BAY AREA COUNCIL
ECONOMIC
INSTITUTE

Sea Level Rise

Climate Adaptation Policies and Strategies in the San Francisco Bay Area

June 2022

Framing the Challenge

California has been among the most aggressive U.S. states in its policies to reduce CO2 emissions. Its policies and strategies have been developed and expanded over several administrations led by governors from different parties, reflecting a broad political consensus on their priority. At the sub-state level, cities and regions in California have taken on the role of planning for the anticipated rise in sea levels, which will occur at some level whether or not C02 reduction goals are met.

Scientific estimates suggest that the magnitude of sea-level ride (SLR) in California could be at least six inches by 2030 and as much as seven feet by 2100. The impact of that rise will be magnified at times by exceptionally high tides ("king tides") that regularly occur and by major storm events. While the exact magnitude of sea-level rise and its timing is still unknown, current research suggests that the most widespread physical impact will take the form of increased coastal flooding from sea and waves, through both permanent inundation and episodic events aggravated by storms. Consequent impacts include the erosion of coastal cliffs and rising groundwater levels which can cause flooding away from the immediate coastline. One recent study has suggested that flooding from emergent groundwater in the San Francisco Bay Area could impact a larger area across the region than wave-induced flooding.[1]

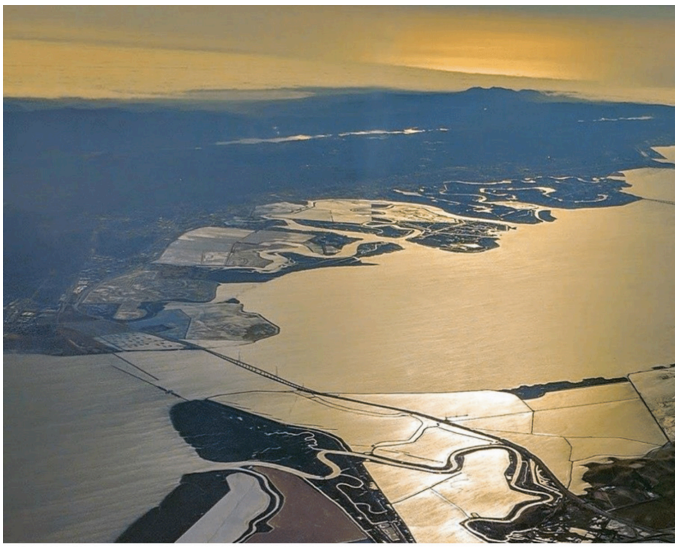
Specific vulnerabilities include:

- **Public Infrastructure:** ports and airports, water treatment plants, roads and highways, railways, piers and marinas. In the San Francisco Bay Area this includes 59 miles of highways and bridges, 48 miles of freight railway lines, 20 miles of passenger rail lines, 11 acres of ferry terminals, 780 acres of seaports, 4,670 acres of airports, and 30 wastewater treatment plants.
- **Private Property:** A 2015 study has estimated that if current GHG trends continue, between $8 billion and $10 billion of existing property in California could be underwater by 2050, with an additional $6 billion to $10 billion at risk during high tide.[2] Another study by the U.S. Geological Survey (USGS) estimates that by 2100 six feet of sea level rise and recurring storms could impact over 480,000 California residents and $119 billion in property.[3]
- **Vulnerable populations:** four feet of higher water levels would cause daily flooding for nearly 28,000 economically vulnerable residents in the San Francisco Bay Area[4];
- **Natural Resources:** Flooding threatens to impair important habitats for fish, plants, marine mammals and migratory birds. This would particularly occur as tidal marshes flood and drown. A study by the State Coastal Commission and the Nature Conservancy found that 55% of California's existing coastal habitats are highly vulnerable to five feet of sea level rise, including 58% of marshes.[5] Under scenarios of three to six feet of sea level rise up to two-thirds of Southern California's beaches could become completely eroded by 2100.[6]
- **Drinking and Water Supplies:** There is significant risk that sea level rise will cause salty water to contaminate some fresh groundwater supplies, degrading underground aquifers that residents and crops that depend on.
- **Toxic Contamination:** Where underground seawater pushes the water table up toward the ground surface, there is a significant risk that water could intrude into underground sewer pipes and systems, increasing incidents of seepage.
- **Economy:** Many of the region's key transportation assets are located in low lying areas near the Bay. Disruption would occur through the flooding of docks, roadways and water-adjacent railways through which residents commute and goods are distributed, impacting productivity. A recent study estimates that with four feet of flooding more than 104,000 existing jobs in the San Francisco Bay Area could be affected, including many in Silicon Valley. A decline over time in the value of threatened water-facing properties would also impact property tax revenues on which local governments depend.

Much of the detailed planning for how to address these challenges is taking place at the regional and local level. The state supports those efforts by encouraging regional-scale collaboration, supporting local planning and adaptation projects, providing data and analysis, and enhancing public awareness of sea level rise risks and impacts.[7] Much of this occurs through the Ocean Protection Council (OPC), a high-level state government panel created in part to protect ocean health in the face of climate change. Based on evolving scientific knowledge, the OPC develops state-level approaches that respond to the anticipated impacts of storms, erosion and sea level rise on coastal communities.

In April 2017 a working group of the Ocean Protection Council's Science Advisory Team (OPC-SAT) released a report titled Rising Seas in California: an Update on Sea Level Rise, which incorporated the latest modeling and data on ice loss from the Greenland and Antarctic ice sheets. In 2018 those findings led the state to update its sea-level rise planning guidance, which was first issued in 2010 and later updated in 2013, to ensure that government decisions are based on the best available science.

State of California Sea-Level Rise Guidance provides a science-based methodology for use by state and local governments when analyzing the risks associated with sea-level rise and making planning, permitting and investment decisions. The guidance document also provides links to a variety of geospatial and visualization tools and a database and library of additional resources.[8]



"Because the most severe effects of SLR likely will manifest decades in the future, taking actions to address them may seem less pressing now. The magnitude of the potential impacts, however, mean that the state cannot afford to indefinitely delay taking steps to prepare. Waiting too long to initiate adaptation efforts likely will make responding effectively more difficult and costly. Planning ahead means coastal adaptation actions can be strategic and phased, helps "buy time" before more extreme responses are needed, provides opportunities to test approaches and learn what works best, and may make overall adaptation efforts more affordable and improve their odds for success. The next decade represents a crucial time period for taking action to prepare for SLR."

California Legislative Analyst's Office

		Probabilistic Projections (in feet) (based on Kopp et al. 2014)				*H++ scenario (Sweet et al. 2017) *Single scenario*
		MEDIAN	**LIKELY RANGE**	**1-IN-20 CHANCE**	**1-IN-200 CHANCE**	
		50% probability sea-level rise meets or exceeds...	*66% probability sea-level rise is between...*	*5% probability sea-level rise meets or exceeds...*	*0.5% probability sea-level rise meets or exceeds...*	
			Low Risk Aversion		**Medium - High Risk Aversion**	**Extreme Risk Aversion**
High emissions	2030	0.4	0.3 - 0.5	0.6	0.8	1.0
	2040	0.6	0.5 - 0.8	1.0	1.3	1.8
	2050	0.9	0.6 - 1.1	1.4	1.9	2.7
Low emissions	2060	1.0	0.6 - 1.3	1.6	2.4	
High emissions	2060	1.1	0.8 - 1.5	1.8	2.6	3.9
Low emissions	2070	1.1	0.8 - 1.5	1.9	3.1	
High emissions	2070	1.4	1.0 - 1.9	2.4	3.5	5.2
Low emissions	2080	1.3	0.9 - 1.8	2.3	3.9	
High emissions	2080	1.7	1.2 - 2.4	3.0	4.5	6.6
Low emissions	2090	1.4	1.0 - 2.1	2.8	4.7	
High emissions	2090	2.1	1.4 - 2.9	3.6	5.6	8.3
Low emissions	2100	1.6	1.0 - 2.4	3.2	5.7	
High emissions	2100	2.5	1.6 - 3.4	4.4	6.9	10.2
Low emissions	2110*	1.7	1.2 - 2.5	3.4	6.3	
High emissions	2110*	2.6	1.9 - 3.5	4.5	7.3	11.9
Low emissions	2120	1.9	1.2 - 2.8	3.9	7.4	
High emissions	2120	3	2.2 - 4.1	5.2	8.6	14.2
Low emissions	2130	2.1	1.3 - 3.1	4.4	8.5	
High emissions	2130	3.3	2.4 - 4.6	6.0	10.0	16.6
Low emissions	2140	2.2	1.3 - 3.4	4.9	9.7	
High emissions	2140	3.7	2.6 - 5.2	6.8	11.4	19.1
Low emissions	2150	2.4	1.3 - 3.8	5.5	11.0	
High emissions	2150	4.1	2.8 - 5.8	5.7	13.0	21.9

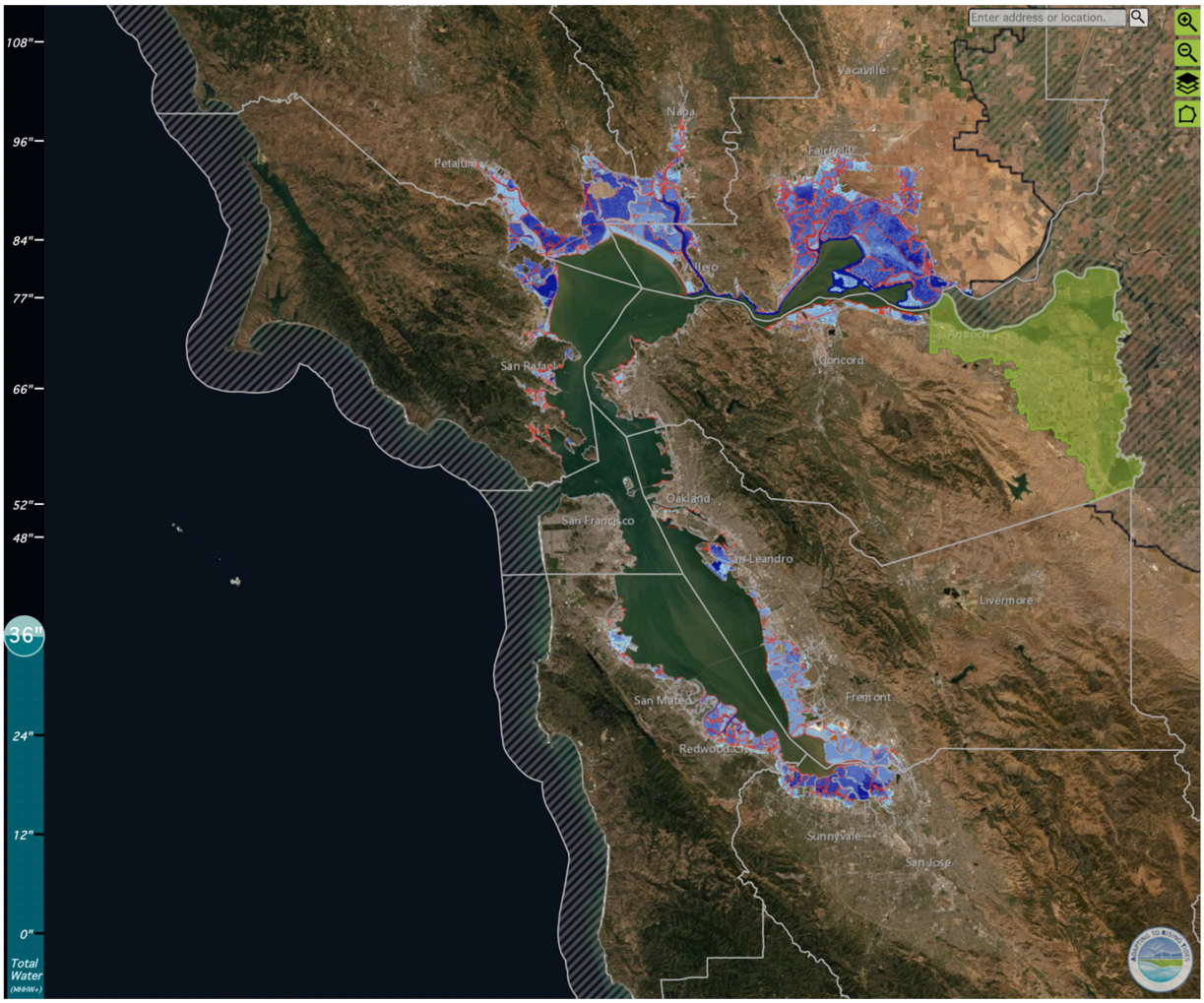
Source: BCDC

Sea Level Rise Adaptation Strategies in the San Francisco Bay Area

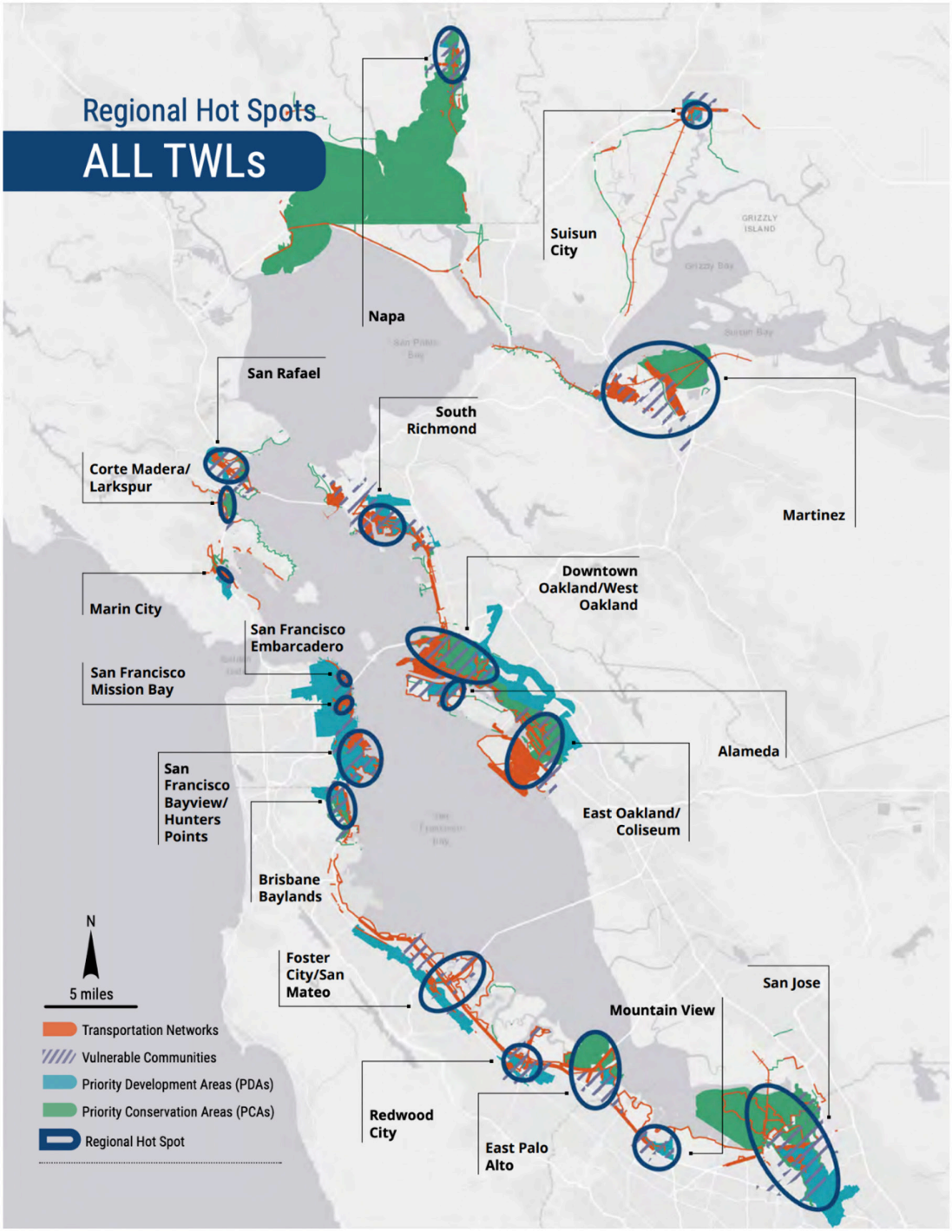
One of California's three major metropolitan centers, the San Francisco Bay Area encompasses a region of nine counties and 101 cities and is home to 7.8 million people. The region is named for and defined by the Bay, which all nine counties border. It is also the largest estuary on the West Coast of North America.[9] The Bay itself covers 550 square miles, and if its shoreline were extended it would be half the length of California's coastline.[10]

A wide range of high-value assets are located along that shoreline: the technology campuses of Silicon Valley (many of which sit on land below sea level), the downtowns of two major cities – San Francisco and Oakland, San Francisco International and Oakland International Airports, the Port of Oakland (fourth largest in the United States), major highways and rail lines, and numerous refineries, electrical and wastewater treatment facilities.

Because the topography of the Bay Area is varied, planning calls for a diverse portfolio of responses. Some areas surrounding the Bay are low lying and highly prone to flooding, including several transportation arteries. Others are low lying but



Source: BCDC ART Shoreline Flood Explorer.

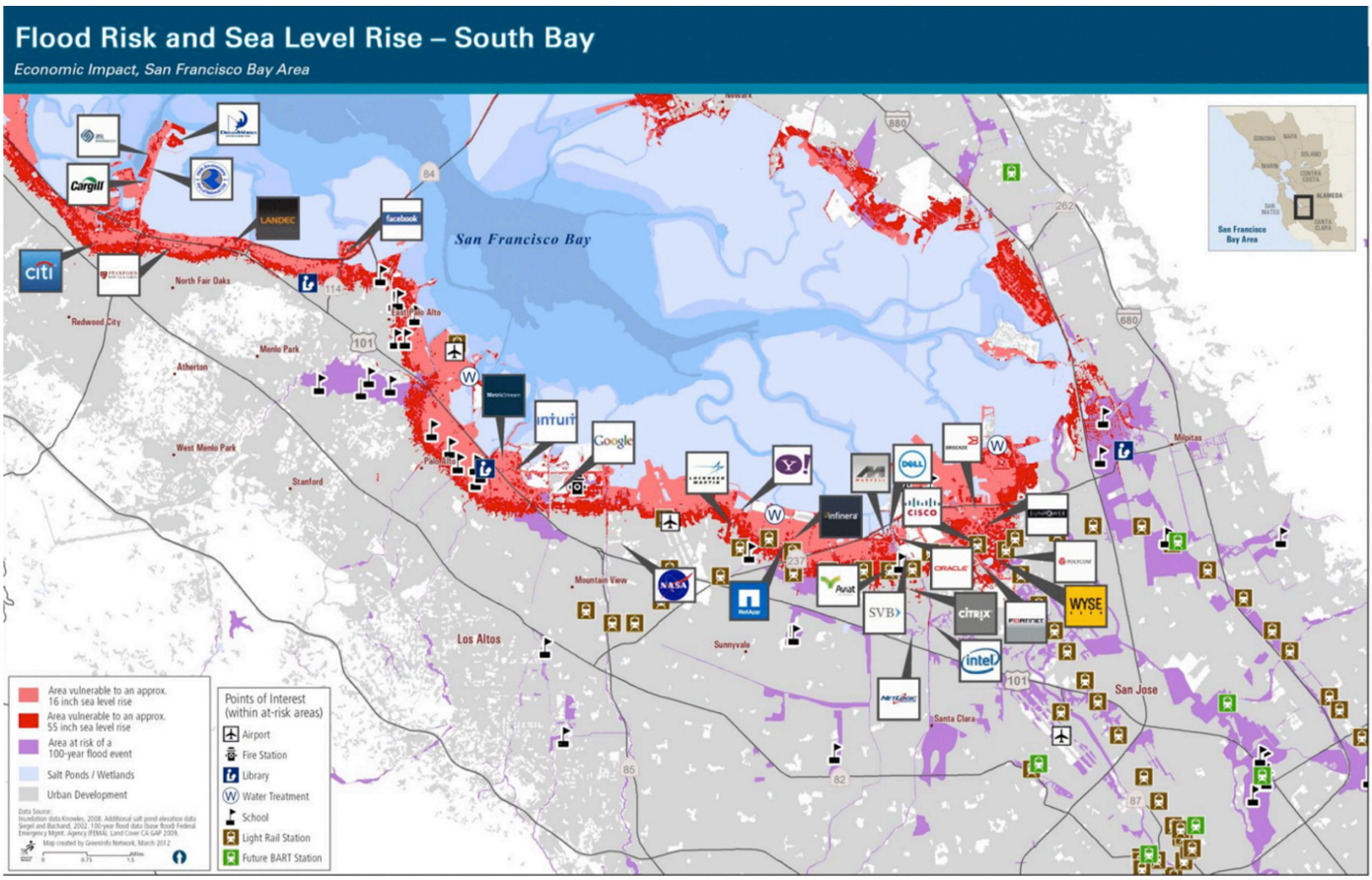


Notes: Transportation Networks include ports, airports and major road or rail lines. Vulnerable Communities indicate lower income neighborhoods where additional assistance in planning for sea level rise may be required. Priority Development Areas (PDAs) are zones where regional planning calls for new jobs and housing and housing to be clustered in proximity to public transit. Priority Conservation Areas (PCAs) are zones where regional planning prioritizes the preservation of open space.

Source: BCDC ART Shoreline Flood Explorer. Indicates expected inundation from 36" of total water magnitude increase.

protected by historic marshes and diked wetlands that provide a measure of level of protection in the near and medium term but require design and maintenance. Gently sloping "horizontal levees" for example can allow wetlands to adapt and migrate upwards as water levels rise, and dredged sediment (under the concept of "beneficial reuse" can be used to elevate wetlands to extend their lifespans and protective benefits.[11] Other regions of the Bay, such as downtown San Francisco, have no protective wetlands and require hard infrastructure such as seawalls. Those walls too will require design and maintenance as water levels rise.

The San Francisco Bay Area does not have a regional government, which means that regional actions and policies need to be coordinated across many jurisdictions. Because cities and counties are protective of local control over land use and other decisions, this makes the development of regional



Source: BCDC ART Shoreline Flood Explorer.

strategies of any kind challenging. There are four regional governmental agencies that have regulatory authority within certain domains:

- The Metropolitan Transportation Commission (MTC) and the Association of Bay Area Governments (ABAG), which coordinate transportation and housing respectively;
- The Bay Area Water Control Management District (BAWQMD) which manages water quality;
- The Bay Area Air Quality Management District (BAAQMD) which regulates air quality; and
- The San Francisco Bay Conservation and Development Commission (BCDC), which regulates development on and around the Bay.

The mandate of BCDC, America's first coastal management authority, extends to development within 100 feet of the mean high tide line of the Bay and under its guiding legislation the McAteer-Petris Act is focused on two things: preventing unnecessary filling of the Bay, and ensuring maximum feasible public access for the public to the Bay's shoreline. That mandate does not include climate change (BCDC was created in 1965 before sea level rise was considered an issue). Because its jurisdiction relates most directly to the Bay and its waters, however, BCDC has been designated by the other regional agencies to lead and coordinate an integrated sea level rise on their behalf.

This has produced an extensive series of public consultations and planning exercises, leading to the phased development of policies and pilot programs that are crafting regional strategies in an evolutionary manner. Those consultations have included local governments, business organizations, environmental organizations, and diverse community representatives including environmental and social justice advocates. Because of the diversity of interests that are impacted, BCDC's guiding approach has been to progressively build consensus around plans and strategies that enable an informed and engaged public to make what eventually may be difficult or costly decisions.

San Francisco Bay Plan Policies

As an early step in that effort BCDC, following an extended consultative process, updated its guiding policy document the San Francisco Bay Plan in 2011 to deal with the expected impacts of climate change in San Francisco Bay region. The plan provides guidance for specific regulatory decisions when applicants apply for permits for developments withing the Commission's jurisdiction. Applicants for those development permits are now required to meet the following requirements:

Risk Assessments: Sea level risk assessments are required when planning shoreline areas or designing larger shoreline projects. If sea level rise and storms that are expected to occur during the life of the project (generally over 30 years) would result in public safety risks, the project must be designed to deal with flood levels expected by mid-century. If the project is expected to remain in place longer than mid-century, the applicant must have a plan to address the flood risks expected at the end of the century.

Protecting Existing and Planned Development: Fill may be placed in the Bay to protect existing and planned development from flooding as well as erosion. New projects that are likely to be affected by sea level rise and storm activity during the life of the project must:

- Be set back far enough from the shoreline to avoid flooding;
- Be elevated above expected flood levels;
- Be designed to tolerate flooding; or
- Employ other means of addressing flood risks.

Designing Shoreline Protection: Shoreline protection projects, such as levees and seawalls, must e designed to withstand the effects of projected sea level rise and be integrated with adjacent shoreline protection. Whenever possible projects must integrate hard shoreline protection structures with natural features that enhance the Bay's ecosystem, for example by including marsh or upland vegetation in the design.

Preserving Public Access: Public access to the shoreline must be designed and maintained so as to avoid flood damage due to sea level rise and storms. Any public access provided as a condition of approval for a planned development must either remain viable in the event of future sea level rise or flooding or equivalent access consistent with the project must be provided nearby.

Ecosystem Protection and Restoration: Where feasible, ecosystem restoration projects must be designed to provide space for marsh migration upwards as sea level rises.

Preserving Undeveloped Areas: The policies encourage preservation and habitat enhancement in undeveloped areas that are vulnerable to future flooding and either contain significant habitats or species or are especially suitable for ecosystem enhancement.

Regional Strategy: The policies call on the Commission, working with other agencies and the public, to develop a broad regional strategy for:

- Protecting critical developed areas along the shoreline from flooding;
- Enhancing the natural resources of the Bay by preserving existing habitat and identifying areas where tidal wetlands can migrate landward;
- Improving the ability of communities to adapt to sea level rise in ways that advance economic prosperity, social equity and environmental protection.[12]

Adapting to Rising Tides Program (ART)

The Adapting to Rising Tides (ART) program managed by BCDC and also launched in 2011 provides planning guidance, tools and information to help communities and industry address specific challenges related to sea level rise. Based on in-depth studies, findings are available regarding specific vulnerabilities including: airports; business and industry; communities and housing; energy, pipelines and telecommunications facilities; ground transportation; seaports; structural shoreline protection; water management; and natural areas.

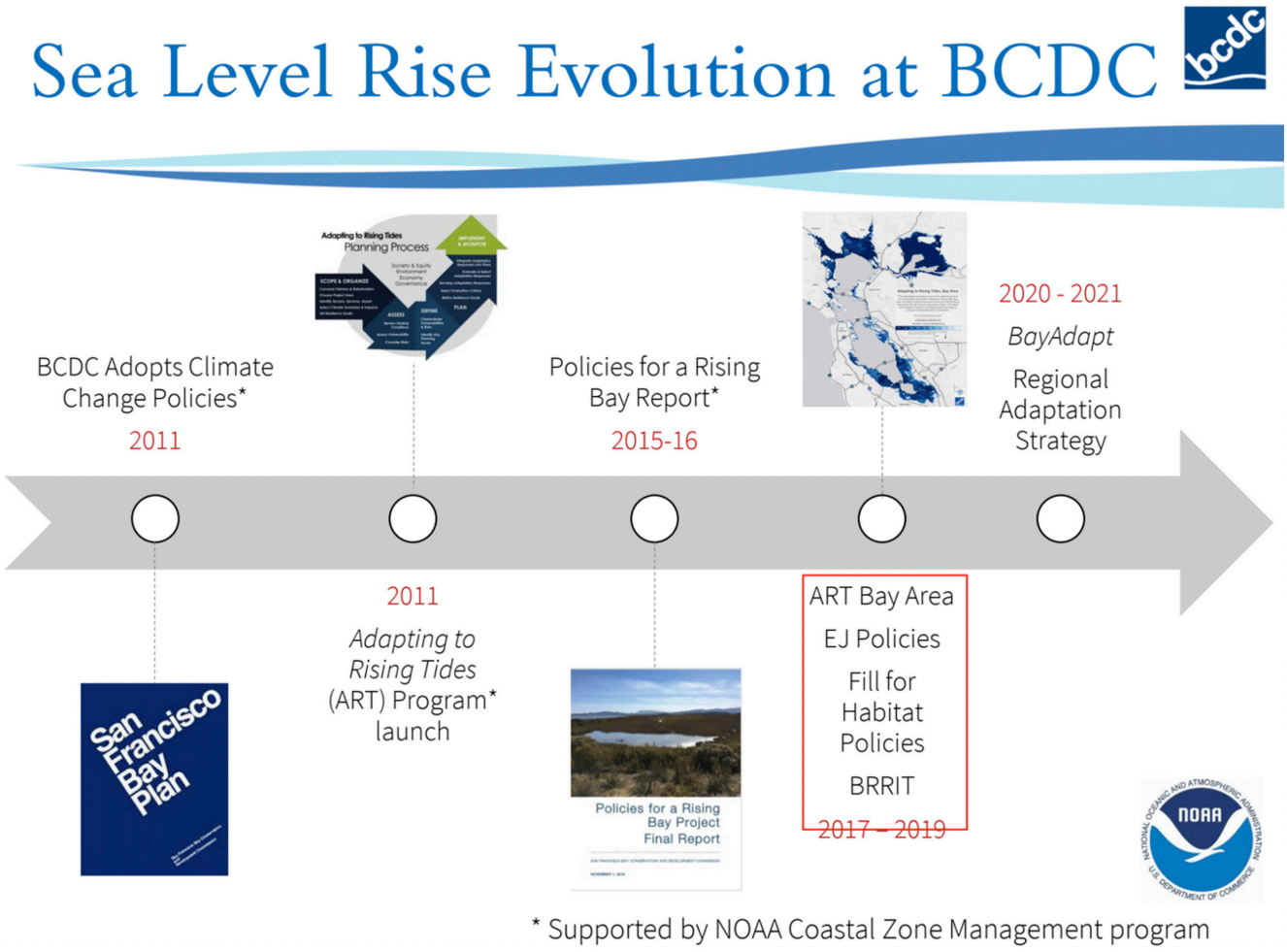
The project also provides Bay Area sea level rise and shoreline analysis maps to support consistent assessment and adaptation strategies across the region. This includes:

- The ART Bay Shoreline Flood Explorer, a website designed to help Bay Area communities and the general public understand current and future flooding risks. Maps show what could be at risk from rising waters without adaptation, and identify areas facing the greatest risk. Inundation mapping is available for ten scenarios that capture 90 combinations of future sea levels and tidal conditions, and overtopping maps are available for the same ten scenarios that depict where the Bay may overtop the shoreline and lead in inland flooding.
- ART is partnering with the Association of Bay Area Governments to assist local governments with the development of Local Hazard Mitigation Plans that include climate change.
- Partnerships have been created with other regional agencies to coordinate adaptation plans and measures.
- Sector-specific projects are developing strategies for resilient shoreline systems encompassing transportation, passenger rail, regional parks, wetlands, and tidal creeks. Specific projects that have been selected as test cases for adaptation planning including Highway 37, a low-lying roadway in the North Bay that crosses marshes and is already prone to flooding, and Colma Creek, a waterway near San Francisco International Airport. Other assessments and planning exercises have been developed for vulnerable ground transportation sites such as the ends of the San Francisco-Oakland Bay Bridge and the Capital Corridor train that connects the state capitol Sacramento with the San Francisco Bay Area and at key points parallels the Bay.
- A demonstration project has been developed at the Corte Madera Baylands, a marsh in the North Bay, to test the design and viability of coastal marshes as the first line of defense against coastal flooding. Findings

from the project are intended to provide managers, planners, regulators, funders and decision makers with experience-based information can facilitate the development of nature-based strategies for shoreline resilience.[13]

Bay Adapt

Planning for sea level rise and adaptive measures is seen as a process that must be consultative, collaborative, and open to participation from the diverse range of communities that will be affected. Bay Adapt is an initiative to forge regional agreement on the actions necessary to protect people and the built environment from rising sea levels, drawing on government agencies and stakeholders. The effort is designed to be open, inclusive, and engages a broad base of participants including business, environmental organizations, members of the scientific community, and representatives of economically vulnerable communities. Under Bay Adapt public forums have been held throughout the region to solicit and engage public input.[14]

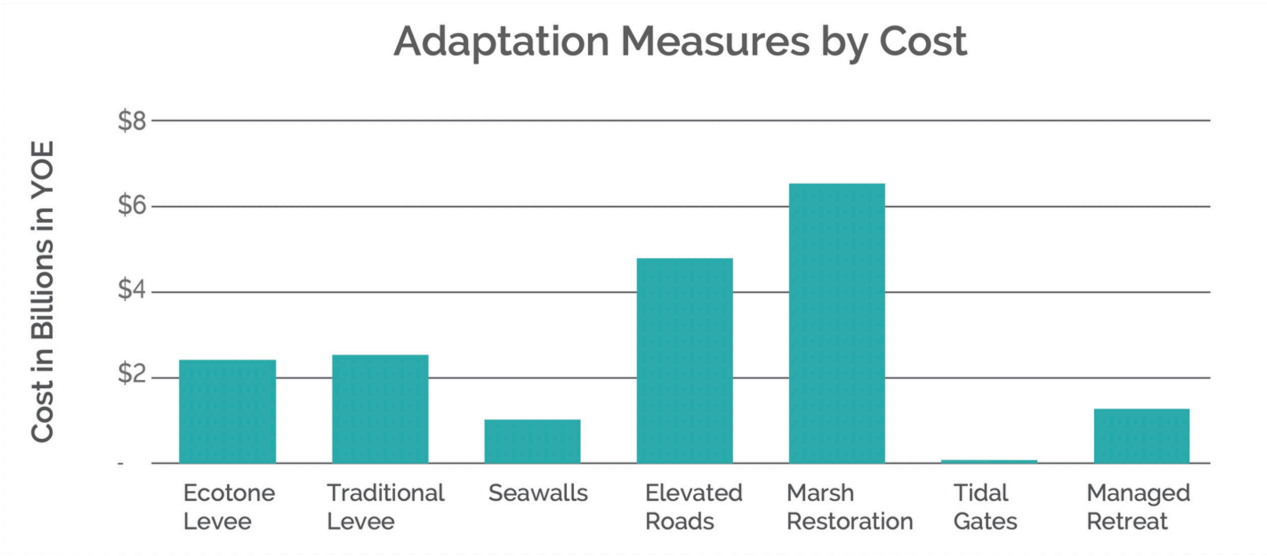


Source: BCDC ART Shoreline Flood Explorer.

Plan Bay Area

Sea level rise has been incorporated into Plan Bay Area 2050, the long-range inter-governmental plan for the nine-county San Francisco Bay Area that formulates a vision for growth and infrastructure in future decades. It articulates public policies or investment priorities that can be implemented at the local, regional or state levels over the next thirty years. The plan is updated every four years, with the latest version extending to 2050.

The environmental component of the latest plan focuses on three specific areas: climate and hazard resilience, climate mitigation, and environmental strategies. In addition to incorporating the strategies outlined above, it also produces for the first time a high-level estimate of the near-term cost for sea level rise adaptation within the region. The current estimate is that based on two feet of sea level rise an investment of $20 billion will be required in the next thirty years, including levees, seawalls, elevated roads, marsh restoration, tidal gates and managed retreat. Of that, approximately $11 billion has been identified as likely to come from identified revenue sources, leaving a gap of $8 billion to be filled.



Source: Plan Bay Area 2050 and Sea Level Rise, September 2020

Acknowledgements

This analysis was prepared by Dr. Sean Randolph, Senior Director at the Bay Area Council Economic Institute and a member of the San Francisco Bay Conservation and Development Commission (BCDC).

About the Institute

Since 1990, the Bay Area Council Economic Institute has been a leading think tank focused on the economic and policy issues facing the San Francisco/Silicon Valley Bay Area, one of the most dynamic regions in the United States and the world's leading center for technology and innovation. A valued forum for stakeholder engagement and a respected source of information and fact-based analysis, the Institute is a trusted partner and adviser to both business leaders and government officials. Through its economic and policy research and its many partnerships, the Institute addresses major factors impacting the competitiveness, economic development, and quality of life of the region and the state, including infrastructure, globalization, science and technology, and health policy. It is guided by a Board of Trustees drawn from influential leaders in the corporate, academic, non-profit, and government sectors.

The Institute is housed at and supported by the Bay Area Council, a public policy organization that includes hundreds of the region's largest employers and is committed to keeping the Bay Area the world's most competitive economy and best place to live. The Institute also supports and manages the Bay Area Science and Innovation Consortium (BASIC), a partnership of Northern California's leading scientific research laboratories and thinkers.

Endnotes

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