



EXIT 93
San Ysidro
Road
1/2 MILE

Extreme Weather, the New Normal

Report, First in Series, Assesses Risks to Highway System from Changing Climate

Earlier springs, hotter summers and more volatile winters will affect desert highways differently than coastal roads, so Caltrans is analyzing the potential effects of climate change on one regional transportation network at a time.

The Department's first [Climate Change Vulnerability Assessment](#) explores predicted climate challenges specific to the San Francisco Bay Area as the century progresses. It focuses on roads, bridges, drainage systems and traffic components that may be susceptible to damage in Caltrans' regional District 4, made up of nine Bay Area counties.

Studies are underway to examine risks in all of the state's 16 climate zones. The assessments for each of Caltrans' 11 other regional districts will identify specific locations along the State Highway System that may be impacted by rising sea levels and larger storm surge, more frequent wildfires, changing precipitation patterns and higher temperatures linked to climate change.

The report's findings are supported by extensive geographic mapping and an interactive application for public use that shows potentially affected locations and the climate model results.

The Bay Area, already feeling the effects of climate change, will be under more pressure as the century unfolds, according to the assessment's projections. As global temperatures warm and sea levels rise, major parts of the transportation system could be overwhelmed without significant infrastructure improvements.

Among the findings:

- Destructive storm surges — a rise in sea level that occurs during intense storms — will threaten more than 100 miles of Bay Area roads by the end of the century.
- More intense rain storms will likely flood low-lying routes like Highway 37 in Marin, Sonoma and Solano counties and Highway 12 in the Napa area.
- Rising temperatures will increase the likelihood of wildfires in the forested eastern edges of the region — where catastrophic blazes erupted last October.

The 2016-17 storm season in California offered a glimpse of the strain that extreme weather events can put on the State Highway System in the Bay Area. Flooding, landslides and coastal erosion caused nearly \$390 million of damage in District 4, nearly a third of the statewide tally of almost \$1.4 billion that's still being tabulated months later.

Left: A massive mudslide came roaring down a Santa Barbara-area hillside in early January and spewed tons of mud, trees, cars, pieces of houses and other debris onto US 101. The Montecito slide claimed 21 lives. Extreme weather events are predicted to become more common in the state.

Contending with rising waters

The Bay Area has felt the creep of climate change for some time. Sea level, which has been measured at the Presidio tidal gauge in San Francisco since 1854, has risen 7.6 inches in the last 100 years, a rate expected to accelerate.

If the sea rise continues, State Route 37 — one of the lowest-lying highways in California — will be under water. This major east-west highway across the northern edge of San Francisco/San Pablo Bay connects Vallejo on Interstate 80 to Novato on US Highway 101.

Surrounded by marshes and farmland that provide important habitat to endangered species, Highway 37 is barely above water level and has only slight protection against flooding.

The sea has already begun to overtake the corridor, especially during king tides (occasional very high tides)

and storm surges, requiring its shutdown. It's expected that these events will happen more frequently and last longer. It would take a 24-inch rise in sea level to permanently put SR 37, in its present configuration, under water.

The Climate Change Vulnerability Assessment also notes the susceptibility of Highway 101, particularly near Corte Madera Creek in Marin County, Highway 1 in Marin, and Interstate 80 in Oakland.

Sea level rise also threatens aging levees in the Delta. Collapse there could damage highways, inundate farmland and allow salt water to infiltrate one of the largest freshwater supplies in the state.

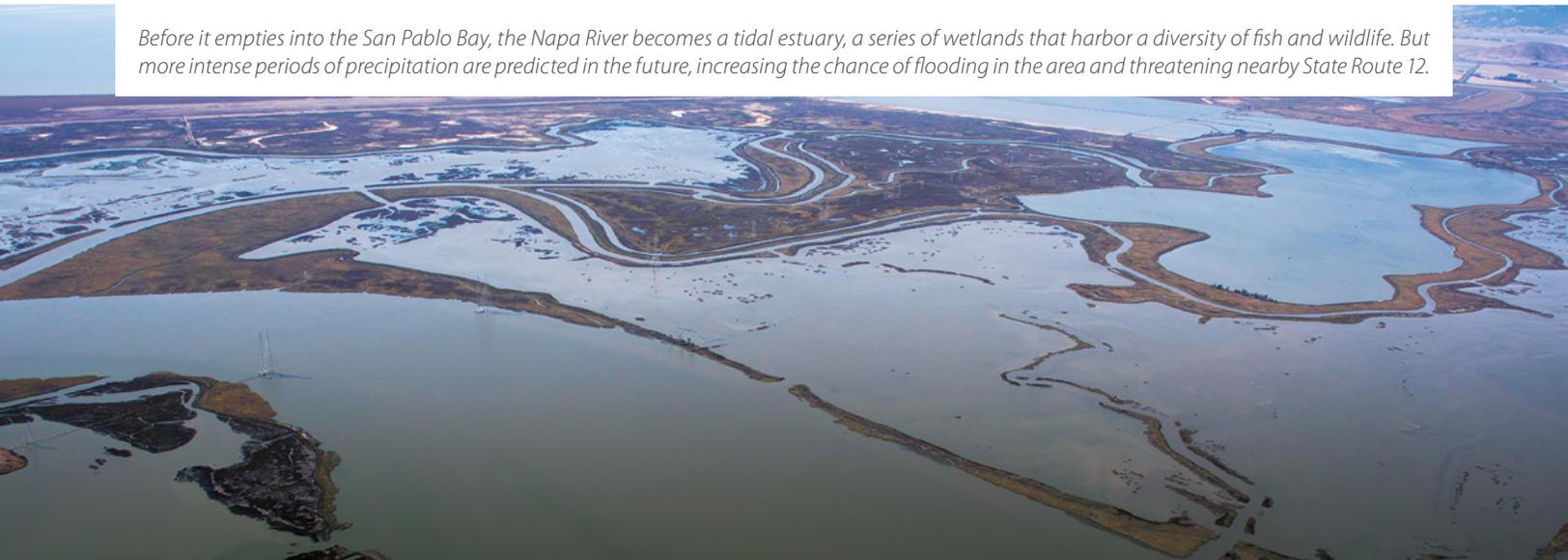
On a statewide scale, more than 800 miles of coastline renders California vulnerable to sea level rise. Roads, homes, power plants and water treatment facilities all are at risk of inundation by 2050.

Roads at Risk to Sea Level Rise in the Bay Area



- Flooded Bayshore Road: Highway 37
- Flooded Bridge Access: I-80 Oakland
- Eroding Coastal Road: Highway 1
- 🌉 Bridge
- At-risk stretch of roadway
- At-risk areas of sea level rise

Before it empties into the San Pablo Bay, the Napa River becomes a tidal estuary, a series of wetlands that harbor a diversity of fish and wildlife. But more intense periods of precipitation are predicted in the future, increasing the chance of flooding in the area and threatening nearby State Route 12.





On US 101 north of Ventura, travelers braved flames and choking smoke as wildfires charred the area in late fall 2017 — usually well past the fire season. Because of changing weather patterns, parts of the state will be more susceptible to destructive blazes, according to a Caltrans report.

Increased threat of wildfires

The Tubbs and Nuns fires in Sonoma County, and the Atlas fire in Solano and Napa counties, represent three of the most destructive wildfires in recorded California history — with a combined 143,000 acres burned, 7,800 structures damaged or destroyed, and 29 lives lost.

About 42 miles of the highway system were within the areas impacted by the October 2017 wildfires. Various roadways were closed over 16 days as the fires raged, including US 101, and State Routes 121, 29, 128, and 12. Highway repairs in District 4 after the fires were extinguished cost \$14.4 million.

Hillsides denuded by wildfire are especially vulnerable to erosion and pose a heightened risk of mudslide during

heavy rains. The report concludes that by 2085, almost 14 miles of roadway in District 4 (portions of Santa Clara, Solano and Napa counties) would be more vulnerable to wildfires — with Highway 130 in Santa Clara County at most risk.

Wildfires have become a top concern for agencies such as Caltrans. California’s fire seasons are expected to enter a more dangerous cycle of intense periods of precipitation, fueling plant growth, followed by prolonged droughts — a recipe for disastrous wildfires fed by dried-out vegetation.

Higher temperatures

Heat waves have buckled pavement and strained the electrical grid in parts of California. Elevated temperatures, dry vegetation and ground conditions could affect roadways, foundations, retaining walls and bridge joints.

Much of the Bay Area enjoys cooler coastal air, but inland eastern areas could experience as much as a nine-degree rise at the height of heat waves by midcentury, according to the report.



Caltrans photo by Lelia Charli Harris

The Thomas Fire in Ventura County last December destroyed road signs and guardrail, and toppled trees onto the highway.

Miles of Roadways in Moderate to High Wildfire Exposure Areas (estimated)

County	Miles		
Santa Clara	1.0	2.8	4.0
Solano	—	4.0	7.5
Napa	—	1.4	2.4
	2025	2055	2085

Economic impacts of climate change

Road closures pose major implications for the economic health of the area, which depends on a stable transportation system. The Bay Area is a major freight hub, with the nation's fifth most active container port (the Port of Oakland) and several specialized seaports; two of the most active air cargo airports in the western U.S. (San Francisco International Airport and Oakland International Airport); major rail lines and rail terminals; freight distribution centers and warehouses; and highways that carry some of the highest volumes of trucks in California, according to the [Metropolitan Transportation Commission](#) (MTC), the transportation planning, financing and coordinating agency for the nine counties in the Bay Area.

Caltrans coordinated with various state and federal agencies and academic institutions for this study. Consultant WSP (formerly WSP/Parsons Brinckerhoff) worked with Caltrans staff to produce the document.

Lawmakers, Caltrans proactive on climate change

The assessments represent the latest in Caltrans' series of actions on the climate change front. The Department has taken numerous steps to reduce its greenhouse gas emissions in the areas of maintenance, materials used,

project planning activities, and facilities, as described in its 2013 report, [Caltrans Activities to Address Climate Change](#). Caltrans also developed the [Guidance on Incorporating Sea Level Rise](#) document for use by Caltrans Planning staff and Project Development Teams as a strategy to protect California's transportation infrastructure.

Caltrans maintains a dedicated Climate Change Branch under its Division of Transportation Planning, and features a [webpage](#) about climate change on its website.

State lawmakers set the precedent with Assembly Bill 32 — the California Global Warming Solutions Act of 2006 — that established with a broad program that gave the state power to regulate, and reduce, greenhouse gas emissions in California. The Legislature took the climate change fight further with a pair of bills that required state agencies such as Caltrans to prepare and take into account climate change impacts as part of their overall transportation strategy, and in all phases of project development project delivery, maintenance and continued investments in transportation assets.

Gov. Edmund G. Brown Jr. issued an Executive Order in 2015 that climate change be considered in all state investment decisions using life cycle accounting methods, among other related actions.

The [Road Repair and Accountability Act of 2017](#) (Senate Bill 1) also includes funds for climate change mitigation. SB 1 allots \$20 million over three years to local and regional agencies for adaptation planning for a warming climate, awarded on a competitive basis.

The next steps in Caltrans' climate change response will be to plot a strategy for the future. After identifying the transportation elements at risk from climate changes or severe weather incidents, the Department can then develop repair/replacement cost scenarios, loss of use estimates, and response priorities. Reports are now being prepared that explore the best way to achieve long-term highway system resiliency.

The District 4 summary assessment, more extensive technical report and interactive mapping application can be accessed on the district's [website](#). **MM**



The Montecito mudslide looked like an impenetrable mess at first, but Caltrans and first responders had US 101 open in two weeks.

Sources: *Climate Change Vulnerability Assessment*; Reza Navai, Assistant Division Chief, Division of Transportation Planning; Julia Biggar, Climate Change Branch Chief; Tracey Frost, Supervising Transportation Planner; Dillon Miner, associate transportation planner



Near Pacifica on Highway 1, the Tom Lantos Tunnels project bypassed an unstable cliffside known as Devil's Slide that frequently buried the highway in rock. Two 1,000-foot bridges shown here being constructed connect the north portal of each tunnel to Highway 1. The tunnels opened in 2013.

Projects Planned, Built to Withstand Climate Shift

A changing climate was a major factor in the design and engineering of a pair of major projects on the Northern and Southern California coastline.

The North Coast Corridor is a long-term collaborative effort involving Caltrans and local agencies to upgrade the transportation system in San Diego County. Over its expected 40-year lifespan, the project proposes additional lanes on Interstate 5, coastal rail and transit improvements, more environmental protections and coastal access.

Consultants prepared a sea level analysis as part of the massive San Diego-area project. It noted that large amounts of beach and wetlands along the shorelines of Del Mar and Oceanside could erode by 2050. The report also said a combination of river and sea level rise could, on occasion, be enough to exceed design guidelines for several bridges.

In the analysis, consultants said that designs for bridges and other infrastructure should consider, if necessary, appropriate adaptation strategies.

In Northern California, the Tom Lantos Tunnels between Montara and Pacifica in San Mateo County bypass a stretch of Highway 1 near a steep and unstable cliff known as Devil's Slide. For years, the roadway was repeatedly buried by tons of rock, prompting costly repairs

The recently released Climate Change Vulnerability Assessment advocates adaptive design, which considers the uncertainties associated with a changing climate.

and long periods of detours. Rather than continue to fight the natural forces, Caltrans decided to bypass the area prone to slides by tunneling, creating a new, more stable passageway.

The recently released [Climate Change Vulnerability Assessment](#) advocates adaptive design, which considers the uncertainties associated with a changing climate. Toward that end, the report recommends adopting a Federal Highway Administration model called the "Adaptation Decision-Making Assessment Process," or ADAP.

ADAP incorporates broader economic social costs, as well as the future climate conditions, into the design decision-making process. The Caltrans assessment suggests that folding adaptive design into its design and construction processes will enable Caltrans to create a durable, resilient transportation system that can absorb adverse weather events associated with climate change.