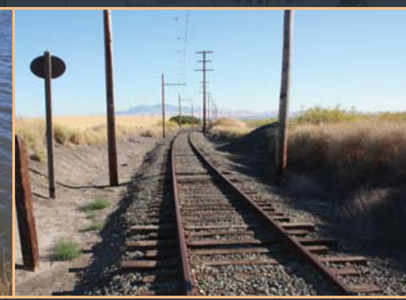
AECOM

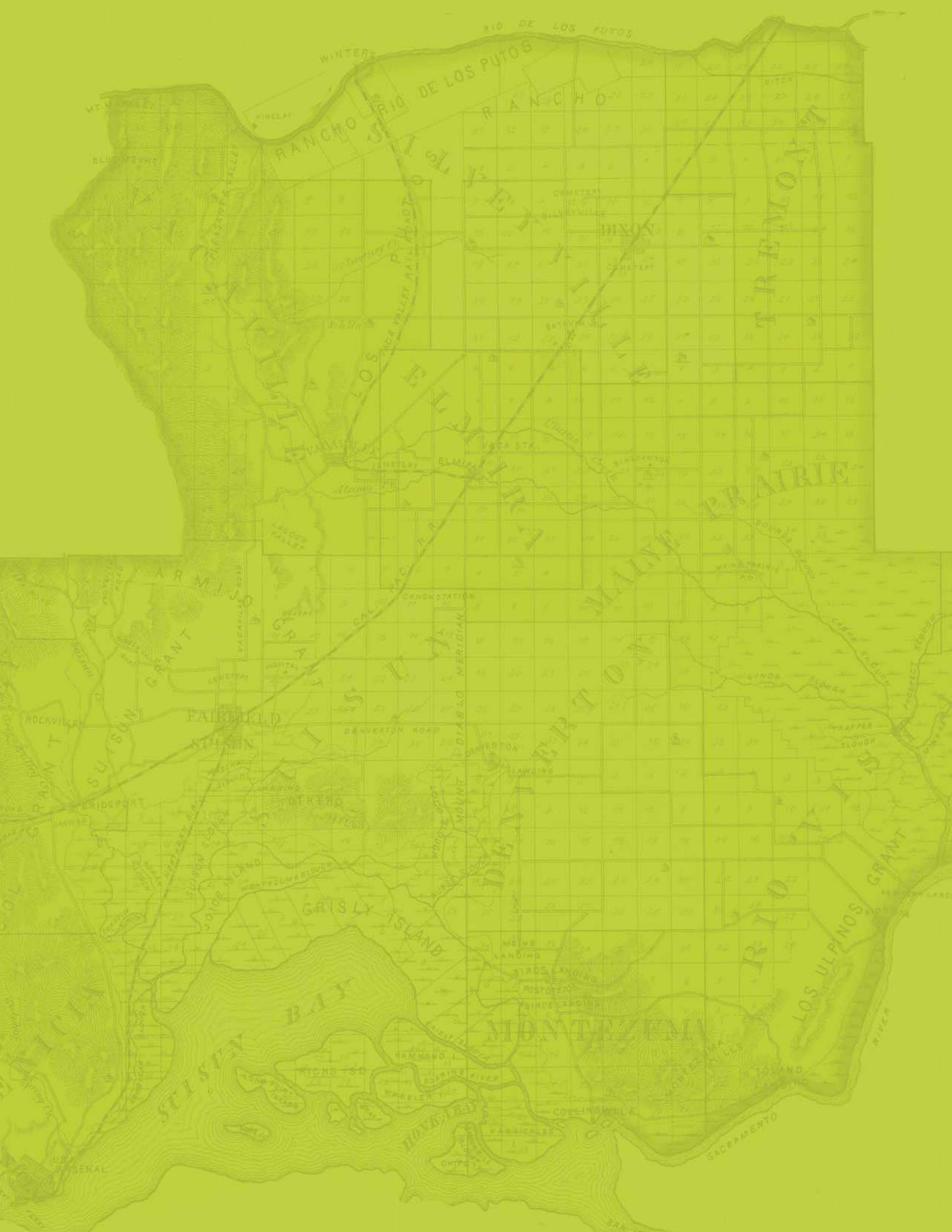
County of Solano

Sea Level Rise Strategic Program





Adopted by the Board of Supervisors June 7, 2011


RIO DE LOS PUTOS
WINTERS
RANCHO RIO DE LOS PUTOS
DIXON
CEMETERY
SILVEYVILLE
BATAVIA
TREMONT
ELMIRA
VACA STA.
MAINE PRAIRIE
ARMIJO
SUISUN GRANT
FAIRFIELD
SUISUN
DENVERTON ROAD
DENVERTON
BRIDGPORT
POTRERO HILLS
MOUNT DIABLO MERIDIAN
MONTEZUMA SLOUGH
GRISLY ISLAND
BIRDS LANDING
SUISUN BAY
MONTEZUMA
COLLINSVILLE
RIO VISTA
LOS ULPINOS GRANT
SACRAMENTO
RIVER

Solano County Sea Level Rise Strategic Program

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Global carbon dioxide at 391 ppm

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0 Acronyms and Glossary

Acronyms

AB Assembly Bill

ARB California Air Resources Board

BCDC San Francisco Bay Conservation and Development Commission

CalEPA California Environmental Protection Agency

CAP Climate Action Plan

CAT Climate Action Team

cm Centimeter

CWC California Water Code

DRMS Delta Risk Management Strategy

DWR California Department of Water Resources

EO Executive Order

EOS Earth Observing System - NASA program comprising a series of satellite missions and scientific instruments in Earth orbit designed for long-term global observations of the land surface, biosphere, atmosphere, and oceans. The satellite component of the program was launched in 1997. The program is centerpiece of NASA's Earth Science Enterprise (ESE).

GHG greenhouse gas

GIS Geographic Information System

GISS NASA Goddard Institute for Space Studies

IPCC International Panel on Climate Change

MSL Mean Sea Level

mm Millimeter

MMT Million Metric Tons

NASA National Aeronautics and Space Administration

NOAA National Oceanic and Atmospheric Administration

PPIC – Public Policy Institute of California

SEI Stockholm Environment Institute

SLR Sea Level Rise

SLRSP Sea Level Rise Strategic Program

SRES Special Report on Emissions Scenarios

USGS United States Geological Survey

GLOSSARY

Ablation - The melting of snow or ice that runs off the glacier, evaporation, sublimation, calving, or erosive removal of snow by wind In glaciology and meteorology, ablation--the opposite of accumulation--refers to all processes that remove snow, ice, or water from a glacier or snowfield[i].

Adaptation - Actions in response to actual or projected climate change and impacts that lead to a reduction in risks or a realization of benefits. A distinction can be made between a planned or anticipatory approach to adaptation (i.e. risk treatments) and an approach that relies on unplanned or reactive adjustments.

Adaptive capacity - The general ability of institutions, systems, and individuals to adjust to potential damage, to take advantage of opportunities, or to cope with the consequences. Adaptive capacity can be an inherent property or it can be developed as a result of previous policy, planning or design decisions.

Climate change - Climate change is a long-term change in the statistical distribution of weather patterns over periods of time that range from decades to millions of years. It may be a change in the average weather conditions or a change in the distribution of weather events with respect to an average, for example, greater or fewer extreme weather events. Climate change may be limited to a specific region, or may occur across the whole Earth.

Climate scenario - A plausible but often simplified description of a possible future state of the climate.

Climatic vulnerability is defined as “the degree to which a system is susceptible to, and 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 change and variation to which a system is exposed, its sensitivity, and its adaptive capacity” by the International Panel on Climate Change (IPCC)[ii]

Glaciers - A glacier is a perennial mass of ice which moves over land. Glaciers form in locations where the mass accumulation of snow and ice exceeds ablation over many years. Glacier ice is the largest reservoir of fresh water on Earth, and is second only to oceans as the largest reservoir of total water. Glaciers are indicators of climate change and are important to world water resources and sea level variation.

Hazard - A physically defined source of potential harm, or a situation with a potential to cause harm, in terms of human injury; damage to health, property, the environment, and other things of value; or some combination of these.

Ice sheets - An ice sheet is a mass of glacier ice that covers surrounding terrain and is greater than 50,000 km^2 (20,000 $mile^2$); also known as a continental glacier. The only current ice sheets are in Antarctica and Greenland.

Mitigation - A human intervention to actively reduce the production of greenhouse gas emissions (e.g., reducing energy consumption in transportation, construction, at home, at work), or to remove greenhouse gases from the atmosphere (sequestration).

Resilience - An ability to recover from or adjust easily to misfortune or change. For example, a resilient society can withstand and bounce back from disturbances and climate change effects, learn from what happened, and transform itself while continuing to provide essential support, services, and amenities to its citizens.[iii]

Risk - The product of the frequency (or likelihood) of a particular event and the consequence of that event, in terms of lives lost, financial cost and/or environmental effects.

Sensitivity - The degree to which a system is affected, either adversely or beneficially, by climate-related variables including means, extremes and variability.

Sea level is the level of the ocean's surface used as a standard in reckoning land elevation or sea depth. There is an important distinction between the global sea level trend and relative sea level trends, which must be understood in order to interpret changes to a coastline or particular location. Just as the surface of the Earth is not flat, the surface of the oceans is also not flat, and this sea surface is not changing at the same rate globally. For instance, absolute water level height is higher along the west coast of the United States than the east coast. However, publications often refer to global sea level, or the average height of all the Earth's oceans.[iv]

- ***Global sea level*** is based on tide station measurements around the world. Global seal level rise refers to the increase currently observed in the average global sea level trend, which is primarily attributed to changes in ocean volume due to two factors: ice melt and thermal expansion. Melting of glaciers and continental ice masses, such as the Greenland ice sheet can contribute freshwater to the Earth's oceans. Additionally, a steady increase in global atmospheric temperature creates an expansion of salt water molecules (i.e., thermal expansion), thereby increasing ocean volume.[v]
- ***Local sea level*** refers to the height of water as measured along the coast relative to a specific point on land and is based on local tide stations measurements. Water level measurements at tide stations are referenced to stable vertical benchmarks on the land, and a known relationship is established. Measurements at any given tide station include both global sea level rise and vertical land motion, such as subsidence, glacial rebound, or large-scale tectonic motion. Relative sea level trends reflect changes in local sea level over time and are typically the most critical sea level trend for many coastal applications, including coastal mapping, marine boundary delineation, coastal zone management, coastal engineering, habitat restoration, and recreation.
- ***Mean sea level*** (MSL) is the level of the ocean's surface halfway between mean high and low tide. Monthly means are generated in the datum calculation process, which are used to generate the relative local sea level trends observed by NOAA.[vi]

Tipping point The levels at which the momentum for change becomes unstoppable."[vii]

Vulnerability is 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 change and variation to which a system is exposed, its sensitivity, and its adaptive capacity.

[i] Paterson, W. S. B. 1999. The Physics of Glaciers. Tarrytown, N.Y., Pergamon. 496 p.

[ii] Intergovernmental Panel on Climate Change (2007) *The Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, eds Solomon S, et al. (Cambridge Univ Press, Cambridge UK).

[iii] 2008 The Future is Now, CA Energy Commission

[iv] http://tidesandcurrents.noaa.gov/sltrends/faq.shtml#q1, accessed August 2010

[v] Source: http://tidesandcurrents.noaa.gov/sltrends/faq.shtml#q1, accessed August 2010

[vi] http://tidesandcurrents.noaa.gov/sltrends/faq.shtml#q1, accessed August 2010

[vii] Gladwell, Malcolm; 2000. The Tipping Point: How Little Things Can Make a Big Difference (ISBN 0-316-31696-2) is a book by Malcolm Gladwell, published by Little Brown.

0 EXECUTIVE SUMMARY

Purpose

The County of Solano (County) has developed this Sea Level Rise Strategic Program (SLRSP) to address climate change and associated sea level rise (SLR) at the local level.

This document provides an overview of SLR (in Chapter 1), and investigates its potential effects on Solano County (in Chapter 2). Consistent with General Plan Program HS.I-1, the SLRSP further identifies properties and resources susceptible to SLR (in Chapter 3), and presents protection and adaptation strategies (in Chapter 4).

The County recognizes that preparing an effective SLRSP is necessary to promote safety and economic well being, as much of the county's land area is within a few feet of current sea level. To raise awareness of this issue and allow for effective, cost-efficient, and timely land use planning and adaptation, the SLRSP evaluates both a short-term and a long-term scenario, assessing vulnerabilities using 16 inches of SLR at mid-century (2050) and 55 inches at the end of the century (2100).

Agriculture; critical public infrastructure and essential development (e.g., roads and highways, rail, transmission lines and pipelines, and buildings); hazardous sites, public access areas, and wetlands and coastal marshes (i.e., Suisun Marsh); are vulnerable to SLR under the 16-inch and 55-inch scenarios.

Guidance

The Solano County Planning Commission and Board of Supervisors recommended using statewide adaptation guiding principles to develop County policy. The statewide adaptation strategy for the coast and ocean provides the following guiding principles that support difficult decisions about maintaining and restoring natural features and functions while also supporting development through rehabilitation, retrofit, and relocation:

1. Protect public health and safety and critical infrastructure.
2. Protect, restore, and enhance ocean and coastal ecosystems, on which our economy and well-being depend.
3. Plan and design new development and communities so they will be sustainable over

the long term in the face of climate change.

4. Facilitate adaptation of existing development and communities to reduce their vulnerability to climate change impacts over time.
5. Begin now to adapt to the impacts of climate change.

Adaptive Management and Next Steps

It is currently not possible to predict the exact time when the sea level will be 16 inches or 55 inches higher than present. Therefore, Solano County will use the rise level as a threshold for action. By monitoring local tide gages (e.g., Port Chicago), the state of the levees, and the shoreline; the County, working with flood management and emergency services agencies, will determine rise level thresholds per resource area. For example, thresholds could include rise levels that could cause frequent or permanent inundation. These will be used to establish a response plan for each resource area. The process is summarized in Figure E-1.

In addition, the County will:

- Collaborate on a Regional SLR Plan.
- Adopt guidance within planning documents.
- Set aside funding for emergencies, levee failures, and inundation.
- Continue to consider critical SLR vulnerabilities, increased storm effects, and likely near-term inundation.
- Ensure emergency preparedness in areas already prone to flooding and areas that may experience inundation.
- Coordinate with emergency management and response agencies.

This SLRSP provides Solano County with a framework to successfully adapt to SLR and its anticipated effects. This program represents a first step and call to action to identify opportunities inherent in the challenge.

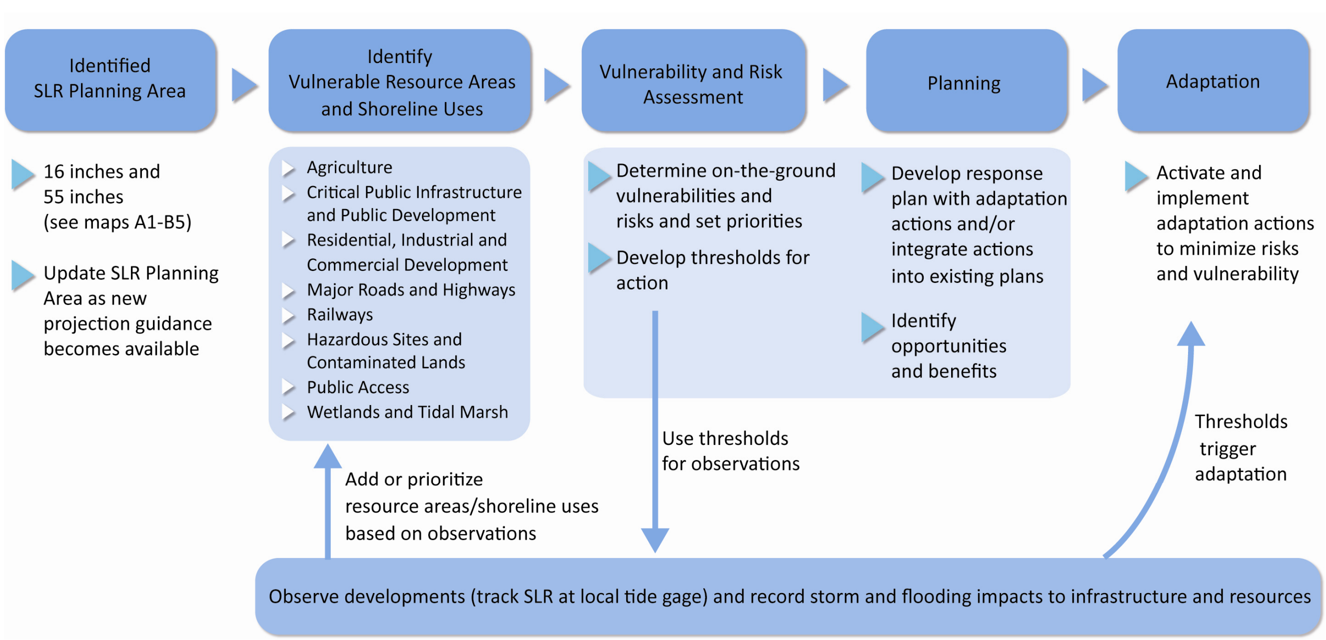


Figure E-1. Adaptation Planning Process

1 SEA LEVEL RISE AND SOLANO COUNTY

Background and Purpose

We live in a changing world. Climate change is already affecting California[1]: sea levels have risen by as much as seven inches along the California coast over the last century, increasing erosion and pressure on the state's infrastructure, water supplies, and natural resources. During this time period, and despite annual variations in weather patterns, the state has also seen a trend of increased average temperatures, more extreme hot days, fewer cold nights, longer growing seasons, less winter snow, and earlier snowmelt and rainwater runoff.[2]

The County of Solano (County) has developed this Sea Level Rise Strategic Program (SLRSP) to address climate change and associated sea level rise (SLR) at the local level. This document provides an overview of SLR and its potential effects on Solano County.

> ***Undertake some "no regrets" measures now.***
> *In some areas, failure to consider future climate changes in current planning will result in unacceptably high costs.*
> *For example, considering climate change in today's land-use planning decisions could facilitate species migration as the climate changes. Limiting development in areas of increasing flood risk will avoid future costs.*
> *PPIC, 2010*

Adaptation Planning Objectives

In the 2008 General Plan, Solano County recognized the threat of global climate change and is taking local action to reduce communitywide GHG emissions and reduce the likelihood of negative climate change effects on the county. Following the General Plan, the County has developed a Climate Action Plan (CAP), which addresses both municipal and communitywide emissions for the unincorporated county.

The General Plan also requires the County to develop an accompanying SLRSP. Specifically, General Plan Program HS.I-1 requires the development and adoption of the SLRSP for Solano County by 2010. General Plan Program HS.I-1 further defines three primary objectives for this SLRSP:

(1) investigate the potential effects of SLR on Solano County,

(2) identify properties and resources susceptible to SLR in order to prioritize management strategies,

and (3) develop protection and adaptation strategies to meet the County's and region's goals.

These primary objectives are addressed in chapters two through four of this document. The County recognizes that preparing an effective SLRSP is necessary to promote safety and economic well being, as much of the county's land area is within a few feet of current sea level. Due to the complexity and regional implications of SLR, this program was prepared in coordination with the San Francisco Bay Conservation and Development Commission (BCDC) and the Bay Delta Authority.

Application

The SLRSP provides an overview and risk assessment describing how climate change and associated SLR could affect Solano County. It outlines possible sea level rise scenarios and associated effects to raise awareness of this issue and allow for effective, cost-efficient, and timely land use planning and adaptation. This will likely be the first document of a series to implement this program. Heightened public awareness and support will ease adaptation to a slowly but surely changing Solano County.

CLIMATE SCIENCE OVERVIEW

An increase in the rate of SLR is one of the primary effects of projected increasing global climate change.

Recent Sea Level Change Trends

Sea levels are constantly in flux, subject to the influence of astronomical forces from the sun, moon, and earth, as well as meteorological effects like El Niño. A worldwide network of more than 1,750 tidal gages continuously collects data on water levels[3]. Sea level has been rising globally since the end of the last glaciation more than 10,000 years ago. Tidal gage data indicate that the global mean sea level is rising at an increasing rate:

- Global average sea level rose at an average rate of 0.07 inches per year between 1961 and 2003.
- The rate of SLR has accelerated to an average rate of 0.13 inches per year between 1993 and 2010.[4]
- The combination of higher sea levels and larger precipitation events has increased the frequency of extreme tidal events in the San Joaquin Delta.[5]

SLR is already affecting much of California's coastal region, including the San Francisco Bay and upper estuary. Water level measurements from the San Francisco gage (CA Station ID: 9414290), shown in Figure 1, indicate that mean sea level rose by an average of 2.01 millimeters (mm) per year from 1897 to 2006, equivalent to a change of eight inches in the last century.[6]

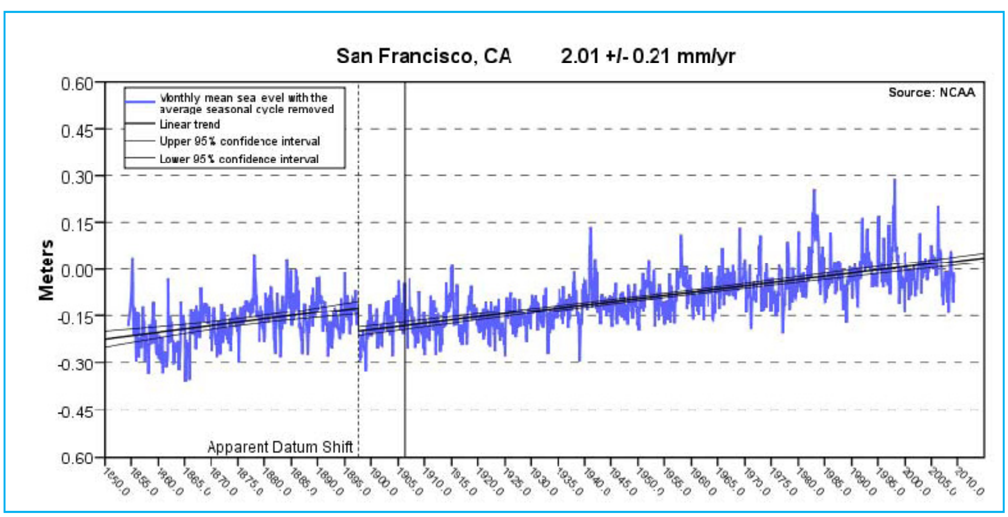


Figure 1. Monthly Mean Sea Level at the San Francisco Tide Station: 1854–2006

Source: NOAA Sea Levels Online, <http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=9414290> Accessed August 12, 2010

Notes: The solid vertical line shows the earthquake of 1906. NOAA researchers fit separate trendlines before and after an apparent datum shift (vertical movement of the land surface) that occurred in 1897, disrupting consistent measurements.

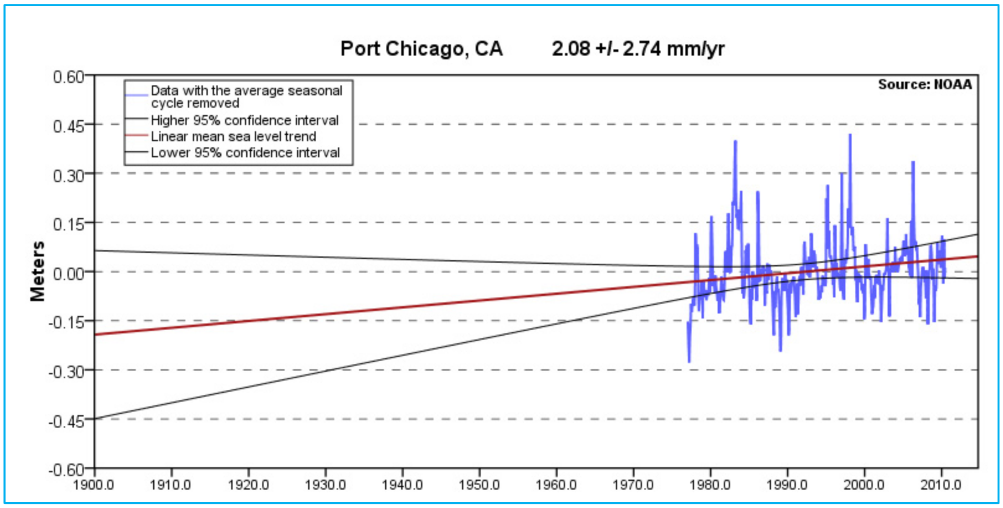


Figure 2. Monthly Mean Sea Level at the Port Chicago Tide Station: 1976–2006[7]

Source: NOAA Sea Levels Online, <http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=9415144> Accessed August 12, 2010.

Figure 2 shows the monthly mean sea level rise at the tidal gage at Port Chicago (CA Station ID: 9415144) located just south of Suisun Marsh on the Suisun Bay between Pittsburg and Martinez. This tidal gage has only been in operation since 1976, however it shows a similar increase in mean sea level to the San Francisco gage: 2.08 millimeters a year, which is equivalent to a change of 0.68 feet (8.6 inches) in 100 years.

According to the Ocean Protection Council Science Advisory Team, future SLR projections should not be based on linear extrapolation of historic sea level observations. For estimates beyond one or two decades, linear extrapolation of SLR based on historic observations is considered inadequate and would likely underestimate the actual SLR, because of expected non-linear increases in global temperature and the unpredictability of complex natural systems.[8]

Causes of Sea Level Rise

Global SLR is primarily the result of thermal expansion of ocean water (i.e., water expanding as it heats up) and widespread melting of land-based ice due to increasing global surface temperatures, which in turn are linked to increasing amounts of greenhouse gases (GHGs) in our atmosphere.

One point of continuing debate is what the rate of SLR will be in the future. Similar to the approach used to evaluate climate change, using future SLR scenarios enables us to understand risks and develop a strategy that supports appropriate responses.

Global Projections

Sea levels are expected to continue to rise, and the rate of increase will also likely accelerate, as the earth continues to warm and melting of ice sheets increases.

Data from the National Aeronautics and Space Agency’s (NASA’s) Grace satellite show that land ice sheets in both Antarctica and Greenland are losing mass. Antarctica has been losing more than 100 cubic kilometers (24 cubic miles) of ice per year since 2002.[9] Due to pressure and glacial physics, the tipping point for ablation (reduction in volume of glacial ice) appears to begin at 23 degrees Fahrenheit.[10] The accelerated melting of ice sheets, once begun, cannot be reversed until average temperatures at the poles are consistently cooler than they are and have been in the recent past.

Figure 3: Ice Bridge Collapse and Disintegration of the Wilkins Ice Shelf, Antarctica: April 2009. Credit: AP/British Antarctic Survey

The retreat of West Antarctica's glaciers is being accelerated by ice shelf collapse. Ice shelves are the part of a glacier that extends past the grounding line towards the ocean that are most vulnerable to warming seas. A longstanding theory in glaciology is that these ice shelves tend to support the end wall of glaciers. This was confirmed by the spectacular collapse of the Rhode Island-sized Larsen B shelf along the Eastern edge of the Antarctic Peninsula in 2002. The disintegration, which was caught on NASA cameras was dramatic: it took just three weeks to crumble a 12,000-year old ice shelf.

Source: NASA 2010

However, global temperatures are expected to continue to increase, particularly at the poles.[11]

The warming effect of GHG concentrations is currently being felt. Over the last 50 years, considerable worldwide economic growth, powered by carbon-based fossil fuels and extensive land use changes such as deforestation, has created a dramatic increase in atmospheric CO_2. Recent measurements indicate global atmospheric CO_2 concentrations of 389 ppm, a 38 percent increase over pre-industrial times.[12] The rate of annual increase of CO_2 continues to accelerate, largely determining future warming for the next few decades. In addition, other GHGs such as methane (CH_4), nitrous oxide (N_2O), and other gases, have dramatically increased over the last 200 years, adding to the heat-trapping effect of the atmosphere.

In order to evaluate climate change effects such as SLR, the Intergovernmental Panel on Climate Change (IPCC) developed future emission scenarios[13] that differ based on varying assumptions about economic development, population, regulation, and technology. In order to examine a lower and an upper end of future emissions, as well as a "business as usual" case, three of IPCC's emission scenarios were chosen to develop SLR projections, which the IPCC published in its AR4 Report in 2007[14]:

- **A2 - High-Emissions Scenario**
  The A2 future scenario represents a competitive world lacking cooperative development. It portrays a future in which economic growth is uneven, leading to a growing income gap between developed and developing nations. Under this scenario, world population exceeds 10 billion by 2050. Atmospheric carbon dioxide (CO_2) concentrations at the middle and end of the 21st century in this scenario would be about 575 and 870 parts per million (ppm), respectively, which exceeds concentrations associated with dangerous climate change (at ~350-400 ppm).
- **B1 - Low-Emissions Scenario**
  The B1 future scenario reflects a high level of environmental and social consciousness combined with global cooperative and sustainable development and high economic growth. Global population would peak by mid-century, then decline. The low-emission scenario also includes a shift to less fossil fuel-intensive industries and increased use of clean and resource-efficient technologies. Atmospheric CO_2 concentrations would reach 550 ppm by 2100, below catastrophic levels, but about double pre-industrial levels (~280 ppm).[15]
- **A1Fl - Fast-Paced High-Emissions Scenario**
  The A1Fl future scenario describes a world characterized by rapid economic growth. Global population would peak at mid-century and decline thereafter. New and more efficient technologies would be rapidly introduced. However, fossil fuels would remain the primary energy supply, with coal, oil, and gas use dominating for the foreseeable future. Atmospheric carbon dioxide concentrations would reach 940 ppm by 2100—more than triple pre-industrial levels, and more than

double the level associated with dangerous climate change.

Since the IPCC released these scenarios, the world has followed a "business-as-usual" emissions path, which most closely resembles the A2 High-Emissions Scenario.[16]

Based on these scenarios, global mean sea level was projected to rise by 0.2 meters (m) to 0.6 m by 2100, relative to a 1980-2000 baseline in IPCC's AR4 Report.[17]. More recent research using an empirical approach developed by German scientist Stefan Rahmstorf to project future SLR, by calculating the relationship between SLR and global mean surface temperature, indicates that SLR from 1993 to 2010 has outpaced IPCC projections.[18 19] Estimates of SLR by 2100 range from 10 inches (50 cm) to 55 inches (140 cm) respectively.[20] The estimate of 55 inches (140 cm) by 2100 is now widely used by the State of California for planning purposes. Since 2007, projections have increased slightly, particularly for the B1 scenario (see Table 1 and Figure 4). The A1Fl scenario projects a sea level rise of up to nearly 1.8 m, or almost 6 feet by 2100.

Table 1. Temperature Ranges and Associated Sea Level Ranges by the year 2100 for different IPCC emission scenarios[21]

Scenario	Temperature range, °C above 1980–2000	Model average, °C above 1980–2000	Sea level range, cm above 1990	Model average, cm above 1990
B1	1.4–2.9	2.0	81–131	104
A2	2.9–5.3	3.9	98–155	124
A1FI	3.4–6.1	4.6	113–179	143

Source: Rahmstorf and Vermeer, 2009.

California's interim guidance for incorporating SLR projections into planning and decision making directs state agencies to "use the ranges of SLR presented in the December 2009 *Proceedings of National Academy of Sciences* publication by Rahmstorf and Vermeer and as a starting place and select SLR values based on agency and context-specific considerations of risk tolerance and adaptive capacity."[22]

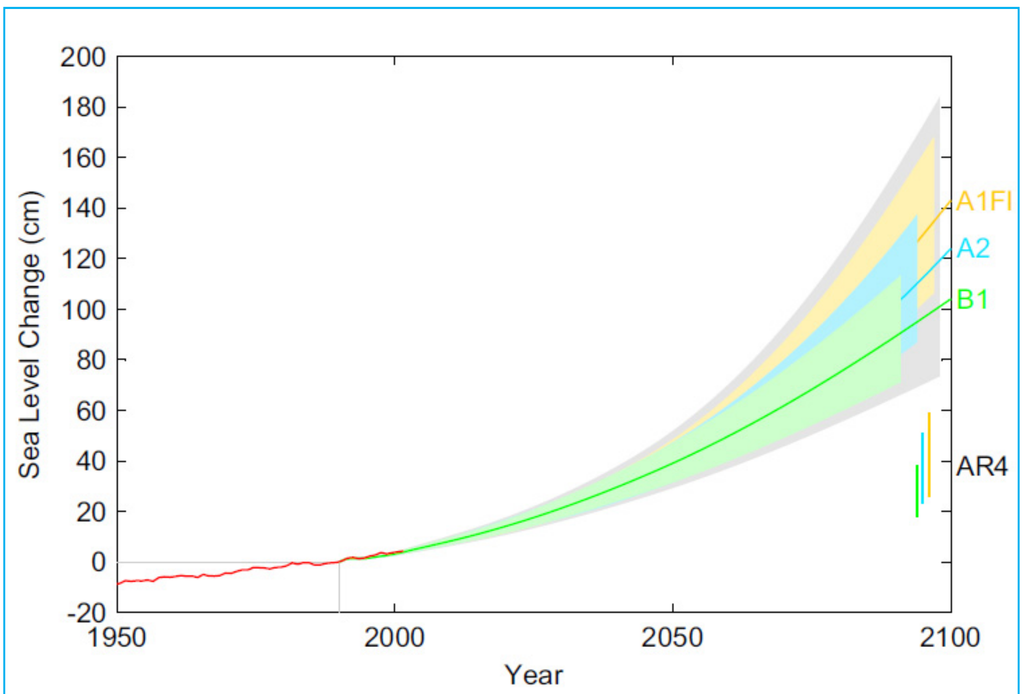


Figure 4. Projected Sea Level Rise: 1990 - 2100.
Note: Based on IPCC temperature projections for three different emission scenarios. The sea level range projected in the IPCC AR4[23] for these scenarios is also shown for comparison in the bars on the bottom right. Observation-based annual global sea level data[24] is shown in red.

Table 2 provides an overview of the SLR projections provided in the interim guidance document. The California Ocean Protection Council (OPC) used Rahmstorf and Vermeer's 2009 projections, but adjusted them to a 2000 baseline to reflect the SLR of about 3.4 cm (1.3 inches) that had already occurred between 1990 and 2000 by subtracting them from the projected ranges.

Table 2. Sea Level Rise Projections using 2000 as the Baseline[25]

Year	Emissions Scenario	Range of Models, inches (cm) above 2000*	Average of Models, inches (cm) above 2000*
2030		5-8 in (13-21 cm)	7 in
2050		10-17 in (26-43 cm)	14 in (36 cm)
2070	Low (B1)	17-27 in (43-70 cm)	23 in (59 cm)
	Medium (A2)	18-29 in (46-74 cm)	24 in (62 cm)
	High (A1FI)	20-32 in (51-81 cm)	27 in (69 cm)
2100	Low (B1)	40 in (101 cm)	31-50 in (78-128 cm)
	Medium (A2)	47 in (121 cm)	37-60 in (95-152 cm)
	High (A1FI)	55 in (140 cm)	43-69 in (110-176 cm)

Source: California Ocean Protection Council, 2010. *Note: Rahmstorf and Vermeer 's paper presents values using 1990 as a baseline. Here the values are adjusted by subtracting 3.4 cm, which represents 10 years of sea-level rise that has already occurred, at an average rate of 3.4mm/year.

Note: These projections do not account for catastrophic ice melting, so they may underestimate actual SLR. The SLR projections included in this table do not include a safety factor to ensure against underestimating future SLR. For dates after 2050, three different values for SLR are shown - based on low, medium, and high future greenhouse gas emission scenarios. These values are based on the Intergovernmental Panel on Climate Change emission scenarios as follows: B1 for the low projections, A2 for the medium projections and A1FI for the high projections.

Table 3 provides an overview of SLR projections under high emission scenarios by 2100 from various sources. The highest estimates consider continued melting of the West Antarctic and Greenland ice sheets.

Table 3. Sea Level Rise Projections: 2100

Source	Meter Sea Level Rise by 2100	Inches	Feet
IPCC 4AR (2007)	**Up to 79 cm**	**31**	**2.6**
Rahmstorf (2007)	**1.4 m**	**55**	**4.5**
Rahmstorf & Vermeer (2009)	**1.8 m**	**70**	**5.8**
Hansen (2007)	**5 m**	**197**	**16**

Catastrophic Sea Level Rise

West Antarctica is particularly vulnerable to climate changes because its ice sheet is grounded below sea level and surrounded by floating ice shelves, making it more susceptible to warming ocean waters. If the West Antarctic ice sheet completely melted, global sea level would rise by 16 to 20 feet (5 to 6 meters).[26] In addition, Greenland's ice sheets could add another 20 feet. [27] Neither ice sheet is anticipated to melt completely by 2100; however they will continue to melt after temperatures stabilize, which will likely take a few millennia.

Regardless of the time scale involved, an analogy to the previous interglacial period suggests that a few degrees Celsius of sustained warming can cause enough melting to raise sea level 4-6 m (20 feet) before the ice sheets reach equilibrium.[28]

Perhaps the most notable finding from the IPCC is that the effects of GHG emissions will continue long after emissions are reduced. The IPCC projects that temperature increases would continue for a few centuries before temperatures stabilize. SLR from thermal expansion would continue for centuries to millennia. SLR from ice-sheet melting would continue for several millennia (see Figure 5) (IPCC 2007). However, as shown in Figure 4 above, higher emissions translate into higher temperatures and faster melting. This level of warming is probable to be achieved or even exceeded by 2100 in the absence of intervention, though it would likely take far longer to realize the full sea level change of 20 feet.

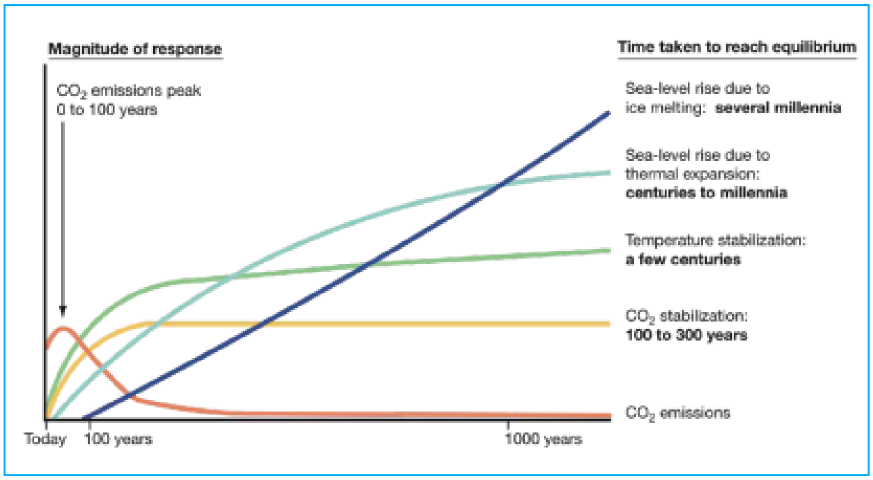


Figure 5. Long Term Sea Level Rise Trends

Source: IPCC, California Department of Water Resources, based on IPCC

Solano County Projections

For the purpose of this report, a short-term and a long-term scenario and respective SLR planning areas were evaluated. This report assesses vulnerability using 16 inches of SLR at mid-century (2050) and 55 inches at the end of the century (2100) to address the potential for SLR to threaten lives and damage property and natural resources in the San Francisco Bay, and to be consistent with other State planning efforts.[29] The California Climate Action Team (CAT) Interim Guidance Document (October 2010) further supports this approach, by recommending coordination with other state agencies when selecting SLR values and, where appropriate and feasible, using the same SLR projections to increase efficiency and consistency among analyses.

The California Coastal Conservancy and the State Lands Commission have adopted a policy to use 16 inches (41 cm) as the estimate of SLR for 2050. The CAT Interim Guidance Document recommends using 55 inches (140 cm) of SLR for 2100. These values are not referenced to a specific baseline year and agencies may revise them as new scientific information becomes available. Agencies may also select other values depending on their particular guiding policies and risk considerations.

16-inch Scenario (SLR by 2050)

The 16-inch scenario is based on current State and BCDC planning guidance, which project approximately 12 to 18 inches of SLR under the A2 emissions scenario.[30]

55-inch Scenario (SLR by 2100)

The scenario 55-inch scenario for 2100 also builds on State guidance and research, which project approximately 55 inches (140 cm) of SLR. This accounts for global growth of dams and reservoirs and their effects on surface runoff. It does not account for possible ice melting from Greenland or the West Antarctic ice sheet, which could further increase SLR along the California coast.[31]

Figure 6: Glacier calving in Tongass National Forest, Alaska: 2008. Credit: iStockphoto/Nancy Nehring

State and Local Leadership

To limit global SLR to a maximum of 1,4 m beyond 2100, deep emission reductions will be required to to achieve negative net carbon emissions by mid-century and reach 350 ppm by 2100.[32] (We are currently at 391 ppm). Likely, these reductions would have to be deeper than those needed to limit global warming to 2°C - a policy goal now supported by many countries. Scientific analysis further suggests that emission reductions need to occur early in this century to be effective.[33]

California has adopted a wide variety of regulations aimed at reducing the state's vulnerability to climate change. While State actions alone will not stop global warming or associated SLR, adopting and implementing this legislation demonstrates California's leadership in addressing this critical challenge. Key emissions reduction and climate change adaptation legislation is described below.

Assembly Bill 32 (2006)

The California Global Warming Solutions Act of 2006 (Assembly Bill [AB] 32) was enacted by the state legislature to address the threat global warming poses to the state's "economic well-being, public health, natural resources, and the environment." AB 32 directs the California Air Resources Board (ARB) to "adopt a statewide GHG emissions limit equivalent to the statewide GHG emissions levels in 1990 to be achieved by 2020." This requires maintaining an inventory of emission levels as well as taking action to decrease statewide emissions to 1990 levels.

Climate Change Scoping Plan

The *Climate Change Scoping Plan* was approved by ARB in December 2008 and outlines the State's plan to achieve the emissions reductions required in AB 32. The Scoping Plan contains the primary strategies California will implement to achieve a reduction of 169 million metric tons (MMT) of carbon dioxide equivalent (CO_2e) emissions, or approximately 28% from the state's projected 2020 emission levels.

Executive Order S-3-05

Executive Order S-3-05 (EO-S-3-05) recognizes California's vulnerability to reduced snowpack in the Sierra Nevada Mountains, exacerbation of air quality problems, and potential SLR due to a changing climate. To address these concerns, the executive order established targets to reduce GHG emissions to 2000 levels by 2010, to 1990 levels by 2020, and to 80% below 1990 levels by 2050.

Climate Action Team

The CAT was established pursuant to EO S-3-05. The CAT is led by the Secretary of the California Environmental Protection Agency (CalEPA) and includes representatives of numerous other state agencies. The CAT coordinates statewide efforts to implement global warming emission reduction programs and the state's Climate Adaptation Strategy (CAS). The CAT also reports on the progress made toward meeting statewide GHG targets established in the executive order and further defined by AB 32. [34]

To date, the CAT has released three reports and an interim guidance document on SLR. The first Assessment Report was released in March 2006, followed by the 2008 Assessment Report, which recommended the development of new climate and sea level projections. The April 2010 Biennial Report proposes adaptation strategies developed by the Ocean Protection Council and BCDC to address climate change impacts to existing development, new development, and ecosystems located in coastal areas. For existing development, these strategies include rolling easements, relocating structures from high-risk areas, government purchase of vulnerable properties, seawalls and levees, and planned retreat. Strategies for new development include using building materials and designs that protect structures from flooding and storm surges, using clustered development, and mandatory setbacks to minimize new development in vulnerable areas, and developing expendable or movable structures to be placed in high-risk areas. Ecosystem strategies include regional sediment management planning, beach nourishment, and creating buffer zones to allow wetland migration, new wetlands and Marine Protected Areas[35]. In October 2010, the CAT Sea Level Rise Task Force released an Interim Guidance Document on Sea Level Rise, which was followed by a draft resolution on SLR proposed by the OPC.

Executive Order S-13-08

Executive Order S-13-08 (2008) directs the Governor's Office of Planning and Research (OPR), in cooperation with CRA, to provide land use planning guidance related to SLR and other climate change effects. The order also directed CRA to develop the CAS and to convene an independent scientific panel to complete the first California Sea Level Rise Assessment Report, which was released in December 2009.

Executive Order S-13-08 also directed the OPC to work with other state agencies to support an expert panel through the National Academy of Sciences (NAS) to recommend ranges of SLR to use for vulnerability assessments. Because the NAS final report is unlikely to be released until 2012, and because the State is making decisions now which would benefit from guidance on SLR, OPC staff led an effort to coordinate state agencies to develop an Interim Guidance Document to assist state agencies to incorporate SLR into planning decisions prior to release of the NAS report.[36]

California Climate Adaptation Strategy

In response to EO S-13-08 and in cooperation and partnership with multiple state agencies, the CRA led development of the 2009 CAS which summarizes the current science on climate change impacts and provides recommendations regarding how best to manage adaptation threats across seven sectors: public health, biodiversity and habitat, ocean and coastal resources, water management, agriculture, forestry and transportation and energy infrastructure. As new data continues to emerge, the CAS will be updated to reflect current findings.

Cal Adapt

The State has identified the lack of tools and methods to explain the risks posed by climate change to a wider audience as a major challenge. Much of the relevant information is spatially-based. To overcome this problem, the California Energy Commission and Google provided funding for the Stockholm Environment Institute (SEI) to conduct an exploratory project to develop a Google Earth-based platform to provide public information on climate change impacts and adaptation in California.

The prototype is accessible at: http://www.climatechange.ca.gov/visualization/sealevel.html.

Delta Risk Management Strategy

The Delta Risk Management Strategy (DRMS) examines sustainability of the Sacramento-San Joaquin Delta (Delta), and assesses major risks to Delta resources from floods, seepage, subsidence, and earthquakes. The DRMS also evaluates the potential consequences of these events, and presents recommendations to manage the risk. The contractual definition of the DRMS work area includes Suisun Marsh east of the Benicia-Martinez Bridge on Interstate 680; and the Delta as legally defined in Section 12220 of the California Water Code (CWC).

Assembly Bill 1200

AB 1200 (CWC Section 139.2 et seq) requires that the California Department of Water Resources (DWR) evaluate the potential impacts on water supplies derived from the Delta based on 50-,100-, and 200-year projections for subsidence, earthquakes, floods, climate change and SLR, or combinations of the above. The DRMS provides most of this information.

San Francisco Bay Conservation and Development Commission

BCDC is a state agency initially created by the California Legislature in 1965 with the charge of minimizing future unnecessary filling of San

Francisco Bay. In the recent years, BCDC's mission has evolved to address climate change and the threat of SLR to Bay Area communities, public infrastructure and wetlands. BCDC has initiated a climate change planning project to identify potential SLR impacts on the Bay and approaches to adapting to climate change. As part of this project, BCDC staff has developed a broad outline for a comprehensive strategy to address climate change in the Bay Area, including the southern portions of Solano County. BCDC is committed to working with its regional partners and local municipalities to build awareness, and a plan, for accelerated SLR in San Francisco Bay.

Suisun Marsh Protection Plan

Managed wetlands located in primary and secondary management areas of the Suisun Marsh are subject to additional policies in the Suisun Marsh Protection Plan and the Suisun Marsh Preservation Act of 1977. Those policies address a range of ecosystem and infrastructures issues, such as: water supply and quality, natural gas resources, utilities, transportation, and recreation.[37]

Content

The Solano County SLRSP is organized into the following chapters:

Chapter 1: Background and Purpose

This chapter outlines the County's rationale and motivation for addressing SLR and developing the SLRSP. The chapter provides a brief overview of the most recent science and projections for changing sea levels, and outlines state policy mandates and guidance on the topic.

Chapter 2: Potential Effects of Sea Level Rise on Solano County

This chapter identifies the areas of Solano County that may be affected by SLR, extreme water level events and potential saltwater intrusion based on the most recent projections and information made available by BCDC, the State of California and other agencies.

Chapter 3: Evaluation and Prioritization

This chapter evaluates areas of unincorporated Solano County susceptible to SLR and provides a cost-benefit analysis, based on BCDC's regional prioritization process and feasible adaptation strategies for the short and long terms.

Chapter 4: Protection and Adaptation Strategies

This chapter presents management strategies and policies to protect unincorporated Solano County from and facilitate adaptation to the potential effects of SLR.

Appendices– The appendices provide additional background information supporting the SLRSP's technical analysis, maps (Appendix A) the full text of EO S-13-08 (Appendix B) and BCDC's Regional Strategy Goals (Appendix C).

Presentations to the Planning Commission and Board of Supervisors

In October 2010, the SLRSP process and preliminary findings were presented to the Solano County Planning Commission in a public meeting. In December 2010, these same items were presented to the Solano County Board of Supervisors in a public forum. In each case, decision-makers listened to public comments and provided direction and guidance regarding the SLR scenarios, vulnerable property and infrastructure and preliminary management strategies. This direction was incorporated within the draft SLRSP.

Public Review

The County strongly encourages residents, business owners, farmers, ranchers and others within Solano County to review this Draft SLRSP and provide comments to the County. This Draft will be available for public review for a period of 30 days, prior to presentation and public hearings before the Solano County Planning Commission and Board of Supervisors. The public is encouraged to attend these hearings and provide public comment.

2 POTENTIAL EFFECTS OF SEA LEVEL RISE

POTENTIAL EFFECTS OF SEA LEVEL RISE ON SOLANO COUNTY

In Solano County, climate change and resulting sea level rise (SLR) is expected to increase occurrences and severity of storm events, causing additional coastal flooding and saltwater intrusion. In addition, rising temperatures may increase the likelihood of water and energy supply shortages, increased wildfire risk, habitat loss and species endangerment, declining agricultural production and changes in crops, and the distribution of diseases and other public health problems. This chapter identifies areas of unincorporated Solano County that are most likely to be affected by SLR, extreme water level events and potential saltwater intrusion based on the most recent projections and information made available by the Bay Conservation and Development Commission (BCDC) and the State.

PLANNING AREA

Maps depicting the planning areas for scenarios described in Chapter 1 through 2100 were developed with Geographic Information System (GIS) information from the U.S. Geological Survey (USGS) and information prepared by the Department of Water Resources. Additional information regarding analysis methods is provided in Appendix A.

Although data is not as reliable for long-term scenarios, sea level is anticipated to continue rising past 2100. Sea level rise of up to 20 feet or more could have a dramatic effect on California, the entire Bay Area and the Sacramento Valley. In unincorporated Solano County, approximately 80 additional square miles, including large parts of the Sacramento River floodplain in eastern Solano County, would be vulnerable to flooding under this scenario. The County recognizes that significant infrastructure improvements implemented by other agencies is the most likely course of action to mitigate such a sea level rise.

Maps were created to show the 16-inch scenario (map series A – provided in Appendix A) and 55-inch scenario planning areas (map series B – provided in Appendix A). Figure 7 provides an overview map based on each scenario.

Today's big flood is tomorrow's high tide. BCDC 2009

16-inch Scenario (SLR by 2050)

Under the 16-inch scenario, approximately 82,240 acres, or 130 square miles, of Solano County's unincorporated area are vulnerable to flooding and inundation by mid-century. The area vulnerable to inundation corresponds to today's 100-year floodplain.[1] As visible on Figure 6 and maps A-1 through A-5 in the appendix, this includes the majority of the eastern portion of the unincorporated county south of Napa County and between Sonoma County and the City of Vallejo, as well as most of Suisun Marsh and a large area of the eastern portion of the County in the floodplain northeast of Rio Vista. Extreme storm events are expected to cause shoreline damage from flooding, as changes in climate and sea level cause increased storm activity, which in combination with higher sea levels will cause greater flooding.

55-inch Scenario (SLR by 2100)

Under the 55-inch scenario, approximately 103,990 acres, or 163 square miles of the unincorporated county are vulnerable to flooding and inundation by the end of the century. As shown in Figure 6 and Maps B-1 and B-2 in the Appendix, most of the anticipated flooding occurs under the 16-inch scenario. In the 55-inch scenario, the additional 21,750 acres (33 square miles) of vulnerable area is scattered around the perimeter of the vulnerable area under the lower 16-inch rise scenario. The 16-inch scenario would also likely flood potential wetland and marsh migration areas, identified in maps A-1 through A-5 in the appendix as necessary migration areas.

Associated Issues

Extreme Water Level Events and Flooding

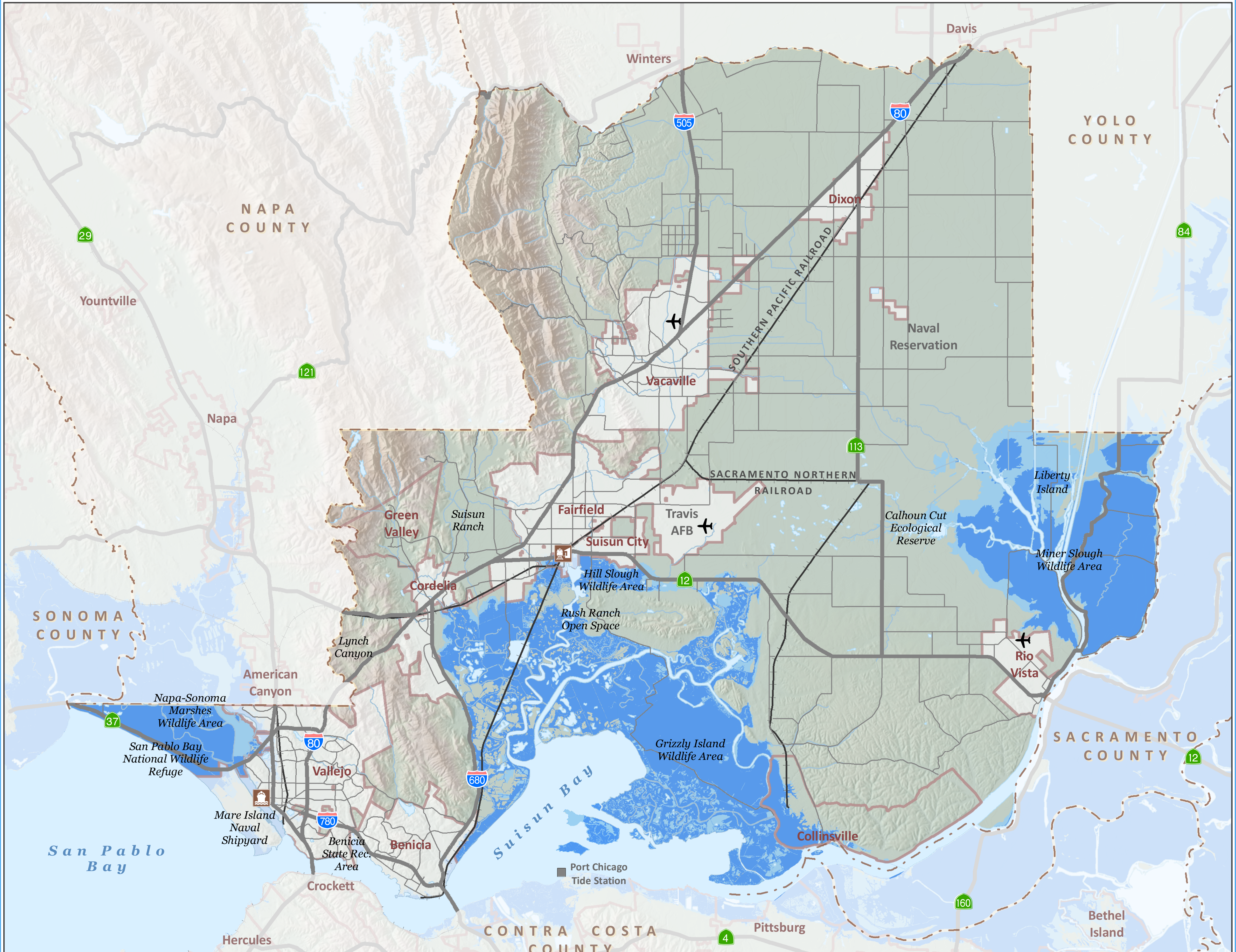
Most shoreline damage from flooding would occur as a result of storm activity in combination with higher sea levels. Climate change-induced SLR would change the key factors contributing to coastal flooding: tide heights, storm surges, river flows released from major reservoirs in the Sacramento and San Joaquin watersheds, and wind-waves.[2]

Storms and flooding in California occur primarily during the winter from November to April and are influenced by several climate patterns, most prominently El Niño.[3] In contrast to La Niña[4], "El Niño years", which can happen every two to seven years, generally result in persistently low air pressure, greater rainfall, and dominantly western winds[5], all of which contribute to coastal flood hazards.[6] Low air pressure causes an instantaneous rise in sea level above predicted tides, referred to as storm surge.[7] During storms with high rainfall, Bay tributaries flood, elevating Bay waters beyond the initial storm surge, and low air pressure increases wind activity, generating erosive waves superimposed on already high sea levels.[8,9]

The recent period of accelerated SLR (1993 to 2003), has been characterized by an increase in both the number of storm surge events and high tides exceeding previously observed extremes. This increase in storm activity and extreme tides is projected to continue into the future.[10] Should the state's reservoirs lack capacity to capture rainfall and earlier Sierra snow melt, water managers would need to release flows through the Delta during winter months, resulting in even higher water levels.[11,12]The combined effects of SLR, storm surge and river flooding may result in water levels elevated as high as 51 inches for a period of 10 to 12 hours in the Delta and Suisun Marsh region,[13] which is already located below mean tide elevation and surrounded by fragile levees.[14]

Inundation of Shoreline Areas and Infrastructure

By 2050, shoreline development located in the current 100-year floodplain will be subject to flooding from both a 100-year flood and from a high tide. A summary of these vulnerabilities is provided in Table 3 at the end of this chapter.



Overview of Potential Sea Levels

in County Solano

Potential Sea Level Rise

- 16 Inches
- 55 Inches

- Commuter Rail Station
- Ferry Terminal
- Airport

- Incorporated City Limits

- Note: Inundation data does not account for existing levees or other shoreline protection.

USGS NED 10 meter elevation data was used to depict 16 and 55 inch sea levels in the eastern portion of Solano County; and at 20 feet for the entire County.

DRAFT

1 in = 4 miles

0 4 8 12

Miles

8/18/2010

Source:
BCDC, Pacific Institute, Solano County, AECOM

Placeholder Figure 7

11x17 back

Most of the area vulnerable to SLR is located in the Suisun Marsh (Marsh), described in the next section. However, along the edges of the Marsh, agricultural lands, residences, businesses, and important infrastructure would be vulnerable to flooding and inundation by 2100. Rising sea levels can affect daily life in Solano County, as they would flood major roads (e.g., segments of State Route [SR] 37 and SR 12) and numerous roads atop levees in the Suisun Marsh, affecting movement of people and delivery of goods. Delivery of other key resources such as petroleum products (through pipelines), electricity, and drinking water is also vulnerable. Fortunately, no waste water treatment facilities, schools or emergency facilities have been identified within either the 16-inch or 55-inch SLR planning areas for the unincorporated county. A summary of properties, infrastructure and resources that may warrant protection, as well as areas where a managed retreat may be more cost-effective, is presented in Chapter 3. Inundation of coastal infrastructure could in-turn cause widespread pollution and contamination, further jeopardizing marine and near-marine environments.

Inundation and Subsidence of Suisun Marsh

Suisun Marsh is the largest contiguous brackish water marsh remaining on the west coast of North America and a critical part of the San Francisco Bay-Delta estuary ecosystem. Encompassing 116,000 acres, the Suisun Marsh includes 52,000 acres of managed wetlands, 27,700 acres of upland grasses, 6,300 acres of tidal wetlands, and 30,000 acres of bays and sloughs. The Marsh encompasses more than 10% of California's remaining natural wetlands and serves as the resting and feeding ground for thousands of waterfowl migrating on the Pacific Flyway. In addition, the Marsh provides essential habitat for more than 220 bird species, 45 animal species, 16 different reptilian and amphibian species, and more than 40 fish species.

The Marsh supports 80 percent of the state's commercial salmon fishery by providing important tidal rearing areas for juvenile fish, greatly enhancing their survival. The Suisun Marsh is located within the Bay-Delta estuary which also means that its water quality affects, and is affected by, California's two largest water supply systems, the Federal Central Valley Project, and the State Water Project, and other upstream diversions.[15] The two hundred and thirty miles of levees within the Marsh, all of which are non-project (i.e., local) levees,[16] thus play a role in providing critical protection of the drinking water for 22 million people by preventing salt water intrusion into the Delta.[17] The Suisun Marsh is an area where relative SLR is substantial, due to ongoing subsidence, as subsided areas are particularly vulnerable to SLR and extreme events.[18]

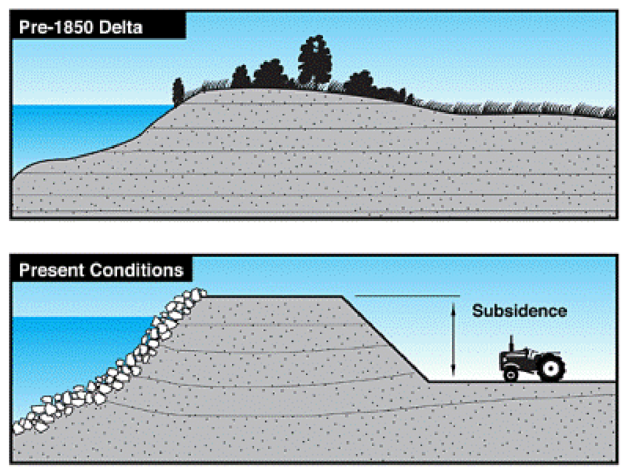


Figure 8. Subsidence of Managed Wetlands:
As the peat soils of the Delta have subsided over time, the elevation of Delta islands has gradually become lower, with some parcels now more than 20 feet below sea level. Source: DWR[19]

Consequently, the Delta levees hold back water all the time, not just during major storms. Considering the hydrodynamics involved, whether individual levees prevail or fail often already becomes a matter of inches.[20] In addition to overtopping, the low-lying areas behind levees also are vulnerable to failure due to earthquakes and burrowing animals. According to research from the Pacific Institute, the 16-inch Scenario is sufficient to affect 90% to 95%

percent of the existing tidal marshes and tidal flats by changing the frequency and duration of inundation. Of these tidal marsh areas, almost 20% are lower than the tidal zone, which makes them vulnerable to permanent submersion and erosion.[21] A 16-inch rise in sea level would also permanently flood approximately 70% to 75% of the subsided wetlands in Suisun Marsh if their fragile levees were to fail.

Increased frequency and duration of inundation in some areas, and permanent flooding of other areas induced by SLR would initiate a number of complex physical, ecological, and biological responses in the estuarine ecosystem. Combined with other climate change effects, these would further increase the vulnerability of the marsh ecosystem and may result in the loss of substantial areas of critical habitat for a variety of coastal species. Given sufficient sediment and room to migrate, wetlands and biological species that inhabit wetlands can adapt to SLR by moving inland; however, considering the pace of SLR, armoring the shoreline may hamper or prevent this and result in more loss of tidal marsh habitat.[22] A summary of Bay Ecosystem Vulnerabilities is presented in Table 4 at the end of this chapter.

Saltwater Intrusion

Levee failure during floods in the Marsh and the Delta would also increase the likelihood of saltwater intrusion into groundwater aquifers, saltwater contamination of agricultural lands, and changes to the salinity of freshwater ecosystems.[23]

Saltwater intrusion into fresh water resources near the coast would also reduce the amount of fresh water available for plants, wildlife, and competing agricultural and residential uses. Species with greater salt tolerances may have a selection advantage where habitats can naturally transform, without human interference. SLR, in conjunction with storms, may also lead to flooding that extends further inland, thus increasing the risk of pollution, runoff, and sedimentation in fresh water sources of previously unaffected areas. Shifts in the type and location of agriculture would also occur, as saltwater intrudes into coastal aquifers and natural recharge of groundwater resources decreases with the drying climate. Water transfer and management effects may become more complex, as effects on hydropower and hatchery project operations as well as water diversion projects also occur.[24]

Efforts to use water control structures, such as salinity gates, to artificially reduce salinity in Suisun Marsh in dry years will likely become difficult in the face of climate change. The Suisun Marsh Salinity Control Gates at Montezuma Slough (location shown in Figure 9) restrict the flow of higher salinity water from incoming tides and retain low-saline, Sacramento River water from the previous outgoing tide. An eastward shift of the salinity gradient caused by SLR and reduced river flows due to a decreasing snowpack, will likely reduce opportunities to import freshwater into the Suisun Marsh.[25]

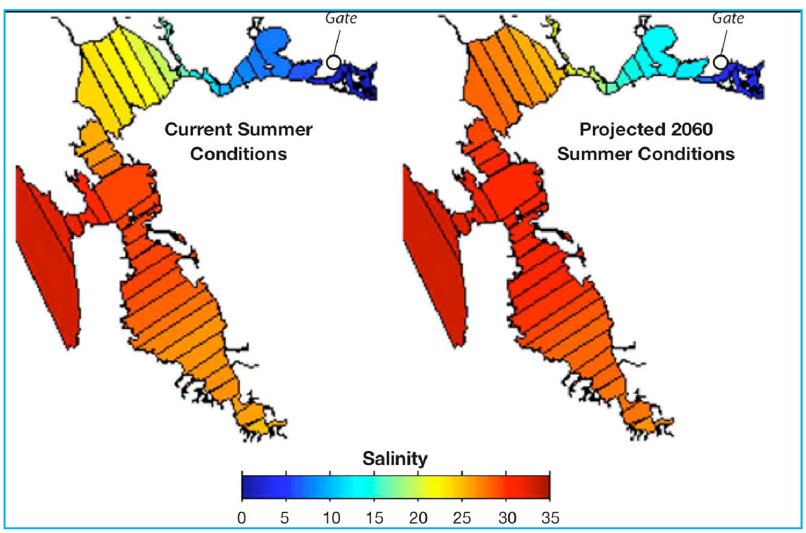


Figure 9. Salinity Change in San Francisco Bay: 2009 to 2060

Current and projected 2060 Summer Conditions.
Source: Dr. Noah Knowles, BCDC 2009

Water Quality

In the eastern Delta portion of Solano County, many growers divert water directly from local waterways. Growers hold riparian rights (i.e., water rights derived from land ownership) or appropriative rights, which have provided reliable water resources in the past. However, SLR and reduced freshwater flows from a decreasing Sierra Snowpack, combined with continued diversion would result in increased salinity in the Bay and Delta, decreasing water quality.

In addition, marine processes that affect the Bay ecosystem are affected by temperature increases and SLR, which can kill phytoplankton, alter fresh and salt water mixing and upwelling, and disrupt primary productivity. Effects on these processes could lead to algal blooms and hypoxia, which could additionally affect water quality.[26]

Groundwater

About 23,300 acre-feet per year of Solano County's regional water supplies are obtained from ground water.[27] The City of Rio Vista and rural residential landowners who use groundwater as their freshwater source would be most affected by increasing salinity intrusion. The biggest effects would likely be to the Suisun-Fairfield Valley Basin, which is the second largest groundwater basin in Solano County. It is located west of the English Hills beneath the Cities of Fairfield and Suisun City. This basin is not used in a significant capacity due to low yields and already poor water quality.

See Figure 10 for a summary of water-related climate change effects.

Figure 10. How Climate Change can affect Solano County

Source: DWR 2008, Managing an Uncertain Future

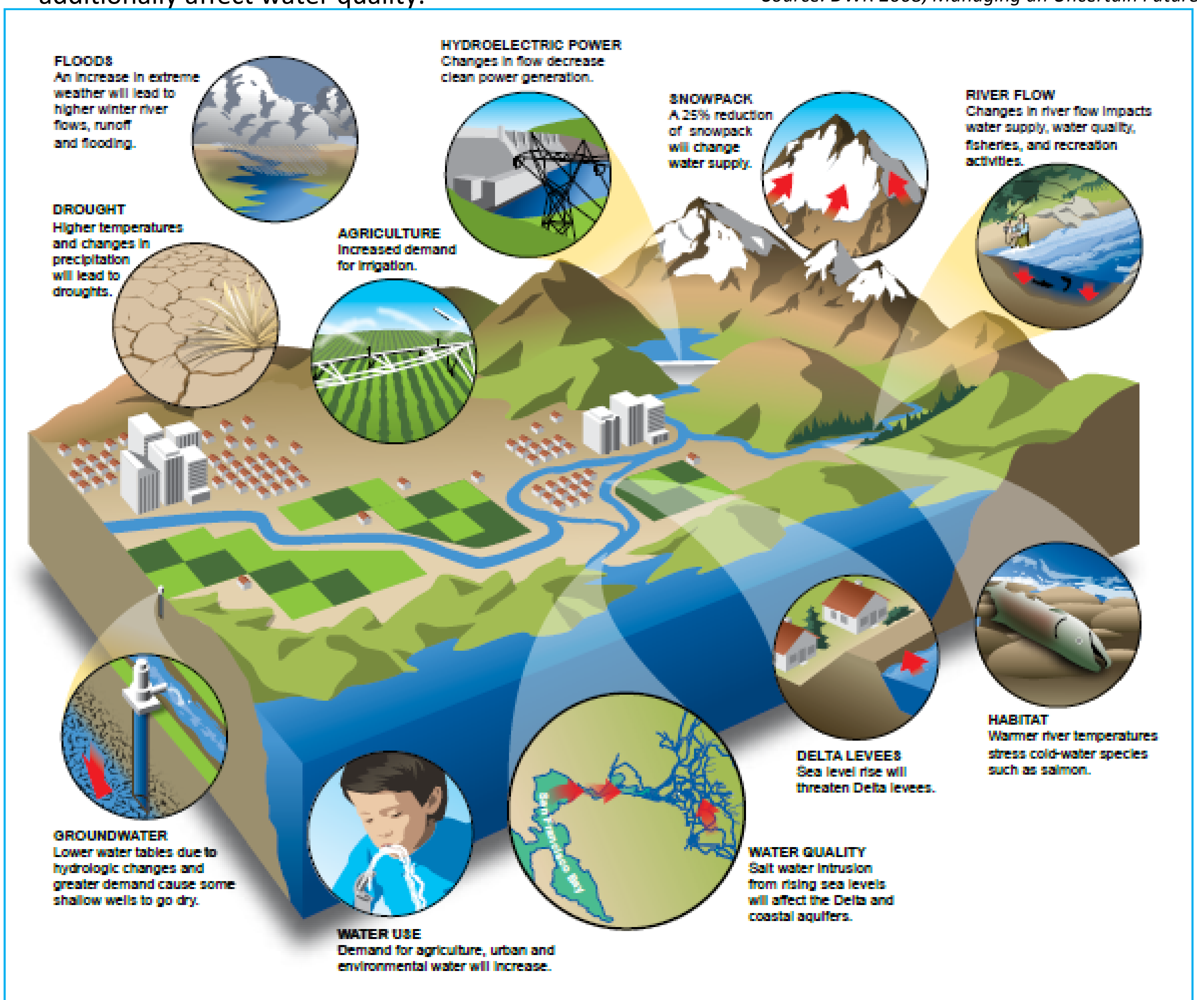


Table 4. Summary of Shoreline Vulnerabilities

Shoreline Use	Location(s) and Challenges	Anticipated Effects	Sensitivity	Adaptive Capacity	Vulnerability
Agriculture	Low-lying areas may experience salt water intrusion, subsidence and flooding.	Higher temperatures and widespread flooding would create crop and plant failures.	**High** –Particularly in low-lying areas.	**Medium**-	**High**
Residential	Little residential acreage exists in low-lying rural areas. However, these areas may represent a disproportionate number of low-income residents; many of whom are already vulnerable to flooding (e.g., Collinsville, residences in Suisun Marsh, residences on Ryer Island and others located in the Sacramento River floodplain).	Widespread flooding and permanent inundation, as sea levels rise.	**High** – Lost investments and property and/or relocating residents has financial and social repercussions.	**Medium** –For those with sufficient resources. **Low** - For low-income residents that generally have less financial flexibility and fewer resources to pursue alternative housing and transportation.[xxviii]	**High**
Industrial and Commercial	Existing flood risks occur in low-lying areas. Economic effects on enterprises depend on waterfront locations (e.g., Snug Harbor, boating and duck clubs)	Widespread flooding and permanent inundation as sea levels rise.	**High** – Lost investments and property and/or relocating businesses has financial and social repercussions.	**Medium** – For those with sufficient resources. **Low** - For small enterprises and those with fewer resources to pursue alternative locations who are dependent on their current location for business success.	**High**
Major Roads and Highways	Congested SR 37 and SR 12. Other key passenger and truck routes.	Widespread flooding of approximately 27 to 45 miles of SR 37 and SR 12, (under the 2050 Scenario and 2100 Scenario respectively).	**High** - These roads are located on low-lying lands, and wetlands. Use of these highways is projected to grow.	**Low**- Current road locations limit expansion or modification options . Current congestion makes costly adaptations difficult.	**High**
Railways	East-west track provides vital connection between Sacramento and the Bay Area. Currently congested with multiple users sharing single tracks.	Flooding of approximately eight to 15 miles of key segments of rail traversing Suisun Marsh (under the 2050 Scenario and 2100 Scenario respectively).	**High**- This rail line carries passengers and freight, across low-lying areas and wetlands. Freight demand is projected to grow	**Low**- The current location of the tracks limits expansion or modification options.	**High**
Pipelines and Transmission lines	Numerous pipelines and power transmission lines cross under the Bay, cut across wetlands,	Increased flooding, storm events, and saltwater corrosion. Increased risk of	**High** – These pipelines and transmission lines traverse low-lying areas and	**Low**- The current locations of pipeline and transmission lines limit expansion and	**High**

Table 4. Summary of Shoreline Vulnerabilities

Shoreline Use	Location(s) and Challenges	Anticipated Effects	Sensitivity	Adaptive Capacity	Vulnerability
	and parallel the shoreline, distributing water, petroleum and energy. Transmission towers sit atop footings which are increasingly exposed to corrosive salt water. Such facilities must be able to withstand increasing extreme storm events.	pipeline spills in vulnerable wetlands and low-lying areas.	wetlands.	modification options in the immediate vicinity.	
Hazardous Sites and Contaminated Lands	Bay fill includes garbage and waste materials that contain toxins and chemicals. Past industrial uses may also have caused contamination, despite ongoing remediation efforts. Sites include Suisun Marsh, Southern Pacific Derailment Site (1969); and Travis Air Force Base NIKE Battery 53 located south of SR 12 at Denverton Road.	Higher sea levels and extreme storm events may cause flooding and erosion that may affect the integrity of shoreline landfills and release contaminated leachate, adversely affecting ecosystems and public health.	**High** – Site security must be addressed before SLR makes access more difficult.	**Medium** – Extensive ongoing efforts have been made to remediate contaminated sites.	**Medium**
Public Access	Current public access areas in Suisun Marsh are subject to flooding.	Widespread flooding and permanent inundation. Prospects to expand shoreline and waterfront recreational opportunities are further limited by proximity to sensitive habitat, costs of purchasing shoreline property, and long-term maintenance and operations expenses.	**High** - Public access is not currently designed or sited to minimize flooding.	**Low**- Public access concerns are unique to the shoreline. As the shoreline moves, public access must be designed to move with it. Upland movement may be blocked by development.	**High**

Source: BCDC 2009, adapted by AECOM for Solano County

Table 5. Summary of Bay Ecosystem Vulnerabilities

Bay Ecosystem	Location(s) and challenges	Anticipated Effects	Sensitivity	Adaptive Capacity	Vulnerability
Suisun Marsh	Subsided wetlands that rely on freshwater inflow imported through salinity gates. Older levees are constructed on peat.	Potential flooding from levee failure. Change in salinity. Loss of species. Lack of sediment. Erosion and invasive species.	**High** - Subsidence and older levees make the Marsh very sensitive to flooding. Salinity changes can alter habitats.	**Low/Medium** –The Marsh has space to migrate upland.	**High**
North Bay	Tidal flats are eroding, reducing sediment supply to marshes. Brackish marsh areas have high biodiversity, but require freshwater inflow.	Increased erosion and lack of sediment for restoration. Invasive species and loss of biodiversity. Salinity changes in and near tributaries.	**High** – Managed wetlands are especially susceptible to erosion. Brackish marsh areas are unique habitats in the Bay Area.	**Medium** –Current rates of erosion and lack of sediment may hamper marsh restoration efforts and upland migration. Open space is available for upland migration.	**Medium/ High**
Sacramento River Floodplain and Delta Islands	Floodplain and levees with associated flood risk management issues.	Flood management systems should seek to reestablish natural hydrologic connectivity between rivers and their historic floodplains. Reversing subsidence of delta islands and land accretion to create equilibrium between land and estuary elevations along select Delta fringes and islands is needed.	**High** – Subsidence is prevalent behind Sacramento River levees.	**Medium** - Setback levees and bypasses help retain and slowly release floodwater, facilitate groundwater recharge, provide seasonal aquatic habitat, support corridors of native riparian forests and create shaded riverine and terrestrial habitats, promoting carbon sequestration.	**Medium/ High**

Source: BCDC 2009, DWR 2008, adapted by AECOM for Solano County

3 EVALUATION AND PRIORITIZATION

EVALUATING AND PRIORITIZING IMPACTS

Overview

The statewide adaptation strategy[1] for the coast and ocean provides guiding principles for making difficult decisions about maintaining and supporting existing natural features while supporting development through rehabilitation, retrofit, and possibly relocation:

- Protect public health and safety and critical infrastructure.
- Protect, restore, and enhance ocean and coastal ecosystems, on which our economy and well-being depend.
- Plan and design new development and communities so they will be sustainable over the long term in the face of climate change.
- Facilitate adaptation of existing development and communities to reduce their vulnerability to climate change impacts over time.
- Begin now to adapt to the impacts of climate change.

These steps are useful in determining the appropriate course of action when preparing for the effects of sea level rise (SLR). However, a more in-depth analysis of the effects of various SLR scenarios aids prioritization of associated mitigation efforts, infrastructure investments, and disaster preparation.

Critical public infrastructure and essential development in unincorporated Solano County shoreline areas must be protected to prevent negative impacts from SLR. For both individual projects and regional efforts, difficult decisions are necessary to determine what to protect and what should not be protected. Further analysis is needed to determine the appropriate forms of shoreline protection and SLR mitigation over both the short- and long-term. The following primary factors should be defined and explored to better evaluate the effects of various SLR scenarios, and assess their potential effects: agriculture, buildings, roads and highways, rail, transmission and pipelines, hazardous sites, public access areas, and wetlands. Following this section, a summary of anticipated effects for each will be presented for each SLR scenario.

Agriculture

Based on the 2008 Solano County Crop and Livestock Report, there were 360,562 acres of land in agricultural production in all of Solano County, which generated $292.8 million of revenue,

supporting approximately 2,010 agricultural jobs and 470 full-time farms[2]. The average annual economic productivity of an acre of agricultural land is between $769 and $940 (2010 dollars).
Table 6 summarizes the projected effects on land zoned as extensive or intensive agriculture across the two sea level rise scenarios defined in Chapter 1, as well as the associated economic value of agricultural productivity losses.

Table 6a. Anticipated Sea Level Rise Effects on Agricultural Land (acres)

SLR Scenario	Extensive	Intensive	Total
16-inch	9,911	24,136	34,046
55-inch	12,763	33,348	46,111

Table 6b. Economic Impact of Lost Agriculture Productivity (2010 dollars)

SLR Scenario	Extensive	Intensive	Total
16-inch	$8,473,000	$20,635,000	$29,108,000
55-inch	$10,912,000	$28,512,000	$39,424,000

Built Area

Most buildings in Solano County are located within incorporated cities. However, there are structures that warrant protection in unincorporated areas. The estimated replacement cost for all built structures in Solano County threatened by the 55-inch Scenario is approximately $1.9 billion[3]. However to understand what proportion of this replacement cost could be attributed to the unincorporated areas, an analysis was conducted to show impacts on residential, commercial, and industrial built areas. Table 7 summarizes the approximate built land acreage that is projected to be affected by both SLR scenarios.

Table 7. Anticipated Sea Level Rise Effects on Built Areas

SLRSLRSLR Scenario	Acres	Replacement Cost
16-inch	865	$133,993,000
55-inch	1,236	$191,057,000

Residential Built Area

Table 8 summarizes the anticipated effects on residentially-zoned land (represented in acres and approximate dwelling units) across the two SLR scenarios, as well as their associated replacement costs. These figures do not include approximately 100 residences (including US Fish and Wildlife Service (USFWS) employee residences) located on the Suisun Marsh, which would be threatened by a levee breach, but are not considered affected areas based on the SLR scenarios that have been developed. The average home on the market in unincorporated Solano County is currently priced between $215,000 and $299,000[4]. These home values do potentially represent a conservative estimation of home value due to the recent volatility in the residential market.

Table 8a. Anticipated Sea Level Rise Effects on Residential Land

SLR Scenario	Rural (2.5-10 acres/du)	Low (2-7 du/acre)	Suburban (1-4 du/acre)	Total
16-inch	0	19	0	19
55-inch	7	26	4	36

Table 8b. Anticipated Sea Level Rise Effects on Residential (approximate units)

SLR Scenario	Rural (2.5-10 acres/du)	Low (2-7 du/acre)	Suburban (1-4 du/acre)	Total
16-inch	0	86	0	87
55-inch	1	117	9	128

Table 8c. Average Replacement Value for Residential (2010 dollars)

SLR Scenario	Rural (2.5-10 acres/du)	Low (2-7 du/acre)	Suburban (1-4 du/acre)	Total
16-inch	$ -	$22,261,000	$ -0	$22,261,000
55-inch	$268,000	$30,245,000	$2,394,000	$32,907,000

Commercial Built Area

Table 9 summarizes the projected effects on commercially-zoned land (represented in acres) across the two SLR scenarios, as well as their associated replacement costs. Replacement costs were based on an average land value of $2 per square foot[5].

Table 9a. Anticipated Sea Level Rise Effects on Commercial Land (acres)

SLR Scenario	Highway Commercial	Community Commercial	Total
16-inch	8	17	25
55-inch	12	17	30

Table 9b. Average Replacement Value for Commercial (2010 dollars)

SLR Scenario	Highway Commercial	Community Commercial	Total
16-inch	$721,000	$1,451,000	$2,172,000
55-inch	$1,068,000	$1,514,000	$2,582,000

Industrial Built Area

Table 10 summarizes anticipated SLR effects on industrially-zoned land (represented in acres) across the two SLR scenarios, as well as their associated replacement costs. Replacement costs were based on an average land value of $1.50 per square foot[6]. As of 2002, Solano County was home to nearly $1.8 billion of added-value manufacturing[7], much of which depends on transport and shipping infrastructure. It is not possible to know what percentage of this estimate is located within the unincorporated area, though it should be noted that dependency on regional infrastructure links this economic value to much of the County.

Table 10a. Anticipated Sea Level Rise Effects on Industrial Land (acres)

SLR Scenario	Water Dependent Industrial	General Industrial	Total
16-inch	624	197	821
55-inch	908	262	1,170

Table 10b. Average Replacement Value for Industrial (2010 dollars)

SLR Scenario	Water Dependent Industrial	General Industrial	Total
16-inch	$40,788,000	$12,906,000	$53,694,000
55-inch	$59,365,000	$17,128,000	$76,493,000

Roads and Highways

Interstate highways, State highways, and local roads are vulnerable to flooding under current conditions. Greater flood risks are anticipated in the future due to SLR. Based on average construction costs for interstates, highways, and roads, the following ranges were used to calculate infrastructure replacement costs: interstate construction costs of $30 million to $50 million per mile, highway construction costs of $12.5 million to $35 million per mile and road construction costs of $5 million to $10 million per mile. These assumptions were obtained from the US Department of Transportation (DOT) and California Department of Transportation (Caltrans).

Table 11 summarizes the anticipated effects on interstates, highways, and local roads across the two SLR scenarios, as well as their associated replacement costs. Additional costs for adaptive strategies such as re-routing or structural adaptations, such as elevating the roadway, could increase these costs. Adaptive strategies would be developed based on future vulnerability and risk analyses specific to each asset and thus are difficult to gage at this time.

Table 11a. Anticipated Sea Level Rise Effects on Interstates, Highways and Local Roads (miles)

SLR Scenario	Interstates	Highways	Roads	Total
16-inch	0.49	14.92	11.72	27.12
55-inch	7.11	26.90	46.48	80.49

Table 11b. Replacement Cost for Infrastructure (thousands, 2010 dollars)

SLR Scenario	Interstates	Highways	Roads	Total
16-inch	$19,480	$354,290	$ 87,900	$461,670
55-inch	$284,375	$638,775	$348,625	$1,271,775

Rail

Rail infrastructure is also vulnerable to flooding under current conditions. The average replacement cost for a mile of surface rail was calculated based on average published rail construction costs from the Railway Technical Journal, which is 2010 dollars are approximately $69 million and $84 million per mile. Greater flood risks are anticipated in the future due to SLR. Table 12 summarizes the projected replacement costs of SLR on existing rail for both sea level rise scenarios. Additional costs for adaptive strategies such as re-routing or structural adaptations, such as elevating the railway, could increase these costs.

Table 12. Anticipated Sea Level Rise Effects on Rail

SLR Scenario	Miles	Replacement Cost
16-inch	8	$609,355,000
55-inch	15	$1,142,535,000

Wetlands

Wetlands are necessary for the health and functioning of the Bay. Suisun Marsh is the largest contiguous brackish water marsh remaining on the west coast of North America and a critical part of the San Francisco Bay-Delta estuary ecosystem. Much of the affected wetland area is located in the Suisun Marsh, a 116,000-acre managed preserve. The table below summarizes the anticipated effects of SLR on marshes or water bodies and courses.

According to the Pacific Institute, the approximate value of wetland habitat ranges between $5,000 and $200,000 per acre (2009 dollars)[8]. This figure was generated by calculating the average restoration cost of wetland ecosystems. Based on this estimate, wetlands threatened by SLR are valued between $5 billion and $6 billion (see Table 13). These wetlands have broad regional significance, as the vast majority of coastal wetlands in California are located in San Francisco Bay and the Sacramento-San Joaquin Delta.

Table 13a. Anticipated Sea Level Rise Effects on Wetlands and Watercourses (acres)

SLR Scenario	Marsh	Water Bodies & Courses	Total
16-inch	44,034	3,589	47,624
55-inch	51,440	5,922	57,362

Table 13b. Economic Value of Wetlands (thousands, 2010 dollars)

SLR Scenario	Marsh	Water Bodies & Courses	Total
16-inch	$4,513,503	$367,921	$4,881,424
55-inch	$5,272,650	$606,977	$5,879,627

Structural Coastal Protection Measures

For the purposes of this SLRSP, the primary structural costal protection measures recommended are levees and raising existing structures. Other strategies such as beach nourishment, groins, seawalls, bulkheads, revetments, and breakwaters could also be considered, if supported by additional site-specific engineering studies.

Levees

Levees are embankments that protect low-lying land. SLR can reduce stability and increase overtopping of levees. New levees may be constructed to protect developed areas. Whether existing levees can be modified to accommodate SLR depends on availability of material to raise the levee, suitability of foundation material to support additional weight of new material, stability of the levee to withstand increased water levels, and accessibility of additional area to support widening the levee base.

According the Pacific Institute, a new levee between 10 and 20 feet in height with a waterside slope of

3:1 would cost about $1,500 per linear foot (2000 dollars). Retrofitting existing levees would cost about $530 per linear foot (2000 dollars). These cost estimates have been converted into 2010 dollars using the Consumer Price Index-adjusted inflation rate for the 2000 to 2010 period. This adjustment increases the cost of a new levee to approximately $1,899 per linear foot and the cost of retrofitting an existing levee to $670 per linear foot.

Table 14 summarizes the anticipated need for both new and retrofitted levees in unincorporated Solano County, as determined by the Bay Conservation and Development Commission (BCDC) for the 55-inch SLR scenario, as well as associated construction costs.

Table 14. Anticipated Sea Level Rise Effects on Levees

SLR Scenario	New Levees		Retrofitted	
	Linear Feet	Cost	Linear Feet	Cost
55-inch	94,695	$179,827	12,300	$8,254

Note: Cost in thousands, 2010 dollars.

Raising Existing Structures

In some portions of coastal Solano County, building levees or seawalls to protect a small number of structures may not be cost-effective. In these cases, raising structures may offer a better alternative. Roadways, railroads, and other structures may also be raised to avoid flood damage.

16-Inch Sea Level Rise Effects

Under a 16-inch rise scenario, approximately 82,240 acres, or 130 square miles, of unincorporated Solano County are vulnerable to flooding by mid-century. The area vulnerable to inundation corresponds to today's 100-year floodplain. The following is a summary of the key properties, infrastructure and resources that may warrant protection under this scenario:

- *Agriculture*: Approximately 34,046 acres of agricultural land is threatened. Estimated losses are between $26 million and $32 million.
- *Residential*: Approximately 19 acres of residential land supporting about 87 units are threatened. The estimated replacement cost for residential buildings is $22 million.
- *Commercial and Industrial*: Approximately 821 acres of industrial land and 25 acres of commercial land are threatened. The estimated replacement cost for industrial buildings is $54 million. The estimated replacement cost for commercial buildings is $2.2 million.
- *Roads and Highways*: Approximately 0.49 miles of Interstate highways, 14.92 miles of State highways and 11.72 miles of County roads are threatened. The estimated replacement cost for this infrastructure is $19 billion for Interstate highways, $354 billion for State highways and $88 billion for County roads.
- *Rail*: Approximately eight miles of rail infrastructure are threatened. The estimated replacement cost is $609 million.
- *Wetlands*: Approximately 47,642 acres of wetlands and watercourses valued at approximately $4.9 billion are threatened.

55-Inch Sea Level Rise Effects

Under a 55-inch rise scenario, approximately 103,990 acres, or 163 square miles, are vulnerable to flooding by the end of the century. The following is a summary of key properties, infrastructure and resources that may warrant protection under this scenario:

- *Agriculture*: Approximately 46,111 acres of agricultural land is threatened. Estimated losses are between $35 million and $43 million.
- *Residential*: Approximately 36 acres of residential land supporting about 128 units are threatened. The estimated replacement cost for these buildings is $33 million.
- *Commercial and Industrial*: Approximately 1,170 acres of industrial land and 30 acres of commercial land are threatened. The estimated replacement cost for industrial buildings is $76 million. The estimated replacement cost for

commercial buildings is $2.6 million.

- *Roads and Highways*: Approximately 7.11 miles of Interstate highways, 26.90 miles of State highways and 46.48 miles of County roads are threatened. The estimated replacement cost for this infrastructure is $284 billion for Interstate highways, $639 billion for State highways and $349 billion for County roads.

- *Rail*: Approximately 15 miles of rail infrastructure are threatened. The estimated replacement cost is $1,142 million.

- *Wetlands*: Approximately 57,362 acres of wetlands and watercourses, valued at approximately $4.9 billion are threatened.

  Wetland Migration: Unincorporated Solano County wetlands would require approximately 14,218 acres of migration land to withstand a 55-inch SLR (see Table 15). Of this amount, 12,065 acres, or 85%, is viable wetland habitat. These areas should be protected to ensure their habitat viability is maintained. Approximately 554 acres, or 4%, is land viable for wetland migration but at some loss of alternative value, including parks, orchards, and agricultural land. The remaining 11% of the available space has been developed and thus is unsuitable for wetland migration.

- *Structural Coastal Protection*: Approximately 94,965 linear feet of new levees and 12,300 linear feet of retrofitted levees may be needed, at an estimated cost of $180 million and $8 million respectively.

Table 15. Wetland Migration Potential

Land Cover Type	Total Area (acres)
Not Viable for Wetland Mitigation	
Low Intensity Developed	660
Medium Intensity Developed	436
High Intensity Developed	503
Subtotal	**1,599**
Viable for wetland mitigation, but will cause property loss	
Cultivated	352
Developed Open Space + Pasture	201
Subtotal	**553**
Viable for wetland mitigation	
Estuarine Emergent Wetland	7,832
Estuarine Scrub/Shrub Wetland	123
Grassland	3,266
Palustrine Emergent Wetland	553
Scrub/Shrub	29
Water	231
Other	31
Subtotal	**12,065**
Total	**14,217**

Other Considerations

Transmission and Pipelines

Transmission lines and pipelines are critical infrastructure threatened by increased flooding, storm events and saltwater corrosion. The value of pipelines and transmission lines is both highly variable and proprietary information. However, this critical infrastructure is integral to a healthy, functioning economy.

Kinder Morgan Energy Partners Pipeline

This 14-inch-wide pipeline, buried three feet underground, travels parallel to the Union Pacific railroad tracks. It is part of a network of pipelines from various refineries located in the East Bay that send their finished product – diesel, jet or auto fuel - to Kinder Morgan's tank farm in Concord. From there, Kinder Morgan transports the petroleum products by pipeline to distributors in Sacramento, Rocklin, Reno and Chico. In 2004, a rupture in a pipeline spilled approximately 60,000 gallons of diesel fuel into Suisun Marsh.

Hazardous Sites

The Southern Pacific Derailment Site and Travis AFB Nike Battery 53 are two hazardous sites identified as potentially threatened by SLR. Both sites contain hazardous material that could be dispersed throughout the Bay if SLR exceeds current protections. Other sites may pose a threat to public health, such as capped landfills, or sites that contain hazardous materials located within the SLR impact areas. Additional analysis of these threats is recommended.

Southern Pacific Derailment Site, Suisun Marsh[9]

This site is the location of a 1969 train derailment that included two tank cars containing approximately 90 tons each of elemental white phosphorus, a solid substance that spontaneously ignites when exposed to the atmosphere. Southern Pacific Train Company (SPTCo) operated the train. The tank cars were ruptured during the derailment causing a fire involving a limited amount of the phosphorus. The fire was extinguished with most of the phosphorus left unburned in the tank cars. Immediately after the derailment and suppression of the resulting fire in 1969, SPTCo covered the two derailed tank cars containing phosphorus and an adjacent railcar containing corn, with marsh soil, capped them with unreinforced concrete, and surrounded them with a 65- by 40-foot chain-link fence. Ongoing public health effects include potential dissemination of phosphorous into groundwater.

Travis AFB Nike Battery 53[10]

This former missile launch area, used by Explosive Technology, Inc. (ET) to test explosives, contains the original structures (minus one magazine, which was destroyed by ET during an explosives test) and ET constructed buildings. Debris resulting from current property use was observed near the missile assembly room. Two underground storage tanks (USTs), which are not in use, but still contain fuel oil, are present. A 275-gallon UST is located on the north side of the missile assembly room, and a 4,000-gallon UST is located on the north side of the ready room. Potential environmental costs of dissemination of pollutants from this site into the Bay have not been estimated.

Public Access

Shoreline and waterfront areas could be threatened by flooding and permanent inundation associated with SLR. Prospects to expanding shoreline and waterfront recreation opportunities are further limited by their proximity to sensitive habitat, the cost of purchasing shoreline property, and long-term maintenance and operations expenses. The economic impact of these shoreline and waterfront effects is difficult to derive from existing economic data. However, rough estimates can be developed by considering current levels of recreation employment.

In 2006, there were 13,000 employees in the Leisure and Hospitality category[11] (out of 144,300 total employees in Solano County). Though SLR would clearly not affect all of these jobs, some portion of the affected jobs would fall in this category, in addition to other categories such as Retail Trade[12]. Table 16 summarizes anticipated effects on land zoned for park and recreation or commercial recreation use across the two SLR scenarios.

Table 16. Anticipated Sea Level Rise Effects on Parks and Recreation or Commercial Recreation Land (acres)

SLR Scenario	Park & Recreation	Commercial Recreation	Total
16-inch	237	123	360
55-inch	323	135	457

Environmental Justice[13]

Potential environmental justice effects of SLR consider the population located within areas at risk and their vulnerability to the potential effects described above. There is little difference between the overall race and income characteristics of Californians residing in areas affected by a 55-inch SLR and those of the state as a whole. However, some important differences exist between the race and income characteristics of the affected population and those of the total population of each county in the state.

Flooding may disproportionately affect Asians, Blacks, Latinos, Native Americans, and other non-whites. In Solano County overall, 38% of those who would be affected by a 55-inch SLR are white, whereas whites comprise 49% of the total population. Conversely, communities of color are disproportionately affected by SLR in many regions of California. Such communities comprise 58% of the affected population, but only 46% of the total population (Pacific Institute 2009). The greater proportion of people of color located in areas affected by SLR highlights the need for the County to make concerted efforts to further understand and mitigate potential environmental injustice.

Economic Conditions[14]

The period preceding a disaster is the key phase for action to reduce vulnerabilities and proactively prevent harm. For example, reinforcing residential buildings, obtaining insurance, and storing emergency supplies can reduce injury and loss. Key demographic factors affecting vulnerability prior to a disaster include residential tenure (renter or homeowner), income, and linguistic isolation.

Studies show that the most vulnerable are typically the least likely to adopt preventive measures. [15]. In California, 23% of households earn less than 150% of the federal poverty threshold ($30,000). About 38% of those vulnerable to a 100-year flood with a 55-inch sea-level rise in Solano County earn less than $30,000. These households are less likely than their counterparts to be able to afford emergency preparedness materials, buy insurance policies, and complete needed building reinforcements.

Renters are also less likely to reinforce buildings and buy insurance because the decision to make major improvements typically lies with the property owner. In Solano County, 33% of households are renters, some portion of which is located in the unincorporated areas.

Following a flood event or other disaster, a range of conditions determines a victims' ability to recover and reconstruct. Important factors include mobility to relocate where opportunities arise, ability to obtain insurance compensation for losses, and ability to receive medical care and public services. Household income, insurance coverage, legal residency status, and race all affect the vulnerability of individuals living in potential flood areas.

The correlation of lower income and race, and the over-representation of communities of color among those without legal residency and without health insurance, increases these communities' vulnerability to the harms of SLR, even in the period following a disaster.

Table 17. Summary of Shoreline Use Economic Effects

<table>
<tr><th rowspan="2">Shoreline Use</th><th colspan="3">Economic Assessment</th></tr>
<tr><th>Cost Factors</th><th>Short-term (15-inch SLR)</th><th>Longer-Term (55-inch SLR)</th></tr>
<tr><td>Agriculture</td><td>Based on the 2008 Solano County Crop and Livestock Report, there were 360,562 acres of land in agricultural production in all of Solano County, which generated $292.8 million of revenue, supporting approximately 2,010 agricultural jobs and 470 full-time farms[16]. The average annual economic productivity of an acre of agricultural land is between $769 and $940 (2010 dollars).</td><td>$29 million (34,046 acres)</td><td>$39 million (46,111 acres)</td></tr>
<tr><td>Residential, Commercial, and Industrial Buildings</td><td>Residential replacement costs were based on the average home on the market in unincorporated Solano County is currently priced between $215,000 and $299,000[17]. These home values do potentially represent a conservative estimation of home value due to the recent volatility in the residential market.

Commercial replacement costs were based on an average land value of $2 per square foot.

Industrial replacement costs were based on an average land value of $1.50 per square foot.</td><td><u>Residential:</u>
~$22 million
(19 acres, 87 units)

<u>Commercial:</u>
~$2.1 million
(25 acres)

<u>Industrial:</u>
~$54 million
(821 acres)</td><td><u>Residential:</u>
~$22 million
(19 acres, 87 units)

<u>Commercial:</u>
~$2.6 million
(30 acres)

<u>Industrial:</u>
~$76 million (1,170 acres)</td></tr>
<tr><td>Major Roads and Highways</td><td>Based on average construction costs for interstates, highways, and roads from DOT and Caltrans.

Interstate: $30 million - $50 million
State Highway: $12.5 million - $35 million
County Road: $5 million - $10 million

As of 2002, Solano County was responsible for nearly $1.8 billion of added-value manufacturing (DOF), much of which depends on transport and shipping infrastructure.</td><td><u>Interstates:</u>
~$20 million (0.49 miles)

<u>State Highways:</u>
~$354 million (14.92 miles)

<u>County Roads:</u> ~$88 million (11.72 miles)</td><td><u>Interstates:</u>
~$284 million (7.11 miles)

<u>State Highways:</u>
~$639 million (26.90 miles)

<u>County Roads:</u> ~$349 million (46.48 miles)</td></tr>
<tr><td>Rail</td><td>Flooding of approximately 8- 15 miles of key segment of rail track traversing Suisun Marsh. The average replacement cost for a mile of surface rail was calculated based on average published rail construction costs from the Railway Technical Journal, which is 2010 dollars are approximately $69 million and $84 million per mile.</td><td>~$609 million
(8 miles)</td><td>~$1,142 million
(15 miles)</td></tr>
</table>

Table 17. Summary of Bay Ecosystem Economic Effects

Bay Ecosystem	Cost Factor	Short-term (15-inch SLR)	Longer-Term (55-inch SLR)
Suisun Marsh	Wetland values are estimated between $5,000 and $200,000 per acre These estimates represent the economic value of wetlands in California using recent wetland restoration cost estimates. These values represent the public's willingness to pay for these ecosystems rather than their actual value. (*Pacific Institute 2009.)*	~$4.9 billion (47,624 acres)	~$5.9 billion (57,362 acres) Migration ~$1.2 billion (12,065 acres)
North Bay			
Sacramento River Floodplain and Delta Islands	New levees: ~$1,900 per linear foot Retrofitted levees: ~$675 per linear foot *(Pacific Institute 2009).*	New levees: ~$180 million (94,695 linear feet) Retrofitted levees: ~$8 million (12,300 linear feet)	

4 PROTECTION AND ADAPTATION

Protection and Adaptation Strategies

Overview

Management strategies and policies to protect unincorporated Solano County from the potential effects of sea level rise (SLR), and to facilitate adaptation to higher sea levels, were based on guidance received in November and December 2010 from the Solano County Planning Commission and Board of Supervisors. Specifically, the Planning Commission and Board of Supervisors recommended:

- Using statewide adaptation guiding principles to develop County policy.
- Incorporating the latest science and regulatory guidance and applying adaptive management, making County actions dependent on and responsive to SLR increase-thresholds.
- Coordinating adaptation efforts with cities for incorporated areas of the County.

Statewide Adaptation Guidance

The statewide adaptation strategy[1] for the coast and ocean provides the following guiding principles that support difficult decisions about maintaining and restoring natural features and functions while also supporting development through rehabilitation, retrofit, and relocation:

1. Protect public health and safety and critical infrastructure.
2. Protect, restore, and enhance ocean and coastal ecosystems, on which our economy and well-being depend.
3. Plan and design new development and communities so they will be sustainable over the long term in the face of climate change.
4. Facilitate adaptation of existing development and communities to reduce their vulnerability to climate change impacts over time.
5. Begin now to adapt to the impacts of climate change.

Initial analysis of the state's guiding principles has identified potential SLR vulnerabilities in several resource areas and for shoreline uses in the County. Agriculture; critical public infrastructure and essential development (e.g., roads and highways, rail, transmission lines and pipelines, and buildings); hazardous sites, public access areas, and wetlands and coastal marshes (i.e., Suisun Marsh); are vulnerable to SLR under the 16-inch and 55-inch scenarios.

SOLANO COUNTY ADAPTATION STRATEGY

Solano County addresses protection from climate change in two ways: mitigation and adaptation.

Mitigation

In the context of climate change, mitigation refers to actions taken to reduce greenhouse gas (GHG) emissions. As mentioned in Chapter 1, Solano County has prepared a Climate Action Plan (CAP) which lays out a plan to reduce both municipal and communitywide GHG emissions for the unincorporated county by more than 20% by 2020, contributing to statewide efforts to reduce GHGs.

In the future, the GHG emissions potential of the SLR adaptation strategies proposed in this chapter should be evaluated, and the measures with the least emissions preferred, if SLR adaptation effectiveness is comparable. For example, some actions can accomplish both SLR adaptation and GHG mitigation, such as restoring tidal marshes that sequester carbon and provide flood protection.

Adaptation

Adaptation refers to *actions* taken in response to actual or projected climate change effects. These actions can reduce risks and/or realize benefits and opportunities. A response can be anticipatory or reactive. Reactive responses tend to be much higher in cost and much less likely to create benefits.

The goal of this program is to increase Solano County's adaptive capacity and to be prepared for increasing sea levels by: (1) limiting potential damages; (2) taking advantage of new opportunities arising from climate change; or (3) accommodating SLR effects.

The following steps should be taken to increase adaptive capacity for vulnerable resource areas in Solano County:

1. Assess vulnerability and risk of identified shoreline uses and resource areas.
2. Determine action thresholds (e.g., assess vulnerability of crucial levees and determine at which sea level the integrity of the levee is endangered (including increased wave heights during storm events)).
3. Develop response plans with *adaptation actions* for identified shoreline uses and resources.
4. Observe developments: track SLR at local tide gages (i.e. Port Chicago) and record storm impacts to infrastructure and resources.
5. Apply the precautionary principle: when vulnerability and risk analyses provide sufficient evidence that effects are immanent (i.e., highly likely to occur within the next 5-10 years), implement adaptation actions to reduce risks and vulnerability.
6. Uncover opportunities and benefits with anticipatory planning. The more lead time is available, the more opportunities can be developed.

These steps are also represented in Figure 21 at the end of this chapter.

Critical public infrastructure and essential development in unincorporated Solano County shoreline areas must be protected to prevent negative effects from SLR. For both individual projects and regional efforts, difficult decisions are necessary to determine what to protect and where to allow flooding and possible inundation. Choosing the appropriate form of protection is critically important.

Guiding Principles for Adaptation

Adopt Integrated Approaches: Incorporate adaptation into core policies, planning, practices, and programs whenever possible.

Prioritize the Most Vulnerable: Prioritize helping people, places, and infrastructure that are most vulnerable to climate change effects. Design and implement adaptation strategies with meaningful involvement from all parts of society.

Use Best-Available Science: Use the best-available scientific understanding of climate change risks, effects, and vulnerabilities.

Build Strong Partnerships: Coordinate across multiple sectors and scales and build on existing efforts and knowledge of a wide range of public and private stakeholders.

Apply Risk-Management Methods and Tools: Incorporate risk management methods and tools that identify, assess, and prioritize options.

Apply Ecosystem-based Approaches: Account for strategies that increase ecosystem resilience and protect critical ecosystem services.

Maximize Mutual Benefits: Use cost-effective strategies that complement or directly support other related climate or environmental initiatives, such as efforts to improve disaster preparedness, promote sustainable resource management, and reduce GHG emissions.

Continuously Evaluate Performance: Include measureable goals and performance metrics to continuously assess whether adaptive actions are achieving desired outcomes.

Adapted from The White House Council on Environmental Quality, Progress Report of the Interagency Climate Change Adaptation Task Force, 2010

In the long-term, State and local governments within the region should facilitate an open and vigorous public dialogue about what to protect and how. Engaging the public is also supported by the federal Interagency Climate Change Adaptation Task Force[2]. Even though national guidance on adaptation is still being developed, the Task Force released some useful principles in October 2010[3]. They are listed in the sidebar to support County efforts, especially regarding prioritization and building partnerships with Solano County cities.

Adaptation Actions

Adaptation actions can include protecting shorelines, designing new construction to be resilient to SLR, and relocating structures out of flood and inundation zones. Adaptation and mitigation measures implemented before sea level rises are expected to be more cost-effective.[4]

Recommended adaptation actions focus on *protection measures*, *wetland and ecosystem restoration*, and *land use planning*. Recommended adaptation actions for each identified vulnerable shoreline use are provided in Table 19.

Protection Measures

Shoreline protection projects can reduce anticipated widespread flooding from storm activity and SLR, and safeguard high-value areas from inundation in Solano County. This protection can be structural, natural, or both.

Approaches to reduce flood damage include protecting structures or areas with strengthened or additional levees, seawalls, tidal marshes, or other means; and employing innovative design concepts that increase a building’s resilience to periodic flooding or allow easy relocation. The following shoreline protection measures are potentially applicable to Solano County.

Table 19 Adaptation Actions for Vulnerable Shoreline Uses

Shoreline Use	Vulnerability (Table 4, Chapter2)	Anticipated Risk at 16 Inches and 55 Inches SLR	Adaptation Actions	SLR Threshold Timeline for Action	Next Steps
Agriculture -Suisun Marsh -Sacramento River Floodplain	**High** - Low-lying areas will likely experience salt water intrusion, subsidence and flooding.	Increased flooding at 16 inches. Widespread inundation at 55 inches.	**Protection** – Raise levees, create buffers, restore wetlands, and enhance sedimentation **Adaptation** – Encourage alternative agricultural practices more resilient to flooding and salt water intrusion and consistent with adaptive stormwater management and with ecosystem benefits or consistent with ecosystem restoration **Planning** –Provide for uses that can be adapted or relocated over time	**Levee assessments** to determine how many more inches of SLR current levees can withstand	**Ground truthing -** Assess vulnerability and risk of specific agricultural areas. Incorporate latest high-resolution topography and bathymetry mapping (i.e., LIDAR)
Critical public infrastructure and public development **Residential** -Collinsville -Sandy Beach -Residences in Suisun Marsh	**High** - Little residential acreage exists in low-lying rural areas. However, these areas may represent a disproportionate number of low-income residents; many of whom are already vulnerable to flooding (e.g., Collinsville, residences in Suisun Marsh, residences on Ryer Island, and others located in the Sacramento River floodplain).	Widespread flooding and permanent inundation. Potential for erosion along immediate shoreline (e.g., Sandy Beach).	**Protection** – Reinforce and raise levees, create buffers, establish flood defenses **Adaptation** – Design and upgrade residences to tolerate periodic flooding (e.g., lift onto higher ground, leave ground floors empty for flooding, raise structures, use flood-resistant construction material). Manage flood pathways to accommodate heavy rain events, storm water drainage, and pumping. **Planning** –Provide for new development that can be adapted or relocated. Relocate existing buildings vulnerable to flooding when possible.	**Levee assessments** to determine how many more inches of SLR current levees can withstand	**Integrate development standards in SLR planning area into zoning ordinances** - New development needs to be adaptable, existing development needs to remodel/adapt). Ensure emergency preparedness for residences in SLR areas.
Industrial and Commercial -Snug Harbor	**High** - Existing flood risks occur in low-lying areas. Economic effects on enterprise dependant	Widespread flooding and permanent inundation.	**Protection** – Reinforce and raise levees, create buffers **Adaptation** – Design and upgrade	**Levee assessments** to determine how	**Work with business stakeholders to**

Shoreline Use	Vulnerability (Table 4, Chapter2)	Anticipated Risk at 16 Inches and 55 Inches SLR	Adaptation Actions	SLR Threshold Timeline for Action	Next Steps
-Boating and Duck Clubs	on waterfront locations (e.g., Snug Harbor, boating and duck clubs).		businesses to tolerate periodic flooding and possible long-term inundation. **Planning** –Provide for new development that can be adapted or relocated.	many more inches of SLR current levees can withstand	**find innovative solutions** – Find new areas to support access/business enterprises.
Major Roads and Highways	**High** - Congested SR 37 and SR 12. Other key passenger and truck routes. These roads are located on low-lying lands, and wetlands. Use of these highways is projected to grow. Current road locations limit expansion or modification options. Current congestion makes costly adaptation difficult.	Widespread flooding of approximately 27 (at 16 inches of SLR) to 45 miles (at 55 inches of SLR) of SR 37 and SR 12.	**Protection** – Reinforce and raise levees, create buffers **Adaptation** – Design and upgrade roadways to tolerate periodic flooding and possible long term inundation (i.e., storm water drainage, elevation of roadways, relocation to higher ground, into protected infrastructure corridor). **Planning** – Provide for new development that can be adapted or relocated; collaborate with Caltrans and MTC on adaptation planning for affected state routes and major roadways.	**Levee and roadway assessments** to determine how many more inches of SLR current levees and highways can withstand	**Ground truthing -** Assess vulnerability and risk of identified roadways. Incorporate latest high-resolution topography and bathymetry mapping (i.e., LIDAR). Work collaboratively with MTC and Caltrans.
Railway	**High** - East-west track provides vital connection between Sacramento and the Bay Area. Currently congested with multiple users sharing single tracks. This rail line carries passengers and freight across low-lying areas and wetlands. Freight demand is projected to grow.	Flooding of approximately eight (at 16 inches of SLR) to 15 miles (at 55 inches of SLR) of rail traversing Suisun Marsh.	**Protection** – Reinforce and raise levees, create buffers **Adaptation** – Design and upgrade rail lines to tolerate periodic flooding and possible long term inundation (I.e., storm water drainage, elevation of railway, relocation to higher ground, into protected infrastructure corridor). **Planning** – Collaborate with the Union Pacific Railroad, Amtrak, and other applicable transportation agencies to upgrade/reroute the railway through Suisun Marsh.	**Levee and railway assessments** to determine how many more inches of SLR current levees and railways can withstand	**Ground truthing -** Assess vulnerability and risk of identified railways. Incorporate latest high-resolution topography and bathymetry mapping (i.e., LIDAR). Work collaboratively with rail companies.
Pipelines and Transmission	**High** - Numerous pipelines and power transmission lines cross	More detailed information should be	**Protection –** Reinforce and raise levees, create buffers	**Levee and transmission**	**Ground truthing -** Assess vulnerability

Shoreline Use	Vulnerability (Table 4, Chapter2)	Anticipated Risk at 16 Inches and 55 Inches SLR	Adaptation Actions	SLR Threshold Timeline for Action	Next Steps
lines	under the Bay, cut across wetlands, and parallel the shoreline, distributing water, petroleum, and energy. Transmission towers sit atop footings which are increasingly exposed to corrosive salt water. Such facilities must be able to withstand increasing extreme storm events, flooding, inundation, and saltwater corrosion. SLR will increase risk of pipeline spills in vulnerable wetlands and low-lying areas.	collected.	**Adaptation** – Design and upgrade pipelines and transmission lines to tolerate periodic flooding and possible long term inundation (I.e., storm water drainage, sea water resilience, elevation of pipelines and transmission lines, relocation to higher or lower ground, and /or to protected infrastructure corridors). **Planning** – Collaborate with the pipeline and transmission line companies to upgrade/reroute infrastructure through Suisun Marsh.	**infrastructure assessments** to determine how many more inches of SLR current levees and transmission infrastructure can withstand	and risk of identified infrastructure. Incorporate latest high-resolution topography and bathymetry mapping (i.e., LIDAR). Work collaboratively with pipeline and transmission line companies to assess risk.
Hazardous Sites and Contaminated Lands - Suisun Marsh, Southern Pacific Derailment Site (1969) - Travis Air Force Base NIKE Battery 53	**Medium** - Bay fill includes garbage and waste materials that contain toxins and chemicals. Past industrial uses may also have caused contamination, despite ongoing remediation. Sites include Suisun Marsh, Southern Pacific Derailment Site (1969); and Travis Air Force Base NIKE Battery 53 located south of SR 12 at Denverton Road. Higher sea levels and extreme storm events may cause flooding and erosion that affect the integrity of shoreline landfills and release contaminated leachate, adversely affecting ecosystems and public health.	Higher sea levels and extreme storm events may cause flooding and erosion that may threaten the integrity of shoreline landfills and release contaminated leachate, adversely affecting ecosystems and public health.	**Protection** – Create buffers **Adaptation** – Design and upgrade caps to tolerate periodic flooding and possible long term inundation. **Planning** – Remediate to withstand increased flooding and potential inundation.	**Levee and infrastructure assessments** to determine how many more inches of SLR caps can withstand	**Ground truthing -** Assess vulnerability and risk of identified sites. Incorporate latest high-resolution topography and bathymetry mapping (i.e., LIDAR)
Public Access	**High** - Current public access	Widespread flooding	**Protection –** Create buffers	**Levee and public**	**Ground truthing -**

Shoreline Use	Vulnerability (Table 4, Chapter2)	Anticipated Risk at 16 Inches and 55 Inches SLR	Adaptation Actions	SLR Threshold Timeline for Action	Next Steps
	areas in Suisun Marsh are subject to flooding. Public access is not currently designed or sited to minimize flooding.	and permanent inundation. Prospects to expand shoreline and waterfront recreational opportunities are further limited by proximity to sensitive habitat, costs of purchasing shoreline property, and long-term maintenance and operation expenses.	**Adaptation** – Design and upgrade public access to tolerate periodic flooding and possible long term inundation. **Planning** – As the shoreline moves, public access must be designed to move with it. Upland movement may be blocked by development. Collaborate with public agencies to ensure continued public access along the shoreline and in the Suisun Marsh.	**access assessments** to determine how many more inches of SLR public access points can withstand. Some public access areas in Suisun Marsh are already subject to flooding during high tides.	Assess vulnerability and risk of identified public access points. Incorporate latest high-resolution topography and bathymetry mapping (i.e., LIDAR). Develop design and access alternatives with agencies and stakeholders.
Bay Ecosystems and Wetlands - Suisun Marsh - North Bay - Sacramento River Floodplain and Delta Islands	**Medium/High** – Subsided wetlands in Suisun Marsh rely on freshwater inflow. Older levees are constructed on peat. Both are sensitive to flooding and salinity changes. Tidal flats are eroding throughout the North Bay. Subsidence is prevalent behind Sacramento River levees, increasing flood risks. Delta Island erosion is also a critical concern.	Widespread flooding and permanent inundation. Increased salinity intrusion and erosion. Lack of sediment for restoration.	**Protection** – Create buffers **Adaptation** - Restore wetlands and build-up sedimentation. Provide upland areas for wetland migration. **Planning** – Plan for upland migration and managed retreat. Continue wetland restoration that provides value if flooded and/ or inundated (i.e., supports wetland habitat, sedimentation, transition habitat, and migration). Reverse subsidence of Delta islands and promote land accretion to create equilibrium between land and estuary elevations. Reestablish natural hydrologic connectivity between rivers and their historic floodplains. Create natural buffers and manage retreat from river edges.	**Incorporate adaptation objectives in ongoing wetland restoration**. Most wetland areas in the SLR planning area are located below sea level, and restoration efforts are in progress, providing opportunities for adaptation.	**Ground truthing -** Assess vulnerability and risk of Bay ecosystems and wetlands. Assess, track, and support restoration progress. Plan for upland migration with resource agencies and stakeholders**.**

Adding, Strengthening and Raising Levees and Seawalls

Existing levees[5] protecting portions of Solano County will likely need to be reinforced (i.e., strengthened and raised) and additional levees will be needed in strategic locations. Levees are usually built by piling earth on a cleared, level surface. Broad at the base, levees taper to a level top, where temporary embankments or sandbags can be placed. Fragile levees in the Suisun Marsh are mostly built from and on peat. Subsidence of land areas behind them increases potential flood risk. In addition, silt deposits raise the level of the Sacramento River, adding to potential risk. Because a levee is only as strong as its weakest point, levee height and construction standards must be consistent along its length. Levee sections can be set back from the river or coast to form a wider channel and deflect wave energy, and often multiple levees can prevent a single breach from flooding a large area.[6]

Figure 11. Edge of the Suisun Marsh near Collinsville

Source: AECOM

Seawalls are usually constructed to protect urban coastal shorelines and ports, as they reduce the effects of strong waves. Seawalls are most commonly constructed using reinforced concrete, boulders, steel, or gabions and often create a hard edge. Modern concrete seawalls tend to be curved to reflect wave energy back out to sea. Poor designs require constant maintenance as waves erode the base of the seawall.[7]

Figure 12. Seawall at La Jolla Cove near San Diego

Source: flickr user flopper, Dec 19, 2009[8]

Considering existing threats to Solano County levees due to overtopping, burrowing animals and earthquakes; strengthening and raising levees is a reasonable approach to increase protection of vulnerable shoreline infrastructure. However, these investments should be considered in light of the following challenges:

- Artificial levees require substantial engineering and ongoing maintenance to prevent erosion, water logging, and possible breach.[9][10] A levee breach could be perilous, as large portions of Suisun Marsh and residential areas such as Collinsville already lie below sea level behind levees. A breach would likely cause immediate inundation; thus, this protection strategy may create false security.

- As the rate of SLR accelerates and potential for shoreline flooding increases, demand for new shoreline protection projects will likely increase, potentially making this a perpetual undertaking and perennial cost to the County and other stakeholders.

Figure 13. Aerial View of 2004 Levee Break at Jones Tract in the Delta

Shot 06/03/04. Source: DWR. [11]

- Levee construction projects may involve extensive fill, which can adversely affect water surface area and volume, tidal circulation, and wildlife habitat[12], and may have cumulative effects. [13]
- Levees and seawalls can be counterproductive to natural shoreline protection and tidal wetland restoration efforts. Levees and sea walls can cause and increase erosion of tidal wetlands and tidal flats, preventing wetland migration.
- Levees and seawalls can create barriers to physical and visual public access to the shoreline. However, they can also facilitate access, if built wide and strong enough to support trails and small roads.

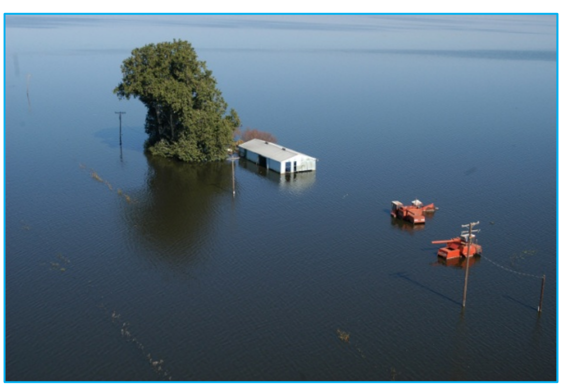


Figure 14. Aerial View Showing Flooding caused by the 2004 Jones Tract Levee Break in the Delta

Source: DWR[14]

Strengthening and raising levees may be a good short-term solution to buy time while preparing non-structural and ecosystem supportive shoreline protection. New levees and seawalls in specific locations can supplement a broader adaptation strategy. Priority areas for potential levee upgrades and additions have been identified by the Pacific Institute, and are shown on Maps A1 through B5 in Appendix A.

Innovative Design at the Neighborhood/Building Scale

Flood protection measures can also be implemented on a local level by neighborhoods and individual building owners. This section addresses adaptation for existing development. Where more permanent flood defenses are not yet in place, too vulnerable or too costly, these localized strategies are recommended for vulnerable buildings located in the SLR planning areas. Many residences in and around Suisun Marsh are already elevated on stilts and have primary uses located on the higher levels of the building. In other countries, the lack of more permanent barriers has led to increased use of temporary, free-standing barriers which hold back floodwater when necessary.

Protection measures for existing buildings can include use changes, new materials and products, such as removable flood boards, which are fitted temporarily to individual properties to form a barrier[15].[16]

Figure 15. Removable Flood Boards.[17]

Localized structural protection measures[18] recommended for existing buildings in the SLR planning areas include:

- Elevating structures onto stilts or mounds
- Minimizing habitation and storing only easily removable items on the ground level
- Raising floor levels, electrical fittings, and equipment
- Preparing for emergencies with back-up generators and freshwater reserves in remote areas
- Fitting one-way valves permanently in drains and sewage pipes to prevent backflow. Pipes, drains and toilet bowls can also be temporarily blocked using an expandable/inflatable drain and pipe barriers to prevent backflow.
- Using temporary free-standing barriers which hold back floodwater from properties.

Figure 16. Old and New Homes in New Orleans.

Source: flickr user werdsnave[19]

- Installing removable household products like flood boards, vent covers and flood skirts which are fitted temporarily to properties to form a barrier to water.
- Applying flood-resilient materials that can withstand sustained direct contact with floodwaters without damage. These include concrete, vinyl and ceramic tiles, pressure-treated timber, glass block, and metal doors and cabinets.

Figure 17. A Fence that doubles as Flood Barrier Protecting Private Property.

Source: Metalihh2o[20]

Building specific adaptation provides options to local home and business owners in the SLR planning area to protect their property during high flood events. However, considering that sea levels are expected to continue to rise, the overall strategy should be to relocate vulnerable land uses out of the SLR planning area, as these strategies do not reduce the threat of long-term inundation.

Nonstructural Shoreline Protection Methods and Buffers

Nonstructural shoreline protection can also provide effective flood control that is simultaneously supportive of ecosystems. Nonstructural methods include using tidal marshes and wetlands as natural buffers and enhancing these systems through restoration. Natural systems and human communities are both considered resilient when they can absorb and rebound from the effects of weather extremes or climate change and continue functioning without outside assistance.[21] Non-structural shoreline protection methods rely on the ability of wetlands to act as a sponge during flood events and to support erosion control and land accretion.

Restoration and Migration

Enhancing wetlands through restoration, returning managed wetlands to tidal influences and providing migration areas are desirable nonstructural shoreline protection techniques. They may require allowing previously managed and reclaimed land to flood again. However, sediment soil accretion through wetlands and ecosystem tidal restoration is a cost-effective, natural process that can help sustain the Delta ecosystem and protect Delta communities from inundation.[22] In some locations in the Delta, agencies and conservancy landowners are already looking at alternative approaches (such the Nature Conservancy and the McCormack-Williamson Tract Habitat Friendly Levee Rehabilitation Project) in which levees will be "degraded" (lowered, with weirs added) at strategic locations to allow for controlled flood management and ecosystem restoration.

Buffers

Buffers are areas established adjacent to a habitat to reduce the adverse effects of surrounding land uses. Buffers can also minimize additional loss of habitat from shoreline erosion resulting from accelerated SLR and allow tidal habitats to move landward. Buffer areas are critical for achieving regional goals for the types, amounts, and distribution of habitats.[23]

Whenever feasible and appropriate, the State requests that shoreline protection projects include provisions for nonstructural methods such as marsh vegetation, and integrate shoreline protection and Bay ecosystem enhancement. Where feasible along shorelines that support marsh vegetation, or where marsh establishment has a reasonable chance of success, project designs should include provisions for establishing marsh and transitional upland vegetation as part of the protective structure.[24]

Figure 18: Suisun Marsh Grizzly Island Road (Summer 2010)

Ecosystem Tidal Restoration

Tidal wetlands comprise the margins of the estuary that are periodically inundated by tides. They include the following habitats within the elevation range between the lowest and highest tide: intertidal mudflats; regularly inundated tidal marsh plain; tidal channels within the marsh; and infrequently inundated wetland-upland transition zones at the edge of the upland.[25] In addition to protecting shorelines from floods and erosion by absorbing waves, and slowing the flow of high water, wetlands filter pollutants out of water, sequester carbon, provide recreational open space, and create critical habitat for fish, wildlife, and millions of organisms that live in tidal mud and form the basis of aquatic food chains.

Wetlands require space and time to work. Wetlands are generally "thicker" than structural protection strategies such as levees, so they need more land. They also require management, monitoring and time to become established. However, wetlands are also naturally adaptive to SLR, as long as two conditions are met: (1) wetlands must have space to migrate landward, and (2) wetlands must be sufficiently supplied with sediment to keep pace with SLR. Due to the many dams and modified hydrology of the Delta and its major rivers, this is a concern for restoration success.

Figure 19: Grizzly Island Road in Suisun Marsh (Summer 2010)

Reserving a buffer or setback area where wetlands can form and migrate between developed places and today's shoreline is a cost-effective flood protection strategy. Important challenges for our region will be determining how much flooding new tidal marshes could attenuate, restoring them in appropriate places, and conducting restoration at a faster rate than we would without the looming threat of rising seas.[26] Ecosystem tidal restoration projects have been ongoing, particularly in the Suisun Marsh. The latest state guidance[27] identifies that ecosystem tidal restoration projects should include clear and specific long-term and short-term biological and physical goals and success criteria, along with a monitoring program to assess the sustainability of the project.

In some instances, it may be possible to combine habitat restoration with structural approaches to provide protection from flooding and control shoreline erosion, thereby minimizing the shoreline protection project's effect on natural resources.[28]

Managed Retreat

In the context of coastal erosion, managed retreat allows an area that was not previously exposed to flooding to become flooded by removing coastal protection. This process usually occurs in low lying estuarine areas and almost always involves flooding of land that has at some point in the past been claimed from the sea.[29] In the context of development and infrastructure, managed retreat describes planned and safe abandonment of threatened areas near the shoreline. It involves abandoning, demolishing or moving existing buildings and infrastructure to higher ground. It usually also includes prohibiting new development in areas likely to be inundated. This approach should be used when structural protection methods and other shoreline protection efforts become very expensive or ineffective. The "managed" part of retreating from the shoreline involves establishing thresholds to trigger activities such as demolishing buildings or abandoning efforts to control shoreline erosion. These thresholds should be coupled with buy-back programs to compensate property owners for loss, and strict building codes that allow only relocatable or floodable structures in the SLR planning area.

Land Use Planning

The adaptation approach that the County can most directly manage is land use planning. If integrated early, it can also be the most cost effective approach. To ensure public safety in vulnerable shoreline areas, land use planning protects existing development, and accommodates flooding by enhancing structures to be resilient. Land use planning should also discourage permanent new development; allow only interim new uses that can be removed or phased out as inundation threats are realized, and facilitate managed retreat by removing existing unsafe development over time.[30]

Fortunately the majority of General Plan land use designations in the SLR planning area are Marsh and Agriculture, with a Resource Conservation Overlay, precluding substantial new development. Notable exceptions include the areas around Collinsville and Sandy Beach, where infill development is allowed under certain circumstances within the Traditional Community land use designation.

Updates to these land use designations and development regulations to minimize risk and protect public safety, welfare, and health should include establishing upland migration areas for the marsh and adding adaptation conditions to new development in the SLR planning area, particularly within the Collinsville Traditional Community.

New Development in Sea Level Rise Planning Areas

Current (2010) state guidance on new development identifies that projects should be designed to be resilient to a mid-century SLR projection based upon a risk assessment conducted for the project. If it is likely the project will remain in place longer than mid-century, an adaptive management plan should be developed to address the long term effects that will arise based on a risk assessment using the best available science-based projection for SLR at the end of the century.[31]

New projects should be limited to minor repairs of existing facilities, small projects that do not increase public safety risks, remediation of existing environmental degradation or contamination, interim or temporary projects that can be easily removed or relocated to higher ground and won't require shoreline protection, and infill projects within existing urbanized areas that likely will be protected.[32]

Ecosystem Enhancement and Protection in the Sea Level Rise Planning Areas

Another land use planning approach promoted in the state guidance is to preserve, enhance and permanently protect undeveloped, vulnerable shoreline areas that currently sustain diverse habitats and species or possess conditions that make the areas especially suitable for ecosystem enhancement.[33] This applies to the upland areas suitable for migration of the Suisun Marsh (identified in Maps A1-5 in Appendix A) that would allow inland habitat migration as sea level rises.

Encouraging innovative Sea Level Rise Approaches

The state also encourages effective, innovative SLR adaptation, wherever feasible and appropriate.[34] In the context of SLR adaptation, innovative approaches will likely include financing mechanisms, design concepts, and land management practices. Effective, innovative adaptation approaches minimize public safety risks; maximize compatibility with, and integration of natural processes; are resilient over a range of sea level and potential flooding impacts and storm intensities; and are adaptively managed. Developing innovative adaptation approaches will require financial resources, testing, and refinement before they are implemented on a large scale.[35]

Figure 20. Houses in the Netherlands that Float when the Adjacent River Rises.
Source: Dura Vermeer[36]

Adaptation may also foster discovery of beneficial and more sustainable development styles. Examples include floatable houses and communities. Adaptation design guidelines for new development in SLR planning areas will continue to evolve rapidly in California and around the world. The County will

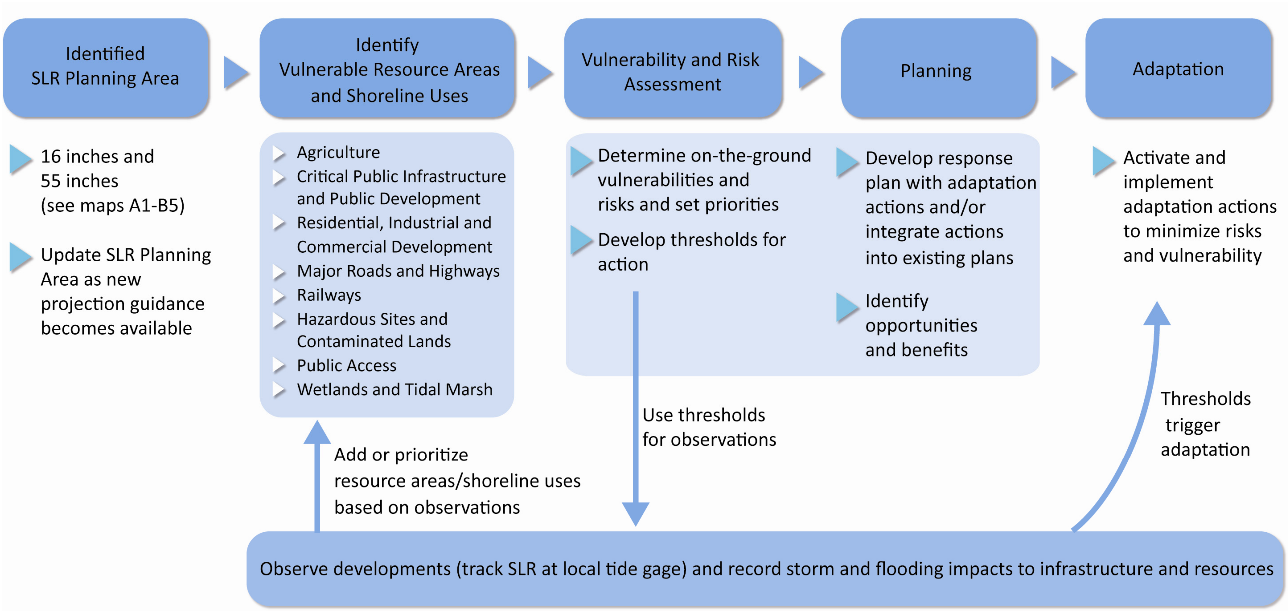


Figure 21. Adaptation Planning Process

review and consider the latest applicable adaptation design guidelines for inclusion.

The state also recommends a regional strategy to determine:

- where existing development should be protected and infill development encouraged,
- where new development should be permitted, and
- where existing development should eventually be removed to allow the Bay to migrate inland.[37]

The recommended goals of this strategy are provided in Appendix C. This approach is consistent with the guidance received from the Solano County Board of Supervisors to coordinate with incorporated areas.

Adaptive Management and Next Steps

It is currently not possible to predict the exact time when the sea level will be 16 inches or 55 inches higher than present. Therefore, Solano County will

Regional Collaboration for SLR Planning

Multiple local, state, federal, and regional agencies have authority over the Bay and shoreline. Local governments have broad authority over shoreline land uses, but limited resources to address climate change adaptation. Working collaboratively can optimize scarce resources and create the flexibility needed to plan amidst a high degree of uncertainty.

For example, a Federal Highway Administration (FHWA) Vulnerability and Risk Assessment Pilot Model is being assessed by the Metropolitan Transportation Commission (MTC) in the Bay Area in 2011.

Outcomes will help inform next steps for state agencies and Solano County in identifying vulnerable infrastructure and development.

use the rise level as a threshold for action. By monitoring local tide gages (e.g., Port Chicago), the state of the levees, and the shoreline; the County, working with flood management and emergency services agencies, will determine rise level thresholds per resource area. For example, thresholds could include rise levels that could cause frequent or permanent inundation. These will be used to establish a response plan for each resource area. The process is summarized above in Figure 21.

In addition, the County will:

- Collaborate on a Regional SLR Plan. [38]
- Adopt guidance within planning documents.
- Set aside funding for emergencies, levee failures, and inundation.
- Continue to consider critical SLR vulnerabilities, increased storm effects, and likely near-term inundation.
- Ensure emergency preparedness in areas already prone to flooding and areas that may experience inundation.
- Coordinate with emergency management and response agencies.

This SLRSP provides Solano County with a framework to successfully adapt to SLR and its anticipated effects. This program represents a first step and call to action to identify opportunities inherent in the challenge.

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3. Relative to a nearby geodetic reference, and new satellite-based sensors are extending measurements.

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Notes: The mean sea level trend is 2.08 millimeters/year with a 95% confidence interval of +/- 2.74 mm/yr based on monthly mean sea level data from 1976 to 2006 which is equivalent to a change of 0.68 feet in 100 years.

The plot shows the monthly mean sea level without the regular seasonal fluctuations due to coastal ocean temperatures, salinities, winds, atmospheric pressures, and ocean currents. The long-term linear trend is also shown, including its 95% confidence interval. The plotted values are relative to the most recent Mean Sea Level datum established by CO-OPS. The calculated trends for all stations are available as a table in millimeters/year or a table in feet/century (0.3 meters = 1 foot).

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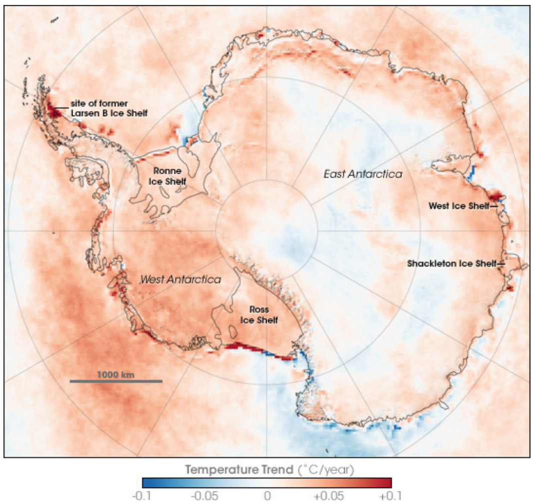

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Table R-1. Estimated potential maximum sea levelsea level rise from the total melting of present-day glaciers.
[Modified from Williams and Hall (1993). See also http://pubs.usgs.gov/factsheet/fs50-98/]

Location	Volume (km³)	Potential sea-level rise (m)
East Antarctic ice sheet	26,039,200	64.80
West Antarctic ice sheet	3,262,000	8.06
Antarctic Peninsula	227,100	.46
Greenland	2,620,000	6.55
All other ice caps, ice fields, and valley glaciers	180,000	.45
Total	32,328,300	80.32

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34. A REPORT ON SEA LEVEL RISE PREPAREDNESS, California State Lands Commission. December 2009. http://www.slc.ca.gov/Reports/SEA_LEVEL_Report.pdf , accessed August 2010

35. A Marine Protected Area is "any area of the marine environment that has been reserved by federal, state, territorial, tribal, or local laws or regulations to provide lasting protection for part or all of the natural and cultural resources therein." Executive Order 13158, of May 26, 2000 http://mpa.gov/pdf/eo/execordermpa.pdf , accessed August 2010

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http://www.opc.ca.gov/webmaster/ftp/pdf/agenda_items/20100911/14.%20SLR/20101129_OPC_SLR_Draft_Resolution_Memo.pdf; accessed December 2010

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CHAPTER 2 – POTENTIAL EFFECTS OF SEA LEVEL RISE

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4. La Niña is defined as cooler than normal sea-surface temperatures in the central and eastern tropical Pacific ocean that impact global weather patterns. La Niña conditions recur every few years and can persist for as long as two years.

El Niño and La Niña are extreme phases of a naturally occurring climate cycle referred to as El Niño/Southern Oscillation. Both terms refer to large-scale changes in sea-surface temperature across the eastern tropical Pacific. Usually, sea-surface readings off South America's west coast range from the 60s to 70s F, while they exceed 80 degrees F in the "warm pool" located in the central and western Pacific. This warm pool expands to cover the tropics during El Niño, but during La Niña, the easterly trade winds strengthen and cold upwelling along the equator and the West coast of South America intensifies. Sea-surface temperatures along the equator can fall as much as 7 degrees F below normal.

El Niño and La Niña result from interaction between the surface of the ocean and the atmosphere in the tropical Pacific. Changes in the ocean impact the atmosphere and climate patterns around the globe. In turn, changes in the atmosphere impact the ocean temperatures and currents. The system oscillates between warm (El Niño) to neutral (or cold La Niña) conditions with an on average every 3-4 years. http://www.elnino.noaa.gov/lanina_new_faq.html, accessed August 12, 2010.

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6. Bromirski and Flick demonstrated that extreme sea-level events in the ocean near San Francisco propagate to the Sacramento/San Joaquin Delta. For this reason, extreme sea-level events (also known as “surge events”) observed at San Francisco are associated with extremes within the Delta. According to these authors, since the 1950s, extreme sea water level events have become more frequent in the ocean close to San Francisco. This upward trend in extreme sea-level events “underscores the potential impact of sea level rise on the Delta levees and Bay/Delta ecosystem, and also suggests an increased risk of saltwater intrusion into coastal aquifers.” In addition, in the historical record, extremes in storm surge and floods due to high runoff levels in California rivers coincide very frequently. During such instances, the risk of levee failure is enhanced. Bromirski and Flick 2008; Bromirski, P.D. and R.E. Flick. 2008. Storm surge in the San Francisco Bay/Delta and nearby coastal locations. Shore & Beach. 76(3): 29-37.

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10. Cayan et. al. 2008, Bromirski and Flick 2008

11. Knowles, N., and D. R. Cayan (2002), Potential effects of global warming on the Sacramento/San Joaquin watershed and the San Francisco estuary, *Geophys. Res. Lett.*, 29(18), 1891, doi:10.1029/2001GL014339.

12. BCDC 2009, Ibid.

13. Bromirski and Flick 2008, Ibid.

14. DWR. 2008. Managing An Uncertain Future - Climate Change Adaptation Strategies for California’s Water.

15. http://www.dfg.ca.gov/delta/suisunmarsh/ accessed June 2011

16. http://www.water.ca.gov/floodmgmt/dsmo/sab/drmsp/ accessed August 2010

17. http://www.iep.ca.gov/suisun/facts/index.html, accessed August 2010

18. As managed wetlands (wetlands behind levees) such as the Suisun Marsh are drained, the organic matter in the soil oxidizes, leading to loss and subsidence. Much of the land behind the levees lies below sea level due to more than a century of subsidence of drained organic soils.

19. http://www.water.ca.gov/levees/history/

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21. PWA and Faber 2004; Philip Williams & Associates, Ltd., and P.M. Faber. 2004. Design Guidelines for Tidal Wetland Restoration in San Francisco Bay. The Bay Institute and California State Coastal Conservancy, Oakland, CA; Heberger et. al, 2009.

22. 2009 BCDC, Ibid. Page 98

23. BCDC 2009, Ibid.

24. 2009, CNRA. CA Climate Adaptation Strategy. Page 52.

25. 2009 BCDC, Ibid. Page 102

26. 2009 BCDC, Ibid.

27. Solano Agencies, 2005 Integrated Regional Water Management Plan (IRWMP), February, page 3-6; http://www.scwa2.com/UWMP_IRWMP.aspx

28. BCDC 2009, Ibid. Page 93

Chapter 3 – Evaluation and Prioritization

1. BCDC 2009, Living with a Rising Bay (page 139)

2. California Employment Development Department

3. Pacific Institute, 2009

4. Trulia Real Estate Search, August 2010

5. LandWatch.com, LandsofCalifornia.com, August 2010

6. LandWatch.com, LandsofCalifornia.com, August 2010

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8. Pacific Institute, 2009

9. 2009 Annual Inspection Report Southern Pacific, Suisun Marsh Site.

10. Site Survey Summary Sheet for the DERP-FUDS Site No. J09CA097600 Travis Air Force Defense Area Nike Battery 53

11. California Employment Development Department, NAICS 71-72

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13. Paraphrased from Pacific Institute, The Impacts of Sea level Rise on the California Cost, 2009.

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15. Bolin and Bolton 1986; Blanchard-Boehm 1997

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17. Trulia Real Estate Search, August 2010

Chapter 4 – Protection and Adaptation

1. 2009 BCDC Living with a Rising Bay (page 139)

2. The Task Force began meeting in Spring 2009 and is co-chaired by the Council on Environmental Quality (CEQ), the National Oceanic and Atmospheric Administration (NOAA), and the Office of Science and Technology Policy (OSTP). - The White House Council on Environmental Quality, Progress Report of the Interagency Climate Change Adaptation Task Force: Recommended Actions in Support of a National Climate Change Strategy, October 5, 2010; Guiding Principles for Adaptation, page 4

3. The White House Council on Environmental Quality, Progress Report of the Interagency Climate Change Adaptation Task Force: Recommended Actions in Support of a National Climate Change Strategy, October 5, 2010; Guiding Principles for Adaptation, page 10; and Summary of Policy Goals and Recommended Actions for the Federal Government

4. BCDC Staff Report and Revised Preliminary Recommendation for Proposed Bay Plan Amendment 1-08 Concerning Climate Change (For Commission consideration on October 7, 2010), September 3, 2010, page 10, (g)

5. A levee, dike, embankment, floodbank or stopbank is a natural or artificial slope or wall to regulate water levels. It is usually earthen and often parallel to the course of a river or the coast. Levees can also be permanent earthworks or emergency constructions (often of sandbags) built hastily in a flood emergency. When such an emergency bank is added on top of an existing levee it is known as a cradge. ^ Henry Petroski (2006). Levees and Other Raised Ground. 94. American Scientist. pp. 7–11.

6. http://en.wikipedia.org/wiki/Levee, accessed January 2011

7. N.W.H. Allsop. (2002). Breakwaters, coastal structures and coastlines.Thomas Telford. ISBN 0727730428. http://en.wikipedia.org/wiki/Seawall, accessed January 2011

8. http://www.flickr.com/photos/62025290@N00/4315564608/, accessed January 2011

9. A levee breach occurs when part of the levee actually breaks away, leaving a large opening for water to flood the land protected by the levee. A breach can be a sudden or gradual failure that is caused either by surface erosion or by a subsurface failure of the levee. Sometimes levees can fail when water overtops the crest of the levee.

10. The levee surface must be protected from erosion on both sides. Erosion from strong waves or currents presents an even greater threat to the integrity of the levee. (The effects of erosion are usually countered by planting with vegetation, weighted matting or concrete revetments. Separate ditches or drainage tiles are constructed to ensure that the foundation does not become waterlogged.)

11. http://www.water.ca.gov/newsroom/photo/levee.cfm, accessed January 2011

12. BCDC 2010, page 22

13. BCDC 2010, page 22

14. http://www.water.ca.gov/newsroom/photo/levee.cfm, accessed January 2011

15. To use floor boards to best effect, consideration needs to be given to the fabric of individual building (walls, services, floors, and so on) and how they respond to the pressure of the floodwater above and seepage below ground level.

16. Shaw, R., Colley, M., and Connell, R. (2007) Climate change adaptation by design: a guide for sustainable communities. TCPA, London

17. http://www.theconstructioncentre.co.uk/images/logos/10796/WaterWall-Flood-Barrier.jpg, accessed January 2011

18. Shaw, R., Colley, M., and Connell, R. (2007) Climate change adaptation by design: a guide for sustainable communities. TCPA, London, page 29

19. http://www.spur.org/publications/library/report/strategiesformanagingsealevelrise_110109

20. http://www.metalithh2o.com/applications.html, accessed January 2011

21. BCDC Staff Report and Revised Preliminary Recommendation for Proposed Bay Plan Amendment 1-08 Concerning Climate Change (For Commission consideration on October 7, 2010), September 3, 2010, page 10, (f)

22. DWR 2008

23. BCDC Staff Report and Revised Preliminary Recommendation for Proposed Bay Plan Amendment 1-08 Concerning Climate Change (For Commission consideration on October 7, 2010), September 3, 2010, page 5

24. BCDC 2010, page 25

25. Design Guidelines for Tidal Wetland Restoration in San Francisco Bay, Bay Institute, December 2004.

26. http://www.spur.org/publications/library/report/strategiesformanagingsealevelrise_110109, accessed January 2011

27. Design and evaluation of the project should further include an analysis of: (a) how the system's adaptive capacity can be enhanced so that it is resilient to SLR and climate change; (b) the effect of the project on the Bay's sediment budget; (c) localized sediment erosion and accretion; (d) the role of tidal flows; (e) potential invasive species introduction, spread, and control; (f) rates of colonization by vegetation; (g) the expected use of the site by fish, other aquatic organisms and wildlife; (h) an appropriate buffer, where feasible, between shoreline development and habitats to protect wildlife and provide space for marsh migration as sea level rises; and (i) site characterization. BCDC Staff Report and Revised Preliminary Recommendation for Proposed Bay Plan Amendment 1-08 Concerning Climate Change (For Commission consideration on October 7, 2010), September 3, 2010, page 7, Policy 6.

28. BCDC 2010, page 23 (f)

29. Atkinson, P. W., S. Crook, A. Grant, and M. M. Rehfisch. 2001. The success of creation and restoration schemes in producing intertidal habitat suitable for waterbirds. English Nature. Hulme, P. E. 2005. Adapting to climate change: is there scope for ecological management in the face of a global threat? Journal of Applied Ecology 42:784-794.

30. BCDC Staff Report and Revised Preliminary Recommendation for Proposed Bay Plan Amendment 1-08 Concerning Climate Change (For Commission consideration on October 7, 2010), September 3, 2010, page 12, (o)

31. BCDC 2010, page 15, (2)

32. BCDC 2010, page 16, (5)

33. BCDC 2010, page 15, (3)

34. BCDC 2010, page 15, (4)

35. BCDC Staff Report and Revised Preliminary Recommendation for Proposed Bay Plan Amendment 1-08 Concerning Climate Change (For Commission consideration on October 7, 2010), September 3, 2010, page 10 (h)

36. Flood prevention is better than flood resilience' according to the philosophy of the innovative Dutch floating house. A new daring development of 46 houses built on a government-designated flood-overflow plane offers a new solution for the UK. Each two story home is built upon a 70 ton watertight-hollow concrete box (acting as the 'hull'), that floats secured laterally by two 5.5m horizontal mooring posts that connect to the neighboring house and six iron posts sunk into the bottom. When the river swells, the house floats as much as 5.5m. Flexible pipes house the building services and utilities, and when the floodwaters subside, the houses return to their original position. Developed by Dura Vermeer builders and designed by Factor Architecten. Prices start at 260,000 euros (£180,000 or $310,000). http://blog.pandhs.co.uk/archives/author/phsguest/page/4 , accessed January 2011

37. BCDC 2010, page 16, (5)

38. BCDC Staff Report and Revised Preliminary Recommendation for Proposed Bay Plan Amendment 1-08 Concerning Climate Change (For Commission consideration on October 7, 2010), September 3, 2010, page 14, (t)

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APPENDIX A

SEA LEVEL RISE PLANNING AREA

Two map series containing close-ups of a 16-inch and 55-inch sea level rise (SLR) scenario, respectively, are provided in this appendix.

Series A (maps A-1 through A-5) illustrate a 16-inch SLR scenario using five “zoom-in” maps prepared at 1:77,000 scale. Map series B (maps B-1 through B-5) illustrate a 55-inch SLR scenario. On each map, the applicable SLR planning area is superimposed on an aerial photograph and important infrastructure and public lands located in the unincorporated county are labeled for easy identification. The maps include two data layers, depicting existing levees (in black) and needed levees and seawalls to protect against SLR (in red), as determined by the Pacific Institute (2009). Required protection structures were estimated as "necessary" based on anticipated flooding extents overlaid on high resolution aerial photographs (NAIP 2009)[i]. For the open coast, seawalls were deemed necessary; for bays and protected waterfronts, levees were deemed adequate. Structures were protected while agriculture was flooded.

Map series A also shows the area required for wetland mitigation under a 55-inch SLR scenario using data from the Pacific Institute. These areas represent additional lands inundated due to Mean Higher High Water (MHHW) in the year 2100 that is not inundated in the year 2000. This data was created to estimate wetland migration potential as the area inundated due to MHHW changes along the California coast.

This information is being made available for informational purposes only. Users of this information agree by their use to hold blameless the State of California, and its respective officers, employees, agents, contractors, and subcontractors for any liability associated with its use in any form. This work shall not be used to assess actual coastal hazards, insurance requirements, or property values and specifically shall not be used in lieu of Flood Insurance Studies and Flood Insurance Rate Maps issued by the Federal Emergency Management Agency (FEMA).

DATA USED TO CREATE THE MAPS

The following datasets were used to create the maps:

- Geographic data created or modified by Pacific Institute researchers describing potential SLR effects on the California coast. This data covers the California coast with the exception of San Francisco Bay, which is covered in USGS/Scripps

Geographic Information System (GIS) layers.[ii] Pacific Institute data used in this report include the following:

- Areas inundated by unimpeded Pacific coastal flooding under a 55-inch SLR scenario
- Pacific coast bluff erosion hazard zones (high scenario)
- Pacific coast dune erosion hazard zones (high scenario)
- Coastal wetlands (a filtered subset of wetlands from the National Wetlands Inventory that lie below or within 100 meters of the MHHW line)
- Raster surface of MHHW elevations for California's Pacific coast under a 55-inch SLR scenario
- Area inundated by MHHW under a 55-inch SLR scenario
- Area required for wetland migration under a 55-inch SLR scenario
- Land cover in area required for wetland migration under a 55-inch SLR scenario
- Existing levees and other coastal defenses in San Francisco Bay, compiled from numerous sources
- Required levees and seawalls to protect against SLR in San Francisco Bay
- Wastewater treatment plants in California coastal counties
- Footprints of wastewater treatment plants in the San Francisco Bay area
- Wastewater treatment plants vulnerable to coastal flooding under baseline conditions and a 55-inch SLR scenario
- EPA-listed facilities vulnerable to coastal flooding following a 55-inch SLR (Superfund sites. hazardous waste generators, facilities required to report emissions for the Toxics Release Inventory, facilities regulated under the National Pollutant Discharge Elimination System [NPDES], major dischargers of air pollutants with Title V permits, and brownfield properties)
- Schools (extracted from FEMA HAZUS)
- Schools vulnerable to coastal flooding under baseline conditions
- Schools vulnerable to coastal flooding under baseline conditions and a 55-inch SLR scenario
- Fire stations and training facilities (extracted from HAZUS)
- Fire stations and training facilities vulnerable to coastal flooding under baseline conditions
- Fire stations and training facilities vulnerable to coastal flooding under a 55-inch SLR scenario
- Police stations (extracted from HAZUS)
- Police stations vulnerable to coastal flooding under baseline conditions
- Police stations vulnerable to coastal flooding under baseline conditions and a 55-inch SLR scenario
- Health care facilities vulnerable to coastal flooding under baseline conditions
- Health care facilities vulnerable to coastal flooding under a 55-inch SLR scenario
- Replacement cost for buildings and contents by census block, estimated by the FEMA HAZUS model
- Census blocks, percent vulnerable to unimpeded coastal flooding under baseline conditions and with a 55-inch SLR

- Aerial Imagery from NAIP (2009)[iii]
- USGS NED 10-meter Elevation Dataset
- Cal Atlas[iv]

Methods Used to Create 16-Inch and 55-Inch Scenarios

The following section describes methods used to perform the analysis and mapping necessary to identify areas vulnerable to projected SLR, as excerpted from the 2009 Bay Conservation and Development Commission (BCDC) report.[v] These methods underlie creation of the GIS layers used by the AECOM team.

A United States Geological Survey (USGS) team led by Noah Knowles built a hydrodynamic model to identify areas at risk of inundation under a variety of SLR scenarios. To identify areas vulnerable to each scenario, the best available elevation data was assembled into a regional grid, historic (1996-2007) tidal data was integrated and overlayed with estimated increases in sea level of 16 inches and 55 inches respectively. A regional digital elevation data set was assembled for portions of Solano County and Napa County from numerous sources, including LiDAR (Light Detection and Ranging). Additional photogrammetry and satellite-based data were assembled to create the regional data set. The data has a horizontal resolution of 2 meters and nearly all areas have a vertical accuracy of between 10 and 30 centimeters.

To integrate the elevation of the water within the estuary, a hydrodynamic system model was created using hourly data collected between 1996 and 2007 at the Golden Gate. This historic data captures the temporal range in tides, as well as storm surges. The model then propagates fluctuations throughout the Bay and towards the Delta as far east as Mallard Island. The model was verified using tide gage data from various locations throughout the Bay. Based on the historic data, MMHW was mapped for the Bay at 200-meter resolution. Finally, the water surface height within the model was modified by 40 centimeters and 140 centimeters to integrate Ramstorf's [2007] projections. Further verification was performed by comparing water height fields for present day and projected conditions to land elevations.[vi]

Development of Methodology for Additional Areas

BCDC SLR data reaches only as far as the eastern border of Suisun Marsh, presenting a need to extend the dataset to the eastern boundary of unincorporated Solano County along the Sacramento River. AECOM's GIS team used USGS National Elevation Dataset (NED) 10-meter elevation datavii to depict SLR of 16 inches and 55 inches in the eastern portion of Solano County, supplementing BCDC's USGS-based data.

Analysis Limitations

The following limitations to these methods were identified by Herberger et.al. from the Pacific Institute in 2009.

All models are subject to errors and inaccuracies. The location of the shoreline is inexact and probably subjective. Knowles used a "mask" of open water as a filter to report only land areas that are flooded. However, the shoreline is constantly in flux and difficult to map precisely. Further, there are errors and inaccuracies in the terrain data. The digital terrain model creates a smoothed or average surface from raw elevation data. It does not accurately depict breaks in elevation that occur at a vertical wall such as a cliff or a curb. Another limitation is that the automatic, computerized method classifies flooding only by depth. An algorithm using only depth to determine flooding does not factor in the presence of a flow pathway. In some cases, high ground may be a levee specifically designed to protect adjacent low-lying areas. In other locations, there are depressions, but they are not really at risk because there is no path for seawater to flow into them. Thus, low-lying objects or features such as ditches, stormwater detention basins, subway tunnels, and empty swimming pools are filled in inappropriately at times.[viii]

Thus, this work shall not be used to assess actual coastal hazards, insurance requirements, or property values and specifically shall not be used in lieu of Flood Insurance Studies and Flood Insurance Rate Maps issued by the Federal Emergency Management Agency (FEMA).

Appendix References

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[i] http://atlas.ca.gov/download.html#/casil/imageryBaseMapsLandCover/imagery/naip/naip_2009 accessed July 2010

[ii] Heberger, Matthew, Cooley, Heather, Gleick, Peter, and Herrera, Pablo, 2009, The Impacts of Sea-Level Rise on the California Coast: Pacific Institute, Oakland CA. http://www.pacinst.org/reports/sea_level_rise/ accessed July 2010

[iii] http://atlas.ca.gov/download.html#/casil/imageryBaseMapsLandCover/imagery/naip/naip_2009 accessed July 2010

[iv] http://www.atlas.ca.gov/, layers retrieved in 2007 and 2010

[v] 2009 San Francisco Bay Conservation and Development Commission, Draft Staff Report Living with a Rising Bay: Vulnerability and Adaptation in San Francisco Bay and on its Shoreline April 7, 2009; Appendix A

[vi] BCDC 2009, Ibid. Appendix A; Knowles, N. 2008. Inundation data provided by Dr. Noah Knowles, U.S. Geological Survey, with funding from the California Energy Commission's Public Interest Energy Research (PIER) Program through the California Climate Change Center at Scripps Institution of Oceanography, and from the CALFED Science Program CASCaDE Project. http://www.bcdc.ca.gov/proposed_bay_plan/bp_1-08_cc_draft.pdf

[vii] http://ned.usgs.gov/, accessed July 2010

[viii] Heberger et al. 2009.

Zoom-in of Potential Sea Levels in Solano County

Map A-1

- Commuter Rail Station
- Ferry Terminal
- Airport
- Levees
- Needed Levees and Seawalls to Protect Against Sea Level Rise
- Area Required for Wetland Migration Under 55"

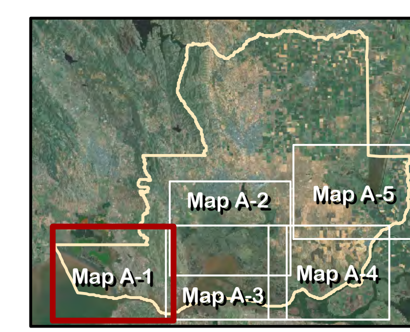
Potential Sea Level Rise

- 16 Inches
- Incorporated City Limits

- Note: Inundation data does not account for existing levees or other shoreline protection.

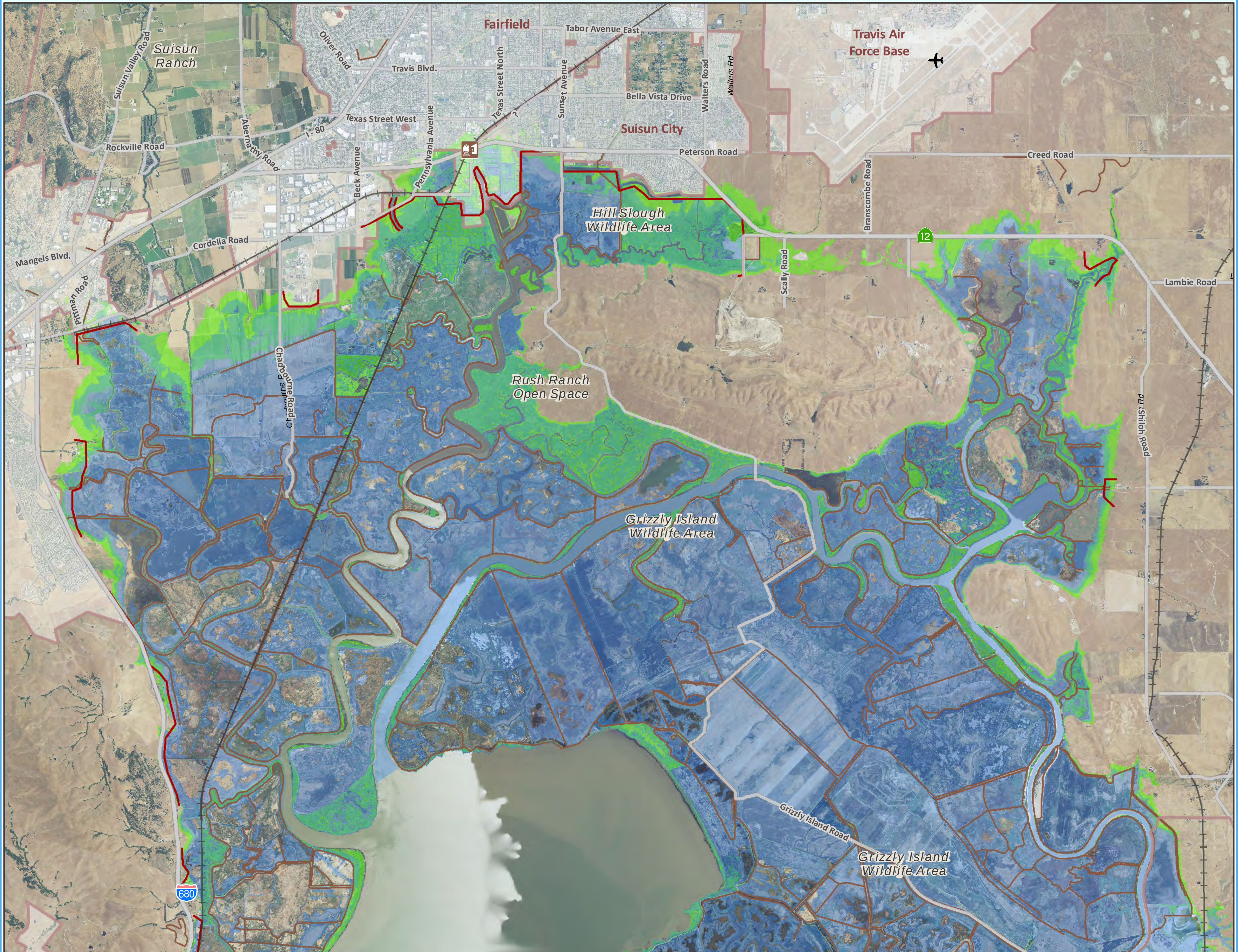
USGS NED 10 meter elevation data was used to depict 16 and 55 inch sea levels in the eastern portion of Solano County; and at 20 feet for the entire County.

DRAFT



0 1 2 3
Miles

8/18/2010
Source: Aerial image; NAIP, 2009
BCDC, Pacific Institute, Solano County, AECOM



Zoom-in of Potential Sea Levels

in Solano County

Map A-2

Commuter Rail Station

Ferry Terminal

Airport

Levees

Needed Levees and Seawalls to Protect Against Sea Level Rise

Area Required for Wetland Migration Under 55"

Potential Sea Level Rise

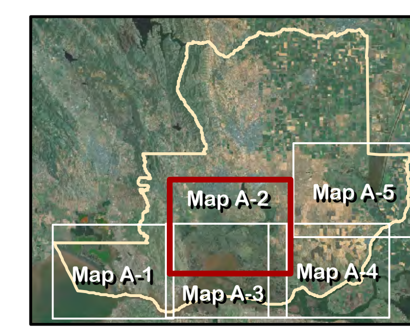
16 Inches

Incorporated City Limits

- Note: Inundation data does not account for existing levees or other shoreline protection.

USGS NED 10 meter elevation data was used to depict 16 and 55 inch sea levels in the eastern portion of Solano County; and at 20 feet for the entire County.

DRAFT



N

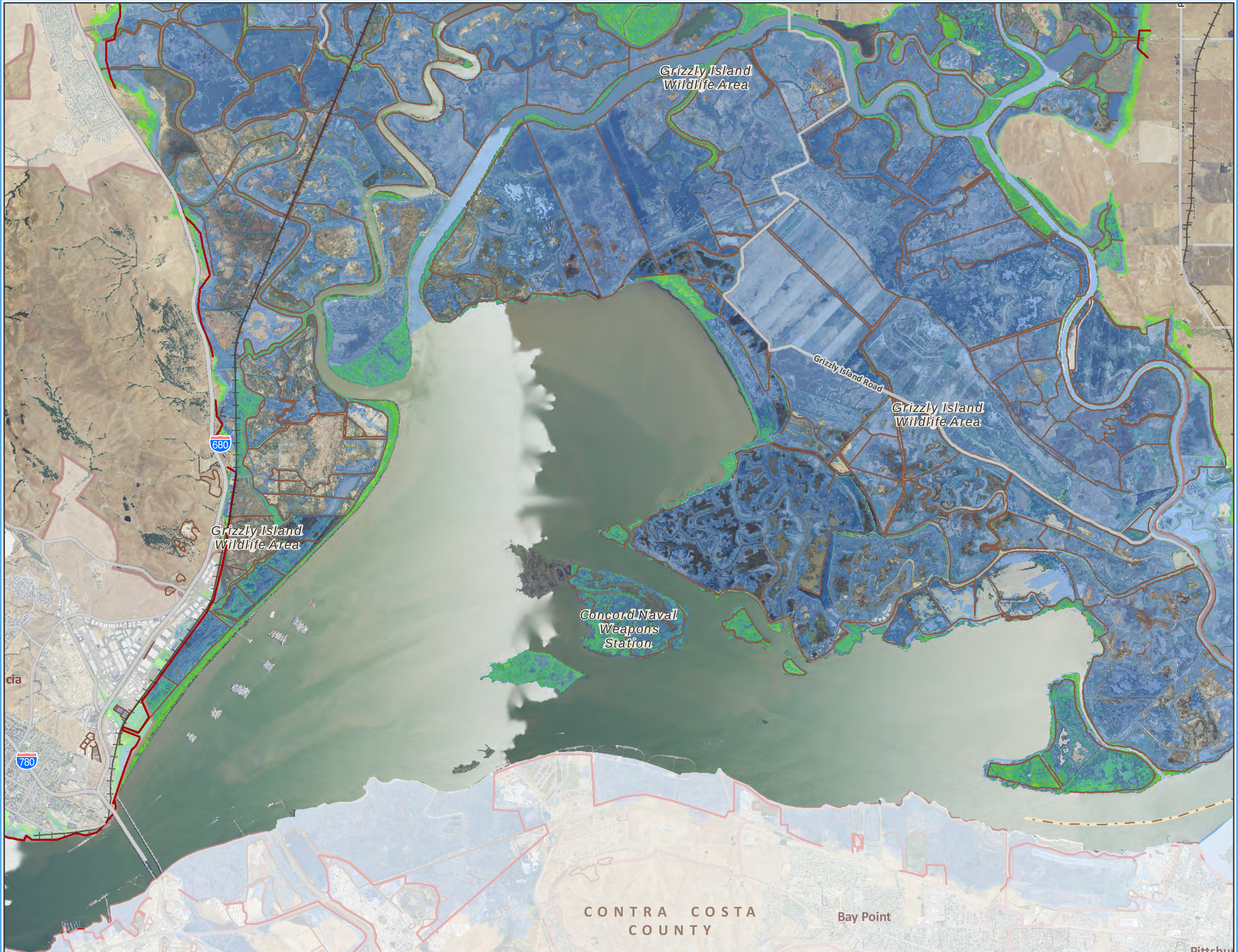
0 1 2 3

Miles

8/18/2010

Source: Aerial image; NAIP, 2009

BCDC, Pacific Institute, Solano County, AECOM



Zoom-in of Potential Sea Levels

in Solano County

Map A-3

Commuter Rail Station

Ferry Terminal

Airport

Levees

Needed Levees and Seawalls to Protect Against Sea Level Rise

Area Required for Wetland Migration Under 55"

Potential Sea Level Rise

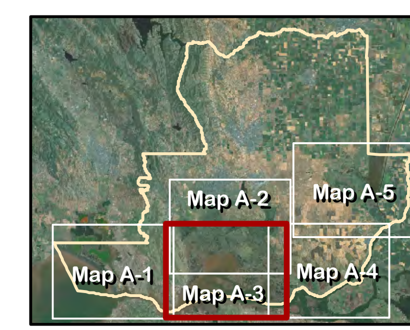
16 Inches

Incorporated City Limits

- Note: Inundation data does not account for existing levees or other shoreline protection.

USGS NED 10 meter elevation data was used to depict 16 and 55 inch sea levels in the eastern portion of Solano County; and at 20 feet for the entire County.

DRAFT



N

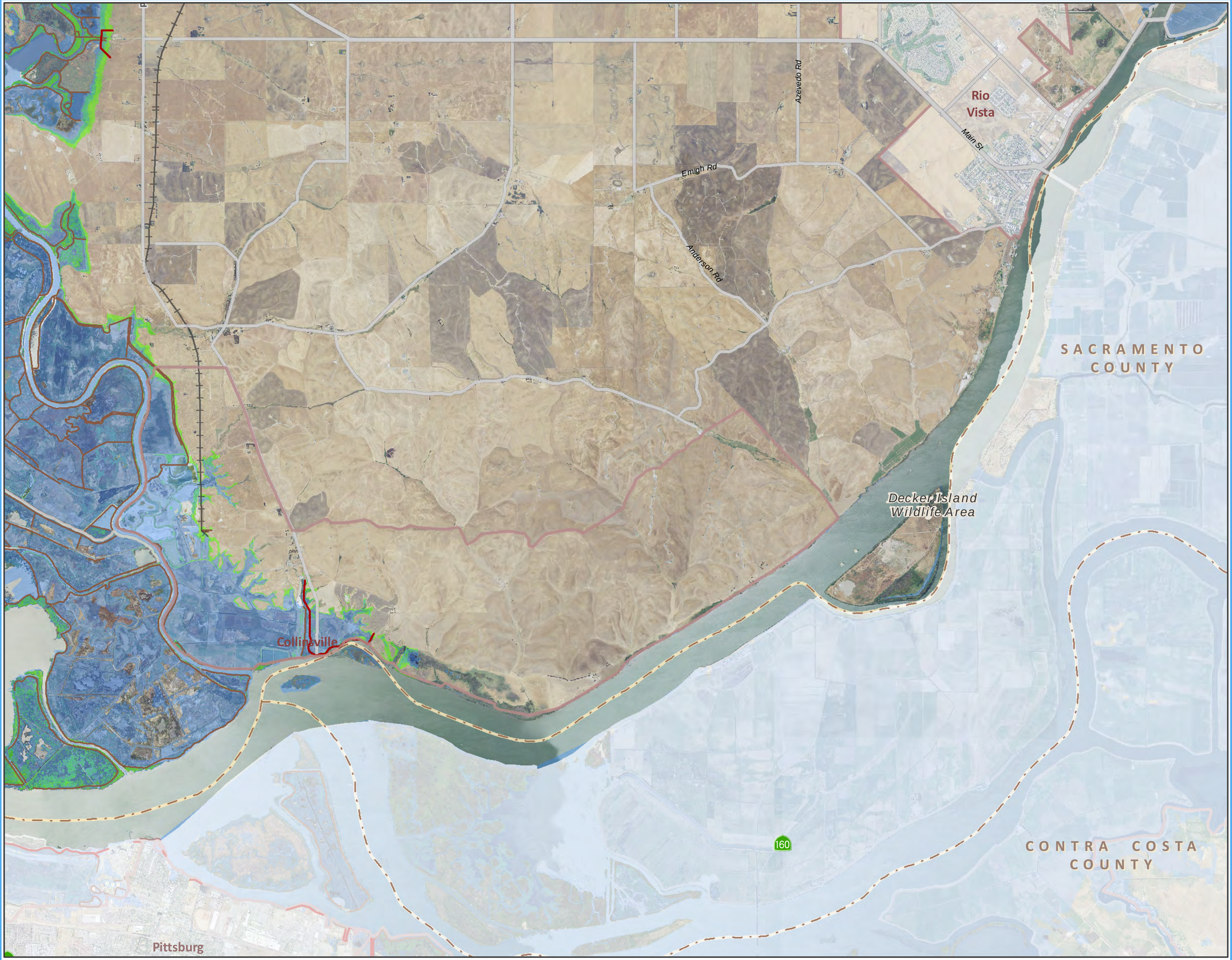
0 1 2 3

Miles

8/18/2010

Source: Aerial image; NAIP, 2009

BCDC, Pacific Institute, Solano County, AECOM



Zoom-in of Potential Sea Levels

in Solano County

Map A-4

Commuter Rail Station

Ferry Terminal

Airport

Levees

Needed Levees and Seawalls to Protect Against Sea Level Rise

Area Required for Wetland Migration Under 55"

Potential Sea Level Rise

16 Inches

Incorporated City Limits

- Note: Inundation data does not account for existing levees or other shoreline protection.

USGS NED 10 meter elevation data was used to depict 16 and 55 inch sea levels in the eastern portion of Solano County; and at 20 feet for the entire County.

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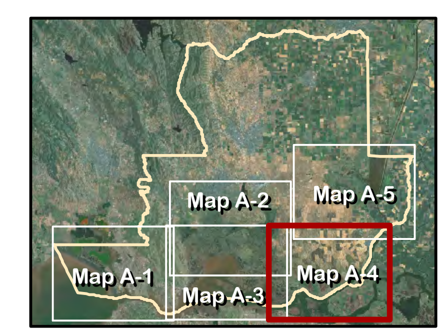


N

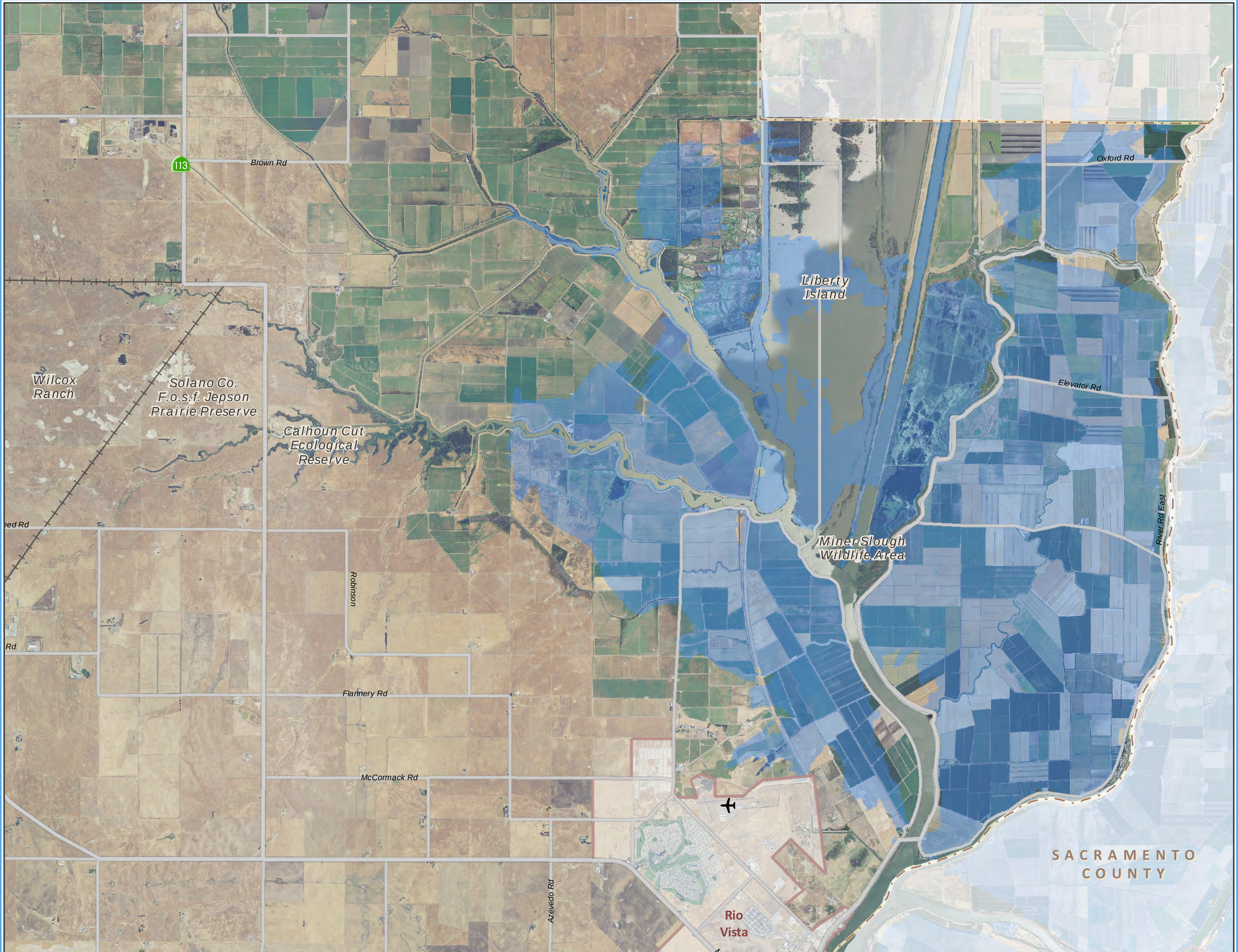
0 1 2 3

Miles

8/18/2010

Source: Aerial image; NAIP, 2009

BCDC, Pacific Institute, Solano County, AECOM



Zoom-in of Potential Sea Levels in Solano County

Map A-5

Commuter Rail Station

Ferry Terminal

Airport

Levees

Needed Levees and Seawalls to Protect Against Sea Level Rise

Area Required for Wetland Migration Under 55"

Potential Sea Level Rise

16 Inches

Incorporated City Limits

- Note: Inundation data does not account for existing levees or other shoreline protection.

USGS NED 10 meter elevation data was used to depict 16 and 55 inch sea levels in the eastern portion of Solano County; and at 20 feet for the entire County.

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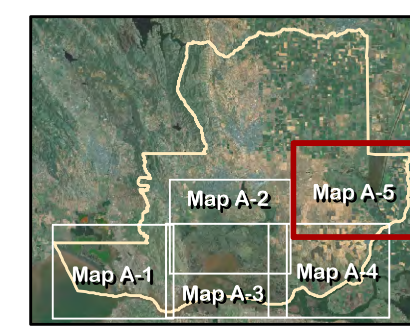


N

0 1 2 3

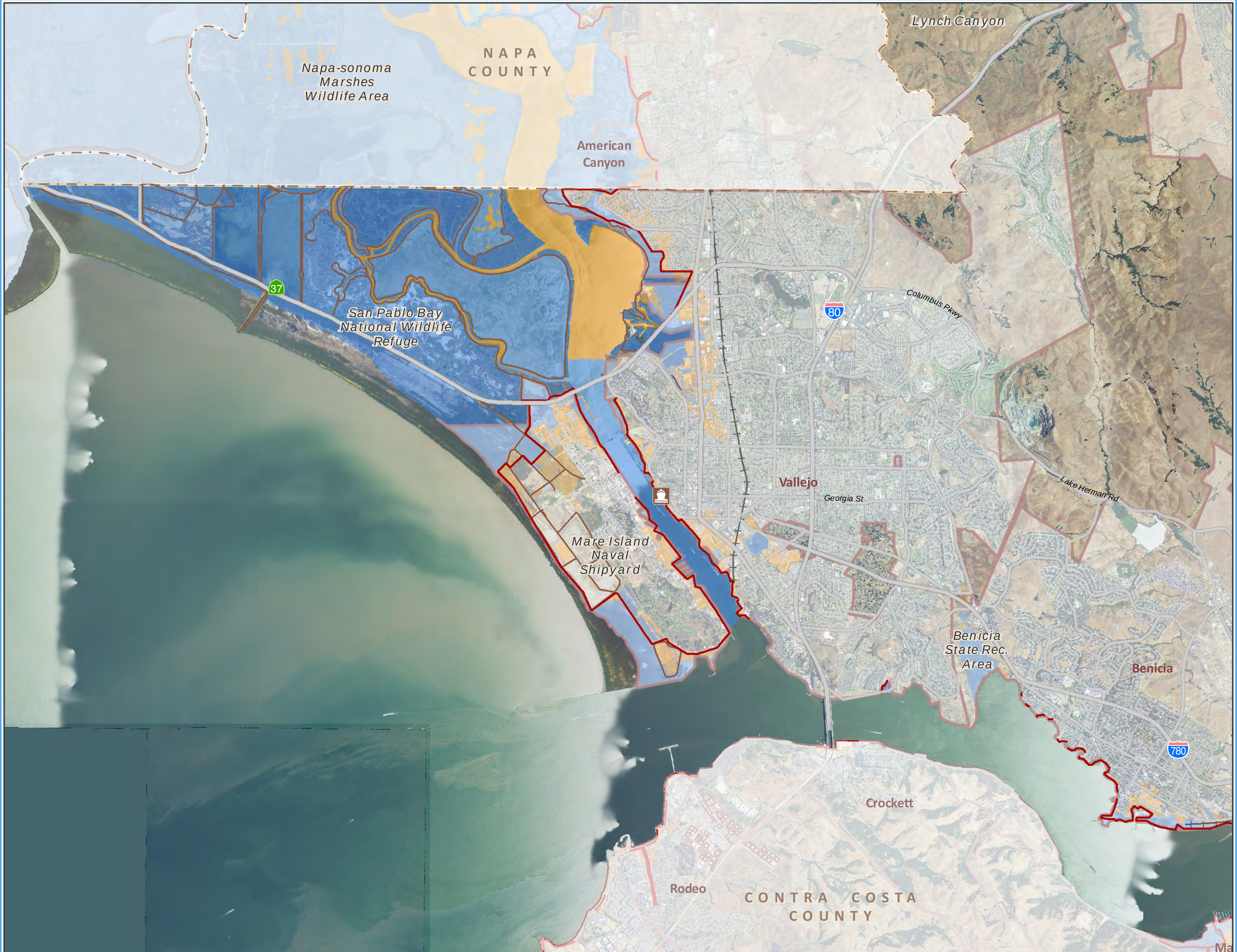
Miles

8/18/2010

Source: Aerial image; NAIP, 2009

BCDC, Pacific Institute, Solano County, AECOM

Zoom-in of Potential Sea Levels in Solano County



Map B-1

Commuter Rail Station

Ferry Terminal

Airport

Levees

Needed Levees and Seawalls to Protect Against Sea Level Rise

Potential Sea Level Rise

16 Inches

55 Inches

Incorporated City Limits

- Note: Inundation data does not account for existing levees or other shoreline protection.

USGS NED 10 meter elevation data was used to depict 16 and 55 inch sea levels in the eastern portion of Solano County; and at 20 feet for the entire County.

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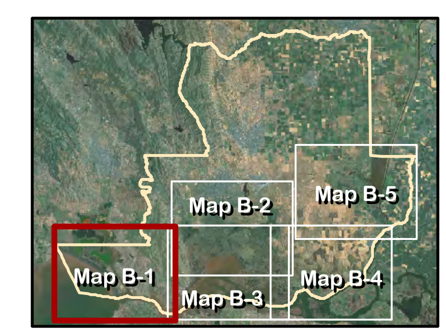


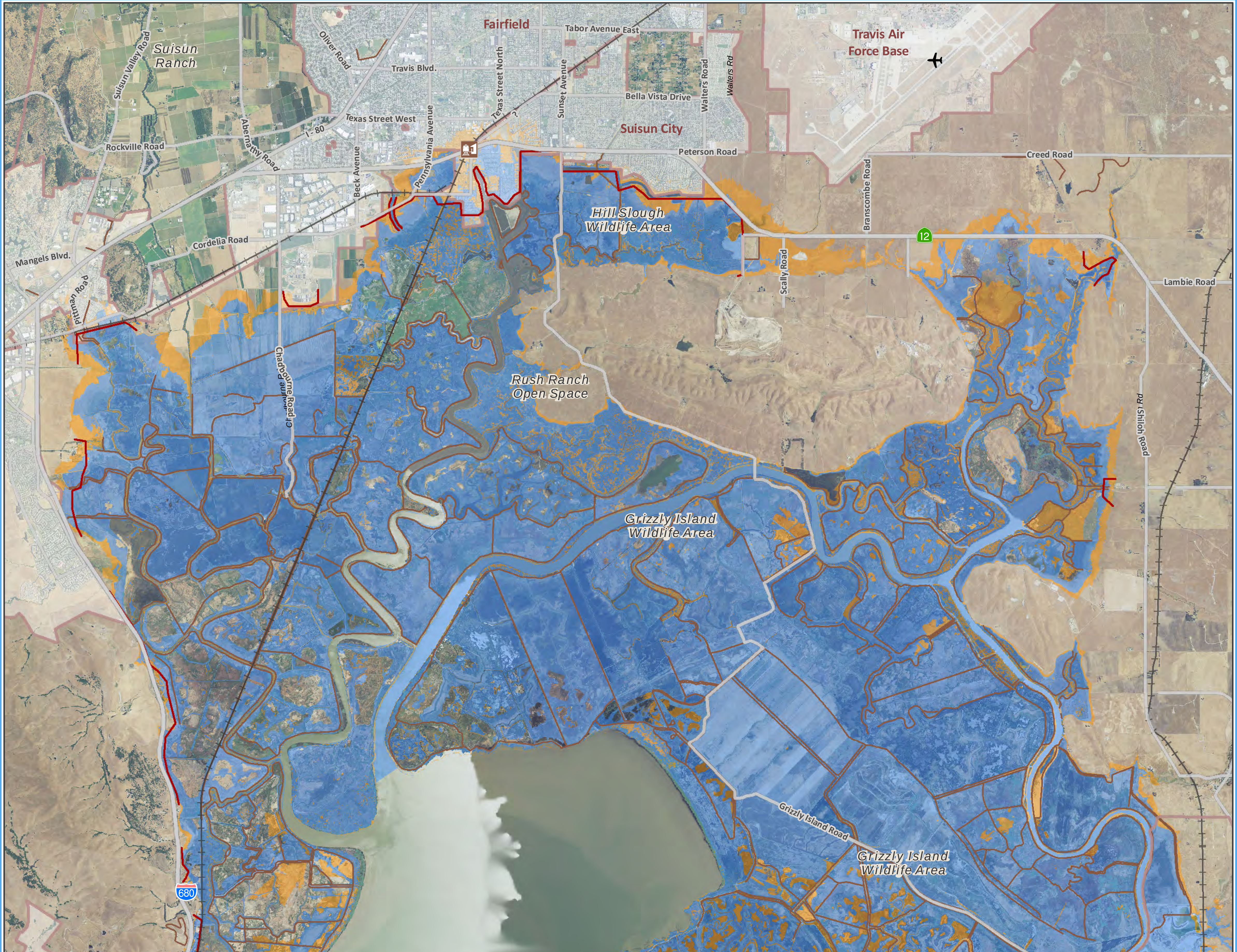
0 1 2 3

Miles

8/18/2010

Source: Aerial image; NAIP, 2009

BCDC, Pacific Institute, Solano County, AECOM



Zoom-in of Potential Sea Levels
in Solano County

Map B-2

Commuter Rail Station

Ferry Terminal

Airport

Levees

Needed Levees and Seawalls to Protect Against Sea Level Rise

Potential Sea Level Rise

16 Inches

55 Inches

Incorporated City Limits

- Note: Inundation data does not account for existing levees or other shoreline protection.

USGS NED 10 meter elevation data was used to depict 16 and 55 inch sea levels in the eastern portion of Solano County; and at 20 feet for the entire County.

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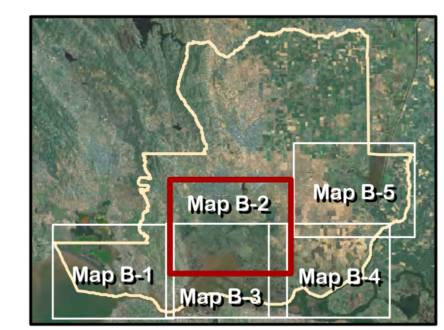

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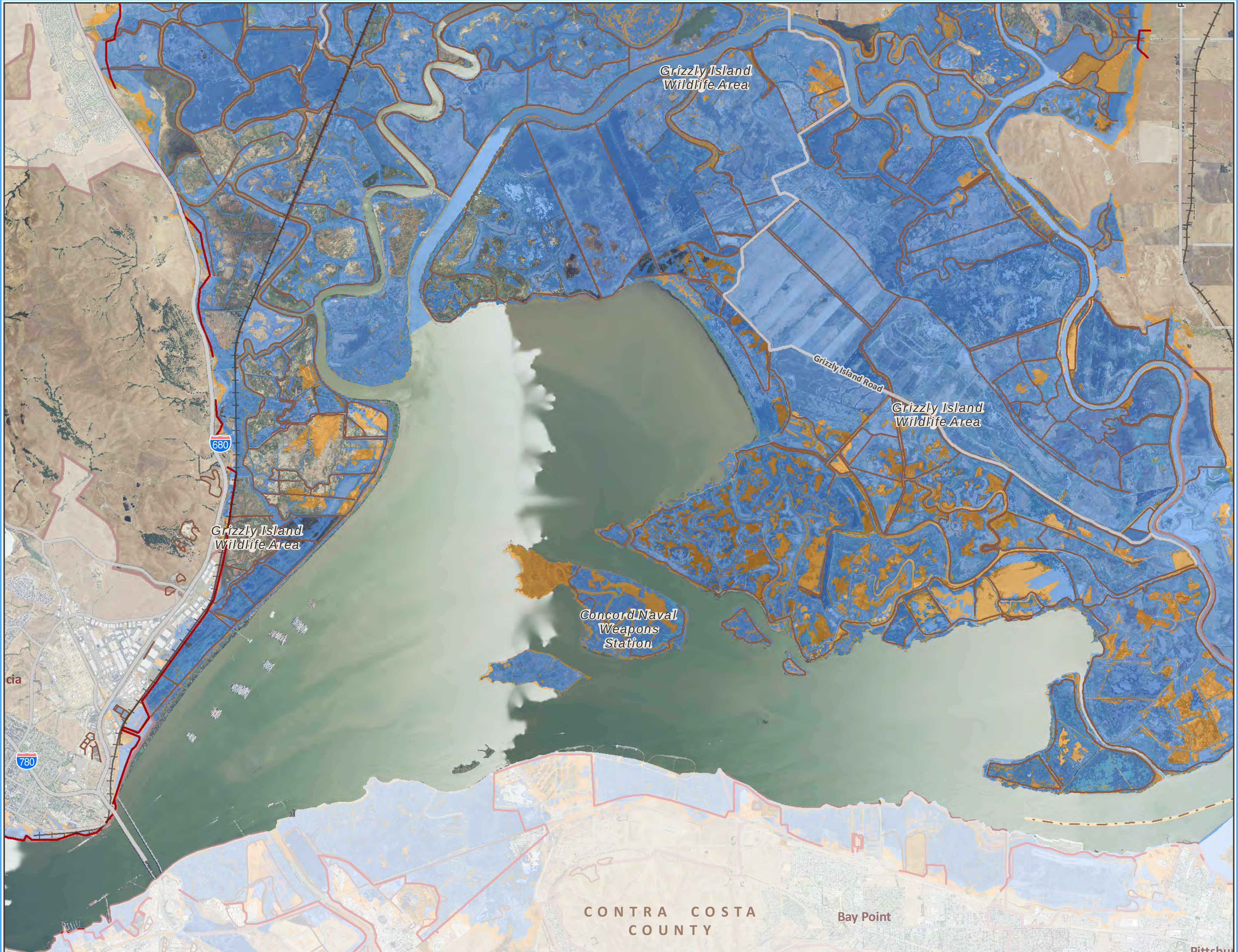
Miles

8/18/2010

Source: Aerial image; NAIP, 2009

BCDC, Pacific Institute, Solano County, AECOM

Solano County Sea Level Rise Strategic Program



Zoom-in of Potential Sea Levels
in Solano County

Map B-3

- Commuter Rail Station
- Ferry Terminal
- Airport
- Levees
- Needed Levees and Seawalls to Protect Against Sea Level Rise

Potential Sea Level Rise

- 16 Inches
- 55 Inches
- Incorporated City Limits

• Note: Inundation data does not account for existing levees or other shoreline protection.
USGS NED 10 meter elevation data was used to depict 16 and 55 inch sea levels in the eastern portion of Solano County; and at 20 feet for the entire County.

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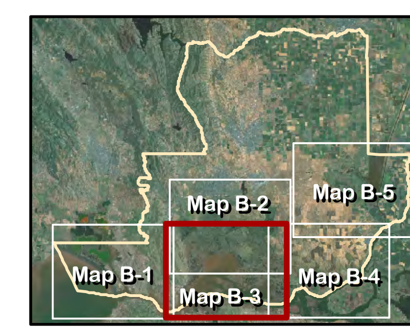

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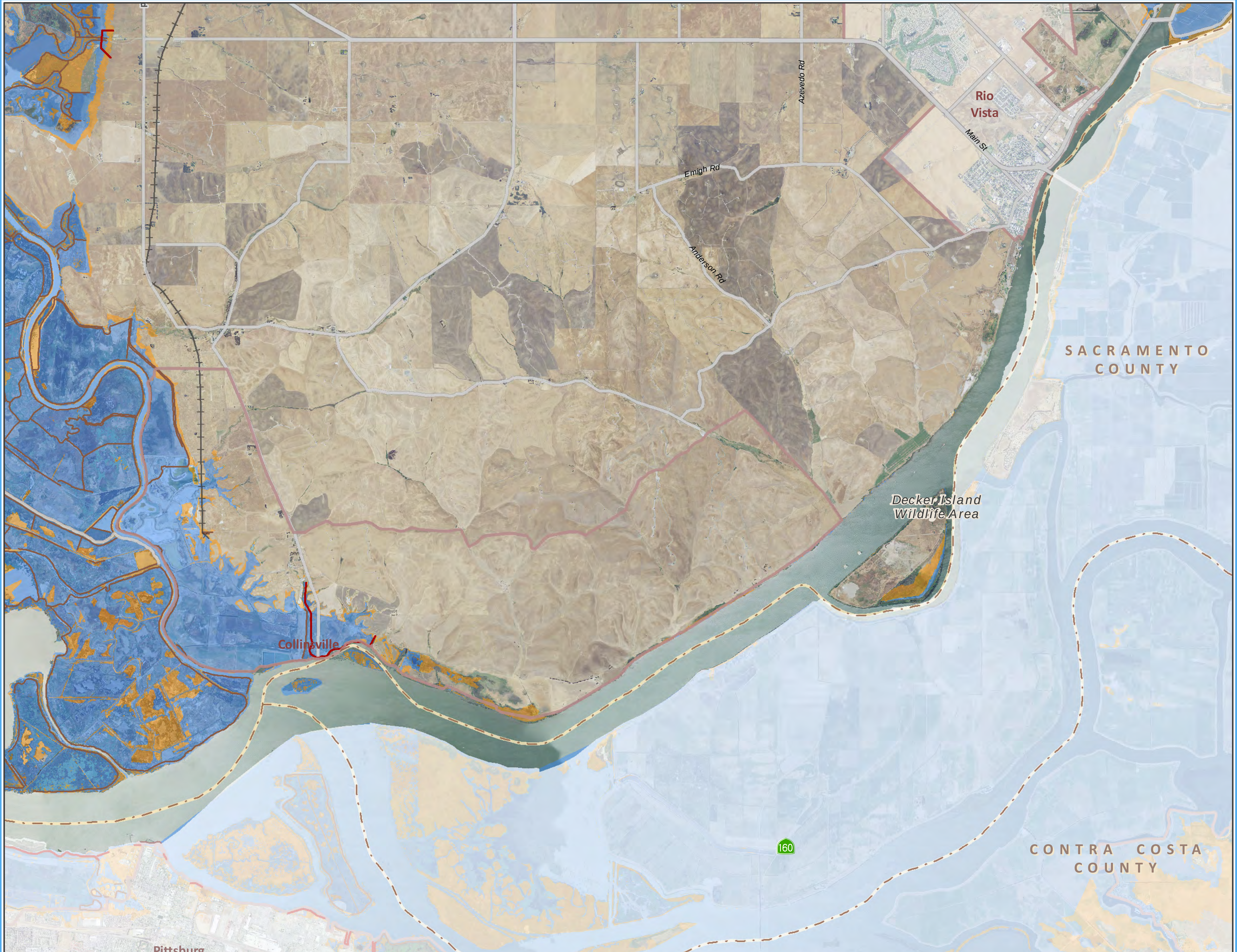
8/18/2010
Source: Aerial image; NAIP, 2009
BCDC, Pacific Institute, Solano County, AECOM



Zoom-in of Potential Sea Levels in Solano County

Map B-4

- Commuter Rail Station
- Ferry Terminal
- Airport
- Levees
- Needed Levees and Seawalls to Protect Against Sea Level Rise

Potential Sea Level Rise

- 16 Inches
- 55 Inches
- Incorporated City Limits

• Note: Inundation data does not account for existing levees or other shoreline protection.
USGS NED 10 meter elevation data was used to depict 16 and 55 inch sea levels in the eastern portion of Solano County; and at 20 feet for the entire County.

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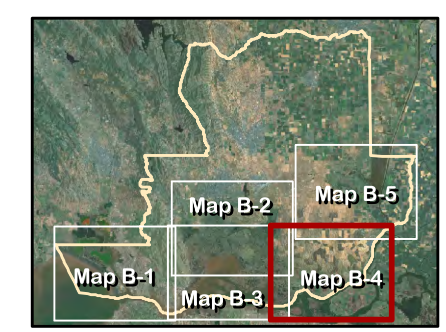
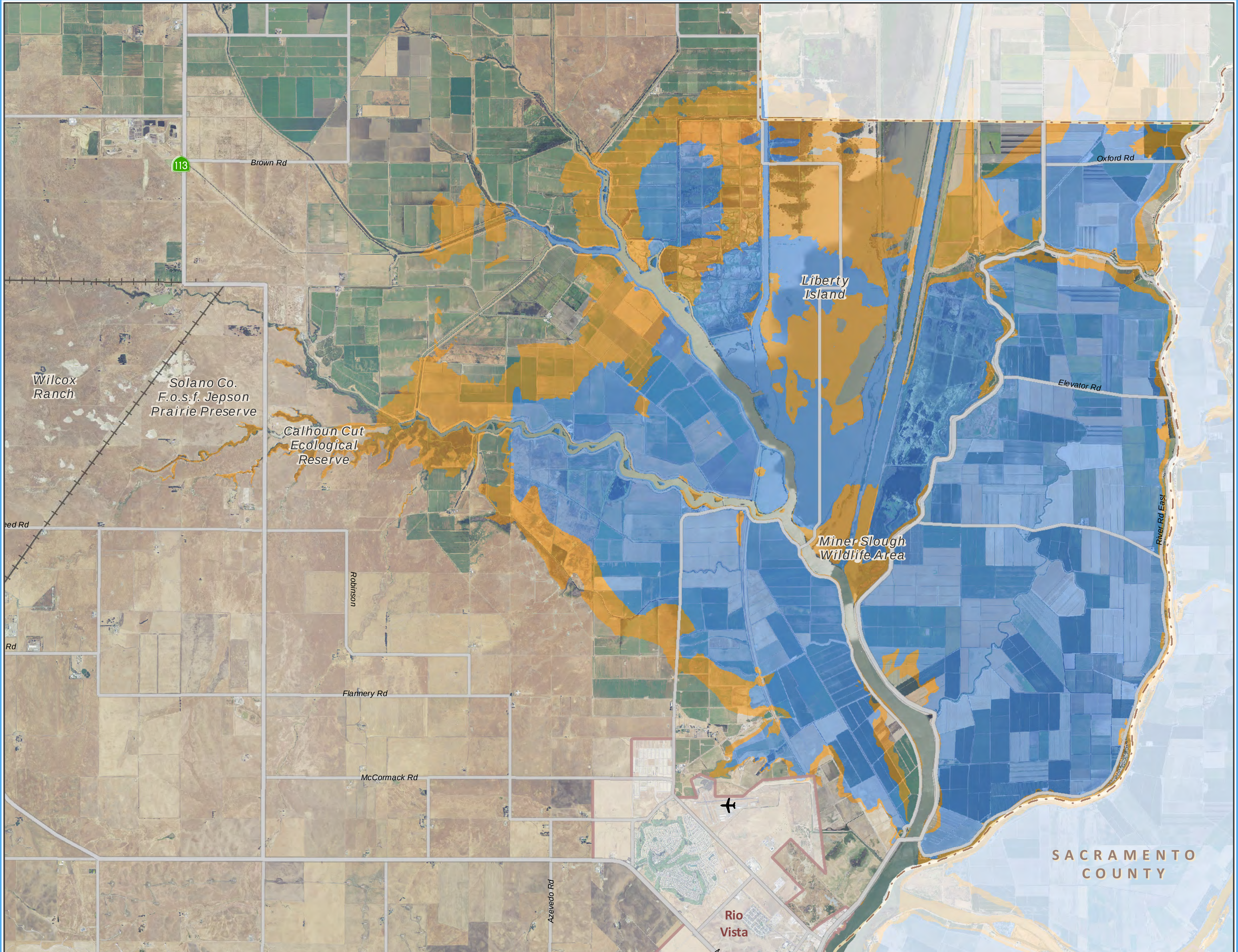


8/18/2010
Source: Aerial image; NAIP, 2009
BCDC, Pacific Institute, Solano County, AECOM

Solano County Sea Level Rise Strategic Program



Zoom-in of Potential Sea Levels
in Solano County

Map B-5

- Commuter Rail Station
- Ferry Terminal
- Airport
- Levees
- Needed Levees and Seawalls to Protect Against Sea Level Rise

Potential Sea Level Rise

- 16 Inches
- 55 Inches
- Incorporated City Limits

• Note: Inundation data does not account for existing levees or other shoreline protection.
USGS NED 10 meter elevation data was used to depict 16 and 55 inch sea levels in the eastern portion of Solano County; and at 20 feet for the entire County.

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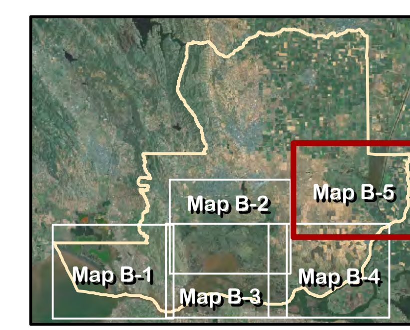

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Miles

8/18/2010
Source: Aerial image; NAIP, 2009
BCDC, Pacific Institute, Solano County, AECOM

APPENDIX B

EXECUTIVE ORDER S-13-08

Office of the Governor

ARNOLD SCHWARZENEGGER
THE PEOPLE'S GOVERNOR

PRESS RELEASE

11/14/2008 GAAS:779:08 FOR IMMEDIATE RELEASE

Gov. Schwarzenegger Issues Executive Order Directing State Agencies to Plan for Sea Level Rise and Climate Impacts

Given the serious threat of sea level rise to California's water supply and coastal resources and the impact it would have on our state's economy, population and natural resources, Governor Arnold Schwarzenegger today issued an Executive Order (EO) S-13-08 to enhance the state's management of climate impacts from sea level rise, increased temperatures, shifting precipitation and extreme weather events.

"We have to adapt the way we work and plan in order to manage the impacts and challenges that California and our entire planet face from climate change," Governor Schwarzenegger said. "Given the serious threat of sea level rise to California's water supply, population and our economy, it's critically important that we make sure the state is prepared when heavy rains cause flooding and the potential for sea level rise increases in future years."

There are four key actions in the EO including: (1) initiate California's first statewide climate change adaptation strategy that will assess the state's expected climate change impacts, identify where California is most vulnerable and recommend climate adaptation policies by early 2009; (2) request the National Academy of Science establish an expert panel to report on sea level rise impacts in California to inform state planning and development efforts; (3) issue interim guidance to state agencies for how to plan for sea level rise in designated coastal and floodplain areas for new projects; and (4) initiate a report on critical existing and planned infrastructure projects vulnerable to sea level rise.

One key benefit that the EO will facilitate is California's first comprehensive climate adaptation strategy. This effort will improve coordination within state government and adapt the way work so that better planning can more effectively address climate impacts to human health, the environment, the state's water supply and the economy.

Another benefit from the EO includes providing consistency and clarity to state agencies on how to address sea level rise in current planning efforts, reducing time and resources unnecessarily spent on developing different policies using different scientific information.

The EO and its actions carry on the Governor's environmental leadership by continuing to address climate change adaptation in coordination with our climate change mitigation policies as outlined in AB 32. The states of Washington and Oregon, as well as Canada and Mexico, along with several global institutions have expressed interest in coordinating our climate change adaptation policies as outlined in this EO.

California's Energy Commission, the California Ocean Protection Council and Caltrans are conducting numerous scientific studies on the impact of climate change, including new sea level rise impact projections that are being used to develop the state's climate change adaptation strategy.

Full text of executive order:

EXECUTIVE ORDER S-13-08
by the Governor of the State of California

WHEREAS climate change in California during the next century is expected to shift precipitation patterns, accelerate sea level rise and increase temperatures, thereby posing a serious threat to California's economy, to the health and welfare of its population and to its natural resources; and

WHEREAS California is a leader in mitigating and reducing its greenhouse gas emissions with the 2006 Global Warming Solutions Act (Assembly Bill 32), the Low Carbon Fuel Standard (Executive Order S-01-07), the 2008 Senate Bill 375 and the Renewable Portfolio Standard; and

WHEREAS these efforts, coupled with others around the world, will slow, but not stop all long-term climate impacts to California; and

WHEREAS California must begin now to adapt and build our resiliency to coming climate changes through a thoughtful and sensible approach with local, regional, state and federal government using the best available science; and

WHEREAS there is a need for statewide consistency in planning for sea level rise; and

WHEREAS California's water supply and coastal resources, including valuable natural habitat areas, are particularly vulnerable to sea level rise over the next century and could suffer devastating consequences if adaptive measures are not taken; and

WHEREAS the country's longest continuously operating gauge of sea level, at Fort Point in San Francisco Bay, recorded a seven-inch rise in sea level over the 20th century thereby demonstrating the vulnerability of infrastructure and resources within the Bay; and

WHEREAS global sea level rise for the next century is projected to rise faster than historical levels with the Intergovernmental Panel on Climate Change predicting that global sea levels will rise by between seven to 23 inches this century and some experts predicting even higher rises; and

WHEREAS while climate models predicting global sea level rise are generally understood and improving, less information is available for sea level rise projections specific to California that accounts for California's topography, coastal erosion rates, varying land subsidence levels and tidal variations; and

WHEREAS billions of dollars in state funding for infrastructure and resource management projects are currently being encumbered in areas that are potentially vulnerable to future sea level rise; and

WHEREAS safety, maintenance and operational efforts on existing infrastructure projects are critical to public safety and the economy of the state; and

WHEREAS the longer that California delays planning and adapting to sea level rise the more expensive and difficult adaptation will be; and

WHEREAS the California Resources Agency is a member of the California Climate Action Team and is leading efforts to develop and implement policy solutions related to climate change adaptation regarding current and projected effects of climate change; and

WHEREAS the Department of Water Resources (DWR) is responsible for managing the state's water resources to benefit the people of California, and to protect, restore and enhance the natural and human environments; and

WHEREAS California's coastal management agencies such as the California Coastal Commission, the California Ocean Protection Council (OPC) and California State Parks are charged with managing and protecting the ocean and coastal resources of the state; and

WHEREAS the California Energy Commission's (CEC) Public Interest Energy Research Program has funded research on climate change since 2001 including funding the development of preliminary sea level rise projections for the San Francisco Bay area by the Scripps Institution of Oceanography/University of California at San Diego.

NOW, THEREFORE, I, ARNOLD SCHWARZENEGGER, Governor of the State of California, by virtue of the power vested in me by the Constitution and statutes of the State of California, do hereby order effective immediately:

1. The California Resources Agency, in cooperation with DWR, CEC, California's coastal management agencies, and the OPC, shall request that the National Academy of Sciences (NAS) convene an independent panel to complete the first California Sea Level Rise Assessment Report and initiate, within 60 days after the signing of this Order, an independent sea level rise science and policy committee made up of state, national and international experts.

workshop to gather policy-relevant information specific to California for use in preparing the Sea Level Rise Assessment Report and to raise state awareness of sea level rise impacts.

3. The California Resources Agency shall request that the final Sea Level Rise Assessment Report be completed as soon as possible but no later than December 1, 2010. The final Sea Level Rise Assessment Report will advise how California should plan for future sea level rise. The report should include: (1) relative sea level rise projections specific to California, taking into account issues such as coastal erosion rates, tidal impacts, El Niño and La Niña events, storm surge and land subsidence rates; (2) the range of uncertainty in selected sea level rise projections; (3) a synthesis of existing information on projected sea level rise impacts to state infrastructure (such as roads, public facilities and beaches), natural areas, and coastal and marine ecosystems; and (4) a discussion of future research needs regarding sea level rise for California.

4. The OPC shall work with DWR, the CEC, California's coastal management agencies and the State Water Resources Control Board to conduct a review of the NAS assessment every two years or as necessary.

5. I direct that, prior to release of the final Sea Level Rise Assessment Report from the NAS, all state agencies within my administration that are planning construction projects in areas vulnerable to future sea level rise shall, for the purposes of planning, consider a range of sea level rise scenarios for the years 2050 and 2100 in order to assess project vulnerability and, to the extent feasible, reduce expected risks and increase resiliency to sea level rise. However, all projects that have filed a Notice of Preparation, and/or are programmed for construction funding the next five years, or are routine maintenance projects as of the date of this Order may, but are not required to, account for these planning guidelines. Sea level rise estimates should also be used in conjunction with appropriate local information regarding local uplift and subsidence, coastal erosion rates, predicted higher high water levels, storm surge and storm wave data.

6. The Business, Transportation, and Housing Agency shall work with the California Resources Agency and the Governor's Office of Planning and Research (OPR) to prepare a report within 90 days of release of this Order to assess vulnerability of transportation systems to sea level rise that will include provisions for investment critical to safety, maintenance and operational improvements of the system and economy of the state.

7. By June 30, 2009, the California Resources Agency, through the Climate Action Team, shall coordinate with local, regional, state and federal public and private entities to develop a state Climate Adaptation Strategy. The strategy will summarize the best known science on climate change impacts to California (led by CEC's PIER program), assess California's vulnerability to the identified impacts and then outline solutions that can be implemented within and across state agencies to promote resiliency. A water adaptation strategy will be coordinated by DWR with input from the State Water Resources Control Board, an ocean and coastal resources adaptation strategy will be coordinated by the OPC, an infrastructure adaptation strategy will be coordinated by the California Department of Transportation, a biodiversity adaptation strategy will be jointly coordinated by the California Department of Fish and Game and California State Parks, a working landscapes adaptation strategy will be jointly coordinated by the California Department of Forestry and Fire Protection and the California Department of Food and Agriculture, and a public health adaptation strategy will be jointly coordinated by the California Department of Public Health and the California Air Resources Board, all as part of the larger strategy. This strategy will be facilitated through the Climate Action Team and will be coordinated with California's climate change mitigation efforts.

8. By May 30, 2009, OPR, in cooperation with the California Resources Agency, shall provide state land-use planning guidance related to sea level rise and other climate change impacts.

This Order is not intended to, and does not, create any rights or benefits, substantive or procedural, enforceable at law or in equity, against the State of California, its agencies, departments, entities, officers, employees, or any other person.

I FURTHER DIRECT that as soon as hereafter possible, this Order shall be filed with the Office of the Secretary of State and that widespread publicity and notice be given to this Order.

IN WITNESS WHEREOF I have hereunto set my hand and caused the Great Seal of the State of California to be affixed this 14th day of November 2008.

ARNOLD SCHWARZENEGGER
Governor of California

ATTEST:
Debra Bowen
Secretary of State

APPENDIX C

BAY CONSERVATION AND DEVELOPMENT COMMISSION REGIONAL STRATEGY GOALS (2010)

5. A regional strategy should be developed to determine where existing development should be protected and infill development encouraged, where new development should be permitted, where existing development should eventually be removed to allow the Bay to migrate inland.[i]

The goals of the strategy should be to:

a. advance regional public safety and prosperity by protecting most existing shoreline development, especially development that provides regionally significant benefits, and by protecting infrastructure that is critical to public health or the region's economy, such as airports, ports, regional transportation, wastewater treatment facilities, major parks, recreational areas and trails;
b. enhance the Bay ecosystem (e.g., Bay habitats, fish, wildlife and other aquatic organisms) by identifying both developed and undeveloped areas where tidal wetlands and tidal flats can migrate landward; assuring adequate volumes of sediment for marsh accretion; identifying priority conservation areas that should be considered for acquisition, preservation or enhancement; developing and planning for flood protection; and maintaining sufficient transitional habitat and upland buffer areas around tidal wetlands.
c. integrate the protection of existing and future shoreline development with the enhancement of the Bay ecosystem, such as by using feasible shoreline protection measures that incorporate natural Bay habitat for flood control and erosion prevention;
d. encourage innovative approaches to sea level rise adaptation;
e. identify a framework for integrating the adaptation responses of multiple government agencies;
f. integrate regional mitigation measures designed to reduce greenhouse gas emissions with regional adaptation measures designed to address the unavoidable impacts of climate change;
g. advance regional sustainability, encourage infill development and job creation, and provide diverse housing served by transit;
h. address any existing contamination and the implications of the contamination on water quality;
i. support research that provides information useful for planning and policy development on the impacts of climate change on the Bay, particularly those related to shoreline flooding;

j. identify actions to prepare and implement the strategy, including any needed changes in law; and
k. identify mechanisms to provide information, tools, and financial resources so local governments can integrate regional climate change adaptation planning into local community design processes.[ii]

6. Until a regional sea level rise adaptation strategy can be completed, when planning or regulating new development in areas vulnerable to future shoreline flooding, new projects should be limited to:

a. minor repairs of existing facilities or small projects that do not increase risks to public safety;
b. transportation facilities, public utilities or other critical infrastructure that is necessary for the continued viability of existing development;
c. infill development within existing urbanized areas that contain development and infrastructure of such high value that the areas will likely be protected whether or not the infill takes place;
d. redevelopment that will remediate existing environmental degradation or contamination, particularly on closed military bases, if the redevelopment will:
    1) provide significant regional benefits and meet regional goals by concentrating employment or housing near adequate transit service sufficient to serve the project, and
    2) include the following elements:
        i. an adaptation strategy for dealing with rising sea level and shoreline flooding with definitive goals and an adaptive management plan for addressing key uncertainties for the life of the project;
        ii. measures that will achieve resilience and sustainability in all elements of the project;
        iii. a permanent financial strategy that will guarantee the general public will not be burdened with the cost of protecting the project from any sea level rise or storm damage in the future; or;
e. projects or uses that are interim or temporary in nature where the use or structures:
    1) can be easily removed or relocated to higher ground;
    2) can be amortized within a period before removal or relocation of the proposed use is required; and
    3) will not require shoreline protection during the life of the project.
f. public parks, natural resource restoration or environmental enhancement projects;

7. To effectively address sea level rise and flooding, if more than one government agency has authority or jurisdiction over a particular issue or area, project reviews should be coordinated to resolve conflicting guidelines, standards or conditions.iii

Appendix References

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[i] BCDC 2010, page 16, (5)

[ii] BCDC 2010, pages 16-17

[iii] BCDC 2010, pages 17-18

RIO DE LOS PUTOS
RANCHO RIO DE LOS PUTOS
WINTERS
DIXON
TREMONT
MAINE PRAIRIE
ELMIRA
CANON STATION
FAIRFIELD
SUISUN
DENVERTON
BRIDGEPORT
GRISLY ISLAND
SUISUN BAY
MONTEZUMA
COLLINSVILLE
LOS ULPINOS GRANT
RIO VISTA
SACRAMENTO

SOLANO COUNTY