the shutdown.
- **Community services**: Access to community services and facilities could be affected, leading to significant cumulative impacts.
- **Pathogens**: Disruption of sewer service or failure of particular wastewater system components could result in backups in the community collection system or sewer laterals that may result in overflows of raw sewage into basements and streets. The result may be exposure of the public to disease-causing microorganisms (pathogens), requiring decontamination, cleanup, and repair or rehabilitation of affected areas.
- **Recreation:** Overflows or discharges of treated or partially treated wastewater could result in limitations on the use of shoreline recreational resources such as the Marina and boat launches, as well as contact recreation such as swimming or boating in areas near the discharge location.
- **Aquatic Resources:** If sewage overflows occurs into the nearshore waters of the Bay at low tide when there is minimal dilution or mixing, the consequences could be significant for the Bay

ecosystem. Pathogens, organic loading, nutrients, and toxics in untreated wastewater could cause a variety of adverse effects on the Bay's aquatic resources.

6.5 Stormwater

The City stormwater system is designed to minimize flooding. Over the last several years, the City has worked to decouple all identified storm and sewer system cross-connections.

Stormwater runoff is generated when rain flows over land or impervious surfaces and does not infiltrate into the ground. Stormwater infrastructure consists of storm drains that collect urban runoff and underground pipes that carry water to the Bay.

While precipitation and associated stormwater can cause flooding directly, this assessment addresses only the affects from the interaction of sea level rise with the stormwater management at the outfalls that discharge stormwater to the Bay. This chapter does not address the potential effects of precipitation based flooding because changes in intensity of precipitation events are projected to be minimal within the Project Area; however, extreme rainfall events may occur slightly more frequently (from the current five times per year to six times per year). See the Task 2 Summary Report for additional information.

The City provides annual reports on its Storm Water Management Plan (SWMP)[19], adopted in 2003, which outlines storm water reduction and control measures, including routine maintenance of infrastructure, removal of blockages and cleaning inlets and basins, and preventative activities such as street sweeping, public outreach, and inspections for illicit discharge.

A high level summary of the vulnerability findings is presented in Table 10. This table is meant to be informative and serve as a jumping-off point for discussion rather than a definitive assessment of all assets within this sector.

Table 10: Stormwater System Key Vulnerabilities

Exposure
• Due to the sub-grade nature of the stormwater system, it will only experience minimal temperature fluctuations • The stormwater outfalls at East 2nd Street and East 5th Street (other outfalls were not assessed) are currently submerged during high tide and extreme storm events and will likely be permanently submerged by mid-century
Sensitivity (select examples)
Physical/Functional Sensitivities • No heat sensitive elements have been identified in the stormwater outfalls • Groundwater intrusion from degraded pipes and rising groundwater levels may decrease the stormwater system capacity • The gravity-fed outfalls are will not operate when submerged, resulting in flooding up the line • Sea level rise and storm surge driven erosion and scour may undermine the stormwater outfalls **Management Sensitivities**

[19] City of Benicia Storm Water Management Plan. 2003. Accessible at: http://www.ci.benicia.ca.us/vertical/Sites/%7B3436CBED-6A58-4FEF-BFDF-5F9331215932%7D/uploads/%7BE61263F5-2CD8-4246-95EB-F4105923D226%7D.PDF.

• The most recent Stormwater Management Plan was adopted in 2003 and only contained an implementation plan that ran through 2008; the City plans to update this document within the next 3 years. • The stormwater system and the WWTP are intrinsically liked (e.g., reducing versus managing wet weather flows) and will need to coordinate in response to climate change **Information Sensitivities** • There is a lack of detailed, easily accessible, and well-coordinated information on the current capacity, design, elevation, and condition of the stormwater system which is needed for site-specific vulnerability assessments • The location of cross-connections between the storm and sewer lines (if any) are unknown—many connections have been eliminated over time
Adaptive Capacity
• **Maintenance:** Routine maintenance of the stormwater system (e.g., cleaning out the pipes) allows for some monitoring and response as changes in climate occur

Extreme Temperature

The Vulnerability Survey responses revealed no stormwater sensitivities to temperature extremes. The underground nature of the system buffers it from temperature extremes.

Sea Level Rise/Storm Surge

Exposure

The focus of the stormwater system assessment is on the storm drain outfalls into the Carquinez Strait. Information from City staff indicates that outfalls at the base of E 2nd Street and E 5th Street are essentially at sea level and currently become inundated during storm events. When the outfalls are submerged, the storm drain system becomes surcharged and rainfall runoff backs up into the community.

Previously, this would cause significant flooding in residential areas, but now the storm water is redirected to the Fitzgerald baseball field which serves as a catchment basin for the water. This level of flooding tends to occur on an annual basis.

With as little as one foot of sea level rise, East B Street and the shoreward portions of East 2nd Street and East 5th Street could begin to flood. This indicates that by the middle of the century, any significant rain event could result in inland flooding due to the storm water outfalls being permanently submerged.

Sensitivity

The following sensitivities affect the vulnerability of the stormwater system to sea level rise and storm surge.

- **Gravity-driven system:** The stormwater system is gravity-driven and has been noted to be under sized for present demand. As sea levels rise, there will be less of a gradient between the source of the stormwater and its eventual destination, and some of the outfalls could be below sea level during high tide or a storm event. This means that Carquinez Strait water could enter the stormwater systems and travel up creeks, channels, and pipes. If elevated Carquinez Strait levels

coincide with a precipitation event, the presence of Bay water in stormwater infrastructure could reduce the system's capacity to store and convey stormwater, which could result in stormwater backing up and causing inland flooding.

- **Location:** The two stormwater outlets analyzed as part of this vulnerability assessment are located essentially at sea level. As sea levels rise, the outlets could be submerged more frequently, increasing inland flooding issues.
- **Soil levels**: Depending on outfall location with respect to Carquinez Strait water levels, the storm system outfalls can be affected by increased erosion or sedimentation, which can impact the stability of the pipelines or their ability to convey stormwater, respectively.
- **Saltwater**: If saltwater travels up the outfall pipes, it could corrode or otherwise damage infrastructure that was only designed to process freshwater.
- **Redirect water:** The City has the ability to reroute stormwater during high tide events to minimize flooding in residential neighborhoods. This minimizes the sensitivity of the area to SLR; however, the future viability of this strategy as sea levels rise, causing more frequent flooding, is unknown.

Adaptive Capacity

The City has limited adaptive capacity measures in place to mitigate the effects of sea level rise and storm surge on the stormwater system.

- **Routine maintenance:** Regular maintenance of stormwater infrastructure, such as keeping storm drains clear of debris and trash, contributes to adaptive capacity. Such maintenance is required in NPDES permits.

Consequence

In the event of impact, the following consequences would occur:

- **Repair costs:** The submersion of the stormwater outfalls increases inland flooding which requires cleanup and costly repairs to structures and landscapes damaged by flooding.
- **Access:** Since the stormwater outfall inundation exacerbates inland flooding, an indirect economic consequence is the business or productivity that could be lost due to commercial buildings being inaccessible if they or the roads required to reach them are flooded. Additionally, residents would be affected if they do not have access to their homes or places of employment.
- **Emergency response:** Flooding could impede emergency response, important not only for immediate problems that could be caused by flooding, but also for related medical or other issues that require urgent attention.
- **Disease**: If floodwaters are not removed quickly, they could become breeding grounds for mosquitoes and other disease vectors.
- **Contaminants**: Flooding can cause the redistribution of contaminants that water picks up from the land surface. An impaired stormwater system would distribute contaminated runoff differently – rather than flowing directly to the Bay, pollutants could be deposited wherever the floodwaters flow.

6.6 Natural Areas/Shoreline Protection

The natural shorelines in the Project Area include:

- The Benicia State Recreation Area,
- The marsh along the Benicia Industrial Park, and
- The marsh adjacent to the Marina and the Waterfront Park area.

These marshes provide ecosystem functions such as wave energy dissipation, flood protection, water filtration, and carbon sequestration, as well as ecological benefits and habitats. Arts Benicia is currently creating an educational public art display on the benefits of biofiltration (i.e., a pollution control technique that uses living material to capture and biologically degrade pollutants). This piece of art will be on display at the Benicia Waterfront.

A high level summary of the vulnerability findings is presented in Table 11. This table is meant to be informative and serve as a jumping-off point for discussion rather than a definitive assessment of all assets within this sector.

Table 11: Natural Areas and Shoreline Protection Key Vulnerabilities

Exposure
• The number of high heat days (over 92.4°F) is projected to increase by 36-48 days by mid-century and 44-83 days by end-of century • The average summer temperature is projected to increase by 4-5°F by mid-century and 5-9°F by end of century • The low lying, natural areas are currently exposed to storm surge events and will be exposed to any changes in sea level
Sensitivity (select examples)
Physical/Functional Sensitivities • Tidal marshes will not keep up with sea level rise on their own due vertical accretion and they are constrained from shifting landward due to hardened infrastructure. This will result in a change in the type of habitats provided by mid-century and an extreme loss of marsh areas by end-of-century • Local plants and animals are sensitive to changes in extreme temperatures and migratory patterns will likely change **Management Sensitivities** • The natural areas are owned, managed, and permitted by a variety of agencies (e.g., CA State Parks, CA Fish and Wildlife, the City of Benicia, BCDC) which will have to coordinate in their response to climate impacts • Existing funding levels are insufficient for planning and implementing large scale responses to climate change vulnerabilities
Adaptive Capacity
• While natural systems have some ability to self-repair, the anticipated changes in temperature and sea level rise will outpace their ability to respond

Extreme Temperature

Sensitivity

The following elements of Benicia's marshes are sensitive to extreme temperatures:

- **Vegetation:** For the most part, marsh vegetation has evolved to withstand a wide range of temperatures. However, changing temperatures could affect plant life cycles and extreme temperatures could threaten natural species and provide advantages to invasive species.
- **Wildlife:** Certain wildlife may be forced out of the area due to changing temperatures and environment**.** For example, adult striped bass only resides locally when water temperatures are sustained below 64.4° F. Larger animals and birds can easily relocate while smaller, less mobile animals may have difficulty relocating to a more hospitable environment.

Adaptive Capacity

The adaptive capacity of the marshes includes:

- **Natural systems:** Natural systems may be able to adjust to small changes in temperature by changing the mix of flora within the marsh. It is unknown how effective this response will be in Benicia.

Sulphur Springs Creek

- There used to be a tide gate approximately 0.4 miles from the Bay to prevent tides from propagating upstream; however, this feature was removed.
- Existing constrictions (e.g., bridge crossings, culverts, beaver dams) in the creek result in bank overtopping.
- Overtopping will increase in frequency and intensity with changes in sea level rise and precipitation.
- The creek flow capacity is restricted due to significant vegetation growth within the creek and on its banks.
- The adaptive capacity is low as the creek is restrained by the industries along the banks as well as the many bridge crossings and several culverts which convey the flow of the creek.

Consequence

Loss of the marshes could impact the community, economy, and species conservation in the following ways:

- **Shoreline protection:** The complete or partial loss of marsh systems would reduce the wave attenuation benefits of natural shoreline protection which could place shoreline residents and businesses at a greater risk of flooding.
- **Recreation:** The community may also face loss of aesthetics and opportunities for outdoor recreation, which may diminish the value of Benicia as a desirable place to live.
- **Habitat:** Downshifts (e.g., changes in classification from mid to low marsh) and loss of marsh habitat could impact plants and animals including several state-listed or federally threatened and endangered species that rely on tidal marsh for breeding, foraging, and high tide refugia.
- **Environmental quality:** Loss of tidal marsh could decrease the potential for carbon sequestration and water quality improvement.

Sea Level Rise/Storm Surge

The vulnerability of the marshes to sea level rise was evaluated through the use of the Point Blue Conservation Science online decision support tool, Future San Francisco Bay Tidal Marshes (hereafter referred to as the Future Tidal Marshes tool)[20]. Marshes are dynamic systems and their response to sea

[20] Future San Francisco Bay Tidal Marshes: A Climate–Smart Planning Tool is available at:

level rise will depend on factors including the rate of sea level rise, their current elevation relative to the tidal frame, mineral sediment availability, and the rate of organic matter accumulation. These factors are incorporated into the Future Tidal Marshes tool, making it a more suitable approach to assessing marshes compared to the NOAA Digital Coast sea level rise maps (used to assess the other asset categories in this study) which do not take into account marsh accretion dynamics. The marsh accretion modeling that forms the basis of the tool have been published in a peer-reviewed journal.[21]

Exposure

By nature, these marshes are low-lying and exposed to tidal flows. When evaluating these areas, the most important question is not whether they will be exposed but rather, how they will naturally respond to changes in exposure.

Sensitivity and Adaptive Capacity

The marsh sensitivity and adaptive capacity was assessed for two time frames, mid-century (2050) and end-of-century (2100), based on the following parameters:

- The tool's "high" rate of sea level rise, 5.41 feet over 100 years from the 2010 baseline, which approximately corresponds (±2 inches) to the sea level rise scenarios of 24 inches by 2050 and 60 inches for 2100 used for the other assets in this assessment. Selecting the exact same rate of sea level rise was not an option provided by this tool.
- Assumed low and high suspended sediment concentration (SSC) values of 50 milligrams per liter (mg/L) and 100 mg/L respectively, determined based on the location within the South Suisun Marsh biogeomorphic subregion (as determined by the tool default values)
- Assumed low and high organic matter (OM) accumulation rates of 2 millimeters per year (mm/yr) and 3 mm/yr respectively, determined based on the marshes' location within the South Suisun Marsh biogeomorphic subregion (as determined by the tool default values)

Historically, under sufficient suspended sediment concentrations, tidal marshes have been able to respond to sea level rise by accumulating mineral sediment and organic material (i.e., vertical accretion), and/or by migrating landward (i.e., upland transgression). This requires a sufficiently high sediment suspension rate and/or there to be inland areas to migrate to. These natural adaptive capacity processes reduce the vulnerability of wetlands to sea level rise. However, these natural shorelines could face difficulties in utilizing accretion of mineral sediment and organic matter to maintain elevation relative to future rates of sea level rise. Even in scenarios with high amounts of sediment and organic matter available, the marshes could downshift in habitat type (e.g., from mid to low marsh to mudflat) as sea level rises. The marshes are especially sensitive to future sediment availability; under the low sediment scenario by 2100, the habitats could significantly transition, including to subtidal in some areas. The marshes are also impeded from inland migration due to limited space between the marshes and adjacent development.

---

http://data.prbo.org/apps/sfbslr/

[21] Diana Starlberg, Matthew Brennan, John C. Callaway, Julian K. Wood, Lisa M. Schille, Dennis Jongsomjit, Maggi Kelly, V. Thomas Parker, and Stephen Crooks. November 2011. "Evaluating Tidal Marsh Sustainability in the Face of Sea-Level Rise: A Hybrid Modeling Approach Applied to San Francisco Bay." Accessible at: http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0027388

The Benicia State Recreation Area is currently composed of upland, mid marsh, and high marsh around the park's intermittent stream, which runs on a mudflat (see Figure 7). By mid-century, the marsh could downshift to mid marsh and low marsh (see Figure 8 for a graphic representation of two potential mid-century scenarios). By end-of-century, most of the marshes could convert to mudflat. The park's intermittent stream could become sub-tidal in the end-of-century scenario due to low suspended sediment concentration. Marsh upland transgression will be constrained by I-780 and Dillon Point Road by end-of-century (see Figure 9 for a graphic representation of two potential end-of-century scenarios).

Figure 7: Current Benicia State Park Marsh Conditions. Source: Point Blue Conservation Science

Figure 8: Benicia State Park in 2050, low vertical accretion (left), high vertical accretion (right). Source: Point Blue Conservation Science

Figure 9: Benicia State Park in 2100, low vertical accretion (left), high vertical accretion (right). Source: Point Blue Conservation Science

The area in front of the Industrial Park is currently composed of a mosaic of mudflats, low marsh, mid marsh, and a few patches of high marsh (see Figure 10). By mid-century, the marsh could transition to a higher percentage of mudflat and low marsh. Some inland migration is expected to occur but is mostly constrained by built infrastructure (see Figure 11 for a graphic representation of two potential mid-century scenarios). The marsh could transition to mostly mudflat by end-of-century, and some areas could become subtidal under the low suspended sediment concentration scenario (see Figure 12 for a graphic representation of two potential end-of-century scenarios).

Figure 10: Benicia Industrial Park Current Marsh Conditions. Source: Point Blue Conservation Science

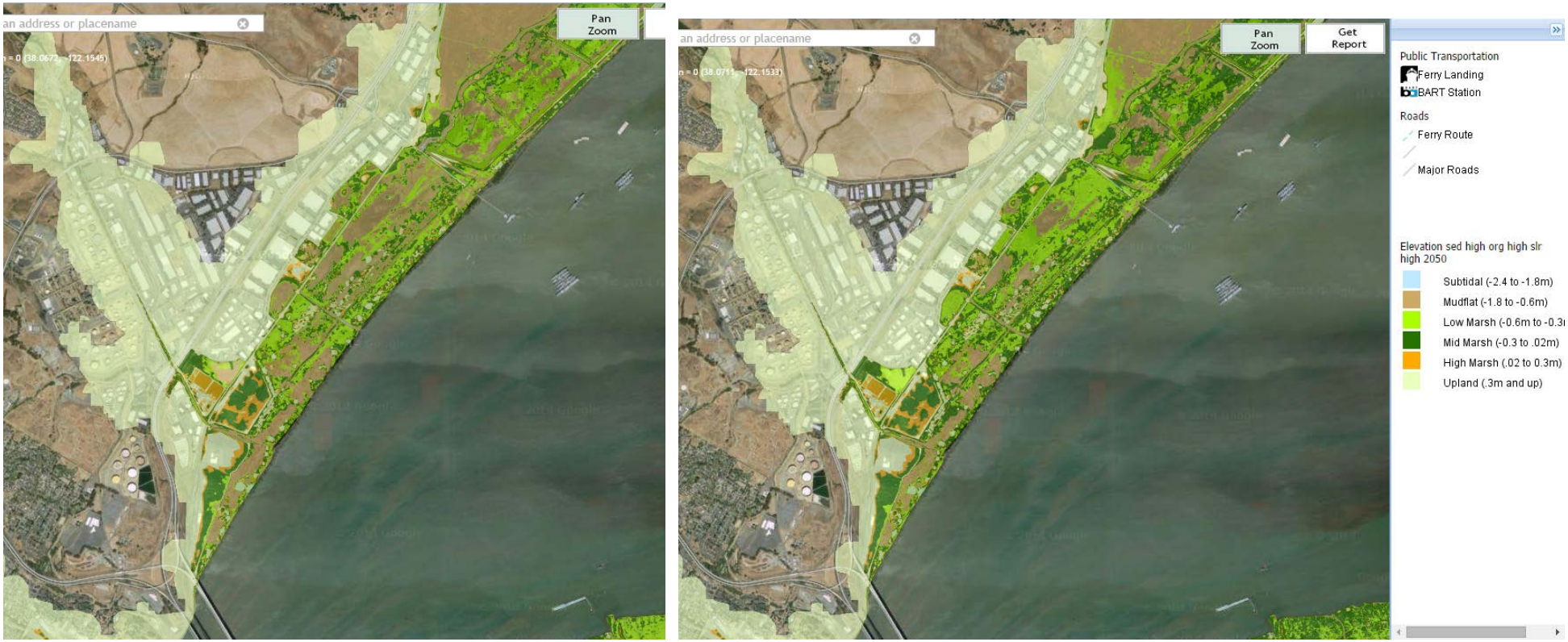


Figure 11: Benicia Industrial Area in 2050, low vertical accretion (left), high vertical accretion (right). Source: Point Blue Conservation Science

Figure 12: Benicia Industrial Area in 2100, low vertical accretion (left), high vertical accretion (right). Source: Point Blue Conservation Science

The marsh area in the front of the Marina is currently comprised of alternating bands of mudflat, high marsh, mid marsh, and low marsh and is directly adjacent to roads (see Figure 13). In the mid-century scenario, the mudflat area could increase and high marsh will decrease (see Figure 14 for a graphic representation of two potential mid-century scenarios). At the end-of-century, the marsh could downshift to entirely mudflat, and some areas could become subtidal under the low suspended sediment concentration scenario (see Figure 15 for a graphic representation of two potential mid-century scenarios). The maps, below, have been cropped to edit out a modeling shortcoming of the tool The tool indicates that, barring human interference, portions of the community would be converted to tidal marshes. This is a limitation of the modeling system and in no way represents current or future plans of the City.

Figure 13: Benicia Marina Current Marsh Conditions. Source: Point Blue Conservation Science

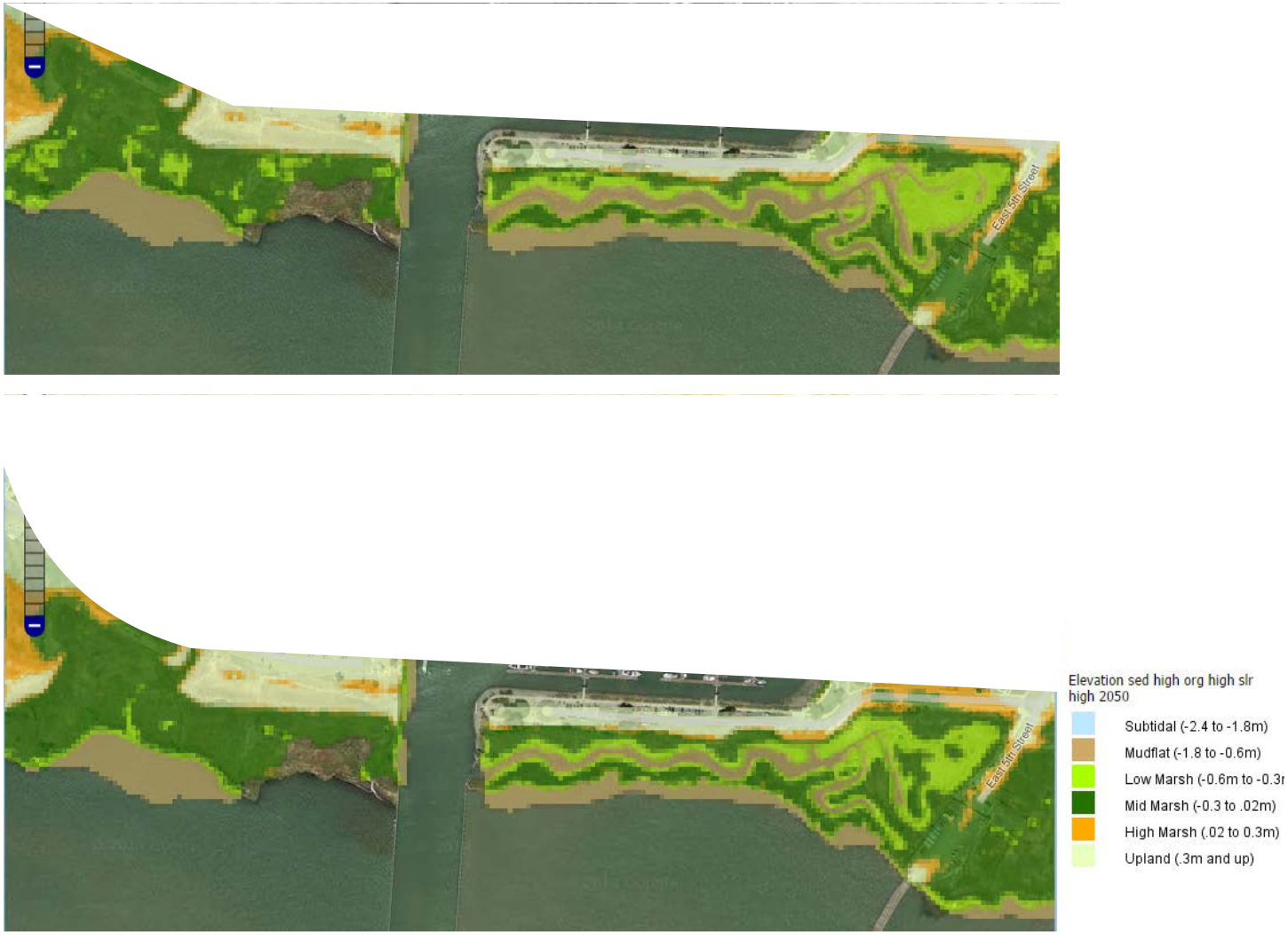


Figure 14: Benicia Marina in 2050, low vertical accretion (top), high vertical accretion (bottom). Source: Point Blue Conservation Science

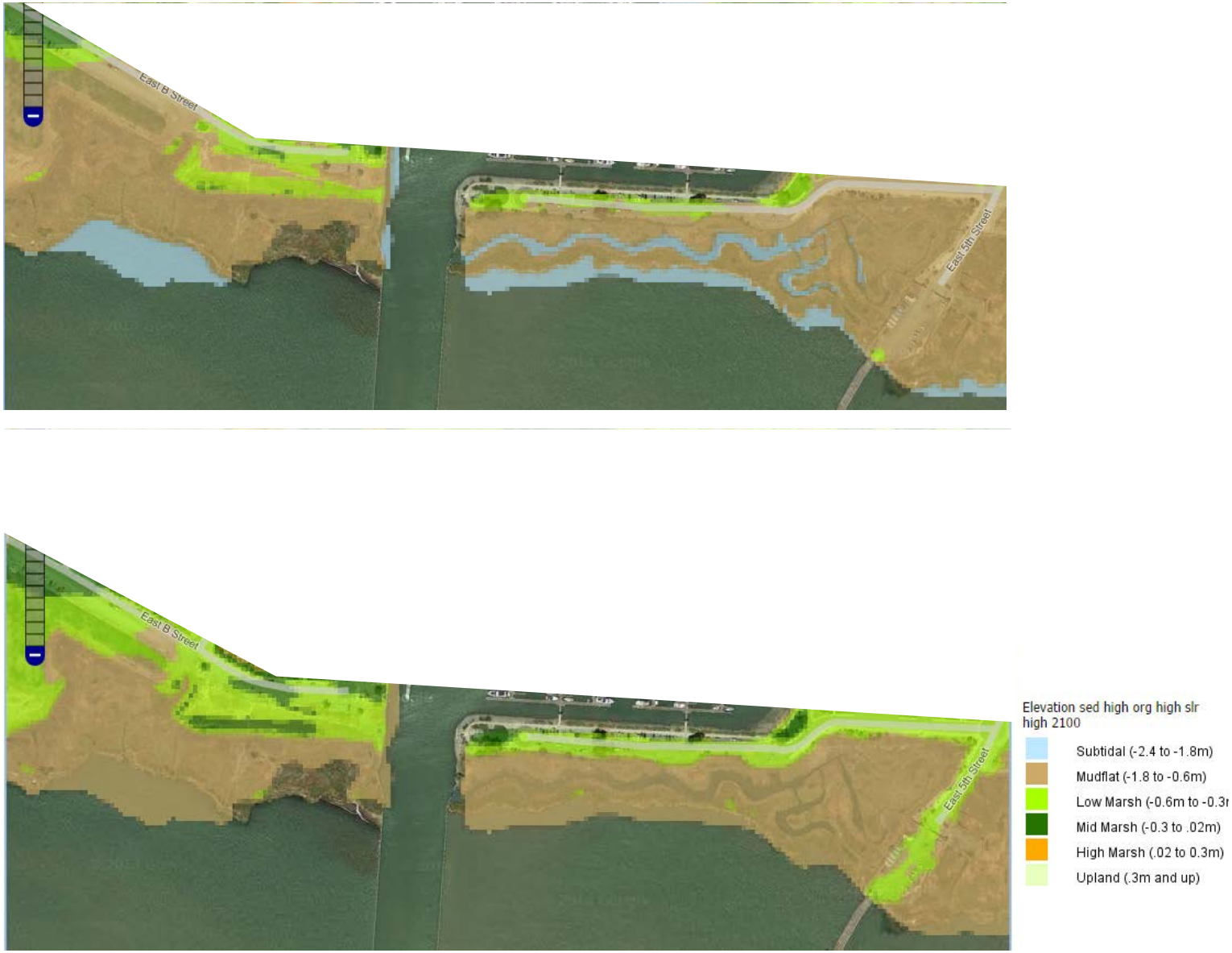


Figure 15: Benicia Marina in 2100, low vertical accretion (top), high vertical accretion (bottom). Source: Point Blue Conservation Science

Consequences

Loss of the marshes would affect the community, economy, and species of conservation concern.

- **Shoreline protection:** The complete or partial loss of marsh systems would reduce the wave attenuation benefits of natural shoreline protection, which would place shoreline residents and businesses at a greater risk of flooding.
- **Economic impact:** The reduction of shoreline protection would have a major economic impact on the Marina and the Benicia Industrial Park, where flooding could require increased maintenance, repair, and upgrade of expensive assets.
- **Recreation:** The community may also face loss of aesthetics and opportunities for outdoor recreation, which may diminish the value of Benicia as a desirable place to live.
- **Habitat:** Downshifts and loss of marsh habitat would affect plants and animals including several State-listed or federally threatened and endangered species that rely on tidal marsh for breeding, foraging, and high tide refugia.
- **Environmental quality:** Loss of tidal marsh would decrease the potential for carbon sequestration and water quality improvement.

6.7 Energy and Pipeline Infrastructure

PG&E is currently the energy provider for the City of Benicia; however, Benicia recently joined Marin Clean Energy (MCE), which supplies customers with an electricity energy mix either 51% or 100% renewable sources. MCE optional services have not yet been rolled out to residents and businesses (service begins May 2015), users will be able to elect to keep their existing PG&E account as well (customers have five chances to opt out). Once MCE is fully operational, they will use PG&E's transmission infrastructure to provide clean energy to their users; therefore, this analysis focuses on the vulnerability of PG&E infrastructure.

PG&E representatives are aware that climate change poses risks to their infrastructure and are internally conducting vulnerability assessments. The City of Benicia is actively working with PG&E to coordinate on developing an appropriate response to climate change vulnerabilities. However, PG&E is sensitive to publicly sharing specifics on their systems vulnerabilities. Due to these concerns, this section only provides a summary of generic risks that heat and sea level rise pose to energy infrastructure, with a few specifics as permitted by PG&E.

Electricity is carried from where it is generated via high-voltage transmission lines, which can be overhead or underground, while natural gas is transported via underground pipelines. Substations link the energy transmission system to the distribution system, transforming power from the high voltage at which it is generated to a lower voltage for distribution to individual homes and businesses via overhead and underground utility lines. There are two substations within the city of Benicia, one of which is owned by PG&E.

Table 12: Energy Infrastructure Key Vulnerabilities

Exposure
• The number of high heat days (over 92.4°F) is projected to increase by 36-48 days by mid-century and 44-83 days by end-of century • The average summer temperature is projected to increase by 4-5°F by mid-century and 5-9°F by end of century • Based on an analysis by PG&E, the two electrical substations in Benicia are not projected to be impacted by sea level rise within the project timeframe
Sensitivity (select examples)
Physical/Functional Sensitivities • Transmission lines are sensitive to high temperatures which may cause line sag and decrease their transmission capacity • Older substations may be sensitive to extreme temperatures due to their design • PG&E actively upgrades their infrastructure to be more resilient to high temperatures • Electrical components are sensitive to corrosion from saltwater **Management Sensitivities** • Increased temperatures will increase energy demand for cooling, thus adding additional stress to the grid • Coordination between public and private companies will be required to address changing demands and vulnerable infrastructure • Emergency operating procedures decrease sensitivity but may need to be updated to prepare for additional extreme heat days and more frequent flooding **Information Sensitivities** • Data sharing between MCE, PG&E, and the City will be required to inform an appropriate response to climate change vulnerabilities
Adaptive Capacity
• **Redundancy:** The electrical grid is highly redundant and loss of any one particular substation is unlikely to have an impact on the City of Benicia • **High Heat Upgrades:** Annual high heat peak load assessments are conducted and equipment is replaced as needed to meet demand • **Influencing Demand:** PG&E operates several demand-response programs to reduce energy demands on hot days

Extreme Temperature

Sensitivity

Energy and pipeline infrastructure is sensitive to high heat conditions in the following ways:

- **Underground pipelines:** Temperature shifts are not expected to have direct or indirect impacts on underground pipelines because pipelines are already designed to accommodate significant temperature variations and the soil that covers the pipelines moderates the temperature effects.
- **Increased demand:** Increased temperatures increase electricity demand, which can overburden the network. This can result in brownouts and rolling blackouts.
- **Mechanical equipment:** Older substations may be damaged by extreme high temperatures.

- **Transmission lines:** Thermal expansion of transmission and distribution power lines causes line sag, decreasing the amount of power that can be securely transported through lines.
- **Planning processes:** PG&E is working to expand their collaboration with cities, counties, and businesses to be better prepared for the impacts of climate change. MCE's core operating mission is to reduce emissions that contribute to climate change.
- **Installing Intelligent Switches:** PG&E installed automated "intelligent" switches on more than 500 electric distribution circuits in 2013. This smart grid technology dramatically reduces the amount of time it takes to restore power to customers. Instead of waiting for a crew to arrive on scene to restore circuits manually, the new devices do it automatically, often within minutes.
- **Enhanced Substations and Circuit Interconnectivity:** PG&E replaced and upgraded substation equipment and added circuit capacity to maintain or restore service when electricity needs to be rerouted during an outage. These upgrades also enable their system to handle increases in demand, such as on hot summer days.

Adaptive Capacity

PG&E and MCE's adaptive capacity is affected by:

- **Redundancy:** The electricity grid is a highly interconnected system. The loss of any particular substation may have no effect on individual energy availability. This is due to the highly interconnected nature of the electrical grid.
- **Emergency power:** MCE has capacity to meet overall peak demand plus a 15% reserve margin that are procured from local reliability areas. This reserve margin can provide temporary relief during high heat events.
- **High Heat Upgrades:** PG&E has a structured process in place to mitigate the impacts of hot weather on their system. On an annual basis, their planning process includes the use of a sophisticated model and past summer season data to forecast peak load on their system relative to system capacity, so that they can take the necessary steps to meet customer demand – from reconfiguring the system to installing new equipment.
- **Influencing Demand:** For heat events, PG&E's demand-response programs (e.g., SmartRate, Peak Day Pricing, SmartAC) help to mitigate peak demand, while PG&E's customer energy efficiency programs help to reduce energy demand on an ongoing basis.

Consequence

In the event of an impact, the following consequences may occur:

- **Loss of power:** If power cannot be shifted, the areas served by affected substations would lose power until any damaged or moved equipment is repaired or replaced.
- **Long-term outages:** Sustained outages could result in a loss of productivity and economic losses due to workplaces and schools being closed. Additionally, businesses may not reopen after being closed for significant periods of time.
- **Loss of vital services:** Telecommunications components and pumps, which are vital during an emergency, could be forced out of service unless backup power is available.

Sea Level Rise and Storm Surge

Exposure

PG&E has conducted a GIS analysis and determined that the two substations located within the Benicia study area are not at risk of flooding between now and mid-century. They assessed the substations using 1) the FEMA 100-year flood zone map, and 2) the projected sea level rise by 2050 (provided by the ICF team). In both cases, the substations are outside of the flood risk area. PG&E did not assess flooding in 2100 because it is beyond their planning horizons.

Sensitivity

Based on academic literature on the potential impacts of climate change on energy infrastructure, PG&E may be sensitive (positively or negatively) to:

- **Corrosion:** Electrical components and pipes that are exposed to sea water are susceptible to damage or destruction due to the corrosive nature of salt water.
- **Underground pipelines:** Waves and storm surge generally do not damage either aboveground or belowground pipelines (e.g., natural gas); however, damage can occur from changes in water tables or soil stability due to sea level rise and from wave action and storm surge, particularly for submerged or low-elevation pipelines.
- **Overhead electric lines:** Overhead electric lines are not sensitive to flooding, unless waves or currents are so strong that they affect pole foundations or cause poles to topple.
- **Groundwater**: Electricity assets are not sensitive to rising groundwater, unless they have underground components – such as a belowground floor of a substation with sensitive equipment that could be exposed to groundwater seeping into the building.
- **Temporary protection:** On-site protection measures such as sandbags or pumping can keep water away from sensitive equipment and reduce sensitivity.
- **Operating procedures:** Substations can be shut down to prevent major damage from floodwaters such as corrosion to transformers, capacitors, switches and other equipment. The proper shutdown of power plants takes time, however, which adds to the sensitivity.

Adaptive Capacity

PG&E and MCEs system adaptive capacity is influenced by:

- **Redundancy:** The electricity grid is a highly interconnected system. The loss of any particular substation may have no impact on individual energy availability. This is due to the highly interconnected nature of the electrical grid.

Consequence

The following consequences could affect the City of Benicia in the event of a sea level rise and storm surge based power outage:

- **Loss of power:** If power cannot be shifted, the areas served by flooded substations would lose power until any damaged or moved equipment is repaired or replaced.

- **Loss of vital services:** Telecommunications and pumps, which are vital during an emergency, could be forced out of service unless backup power is available.
- **Long-term outages:** Sustained outages could result in a loss of productivity and economic losses due to workplaces and schools being closed. Additionally, businesses may not reopen after being closed for significant periods of time.
    - The economic impacts of power outages can be calculated using a spreadsheet calculator tool developed for the Silicon Valley 2.0 project[22]. This tool was not used for this project because the substations are not projected to be impacted by sea level rise.

Table 13: 2012 Cost per Outage Event Estimates by Region and Customer

Region	Outage Duration	Residential ($/Event)	SMB ($/Event)	Large Business ($/Event)
Bay Area	5 minutes	$8.18	$585.2	$761,784
	1 hour	$13.22	$2,679.4	$861,359
	4 hours	$19.59	$6,607.7	$1,073,743
	8 hours	$26.63	$16,463.6	$1,080,310
	24 hours	$37.83	$33,780.9	$2,252,293

Source: Freeman, Sullivan, et al. (2012). Pacific Gas & Electric Company's 2012 Value of Service Study. Available at: http://www.caiso.com/Documents/AttachmentB_ISOResponsesCommentsDraft2012-2013TransmissionPlan.pdf

[22] For more information, see the project website at: http://www.sccgov.org/sites/osp/SV2/Pages/SV2.aspx

7 Next Steps

Following the approval of this report, the City of Benicia and the ICF team will work with the asset owners/managers to confirm the identified vulnerabilities. This finalized information will then be used to inform the development of adaptation strategies. These strategies may be designed to increase the resiliency of an individual asset or a suite of assets. The strategies will include physical changes, management changes, and information gathering and monitoring strategies.

The draft adaptation strategies will be presented at a public meeting and will be available online for public comment. The strategies will be refined, evaluated, and presented to the advisory groups for additional input.

Following the completion of the adaptation plan, ICF will conduct an individual adaptation case study for one business in the Benicia Industrial Park and develop an adaptation effectiveness monitoring plan.

Attachment A: Individual Asset Profile Sheets

The asset profile sheets provide an overview of the asset and a concise summary of the vulnerability to and consequence of climate change impacts on individual assets. The vulnerability data is broken into three key components—exposure, sensitivity, and adaptive capacity—while the vulnerability statements are further classified into physical/functional vulnerabilities, governance vulnerabilities, and informational vulnerabilities. The consequences are divided into economic, environment, and equity consequences.

The purpose of the asset profiles is to act as an information source and tool for the development and prioritization of adaptation strategies for the agencies responsible for each asset. The asset profile sheets contain summarized information collected from the asset owner surveys regarding the vulnerability of specific assets. In some locations, that information is supplemented with the ICF Team's professional experience.

Asset profiles were only created when a completed vulnerability survey was submitted; however, additional information from the ICF Team's professional experience has been used to supplement the survey responses.

Benicia Wastewater Treatment Plant

General Information	
Asset Name	Benicia Wastewater Treatment Plant (WWTP)
Asset Type	Wastewater
Asset Owner/ Managing Agency	City of Benicia
Location	614 East 5th St.
Existing Conditions	
Physical Characteristics	• Built in 1958; remaining service life is undefined. • Major upgrade projects in 1978, 1991, 2000, 2003 • A sheet pile flood wall was constructed in 2000 around the lower perimeter of the WWTP • Preventative and corrective maintenance frequently performed, structural maintenance occurs less frequently • Plant is constructed on bay mud, but the structures are pile supported and do not move
Management Status	• Required to comply with various Federal, State, and local regulatory requirements mainly relating to water quality • Required to inform various agencies about discharges during emergency situations because it is considered a small hazardous waste generator
Public Health and Safety Value	• Vital for public health; treats incoming sewage from domestic and industrial discharges
Community and Economic Value	• Vital public service for the community
Vulnerability	
Exposure	• Although the maps indicate exposure to daily inundation under 24 inches of sea level rise (high, mid-century; low end of century timeframe) and 60 inch of sea level rise (high end of century), they do not take into account the sheet pile flood wall around the structure that will delay exposure to sea level rise

	• By 60 inches of sea level rise, water will travel up East 5th Street and circumnavigate the flood walls • Hottest temperature projected between 2046 and 2099 is 112°F
Sensitivity	• Contains subgrade water and salt sensitive components, including main plant electrical systems, process piping, and concrete process structures • Minimal sensitivity to high temperatures; some equipment fails to operate at temperatures exceeding 120° F (as estimated by WWTP staff) • A sheet pile flood wall around the lower perimeter of the WWTP prevents water from entering during severe storms and high tides • In-plant stormwater pump stations and sump pumps can remove water from the premises during flooding events • Back-up power generators are available for WWTP and sewage lift stations • Underground process pipes are designed to withstand small earth movements
Adaptive Capacity	• WWTP has additional operating capacity to serve future demand • Information from previous studies (e.g., soil studies, process heights) is available • Some redundant operational processes are in place to activate in the event of damage • If back-up generators fail, protocols are in place for two local companies that can bring portable generators to the plant • Emergency food and water is available for staff • WWTP Master Plan calls for monitoring and recording sea level rise, and to incorporate problems/solutions into future projects • Backup chemical supply providers and back-up generator providers increases likelihood of access during climate events • Standard Operating Procedures covers emergency response to flooding
Vulnerability Statements/Key Issues	
Physical and Functional Vulnerabilities	• Wastewater flows increase during severe storms. Historically, such flows have not exceeded capacity but future flows are unknown • Groundwater infiltration may affect subgrade water and salt sensitive components, including main plant electrical systems, process piping, and concrete process structures • Below ground electrical vaults sump pumps only have capacity to remove small quantities of water • Stormwater pump stations may be undersized for future flooding levels • Lack of redundancy throughout the plant

	• This is the only water treatment plant that serves the City of Benicia • Many processes rely on electricity which may fail during flooding events. Off-site emergency generators are available but not feasible for long-term use • Contracts with back-up providers for treatment chemicals increases adaptive capacity
Governance Vulnerabilities	• Permitting and oversight involves many agencies (e.g., BCDC, NPDES, Regional Water Quality Control Board, Bay Area Air Quality Management District)
Informational Vulnerabilities	• Informational vulnerabilities are not apparent at this time
Consequences	
Equity	• The community would be affected if WWTP service is interrupted, as the WWTP receiving waters connect to the community; this could pose a health risk • Shoreline and recreational water activities could be affected depending on severity of chemical/sewage spill
Environment	• Raw or partially treated sewage can be released if the asset fails, affecting public health and the surrounding ecosystem. There is a small potential that chemicals could be released
Economy	• Fines can be levied against the WWTP if it violates water quality permits. Fines vary depending on severity and duration of violation. • If surrounding area and receiving waters were affected by damaged asset, police and/or fire department or outside clean-up firm may be required to assist with emergency response • If the asset failed and affected the receiving waters, the Marina, First Street business owners, and boat launch ramps would face economic impacts because they would have to close during cleanup and remediation

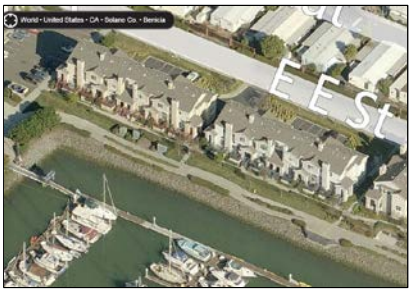
Turnbull Park

General Information	
Asset Name	Turnbull Park
Asset Type	Natural area
Asset Owner/ Managing Agency	City of Benicia
Location	Located at the end of East 5th Street, at the Southeast entrance of the Benicia Marina
Existing Conditions	
Physical Characteristics	• 0.5 acres • Features a small turf area, picnic tables, benches, art piece, and lighted pathway that is part of the San Francisco Bay Trail • Built in 1992; expected remaining life service is indefinite • Last major improvement was pathway lighting replacement (200x) • Cleaned daily; mowed weekly and pruned every six months
Management Status	• Repairs may require permits from SF Bay Conservation & Development Commission, Regional Water Quality Control Board, and Army Corps of Engineers
Public Health and Safety Value	• Contributes to public health and welfare
Community and Economic Value	• Small neighborhood park for the community • Features pathway that is part of the Bay Trail, an important community asset
Vulnerability	
Exposure	• Minimal exposure to tidal erosion under current conditions • May be exposed to daily inundation under 12 inch sea level rise (low, mid-century projection), 24 inch sea level rise (high, mid-century; low end of century), and 60 inch sea level rise (high end of century) • Extreme temperatures projected to increase by 5-10°F
Sensitivity	• Vegetation is sensitive to high temperatures and salt water • Below-ground electrical systems for pathway lighting are water-sensitive • Location on waterfront makes asset sensitive to erosion forces
Adaptive Capacity	• Communications within the department and with outside agencies are adequate • Low redundancy at the asset site but recreational functions can be replaced or recreated in other areas if needed
Vulnerability Statements/Key Issues	
Physical and Functional Vulnerabilities	• Vegetation is sensitive to high temperatures and salt water • Below-ground electrical systems for pathway lighting are vulnerable to ground water intrusion and flooding • Location on waterfront makes the park sensitive to erosion forces • Limited marshes to serve as natural shoreline defense

	• Park serves as protection to the Marina. Damage or loss of the park could put the Marina at risk
Governance Vulnerabilities	• Long-term asset management plans have not been developed • Funding sources and asset management plans that can be used to assess vulnerability or improve asset resilience are not available • Sea level rise and more frequent storm impacts may change the needs at some parks, and resource reallocation may be needed to accommodate shifts in management demands • Changes to the park shoreline or park use to address sea level rise and storm events will require coordination with multiple regulatory agencies, and numerous stakeholders
Informational Vulnerabilities	• Planning-level information is not available for this asset
Consequences	
Equity	• Loss of public access to the shoreline at this location
Environment	• No environmental consequences have been identified
Economy	• Minimal economic consequences to the asset. However, there could be a loss or damage to the Marina and personal property if park is eroded and marshland is reduced

Portside Village Townhomes

General Information	
Asset Name	Portside Village Townhomes
Asset Type	Community Assets
Asset Owner/ Managing Agency	Individual townhouse structures are independently owned, but are required to participate in the Portside Village Owners' Association. The City of Benicia owns the land beneath the townhouses and the storm drain infrastructure
Location	East E Street
Existing Conditions	
Physical Characteristics	• Residential community consisting of 116 luxury townhomes • Provides access to Marina and Bay Trail • Built circa 1997; expected useful life of 50 years with proper operations and annual maintenance • Settlement varied throughout the property ranging from tenths of an inch up to 18 inches. Refurbished in 2013 to address settlement and water damage issues • Regular maintenance includes landscaping, painting, and minor repairs (HOA's responsibility)
Management Status	• The City owns and maintains the land and the drainage system while the individual homeowners maintain their homes.
Public Health and Safety Value	• None identified
Community and Economic Value	• Provides access to Marina and the Bay Trail, a public amenity • Homes are of high economic and community value
Vulnerability	
Exposure	• Property directly fronts the Marina; exposed to daily inundation under 60 inch of sea level rise (high end of century scenario) • Storm drain system is below ground • Additional settlement may increase exposure to sea level rise • During previous extreme weather events, flooding originating from exceedance of capacity of the City's storm drains from off-site properties resulted in stormwater inundation of the asset's properties. The frequency is anticipated to occur during a 5-year storm event or greater • Hottest temperature projected between 2046 and 2099 is 112°F
Sensitivity	• Wood structures may be sensitive to high temperatures, thermal variations, and/or high humidity • Structures and electrical equipment sensitive to flooding • Improvements were made to correct settlement issues
Adaptive Capacity	• No redundant or alternative assets exist to maintain capacity, function, or level of service • Homeowners association provides a resource for coordinating residents to respond to communal challenges • Full architecture and environmental information and technical evaluations/studies are available



Vulnerability Statements/Key Issues	
Physical and Functional Vulnerabilities	• Flooding from exceedance of capacity of the City's storm drains from off-site properties resulting in stormwater inundation. The frequency is anticipated to occur during a 5-year storm event or greater • Wood structures are not waterproofed and vulnerable to rot/mold following flood conditions • Wood structures under high temperatures can experience structural and non-structural issues • Lack of redundant power systems • Residents would be displaced in the event of flooding • Residences and facilities housing animals are functionally vulnerable because evacuation requires special equipment, trained personnel, and appropriate temporary shelter or permanent relocation sites. • Neighborhood function depends on the relationship between individuals within them, and among these individuals and the services they rely on. These informal connections are easily severed during disasters and are often difficult to rebuild once disrupted
Governance Vulnerabilities	• The City's Waterfront Master Plan and the City's Storm Drain Master Plan may contain strategies/projects that could reduce vulnerability. • Permits are required by the City for home repair • Improvements to the land or storm drain infrastructure would be led/managed by the City • Permits from various Federal, State and Local agencies may be required depending on the type and scope of the improvements
Informational Vulnerabilities	• Real-time information for the location and specific needs of homeowners, which is critical to emergency response activities, is difficult to collect and maintain and therefore is generally not available or easily accessible when needed
Consequences	
Equity	• Flooding from lack of storm drain capacity may cause the water to enter into the sewer systems, causing comingling and overloading the sewer system pipelines and treatment systems (as occurred in 2005). Untreated discharge may have negative health impacts
Environment	• Flooding from lack of storm drain capacity may cause the water to enter into the sewer systems, causing comingling and overloading the sewer system pipelines and treatment systems (as occurred in 2005). Untreated discharge may have negative impacts on flora and fauna
Economy	• Damage to assets could decrease home values • Flooding may damage personal property and require paying for emergency shelters • Residents may move away from the City if flooding is frequent/persistent • Insurance rates may increase with increased flooding events and updates to FEMA flood zone maps

	• Residents may not be able to get to their places of employment or may not be able to conduct their business if operated from home • Local, regional and statewide elements funded by the asset's property taxes would be affected

Port of Benicia

General Information	
Asset Name	Port of Benicia
Asset Type	Port
Asset Owner/ Managing Agency	Owned and managed by AMPORTS - APS West Coast Inc. and the Benicia Port Terminal Company, a wholly owned subsidiary; land is leased from the City of Benicia (expires 2023). Amports is responsible for all maintenance and upgrades to the property.
Location	1007 Bayshore Rd, extending North and West beneath the Benicia-Martinez bridge
Existing Conditions	
Physical Characteristics	• Comprised of 645 acres with 140,000 square feet of vehicle processing buildings within the Benicia Industrial Park • Deepwater pier measures 2,401 feet in length and is capable of berthing three vessels simultaneously
Management Status	• Transportation links to the port are managed by different agencies such as Union Pacific and the City of Benicia
Public Health and Safety Value	• None identified at this time
Community and Economic Value	• Vital for port processing and logistic support for import and export automobiles • Provides jobs for the local economy
Vulnerability	
Exposure	• While the maps indicate that the port would be exposed to daily inundation under 24 inches of sea level rise (high mid-century scenario; low end of century) and 60 inches of sea level rise (high end of century), these maps do not accurately represent the port's levee system which will delay exposure to sea level rise. • Extreme temperatures projected to increase by 5-10°F; may also increase exposure to dock fires
Sensitivity	• Levees, levee pumps, and pier are sensitive to water • Dredging is conducted annually • Electric storm pumps and diesel backup are available
Adaptive Capacity	• Port has other property available should storage areas become temporarily unusable
Vulnerability Statements/Key Issues	
Physical and Functional Vulnerabilities	• Several areas experienced flooding in the past (3 events over the past 30 years), resulting in disruptions lasting about 1 day • Levees have minor erosion issues • Road access to the seaport may be sensitive due to its location near the shoreline
Governance Vulnerabilities	• AMPORTS will need to coordinate with various entities that manage the transportation links to the port to develop and implement adaptation strategies
Informational Vulnerabilities	• Planning-level information is not available to assess vulnerability

Consequences	
Equity	• Disruption may affect employment
Environment	• Contaminants at the site (e.g., oil, gasoline) could be released with floodwaters
Economy	• Disruption would affect the port's capacity to ship and receive goods and resulting economic revenue

Downtown Commercial Area

General Information	
Asset Name	Downtown commercial area
Asset Type	Community asset
Asset Owner/ Managing Agency	Generally owned by individuals or companies and leased to businesses. Some properties are owned by the businesses that operate in them
Location	First Street, from Military East to the Carquinez Strait
Existing Conditions	
Physical Characteristics	• Most buildings constructed from early 1900s to the present. Several buildings constructed in the mid-1800's. • Most structures have been updated and continue to be viable. Many businesses update the property interiors regularly; exterior renovations occur less often but is well maintained • Streets, access to businesses, and outdoor properties occasionally experience flooding from the combination of high tide and stormwater runoff
Management Status	• Development and building permit information is managed by the City of Benicia Community Development Department • The Benicia Business Owners Association works closely with key local and regional commerce and economic development departments and associations
Public Health and Safety Value	• Features park space and waterfront access
Community and Economic Value	• Businesses contribute extensively to the local community and economy
Vulnerability	
Exposure	• Streets, access to businesses, and outdoor properties currently exposed to flooding from the combination of high tide and stormwater runoff • Exposed to daily inundation under 60 inch of sea level rise (high end of century scenario) • Extreme temperatures projected to increase by 5-10°F
Sensitivity	• Structures and electrical equipment sensitive to flooding • The businesses frequently undergo reinvestment
Adaptive Capacity	• City's Capital Improvement Program has some but limited capacity to assist with asset management or improvement • OneBayArea Grants and other regional funding sources are available for technical assistance, planning assistance, and transportation infrastructure funding to support smart growth and increased development in Downtown Benicia.
Vulnerability Statements/Key Issues	
Physical and Functional Vulnerabilities	• Occasionally affected by flooding that result from the combination of high tide and stormwater runoff. Streets, access to businesses, and outdoor properties are impacted

	• Properties that rely on electric or mechanical components that are located below grade or on the ground floor may not be able to function when wet
Governance Vulnerabilities	• Owned by various individuals or companies, with limited ability for any given tenant or owner to protect his or her property. May require additional effort to coordinate adaptation actions
Informational Vulnerabilities	• Owned by various individuals or companies; information may not be easily accessible when needed. Communication is also required between the owners and tenants
Consequences	
Equity	• Individual businesses and employment would be affected, resulting in broader impacts to the community
Environment	• None identified at this time
Economy	• Individual businesses may temporarily lose revenue and/or need to pay to repair property damages • Impact to sales and property tax revenue generated to the City of Benicia

Benicia Industrial Park

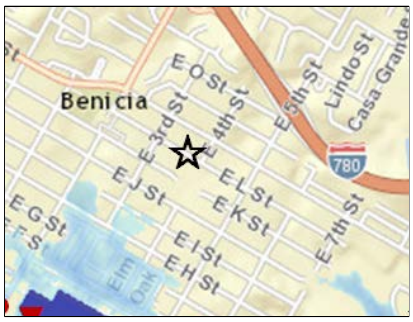
General Information	
Asset Name	Benicia Industrial Park
Asset Type	Community asset
Asset Owner/ Managing Agency	A large percentage of property is owned by large real estate holding companies and leased to businesses of varying size. Some properties are owned by businesses that use them
Location	Located adjacent to Interstate 680
Existing Conditions	
Physical Characteristics	• Approximately 7,000,000 square feet of industrial and businesses park space on about 3,000 acres • Many properties were constructed between the 1950s and the present day. Some properties date back to the mid-1800s to 1930s, when the lower Arsenal was developed • Most structures have been updated and continue to be viable. Businesses update the property interiors regularly; exterior renovations occur less often but properties are generally well maintained • Adjacent to a marsh that serves as a habitat area
Management Status	• Development and building permit information is managed by the City of Benicia Community Development Department • Benicia Industrial Park Association works closely with key local and regional economic development departments and associations
Public Health and Safety Value	• None identified at this time
Community and Economic Value	• Businesses contribute extensively to the local economy
Vulnerability	
Exposure	• Several key streets, access to selected businesses, and some outdoor properties are currently exposed to flooding from the combination of high tide, stormwater runoff, and impeded drainage • Exposed to daily inundation under 60 inch of sea level rise (high end of century scenario) • Many of the buildings have truck access openings that are "dock high" and at grade level, increasing the interiors' exposure to flooding • Extreme temperatures projected to increase by 5-10°F
Sensitivity	• Access roads, structures, and electrical equipment sensitive to flooding • Industrial equipment sensitive to high temperatures • The businesses frequently undergo reinvestment
Adaptive Capacity	• City's Capital Improvement Program (CIP) has some limited capacity to assist with public infrastructure asset management or

	improvement (spurring economic activity through investment in infrastructure and transit is a key element of the City's CIP)
Vulnerability Statements/Key Issues	
Physical and Functional Vulnerabilities	• Occasionally affected by flooding that result from the combination of high tide and stormwater runoff. Streets, access to businesses, and outdoor properties are affected • Properties that rely on electric or mechanical components that are located below grade or on the ground floor may not be able to function when wet • At grade loading docks may be entry points for flooding in buildings • Rail access would be limited if roads are flooded • Industrial equipment may stop functioning or operate at lower efficiencies under extreme high temperatures • The marsh currently serves as a natural barrier for the Industrial Park, but the marsh's ability to adjust to changes in sea level and future storm conditions is uncertain and may increase the vulnerability of the asset • Power outages due to climate change stressors would impact economic activity as many businesses do not have generators
Governance Vulnerabilities	• Owned by various individuals or companies, with limited ability for any given tenant or owner to protect his or her property. May require additional effort to coordinate adaptation actions
Informational Vulnerabilities	• Owned by various individuals or companies; information may not be easily accessible when needed (e.g., location and operation of critical electrical and mechanical components). Communication is also required between the owners and tenants
Consequences	
Equity	• Individual businesses and employment would be affected, resulting in broader impacts to the community
Environment	• Contaminants at the site could be released with floodwaters (over 80 hazardous material sites exist within the Industrial Park[23])
Economy	• Business operations and production could be severely affected if inundated, affecting business revenue and the local economy • Increased repair costs for buildings and industrial equipment • Impacts to the sales and property tax revenue generated to the City of Benicia

[23] City of Benicia General Plan. Appendix G. 1996. Accessible at: http://www.ci.benicia.ca.us/vertical/Sites/%7B3436CBED-6A58-4FEF-BFDF-5F9331215932%7D/uploads/%7B2C1772BF-228B-4371-9B86-214A487209E5%7D.PDF.

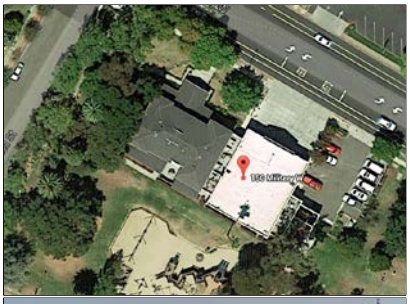
Police Station

General Information	
Asset Name	Police Station
Asset Type	Community asset
Asset Owner/ Managing Agency	City of Benicia
Location	200 E L Street
Existing Conditions	
Physical Characteristics	• Built in 1974 • Houses administrative staff, police officers, detectives, and 911 emergency dispatch center • Consists of meeting rooms, training rooms, two portable buildings, and two holding cells. Locker room and workout room in the basement • Emergency dispatch center recently underwent seismic retrofit
Management Status	• Building permits are required to repair or improve the asset
Public Health and Safety Value	• Vital for police response and public safety
Community and Economic Value	• Police response is important for maintaining a safe community
Vulnerability	
Exposure	• Not exposed to current and future tidal inundation • Hottest temperature projected between 2046 and 2099 is 112°F
Sensitivity	• Minimal sensitivity to high temperature • Recently completed upgrade to 911 system • Facility frequently maintained • Air conditioning is available • Emergency generator is available • Communication mechanisms are adequate for current needs
Adaptive Capacity	• Back-up dispatch available at Fire Station 11 • As built drawings and existing conditions report available (allows for faster diagnosis of issues and development of appropriate responses)
Vulnerability Statements/Key Issues	
Physical and Functional Vulnerabilities	• Critical 911 dispatch and police response would be affected if the asset was disrupted • Police operations would have to be moved to multiple locations if the asset failed
Governance Vulnerabilities	• Funding sources and asset management plans that can be used to assess vulnerability or improve asset resilience are not available
Informational Vulnerabilities	• Informational vulnerabilities are not apparent at this time
Consequences	
Equity	• Medically dependent and those needing emergency response from police would be affected
Environment	• None identified
Economy	• None identified



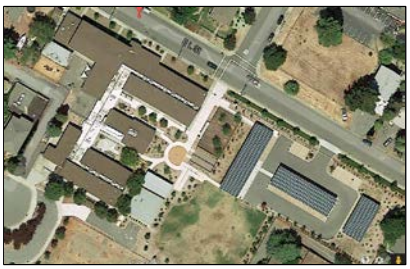
Fire Station

General Information	
Asset Name	Fire Station
Asset Type	Community asset
Asset Owner/ Managing Agency	City of Benicia
Location	150 Military West
Existing Conditions	
Physical Characteristics	• Built around 1995-1996 • Contains a garage for storage of fire trucks and equipment, administrative offices, dormitories for firefighters, a kitchen, workout facility, and living and office areas
Management Status	• Building permits are required to repair or improve the asset
Public Health and Safety Value	• Vital for response to fires and emergencies • The Emergency Operations Center operates out of this location
Community and Economic Value	• Important for maintaining a safe community
Vulnerability	
Exposure	• Asset not exposed to current and future tidal inundation • Hottest temperature projected between 2046 and 2099 is 112°F
Sensitivity	• Minimal asset sensitivity to high temperature • Communication mechanisms are adequate for current needs • Air conditioning is available • Emergency generator is available and recently rebuilt • Facility and emergency generator frequently maintained
Adaptive Capacity	• A second Fire Station is located north of I-780 • A backup Emergency Operations Center is available in the Police Station • As built drawings and existing conditions report available which allows for a faster response following a damaging event
Vulnerability Statements/Key Issues	
Physical and Functional Vulnerabilities	• Critical fire and emergency response services would be affected if the asset is disrupted • Emergency operations center, administrative staff, and firefighters would need to be relocated if the asset fails
Governance Vulnerabilities	• Long-term asset management plans have not been developed • Funding sources and asset management plans that can be used to assess vulnerability or improve asset resilience are not available
Informational Vulnerabilities	• No informational vulnerabilities apparent at this time
Consequences	
Equity	• Medically dependent and those needing emergency response from firefighters would be affected
Environment	• None identified
Economy	• None identified



Benicia Community Center

General Information	
Asset Name	Benicia Community Center
Asset Type	Community asset
Asset Owner/ Managing Agency	Owned by the Benicia Unified School District. Managed by the City of Benicia
Location	370 East L Street
Existing Conditions	
Physical Characteristics	• Built 1957; major building renovation completed in 2011 (LEED Gold certified); expected remaining service life is indefinite • Office space for the Recreation and Administrative Divisions of the Parks and Community Services Department • Provides space for meetings, classes, and community programs
Management Status	• Benicia Unified School District leases the facility to the City of Benicia (40 year lease with two ten year extensions executed by the City of Benicia)
Public Health and Safety Value	• Building used as a public cooling center during high temperatures • Serves as a shelter during a disaster
Community and Economic Value	• Important space for community gathering including after-school program, pre-school programs, senior programs, youth sports, and girl and boy scout programs
Vulnerability	
Exposure	• Asset not exposed to current and future tidal inundation • Hottest temperature projected between 2046 and 2099 is 112°F
Sensitivity	• Minimal asset sensitivity to high temperature • Frequently maintained • Communication mechanisms are adequate for current needs • Air conditioning is provided
Adaptive Capacity	• As built drawings and existing conditions report available • An evacuation plan is in place • Community programs could be relocated to other City facilities • Plan in place to refer community members to the Community Action Council or Family Resource Center during flooding events
Vulnerability Statements/Key Issues	
Physical and Functional Vulnerabilities	• Back-up electricity services are not available. The asset would be unable to serve as a cooling center or shelter during emergencies if power is lost and community members would be referred elsewhere
Governance Vulnerabilities	• Managing entity may have limited ability to make changes to the property under the current lease agreement with the Benicia Unified School District. May require additional effort to coordinate adaptation actions



	• Funding sources and asset management plans that can be used to assess vulnerability or improve asset resilience are not available
Informational Vulnerabilities	• No informational vulnerabilities apparent at this time
Consequences	
Equity	• Impact to community programs, especially for seniors and children • Asset would be unable to serve as a shelter or cooling center for at-risk populations • Full-time City workers would have to be relocated and part-time recreation leaders and instructors would be out of work depending on length of disruption
Environment	• None identified
Economy	• Cost to the community would depend on severity of damage and length of disruption

City Hall

General Information	
Asset Name	City Hall
Asset Type	Community asset
Asset Owner/ Managing Agency	City of Benicia
Location	250 East L Street
Existing Conditions	
Physical Characteristics	• Built around 1927 • Contains offices for administrative staff in the Offices of the City Manager, Finance, City Attorney, Community Development, and Public Works • Contains a Council Chambers and several meeting rooms • Two portable buildings on the east side of City Hall for Human Resources • Roof replaced around 2002 • All lighting upgraded in 2011-2012 • 76 MW solar facility supplies power to City Hall and Electric Vehicle Fast Charger • 40 kWh on site battery storage, not building tied, used only for charging presently
Management Status	• Building permits are required to repair or improve the asset
Public Health and Safety Value	• The Office of Public Works housed within City Hall is responsible for managing services essential to public health, including water and wastewater treatment
Community and Economic Value	• The City's administrative offices are vital for the community's operations and finances
Vulnerability	
Exposure	• Asset not exposed to current and future tidal inundation • Hottest temperature projected between 2046 and 2099 is 112°F
Sensitivity	• Minimal asset sensitivity to high temperature • General maintenance frequently conducted • Communication mechanisms are adequate for current needs • Air conditioning is available
Adaptive Capacity	• As built drawings and existing conditions report available
Vulnerability Statements/Key Issues	
Physical and Functional Vulnerabilities	• When the City experienced a power outage that lasted for half the day, City Hall was able to partially function – how so? • Services would need to be relocated to other City facilities if the asset were disrupted for a significant period or damaged
Governance Vulnerabilities	• Long-term asset management plans have not been developed • Funding sources and asset management plans that can be used to assess vulnerability or improve asset resilience are not available

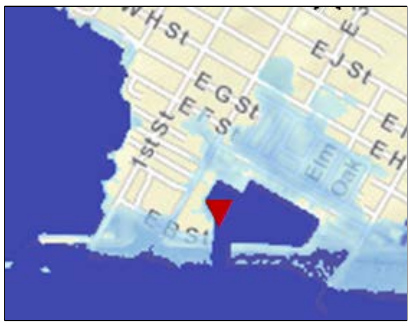
Informational Vulnerabilities	• No informational vulnerabilities apparent at this time
Consequences	
Equity	• Citizens throughout the community may experience disruptions to the City's critical operations
Environment	• None identified
Economy	• Cost to the community that relies on City Hall's services would depend on severity of damage and length of disruption

Fitzgerald Field

General Information	
Asset Name	Fitzgerald Field
Asset Type	Community Facilities and Services
Asset Owner/ Managing Agency	City of Benicia
Location	East 2nd and H Street
Existing Conditions	
Physical Characteristics	• 4 acre field containing a single baseball diamond and parking area • Originally constructed in the 1940's; life expectancy is indefinite • Cleaned daily and mowed weekly • Last major improvement was lighting replacements
Management Status	• Building permits are required for electrical or structural improvements
Public Health and Safety Value	• Contributes to public health and welfare by providing exercise facilities • Area used as retention area during high tides/heavy storms
Community and Economic Value	• One of the City's two baseball field complexes located downtown
Vulnerability	
Exposure	• Exposed to daily inundation under 60 inch of sea level rise (high end of century scenario) • Hottest temperature projected between 2046 and 2099 is 112°F
Sensitivity	• Water-sensitive electrical systems are located underground • Communication mechanisms are adequate for current needs
Adaptive Capacity	• Electrical drawings are available which may facilitate a faster response in the event of climate impacts • Low redundancy at the asset site but recreational functions can be replaced or recreated in other areas if needed
Vulnerability Statements/Key Issues	
Physical and Functional Vulnerabilities	• Flooding can disrupt use of the field during baseball season, depending on how long it takes to dry. Occurs at least once a year. The frequency of use of the field as a flooding retention area may change under future conditions • Safety netting was damaged after a heavy wind and rain storm. Replacement cost was over $2,000
Governance Vulnerabilities	• Funding sources and asset management plan that can be used to assess vulnerability or improve asset resilience are not available
Informational Vulnerabilities	• No informational vulnerabilities apparent at this time
Consequences	
Equity	• Loss of baseball field space for children and adults
Environment	• No environmental consequences have been identified
Economy	• No economic consequences have been identified

Benicia Marina Harbor

General Information	
Asset Name	Benicia Marina Harbor
Asset Type	Community Facilities and Services
Asset Owner/Managing Agency	Owned by the City of Benicia. Managed by the Benicia Harbor Corporation (BHC)
Location	266 East B Street
Existing Conditions	
Physical Characteristics	• Built in 1984; expected service life of 100 years • Features a fuel dock, pump-out station, launch ramp, general store, restrooms and showers, laundry facilities, and secured gates • Upgraded fuel dock in 2009 • Dock maintenance conducted daily
Management Status	• Managed through a long-term lease • BHC has permits to maintain and repair the asset
Public Health and Safety Value	• None identified
Community and Economic Value	• Draws in revenue and contributes to the downtown economy
Vulnerability	
Exposure	• Asset is located on the water • Marina infrastructure (e.g., buildings, fueling facilities, public space, fixed dock elements) may be exposed to daily inundation under 12 inch sea level rise (low, mid-century projection), 24 inch sea level rise (high, mid-century; low end of century), and 60 inch sea level rise (high end of century) • Extreme temperatures projected to increase by 5-10°F • Employees take additional breaks under high temperature conditions to reduce their exposure
Sensitivity	• Asset is built for the water, providing it with lower sensitivity to flooding compared to assets on land • Pipelines that are located below ground are secured so they will not become buoyant
Adaptive Capacity	• Planning-level drawings are available which may allow for a faster response in the event of climate impacts • California Department of Boating and Waterways may serve as a source of funding that can be used to assess hazard risk or vulnerability
Vulnerability Statements/Key Issues	
Physical and Functional Vulnerabilities	• Built to withstand current tidal, wind, and wave conditions, but asset may not be designed to handle future conditions • Tree removal was conducted after a previous weather event. Estimated cost of $10,000 • Breakwall needs major repair



Governance Vulnerabilities	• Permitting and oversight involves many agencies (e.g., BCDC, City of Benicia, Fish and Wildlife)
Informational Vulnerabilities	• Mechanisms to share information between departments within the managing agency are not apparent; mechanisms to share information with the California Department of Boating and Waterways are adequate under current conditions
Consequences	
Equity	• Marina employees may lose their jobs
Environment	• Damage to the fueling station could result in fuel spills
Economy	• Loss in revenue to the downtown economy

Transportation Assets

General Information	
Asset Name	Transportation assets including East 2nd Street, East 5th Street, Bayshore Road, East B Street, and Industrial Way
Asset Type	Transportation
Asset Owner/ Managing Agency	City of Benicia
Location	East 2nd Street, East 5th Street, Bayshore Road, East B Street, and Industrial Way
Existing Conditions	
Physical Characteristics	• Assets built around the turn of century • Ongoing maintenance includes street cleaning, repair, and overlay • Assets flood during storms with high tide, winds, and rainfall • The bottom of East 2nd Street and East B Street continue to settle
Management Status	• Financing mechanisms for improving climate resiliency are limited at this time. Transportation assets are often expensive, require lengthy environmental review and involve multiple permitting agencies. Finding strategies that will allow for a quick response will be a challenge
Public Health and Safety Value	• Assets provide access that is critical for public health and safety
Community and Economic Value	• Assets provide access for community members to homes, workplaces, and recreational areas • Assets provide access for transportation of goods
Vulnerability	
Exposure	• Bayshore Road and East 5th Street exposed to daily inundation under 24 inches of sea level rise (high, mid-century scenario; low end of century) and 60 inch of sea level rise (high end of century). East 2nd Street exposed to daily inundation under 60 inches of sea level rise (high end of century). • Extreme temperatures projected to increase by 5-10°F
Sensitivity	• Road asphalt is sensitive to high temperatures • Location on waterfront makes asset sensitive to erosion forces
Adaptive Capacity	• Capital Improvement Plan is a potential funding source in the event of climate damage • In many locations, there are no transit options to provide transportation alternatives
Vulnerability Statements/Key Issues	
Physical and Functional Vulnerabilities	• Temporary or permanent inundation of coastal roads • The bottom of East 2nd Street and East B Street may become especially vulnerable to sea level rise and storm surge as they continue to settle. Settlement is not being measured • Road asphalt deterioration due to prolonged heat • Access for critical services may be impaired

	• Vehicles have some flexibility to use alternate routes, but these routes may lack the capacity to serve additional traffic and heavy congestion • Insufficient capacity on alternate routes results in a lack of redundancy for the network when one section or asset is temporarily or permanently damaged or affected by inundation or storm events • Rising groundwater increases the risk of liquefaction, which could cause damage to road surfaces • In a few instances, there are communities or facilities that are linked by only one or two access ways and these communities and facilities may be isolated if these access ways were compromised.
Governance Vulnerabilities	• Special processes for emergency repairs may not be available • Improvements to increase climate resilience may involve multiple permitting agencies
Informational Vulnerabilities	• Planning level information is not available to assess vulnerability
Consequences	
Equity	• Disruptions to transportation assets would increase traffic and affect commuters • Some communities lack redundancy in transportation alternatives. A loss or re-routing of a bus route or other transportation service could inhibit the ability of those residents to travel • Community members, especially at-risk populations, may become stranded in a flood • Loss of community access to the shoreline
Environment	• The loss of a portion of the transportation network may increase the region's congestion, resulting in greater emissions and lower fuel efficiency
Economy	• Increased maintenance and repair costs • Goods movement via ground transportation would be impaired and affect the local and regional economy • Workers who rely on vulnerable roads may be unable to get to work, affecting their wages and the economy of the region

Stormwater Outfalls

General Information	
Asset Name	Stormwater outfalls at East 2nd Street and East 5th Street
Asset Type	Stormwater
Asset Owner/ Managing Agency	City of Benicia
Location	East 2nd Street and East 5th Street
Existing Conditions	
Physical Characteristics	• Assets built around the turn of the 20th century • Ongoing maintenance includes storm drain cleaning
Management Status	• Permits from local, State, and federal agencies are required for repairs and improvements
Public Health and Safety Value	• Stormwater outflows contribute to stormwater control, which protects public health and safety during flood events
Community and Economic Value	• Stormwater outflows contribute to stormwater control, which protects assets vital for the community and economy, such as homes, businesses, and transportation networks
Vulnerability	
Exposure	• May be exposed to daily inundation under 12 inch sea level rise (low, mid-century scenarios), 24 inch sea level rise (high, mid-century; low end of century), and 60 inch sea level rise (high end of century). Sea level rise inundation mapping likely does not take into account height of outfalls • Hottest temperature projected between 2046 and 2099 is 112°F
Sensitivity	• Sensitive to large volumes of stormwater that the assets are not designed to handle
Adaptive Capacity	• Assets have lacked capacity during previous storm events when rain events coincide with tide tides • Capital Improvement Plan potential funding source • Lack of redundancy
Vulnerability Statements/Key Issues	
Physical and Functional Vulnerabilities	• Capacities of the outflows are currently insufficient to handle stormwater during storm events when rain events coincide with tide tides and causes upstream flooding. Assets may not be designed to handle future stormwater conditions • Mechanisms to control inflow to the system are not in place; where outflows are below the storm event or high tide water level, inflows from storm surge and sea level rise can cause discharge to back up, resulting in flooding
Governance Vulnerabilities	• Permitting and oversight involves many agencies
Informational Vulnerabilities	• Information such as outfall elevations and pipe capacity are lacking, which hinder the evaluation of vulnerability and identification of adaptation strategies.

Consequences	
Equity	• Backup will cause continued flooding in the community
Environment	• Flooding due to backup could redistribute contaminants (e.g., oil washed from the roadways), possibly harming sensitive habitats
Economy	• Backup in storm drain pipes can cause flooding and damage, resulting in significant repair costs • Flooding can block access to employment centers and businesses and impact the local economy

Benicia State Recreation Area

General Information	
Asset Name	Benicia State Recreation Area
Asset Type	Natural Area
Asset Owner/ Managing Agency	California Department of Parks and Recreation (CA State Parks)
Location	Located at the eastern edge of Benicia near Interstate 780, on the north shore of the Carquinez Strait and Southampton Bay
Existing Conditions	
Physical Characteristics	• Approximately 469 acres • Features 1.2 mile Marsh Trail and a 0.75 mile bike trail along I-780. Dillon Point Road is also utilized as a bike/pedestrian way • Included within it is the Southampton Bay Natural Preserve which protects the marsh and the endangered plant and animal species that inhabit the area • Regular maintenance includes road and trail improvement, weed control, and natural resource protection through invasive species control and special status species monitoring and reporting
Management Status	• Opened in 1967 and is managed and maintained by the State Parks System • Managed to provide health, education, and opportunities for outdoor recreation while preserving natural resources • Managing agency participates in regional planning discussions as needed and has collaborative relationships with State and local municipalities in the region
Public Health and Safety Value	• Offers recreational opportunities and contributes to public health
Community and Economic Value	• Important community asset that offers recreational opportunities, fishing, and scenic views for the public
Vulnerability	
Exposure	• The majority of the park is bayside • Exposed to daily inundation under 24 inches of sea level rise (high, mid-century scenario; low end of century) and 60 inch of sea level rise (high end of century) • Some areas of the park include natural beach environment and tidal marsh, which are exposed to wave action • Extreme temperatures projected to increase by 5-10°F • Rip rap and other hardened shorelines exist at Dillon Point and Military West areas of the park
Sensitivity	• Plant and animal species within the Park are very sensitive to factors including temperature, salinity, and inundation
Adaptive Capacity	• Elevation details describing portions of the tidal marsh were prepared in the 1990s which may be beneficial in the event of climate impacts • Mechanisms to share information within internal departments and partner agencies are sufficient under current conditions

	• General Plan for the State Park, which is relevant to asset management and improvement, is available • Lack of redundancy of the habitats and trails
Vulnerability Statements/Key Issues	
Physical and Functional Vulnerabilities	• Water level in the marsh is not managed; natural ability of the marsh to adapt to storm surge and sea level rise is unknown • Habitats for native species cannot be replaced if inundated • Plant and animal species would be affected by changes in temperature, precipitation, and sea level rise • Trails may be inundated
Governance Vulnerabilities	• State Parks do not have funding available to assess marsh ecosystem vulnerability to climate change. However, outside funding from regulatory agencies seeking to further protect plants and animals that may be endangered in the future (e.g. USFWS or DFW), may be a source of funding
Informational Vulnerabilities	• Information about marsh migration, temperature thresholds for natural vegetation and wildlife, and water quality impacts is unknown. Funding for research on this is required.
Consequences	
Equity	• Damage to the asset would affect community members who rely on the park for recreation and health maintenance, including the elderly and young families
Environment	• Loss of habitat for the federally threatened or endangered soft bird's-beak (a native herb), California clapper rail, salt marsh harvest mouse, and California black rail. The soft birds beak is particularly at risk, whose populations at this location are some of the largest in existence
Economy	• None identified

Liberty High School

General Information	
Asset Name	Liberty High School
Asset Type	Community Facilities and Services
Asset Owner/ Managing Agency	Benicia Unified School District
Location	350 E K St
Existing Conditions	
Physical Characteristics	• Has been closed during extreme weather events due to power loss
Management Status	• The Department of State Architects is required to evaluate and approve all major facilities repairs and upgrades
Public Health and Safety Value	• Safe schools are important for the health and well-being of students
Community and Economic Value	• Vital community asset for both students and parents
Vulnerability	
Exposure	• Asset not exposed to current and future tidal inundation • Extreme temperatures projected to increase by 5-10°F
Sensitivity	• Children are particularly vulnerable to high temperatures • Sensitive to impacts to external services since schools rely on power, clean water, and food supplies for the safety of students • Small pumps are in place to clear small amounts of water but the asset does not have systems in place for larger groundwater issues
Adaptive Capacity	• A facilities needs assessment was recently completed in 2013 and is available • A school facility plan is available and is part of the general facility plan. Plans are made public at governing board meetings • If the school site were compromised, existing school sites with additional portable classrooms would be used. If more than one school site were compromised, the California Department of Education would assist with alternatives • Short term emergency supplies available • Site safety plans include evacuation plans for young children • Individual plans are in place for students with disabilities
Vulnerability Statements/Key Issues	
Physical and Functional Vulnerabilities	• Although small pumps are in place to clear small amounts of water, they may not have sufficient capacity under future stormwater conditions • Specific temperature thresholds at which to close the schools have not been identified • If the City's sewer system were compromised, school would be unable to serve students without a safe, clean water supply • If the power system were compromised, school would be unable to serve students without reliable power

Governance Vulnerabilities	•	Specific funding sources to increase resilience are not available
Informational Vulnerabilities	•	No information vulnerabilities apparent at this time
Consequences		
Equity	•	Children are particularly vulnerable to extreme temperatures and flooding
Environment	•	None identified
Economy	•	School closures would create a major impact for the community, including parents who need to attend work

Attachment B: Vulnerability and Risk Survey

In order to collect information on asset vulnerability and risk, the following survey was programmed into Google Forms and distributed to asset managers as a weblink and PDF. The PDF allowed users to develop their responses prior to entering them into the online form.

The original set of questions (which closely matches this) was developed by BCDC as part of the ART project. The ICF Team tailored BCDC's questions to the scope of the current project. For example, select questions were removed and questions on the impacts of extreme temperatures were added.

Not all questions were asked of all users; asset managers only saw questions that were tailored to their specific asset sector (e.g., the police station was not asked to provide information on the temperature at which local marsh flora would be threatened). The asset specific questions are identified below with X's identifying the sectors the question is applicable to. The ICF Team was able to implement this process by using Google Forms question skip logic.

Background Questions
Thank you for taking the time to complete the City of Benicia Vulnerability and Risk Assessment Survey. The purpose of this survey is to get your best professional judgment on how sea level rise, coastal storms, and high temperatures will affect the services, facilities, and systems that you plan for, operate and/or manage. The survey has four sections. BACKGROUND information about your area of expertise, and the service, facility or system that you wish to address in the survey. EXISTING CONDITIONS consisting of questions about the ownership, management, maintenance, and past damage to your asset. VULNERABILITY ASSESSMENT consisting of four parts - information vulnerabilities, governance vulnerabilities, physical vulnerabilities, and functional vulnerabilities. These questions also ask about the ability of your asset to manage the vulnerabilities. RISK ASSESSMENT consisting of questions about the consequence or magnitude of effect on social, economic, environmental, and governance systems. Your responses to the following survey are confidential. The City of Benicia will not directly quote any of your information without explicit consent.
What is your name?
What agency or organization do you work for?
What department, section, or unit do you work for within your agency or organization?
What is your job title?
Existing Conditions
Briefly describe the asset and its functions.
Where is the asset located and what is its geographic extent?
Who owns and manages the asset? Note if the owner and manager are different entities.
What year was the asset built and what is its expected remaining service life?
When and what was the last major repair or improvement to the asset?
What is the most frequent type of maintenance and how often is it conducted?

Has the asset been disrupted in the past due to an unplanned event e.g., weather related closure, emergency repair or improvement, work strike, or other event? If yes, how long did the disruption last and was the asset able to continue functioning either partially or fully?
Is the asset currently under consideration for capital improvement or investment, or is it in an area that is planned for future development /redevelopment?
Has there been locally observed land subsidence that could potentially put the asset at greater risk of flooding? If yes describe the location, amount of land motion, and the approximate timeframe over which the subsidence has occurred.
Information Vulnerabilities
Is planning-level or project-level information available to assess vulnerability, e.g., as-built drawings, existing conditions reports, monitoring or inspection reports, etc.?
What mechanisms exist to share information between departments within the managing agency? What mechanism exists to share information with partner agencies, non-governmental organizations, and the public? Are these mechanisms adequate?
Governance Vulnerabilities
Is the asset managed to achieve multiple goals or objectives? If yes, are their conflicts among them, e.g., habitat, water quality, flood control, recreation, shoreline access, etc.?
If the asset owner and manager are different, what is the relationship between them, e.g., a legal agreement such as a lease, right-of-way, access easement, MOU or MOA?
Describe any plans that are relevant to asset management or improvement, e.g., Master Plan, Capital Improvement Plan, and if/how they consider sea level rise.
If the asset is protected from flooding by land or assets owned or managed by others (e.g., structural protection, roadways, rail embankments), what is the relationship between the asset owner/manager and these entities? Do they coordinate information, funding or decision-making?
What types of permits and from which agencies are necessary to maintain, repair or improve the asset? Are there special processes for emergency repairs?
What funding sources currently exist that can be used to assess hazard risk or vulnerability to climate change? To improve asset resilience?
Physical Vulnerabilities
To what extent is the asset exposed to tidal, wind or wave erosion or scour?
How sensitive is the asset to high temperatures?

Sector Specific Physical Vulnerability Questions (x indicates question is applicable to the sector)

	TRANSPORT	STORM WATER & FLOOD CONTROL	WASTE WATER	STRUCTURAL SHORELINES	NATURAL AREAS	COMMUNITY FACILITIES AND SERVICES	PARKS	PORT	ENERGY AND PIPELINES
What water or salt sensitive components of the asset are at-grade or below-grade, e.g., mechanical or electrical equipment, pumps, building heat or power systems, or finished basements?	X	X	X	X		X	X	X	X
Pavement binders are designed to withstand specific temperature thresholds. Asphalt may experience rutting if pavement temperatures exceed the high temperature thresholds. What is the high temperature threshold for this asset?	X							X	

At what temperature do the ponds switch from aerobic to anaerobic digestion? Will this lead to odor problems? Has this happened before? Are there established protocols in place to manage this situation?			X						
Are perishables or other heat sensitive products shipped through the port? Are there enough refrigerated options to prevent the loss of or damage to these items?								X	
Safety regulations might require personnel to take more frequent breaks or work different shifts depending on temperature conditions. At what temperature are additional breaks or stop work orders given?								x	
At what temperature does the natural vegetation and wildlife begin to be impacted? Is there a threshold for heat waves (x temperature over y days) that would cause particularly damaging effects?					x				
At what temperature would your facility have to close? Is there air conditioning available? Would your facility be able to serve as a public cooling center in the event of a heat wave?						x			
At what temperature would equipment fail to operate? Is there cooling equipment currently in place to prevent this from happening?			x			x		x	x
Does the asset have openings that are at-grade or below-grade that are entry points for flooding, e.g., entryways, tubes, tunnels, ventilation grates? If yes, are their barriers (temporary or permanent) that can protect these openings from allowing floodwaters to enter? Are there pumps or other systems in place to remove floodwaters if they do enter?	x		x			x		X	X
Are there existing systems in place to manage groundwater, e.g., pumps or other systems to keep water away from below-grade systems, basements, or foundations? Would these systems if they are in place have adequate capacity to remove greater levels of groundwater?	x		x			x		X	X
Is the asset currently at capacity or does it have additional capacity to meet future conditions, e.g., projected increases in demand, level of service, higher Bay water levels, or elevated groundwater?	x		x						x
For storm water and flood control infrastructure, what recurrence-interval tidal or rainfall event was the system designed for and how was the system constructed, e.g., open or closed, earthen, concrete or conduit? Is the asset currently at capacity or does it have additional capacity to meet future conditions, e.g., projected higher Bay water levels, combined riverine and tide levels, or elevated groundwater?		x							
For tidal channels, what is the approximate location of current mean higher high water (MHHW)? Is there a barrier upstream of current MHHW that would prevent migration of the tide as sea level rises? Is there protection in place to prevent overbank (overland) flooding? Are there protections upstream of current MHHW that would prevent overbank flooding if the tide migrates upstream as sea levels rise?		x							

For tidal channels and storm water outfalls, is there a mechanism to control inflow to the system from the Bay such as a flap gate, tide gate, check valve, etc.? Can these water control structures be adjusted to maintain system function as sea level rises?		x							
For pipelines located belowground, are they secured or tied down in a manner that as groundwater levels rises they will not float or become buoyant?			x					X	x
For structural shoreline protection systems what is the design, e.g., engineered levee or floodwall, engineered shoreline protection (revetment or bulkhead), non-engineered berm or levee? Where is the system location, along the Bay shoreline, outboard or inboard of a natural system such as tidal marsh or managed pond, or along the edge of a tidal channel?				x					
For natural and restored tidal marshes, do current sustainability models predict they will keep up with sea level rise (e.g., accrete vertically)? If so, for how long? Is there space adjacent of the marsh that would allow for inland migration (e.g., horizontal migration)?					x				
For managed ponds and managed marshes, can the water control infrastructure such as berms, levees, and tide gates be adjusted to maintain system function as sea level rises?					x				
Functional Vulnerabilities									
Is the asset is part of a networked system such that damage to other parts of the system would affect the assets ability to function? Describe what alternatives or redundancies exists that could help maintain continuity of service if parts of the system are disrupted.									
If the asset is disrupted or damaged what redundant or alternative assets exist that could help maintain asset capacity, function, or level or service?									
What external services, such as power, clean water, and safe food supplies, does the asset rely on? If these external services were interrupted are there back up supplies and how long would they last?									
Sector Specific Functional Vulnerability Questions (x indicates question is applicable to the sector)									
	TRANSPORT	STORM WATER & FLOOD CONTROL	WASTE WATER	STRUCTURAL SHORELINES	NATURAL AREAS	COMMUNITY FACILITIES AND SERVICES	PARKS	PORT	ENERGY AND PIPELINES
Does the asset serve or house the elderly or very young, mobility or medically challenged individuals, or animals? If yes, describe how and if these services and functions can be protected to ensure continuity of service. What systems or plans are in place to guide either the shelter-in-place or the safe evacuation of the facility if necessary?						X			

Does the asset serve or house community members that are recourse limited, e.g., are they low or very low income, housing or transportation cost burdened, or without a car? If yes, what programs or plans in place to help these members prepare for, respond to, or recover from flooding?						X			
Does the asset serve or house community members that are ethnically or culturally diverse, have limited English speaking capacity, or are non-English speakers? If yes, what programs or plans in place to help these members prepare for, respond to, or recover from flooding?						X			
Does the asset serves as a critical access road, emergency or lifeline route, provide sole or limited access to communities or facilities, or provide service to transit dependent communities? If yes describe the communities, services, facilities the asset serves.	X								
What kind of recreational access and opportunities does the asset provide? Are they limited in the region? Could these functions be easily replaced or recreated in other areas?				X	X		X		
What habitat for threatened or endangered species does the asset provide or protect? Is this habitat scarce in the region? Could this habitat be replaced or recreated in other areas?					X				
Consequences									
What degree and scale of economic disruption would occur if the asset was damaged, disrupted, or failed? Local, regional, state, or national? If based on a past weather event or an unplanned disruption describe the type and duration of that disruption.									
If the asset was damaged, disrupted or failed, how much direct revenue would be lost? For how long?									
What would the water quality impacts be if the asset was damaged, disrupted, or failed, e.g., release of hazardous materials stored on site, pollutants leaching into groundwater as the water table rises?									
What habitat or species benefits would be lost if the asset was damaged or lost? What would the effect of this loss have on local and regional biodiversity and ecosystem health?									
If the asset was damaged, disrupted, or failed, would there be a loss of flood protection or wave attenuation benefits? If yes, what would the effect of this loss be on adjacent assets or communities?									
What critical emergency services would be affected if the asset was damaged, disrupted or failed?									
How would the community, particularly at-risk members, be affected by damage, disruption, or loss of asset function, e.g., hospital, fire station, police station, public gathering space, or emergency shelter that serve those with limited mobility, medically dependent, elderly, very young, low income, renters, limited English, transit dependence?									
If the asset was damaged, disrupted or failed, how many and what type of jobs or employment centers would be affected? For how long?									
If the asset was damaged, disrupted or failed, would there be a loss of public access to the shoreline? Of recreational, educational or interpretation opportunities?									

Climate Change Adaptation Plan

Appendix F

Existing Conditions Report

THE CITY OF BENICIA CALIFORNIA

City of Benicia Climate Change Vulnerability and Adaptation Plan

Existing Conditions and Stressors Report

Prepared for:

The City of Benicia

Prepared by:

With Contributions from:

PlaceWorks

Moffat & Nichol

Date: September 2014

Table of Contents

Table of Figures 4
Table of Tables 4
Project Introduction 1
City of Benicia Goals 1
Project Area 2
Framework 4
Asset Existing Conditions and Stressors 4
Community Land Use, Services and Facilities 4
Overview 5
Existing Stressors 7
Transportation 11
Overview 11
Existing Stressors 12
Impacts on Economy/Equity/Governance/Environment 13
Port of Benicia 14
Overview 14
Existing Stressors 15
Impacts on Economy/Equity/Governance/Environment 15
Natural Areas (Includes Parks and Recreation) 16
Overview 16
Existing Stressors 16
Impacts on Economy/Equity/Governance/Environment 17
Shoreline Protection 17
Overview 17
Existing Stressors 21
Impacts on Economy/Equity/Governance/Environment 21
Storm Water/Wastewater 22
Overview 22
Existing Stressors 23
Impacts on Economy/Equity/Governance/Environment 24
Energy, Infrastructure, and Pipelines 24

Overview 24
Existing Stressors 26
Impacts on Economy/Equity/Governance/Environment 27
References 28

Table of Figures

Figure 1: Project Area Map 3
Figure 2: City of Benicia Land Use Diagram 6
Figure 3: Earthquake Shaking Potential 8
Figure 4: Fire Hazard Severity Zones 11
Figure 5: Miles of Benicia infrastructure exposed to existing stressors. 13
Figure 6: Unprotected bluff (left), engineered revetments (center), sea wall (right) 19
Figure 7: Non-engineered slope protection (left) and seawall (right) 20
Figure 8: Flood wall 21
Figure 9: Benicia Pipelines and Tanks 25
Figure 10: Location and outline of the Valero Refinery 26

Table of Tables

Table 1: City of Benicia Principal Employers 7
Table 2: Exposure to Earthquakes (acres of urban land) 8
Table 3: Exposure to Flooding Hazards 9
Table 4: Exposure to Other Hazards 10
Table 5: Port of Benicia Emissions Summary by Source - tons in 2005 16
Table 6: Shoreline Protection Locations 17

Project Introduction

The City of Benicia is a waterfront town in the San Francisco Bay Area that is full of history as one of the State's first capitals, home to the first West Coast U.S. Army post, host to a railroad car ferry, and numerous other historic sites. Today, Benicia is home to a thriving arts community, beautiful weather and scenic vistas, and a downtown full of charming boutiques and antique shops. In order to maintain its high quality of life, prosperous businesses, productive ecosystems, and vibrant neighborhoods, Benicia is planning for the future.

The City of Benicia acknowledges the risks associated with projected changes in climate and is taking steps to prepare and become a more resilient city that can manage the hazards of today as well as those of tomorrow by conducting a Climate Change Vulnerability Assessment and creating an Adaptation Plan. This plan will help ensure that Benicia remains a thriving, sustainable city with resilient communities, infrastructure, and services despite anticipated changes in climate.

This work will build on prior and ongoing sustainability efforts within the City. Climate change mitigation has been thoroughly ingrained in the City's operating procedures, and the City now wishes to do the same with adaptation. The City is poised to capitalize on an important window of opportunity to adopt adaptation measures that are sustainable, equitable, economically viable, and cost effective. Proactively assessing vulnerability and evaluating adaptation measures is a key step towards building a more resilient city.

As one of the first tasks in the project, this report seeks to outline the current conditions within the project area. It documents information gathered from a variety of sources and will serve as the foundation for the vulnerability assessment; however, the vulnerability assessment will also consider the potential impacts of future changes in the climate. This Existing Conditions Report also describes the asset categories under evaluation and explains their significance to the economy, equity, environment, and governance of Benicia. This framework will carry through the project and play a larger role in the vulnerability and risk assessment, and in developing adaptation strategies.

City of Benicia Goals

The City of Benicia has three primary goals for this project:

1. To better prepare the community to deal with current and future climate-related impacts.
2. To focus on how to make a key City asset—the Industrial Park—more resilient to the impacts of climate change.
3. To evaluate how the City can integrate adaptation planning into City governance.

The outcomes of this project also dovetail with the issues of focus outlined in the City's 2013-2015 Strategic Plan, including:

1. Protecting community health and safety;
2. Protecting and enhancing the environment;
3. Strengthening economic and fiscal conditions;

4. Preserving and enhancing infrastructure; and
5. Maintaining and enhancing a high quality of life.

Project Area

The map, below, outlines the extent of the project area and highlights some of the critical infrastructure and natural areas.

Figure 1: Project Area Map

Framework

From October 2010 through December 2013, the San Francisco Bay Conservation and Development Commission (BCDC) with support from the National Oceanic and Atmospheric Administration Coastal Services Center (NOAA CSC) undertook a first-of-its-kind detailed sea level rise vulnerability assessment project for a sub-section of the San Francisco Bay. This project, named Adapting to Rising Tides (ART), developed and piloted a process for conducting vulnerability assessments by bringing together a broad suite of stakeholders and experts to collectively gain a better understanding of how climate change will affect the ecosystems, infrastructure, and economy of the Bay Area.

The current City of Benicia project is modeled off of this larger ART project and seeks to use the tools and framework developed for the ART project as much as possible. However, due to the differing scales of analysis, timelines, and budgetary considerations, the tools will be customized for a local planning effort.

A key element of the ART project that will be replicated here is the focus on four overarching frames of analysis:

- Society and equity
- Economy
- Environment
- Governance

Together, these four frames comprise a sustainability framework that will inform the consideration of adaptation strategies and options and will help address how Benicia can support a sustainable and prosperous economy while building resilience to climate change.

The information contained in this report has been pulled from a variety of sources. Much of the generalized background information is drawn from the ART Existing Conditions Report. The information gleaned from that document has been supplemented with Benicia specific information from conversations with City staff, City of Benicia documents, national databases and resources, and a Technical Advisory Committee (TAC) and Community Advisory Group (CAG) meeting, as well as other online resources.

Asset Existing Conditions and Stressors

Community Land Use, Services and Facilities

Community land use includes the buildings and infrastructure that make up Benicia's neighborhoods, commercial centers, and communities. This infrastructure supports the social and economic structure of the city.

The City of Benicia is located on the interior of the San Francisco Bay, on the north bank of the Carquinez Strait in Solano County. As of the 2010 U.S. Census, Benicia had a population of 26,997 people with a

median income of $88,691 and approximately 5.5% of the population living below the U.S. poverty line. Education levels are high with 93.8% of the population having attained a high school diploma and 40.7% having a bachelor's degree or higher. The population has a median age of 43.9. The city encompasses 15.7 square miles, 12.9 of which are land miles and 2.8 (or 17.8%) of which are water miles. This makes for an average population density of 1,700 residents per square mile; however, portions of Benicia, such as downtown, are significantly denser.

The climate is temperate and Mediterranean, resulting in dry, warm summers and moderate winters. Rainfall averages 19 inches and falls mostly from December through April. The mean annual temperature is 63 degrees with prevailing winds from the west to the southeast.

The project area is located along the City's shoreline, extending from the Benicia State Park in the West to the City's Eastern extent, just past the end of the industrial area (see Figure 1). This area is relatively flat, while outside of the project area, the city gains elevation with inland hills.

The shoreline area encompasses a variety of land uses, including natural, industrial, a port, commercial, and residential areas.

Overview

The city's residential areas (which expand outside of the project area) include approximately 11,422 housing units (2008-2012 American Community Survey). The majority of Benicia's housing stock is single-family units; however, there are a mix of condos, a mobile home park, apartments, and some limited mixed use space along the waterfront and downtown areas.

The current zoning matches this distribution with the vast majority of the land being zoned for low density residential development (0-7 Dwelling Units per Acre). Major exceptions to this generalization include the downtown area and the Benicia Industrial Park. The most recent General Plan update was in 1999 so while that document still guides land use decisions within the City, the statistical information included in the background sections of the Plan is considered to be out of date. However, the current general plan zoning and land use map was last updated in 2005 and can be viewed in Figure 2. More recent specific plans have been developed by the City to present a vision for growth and improvements within specific geographic areas. For example, the Downtown Mixed Use Master Plan was finalized in 2007 and aims to present "sensitive and place-specific design recommendations that relate closely to exiting conditions and aims to promote healthy growth and continued reinvestment in the area in the spirit of community sustainability." Although not adopted, the 2009 Draft Arsenal Specific Plan covers a site approximately 50 acres east of Downtown Benicia. The Plan emphasizes mixed use development through a flexible, form based building code. Additionally, the City is currently in the process of designing a Waterfront Master Plan.

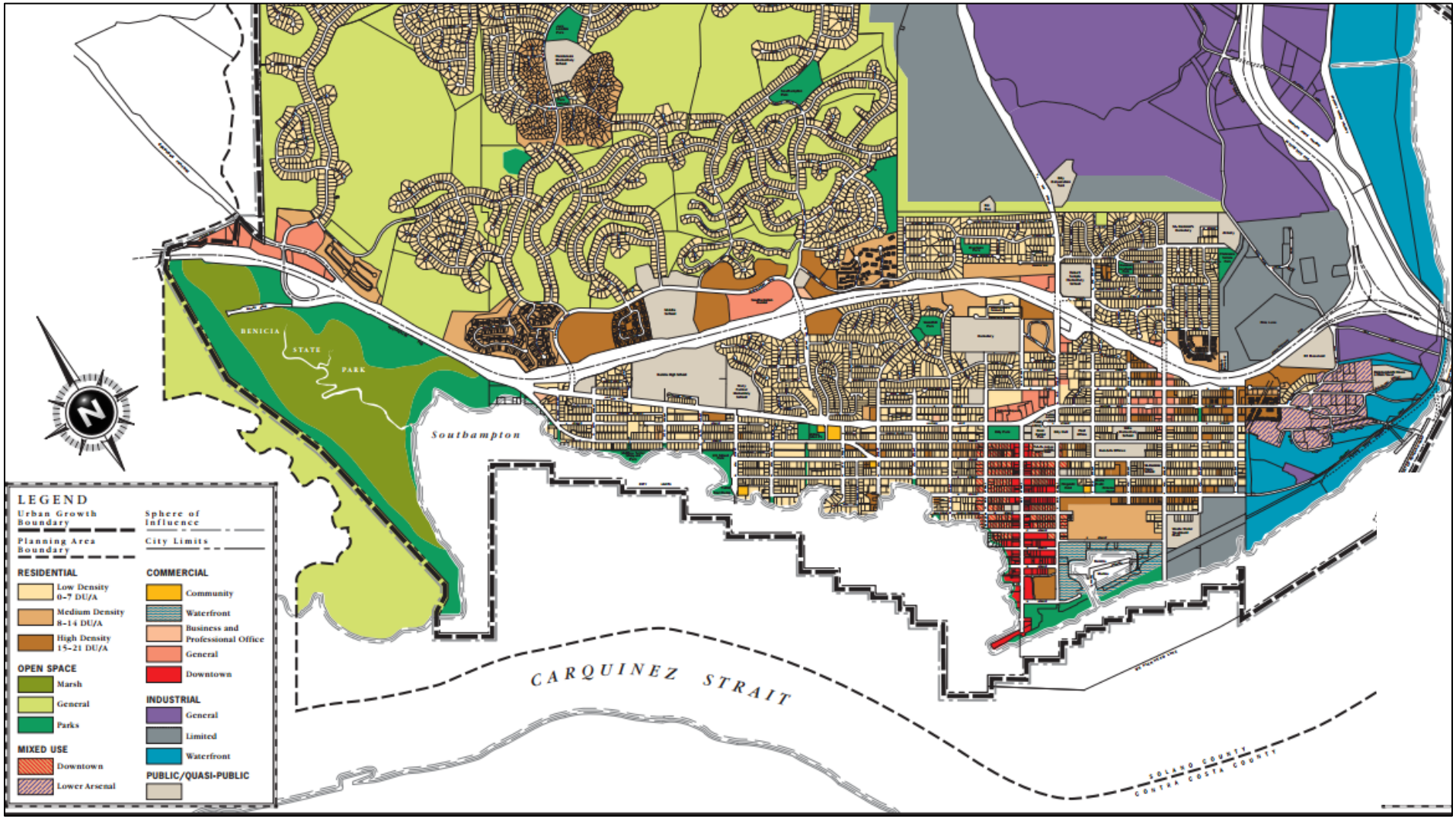


Figure 2: City of Benicia Land Use Diagram

The Benicia 2013 Comprehensive Annual Financial Report documents the top city employers in Table 1. The Benicia Industrial Park (BIP) is the largest industrial park in Solano County. It is comprised of 600 businesses, and employs over 7,000 individuals. Additionally, it is responsible for generating over 60% of Benicia's total sales tax revenue through a large range of business types including: manufacturing, construction, petroleum refining, biotech, and steel fabrication. In particular, the Valero Benicia refinery is the city's top employer and tax payer. The Valero Benicia Refinery produces 10% of the gasoline used in California and 25% of the gasoline used in the San Francisco Bay Area. Approximately 70% of the refinery's product is gasoline; other products include diesel, jet fuel, fuel oil, propane and asphalt.

Table 1: City of Benicia Principal Employers

Employer	No. of Employees	Percentage of Total City Employment
Valero	500	1.9%
Benicia Unified School District	375	1.4%
Cytosport	292	1.1%
Dunlop	234	0.9%
City of Benicia	230	0.9%

Critical facilities within the City of Benicia include seven schools (with one, Liberty High School, within the project area), one police station (which is within the project area and is located by Civic Center Park), and two fire stations (one of which is on Military Way, within the project area). There are no hospitals within the Project Area.

Existing Stressors

Existing stressors are not as substantial within the Benicia Project Area as they are within some portions of the Bay Area. The existing hazards are recorded in the 2011 City of Benicia Local Hazard Mitigation Plan Annex and in detailed maps at quake.abag.ca.gov.

The shaking potential of the City of Benicia during an earthquake is significant within the project area. This is likely due to these areas being constructed on loose, poorly compacted or uncompacted Bay fill. Although these practices have largely been stopped today, the existing fill is still highly susceptible to liquefaction and settlement. Table 2 and Figure 3 provide information on earthquake vulnerability and shaking potential within the City. Although Benicia did not suffer significant damage during the 2014 South Napa Earthquake nor the 1989 Loma Prieta earthquake, it is vulnerable to shaking in future quakes.

There are numerous examples of settlement along the Benicia coast line. For example, the Portside Village townhomes (116 townhomes in 25 buildings) have experienced significant settlement and flooding, and have already had to invest in retrofits to raise and protect their buildings from existing stressors. Continued settlement paired with extreme weather events will exacerbate the flooding and require additional adaptation strategies. Although the protection falls on the individual homeowners, the buildings are located on land that is leased from the City which may impact how future adaptation strategies are implemented.

Table 2: Exposure to Earthquakes (acres of urban land)

Hazard	**2010** (acres of urban land)
Earthquake Faulting	25
Earthquake shaking (within highest two shaking categories)	1,320
Earthquake-Induced Landslides	n/a
Liquefaction (within moderate, high, or very high liquefaction susceptibility)	833

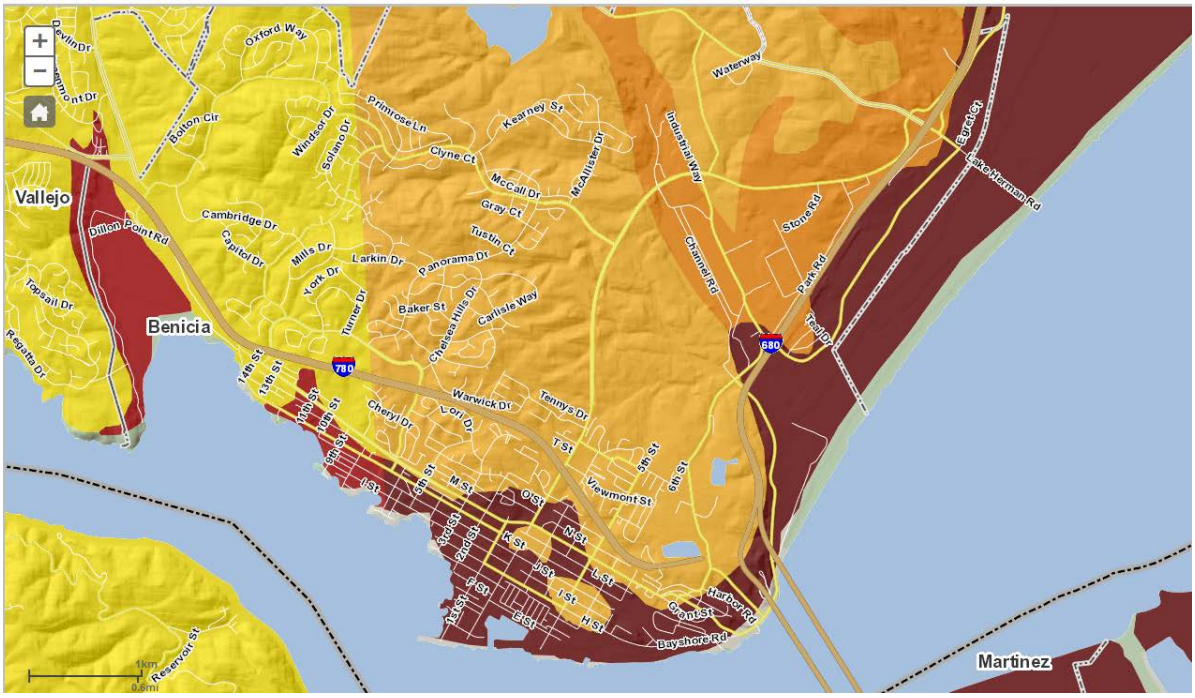


Figure 3: Earthquake Shaking Potential

Earthquake Shaking Potential

- 0
- 0.1 - 10
- 10 - 20
- 20 - 30
- 30 - 40
- 40 - 50
- 50 - 60
- 60 - 70
- 70 - 80
- 80 - 176

Portions of the City of Benicia are within the Federal Emergency Management Agency (FEMA) 100 year and 500 year flood plain insurance maps. A 100 year flood event has a 1% chance of occurring every year, while a 500 year flood event has a 0.5% chance of occurring every year. FEMA is currently in the processing of updating these maps; however, neither the current nor the future maps take into account future changes in sea level rise and storm events. Table 3: Exposure to Flooding Hazards displays the current FEMA flood map risks.

Table 3: Exposure to Flooding Hazards

Hazard	**2010** (acres of urban land)
Flooding (within 100 year floodplain)	524
Flooding (within 500 year floodplain)	85

In 2005, Benicia experienced a 40-year storm event that coupled extreme high tides with heavy rain. This event led to coastal water overtopping local flood protection structures, flooding downtown, neighboring residential areas, and other portions of the City. According to the national weather service, Benicia received 2.11 inches of rainfall in just one day, and a cumulative three inches over the next several days.

Regular flooding during high tide and storm events occurs throughout the project area. Housing that has historically been impacted by flooding includes Portside Village, other properties surrounding the Benicia Marina, the Rancho Benicia mobile home park, and some homes along the 300 block of I Street. Rancho Benicia used to experience flooding during extreme tide events that was severe enough to require evacuation via boat. This issue has somewhat been mitigated by changes to the City drainage system. The City will now divert water during storm events to the Fitzgerald baseball field to minimize flooding in streets and residential areas along E 2nd Street and H Street. Along I Street, there used to be a restaurant named Sam's Harbor that was regularly inundated during high tide events. This resulted in the eventual closure of the restaurant; however, several homes have now been built on the property. There have been no reports of the homes flooding but they are considered susceptible to flood events.

The homes in older portions of Benicia, closer to downtown and to the east, tend to house lower income and elderly residents who require additional assistance during extreme weather events. It is necessary that the community center and other shelters remain open during extreme weather events in order to shelter and care for these residents. There is a family health center at the end of Military West that is low lying and susceptible to extreme weather events; however, there are no major evacuation, police, fire stations, or safety facilities that currently experience flooding.

The lower Benicia Arsenal was originally built as part of a large military reservation and was the primary US Army Ordnance facility on the West Coast. In the early 1960's, the base was redeveloped and today is home to a thriving arts, health, food, and entertainment community. This area is on the National

Historic Registry and is thus important to Benicia for cultural and historical reasons. The shoreward portion of this area is subject to inundation during extreme weather events.

Along East E Street, there is a vacant lot that is prime for redevelopment but the property is subject to extreme event inundation and subsidence.

The boatyard along the west side of First Street by the tannery building currently floods. This property is under review by the Bay Conservation and Development Commission (BCDC) for an improvement project that would protect the structures and prevent further degradation; however, his project will not address the neighboring residential area vulnerabilities and could lead to further erosion on adjacent properties.

Other hazards that Benicia faces include: landslides, wildfire, dam inundation, and drought. Landslides and wildfires are more likely to affect the Benicia hills, inland of the Project Area. Table 4 displays the geographic extent of these hazards.

Table 4: Exposure to Other Hazards

Hazard	**2010** (acres of urban land)
Landslides (within areas of existing landslides)	41
Wildfire (subject to high, very high, or extreme wildfire threat)	316
Dam Inundation (within inundation zone)	429
Drought	5,350

As can be seen in Figure 4, the majority of the Benicia coastline does not fall within a wildfire hazard zone; most of Benicia's fire vulnerability lays farther inland where temperatures tend to be hotter and there are larger quantities of fuel from dry grasslands. The one exception is near the Benicia-Martinez bridge touchdown where there are some fire risks. Although the prevailing winds blow inland off of the coast, there is still the potential for hazardous air quality days within the project area when there are inland fires.

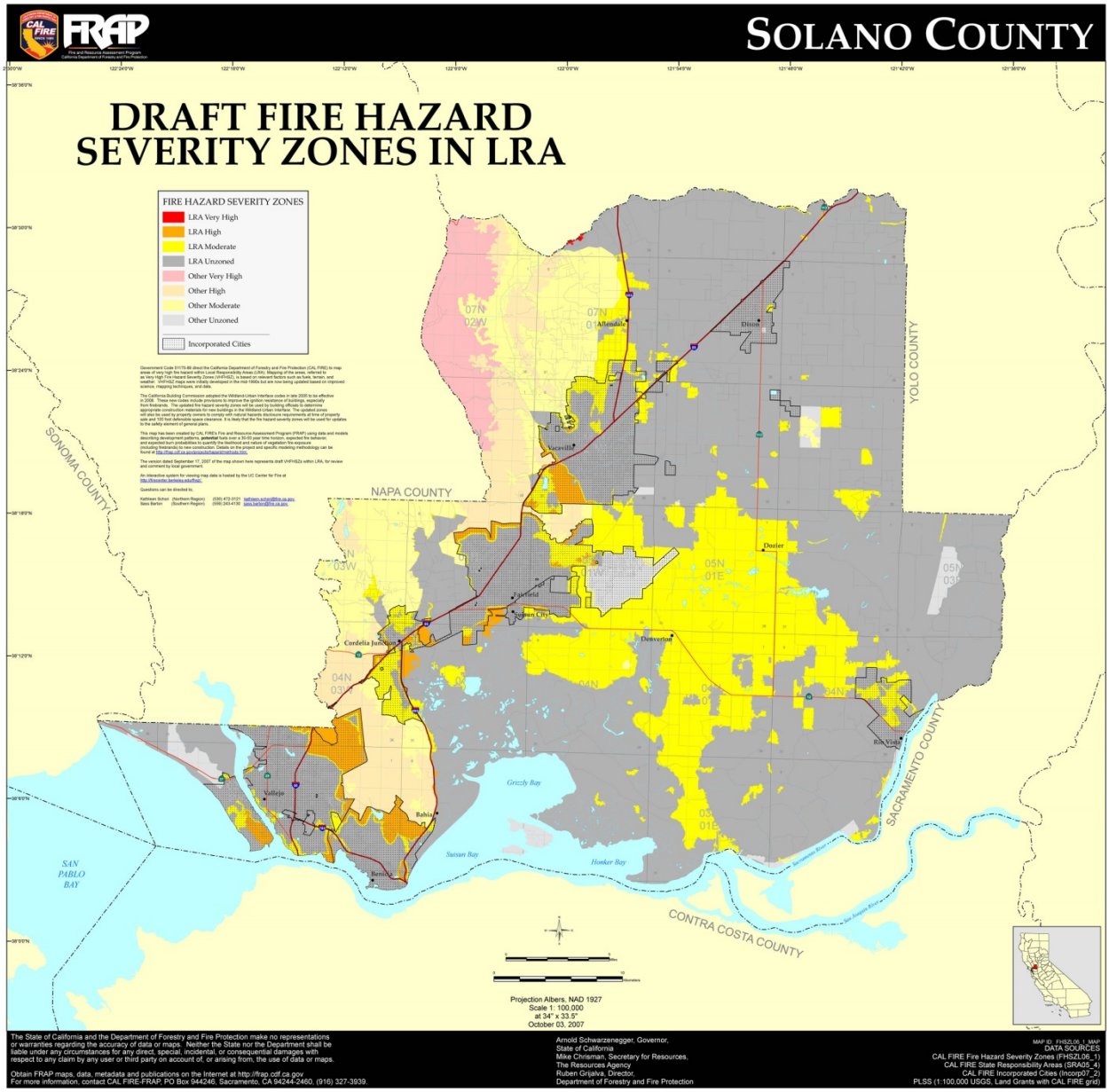


Figure 4: Fire Hazard Severity Zones. ***Source: CAL FIRE***

In 2007, Benicia experienced multiple days of over 100°F temperatures. This heat stress damaged transformers and required the opening of cooling centers. This is currently an infrequent event due to the coastal breezes which lower Benicia's temperature overnight; however, there is a plan in place to respond to these high heat events when they occur.

Transportation

Overview

Benicia is located at the juncture of two major freeways, Interstates 680 and 780. Interstate 80 is also accessible from Benicia by traveling five miles west on I-780. The Benicia–Martinez Bridge is part of I-680

and crosses the Carquinez Strait, connecting Benicia and the City of Martinez. The bridge system consists of three parallel bridges: two traffic bridges that carry a total of nine lanes, and a lower Union Pacific Railroad drawbridge that is used by freight trains and Amtrak passenger trains. The vehicle bridges are owned by Caltrans and maintained by Caltrans and the Bay Area Toll Authority (BATA).

The majority of Benicia commuters drive to their places of employment or to the Pleasant Hill BART station.

Union Pacific Railroad (UP) operates two rail lines that serve the Benicia Industrial Park. UP provides transcontinental "piggyback" services (i.e., transporting loaded truck trailers on flat cars). Also, rail service is provided through siding and tie-ins at company facilities, affording direct service to rail cars.

Solano County Transit (SolTrans) provides public bus transportation services for the City of Benicia and the City of Vallejo. SolTrans has a six member Board of Directors which consists of four City Council members from Benicia and Vallejo and two members from regional planning agency boards of directors, the Metropolitan Transportation Commission (MTC), and the Solano Transportation Authority (STA). The transit system is operated by MV Transportation. Additionally, SolTrans provides a direct link to several major transit hubs, including: the Vallejo Transit Center, Walnut Creek and El Cerrito del Norte BART Stations, and AMTRAK Passenger Rail Service which is available in Martinez, five miles south via I-680. SolTrans brings more workers into Benicia than it carries out, making their service critical for the continued operation of the city's commercial centers.

The San Francisco Bay Trail runs through Benicia. The Bay Trail is a planned recreational corridor that, when complete, will encircle San Francisco and San Pablo Bays with a continuous 500-mile network of bicycling and hiking trails. It provides valuable access to recreational opportunities as well as providing a commute alternative for cyclists and connecting numerous public transportation facilities.

Existing Stressors

Select roadways along within the City of Benicia currently experience flooding during storm and high tide events. The vast majority of the project area consists of low-lying land without any appreciable grade. This constrains the natural drainage systems, some of which have been interrupted by development or eliminated due to Bay fill, and leads to inland back-up of rainfall.

Several stakeholders have referenced frequent flooding along E 2nd and E 5th streets. These roadways are flooded during periods of intense rain and high tide/winds. Neighboring E 1st Street is a core shopping and restaurant area so flooding on E 2nd Street impacts parking and access to these amenities. As mentioned earlier, sections of I Street are also vulnerable to inundation.

Although the freeways are elevated through the project area, their foundations do experience temporary flooding. This could lead to erosion and decay of the assets. Just inland of the industrial area, extreme high tide events lead to water back-up onto the I-680 on and off ramps. For several days after these events, the water line remains very close to the freeway due to blockages in the storm drains.

The Benicia Arsenal only has a single access road – the bridge at Grant Street. If that roadway was flooded then this area would be cut off from the rest of the community. Currently, lower East Street and First Street in the lower Arsenal are periodically flooded.

Flooding along Sulfur Springs Creek pours over to affect several transportation assets; the water floods to the edge of the freeway, blocks access to Park Street and Bayshore, and overtops the Bay Trail.

The Union Pacific rail lines both reduce and exacerbate flooding issues in Benicia. The lines currently serve as a defense against coastal flooding since the tracks are elevated; however, they occasionally overtop and have been subsiding due to Bay fill settlement. When there is inland flooding along Sulfur Springs Creek, the tracks and vegetation growth limit the drainage which causes longer duration flood events. Union Pacific, AMPORTS, Valero, and the BIP are looking to bring in additional rail traffic; the increased weight of these trains will exacerbate the current subsidence issues in the areas which could lead to increased flooding concerns. Additionally, the rail bridge across the Carquinez straight is at a very low elevation and is on the National Registry of Historical structures.

In addition to flooding, roadways are also vulnerable to earthquakes and liquefaction, and wildfires as indicated in Figure 5, below.

Exposure (miles of infrastructure)						
Hazard	**Roadway**		**Pipelines**		**Rail (incl. Amtrak)**	
	2005	**2010**	**2005**	**2010**	**2005**	**2010**
Total Miles of Infrastructure	*157*	*153*	*134*	*117*	*16*	*15*
Earthquake Shaking (within highest two shaking categories)	28	29	26	26	6	7
Liquefaction Susceptibility (within moderate, high, or very high liquefaction susceptibility	17	18	16	12	10	7
Liquefaction Hazard (within CGS study zone)[1]	n/a	n/a	n/a	n/a	n/a	n/a
Earthquake-Induced Landslides (within CGS study zone)[2]	n/a	n/a	n/a	n/a	n/a	n/a
Earthquake Faulting (within CGS zone)[38]	0	0	0	0	0	1
Flooding (within 100 year floodplain)	7	5	7	4	4	5
Flooding (within 500 year floodplain)	1	2	1	1	0	1
Landslides (within areas of existing landslides)	0	1	1	1	0	0
Wildfires (subject to high, very high, or extreme wildfire threat)	15	8	12	4	2	1
Wildland-Urban Interface Fire Threat	115	111	103	90	7	7
Dam Inundation (within inundation zone)	11	10	11	9	3	3
Tsunamis[4]	not applicable					
Drought[5]	not applicable					

Figure 5: Miles of Benicia infrastructure exposed to existing stressors. Source: Benicia 2011 Local Hazard Mitigation Plan Annex

Impacts on Economy/Equity/Governance/Environment

Economy

Ground transportation assets in the project area are critical for the movement of people and goods. The roads and rails move goods to and from the Port of Benicia and the Industrial Park, within the city, and between the city and the larger San Francisco Bay Area, the rest of the state, and the country. I-680 and

780 provide access to the Bay Area and beyond. I-680 links the city to the four nearby airports: Buchanan Field General Aviation Airport, Oakland International Airport, Sacramento International Airport, and San Francisco International Airport.

Congestion currently costs the region's economy significantly, and the increased congestion resulting from temporary or long term damage to a part of the network would cause this cost to the region to rise. Additionally, 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.

Equity

Disruptions to ground transportation will affect commuters both into and out of Benicia, whether they use public transportation or private vehicles, which rely on vulnerable roads and bridges.

Events that limit roadway access to Vallejo and the Vallejo Ferry will impact commuters' ability to reach their workplaces.

Disruptions to ground transportation could cause problems during emergencies if people are unable to evacuate or reach emergency services and family members.

Governance

Transportation operation involves a wide range of local, regional, and state agencies. While these agencies currently coordinate on many topics, including emergency management, they will need to conduct more comprehensive planning to address additional stressors.

Environment

The exposure of some ground transportation assets could cause an increase in the use of other types of transportation - for example, if the rail system is inoperable, the use of trucks to transport goods may increase, which could result in air or water quality problems.

The loss of a portion of the transportation network may increase the region's congestion, resulting in greater emissions and lower fuel efficiency.

Port of Benicia

Overview

The Port of Benicia is privately owned and operated by AMPORTS; however, the underlying land is owned by the City of Benicia. The Port is located in Solano County on the Carquinez Strait, and is indicated in yellow on the Project Area Map. It lies roughly 19 miles north of the Port of Oakland and 25 miles north of the Port of San Francisco. The port spans 645 acres within the 4,000-acre Benicia Industrial Park, with 140,000 square feet of vehicle processing buildings and a 38-foot deep channel. The 2,400-foot long deepwater pier has the capacity to berth 3 ships, while on-terminal rail access from Union Pacific can potentially utilize 170 railcars. Inland access to and from the port is from I-680, I-780, I-80, and SR-4.

The Port of Benicia is a trading hub with Japan, South Korea, and Australia, and handles neo-bulk and dry bulk cargos. The port is the Northern California hub for domestic distribution of Ford and Chrysler, and Toyota delivers to Northern California solely through the port of Benicia. The Port also exports oil from the Valero Benicia refinery.

Existing Stressors

Earthquakes and flooding, due to extreme high tides and inland precipitation, are the main existing stressors to the Port of Benicia. The 1989 Loma Prieta Earthquake damaged similar ports, such as the Port of Oakland, which was built on bay fill. The Port of Benicia is also built on fill which significantly increases its liquefaction potential and has resulted in significant local subsidence. Employees at the Port indicate that some buildings have subsided by as much as four feet over the last three decades.

Additionally, the Port of Benicia currently experiences flooding during extreme high tide and storm events. Significant coastal flooding has been experienced during extreme weather events such as the El Nino years in the 1980's and 1990's. Historically, AMPORTS has used sandbags to fortify their property against coastal flooding and pumps to remove water that infiltrates the Port. In 1986, AMPORTS raised their levees by two to three feet in an effort to reduce future flooding events; however, sandbags are still required during extreme weather. Most of today's coastal flooding affects AMPORTS' Yuba property, which is immediately west of the main port facilities.

Inland flooding during precipitation events infiltrates the Port from Sulfur Springs Creek. There is limited natural drainage along this area, in part due to the lack of maintenance and dredging, as well as frequent blockages from beaver dams. Additionally, water is concentrated in this area due to runoff from the I-680 Benicia-Martinez Bridge, water discharged from Valero's water treatment plant, and reduced drainage due to vegetation growth along the Union Pacific railroad tracks. AMPORTS current response to flooding events is to fortify their property with sandbags and pump water into the Bay. The pumps are currently located on top of their levees.

Impacts on Economy/Equity/Governance/Environment

Economy

Although the Port is exempt from paying taxes to the City of Benicia, it is still a major driver of economic growth and a source of employment. The Port is part of the Benicia Industrial Park (BIP), which houses the majority of Benicia's large employers. Existing stressors such as earthquakes and flooding can put these jobs and economic output at risk by damaging the port.

Equity/Environment

Diesel emissions from the Port of Benicia and the ships, tug boats, trains, and trucks that serve it negatively affect local air quality by emitting criteria air pollutants. As of 2005, the ocean-going vessels had the largest impacts on local air quality. The State of California has been working to better regulate and reduce emissions from these vessels and the Port of Benicia has been involved in the Bay Area Green Ports Initiative since 2007.

Table 5: Port of Benicia Emissions Summary by Source - tons in 2005

Source Category	ROG	CO	NO_x	PM10	SO_2
Ocean-Going Vessels	1.47	3.82	45.63	4.08	29.28
Harbor Craft	1.47	5.80	22.34	0.97	0.17
Cargo Handling Equipment	0.08	1.69	0.27	0.01	0.00
Heavy Duty On-Road Vehicles	0.07	0.49	0.40	0.04	0.01
Total	**3.1**	**11.8**	**68.6**	**5.1**	**29.5**

Source: SF Bay Area Seaports Air Emissions Inventory: Port of Benicia 2005 Emissions Inventory.

Natural Areas (Includes Parks and Recreation)

Overview

The Benicia State Recreation Area features marsh, grassy hillsides, and rocky beaches along the Carquinez Strait. The park consists of 2.5 miles of road and bike paths for cyclists, runners and walkers, equestrians, and roller skaters, and an area for recreational fishing. The recreation area is currently subject to average high tides.

The Vallejo-Benicia Waterfront is part of the Bay Area Ridge Trail and is open for biking, hiking, and horseback riding. The Benicia portion of the trail runs 3.5 miles east from the State Recreation Area to Benicia Point.

Other parks in the project area are the Twelfth Street Park, Ninth Street Park, Willow Park, Civic Center Park, Fitzgerald Park, and the Benicia Marina.

Benicia also has a significant stretch of natural marsh in the west portion of the project area, immediately in front of the BIP. These wetlands and the Benicia State Recreation area serve as natural habitats for a range of flora, birds and other wildlife.

Existing Stressors

The parks are subject to management and budget constraints. Demand for park services, particularly on weekends, can exceed park capacity, lead to heavy use, and lead to traffic congestion. Additionally, tighter budgets have led to deferred preventative maintenance, reduced budgets for maintenance and repairs, and limited operating hours. Regional and state regulatory and permitting requirements for improvements to the parks can often add to park managers' planning costs and timelines.

Both allowed and prohibited or unmanaged activities in the natural areas within the project area can reduce habitat usage by wildlife and cause direct harm to wildlife. Activities such as use of trails adjacent to habitats, intrusion into habitat areas, and littering impact wildlife and their habitats.

The natural areas are also subject to natural and human made hazards. Over the past few years, the area has been affected by severe storms and weather that resulted in flooding, and erosion in the parks. Two recent oil spills in the Bay required cleanup along the beaches and shorelines.

Fitzgerald Park currently serves as a retention area for water during storm events.

The Benicia Marina is subject to inundation during extreme high tide events. The dock is a floating dock which provides it with some protection from tidal changes.

Impacts on Economy/Equity/Governance/Environment

Economy

The parks and recreation assets contribute to quality of life, which helps drive local and regional economic growth by attracting business and generating jobs and income for residents. In some cases, property values of homes adjacent to parks and trails are enhanced due to views and access.

Equity

The parks and recreation assets provide direct health and education benefits and contribute to quality of life. Other benefits include services to underserved communities and transportation resources from trails.

Governance

As noted above, due to state and local funding shortfalls, the ability to manage recreational resources to their fullest public values is limited.

Environment

The natural areas provide habitats for plants and animals in the project area. Preservation of these resources provides ecosystem services such as erosion control, waste treatment, and nutrient recycling.

Shoreline Protection

Overview

The Benicia shoreline consists of a variety of shoreline protection types which vary from engineered sea walls and revetments to natural features, such as wetlands. The various types are described below and their general locations along the shoreline are provided in Table 6.

Table 6: Shoreline Protection Locations

Location	Types
Benicia State Park - W. L St.	Bluff
W. L St. - W 13th St.	Bluff w/ isolated seawalls and engineered revetments
W. 13th St. - W 9th St.	Bluff
W. 9th St. - Gull Point Court	Bluff w/ isolated seawalls and engineered revetments
Gull Point court - W. Kuhland Alley	Engineered revetment
W. Kuhland Alley - E. B St.	Unprotected shoreline w/ isolated sea walls and non-engineered slope protection
1st from E. B St. to the peninsula	Seawall
1st peninsula	Engineered revetment
1st St. - Amport	Wetlands
Benicia Waste Water Treatment Plant	Flood wall

Location	Types
AMPORTS	Engineered revetment small sections unprotected or non-engineered slope protection
AMPORTS – I-680	Unprotected shoreline w/ isolated sea walls and non-engineered slope protection

Engineered Revetments-Revetments harden the shoreline, protecting it from waves and strong currents that could cause erosion and land loss. Revetments are generally constructed using three components: an armor layer of larger rock, an underlayer or smaller rock, and an optional filter layer typical comprised of a geotextile. Engineered revetments also have toe of slope protection.

Revetments are primarily designed to protect the shoreline, but they are susceptible to damage from strong currents and wave conditions that occur beyond the "design" event. As sea level rises, wave heights and velocities may increase, exposing the revetments to conditions beyond those for which the armor layer was designed. Additionally, increased overtopping could result in a loss of foundation material and undercutting of the toe, potentially causing the entire revetment to become unstable.

Revetments generally require ongoing maintenance. They can be upgraded over time by placing additional armoring sized for increasing wave conditions, the revetment height can be increased, and additional toe protection can be added.

Seawall - A sea wall is a vertical retaining structure designed to protect a shoreline from erosion. Sea walls are design to protect shorelines from wave and current action. The life of the wall will vary with material type, due to corrosion or other damage. As sea level rises, wave heights and velocities may increase, exposing the walls to conditions beyond those for which they were designed. Additionally, if portions of the shoreline at the ends of the walls are unprotected they may be susceptible to flanking causing the shoreline behind the wall to slowly erode from the unprotected edges. Over time seawalls may need replacement due to degradation or damage.

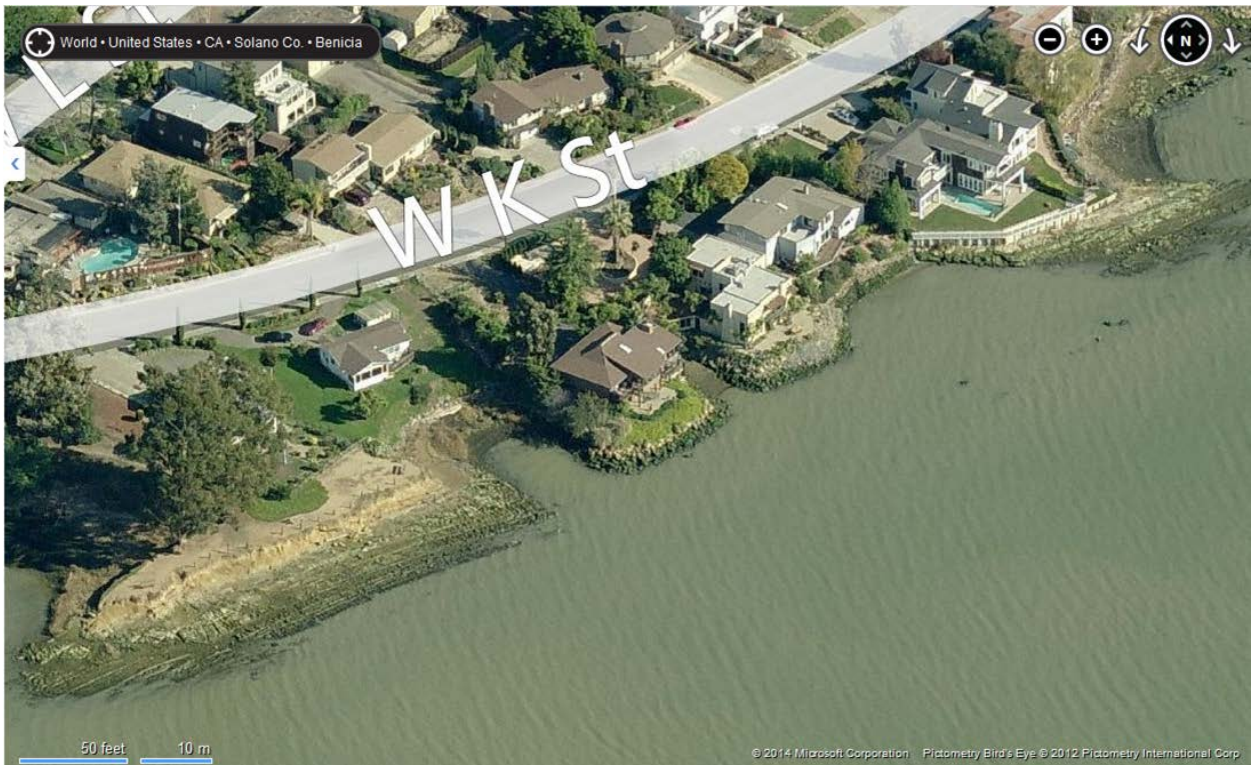


Figure 6: Unprotected bluff (left), engineered revetments (center), sea wall (right)

Non-Engineered Slope Protection - Non-engineered slope protection often may look somewhat similar to Engineered Revetments and are often used to protect the toe of bluffs or side slopes exposed to wave and current action. The primary difference between the two is that for non-engineered slope protection rock, concrete debris, rock and other materials are generally placed in an ad hoc manner to address erosion, and typically not in accordance with specific design standards, to ensure it will withstand waves and currents.

Maintenance of non-engineered slope protection is typically reactive, e.g., when erosion, failures or settling are observed. They are susceptible to damage, displacement, and deterioration due to waves and currents as they are often not designed to resist wave action during storm events. As sea level rises, wave heights and velocities may increase, increasing the amount of damage, displacement and deterioration the placed material undergoes.

Figure 7: Non-engineered slope protection (left) and seawall (right)

Natural Features Bluff (non-wetland) - Much of the Benicia shoreline consists of natural bluff features. These are characterized as tall, steep hill sides. They are made of erosive material subject to wave action as well as erosion due to overland flow. Many of the bluffs exhibit on-going erosion due to wave action at the toe of bluff. In some areas non-engineered slope protection has been added to the toe of slope to slow the process of bluff retreat. As sea level rises, waves may become larger and act higher up on the bluffs, increasing the bluffs susceptibility to erosion. This may require removing structures, infrastructure, etc. away from the bluff or potentially hardening.

Flood Wall - A flood wall is a vertical structure designed to protect inland areas from flooding from a 100-year water level. They are designed to meet specific criteria with respect to freeboard (the distance between the top of wall and the 100-year water level), embankment protection, embankment and foundation stability, and settling. Flood walls require ongoing maintenance and their flood protection value depends on the amount of freeboard and the structural stability. As sea level rises, wave heights and water levels may increase, potentially creating conditions beyond those for which the wall was designed and overtopping may occur. This results in flooding of the areas behind the wall.

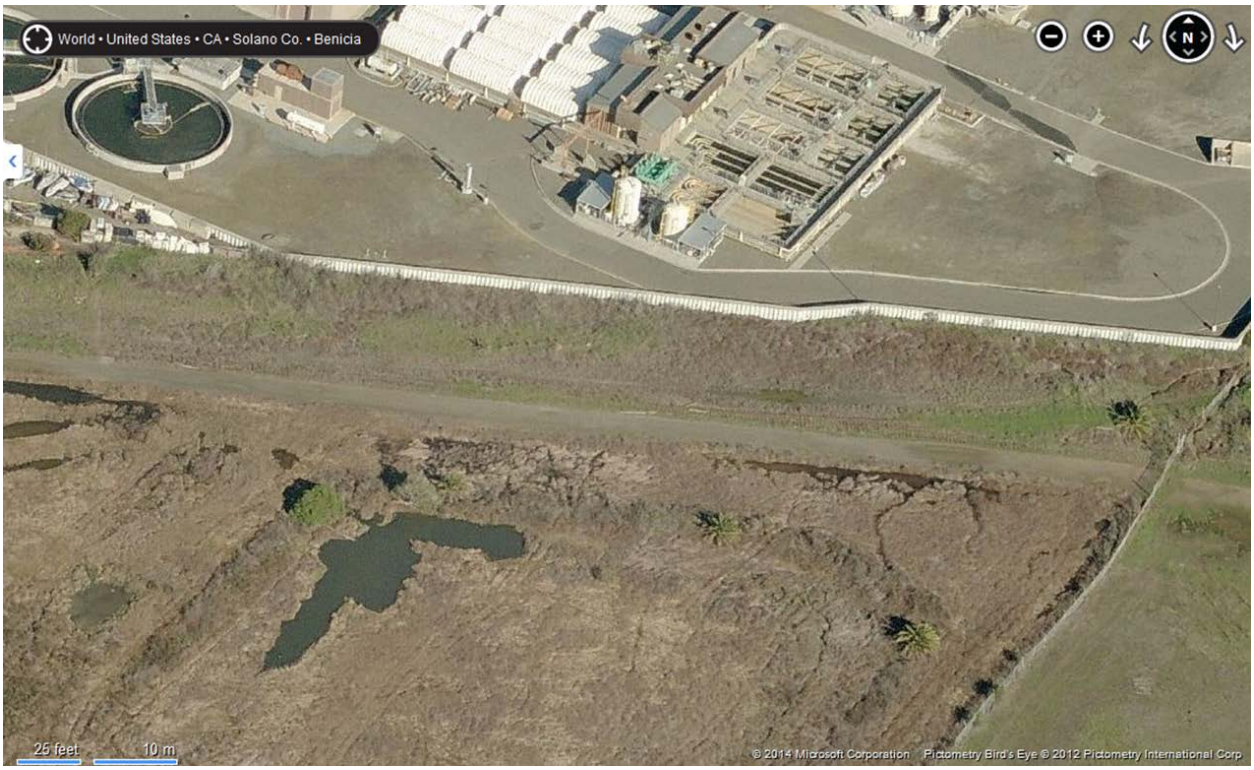


Figure 8: Flood wall

Existing Stressors

Existing stressors to engineered shoreline protection structures include a lack of resources to conduct necessary maintenance, enhancements, and restorations. Engineered shoreline protection along the waterfront is vulnerable to overtopping and is currently subject to erosion and undercutting during storm events.

Regulatory requirements also create barriers to improving, enhancing, or maintaining structural shorelines. In the natural areas, there is concern over potentially inadequate sediment supply to maintain the natural accretion rates, and limited or no access to upland areas for inland migration.

Large invasive plant and animal species can undermine the integrity of both natural areas and human made structures. Additionally, both natural and human made protections are affected by natural erosion and the subsidence of Bay fill.

Impacts on Economy/Equity/Governance/Environment

Economy

Around the Bay Area, many natural shoreline areas have seen significant financial investment in restoration and maintenance. Any future shoreline protection measures should be coordinated across city and county boundaries.

Equity

Engineered shoreline protection often benefits low-income communities that would be most devastated by rising water levels. Accordingly, existing stressors threaten to disproportionally impact the most vulnerable citizens by degrading shoreline protections.

Governance

Engineered shoreline protection structures are regulated by the following federal, state, and regional agencies:

- U.S. Army Corps of Engineers
- U.S. Fish and Wildlife Service
- Federal Emergency Management Agency
- U.S. Environmental Protection Agency
- San Francisco Bay Conservation and Development Commission
- California State Lands Commission

Storm Water/Wastewater

Overview

The Wastewater Treatment Plant on E 5th Street was built in 1958 and has been upgraded and expanded several times to continue to serve the community today. The plant is maintained and operated by the Public Works' Wastewater Operations Division. The plant has a permitted dry weather capacity of 4.5 million gallons per day and a short-term hydraulic capacity of 24 million gallons per day.

The sewer system is managed by the City of Benicia's Public Works & Community Development Department. The collection system consists of 24 lift stations, approximately 150 miles of sewer pipelines, a 3-mile wet weather relief (interceptor) pipeline, and 6 wet weather control structures. The discharge system consists of a 1,100-foot long outfall pipeline and a 150-foot long outfall diffuser pipeline. The system's design and construction standards follow the department's Engineering Design Standards and Standard Plans developed in December 1992 with adopted revisions.

Since 2006, the city implemented a citywide Sanitary Sewer System Management Plan (SSMP) to properly manage, operate, and maintain all parts of the sanitary sewer system to reduce Sewer System Overflows (SSOs). As part of the plan, the department:

- Developed and maintains a map of the sewer system
- Developed a memorandum that describes routine preventative operation and maintenance activities
- Developed a rehabilitation and replacement plan
- Provides regular training to operations and maintenance staff
- Developed equipment and replacement part inventories
- Implemented an outreach program to educate plumbing and sewage contractors about proper practices for preventing blockages in private laterals

The city also developed a Sanitary Sewer Overflow and Backup Response Plan.

The city provides annual reports on the city's Storm Water Management Plan (SWMP), adopted in 2003, which outlines storm water reduction and control measures.

The Valero refinery also operates its own wastewater treatment plant to process water that: is used in the refining process, used for cooling, and that falls as rain on the Valero property. The Valero Refinery has installed complex facilities to treat the refinery's wastewater before discharging it into Suisun Bay through an outfall. The wastewater treatment plant includes surge tanks and retention ponds, a chemical pre-treatment unit, Corrugated Plate Separators, Induced Static Flotation units, an Activated Sludge unit, holding ponds and an outfall.

Existing Stressors

The Benicia storm water and wastewater system can be stressed due to limited treatment capacity coupled with increased demand from population and economic growth, lack of system redundancy, and aging infrastructure that requires ongoing operation and maintenance, and pollutants and organic loading factors.

The Benicia wastewater treatment plant staff have already begun assessing vulnerabilities and identifying adaptation responses in their Wastewater System Master Plan. For example, the Benicia wastewater treatment plant is currently surrounded by a sheet piling sea wall, which was constructed as part of the 1998 plant improvements. The 1998 drawings indicate a top sea wall elevation of at least 6 feet above grade, which would indicate a top wall elevation varying from about 111 to 113 feet above sea level. The wastewater treatment plant currently pumps all of its discharge water into the Bay. There is less vulnerability to coastal blockages since the system does not rely upon gravity for discharge. However, there are interceptor sewer lines along the waterfront which may be inundated during a storm event. This level of inundation could overwhelm the wastewater treatment plant and significantly increase the total dissolved solids in the water, making it harder to process.

The wastewater treatment plant at the Valero Refinery flooded in the 1990's which lead to a period of illegal wastewater discharge into the Bay. Some water from the Valero wastewater treatment plant is pumped into the Sulfur Springs Creek where it then becomes the responsibility of AMPORTS to pump into the Bay.

Due to the limited gravity pull on the storm water system and low water outfalls, there are backups in the storm water system during large storm and high tide events. Along A Street between 1st and E 2nd Street, the storm drains are surcharged which leads to flooding due to their inability to drain. At the base of 9th Street, the outfall is low and can be inundated during high tide events.

During storm events, water can be diverted to avoid significant flooding along critical streets or residential areas. Water is diverted from the Rancho Benicia housing area to the Fitzgerald baseball field. Also, water from E 2nd Street and B Street is diverted to an outfall at W 2nd Street and F Street, where the outfall is set above the high tide level. That outfall was constructed within the last eight years and still has some freeboard during extreme weather events. There is also a large outfall at 9th street

that is approximately 30 feet above sea level. In many locations, the existing storm water pipes are undersized which exacerbates the inland flooding issues.

The City currently dredges along Industrial Ave to the east of E 2nd Street. This reduces the amount of flooding that occurs during a rainfall event.

Impacts on Economy/Equity/Governance/Environment

Economy

Flooding or wastewater limitations would disrupt local business activities which could lower business revenues and employee returns.

Equity

Older neighborhoods within the project area are home to low-income communities. The infrastructure in these neighborhoods is more susceptible to leaking and breaking, and may not be designed to handle additional storm water, which increases the likelihood and risks of flooding.

Governance

Public funding for public infrastructure improvements will remain challenging.

Environment

Untreated storm water runoff can be a source of pollutants such as sediment, toxic chemicals, and industrial waste.

Energy, Infrastructure, and Pipelines

Overview

California obtains 56% of its electricity from natural gas, 15% from nuclear, 13% from renewables, 12% from hydroelectric, and 1% from coal. This significant reliance on natural gas warrants particular attention to the vulnerabilities of energy, infrastructure, and pipelines. Specific location of natural gas pipelines is hard to obtain; however, the U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration maintains a National Pipeline Mapping System that provides a rough sense of the location of pipelines. This information can be viewed in Figure 9.

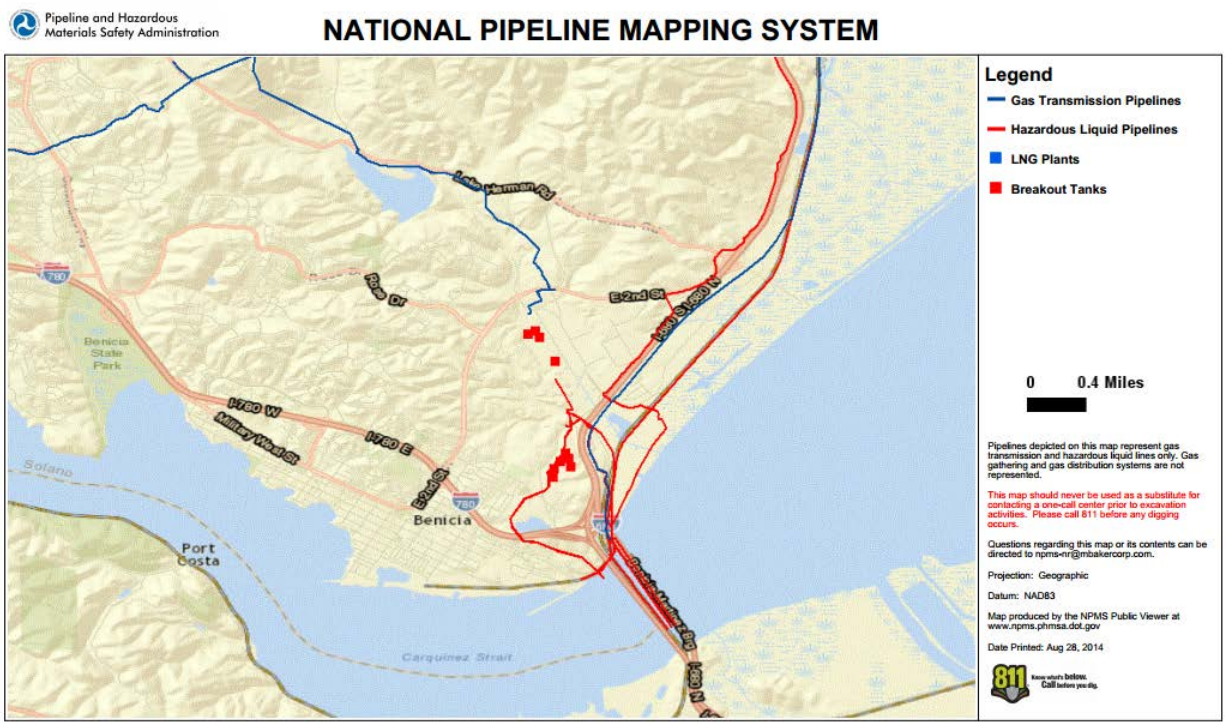


Figure 9: Benicia Pipelines and Tanks

Valero owns and operates a refinery (see Figure 10 and the Breakout Tanks in Figure 9) that produces California regulation-compliant gasoline, as well as asphalt, jet fuel, diesel, and propane. Valero plans to obtain crude oil for its refinery by rail, for which a Draft Environmental Impact Report has been released.

Figure 10: Location and outline of the Valero Refinery

Pacific Gas & Electric (PG&E) provides electricity to the City of Benicia. Due to security issues, PG&E cannot release maps of transformer locations or transmission lines but the company has agreed to actively participate in this project and review deliverables. It is also known that they have energy substations along the Carquinez Strait.

Existing Stressors

The 2010 City of Benicia Hazard Mitigation Plan Annex identified 117 miles of pipeline in Benicia as being exposed to the following stressors:

- 26 miles vulnerable to earthquake shaking
- 12 miles vulnerable to liquefaction susceptibility
- 4 miles vulnerable to flooding (within the 100-year floodplain)
- 1 mile vulnerable to landslides
- 90 miles vulnerable to the wildfire wildland-urban interface
- 9 miles vulnerable to dam inundation
- More generally, changes in natural gas demand could require changes to pipeline infrastructure

Energy transmission infrastructure is also vulnerable to earthquakes, wildfires, floods, and landslides. While pipelines and transmission lines have been built to withstand a wide range of stressors, a major event could nonetheless compromise the infrastructure.

PG&E is conducting their own internal vulnerability assessment and emergency management plan which is slated to be completed in 2015. High heat has led to blackouts and brownouts in California due to the increased energy load from air conditioning and the increased stress on transmission wires. PG&E also maintains high voltage boxes underground that may be susceptible to flooding events. Additionally, transmission lines are vulnerable to wildfires that occur outside of the project area since the lines run for a significant distance.

Impacts on Economy/Equity/Governance/Environment

Economy

The Valero refinery is an important economic engine in Benicia, employing 500 workers. Other energy and telecommunications infrastructure are equally crucial to Benicia's economy. Existing stressors that disrupt these services could negatively affect economic output in the region due to the required closure of businesses and services and the loss of perishable goods.

Equity

Citizens living adjacent to energy infrastructure would be disproportionately negatively impacted by an accidental release or spill.

Governance

While the federal government regulates infrastructure and pipelines, local governments maintain jurisdiction over general plans and zoning requirements, and can thus manage siting of specific projects.

Environment

The siting of new infrastructure has the potential to impact and degrade the local environment. At a larger scale, energy infrastructure, such as pipelines, could negatively impact the environment in the case of a large release or spill.

References

City of Benicia. 2005. General Plan Land Use Diagram. Available: http://www.ci.benicia.ca.us/index.asp?SEC=%7B4961C62F-22A5-4BB7-B402-D050A5856B00%7D.

City of Benicia. 2013. Comprehensive Annual Financial Report FY 2013. Available: http://www.ci.benicia.ca.us/vertical/sites/%7B3436CBED-6A58-4FEF-BFDF-5F9331215932%7D/uploads/CAFR_reduced_size.pdf.

U.S. Census Bureau. 2014. American Factfinder. Available: http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

City of Benicia. 2012. Strategic Plan FY 2013-2015. Available: https://beniciaca.govoffice2.com/vertical/Sites/%7B3436CBED-6A58-4FEF-BFDF-5F9331215932%7D/uploads/Strategic_Plan_2013-15.pdf.

San Francisco Bay Conservation and Development Commission. 2012. Adapting to Rising Tides: Existing Conditions and Stressors Report. Available: http://www.adaptingtorisingtides.org/wp-content/uploads/2012/06/ART_ExistingCondtionsReport_final_sm.pdf.

City of Benicia. 2007. Final Downtown Mixed Use Master Plan. Available: http://www.ci.benicia.ca.us/index.asp?SEC=%7BD87C20DD-AE9B-41D5-84A7-D29CAD93E9F3%7D.

City of Benicia. 2009. Arsenal Specific Plan. Available: http://www.ci.benicia.ca.us/index.asp?Type=B_BASIC&SEC=%7BB60A2F62-3CAC-40A6-A63B-3E732E96518C%7D.

City of Benicia. 2014. Urban Waterfront Enhancement & Master Plan Proposal. Available: http://www.ci.benicia.ca.us/vertical/Sites/%7B3436CBED-6A58-4FEF-BFDF-5F9331215932%7D/uploads/The_Planning_Center_Waterfront_Master_Plan_Proposal.pdf.

City of Benicia. 2011. Annex to 2010 Association of Bay Area Governments Local Hazard Mitigation Plan Taming Natural Disasters. Available: http://quake.abag.ca.gov/wp-content/documents/2010LHMP/Benicia-Annex-2011.pdf.

National Oceanic and Atmospheric Administration. 2014. National Climatic Data Center. Available: http://www.ncdc.noaa.gov/.

Cal Fire. 2012. California Fire Hazard Severity Zone Map Update Project. Available: http://www.fire.ca.gov/fire_prevention/fire_prevention_wildland_zones_maps.php.

Bay Planning Coalition. 2010. SF Bay Area Seaports Air Emissions Inventory: Port of Benicia 2005 Emissions Inventory. Available: http://www.baaqmd.gov/~/media/Files/Planning%20and%20Research/Emission%20Inventory/Port%20of%20Benicia%202005%20Emissions%20Inventory%20June%202010.ashx.

City of Benicia. 2002. Valero Improvement Project Draft EIR: Chapter 3. Available: http://www.ci.benicia.ca.us/vertical/sites/%7B3436CBED-6A58-4FEF-BFDF-5F9331215932%7D/uploads/%7BA1E76598-38AF-4F80-95AF-1D3B9A6573D6%7D.PDF.

City of Benicia. Undated. Transportation. Available: http://www.ci.benicia.ca.us/index.asp?SEC=%7B72C4ED8D-1E6D-4532-8E9D-452343EDD57B%7D.

Caltrans. 2012. Freight Planning Fact Sheet. Available: http://www.dot.ca.gov/hq/tpp/offices/ogm/ships/Fact_Sheets/Port_of_Benicia_Fact_Sheet_073012.pdf.

Amports. Undated. Amports Benicia Terminal. Available: http://www.amports.com/locations.html#beniciaterminal.

City of Benicia. 2012. Business Development Action Plan. Available: http://www.ci.benicia.ca.us/vertical/sites/%7B3436CBED-6A58-4FEF-BFDF-5F9331215932%7D/uploads/BDAP_(March_2012).pdf.

City of Benicia. 2012. Sewer System Management Plan. Available: http://www.ci.benicia.ca.us/index.asp?Type=B_BASIC&SEC=%7B9099ED22-B5BD-4C28-9BF6-78035A3556DA%7D&DE=%7B78F77E9E-3E4E-450C-8453-7875F69875CF%7D.

City of Benicia. Undated. Wastewater Treatment. Available: http://www.ci.benicia.ca.us/index.asp?Type=B_LIST&SEC={CC06BC05-D6FE-4472-BF0F-E8DD5AA4476A}.

Pipeline and Hazardous Materials Safety Administration. 2007. Pipeline Information Management Mapping Application. Available: https://www.npms.phmsa.dot.gov/.

City of Benicia. 2014. Valero Crude by Rail Draft Environmental Impact Report. Available: http://www.ci.benicia.ca.us/index.asp?SEC=%7BFDE9A332-542E-44C1-BBD0-A94C288675FD%7D.

Valero. 2014. Benicia Refinery Overview. Available: http://www.valero.com/ourbusiness/ourlocations/refineries/pages/benicia.aspx.

City of Benicia. 2004. Stormwater Management Plan. Available: http://www.ci.benicia.ca.us/vertical/Sites/%7B3436CBED-6A58-4FEF-BFDF-5F9331215932%7D/uploads/%7BE61263F5-2CD8-4246-95EB-F4105923D226%7D.PDF.

City of Benicia. 2009. Sanitary Sewer Overflow and Backup Response Plan. Available: http://www.ci.benicia.ca.us/vertical/sites/%7B3436CBED-6A58-4FEF-BFDF-5F9331215932%7D/uploads/%7B93C5B2A0-6BCC-4332-9880-49D89D24F47F%7D.PDF.

City of Benicia. 2007. Section V—Design and Construction Standards. Available: http://www.ci.benicia.ca.us/vertical/sites/%7B3436CBED-6A58-4FEF-BFDF-5F9331215932%7D/uploads/Final_Section_V_2011.pdf.

Climate Change Adaptation Plan

Appendix G

Climate Science Summary

THE CITY OF BENICIA CALIFORNIA

City of Benicia Climate Change Vulnerability and Adaptation Plan

Climate Change Summary

Prepared for:

The City of Benicia

Prepared by:

With Contributions from:

PlaceWorks

Date: September 2014

Table of Contents

Project Introduction 1
Framework 1
Technical Advisory Committee and Community Advisory Group 2
Refined Project Area 4
Climate Impacts and Scenarios 4
Sea Level Rise and Storms 5
Downscaled Temperature and Precipitation Data 7
Temperature 9
Precipitation 12
Fire Hazard 15
Sectors and Assets for Assessment 17
Project Resilience Goals 17
Lessons Learned 20
Attachment A: Invitation Letter 22
Attachment B: TAC and CAG Meeting Materials 24

Table of Tables

Table 1: TAC and CAG Invitees 2
Table 2: OPC Sea Level Rise Projections 5
Table 3: Total Water Level Chart 7
Table 4: Differences between CMIP 3 & 5 8
Table 5: Projected Changes in Temperature - RCP 4.5 10
Table 6: Projected Changes in Temperature - RCP 8.5 11
Table 7: Projected Changes in Rain - RCP 4.5 13
Table 8: Projected Changes in Rain - RCP 8.5 14
Table 9: TAC and CAG Identified Sectors and Assets 17

Table of Figures

Figure 1: Revised Project Area Map 4
Figure 2: 60 Inch Total Water Level 6
Figure 3: Climate Data Downscaling Grids 9
Figure 4: Solano County Fire Severity Zones 16
Figure 5: Sample Project Goals 19

Project Introduction

The City of Benicia is a waterfront town in the San Francisco Bay Area that is full of history as one of the State's first capitals, home to the first West Coast Army post, host to a railroad car ferry to San Francisco, and numerous other historic sites. Today, Benicia is home to a thriving arts community, beautiful weather and scenic vistas, and a downtown full of charming boutiques and antique shops. In order to maintain its high quality of life, prosperous businesses, productive ecosystems, and vibrant neighborhoods, Benicia is planning for the future.

The City of Benicia acknowledges the risks associated with projected changes in climate and is taking steps to prepare and become a more resilient city that can manage the hazards of today as well as those of tomorrow by conducting a Climate Change Vulnerability Assessment and creating an Adaptation Plan. This plan will help ensure that Benicia remains a thriving, sustainable city with resilient communities, infrastructure, and services despite anticipated changes in climate.

This work will build on prior and ongoing sustainability efforts within the City. Climate change mitigation has been thoroughly ingrained in the City's operating procedures, and the City now wishes to do the same with adaptation. The City is poised to capitalize on an important window of opportunity to adopt adaptation measures that are sustainable, equitable, economically viable, and cost effective. Proactively assessing vulnerability and evaluating adaptation measures is a key step towards building a more resilient community.

The first task in the project, Task 2, included convening a technical advisory committee (TAC) and a community advisory group (CAG), selecting climate change scenarios and stressors, refining the project area, identifying critical sectors and assets, and developing the project goals. This report provides a summary of this task and the key findings.

Framework

From October 2010 through December 2013, the Bay Conservation and Development Commission (BCDC) with support from the National Oceanic and Atmospheric Administration Coastal Services Center (NOAA CSC) undertook a first-of-its-kind detailed sea level rise vulnerability assessment project for a sub-section of the San Francisco Bay. This project, named Adapting to Rising Tides (ART), developed and piloted a process for conducting vulnerability assessments by bringing together a broad suite of stakeholders and experts to collectively gain a better understanding of how climate change will affect the ecosystems, infrastructure, and economy of the Bay Area.

The current City of Benicia project is modeled off of this larger ART project and seeks to use the tools and framework developed for the ART project as much as possible. However, due to the differing scales of analysis, timelines, and budgetary considerations, the tools will be customized for a local planning effort.

A key element of the ART project that will be replicated in the City of Benicia project is the focus on four overarching frames of analysis:

- Society and equity
- Economy
- Environment
- Governance

Together, these four frames comprise a sustainability framework that will inform the consideration of adaptation strategies and options and will help address how Benicia can support a sustainable and prosperous economy while building resilience to climate change.

Technical Advisory Committee and Community Advisory Group

As in the ART project, this project will bring together a diverse group of advisors who may not have had previous cause to work together. It creates an opportunity to build relationships amongst participants and share information on local assets and climate stressors. The simple act of bringing these people together to discuss a common issue will be an important ancillary benefit of the project.

Involving a diverse range of stakeholders brings a depth of knowledge in the form of "boots-on-the-ground" information. Participation of the technical advisory committee (TAC) and Community Advisory Group (CAG) throughout this project will result in a more robust end product and buy-in on the course of action necessary to move forward and implement the most effective adaptation strategies. Together, the TAC and CAG's knowledge of local geography and historical events provides rich inputs into all stages of the project from creating an asset inventory, detailing past extents of hazards, collecting data on vulnerability, and guiding the creation of politically feasible adaptation options.

ICF International and PlaceWorks worked with the City of Benicia to develop the TAC and CAG invitation lists. The groups include a mix of asset managers/owners, shoreline experts, local and regional government, and community representatives. These groups were invited to attend half day meetings in Benicia on Thursday, August 21st, 2014. The invitation letter can be found in Attachment A: Invitation Letter and the complete set of hand-out materials can be found in Attachment B: TAC and CAG Meeting Materials.

Table 1: TAC and CAG Invitees

Technical Advisory Committee (TAC)		Community Advisory Group (CAG)	
Entity	**Contact Name**	**Entity**	**Contact Name**
Solano County Health Department	Michael Stacy	Benicia Industrial Park Association (BIPA)	See Benicia Chamber of Commerce
Solano Transportation Authority	Bob Macaulay	Benicia Chamber of Commerce	Stephanie Christiansen
County of Solano*	Matt Walsh	Benicia Chamber of Commerce*	Ric Small
City of Benicia*	Mike Roberts	Planning Commission	*To be agendized at their standing meeting*

Technical Advisory Committee (TAC)		Community Advisory Group (CAG)	
Entity	**Contact Name**	**Entity**	**Contact Name**
City of Benicia	Steve Soloman	Community Sustainability Commission	*To be agendized at their standing meeting*
City of Benicia	Vic Randall	Arts & Culture Commission	*To be agendized at their standing meeting*
City of Benicia*	Nick Thomas	Benicia Unified School District	Janice Adams
City of Benicia	Mario Giuliani	Benicia Main Street	Nancy Martinez
City of Benicia*	Amy Million	Arts Benicia*	Larnie Fox
City of Benicia*	Rick Knight	Benicians for a Safe and Healthy Community	Marilyn Bardet
Valero	Joe Muehlbauer	Good Neighbor Steering Committee	Kathy Kerridge
Valero	Sue Fisher Jones	Community Action Council	Viola Robertson
Amports*	Randy Scott	Senior Center	Ann Dunleavy
JPC/BACERP	Bruce Riordan	Iron Workers Union	Jeff McEuen
Solano County Water Agency	Sandra McLean	Rancho Benicia	Pattie and Doug Elmore
Bay Trail	Laura Thompson	Union Pacific Railroad	Lisa Lawson Stark
Bay Trail	Maureen Gaffney	Pointe Benicia	
SF Bay Area Water Trail	Galli Basson	Portside Village	Justin Schouten
BCDC*	Wendy Goodfriend	Portside Village*	Dennis Cullen
BCDC	Lindy Lowe	The Terrace HOA	Kenneth Trosien
SolTrans	Mona Babauta	Benicia Harbor Corporation	John Ash (owner)
Coastal Conservancy*	Kelly Malinowski	California Native Plant Society	Steve Goetz
ICLEI	Melissa Higbee	HPRC*	Maggie Trumbly
Pacific Institute	Matt Heberger	Benicia PCS*	Vic Randall
ABAG*	Dana Brechwald	City of Benicia*	Gina Eleccion
MTC*	Stefanie Hom	PRC Commission*	Rich Payie
US Army Corps of Engineers**	Craig Conner		
CA Dept. of Fish and Wildlife	Crystal Spurr		
Pacific Gas & Electric Company	Jessica Waggoner		
Pacific Gas & Electric Company*	Amy Dao		

* Attended the meeting in person.

** Attended via teleconference.

The ICF Team plans to fully utilize the knowledge and expertise of the TAC and CAG throughout the project duration. There will be a survey sent to at least the TAC to collect information on asset vulnerability and a future in-person meeting to review the proposed climate change adaptation strategies.

Refined Project Area

The base project area map was created by the City of Benicia for inclusion in their original grant application to the California Coastal Conservancy. It was drafted to include projected coastal flooding issues, current inland flooding issues, as well as key community facilities.

Upon review at the TAC and CAG meeting, the project area amp was revised to ensure that it captures the majority of E 1st Street, the main shopping corridor in downtown Benicia. Additionally, the inland flooding areas have been removed since they are not the primary focus of the project.

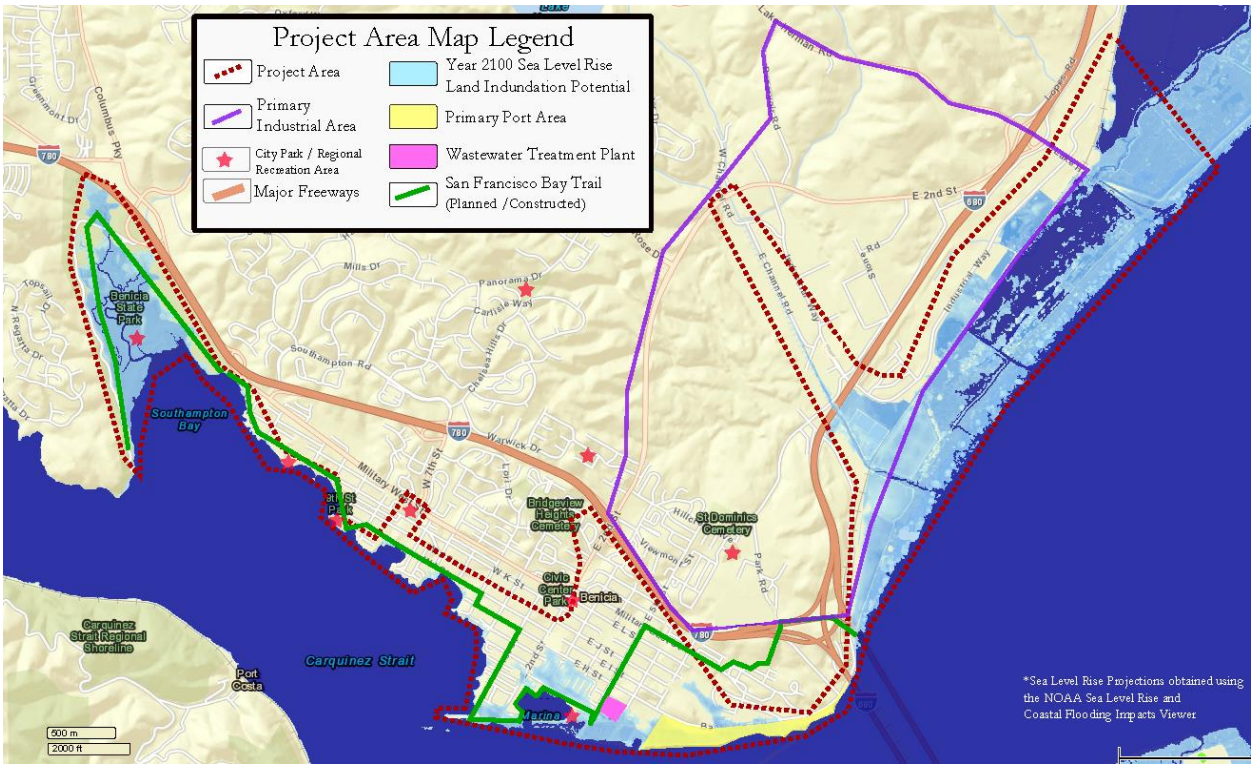


Figure 1: Revised Project Area Map

Climate Impacts and Scenarios

There are a multitude of potential primary and secondary effects of climate change. Primary effects include changing temperatures, rainfall patterns, rising sea levels, altered wind patterns. Secondary impacts include landslides, inland flooding, wildfire, drought, and shifting storm patterns. This project will not be able to assess the impacts from all of these primary and secondary changes due to the uncertainty surrounding some of the changes as well as due to time and financial restrictions.

Climate change scenarios will be assessed from two time periods – mid-century and end-of century. In general, climate models predict mid-century changes with a small uncertainty range, while the end-of century projections generally contain a high level of uncertainty. This is due to unknowns surrounding future global greenhouse gas emission levels. Due to these uncertain futures, it is important to recognize that an "end-of-century" projection does not mean that exactly in the year 2100 the climate will have shifted to a specific new norm. Rather, the information means that around year 2100 – potentially sooner and potentially later depending on future emissions – the climate will behave closer to the projections than it does to current day weather patterns. For this reason, projections are presented as a range and the emphasis is on the trends and order of magnitude of future change.

This project will move forward with two climate stressors – sea level rise/storms and temperature. The following sections provide an overview of those findings as well as additional climate stressors that were not selected for further analysis.

Sea Level Rise and Storms

Consistency amongst planning agencies allows for an apples-to-apples comparison of the future effects of sea level rise and appropriate adaptation measures. Many agencies in California, including the California Coastal Conservancy, are using the state Ocean Protection Council (OPC) 2013 guidance, which includes the scientific findings of the National Research Council (NRC) Sea-Level Rise for the Coasts of California, Oregon, and Washington study released June 2012. This guidance recommends assessing between 5 and 24 inches of sea level rise by mid-century and between 17 and 66 inches by the end-of-century (see Table 2). In the ART project, BCDC assessed 16 inches of sea level rise by midcentury and 55 inches by end of century; however, BCDC now recommends using the higher OPC numbers..

Table 2: OPC Sea Level Rise Projections

Time Period	North of Cape Mendocino	South of Cape Mendocino
2000-2030	-4 to 23 cm (-1.6 to 9 inches)	4 to 30 cm (1.6 to 11.8 inches)
2000-2050	-3 to 48 cm (-1.2 to 18.8 inches)	12 to 61 cm (4.7 to 24 inches)
2000-2100	10 to 143 cm (3.6 to 56 inches)	42 to 167 cm (16.6 to 65.8 inches)

For this project, we will be considering three sea level rise scenarios. Twelve inches will represent that low, mid-century projection, 24 inches will represent both the high, mid-century projection as well as the low end-of-century projection, and 60 inches will represent the high end-of century projection (see Figure 2).

Fortunately, these three sea level rise levels can represent far more than static points in time when using a total water level approach. This allows for the simultaneous consideration of changes in short term, storm related flooding as well as long-term permanent inundation areas. Permanent inundation occurs when an area is exposed to regular daily tidal inundation. A permanently inundated area can no longer be used in the same way due to the frequency of its exposure to the Bay's tides. In contrast,

flooding occurs when an area is exposed to episodic, short duration such as extreme tide events of greater magnitude than normal tide levels. Inland areas may be temporarily flooded during an extreme tidal event while maintaining at least a portion of their functionality once the floodwaters recede. However, sensitive assets may suffer irreversible damage if exposed to any amount of water, even temporarily.

The NOAA Digital Coast Sea Level Rise Viewer was used to produce an intial set of project maps. This resource uses the most recent Lidar digital elevation data sets to map areas of inundationg that are hydrologically connected to the water. This hydrologic conectivity is important because it takes into accoun the existing shoreline protection features. Although it is unkown if these will be properly maintained into the future, the existing investment in infrastructure should be represented on sea level rise maps. However, this does not mean that all shoreline protections features are adequatley captured. For example, the thin sea walls that protect the wastewater treatment plant are too narrow to be detected in the Lidar data. Fo that reason, risks in particular areas may be overestimated. As the vulnerability assessment progresses, the ICF Team will be performing spot checks for these issues.

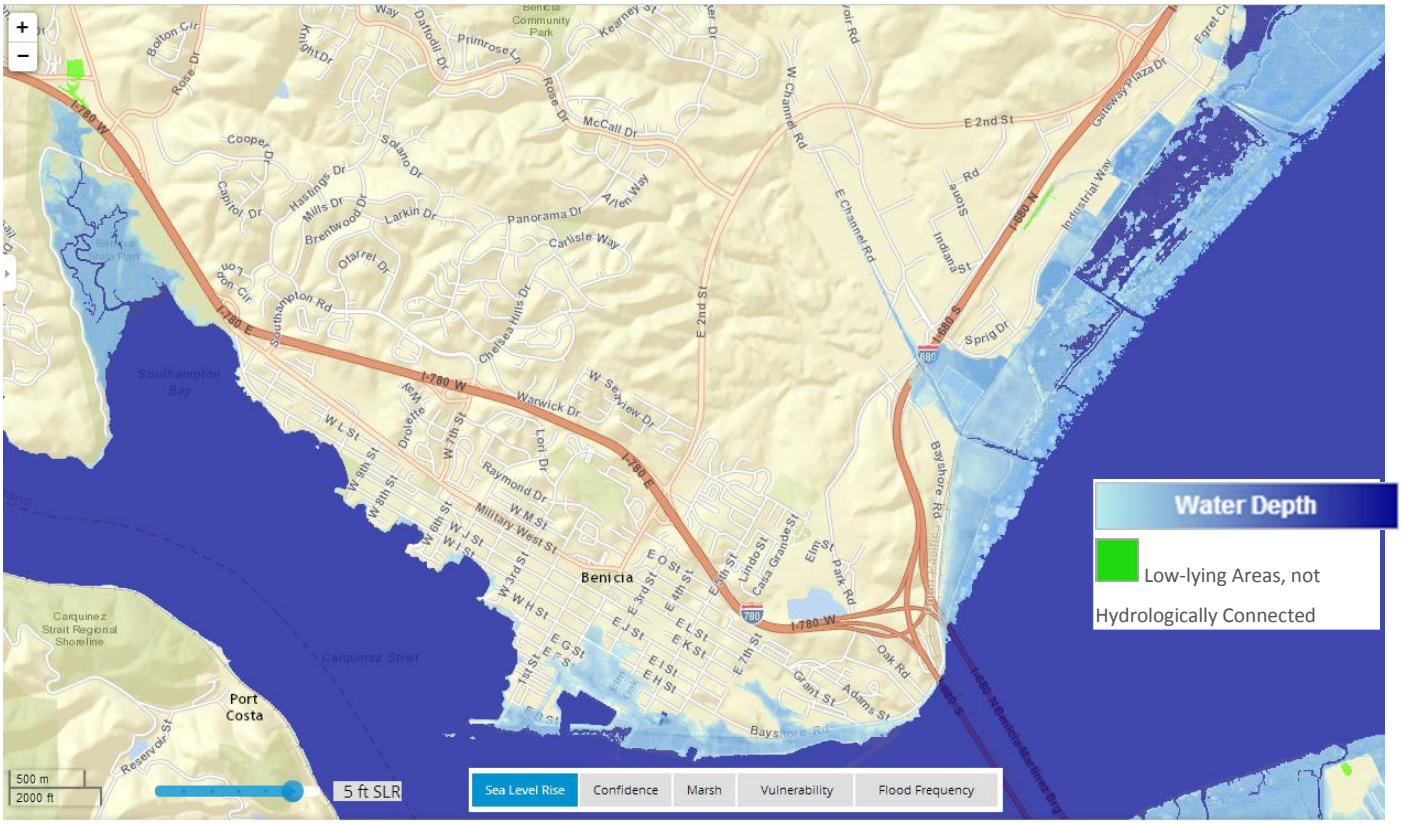


Figure 2: 60 Inch Total Water Level

Table 3: Total Water Level Chart

		Extreme Tide Level						
Sea Level Rise**	**Water Level above MHHW**	**1-yr**	**2-yr**	**5-yr**	**10-yr**	**25-yr**	**50-yr**	**100-yr**
+0	0	12	18	24	30	36	42	48
+6	6	18	24	30	36	42	48	54
+12	12	24	30	36	42	48	54	60
+18	18	30	36	42	48	54	60	66
+24	24	36	42	48	54	60	66	72
+30	30	42	48	54	60	66	72	78
+36	36	48	54	60	66	72	78	84
+42	42	54	60	66	72	78	84	90
+48	48	60	66	72	78	84	90	96
+54	54	66	72	78	84	90	96	102
+60	60	72	78	84	90	96	102	108

** All values in inches above MHHW (NAVD88)

Table Map Key

Color Code	**NOAA SLR Viewer Map Scenario** (inches above MHHW)
	12
	24
	36
	48
	72
	96

Source: San Francisco Bay Conservation and Development Commission (BCDC)

The potential impact of sea level rise includes:

- more frequent and longer lasting flooding
- permanent inundation
- disruptions and decreased access
- increased mobilization of toxins with additional ground water movement
- wetland migration
- loss of public access to waterfront
- increased erosion
- saltwater intrusion
- seismic instability

Downscaled Temperature and Precipitation Data

Developing locally relevant climate change data has historically been very challenging; however, ICF International recently assisted the U.S. Department of Transportation in developing a simple and

accessible spreadsheet tool that takes in downloaded files of downscaled climate model data process the data to provide the user with locally relevant information. This UD DOT Coupled Model Intercomparison Project (CMIP) Climate Data Processing Tool will soon be available on the US DOT's website. When using this tool to obtain information on changes in temperature and precipitation, several decisions have to be made:

Data Source: The World Climate Research Programme (WCRP) develops global climate projections through its Coupled Model Intercomparison Project (CMIP) roughly every 5 to 7 years. These projections have informed Intergovernmental Panel on Climate Change (IPCC) Assessment Reports, as well as various research, assessment, and educational activities related to climate change processes and outcomes, mitigation, and adaptation. CMIP5, released in May 2013, is a more recent version than CMIP3, although both are still available for use. Whereas CMIP3 was used for the Intergovernmental Panel on Climate Change's (IPCC) Fourth Assessment Report (AR4) and uses the Special Report on Emissions Scenarios (SRES) family of emissions scenarios (B1, A1B, and A2), CMIP5 has been used for the IPCC Fifth Assessment Report (AR5), released in 2014. AR5 contains new emissions scenarios called Representative Concentration Pathways (RCPs), which are emissions scenarios used to describe combinations of greenhouse gas emissions, socioeconomic factors, and technological change out to 2100. All RCPs are projected to be equally likely futures.

Table 4: Differences between CMIP 3 & 5

	CMIP3	CMIP5
Used in	IPCC Fourth Assessment Report (2007)	IPCC Fifth Assessment Report (2014)
Years available	1961-2000; 2046-2065; 2081-2099	1950-2099
Emissions scenarios	B1, A1B, A2	RCP2.6, RCP4.5, RCP6.0, RCP8.5
Number of available climate models	9	21

The climate science community has not yet determined whether CMIP5 is a more reliable source of climate projections than CMIP3 projections, largely because this more recent version has not been tested as thoroughly as CMIP3 has. However, for this project, the ICF Team will be using CMIP 5 since it is the most current and up to date data available.

Climate Scenarios: The projections run for this project include two climate scenarios, a "high" and a "moderate-low" global greenhouse gas emissions scenario. This provides a bracketed range for use in the vulnerability assessment. RCP 4.5 represents a moderate-low emissions scenario in which emissions increase in the short term but their growth is curbed and stabilized shortly after 2100. This could be achieved through lower emissions energy technologies, the deployment of carbon capture and geologic storage technology, and the expansion of forest lands. There is a lower emissions scenario (2.6 – substantial and sustained emissions reduction scenario); however, this is not recommended for analysis for two reasons. First, from what we have witnessed thus far, this is not a very likely future scenario. Second, this scenario would result in an extremely low sea level rise—much lower than what we are considering using.

RCP 8.5 represents the highest emissions scenario - high global population growth and relatively slow income growth with modest rates of technological change, high energy demand, and few climate change policies.

How do the RCP's match up with the potential sea level rise scenarios? The IPCC sea level rise projections have always been lower than the majority of academic projections. For example, between 2080 and 2100 the lowest emission scenario (RCP2.6) has a sea level range of 10.2 inches to 21.7 inches and the highest scenario (RCP 8.5) ranges from 17.7 inches to 38.6 inches. This falls below well below the OPC guidance of 16.6 to 65.8 inches by end of century. Due to this discrepancy, this project is separating the sea level rise projections from the temperature and precipitation projections. Plus, the sea level rise projections have been specifically optimized for the West Coast of the United States while the temperture and precipitation data is still using downscaled global climate change models.

Climate Model: The projections pulled data across all 21 available global climate models. This wide range helps to smooth inconsistencies or oddities that may be present in any one model.

Geographic Area: The climate projections pull data from the bottom half of the large red rectangle in Figure 3. Best practices recommends selecting 4-grid cells (the full red box) to help smooth out any oddities in the data; however, for the City of Benicia, this would pull in too much inland data which may result in an overestimation of the increase in high heat days. Therefore, climate projections just use the two coastal grid cells. This still provides some data smoothing without incorporating significant stretches of inland (e.g., Fairfield) data.

Figure 3: Climate Data Downscaling Grids

Temperature

The low emissions (RCP 4.5) range of the temperature projections can be reviewed in Table 5. The first column contains observed data in the area averaged between 1950 and 1999. The 95th percentile means that 95% of the days between 1950 and 1999 were below 92.4°F. However, to cross this threshold, the day only had to hit 92.4°F at some point, it did not necessarily remain that hot for an extend period of

time. Heat waves, or multiple days over a high temperature, can be gleaned from the row titled "Maximum Number of Consecutive Days per Year above 92.4°F" and the hottest heat waves are provided in the last two rows.

The projected data shows that is will be hot much more frequently in the future. The middle column of data provides information on the projected changes around mid-century by averaging daily or yearly data between 2046 and 2065. Likewise, the last column displays end-of-century projections by averaging daily or annual data between 2080 and 2099 (the last year of the climate model runs). Although the hottest temperature of the year only increases from 102 to 107 mid-century, and 108 at the end of the century, there is projected to be an increase in days over 92.4°F from 18 days to 54 days at mid-century and 62 days at the end of the century. This equates to two full months with temperatures over 92.4°F. At the end of the century, there is projected to be 13 days in a row with temperatures over this threshold, and a full week with temperatures over 99°F.

This data does not take into account the "real feel" temperature around coastal Benicia, meaning that the strong coastal breeze frequently makes it feel cooler and reduces the human health impacts of high temperatures.

Table 5: Projected Changes in Temperature - RCP 4.5

Projected Changes in Temperature – RCP 4.5			
Variable	**Baseline (1950-1999)** ***Observed Value***	**Mid-century (2046-2065)** ***Projected Value***	**End-of-Century (2080-2099)** ***Projected Value***
Average Annual Mean Temperature	59.1 °F	62.4 °F	63.0 °F
Average Annual Maximum Temperature	71.5 °F	74.9 °F	75.5 °F
Average Annual Minimum Temperature	46.6 °F	49.9 °F	50.6 °F
Hottest Temperature of the Year	102.0 °F	107.2 °F	107.8 °F
"Very Hot" Day Temperature (95th Percentile Temp)	92.4 °F	97.1 °F	97.8 °F
"Extremely Hot" Day Temperature (99th Percentile Temp)	98.8 °F	103.7 °F	104.4 °F
Average Number of Days per Year Above 92.4°F	18.3 days	54.4 days	62.2 days
Average Number of Days per Year Above 98.8°F	3.7 days	20.2 days	25.2 days
Maximum Number of Consecutive Days per Year above 92.4°F	4.8 days	11.6 days	13.1 days

Projected Changes in Temperature – RCP 4.5			
Variable	**Baseline (1950-1999)** ***Observed Value***	**Mid-century (2046-2065)** ***Projected Value***	**End-of-Century (2080-2099)** ***Projected Value***
Average Summer Temperatures	84.2 ° F	88.1 ° F	88.8 ° F
Highest 4-Day Average Summer Temperature	97.6 ° F	102.4 ° F	102.9 ° F
Highest 7-Day Average Summer Temperature	94.2 ° F	98.9 ° F	99.4 ° F

In the high emissions scenario (RCP 8.5), the general trend towards hotter days occurring more frequently remains the same; however, it is shifted to a more extreme range. For example, at the end of the century the hottest day of the year is projected to be over 112°F and it is projected to be over 92.4°F for 101 days out of the year with a straight month over that threshold. See Table 6 for additional details.

Table 6: Projected Changes in Temperature - RCP 8.5

Projected Changes in Temperature – RCP 8.5			
Variable	**Baseline (1950-1999) Observed Value**	**Mid-century (2046-2065) Projected Value**	**End-of-Century (2080-2099) Projected Value**
Average Annual Mean Temperature	59.1 °F	63.4 °F	66.8 °F
Average Annual Maximum Temperature	71.5 °F	75.9 °F	79.2 °F
Average Annual Minimum Temperature	46.6 °F	51.0 °F	54.4 °F
Hottest Temperature of the Year	102.0 °F	108.4 °F	112.3 °F
"Very Hot" Day Temperature (95th Percentile Temp)	92.4 °F	98.4 °F	102.1 °F
"Extremely Hot" Day Temperature (99th Percentile Temp)	98.8 °F	105.1 °F	108.8 °F
Average Number of Days per Year Above 92.4°F	18.3 days	66.2 days	101.0 days
Average Number of Days per Year Above 98.8°F	3.7 days	28.5 days	59.9 days

Projected Changes in Temperature – RCP 8.5			
Variable	**Baseline (1950-1999) Observed Value**	**Mid-century (2046-2065) Projected Value**	**End-of-Century (2080-2099) Projected Value**
Maximum Number of Consecutive Days per Year above 92.4°F	4.8 days	14.6 days	32.1 days
Average Summer Temperatures	84.2 °F	89.3 °F	93.0 °F
Highest 4-Day Average Summer Temperature	97.6 °F	103.7 °F	107.4 °F
Highest 7-Day Average Summer Temperature	94.2 °F	100.1 °F	103.9 °F

The potential impact of extreme heat includes:

- increased energy demand for cooling
- potential for heat related illnesses (e.g., heat exhaustion and stroke)
- increased potential for wildfires
- decreased efficiency at wastewater treatment plants
- increased urban heat island impacts
- decreased over-night cooling
- potential for economic disruptions due to worker safety
- negative implications for air quality
- increased vulnerability of natural habitats

Precipitation

Precipitation or rainfall in the City of Benicia is only projected to modestly change. In the moderate-low emissions scenario (RCP 4.5), total annual rainfall will increase by almost an inch through the end of the century and then stabilize. There is also projected to be a small increase in the frequency of heavy rain events. These heavy rain events are what can lead to inland flooding issues in the City of Benicia.

In recent years, California has experienced extreme drought conditions; however, cyclical drought patterns have historically occurred and do not indicate a permanent change in weather patterns. One take away from the drought conditions is that weather is becoming more extreme—drought years are even harsher but, at other times, there may be years with heavier than average rainfall events. Across the country, rainfall is the most variable climate change impact with increases in precipitation in some locations and decreases in others.

This graph table only represents rainfall within the general vicinity of the City of Benicia; it does not speak to changes in rainfall in other parts of California or other states. Changes in rainfall in other

locations may impact the availability of clean drinking water for the City of Benicia. Additionally, with the higher temperatures, precipitation in other parts of the state is more likely to fall as rain rather than snowfall which reduces the security and of consistent snowmelt from the mountains throughout the year.

A full summary of the projected changes in rainfall with the moderate-low emissions reduction scenario can be found in Table 7.

Table 7: Projected Changes in Rain - RCP 4.5

Projected Changes in Rain – RCP 4.5			
Variable	**Baseline (1950-1999)** ***Observed Value***	**Mid-century (2046-2065)** ***Projected Value***	**End-of-Century (2080-2099)** ***Projected Value***
Average Total Annual Rain	19.7 inches	20.7 inches	20.8 inches
"Very Heavy" 24-hr Rain Amount (95th percentile)	0.8 inches	0.9 inches	0.6 inches
"Extremely Heavy" 24-hr Rain Amount (99th percentile)	1.5 inches	1.7 inches	1.4 inches
Average # of Baseline "Very Heavy" Rain Events per Year (0.8 inches in 24 hours)	4.8 times	6.0 times	5.9 times
Average Number of Baseline "Extremely Heavy" Rain Events per Year (1.5 inches in 24 hrs)	1.0 times	1.8 times	1.9 times
Average Winter Rainfall	11.5 inches	13.1 inches	13.1 inches
Average Spring Rainfall	4.6 inches	4.3 inches	4.5 inches
Average Summer Rainfall	0.2 inches	0.2 inches	0.2 inches
Average Fall Rainfall	3.5 inches	3.2 inches	3.1 inches
Largest Winter 3-day Rain	2.8 inches	3.4 inches	3.4 inches
Largest Spring 3-day Rain	1.4 inches	1.4 inches	1.4 inches
Largest Summer 3-day Rain	0.2 inches	0.2 inches	0.2 inches
Largest Fall 3-day Rain	1.4 inches	1.4 inches	1.3 inches

The high emissions scenario (RCP 8.5) projects a similar pattern of slight increases in the total amount of rain and the increased frequency of high intensity rainfall events. The RCP 4.5 projections showed a leveling off of changes in rainfall between mid-century and end-of-century while RCP 8.5 displays a slow but gradual continuation of trends from baseline data to mid-century to end-of-century. A full summary of the data can be found in Table 8.

Table 8: Projected Changes in Rain - RCP 8.5

Projected Changes in Rain – RCP 8.5			
Variable	**Baseline (1950-1999) Observed Value**	**Mid-century (2046-2065) Projected Value**	**End-of-Century (2080-2099) Projected Value**
Average Total Annual Rain	19.7 inches	20.2 inches	22.2 inches
"Very Heavy" 24-hr Rain Amount (95th percentile)	0.8 inches	0.9 inches	0.6 inches
"Extremely Heavy" 24-hr Rain Amount (99th percentile)	1.5 inches	1.7 inches	1.5 inches
Average # of Baseline "Very Heavy" Rain Events per Year (0.8 inches in 24 hours)	4.8 times	5.7 times	6.9 times
Average Number of Baseline "Extremely Heavy" Rain Events per Year (1.5 inches in 24 hrs)	1.0 times	1.8 times	2.6 times
Average Winter Rainfall	11.5 inches	12.9 inches	14.9 inches
Average Spring Rainfall	4.6 inches	4.2 inches	4.3 inches
Average Summer Rainfall	0.2 inches	0.2 inches	0.2 inches
Average Fall Rainfall	3.5 inches	2.9 inches	2.9 inches
Largest Winter 3-day Rain	2.8 inches	3.4 inches	3.9 inches
Largest Spring 3-day Rain	1.4 inches	1.4 inches	1.4 inches
Largest Summer 3-day Rain	0.2 inches	0.2 inches	0.2 inches
Largest Fall 3-day Rain	1.4 inches	1.4 inches	1.4 inches

The potential impacts of changes in precipitation include:

- changes in the availability of fresh water

- decreased water quality due to sediment and pollutant increases in runoff
- increased flooding due to more frequent severe rainfall events
- potential for more frequent drought years
- increased landslide susceptibility
- increased potential for sewer system backup
- increased populations of disease-carrying insects and rodents,
- community disruption and displacement
- accelerated deterioration of community assets (e.g., mold infestations, electrical shortages, rust)

Fire Hazard

The California Department of Forestry and Fire Protection (CAL FIRE) oversee the protection of California's privately-owned wildlands from fire risks and varied levels of emergency services via contracts with local governments. As can be seen in Figure 4, the CAL FIRE Fire and Resource Assessment Program (FRAP), Benicia (outlines in red) has very little land that is within a fire hazard severity zone. This is likely due to the coastal location and urban development.

The City of Benicia maintains an active fire control and prevention management system. This minimizes the risk of fires within the city. It is assumed that the City will continue to fund this active fire risk management system in order to minimize the risk of a severe fire within the city limits. However, distant fires could still impact the City of Benicia by negatively impacting air pollution and potentially damaging utility transmission lines.

Currently, there is a limited understanding of how future climate changes will impact wildfire risk. Wildfire risk combines many factors such as:

- available fuel (dry vegetation)
- historical fire regimes and intervals
- weather patterns (e.g., rainfall, temperature, and lightening)
- development patterns

California has experienced a longer fire season but determining the long term changes in actual fire risk is extremely difficult.

ICF International recommends not including increased wildfire risk in the final Climate Change Vulnerability and Adaptation Plan due to the limited existing vulnerability, the city's current proactive management of this issue, and the limited availability of data on future changes to fire risks.

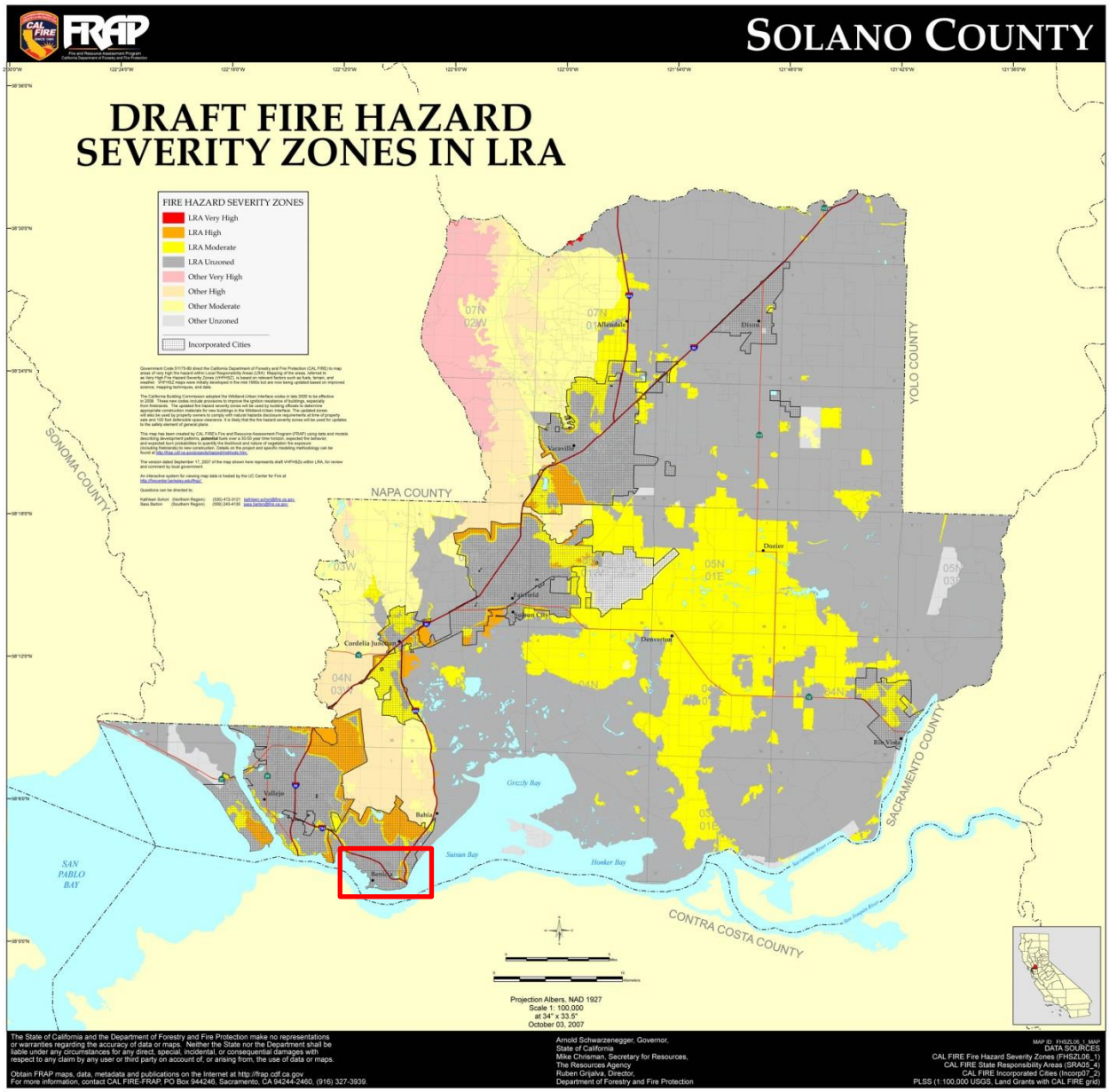


Figure 4: Solano County Fire Severity Zones

Potential impacts of fires includes:

- increased air pollution,
- lease of additional greenhouse gas emissions,
- community disruption and displacement,
- potential for invasive insect colonization and outbreak,
- permanently altered ecosystems.

Sectors and Assets for Assessment

The identification of sectors and specific assets to analyze throughout the rest of the project is a critical step in the process and must be driven by the priorities of the City, TAC, and CAG. Prior to the meeting, the ICF Team identified the following list of potential sectors to include in the vulnerability analysis:

- Transportation;
- Port of Benicia;
- Natural Areas (parks and recreation);
- Shoreline Protection;
- Storm Water and Waste Water;
- Community Land Use, Services, and Facilities; and
- Energy Infrastructure and Pipelines.

At the TAC and CAG meetings, the participants identified important community assets that fit within each of these sectors (see Table 9 for a complete list). The participants remarks were recorded on poster paper around the meeting room and additional assets could be identified on a handout (see Appendix B: TAC and CAG Meeting Materials for a copy of the handout) that was collected at the end of the meeting.

The ICF Team will work with the City to identify assets within these sectors that are critical to the City; have readily accessible information; support for analysis from the asset owner/manager; and are representative of other assets within the sector. For example, not every street within the project area can be assessed; instead, a subset of representative streets that are anticipated to be most vulnerable (such as those identified in Table 9) can be selected for analysis. The results of the analysis will be applicable to the surrounding streets. ICF's initial recommendations of assets for further study are marked with an asterisk in Table 9.

Table 9: TAC and CAG Identified Sectors and Assets

Sector	Assets

Transportation	• UP rail line near Sulphur Springs Creek
	• Local streets subject to inundation
	  ○ E 2nd Street*
	  ○ E 5th Street*
	  ○ Grant Street connection to the Benicia Arsenal
	  ○ Park Street
	  ○ Bayshore (adjacent to AMPORTS)*
	  ○ Industrial Way*
	• I-680
	  ○ near Sulphur Springs Creek
	  ○ Area under Martinez Bridge approach
	• Bay Trail near Sulphur Springs*

Natural Areas	• Benicia State Park (marsh and estuary)* • Marsh in front of Industrial Park* • First St Green • Trumbull Park* • Ninth St Park

Sector	Assets
Engineered Shoreline Protection	• First St. Seawall • AMPORTS levees* • Benicia Wastewater Treatment Plan (WWTPP)Flood Walls* • Benicia Boatyard • Areas of engineered protection along entire shoreline
Wastewater and Water Distribution	• Benicia WWTP* • Force main on Bayshore Boulevard • Sewer interceptors • Water distribution system • Valero WWTP
Stormwater	• Stormwater outfalls from East Second, East Fifth and along entire shoreline* • Storm runoff from above I-780 • Sulphur Springs Creek flooding

Energy and Pipeline Infrastructure	• Underground utilities subject to inundation
	  ○ PG&E**
	  ○ Fiber optic/communication
	• Several PG&E substations on Carquinez Strait**
	• Transmission lines outside Benicia could be vulnerable

Community Land Use	• Downtown commercial areas* • Restaurant on West Seventh closed due to flooding (old Sam's Harbor) • Portside Village townhomes* • West 7th houses – some high, but some near water* • Rancho Benicia Mobile Home Park* • Lots of elderly & lower income people live near marina and in older neighborhoods (potential need for shelter and/or evacuation plan) • Benicia Industrial Park* • E. St lot - Key undeveloped parcels
Port of Benicia	• Port property at large* • Levees and water pumps* • Yuba property
Marina	• Floating dock + Boats serving as residences* • Marina gas pump – asset and liability

Other	• Historical resources
	  ○ Arsenal*
	  ○ Downtown
	• Fitzgerald Field*

** Recommended for further study in the vulnerability assessment*
*** Recommended for qualitative discussion in the vulnerability assessment due to known data sensitivities*

Project Resilience Goals

Early identification of the project resilience goals will help direct the rest of the project and define the project outcomes. Input from the TAC and CAG were critical for this process to ensure that the project focuses on the needs of the community.

Stakeholders at the TAC and CAG meeting were provided with a handout the overall project framework – economy, environment, equality, and governance. It was explained that the project goals should include a reference to all four of these topics but that they may also include other objectives and each goal could address anywhere from one to all of the framework categories. Participants were also provided with a set of sample goals from other projects including, the U.S. Department of Transportation Gulf Coast Study, the Adapting to Rising Tides Project, and the City of Santa Cruz Adaptation Plan. This handout can be found in Appendix B: TAC and CAG Meeting Materials.

Meeting participants were provided with a set of large cards on which to write key words, phrases, or ideas that they would like to be included in the goals. These were collected and thematically grouped into constellations on the wall. There was significant overlap between the TAC and CAG groups; however, the CAG brought in a wider range of topics including education and the arts while the TAC focused more intently on the importance of protecting infrastructure. An example photo from this process can be seen in Figure 5.

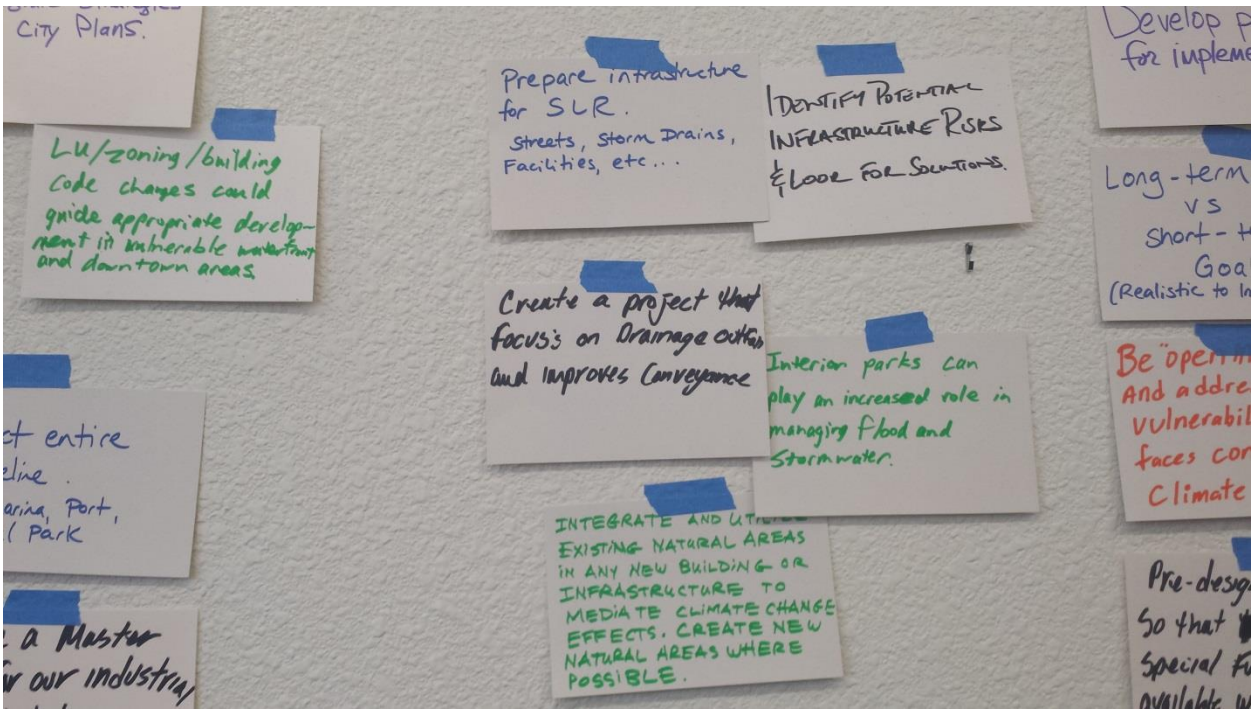


Figure 5: Sample Project Goals

Based on the themes that emerged from the TAC and CAG meeting, the ICF Team has prepared the following set of seven project goals:

1. Protect the beauty and functionality of the many assets that support Benicia's high quality of life, including historic districts and buildings, the shoreline, wetlands, marshes and shoreline recreational features.
2. Support all of Benicia's residents and businesses where they live and work in the face of climate change vulnerability, and help them to plan for and recover quickly from climate-related emergencies.
3. Incorporate planning for climate change, vulnerability and adaptation in all City functions, including planning, public works, parks and recreation, and emergency preparedness.
4. Revise local land use plans, development regulations and building codes to aid and protect future development projects in the face of climate change.
5. Serve as a regional leader and model in planning for climate change and adaptation, and cooperate with regional agencies and neighboring jurisdictions in planning for regional readiness and resilience.
6. Educate the public on the need for personal disaster preparedness, adaptation and investment in resilient infrastructure.
7. Use public art to illustrate issues and educate the public regarding climate change, vulnerability and adaptation.

These goals are highly ambitious and may not be accomplished within the timeframe of the project. However, the project will strive to make progress towards all of these goals by laying the groundwork for them to be implemented over a longer time horizon. There will be an opportunity to revise these goals prior to developing the climate change adaptation strategies.

Lessons Learned

One of the objectives of this project is to modify the Adapting to Rising Tides tools and process for use at the city level, and to communicate this methodology so it may be replicated by other local jurisdictions. While the process used throughout Task 2 has been documented throughout this report, this section serves to clarify lessons learned and best practices developed through Task 2 implementation.

- In general, the project framework of economy, equity, environment, and governance seems to be aligned with the City of Benicia's goals and has provided a useful framework for discussion.
- The TAC and CAG provide an invaluable depth of knowledge, but targeted meetings with specific city departments (such as Public Works) assists in developing a complete view of climate change impacts on city functions.
- The TAC and CAG should include staff level employees that manage facilities and assets on a day-to-day basis. Preferably, the invitation list should include staff that have a history of engaging/working with the city.
- The TAC and CAG provided different insights and opinions that may not have risen to the surface if the groups had been combined.
- The NOAA Digital Coast Sea Level Rise viewer provided an adequate first cut of sea level rise and extreme event exposure. The online tool is easy to use and highly accessible.

- Presenting the coastal inundation maps as total water level maps in order to represent a range of sea level rise and extreme tide events was effective. The material was easily understood and helped to frame the discussion of near term and long term inundation impacts.
- The CMIP Climate Data Processing Tool was an easy to use and publicly available resource for obtaining downscaled temperature and precipitation projections. The side-by-side comparison with historic observed events provides useful context setting information.
- It is beneficial to identify the main sectors proposed for analysis prior to the TAC/CAG meeting but the members of those groups should be the ones to identify the individual assets proposed for further study. This helps conserve project resources and provides an open floor for brainstorming and discussion.
- In setting the project resilience goals, the project deviated from the ART project by not identifying specific area functions and values on a map, as this exercise seemed to be too high level for the small project area. The revised approach of grouping participant goals into thematic areas to develop a constellation of ideas proved to be an effective approach to developing project goals.

Attachment A: Invitation Letter

A SESQUICENTENNIAL CITY
1847 • 1997
THE CITY OF BENICIA CALIFORNIA

CITY HALL • 250 EAST L STREET • BENICIA, CA 94510 • (707) 746-4200 • FAX (707) 747-8120

July 17, 2014

Dear Local Partner,

The City of Benicia invites you to participate on the **Climate Change Vulnerability Assessment and Adaptation Plan Technical Advisory Council (TAC)**. In April 2014, the City was awarded a $150,000 Coastal Conservancy Climate Ready Grant to assess climate related impacts in a 15-mile project area in the City (see attached Project Map).

We will be hosting a kick-off meeting on **Thursday, August 21, 2014 from 9:00 - 12:00p.m.** at the Wastewater Treatment Plant, 614 E. 5th Street, to provide information about this project and to solicit detailed and meaningful input from a diverse group of technical experts. We want to include individuals with technical expertise and understanding of Benicia's economy and resources to help the City identify community assets and climate change related risks and then develop approaches to manage those risks. The final plan will help ensure that Benicia remains a thriving, resilient city with enhanced infrastructure and services.

Climate change and sea level rise can have profound impacts on the City's economic vitality and local ecology. Therefore, we believe immediate and effective local vulnerability and resiliency planning are essential. This work will build upon prior and ongoing implementation of the City's Climate Action Plan. The City is poised to capitalize on an important window of opportunity to develop adaptation measures that are sustainable, equitable, economically viable, and cost effective. Proactively assessing vulnerability and evaluating ways to adapt is a key step towards building a more resilient community.

It is imperative that we actively engage with local technical experts to address two specific questions:

- What assets in Benicia are at greatest risk of being affected by climate change effects including local community, ecosystems, infrastructure and economic resources?
- What strategies should we pursue to address these challenges and reduce and manage risks to local community resources?

As a first step in the project, the City of Benicia is inviting technical experts to join the TAC and meet with our team to:

- Provide further details on the project, the schedule, and the TAC involvement,
- Discuss project resiliency goals,

ELIZABETH PATTERSON, *Mayor*
Members of the City Council
TOM CAMPBELL, *Vice Mayor* . ALAN M. SCHWARTZMAN . MARK C. HUGHES . CHRISTINA STRAWBRIDGE

BRAD KILGER, *City Manager*
H.R. AUTZ, *City Treasurer*
LISA WOLFE, *City Clerk*

Recycled Paper

- Discuss the climate change impacts and scenarios recommended for study,
- Discuss the project area and refine if needed,
- Identify sectors and specific assets to study, and
- Identify potential data sources that may be informative for the remainder of the project.

Agreeing to be a member of the TAC will not require a significant time commitment but we do expect you to be engaged throughout the one-year process and to provide meaningful input when requested. There will be at least one additional TAC meeting (Fall/Winter 2014) and a data collection survey sent to the TAC members. We may also send occasional email updates on the project to ensure that we are keeping you informed and providing opportunities for input.

We are very excited about this project and hope that you can join us on August 21st to learn more about the **City of Benicia Climate Change Vulnerability Assessment and Adaptation Plan** project and find out how you can participate in this critical and timely effort.

Please send questions and RSVP's to aporteshawver@ci.benicia.ca.us.

Sincerely,

Alex Porteshawver
Consulting Climate Action Plan Coordinator

Attachment B: TAC and CAG Meeting Materials

Technical Advisory Group Meeting

August 21st, 2014
9am – 12pm
Wastewater Treatment Plant, 614 E 5th Street, Benicia, CA

Agenda	
9:00 AM	**Welcome and Introductions –** David Early (PlaceWorks) • Welcome and Project Overview– Alex Porteshawver (Benicia) • Role of TAC • Participant introductions
9:15 AM	**Vulnerability and Adaptation 101** – Brenda Dix (ICF International) • Discuss prior planning efforts + outcomes • Terminology, concepts, and process
9:30 AM	**Project Area Overview –** Rich Walter (ICF International) *Virtual walk-through of the project area and the types of infrastructure present in the area.*
9:40 AM	**Selecting Assets and Critical Areas–** David Early (PlaceWorks) *Discussion:* What sectors/assets are you responsible for within the project area? What climate events are making your jobs and lives harder TODAY? Do the boundaries of the project area need to change to include critical assets? *Activity:* Use stickers to vote for the top assets. Identify critical areas for study on the map.
10:15 AM	**Break**
10:30 AM	**Climate Scenarios and Impacts** – Brenda Dix (ICF International) • Sea Level Rise • Temperatures • Rain/inland flooding • Wildfires *Discussion:* Are we focused on the right future climate impacts? How will these climate impacts affect the sectors/assets that you are responsible for?
11:15 AM	**Setting Resiliency Goals –** David Early (PlaceWorks) *Discussion:* Goal framework—economy, environment, equity, and governance. *Activity:* Brainstorming session of appropriate goals.
11:45 AM	**Next Steps** – Alex Porteshawver (Benicia)

Community Advisory Group Meeting

August 21st, 2014
1pm – 4pm
Wastewater Treatment Plant, 614 E 5th Street, Benicia, CA

Agenda	
1:00 PM	**Welcome and Introductions** - David Early (PlaceWorks) • Welcome and Project Overview– Alex Porteshawver (Benicia) • Role of CAG • Participant introductions
1:15 PM	**Vulnerability and Adaptation 101** – Brenda Dix (ICF International) • Discuss prior planning efforts + outcomes • Terminology, concepts, and process
1:30 PM	**Project Area Overview –** David Early (PlaceWorks) *Virtual walk-through of the project area and the types of infrastructure present in the area.*
1:40 PM	**Selecting Assets and Critical Areas –** David Early (PlaceWorks) *Discussion:* What sectors/assets within the community do you depend on? What climate events make your jobs and lives harder TODAY? Do the boundaries of the project area need to change to include critical assets? *Activity:* Use stickers to vote for the top assets. Identify critical areas for study on the map.
2:30 PM	**Break**
2:45 PM	**Climate Scenarios and Impacts** – Brenda Dix (ICF International) • Sea Level Rise • Temperatures • Rain/inland flooding • Wildfires *Discussion:* Are we focused on the right future climate impacts? How will these climate impacts affect the sectors/assets that you depend on?
3:15 PM	**Setting Resiliency Goals –** David Early (PlaceWorks) *Discussion:* Goal framework—economy, environment, equity, and governance. *Activity:* Brainstorming session of appropriate goals.
3:45 PM	**Next Steps** – Alex Porteshawver (Benicia)

Definition of Key Terms

Climate change: Long term changes to the global or regional "average weather" attributed largely to increased levels of atmospheric carbon dioxide produced by the use of fossil fuels.

Extreme weather: Events that are at the extremes of climatological distribution—weather that occurs only 5% or less of the time.

Climate variable: Parameters used to measure and describe climate. For example, temperature, precipitation, wind, storm surge, waves, and relative sea level change.

Climate stressor: Variation in a climate variable that may lead to a climate impact (e.g., high temperatures, heavy rainfall, cyclical variations in temperature over a period of time).

Climate impact: The effect that climate has on a transportation asset.

Adaptation: Adjustment in natural or human systems to a new or changing environment that exploits beneficial opportunities or moderates negative effects.

Vulnerability: The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity.

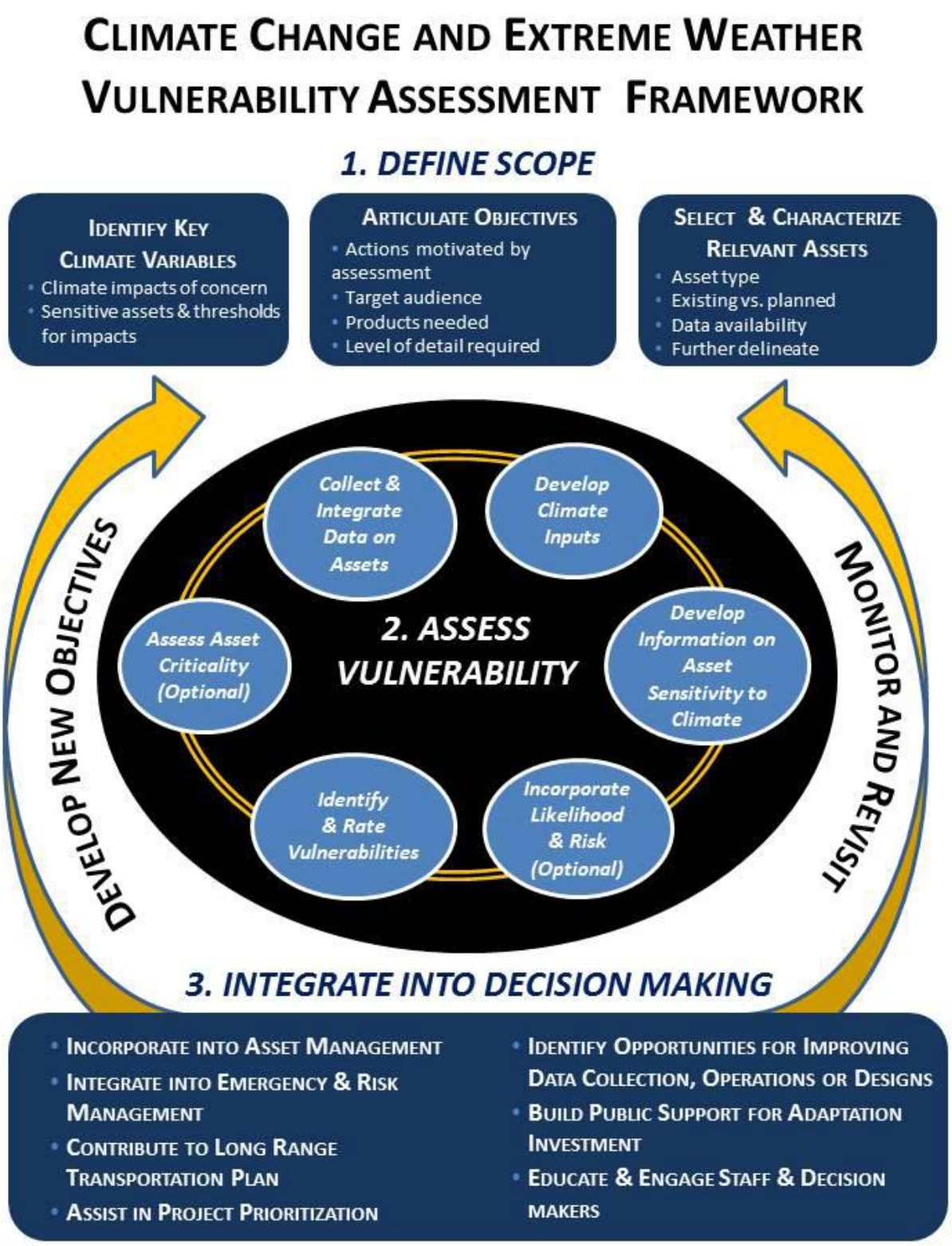
Risk: A combination of the magnitude of potential consequence(s) of climate change impacts(s) and the likelihood that the consequence(s) will occur.

Sensitivity: How an asset or system fares when exposed to a climate impact.

Adaptive Capacity: The ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

Exposure: The combination of stress associated with climate-related change (sea level rise, changes in temperature, frequency of severe storms) and the probability, or likelihood, that this stress will affect transportation infrastructure.

Resilience: A capability to anticipate, prepare for, respond to, and recover from significant multi-hazard threats with minimum damage to social well-being, the economy, and the environment.



Source: FHWA, Climate Change and Extreme Weather Vulnerability Assessment Framework, 2012.

Benicia Sectors and Assets

Transportation (roads, bike/pedestrian trails, bridges, transit)

- _____
- _____
- _____
- _____
- _____
- _____
- _____

Natural Areas (including shorelines, parks and recreation)

- _____
- _____
- _____
- _____
- _____
- _____
- _____

Engineered Shoreline Protection

- _____
- _____
- _____
- _____
- _____
- _____
- _____

Storm Water/Waste Water

- _____
- _____
- _____
- _____
- _____
- _____
- _____

Community Land Use, Services, and Facilities

- _____
- _____
- _____
- _____
- _____
- _____
- _____

Energy Infrastructure and Pipelines

- _____
- _____
- _____
- _____
- _____
- _____
- _____

Port of Benicia

- _____
- _____
- _____
- _____
- _____

Other: _____

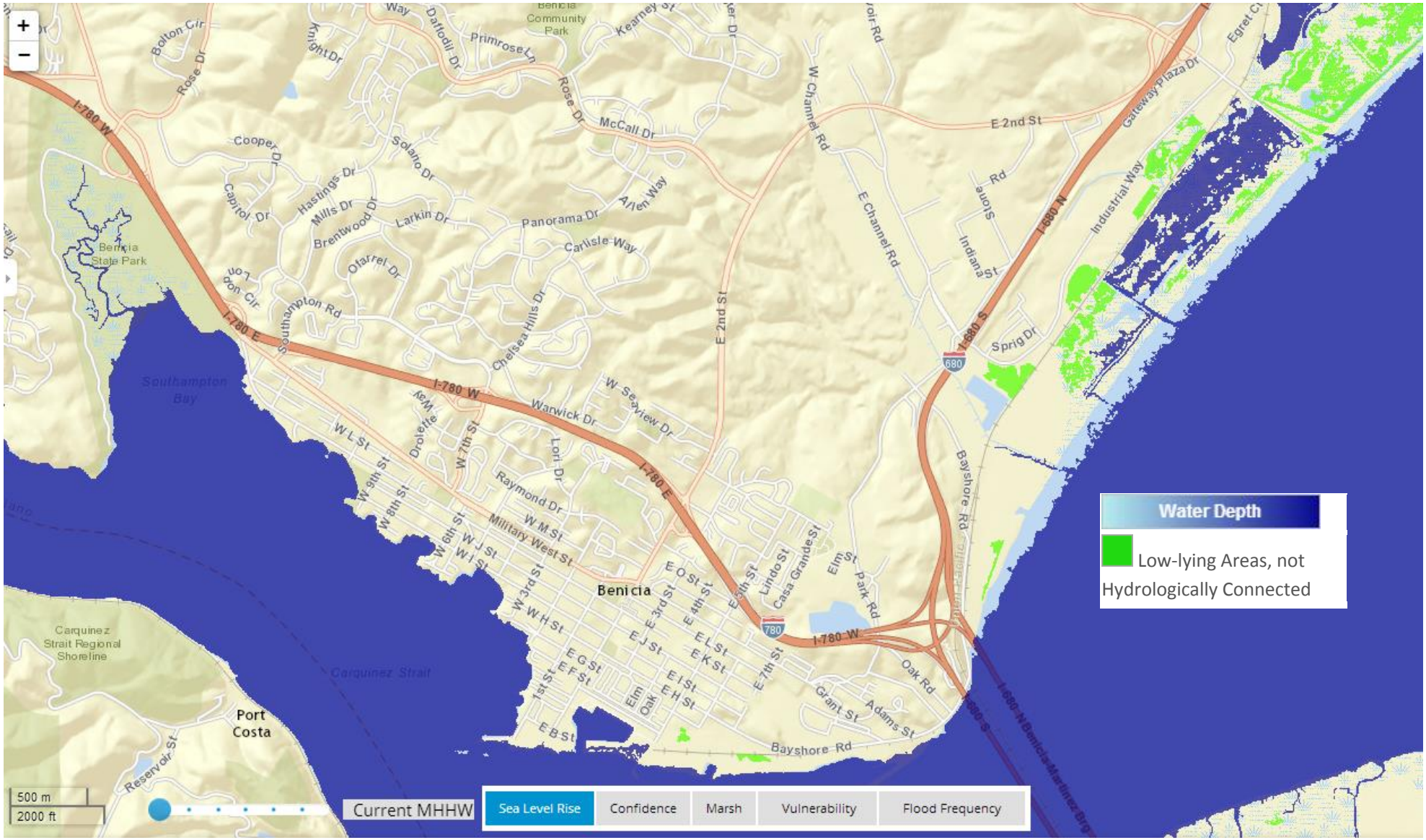
- _____
- _____
- _____
- _____

Other: _____

- _____
- _____
- _____
- _____

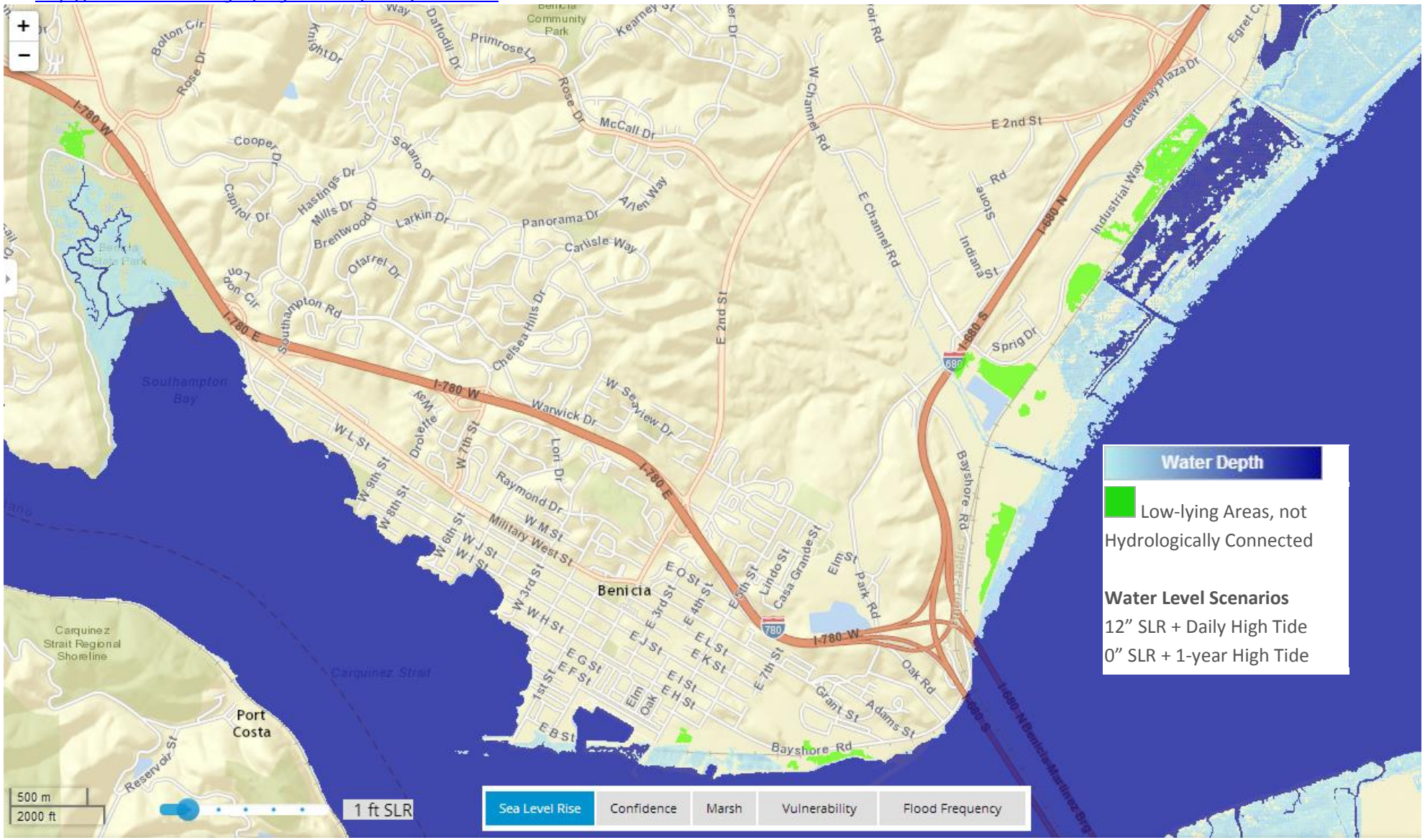
Current Daily Average High Tide

Source: NOAA Coastal Services Center Digital Coast: Sea Level Rise and Coastal Flooding Impacts Viewer, http://www.csc.noaa.gov/digitalcoast/tools/slrviewer



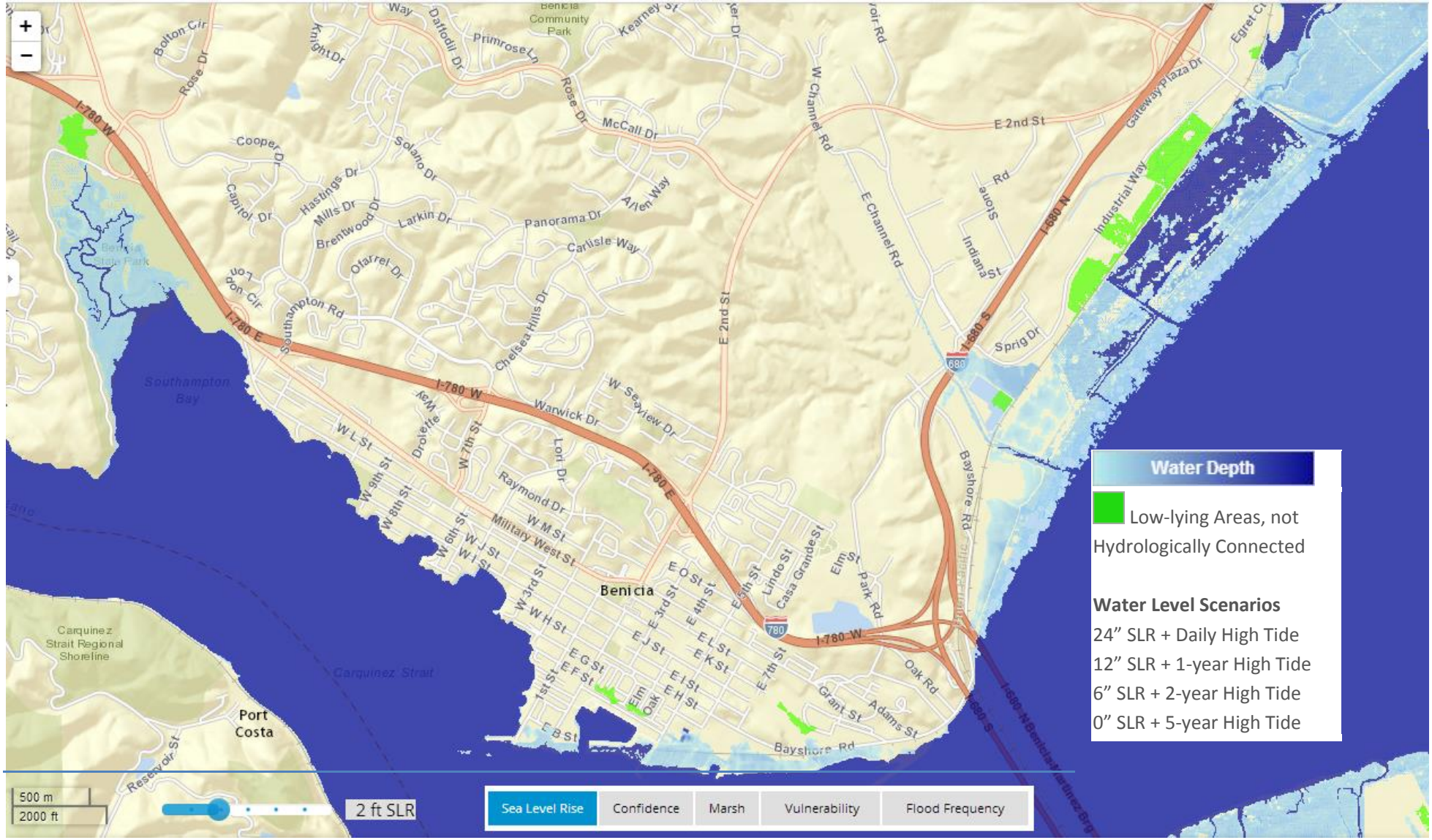
12 Inch Total Water Level

Source: NOAA Coastal Services Center Digital Coast: Sea Level Rise and Coastal Flooding Impacts Viewer, http://www.csc.noaa.gov/digitalcoast/tools/slrviewer



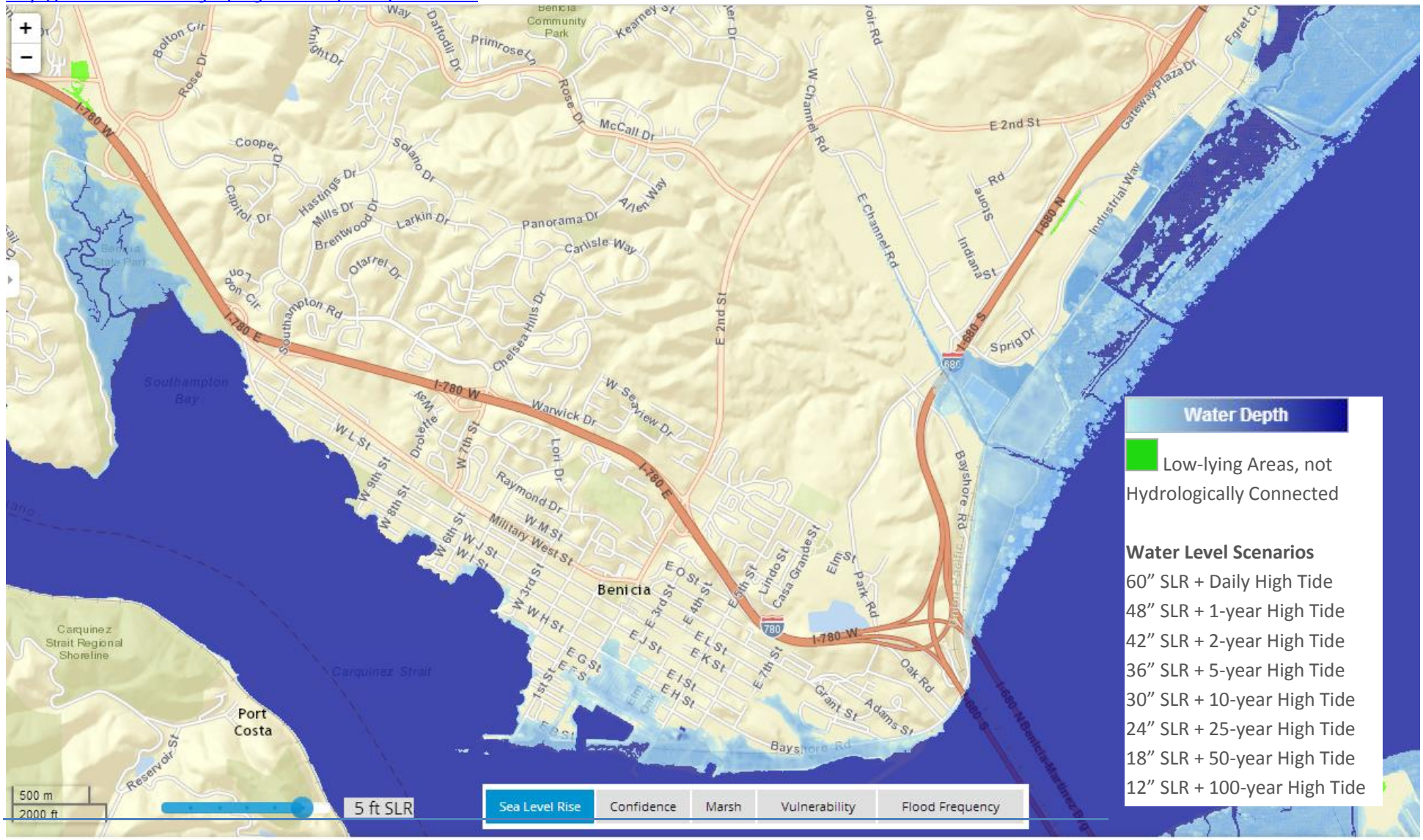
24 Inch Total Water Level

Source: NOAA Coastal Services Center Digital Coast: Sea Level Rise and Coastal Flooding Impacts Viewer, http://www.csc.noaa.gov/digitalcoast/tools/slrviewer



60 Inch Total Water Level

Source: NOAA Coastal Services Center Digital Coast: Sea Level Rise and Coastal Flooding Impacts Viewer, http://www.csc.noaa.gov/digitalcoast/tools/slrviewer



Projected Changes in Temperature

RCPs, or Representative Concentration Pathways, are emissions scenarios used to describe combinations of greenhouse gas emissions, socioeconomic factors, and technological change out to 2100. All RCPs are projected to be equally likely futures. RCP 4.5 represents a moderate-low emissions scenario in which emissions increase in the short term but their growth is curbed and stabilized shortly after 2100. This could be achieved through lower emissions energy technologies, the deployment of carbon capture and geologic storage technology, and the expansion of forest lands.

Projected Changes in Temperature – RCP 4.5			
Variable	**Baseline (1950-1999)** ***Observed Value***	**Mid-century (2046-2065)** ***Projected Value***	**End-of-Century (2080-2099)** ***Projected Value***
Average Annual Mean Temperature	59.1 °F	62.4 °F	63.0 °F
Average Annual Maximum Temperature	71.5 °F	74.9 °F	75.5 °F
Average Annual Minimum Temperature	46.6 °F	49.9 °F	50.6 °F
Hottest Temperature of the Year	102.0 °F	107.2 °F	107.8 °F
"Very Hot" Day Temperature (95th Percentile Temp)	92.4 °F	97.1 °F	97.8 °F
"Extremely Hot" Day Temperature (99th Percentile Temp)	98.8 °F	103.7 °F	104.4 °F
Average Number of Days per Year Above 92.4°F	18.3 days	54.4 days	62.2 days
Average Number of Days per Year Above 98.8°F	3.7 days	20.2 days	25.2 days
Maximum Number of Consecutive Days per Year above 92.4°F	4.8 days	11.6 days	13.1 days
Average Summer Temperatures	84.2 ° F	88.1 ° F	88.8 ° F
Highest 4-Day Average Summer Temperature	97.6 ° F	102.4 ° F	102.9 ° F
Highest 7-Day Average Summer Temperature	94.2 ° F	98.9 ° F	99.4 ° F

RCP 8.5 represents the highest emissions scenario - high global population growth and relatively slow income growth with modest rates of technological change, high energy demand, and few climate change policies.

Projected Changes in Temperature – RCP 8.5			
Variable	**Baseline (1950-1999) Observed Value**	**Mid-century (2046-2065) Projected Value**	**End-of-Century (2080-2099) Projected Value**
Average Annual Mean Temperature	59.1 °F	63.4 °F	66.8 °F
Average Annual Maximum Temperature	71.5 °F	75.9 °F	79.2 °F
Average Annual Minimum Temperature	46.6 °F	51.0 °F	54.4 °F
Hottest Temperature of the Year	102.0 °F	108.4 °F	112.3 °F
"Very Hot" Day Temperature (95th Percentile Temp)	92.4 °F	98.4 °F	102.1 °F
"Extremely Hot" Day Temperature (99th Percentile Temp)	98.8 °F	105.1 °F	108.8 °F
Average Number of Days per Year Above 92.4°F	18.3 days	66.2 days	101.0 days
Average Number of Days per Year Above 98.8°F	3.7 days	28.5 days	59.9 days
Maximum Number of Consecutive Days per Year above 92.4°F	4.8 days	14.6 days	32.1 days
Average Summer Temperatures	84.2 °F	89.3 °F	93.0 °F
Highest 4-Day Average Summer Temperature	97.6 °F	103.7 °F	107.4 °F
Highest 7-Day Average Summer Temperature	94.2 °F	100.1 °F	103.9 °F

Projected Changes in Rain

RCPs, or Representative Concentration Pathways, are emissions scenarios used to describe combinations of greenhouse gas emissions, socioeconomic factors, and technological change out to 2100. All RCPs are projected to be equally likely futures. RCP 4.5 represents a moderate-low emissions scenario in which emissions increase in the short term but their growth is curbed and stabilized shortly after 2100. This could be achieved through lower emissions energy technologies, the deployment of carbon capture and geologic storage technology, and the expansion of forest lands.

Projected Changes in Rain – RCP 4.5			
Variable	**Baseline (1950-1999)** ***Observed Value***	**Mid-century (2046-2065)** ***Projected Value***	**End-of-Century (2080-2099)** ***Projected Value***
Average Total Annual Rain	19.7 inches	20.7 inches	20.8 inches
"Very Heavy" 24-hr Rain Amount (95th percentile)	0.8 inches	0.9 inches	0.6 inches
"Extremely Heavy" 24-hr Rain Amount (99th percentile)	1.5 inches	1.7 inches	1.4 inches
Average # of Baseline "Very Heavy" Rain Events per Year (0.8 inches in 24 hours)	4.8 times	6.0 times	5.9 times
Average Number of Baseline "Extremely Heavy" Rain Events per Year (1.5 inches in 24 hrs)	1.0 times	1.8 times	1.9 times
Average Winter Rainfall	11.5 inches	13.1 inches	13.1 inches
Average Spring Rainfall	4.6 inches	4.3 inches	4.5 inches
Average Summer Rainfall	0.2 inches	0.2 inches	0.2 inches
Average Fall Rainfall	3.5 inches	3.2 inches	3.1 inches
Largest Winter 3-day Rain	2.8 inches	3.4 inches	3.4 inches
Largest Spring 3-day Rain	1.4 inches	1.4 inches	1.4 inches
Largest Summer 3-day Rain	0.2 inches	0.2 inches	0.2 inches
Largest Fall 3-day Rain	1.4 inches	1.4 inches	1.3 inches

RCP 8.5 represents the highest emissions scenario - high global population growth and relatively slow income growth with modest rates of technological change, high energy demand, and few climate change policies.

Projected Changes in Rain – RCP 8.5			
Variable	**Baseline (1950-1999) Observed Value**	**Mid-century (2046-2065) Projected Value**	**End-of-Century (2080-2099) Projected Value**
Average Total Annual Rain	19.7 inches	20.2 inches	22.2 inches
"Very Heavy" 24-hr Rain Amount (95th percentile)	0.8 inches	0.9 inches	0.6 inches
"Extremely Heavy" 24-hr Rain Amount (99th percentile)	1.5 inches	1.7 inches	1.5 inches
Average # of Baseline "Very Heavy" Rain Events per Year (0.8 inches in 24 hours)	4.8 times	5.7 times	6.9 times
Average Number of Baseline "Extremely Heavy" Rain Events per Year (1.5 inches in 24 hrs)	1.0 times	1.8 times	2.6 times
Average Winter Rainfall	11.5 inches	12.9 inches	14.9 inches
Average Spring Rainfall	4.6 inches	4.2 inches	4.3 inches
Average Summer Rainfall	0.2 inches	0.2 inches	0.2 inches
Average Fall Rainfall	3.5 inches	2.9 inches	2.9 inches
Largest Winter 3-day Rain	2.8 inches	3.4 inches	3.9 inches
Largest Spring 3-day Rain	1.4 inches	1.4 inches	1.4 inches
Largest Summer 3-day Rain	0.2 inches	0.2 inches	0.2 inches
Largest Fall 3-day Rain	1.4 inches	1.4 inches	1.4 inches

Goal Setting

Goal Components:

Economy

Economic values that may be affected such as costs of physical/infrastructure damages and lost revenues during periods of recovery due to reduced goods and commuter movement, closed businesses, and lost tax revenues.

Environment

Environmental values that may be affected including ecosystem functions (e.g., habitat) and services (e.g., flood risk reduction, water quality), and species biodiversity.

Society and Equity

Effects on communities (e.g., people and where they live, work , and recreate) and services on which they rely (e.g., public health and safety) with specific attention to disproportionate impacts due to existing inequalities.

Governance

Factors such as organizational structure, ownership, management responsibilities, jurisdiction, mandates, and mechanisms of participation that affect vulnerability and risk.

Sample Goals

- Enhancing regional decision makers' ability to understand potential impacts of climate change on specific critical components of infrastructure and to evaluate adaptation options. (Gulf Coast 2)
- Increase the preparedness and resilience of Bay Area communities to sea level rise and storm events while protecting critical ecosystem and community services. (BCDC, Adapting to Rising Tides)
- Santa Cruz
    - Protect the unique character, scenic beauty and culture in the natural and built environment from being compromised by climate change impacts
    - Support initiatives, legislation, and actions to respond to climate change
    - Build resilience into all programs, polices and infrastructure
    - Encourage climate change resilience planning and actions in private companies, institutions, and systems essential to a functioning City of Santa Cruz
    - Support initiatives, legislation and actions for reducing and responding to climate change
    - Encourage community involvement and public-private partnerships to respond to potential climate impacts.
    - Insure that Santa Cruz remains a safe, healthy and attractive place with a high quality of life for its residents, businesses and visitors

Climate Change Adaptation Plan

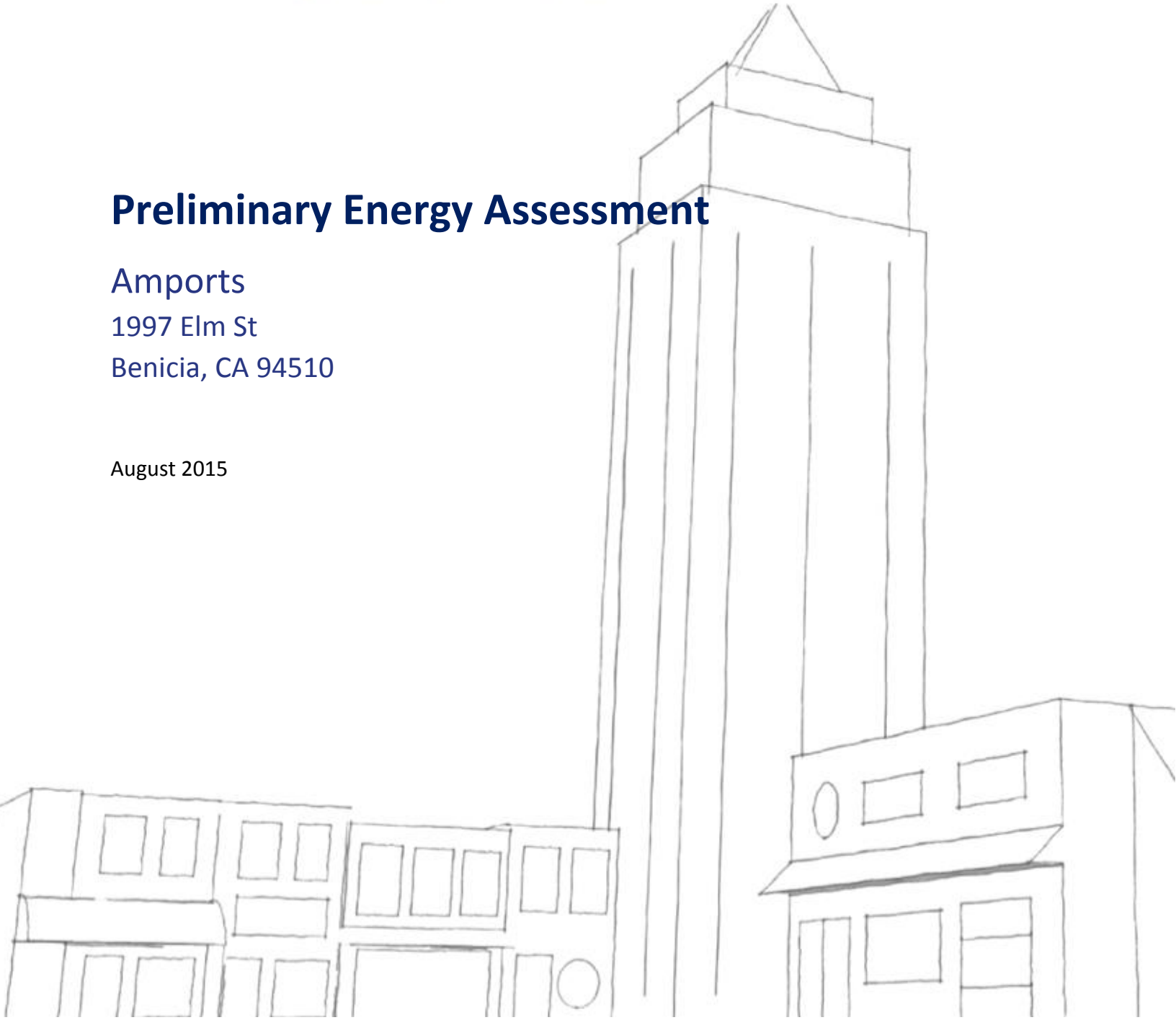
Appendix H

Carbon Lighthouse/OpTerra AMPORTS Reports

THE CITY OF BENICIA CALIFORNIA

carbonlighthouse

better building, better planet, better bottom line



Preliminary Energy Assessment

Amports

1997 Elm St

Benicia, CA 94510

August 2015

Contents

Executive Summary 3
Project Opportunities 3
Overview 3
Lighting 4
Solar PV 6
Combined Project 10
Conclusion 11
Attachment A – Select Solar PV Details 12
Attachment B – Select Noteworthy, but Not Included EEMS 15

Executive Summary

Through the City of Benicia's Business Resource Incentive Program (BRIP), Carbon Lighthouse has completed a preliminary energy efficiency and solar feasibility analysis at the Amports facility located in Benicia, CA. The analysis included a complete site walkthrough and interviews with facility staff to identify, evaluate, and estimate the costs and benefits of a potential energy project for Amports. This effort has uncovered the following opportunities:

Project Opportunity	Project Cost	IRR	Lifetime Savings*	CO_2 Savings (tons/yr)
Lighting	$105,000	21.0%	$329,000	37
Solar	$2,812,000	9.9%	$10,196,000	314
Combined Project	$2,917,000	9.9%	$10,525,000	351

* Assumes an aggregated annual utility increase of 5.2%.

The scope and projected cash flows are on the pages that follow, and Carbon Lighthouse has put forward a proposal for project financing.

Project Opportunities

Overview

Project Opportunity	Finding	Carbon Lighthouse Upgrades
Lighting	Upgrade opportunities were identified for the parking lot light pole fixtures and building exterior light fixtures at 2050 Park Rd and 2650 Bayshore Rd. Additionally, cost and maintenance improvements were identified for the ballasts used for interior fluorescent lighting at the buildings.	Recommend upgrading parking lot and exterior lighting to more efficient LED fixtures. Also recommend switching the interior fluorescent lighting ballasts from instant start ballasts to programmable start ballasts to reduce premature fluorescent lamp burnout.
Solar PV	Building roofs were not optimal for solar panel installation due to their construction and age. However, the elevated, vacant parking lot adjacent to 700 Bayshore Rd is a good site for a potential solar panel installation due to its size, availability, and unobstructed surroundings.	Potential to install a 592 kW ground-mounted solar PV array at the vacant parking lot adjacent to 700 Bayshore Rd.

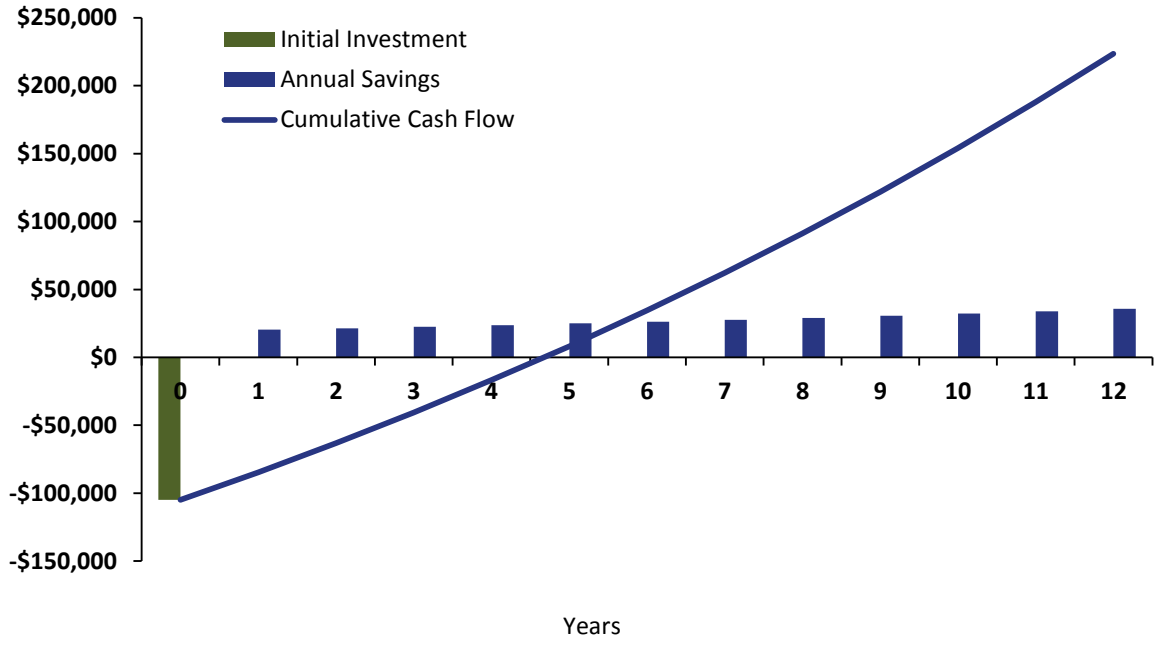
Lighting

The Amports facility mainly uses T8 fluorescent lighting controlled by motion sensors in its building interiors. The T8 lamps are part of 6-lamp fixtures that hang from the ceiling. Interviews with that facility staff revealed that maintenance of these lamps is an issue due to premature lamp burnout caused by frequent shut-on/shut-off of the lights. It is recommended to change the ballasts of these lamps from instant start ballasts, which are currently being used, to programmable start ballasts to allow the lamps to last closer to their rated lifetime.

The facility also uses high wattage metal halide lamps in most of their parking lots and building exteriors. The proposed efficiency project includes savings from upgrading these lamps to efficient, high output LEDs. Additional non-energy benefits would accrue to the facility as well, including reduced maintenance cost and time on lighting. New lighting technology will last longer, meaning exceptionally fewer bulb replacements would be required.

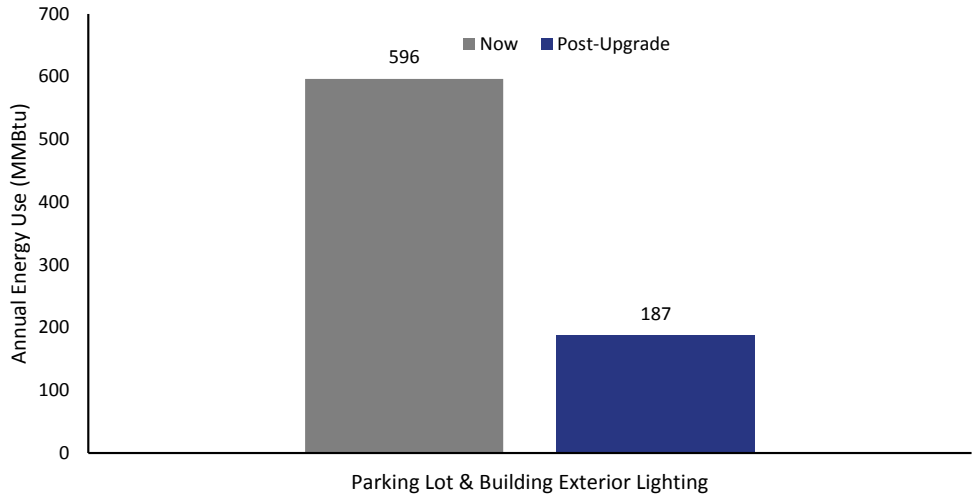
The tables and graphs below show the financial details of the proposed lighting upgrades to the facility. Lighting upgrades will produce substantial energy and environmental savings while also improving facility operations.

	Benefits
Lifetime Savings	**$329,000**
Annual Carbon Footprint Savings	**37 tons**
Project Price	**$105,000**
Unlevered IRR	**21.0%**
Payback	**4.7 years**



Year	Annual Savings	Payment	Net Cash Flow	Cumulative Cash Flow
0		($105,000)	($105,000)	($105,000)
1	$20,400		$20,400	($84,600)
2	$21,500		$21,500	($63,100)
3	$22,600		$22,600	($40,500)
4	$23,800		$23,800	($16,800)
5	$25,000		$25,000	$8,200
6	$26,300		$26,300	$34,500
7	$27,700		$27,700	$62,200
8	$29,100		$29,100	$91,300
9	$30,600		$30,600	$121,900
10	$32,200		$32,200	$154,100
11	$33,900		$33,900	$187,900
12	$35,600		$35,600	$223,600

Figure 1. Energy Savings for Proposed Lighting Upgrades



Solar PV

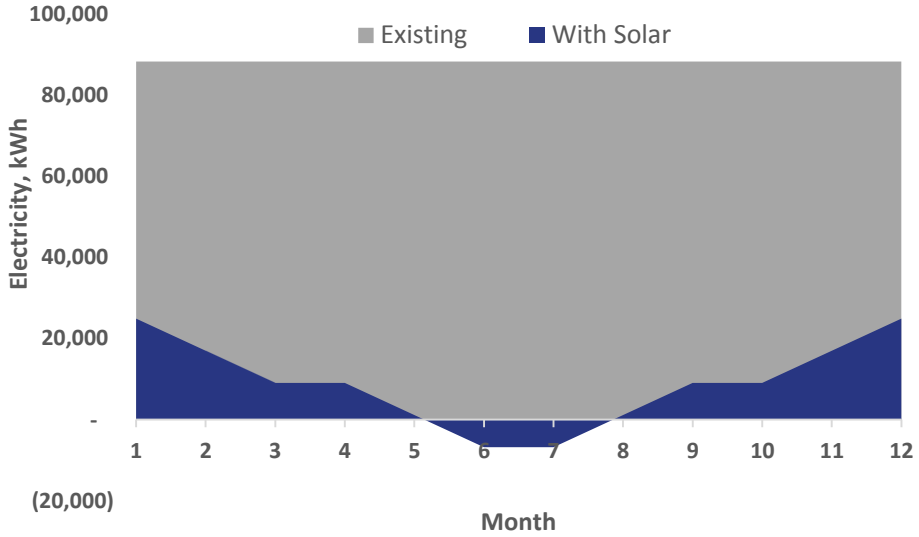
The city of Benicia has a consistent and high quality solar resource. After conducting site assessments, preliminary front-end system design, and budgetary financial analyses, we are excited to present a preliminary solar photovoltaic installation that will reduce energy consumption and environmental impact.

Although it was determined unfeasible to add solar PV arrays to the building roofs due to the roofs' age and construction, there is a potential opportunity to add ground-mounted solar PV to the vacant parking lot adjacent to 700 Bayshore Rd. The solar analysis was conducted based on the facility's estimated annual energy usage and an estimated blended utility rate of $0.17/kWh. Local incentives and tax credits that are available were estimated and also assumed to be included. The expected cost of trenching or bringing highline power to the site was estimated for this assessment, and may vary with additional study.

Although project financial returns vary greatly depending on monetizing tax benefits and decision to opt-in or out of Local Utility Incentive Programs, generating electricity on-site using solar PV may be an economically viable option for Amports. Based on current electrical consumption, the recommended solar project involves the installation of a 592kW array and will reduce utility expenses by $162,000 in the first year alone.

Financial Overview	
System Size	592 kW
Electricity Produced	953,594 kWh
Lifetime Utility Savings*	$10,196,000
Total Cost	$2,812,000
Tax Credits and Incentives	$974,800
Unlevered IRR	9.90%
Payback	9.9 years
Annual Carbon Footprint Savings	351 tons
** Assumes utility escalation rate of 5.2%*	

Figure 2. Amports' annual reduced electricity consumption from the solar PV array.



Financial Details for Upfront Payment

Purchase Price:	**$2,812,000**
Net Present Value:	**$276,836**
Internal Rate of Return:	**9.9%**
Breakeven Year:	**9.9**
Lifetime Utility Savings:	**$10,196,400**

Year	Expenditure	Energy Savings	Operating Expenses	Tax Benefits and Liability	Net Revenue	Cumulative Savings
0	$ (2,812,000)	$0	$0	$0	($2,812,000)	($2,812,000)
1	$ -	$172,100	($17,200)	$974,800	$1,129,700	($1,682,300)
2	$ -	$169,700	($17,300)	$248,700	$401,100	($1,281,200)
3	$ -	$177,600	($17,400)	$121,300	$281,500	($999,700)
4	$ -	$185,900	($17,500)	$43,400	$211,800	($787,900)
5	$ -	$194,600	($20,700)	$40,200	$214,100	($573,800)
6	$ -	$203,700	($17,800)	($19,200)	$166,700	($407,100)
7	$ -	$213,200	($17,900)	($79,100)	$116,300	($290,800)
8	$ -	$223,200	($18,000)	($83,100)	$122,000	($168,800)
9	$ -	$233,600	($18,200)	($87,300)	$128,100	($40,700)
10	$ -	$244,500	($116,000)	($83,800)	$44,700	$4,000
11	$ -	$256,000	($18,500)	($83,700)	$153,800	$157,800
12	$ -	$267,900	($18,600)	($93,600)	$155,700	$313,500
13	$ -	$280,500	($18,800)	($101,700)	$160,000	$473,500
14	$ -	$293,600	($18,900)	($106,900)	$167,700	$641,200
15	$ -	$307,300	($22,100)	($114,500)	$170,700	$811,900
16	$ -	$321,700	($19,200)	($122,400)	$180,000	$991,900
17	$ -	$336,700	($19,400)	($128,600)	$188,700	$1,180,600
18	$ -	$352,400	($19,500)	($135,000)	$197,900	$1,378,500
19	$ -	$368,900	($19,700)	($141,600)	$207,600	$1,586,100
20	$ -	$386,100	($105,800)	($141,700)	$138,700	$1,724,800
21	$ -	$404,200	($20,000)	($144,800)	$239,300	$1,964,100
22	$ -	$423,100	($20,200)	($156,900)	$246,000	$2,210,100
23	$ -	$442,900	($20,400)	($167,500)	$255,000	$2,465,100
24	$ -	$463,600	($20,600)	($175,800)	$267,100	$2,732,200
25	$ -	$485,200	($23,800)	($186,300)	$275,100	$3,007,300
26	$ -	$507,900	($21,000)	($197,300)	$0	$3,007,300
27	$ -	$531,600	($21,200)	($207,000)	$0	$3,007,300
28	$ -	$556,500	($21,400)	($217,100)	$0	$3,007,300
29	$ -	$582,500	($21,600)	($227,600)	$0	$3,007,300
30	$ -	$609,700	($21,800)	($238,600)	$0	$3,007,300

Year 1 operating expenses include a $10,000 grant from BRIP. Assumes a 5% utility price escalator.
Operating expenses assume new inverter purchases every 10 years and new monitoring equipment every 5 years.

Financial Details for Financed Payment

Loan Amount	**$2,812,000**
Upfront Payment	**$0**
Net Present Value	**$1,326,033**
Lifetime Utility Savings	**$10,196,400**
Loan Term	**20 years**
Interest Rate	**2.50%**

Year	Expenditure	Energy Savings	Operating Expenses	Tax Benefits and Liability	Debt Service	Net Revenue	Cumulative Savings
0	$ (2,812,000)	$0	$0	$0	$2,812,000	$0	$0
1	$ -	$172,100	($17,200)	$1,003,300	($180,400)	$977,900	$977,900
2	$ -	$169,700	($17,300)	$276,100	($180,400)	$248,100	$1,226,000
3	$ -	$177,600	($17,400)	$147,600	($180,400)	$127,400	$1,353,400
4	$ -	$185,900	($17,500)	$68,500	($180,400)	$56,500	$1,409,900
5	$ -	$194,600	($20,700)	$64,100	($180,400)	$57,700	$1,467,600
6	$ -	$203,700	($17,800)	$3,500	($180,400)	$9,000	$1,476,600
7	$ -	$213,200	($17,900)	($57,700)	($180,400)	($42,700)	$1,433,900
8	$ -	$223,200	($18,000)	($63,000)	($180,400)	($38,300)	$1,395,600
9	$ -	$233,600	($18,200)	($68,500)	($180,400)	($33,500)	$1,362,100
10	$ -	$244,500	($116,000)	($66,400)	($180,400)	($118,300)	$1,243,800
11	$ -	$256,000	($18,500)	($67,700)	($180,400)	($10,600)	$1,233,200
12	$ -	$267,900	($18,600)	($79,000)	($180,400)	($10,100)	$1,223,100
13	$ -	$280,500	($18,800)	($88,600)	($180,400)	($7,200)	$1,215,900
14	$ -	$293,600	($18,900)	($95,300)	($180,400)	($1,000)	$1,214,900
15	$ -	$307,300	($22,100)	($104,400)	($180,400)	$400	$1,215,300
16	$ -	$321,700	($19,200)	($113,900)	($180,400)	$8,200	$1,223,500
17	$ -	$336,700	($19,400)	($121,700)	($180,400)	$15,200	$1,238,700
18	$ -	$352,400	($19,500)	($129,800)	($180,400)	$22,700	$1,261,400
19	$ -	$368,900	($19,700)	($138,100)	($180,400)	$30,700	$1,292,100
20	$ -	$386,100	($105,800)	($139,900)	($180,400)	($39,900)	$1,252,200
21	$ -	$404,200	($20,000)	($144,800)	$0	$239,300	$1,491,500
22	$ -	$423,100	($20,200)	($156,900)	$0	$246,000	$1,737,500
23	$ -	$442,900	($20,400)	($167,500)	$0	$255,000	$1,992,500
24	$ -	$463,600	($20,600)	($175,800)	$0	$267,100	$2,259,600
25	$ -	$485,200	($23,800)	($186,300)	$0	$275,100	$2,534,700
26	$ -	$507,900	($21,000)	($197,300)	$0	$0	$2,534,700
27	$ -	$531,600	($21,200)	($207,000)	$0	$0	$2,534,700
28	$ -	$556,500	($21,400)	($217,100)	$0	$0	$2,534,700
29	$ -	$582,500	($21,600)	($227,600)	$0	$0	$2,534,700
30	$ -	$609,700	($21,800)	($238,600)	$0	$0	$2,534,700

Year 1 operating expenses include a $10,000 grant from BRIP. Assumes a 5% utility price escalator.
Operating expenses assume new inverter purchases every 10 years and new monitoring equipment every 5 years.

Figure 3. Amports site with 592 kW of photovoltaics.

Combined Project

The following tables and graphs display the financial details for a combined solar PV and lighting upgrade project:

Financial Overview	
System Size	592 kW
Electricity Produced	953,594 kWh
Lifetime Utility Savings*	$10,525,000
Total Cost	$2,917,000
Tax Credits and Incentives	$966,500
Unlevered IRR	9.90%
Payback	9.2 years
Annual Carbon Footprint Savings	351 tons

** Assumes utility escalation rate of 5.2%*

Conclusion

We are excited about the results of the energy efficiency analysis and look forward to implementing the turnkey efficiency project included herein. This represents a significant opportunity for the facility to reduce operating expenses while demonstrating next generation leadership in energy and the environment.

Additionally, generating electricity on-site using Solar PV is a potentially economically viable option for Amports' facility. Carbon Lighthouse is excited to take the next steps and turn the environmental and financial benefits proposed into a profitable, and environmentally beneficial reality.

Attachment A – Select Solar PV Details

HelioScope Annual Production Report produced by Carbon Lighthouse

Parking Lot Ground-Mounted Amports, 1997 Elm St, Benicia, CA 94510

Report

Project Name	Amports
Project Address	1997 Elm St, Benicia, CA 94510
Prepared By	Carbon Lighthouse louis@carbonlighthouse.com

carbonlighthouse

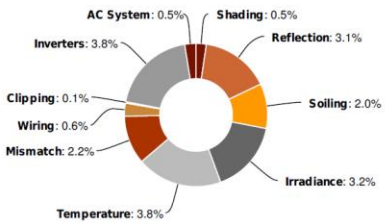
System Metrics

Design	Parking Lot Ground-Mounted
Module DC Nameplate	589.9 kW
Inverter AC Nameplate	500.0 kW Load Ratio: 1.18
Annual Production	950.3 MWh
Performance Ratio	81.9%
kWh/kWp	1,610.8
Weather Dataset	TMY, 10km grid (38.05,-122.15), NREL (prospector)
Simulator Version	153 (443094f0ad-ea93f843ef-fce6caf820-00aa14f623)

Field Segments

Monthly Production

Sources of System Loss



Annual Production

	Description	Output	% Delta
Irradiance (kWh/m²)	Annual Global Horizontal Irradiance	1,830.6	
	POA Irradiance	1,966.4	7.4%
	Shaded Irradiance	1,957.4	-0.5%
	Irradiance after Reflection	1,897.4	-3.1%
	Irradiance after Soiling	1,859.5	-2.0%
	Total Collector Irradiance	**1,859.5**	**0.0%**
Energy (kWh)	Nameplate	1,097,399.5	
	Output at Irradiance Levels	1,062,032.7	-3.2%
	Output at Cell Temperature Derate	1,021,644.4	-3.8%
	Output After Mismatch	999,489.2	-2.2%
	Optimal DC Output	993,722.6	-0.6%
	Constrained DC Output	993,091.0	-0.1%
	Inverter Output	955,045.0	-3.8%
	Energy to Grid	**950,270.0**	**-0.5%**
Temperature Metrics			
	Avg. Operating Ambient Temp		15.8 °C
	Avg. Operating Cell Temp		25.4 °C
Simulation Metrics			
	Operating Hours		4659
	Solved Hours		4659

Condition Set

Description	Condition Set 1			
Weather Dataset	TMY, 10km grid (38.05,-122.15), NREL (prospector)			
Solar Angle Location	Meteo Lat/Lng			
Transposition Model	Perez Model			
Temperature Model	Sandia Model			
Temperature Model Parameters	**Rack Type**	**a**	**b**	**Temperature Delta**
	Fixed Tilt	-3.56	-0.075	3°C
	Flush Mount	-2.81	-0.0455	0°C

Soiling (%)	J	F	M	A	M	J	J	A	S	O	N	D
	2	2	2	2	2	2	2	2	2	2	2	2

Irradiation Variance	5%	
Cell Temperature Spread	4° C	
Module Binning Range	-2.5% to 2.5%	
AC System Derate	0.50%	
Module Characterizations	**Module**	**Characterization**
	CS6X-310P (Canadian Solar)	Default Characterization, PAN

Component Characterizations

Device	Characterization
PVI 100KW-600 (Solectria)	Default Characterization

HelioScope Annual Production Report produced by Carbon Lighthouse

Components

Component	Name	Count
Inverter	PVI 100KW-600 (Solectria)	5 (500.0 kW)
Combiner	3 pole Combiner	5
Combiner	11 pole Combiner	7
Combiner	12 pole Combiner	8
Home Runs	2 AWG (Copper)	15 (344.9 m)
Strings	10 AWG (Copper)	173 (7,864.7 m)
Module	CS6X-310P (Canadian Solar)	1,903

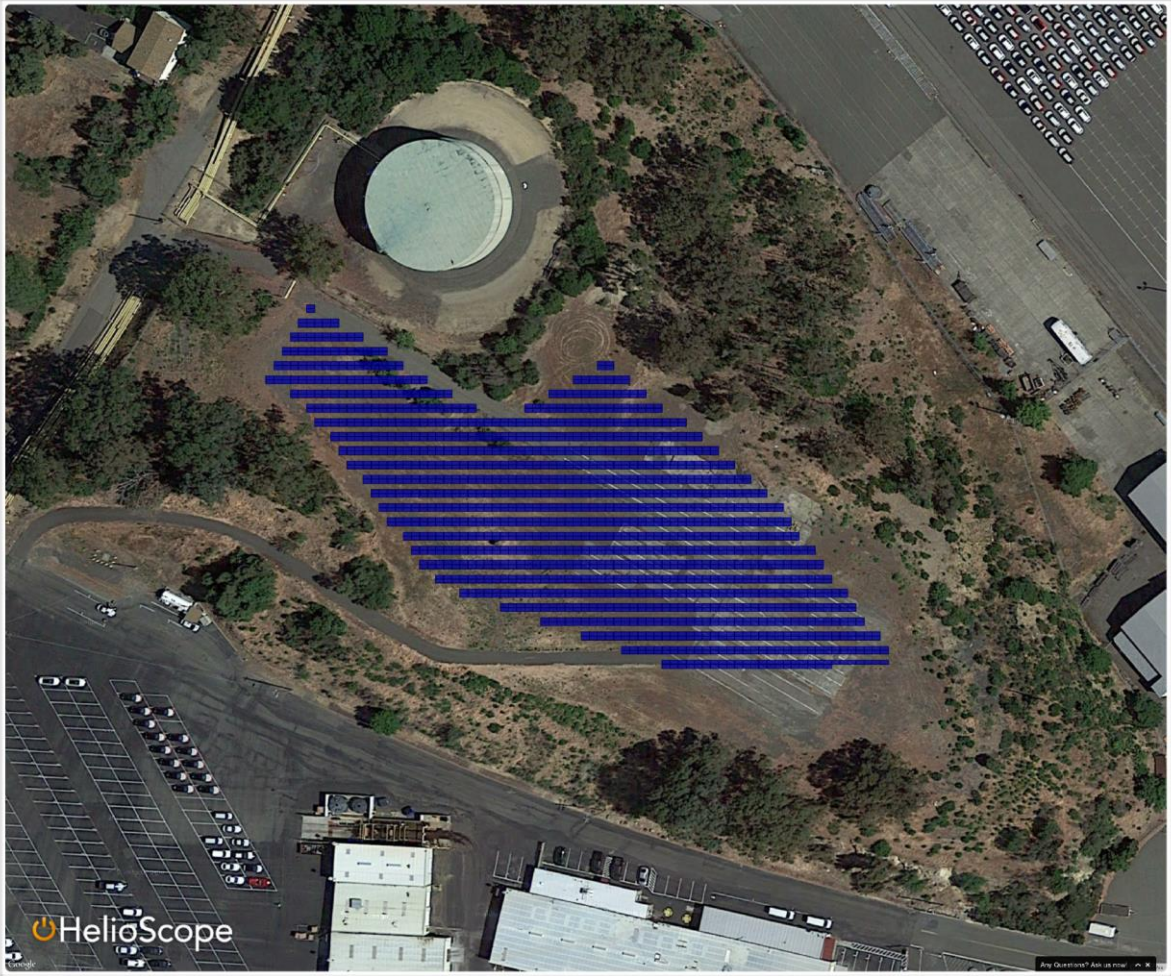
Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
Wiring Zone	12	11	Along Racking

Field Segments

Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules
72-cell module	Fixed Tilt	Horizontal (Landscape)	10°	180°	1.5 m	2x1	952	1,903

Detailed Layout



Attachment B – Select Noteworthy, but Not Included EEMS

The "Noteworthy, but Not Included" table below summarizes some of the measures we explored but for which we were unable to propose cost-effective projects (due to feasibility or financial uncertainty). The measures could produce measurable savings should facility load moderately increase, but none of the measures are included in the proposed projects.

Investigated & Noteworthy

Measure: **Levee pump motor replacement**

Description	The facility utilizes six levee pump sets that run during times of high tide and/or high rainfall to prevent flooding. Replacement of the levee pumps with newer, more efficient motors was considered, but ultimately deemed not cost-effective. This was determined after data logging revealed a relatively low number of operating hours, making any replacement cost-prohibitive, with a 20+ year payback. It is possible that longer run hours during rainy seasons makes these numbers more attractive, but that data was unavailable.

Figure 5. Financial details for replacement of the levee pumps.

Client Project Cost	($80,000)
Total Life Savings	**$27,379**
NPV	**($65,464)**
IRR	**-10.3%**

Amports Clean Energy Project Feasibility Study
A CASE STUDY

October 27, 2015

OVERVIEW:

As part of the City of Benicia's Climate Adaptation efforts, Amports was asked by the City to work with OpTerra Energy Service to explore the possibility of a clean energy project. The purpose of this case study is to provide an example of a process that a local business might undertake to save money and reduce its carbon footprint.

THE PARTIES:

Amports is a global corporation operating various port facilities throughout the world. In Benicia, its primary business concentration is off-loading and storing automotive vehicles from trans-oceanic ships for the American consumer market. Amports customers include a wide range of publicly-familiar automotive manufacturers.

OpTerra Energy Services and its legacy companies have been providing energy services in the United States for 40 years. OpTerra provides design-build-guarantee services to public agencies as well as commercial/industrial entities. Typical technologies utilized in OpTerra's projects include advanced lighting, build control heating, ventilation, and air conditioning systems, wind energy and solar photovoltaic systems. Upgrades to water and electrical infrastructure are also often featured in client projects.

City of Benicia, population 27,000 is located in southern Solano County. Benicia is a full-service city, and is recognized regionally and statewide for its leadership in sustainability efforts. Benicia has an active climate action plan. Benicia and OpTerra

completed a city-wide clean energy project in 2013 which included 10 solar photovoltaic sites, city wide streetlight upgrades to more energy efficient induction and LED equipment, as well as other energy efficiency measures. Actual financial and energy-saving performance of the project is significantly exceeding pre-project expectations.

METHODOLOGY:

Amports initially met with OpTerra and City representatives on July 15, 2015 at Amports' administrative offices. After initial introductions, personnel from all three organization spent approximately 45 minutes performing by-windshield and on-foot surveys of various potential locations for solar photovoltaic installations.

In evaluating potential sites, factors were taken into account such as:

- proximity to potential electrical infrastructure tie-in locations
- robustness of existing electrical infrastructure
- location of existing utility easements and transportation (freeway) corridors
- acreage of potential sites and adjacency to additional potential sites
- slope and aspect of potential sites
- accessibility of potential sites
- potential for existence of abandoned military ordinance on potential sites.

Back in the office, OpTerra made initial models of various solar photovoltaic layout scenarios. In consulting over the phone, Amports and OpTerra agreed to enter into a mutual Non Disclosure Agreement.

OpTerra and Amports met again briefly on August 18, 2015. At the meeting, the two parties agreed on the scope of the Feasibility Study that OpTerra would provide at no cost to Amports. A potential solar site was discussed. The parties also discussed

potential energy-related equipment needs faced by the port business. Finally, Amports authorized OpTerra to obtain port-wide PGE consumption and billing data, which was subsequently provided by PGE.

Back in the office, OpTerra evaluated the PGE consumption and billing data, and performed a high-level assessment of the potential for further energy efficiency measures. Demand was assessed on a meter-by-meter basis. A rough preliminary scope as well as pro forma were developed.

On October 14, 2015, OpTerra and Amports met again in Amports administrative offices. OpTerra presented the results of its Clean Energy Project Feasibility study, including:

- An overview of OpTerra's capabilities and history
- A snapshot of Amports' annual utility spending
- A rough schematic of a solar photovoltaic layout at a potential site
- A rough order-of-magnitude financial pro forma
- A discussion of possible project funding mechanisms
- Potential next steps

Amports provided feedback on the presentation, including the possibility that some PGE data may have been missing when PGE initially provided the data, since the annual total of the monthly checks to PGE signed by the General Manager exceed he annual total inherent in the data provided. This discrepancy will require follow-up with PGE.

NEXT STEPS:

There was consensus among both parties, Amports and OpTerra, that the potential existed for a possible design-build clean energy project. The next steps are to follow up with PGE on data questions, and for OpTerra to provide Amports with a draft contract for review and negotiation.