



State Highways and Rising Sea Level

San Francisco Bay Conservation and Development Commission
Bay Fill Working Group Committee

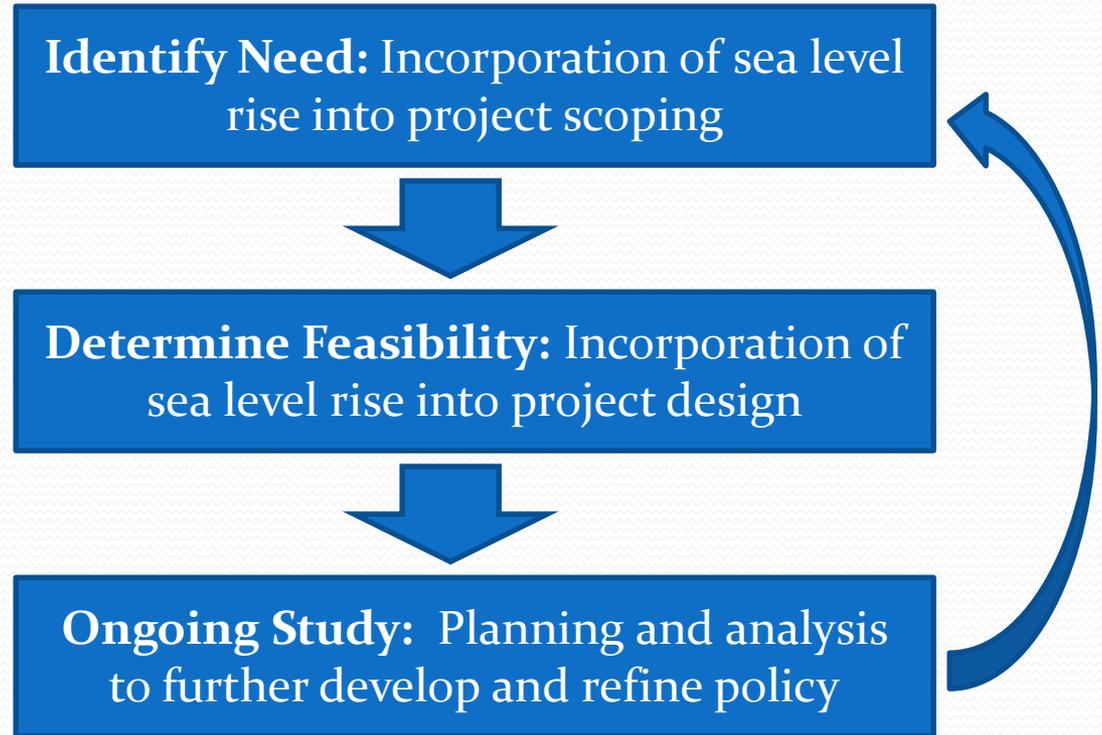
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Summary of Caltrans Policies on Sea Level Rise

Sea level rise is incorporated into project scoping and environmental analysis. Project design implements currently assess feasible solutions or interim measures. Climate Change Vulnerability Assessments are a state wide priority. Ongoing planning efforts identify risks, opportunities, and strategies, which influence the development of policy.



Vulnerable Highways

Caltrans Facilities at Risk

King Tide 2014

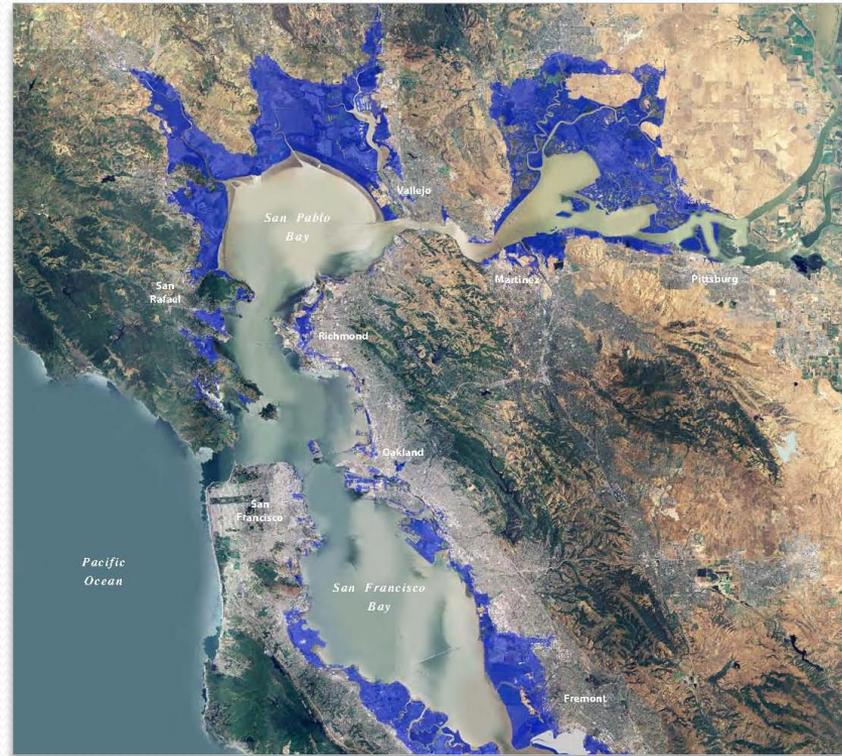




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San Francisco San Pablo Bay Sea Level Rise Map

Areas potentially exposed to
1.4-meter sea level rise by the
end of the century.
(BCDC, 2009)





Highways at risk

Miles of highway vulnerable to a 100-year flood along the San Francisco Bay, by county. (California Climate Change Center, May 2009)

	Miles of Highway			
	Current	0.5 m SLR	1.0 m SLR	1.4 m SLR
Alameda	1.1	4.8	14.0	23.0
Contra Costa	2.4	2.7	3.4	4.5
Marin	16.0	20.0	24.0	28.0
Napa	0.70	0.70	0.80	1.2
San Francisco	0.30	0.60	1.5	3.1
San Mateo	27.0	49.0	66.0	72.0
Santa Clara	9.4	12.0	14.0	15.0
Solano	5.7	14.0	19.0	23.0
Sonoma	11.0	12.0	13.0	14.0
Total	73.6	115.8	155.7	183.8



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Highway Impacts

SF-Oakland Bay Bridge Focus Area - 36" of Sea Level Rise

Source: *Climate Change and Extreme Weather Adaption Options for Transportation Assets in the Bay Area (2014)*



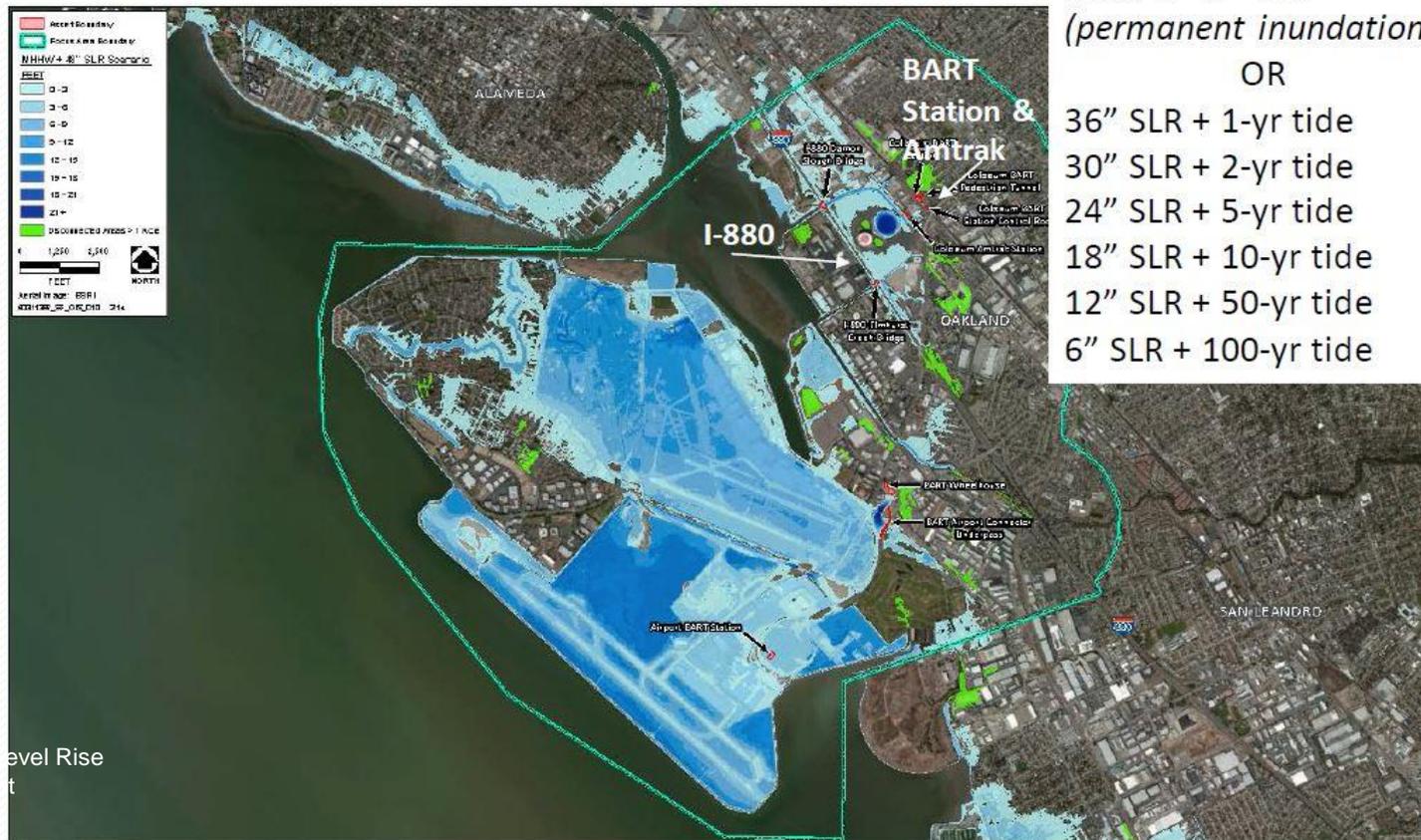


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Highway Impacts

I-880/Coliseum Focus Area - 48" of Sea Level Rise

Source: *Climate Change and Extreme Weather Adaption Options for Transportation Assets in the Bay Area (2014)*



Level Rise
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Vulnerable Routes and Facilities

- Highways vulnerable to sea level rise include:
 - US-101 and SR-84 in San Mateo County
 - SR-1 in Marin County
 - I-80 and US-880 in Alameda County
 - SR-12 and SR-37 in Solano County
 - SR-237 in Santa Clara County
- Caltrans facilities vulnerable to sea level rise include:
 - Toll plaza roadway areas approaching the bridges
 - Roadways on fill material embankments
 - Roadways behind levees
 - Bayside park-and-ride lots (Manzanita on SR-1)



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Current Challenges

- Local highway facilities are increasingly affected by flooding and coastal erosion.
- Associated infrastructure – drainage, footings, electrical, communications – is also at risk.
- The costs for permanently removing the threat posed by sea level rise can be very high
 - For example, putting SR-37 on elevated causeway along the San Pablo Bay shoreline could cost over a \$1 billion.
- New levees and embankments can conflict with wetlands-restoration efforts.



Caltrans Project Development and Climate change

Internal Caltrans Guidance on Sea Level Rise

Table 2. Sea-Level Rise Projections⁵ using 2000 as the Baseline

Year		Average of Models	Range of Models
2030		7 in (18 cm)	5-8 in (9-17 cm)
2050		14 in (36 cm)	10-17 in (26-43 cm)
2070	Low	23 in (59 cm)	17-27 in (43-70 cm)
	Medium	24 in (62 cm)	18-29 in (46-74 cm)
	High	27 in (69 cm)	20-32 in (51-81 cm)
2100	Low	40 in (97 cm)	31-50 in (78-128 cm)
	Medium	47 in (121 cm)	37-60 in (95-152 cm)
	High	55 in (140 cm)	43-69 in (110-176 cm)

**Ocean Protection Council
sea level rise values (2011)**

These standardized set of assumptions are used for determining sea level rise impacts ranges for planning and design until the National Academy of Sciences values are officially adopted. (draft est. 2050 1.6', 2070 3.3', 2100 5.7')



California Adaptation Strategy (2009)

- Caltrans performs a sea level rise risk assessment for each potentially vulnerable project.
- Projects for which needed sea level rise accommodation would require changes beyond the project's scope are deferred.
- Interim measures are identified and evaluated, and implemented when feasible.



Caltrans “Guidance on Incorporating Sea Level Rise” (2011)

- Screen each new proposed project based on the proposed location and design life to determine whether it will be affected by sea level rise.
- Balance the potential impacts with the level of risk and potential consequences, to determine whether adaptation measures should be incorporated into the project – consider defend, adapt, or retreat options.
- Findings recorded in the Project Initiation Document (PID) which outlines alternative scope, cost and schedules for programming a potential project.



Caltrans Director's Policy Director's Policy 30 "Climate Change" (2012)

- Establishes and promotes a strategic Department-Wide Climate Change Program.
- Climate change mitigation and adaptation measures are to be coordinated across all Caltrans programs and with other state agencies, departments, and external stakeholders.
- Caltrans Project Delivery will coordinate the development and implementation of climate-change mitigation and adaptation measures in the design and construction of transportation infrastructure.



Design Recommendations from “Caltrans Activities to Address Climate Change” (2013)

- Change to more resilient building materials.
 - Caltrans is currently using plastic instead of metal, coated rebar, denser concrete, and other alternative materials where sea level rise can be a factor.
- Retrofit/replace existing bridges for new scour conditions.
- Use a combination of hard engineering (human-made structures) and soft engineering measures (implementing ecological principles) to protect coastal infrastructure.



Design Recommendations from “Caltrans Activities to Address Climate Change” (2013)

- **Build larger or additional drainage canals near coastal routes.**
 - No improvement in elevation
 - Potential drainage of coastal wetlands
 - Land-use impacts
 - Potential impacts to habitat
- **Increase base elevation of infrastructure.**
 - Large embankments with larger project footprints
 - High construction costs for new elevated structures
 - Visual impacts of new large structures or embankments
 - Impacts to wetlands if embankments are used
- **Protect bridge piers and abutments with riprap.**
 - Potential displacement of erosion and scour
 - Impacts on aquatic habitat
- **Relocate highly affected or vulnerable infrastructure; relocate sections of track; relocate existing bridges for new scour conditions.**
 - Large amounts of new right-of-way needed; possible relocations
 - Impacts to community and land use
 - Loss of scenic byways and other visual impacts
 - Potential loss of habitat
 - Impacts to navigation
- **Strengthen, heighten, and construct new seawalls and dikes.**
 - Requires constant maintenance
 - Interferes with natural coastal processes
 - Interferes with coastal access
 - Visual impacts
 - Impacts to coastal habitat



Adaptive Management

Sample Caltrans Projects Incorporating
Sea Level Rise



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Sonoma SR-1 Gleason Beach

- At Gleason Beach in coastal Sonoma County, an elevated structure was constructed to replace existing armored embankment.
- With new FHWA standards, coastal highways may not be overtopped by wave action.
- For the Gleason Beach Roadway Realignment project, sea level rise projections for the next century were added to the wave-overtopping projections to establish the elevation of a proposed new bridge structure.





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Solano SR-37 White Slough

- Caltrans incorporated sea level rise estimates into this completed project, which raised the embankment on which the roadway is constructed by five feet.





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US-101 San Francisco Doyle Drive

- The capacity of coastal drainage outfalls decreases as they become more deeply submerged as sea level rises.
- Caltrans increased the size of outfall pipes for US-101 in the San Francisco Presidio to allow drainage systems to continue to operate without impairment.



Doyle Drive

- Caltrans analyzed the potential for sea level rise to impact the bridges and tunnels at Doyle Drive.
- A sea wall was considered, which would have obstructed bay views, so the project now incorporates a pump station and electronic message signs to warn in the event of flooding.



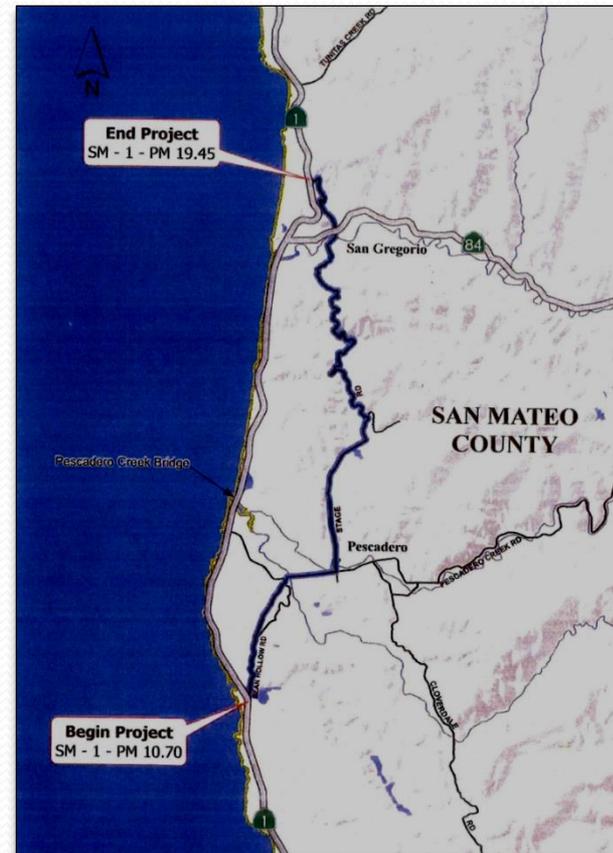


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San Mateo SR-1

Pescadero to San Gregorio

- Caltrans has been using riprap for emergency coastal armoring. The California Coastal Commission has asked Caltrans to study replacing 8.75 miles of SR-1 with an inland bypass.
- The erosion rate is currently 3 to 5 feet per year, and is expected to accelerate due to sea level rise and climatic change.
- Caltrans completed a Preliminary Environmental Assessment Report in 2008.





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San Mateo SR-84

Dumbarton Bridge

- Caltrans used sea level rise estimates in designing a project to protect low-lying roadway at the west bridge approach by constructing a flood wall and pump plant.
- The east approach, the Bay Bridge Toll Plaza and the approaches to the San Mateo Bridge are also considered vulnerable.





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Previous Studies

- *Adapting to Rising Tides: Transportation Vulnerability and Risk Assessment Pilot Project (2011)*; Caltrans, BCDC, MTC.
 - FHWA-funded study on the vulnerability of and potential risks to selected transportation assets, to provide local transportation planners the best available information about future climate change.
- *Climate Change and Extreme Weather Adaptation Options for Transportation Assets in the Bay Area (2014)*; Caltrans, BCDC, MTC, BART.
 - A collaborative sub-regional planning pilot project which refined predictions for sea level rise exposure and potential timing of impacts, and provided adaptation options and implementation approaches, with evaluation criteria for these.
- *State Route 37 Integrated Traffic, Infrastructure and Sea Level Rise Analysis (2016)*; UC Davis, funded by Caltrans Planning grant.
 - Assessed sea level rise risks and vulnerabilities and recommend design solutions for a new, resilient structure.
- *Colma and San Bruno Creeks SLR Study (2015)*; SFO, San Mateo County Working Group
 - Worked with stakeholders to recommend a comprehensive set of improvements to address current and future anticipated flooding to nearby communities.
- BCDC ART - Hayward Shoreline and Oakland/Alameda Resilience Studies.
 - Worked with BCDC and affected stakeholders on developing adaptation solutions to address projected sea level rise in these areas.



State Route 37

Case Study



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Route Setting

- State Route 37 is a low-elevation highway that traverses sensitive marshland habitat on the north shore of San Pablo Bay.
 - Recovery route in the event of emergency/closure of the Richmond Bridge
 - Extreme environmental sensitivity of this area
 - Difficulty of regulatory permitting
 - Some traffic congestion, but less than the more congested adjoining US-101 and I-80 highways
 - Teaming with the four county agencies SR 37 Policy Group to further assess options



State Route 37 Integrated Traffic, Infrastructure and Sea Level Rise Analysis

- Caltrans received \$350,000 for the SR-37 study to
 - Assess sea level rise risk and vulnerability
 - Provide an adaptive-capacity assessment, and
 - Produce design-solution schematics; and cost estimates
- The study will help define a possible Project Initiation Document to reduce the highway's vulnerability while contributing to marshlands restoration.
- The study will serve as a guide for similar projects in the Bay Area.



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Scope of Work

- Modeling of sea level rise inundation and impacts
- Designs and cost estimates for possible resilient structures
- Community and environmental benefits
- Stakeholder outreach and inclusion; information sharing with stakeholders and the public
- Reporting: Assessment, schematics, project alternatives and costs.



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Ongoing/Upcoming Studies

- *SAFER Bay Project*; San Francisquito Creek Joint Powers Authority
 - Working with the San Francisquito Creek JPA and other stakeholders to develop a set of improvements at the west end of the Dumbarton Bridge that will provide protection from future sea level rise and provide environmental benefits as well.
- *Sonoma, Marin and San Mateo counties' Vulnerability Assessments*; County leads
 - Working with each county, and their respective stakeholders, on their individual sea level rise vulnerability assessments.
- *A Resilient Transportation System for Safe and Sustainable Communities*; BARC, BCDC, MTC, Caltrans (Caltrans Sustainable Transportation Planning Grant \$800,000)
 - This project will deliver a regional vulnerability assessment of, and adaptation strategies for, the Bay Area's transportation infrastructure, Priority Development Areas (PDA's), and Communities of Concern. Work to begin this year with a total budget of \$1.2 million.
- *Caltrans District 4 Climate Change Vulnerability Assessment*; Caltrans HQ Climate Change Branch
 - Caltrans Headquarters is conducting a statewide twelve District by District Climate Change Vulnerability Assessment that analyzes all climate-related impacts (SLR, Storm Surge, Wildfire, Temperature and Precipitation changes) to the State Highway System as reported at the January 2017 CTC meeting (Bay Area draft to be completed in early 2017).



Thank you.

Questions?