CALTRANS CLIMATE CHANGE

VULNERABILITY ASSESSMENT

STATEWIDE SUMMARY REPORT

Caltrans | WSP

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KEY DEFINITIONS:

- **ADAPTATION:** The steps taken to prepare a community or modify an asset prior to a weather or climate-related disruption to minimize or avoid the impacts of that event. An example of an adaptation strategy would be elevating an asset in an area likely to experience increased flooding in the future.
- **CLIMATE CHANGE:** Refers to long term variations in average, or typical, weather patterns that define global, regional, and local climates. Modern day, global climate change is attributed to anthropogenic additions of greenhouse gas emissions to the atmosphere.
- **CLIMATE STRESSOR/HAZARD:** An event or condition resultant from a changing climate that could have a potential negative impact, such as to system performance and condition. Stressors and hazards can occur suddenly (e.g., flooding) or be part of a long- term trend (e.g., sea level rise).
- **EXPOSURE:** The presence of infrastructure in places and settings where it could be adversely affected by hazards and threats, for example, a road in a floodplain.[1]
- **GLOBAL CLIMATE MODEL (GCM):** A numerical representation of the Earth's climate system that is based on the physical, chemical, and biological properties of its components, their interactions, and feedback processes.[2]
- **LOCALIZED CONSTRUCTED ANALOGS (LOCA) DOWNSCALING TECHNIQUE:** A technique for downscaling climate model projections of the future climate.[3]
- **REPRESENTATIVE CONCENTRATION PATHWAYS (RCP):** Represent four different pathways of 21st century greenhouse gas emissions and concentrations. The RCPs include a stringent mitigation scenario (RCP 2.6), two intermediate scenarios (RCP 4.5 and RCP 6.0) and one scenario with very high greenhouse gas emissions (RCP 8.5). Scenarios without additional efforts to constrain emissions ("baseline scenarios") lead to pathways ranging between RCP 6.0 and RCP 8.5.[4]
- **RESILIENCE:** The ability of a system to absorb, recover from, or successfully adapt to adverse events.
- **VULNERABILITY:** Per the Federal Highway Administration, "the degree to which a system is susceptible to or unable to cope with adverse effects of climate change or extreme weather events."[5]

1 This definition is adopted from the Intergovernmental Panel on Climate Change (IPCC) 5th Assessment Report. 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

2 Ibid.

3 "What is LOCA." David Pierce, Scripps Institution of Oceanography. Accessed February 1, 2019. http://loca.ucsd.edu/what-is-loca/

4 Planning and Investing for a Resilient California: A Guidebook for State Agencies. March 13, 2018. Governor's Office of Planning and Research. http://opr.ca.gov/docs/20180313-Building_a_Resilient_CA.pdf

5 FHWA. 2014. "FHWA Order 5520. "Transportation System Preparedness and Resilience to Climate Change and Extreme Weather Events." Dec. 15. Retrieved June 30, 2020 from https://www.fhwa.dot.gov/legsregs/directives/orders/5520.cfm

BACKGROUND

The California Department of Transportation (Caltrans) manages California's State Highway System, which includes over 50,000 miles of highway. Caltrans is dedicated to providing a safe, sustainable, integrated, and efficient transportation system for California's residents and travelers. To ensure the longevity and quality of the State Highway System, Caltrans must anticipate future challenges—for this reason, the agency is assessing California's changing climate and how it may affect the State Highway System in terms of damage, travel disruption, and long-term maintenance needs. In addition, as a state agency, Caltrans must respond to recent executive orders and legislative requirements and consider climate change impacts to state investments. See the "California Climate Policy" callout box for some of the key state policies that require state agencies to prepare for climate change.

Caltrans completed a statewide *Caltrans Climate Change Vulnerability Assessment* for the entire State Highway System in 2019. This study involved applying climate data to refine the agency's understanding of potential climate impacts to the State Highway System, and Caltrans coordinated with various state and federal agencies and academic institutions to obtain the best available climate data for California. Discussions with professionals from various engineering disciplines helped identify how changing climate hazards may affect highways, including their design. The assessment allowed Caltrans to begin to understand how climate change may affect the highway and identified a subset of State Highway System assets on which to focus future efforts.

CALIFORNIA CLIMATE POLICY

Several California state climate change adaptation policies apply to Caltrans' decision-making. Some of the major Executive Orders and legislative requirements include:

- **Executive Order (EO) N-19-19 -** Redoubles the state's efforts to "reduce greenhouse gas emissions and mitigate the impacts of climate change." The EO also requires that the California State Transportation Agency leverage $5 billion annual state transportation spending to lower fuel consumption and reduce GHG impacts from the transportation sector.[1]
- **Executive Order (EO) B-30-15** – Requires the consideration of climate change in all state investment decisions through the use of full life cycle cost accounting, the prioritization of adaptation actions which also mitigate greenhouse gases, the consideration of the state's most vulnerable populations, the prioritization of natural infrastructure solutions, and the use of flexible approaches where possible.
- **Assembly Bill 1482** – State agencies and departments must prepare for climate change impacts through efforts including: continued collection of climate data, consideration of climate in state investments, and the promotion of reliable transportation strategies.[2]
- **Assembly Bill 2800** – Requires state agencies to consider potential climate impacts during planning, design, building, operations, maintenance, and investments in infrastructure. It also created a Climate-Safe Infrastructure Working Group consisting of engineers and architects with relevant experience from multiple state agencies, including Caltrans.[3]

1 Executive Order N-19-19," California Office of the Governor, October 7, 2020, https://www.gov.ca.gov/wp-content/uploads/2020/10/10.07.2020-EO-N-82-20-.pdf
2 "Assembly Bill No. 1482," California Legislative Information, October 8, 2015, https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201520160AB1482
3 "Assembly Bill No. 2800," California Legislative Information, September 24, 2016, https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160AB2800

PURPOSE OF THE REPORT

The Caltrans Climate Change Vulnerability Assessment is the first effort of many to gather the critical data needed to understand and effectively respond to climate change impacts on the State Highway System. Each of Caltrans' 12 districts developed Climate Change Vulnerability Assessment Technical and Summary Reports that included their assessment methodologies, findings, potential challenges, and ongoing efforts. The Caltrans website includes all reports. This Caltrans Climate Change Vulnerability Assessment Statewide Summary provides an overview and synthesis of the 12 district Summary Reports and highlights Caltrans' planned next steps. Caltrans is taking both top-down and bottom-up approaches to holistically address the climate change hazards and risks posed to the highway network. Advancing these next steps will enable Caltrans to incorporate climate change assessments in project development, integrate such considerations into multiple aspects of agency decisions, and ensure that staff and stakeholders are engaged. These efforts will culminate in a resilient highway network for the State of California.

NEXT STEPS

The Caltrans Climate Change Vulnerability Assessment initiated a series of next steps for Caltrans to continue to assess climate change vulnerability, as well as prioritize and prepare adaptation responses. Caltrans has identified the following next steps:

- Create a series of district-level **Adaptation Priorities Reports** to rank the most vulnerable assets on the State Highway System for facility-level study.
- Conduct **facility-level assessments of climate change impacts and adaptation options** to highest priority assets.
- Integrate resilience into the **project development and delivery process**.
- Evaluate how **asset management** could track asset impacts and costs from climate change, and adaptation decisions.
- **Influence decision-making** within Caltrans by considering how future climate can be accounted for in planning, design, and other agency actions.
- **Coordinate with stakeholders** to ensure that climate change adaptation projects meet the needs of relevant stakeholders and affected communities.
- **Create tools to implement adaptation** and streamline facility-level assessments.
- **Train Caltrans staff** on how to use the reports, data, and tools produced.

See the "Applying Findings" and "Next Steps" sections of this report for more detail about ongoing and planned Caltrans efforts to advance climate change assessments and adaptation.

OVERVIEW OF VULNERABILITY ASSESSMENT METHODOLOGY

The methodology used to determine the vulnerability of highway system assets varies from one climate stressor to another. Each stressor uses a different set of models, emissions scenarios, and assumptions, and will cause different types of impacts to the State Highway System. Each stressor evaluated has its own dedicated section of this report, but an overview of the general methodology is provided here.

STATE HIGHWAY SYSTEM

Though Caltrans manages different transportation assets around the state, the Climate Change Vulnerability Assessment focused on the State Highway System and the assets that make up the system (e.g., bridges, culverts). Caltrans focused on its highways as they are critical to serving transportation needs and economies across the state, and Caltrans is responsible for managing their condition.

Caltrans evaluated State Highway System exposure to climate stressors one district at a time, for each of the 12 districts across the state. See the statewide map of the Caltrans district boundaries on the following page.

CLIMATE STRESSORS

As climate changes over time, it presents a range of climate stressors or hazards to infrastructure, public health and safety, natural systems, the economy, and other assets and systems that we rely on for a functional society. For Caltrans, the agency needed to consider which climate hazards would impact the State Highway System and its users. At the start of the vulnerability assessment, Caltrans met with internal and external subject matter experts to discuss which climate hazards could impact the highway system and why. Through these conversations, Caltrans focused the assessment on specific events and conditions that could present consequences to the State Highway System. For example, rather than assessing average temperature rise, Caltrans decided to evaluate minimum and maximum temperature rise, as temperature ranges are used to determine highway pavement design. The climate hazards assessed and presented in this assessment are:

- **TEMPERATURE RISE:** Average minimum air temperature and average maximum temperature.[4]
- **CHANGING PRECIPITATION:** Change in precipitation during a 100-year storm event.
- **WILDFIRE:** Expected areas burned over time.
- **SEA LEVEL RISE:** Inundation from different sea level heights with an annual storm event.[5]
- **STORM SURGE:** Flooding from different sea level heights with a 100-year storm event.
- **CLIFF RETREAT:** Expected erosion from different sea level rise heights.[6]

Caltrans analyzed projections for each of the climate stressors and, where possible, identified sections of the State Highway System exposed to that event or condition. For example, sections of highway that pass-through sea level rise inundation areas were flagged as exposed.

Climate stressors varied from district to district. While all districts are affected by temperature rise, changing precipitation, and wildfire, only the coastal districts, along with Districts 3 and 10, are affected by sea level rise.

4 Average maximum temperature was calculated over seven consecutive days.
5 The annual storm was applied depending on the model used.
6 Assumes no interventions to stop the erosion and retreat.

GLOBAL CLIMATE MODELS

The analysis presented in this report is largely based on global climate data compiled by the Intergovernmental Panel on Climate Change (IPCC) and California research institutions like the Scripps Institution of Oceanography. This data was developed to estimate the Earth's natural response to increasing greenhouse gas emissions in the atmosphere. Research institutions represent these physical processes through Global Climate Models (GCMs). 32 different GCMs have been downscaled to a regional level and refined so they can be used specifically for California. Of those, ten were identified by California state agencies to be the most applicable to California. This analysis used all ten of these representative GCMs in the temperature and precipitation assessments, but only the median model (50th percentile result) is reported due to space limitations.

REPRESENTATIVE CONCENTRATION PATHWAYS

The IPCC represents future emissions conditions through a set of representative concentration pathways (RCPs) that reflect scenarios for greenhouse gas emission concentrations under varying global economic forces and government policies.

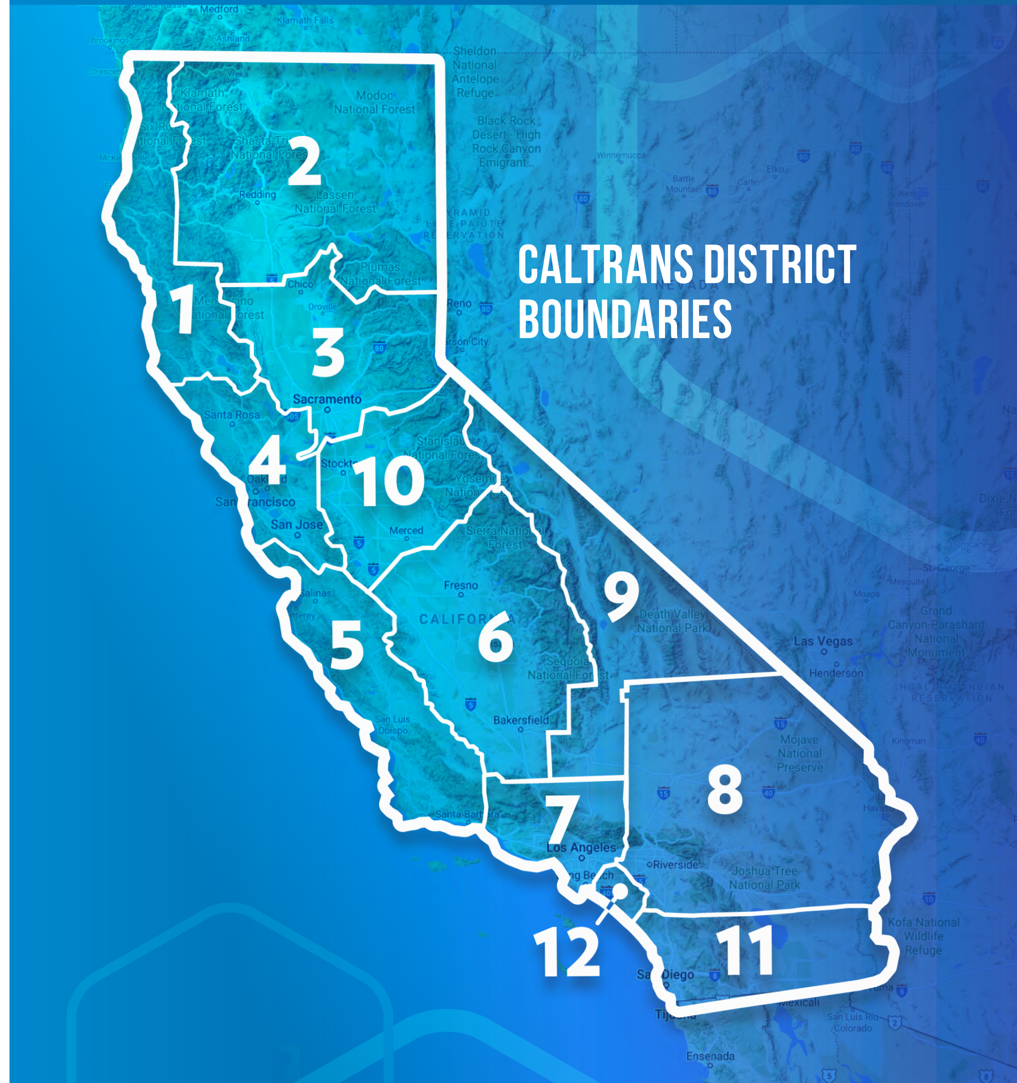
The scenarios used in this assessment are:

- RCP 2.6, which assumes that global annual greenhouse gas emissions will peak in the next few years.
- RCP 4.5, which assumes that emissions will peak near mid-century.
- RCP 8.5, which assumes that high emission trends continue to the end of century.

This statewide summary report presents results from RCP 8.5 for the temperature, precipitation, and wildfire assessments as it generally represents "business as usual" and a continuation of current trends. The district Technical Reports also present RCP 4.5 for the same stressors. The sea level rise projections referenced in this assessment use RCP 2.6 and 8.5.

TIME FRAMES

It is helpful to present climate projections in a way that allows for comparison across the same time periods for different stressors. For this study, the time frames were defined as the beginning, middle, and end of century, represented by the years 2025, 2055, and 2085, respectively. Each of these years represents an averaged 30-year period, 2010 to 2039, 2040 to 2069, and 2070 to 2099, compared to a historical time period of 1975 to 2004. The coastal hazards analyzed did not use these time frames, but rather projections are shown for three different sea level rise heights. These increments were typically 1.64, 3.28, and 5.74 feet of sea level rise, but vary somewhat depending upon data availability for different regions of the state.



DISTRICT 2 | CORNING STATE ROADSIDE REST AREA

TEMPERATURE RISE

According to the US National Climate Assessment, the "number of extremely hot days is projected to continue to increase over much of the United States, especially by late century. Summer temperatures are projected to continue rising, and a reduction of soil moisture, which exacerbates heat waves, is projected for much of the western and central US in summer."[7] California's size and its many highly varied climate zones cause inconsistent temperature rise across the state.

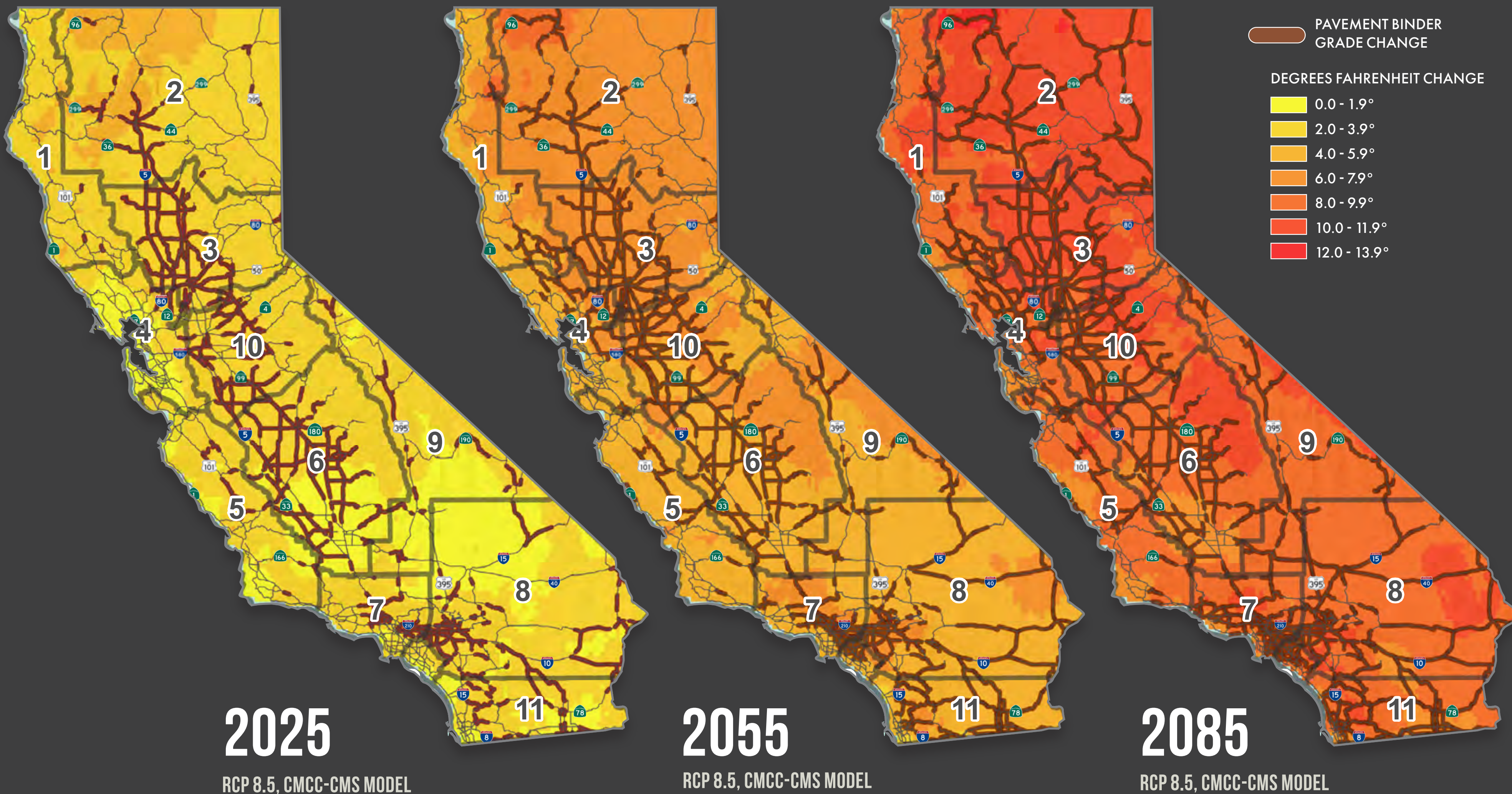
On the following page, Figure 1 shows the average maximum temperature change over seven consecutive days within three different time periods compared to data from 1975 to 2004. Caltrans evaluated the minimum and maximum temperature changes because they are important considerations for selecting pavement binder–the "glue" that binds asphalt aggregates. Regional climate determines which binder mix to use because if the weather is too cold, pavements can contract and crack, and if it is too hot, pavements can expand leading to running and rutting. As temperatures rise, pavement binder chosen for cooler climates may become unsuitable. Figure 1 highlights portions of the State Highway System where the historical pavement binder temperature range is is exceeded. Notice that as time goes on, more of the network becomes exposed to high temperatures that could affect pavement conditions.

Average maximum temperatures will rise across the state and at least portions of each district are projected to experience a 10 – 11.9°F increase in average maximum temperatures over the coming century. However, the greatest temperature rise will be in Northern California, the Central Valley, and part of the Sierra Nevada. District 2 is projected to experience much higher average maximum temperatures.

7 "Extreme Weather," US National Climate Assessment, accessed April 29, 2019, http://nca2014.globalchange.gov/report/our-changing-climate/extreme-weather

FIGURE 1

INCREASE IN THE AVERAGE MAXIMUM TEMPERATURE OVER SEVEN CONSECUTIVE DAYS



Maps represent the change in the average maximum temperature over seven consecutive days for RCP 8.5 and the approximate median model (CMCC-CMS) as calculated across the state using the area weighted mean. Original temperature data is from Cal-Adapt and was downscaled by the Scripps Institution of Oceanography using the Localized Constructed Analogs (LOCA) technique. Exposed sections of the state highway network are where binder grades need to change from current practice based on projected temperature data for that time period. This data was provided under RCPs 4.5 and 8.5, for current conditions (1975-2004) and three future horizons represented by the years 2025, 2055, and 2085, and for ten climate models. Feature classes are arranged by future horizon year and RCP, with fields for binder grade recommendations from each of the ten GCMs.

PRECIPITATION

California has historically experienced a wide range in rain and snowfall (precipitation). This variation includes monthly and yearly rainfall, and it is normal for the state to experience long droughts and rainy periods. Unusually wet years are caused by heavy, winter precipitation events fed by "atmospheric rivers" from the Pacific Ocean. While these storms make beneficial contributions to snowpack, they can also cause flooding. As temperatures rise, atmospheric rivers will hold more moisture and become stronger, which can lead to more extreme precipitation events. While average precipitation is not expected to change drastically, the variance between wet and dry years may become more extreme, leading to more dry years and heavier storm events.[8]

More intense storms, combined with other land cover and land use changes, can raise the risk of infrastructure damage or loss from flooding. Flooding can cause landslides, washouts, erosion, and structural damage to infrastructure—all of which affect California's transportation assets. In the winter of 2016-17, California experienced a very wet year after a long drought. This highly productive winter caused flooding across the state and approximately $1 billion in damages for Caltrans. For this reason, the precipitation analysis focuses on the projected changes to one type of extreme event.

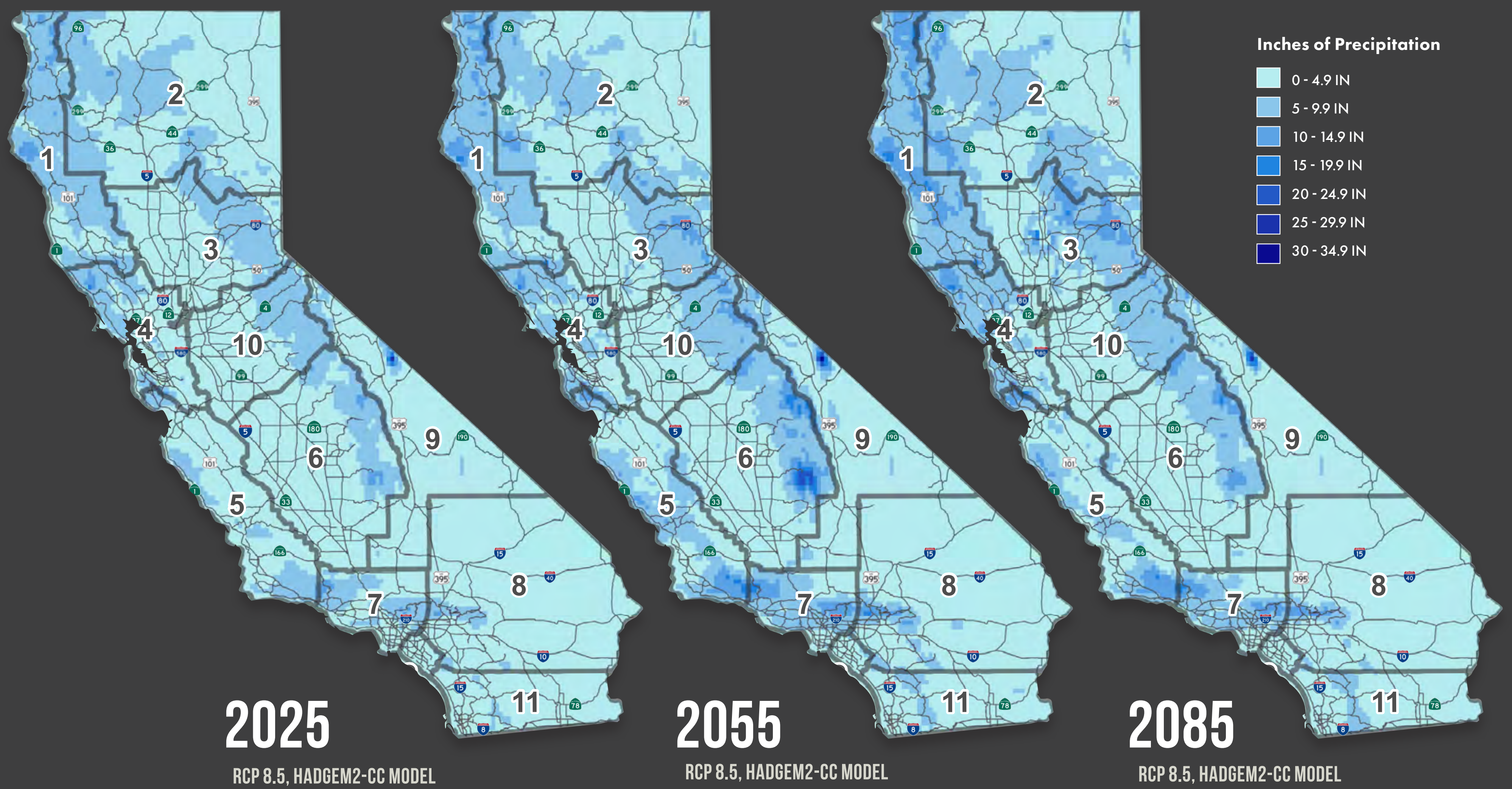
The Scripps Institution of Oceanography at the University of California, San Diego, has downscaled global precipitation data to the year 2100 using RCP 4.5, RCP 8.5, and a variety of models. A storm with a likelihood of occurring once every 100 years (or a one percent chance of occurring in any given year) is known as a "100-year storm event" and it is used by Caltrans to determine certain design measures, such as how high to build a bridge above a waterway. Understanding how the 100-year storm may change in the future can help Caltrans to build more resilient infrastructure that can accommodate heavier storm events. The change in the 100-year storm depth was processed statewide using 10 different models—the median model is shown on the following page.

Figure 2 shows the inches of daily precipitation expected in a 100-year storm event. Parts of Districts 6 and 9 are projected to experience the heaviest precipitation from a 100-year storm, compared to conditions statewide. The highest modeled historical 100-year storm depth is 20 inches, which increases to up to 30 inches by middle and end of century.[9]

8 Bedsworth, Louise, et al. 2018. Statewide Summary Report. California's Fourth Climate Change Assessment. Publication number: SUMCCCA4-2018-013. Accessed on January 3, 2021 from https://www.climateassessment.ca.gov/state/index.html

9 Using the approximate median model for the state (HadGEM2-CC).

FIGURE 2 | MAXIMUM DAILY 100-YEAR STORM PRECIPITATION DEPTH



Maps represent the maximum 100-year return period 24 hour precipitation depth for the historical time period 1975-2004, and the three future time periods (early century (2010-2039), mid-century (2040-2069), and late century (2070-2099). The maps apply the approximate median model (HadGEM2-CC) as calculated across the state using the area weighted mean and the RCP 8.5 scenario. The cell value indicates the 100-year return period daily precipitation depth in inches at that location. Original precipitation data is from Cal-Adapt and was downscaled by the Scripps Institution of Oceanography using the LOCA technique. There are methodological challenges associated with using downscaled GCM projections to derive changes in future extreme precipitation events. Results should be compared across multiple models to make informed decisions that account for this uncertainty.

DISTRICT 12 | TRIANGLE COMPLEX FIRE | NOVEMBER 2018

photo by jstanden | CC

2017 THOMAS FIRE EVACUATIONS | PHOTO BY SALVADOR LOPEZ-ZAMORA

WILDFIRE

Changing precipitation patterns and higher temperatures (which decrease the moisture in vegetation and soils) are expected to affect both the intensity and scale of wildfires. Wildfires can contribute to flooding and landslides by burning off protective land cover and reducing the ability of the underlying soil to absorb rainfall. California is already prone to serious wildfires, and future climate forecasts suggest that this vulnerability will get worse.

Devastating wildfires have become frequent in recent years—six of the top 20 largest California wildfires occurred in 2020 and half of the top 20 largest wildfires have occurred in the past decade.[10] The State Highway System can be greatly affected by wildfires, which can have cascading impacts as highway functions are critical before and after wildfire events. Wildfire debris can litter roadways, making them unsafe, and debris can clog culverts and damage the undersides of bridges. After wildfires, heavy rain can trigger land and mudslides and cause additional evacuations, road closures, and damages.

The red-shaded areas in Figure 3 represent an increased likelihood of wildfires based on projected percentages of area burned over time. This data was generated by the following wildfire models: MC2 – EPA (from the United States Forest Service), MC2 – Applied Climate Science Lab (University of Idaho), and the Cal-Adapt 2.0 (UC Merced). Each model was paired with three downscaled GCMs to produce nine future scenarios. Incorporating three different wildfire models was a conservative approach because the final data shows the highest wildfire risk categorization for all model results. Figure 3 provides the RCP 8.5 results (the high-emissions scenario). Table 1 summarizes the lengths of the State Highway System that passes through medium to very high wildfire exposure areas.

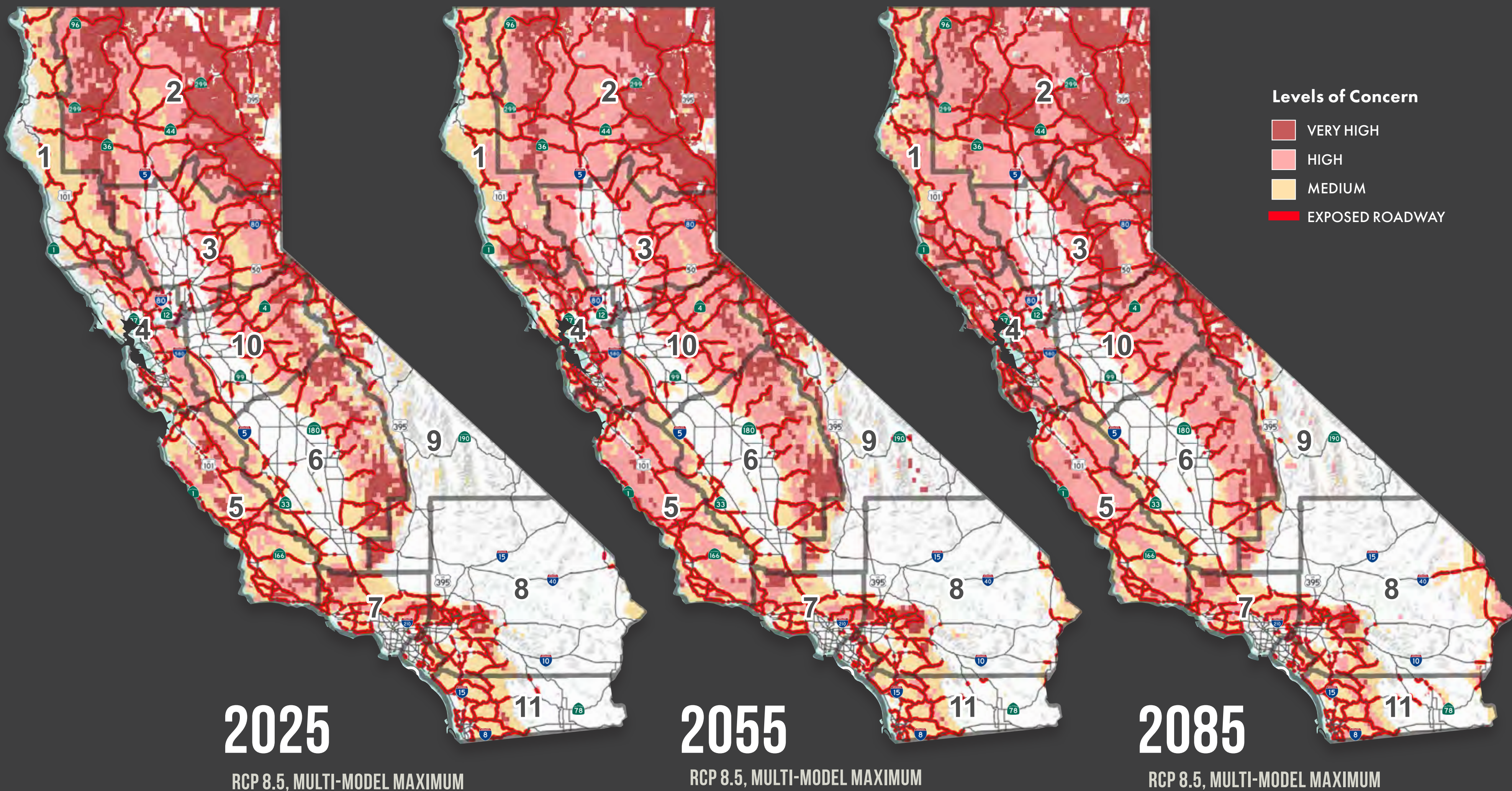
Area burned is expected to increase over time across much of the state, with the greatest exposure anticipated for mid- and end of century. District 2 has by far the greatest exposure, with over 1,500 miles of its State Highway System passing through medium, high, or very high wildfire exposure areas by end of century. Districts 1, 3, 5, and 10 also have large portions of the State Highway System passing through wildfire-concern areas.

Table 1: Centerline Miles of Highway Exposed by Year

District	Year 2025	Year 2055	Year 2085
1	585	702	784
2	1519	1534	1544
3	743	743	743
4	377	546	631
5	761	837	875
6	638	630	638
7	442	451	461
8	483	556	655
9	296	333	349
10	781	786	786
11	371	378	423
12	71	72	72
Total	**7068**	**7567**	**7961**

10 Cal Fire. "Top 20 Largest California Wildfires." Accessed on January 3, 2021 from https://www.fire.ca.gov/media/4jandlhh/top20_acres.pdf

FIGURE 3 | CHANGING LEVEL OF WILDFIRE CONCERN



The fire model composite summaries shown are based on wildfire projections from three models: (1) MC2 - EPA Climate Impacts Risk Assessment, developed by John Kim, USFS; (2) MC2 - Applied Climate Science Lab at the University of Idaho, developed by Dominque Bachelet, University of Idaho; and (3) University of California Merced model, developed by Leroy Westerling, University of California Merced. For each of these wildfire models, climate inputs were used from three GCMs: (1) CAN ESM2; (2) HAD-GEM2-ES; and (3) MIROC5. The maps show the multi-model maximum for each grid cell across the nine combinations of the three fire models, the three GCMs, across three future horizons represented by the years 2025, 2055, and 2085.

SEA LEVEL RISE

Sea level rise presents a serious, near-term challenge for California. Rising temperatures expand ocean volumes, which combine with glacial and ice sheet melt to raise global sea levels. This rise is leading to more "sunny day flooding," which is flooding from typical tidal events without storm surge. Eventually, sea level rise will permanently inundate low-lying areas.

Sea level rise is already threatening cities and counties along the California coast and Sacramento-San Joaquin River Delta (the Delta). This means that many coastal and Delta highways, bridges, and facilities are facing risk of future damages and inundation. The iconic Pacific Coast Highway (State Route 1) already experiences flooding, scour, erosion, and damage from waves and high surf, which is being exacerbated by sea level rise. See the District 4 (Devil's Slide Project) and District 7 (Trancas Creek Bridge Replacement) Climate Change Vulnerability Assessment Summary Reports for examples of damages and repairs to State Route 1.

Like other climate change forecasts, sea level rise projections vary, depending in part on the assumptions made for greenhouse gas concentrations and nature's response. The Ocean Protection Council (OPC) *State of California Sea Level Rise Guidance: 2018 Update* provides the most recent sea level rise scenarios for 12 California coastline locations. This guidance document also provides direction on how to use the projections in project planning and decision-making.

These OPC projections were used alongside a variety of different sea level rise models to identify the State Highway System's exposed areas. To date, no one sea level rise model covers the entire coastline and Delta, so Caltrans assessed sea level rise exposure using best available sea level rise models in California from the US Geological Survey (USGS), National Oceanic and Atmospheric Administration (NOAA), and Climate Central. The models and associated sea level rise heights applied for each district are:

- The USGS Coastal Storm Modeling System (CoSMoS) model was applied in Districts 4, 7, 11, and 12 for sea level rise heights ranging from 0 to 6.56 feet (2.00 meter), and a high 16.40 feet (5.00 meter) scenario.
- The NOAA model was applied in Districts 1 and 5 for sea level rise heights ranging from 1 foot (0.30 meters)[11] to 10 feet (3.05 meters).
- The Climate Central model was applied in the Delta for Districts 3 and 10 (and part of District 4) for sea level rise heights ranging from 0 to 6.56 feet (2.00 meters), and a high 16.40 feet (5.00 meters) scenario.

All sea level rise heights from each model were applied in the *Caltrans Climate Change Vulnerability Assessment.* Figure 4 on the following page shows State Highway System exposure to three increments of rising sea levels. Similar sea level rise heights are applied across the models used and the maps approximately represent sea level rise from 2.00, 3.00, and 6.00 feet. Table 2 shows the centerline miles of State Highway System exposed to these approximate sea level rise heights. The lowest level (2.00 feet) is expected to occur between 2050 and 2100, depending on the location on the California coast and the OPC sea level rise scenario.

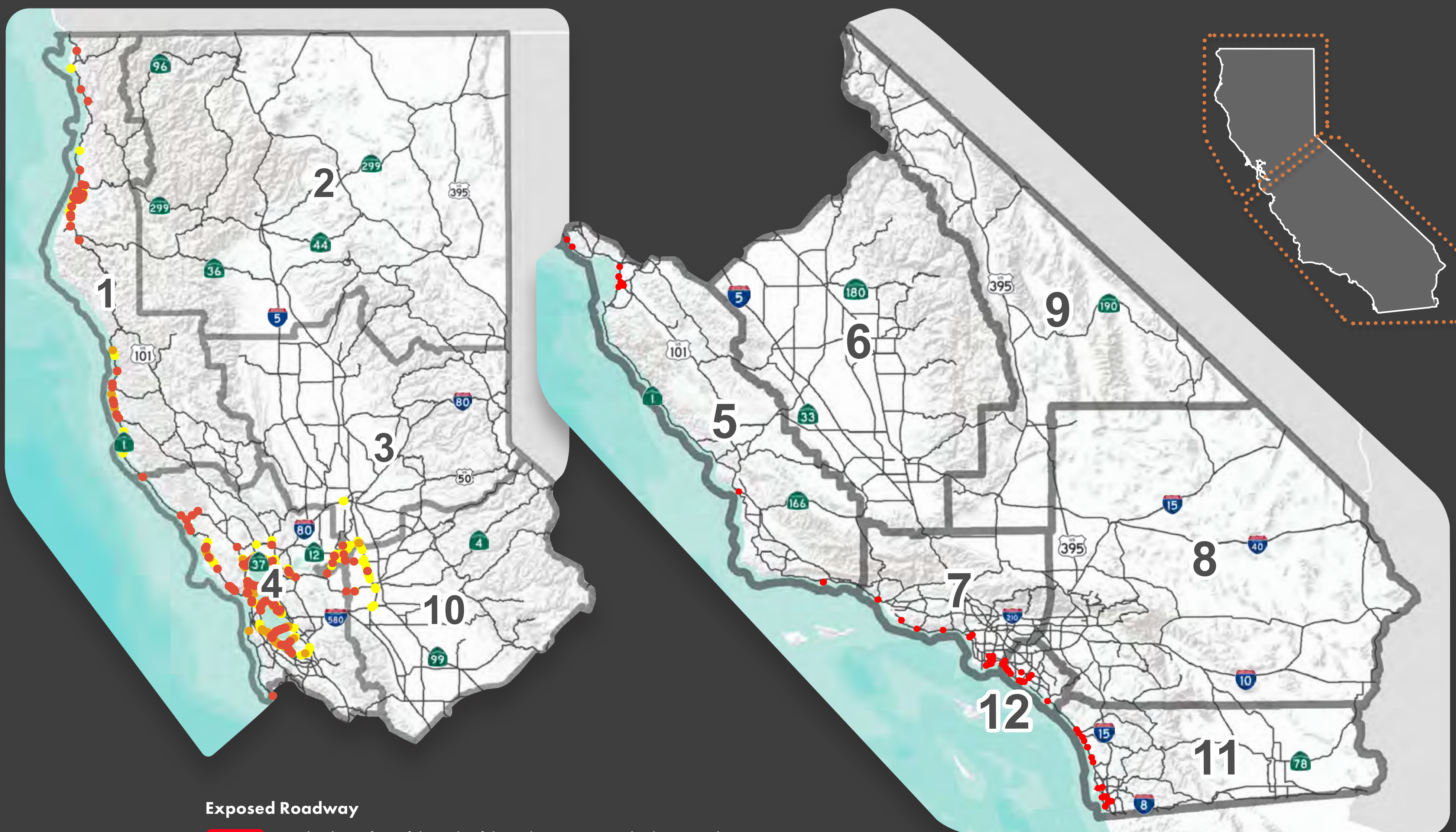
Table 2: Centerline Miles of State Highway System Exposed to Sea Level Rise

District	Approximate Sea Level Rise Height		
	2.00 ft (0.60 m)	3.00 ft (0.91 m)	6.00 ft (1.83 m)
1	3.3	6	14.8
3	1.1	1.1	10.8
4	33.9	54.2	94.3
5	0.3	0.4	2.4
7	2.8	4.2	9.3
10	0.3	0.3	13.9
11	2.0	3.6	6.2
12	2.8	5.2	8.7
Total	46.4	75.1	160.4

Note: Sea level rise heights applied for Districts 3, 7, 10, 11, and 12 are for 1.64, 3.28, and 5.74 feet. Sea level rise heights applied for Districts 1 and 5 are 2.00, 3.00 and 6.00 feet. Centerline miles were not calculated for the Delta portion of District 4 in this assessment. Sea level rise inundation extents received from Climate Central were clipped to be consistent with the storm surge data described in the next section. Mileage includes bridges, which may not flood under sea level rise but could be damaged by rising water levels.

11 The CoSMoS sea level rise modeling included an annual storm event.

FIGURE 4 | SEA LEVEL RISE INUNDATION



Exposed Roadway

- Sea level rise of 1.64 ft (0.5 m); 2 ft (0.6 m) in Districts 1 and 5 (Near term)
- Sea level rise of 3.28 ft (1 m); 3 ft (.91 m) in Districts 1 and 5
- Sea level rise of 5.74 ft (1.75m); 6 ft (1.83m) for District 1 and 5 (Long term)

Coastal sea level rise and annual storm data applied is from the US Geological Survey, Coastal Storm Modeling System (CoSMoS) and from the National Oceanic and Atmospheric Administration (NOAA). See Our Coast, Our Future/the USGS CoSMoS webpage and the NOAA Sea Level Rise viewer for more information on the respective models. Delta sea level rise data was provided by Climate Central; shapefiles represent inundation at the NOAA mean high higher water (MHHW) tidal datum for the Sacramento-San Joaquin River Delta. Levees and other flood control structures, including those that are unmapped that are captured in elevation data, are included in this data and are assumed to provide adequate flood protection unless overtopped. Data limitations, such as an incomplete inventory of levees and their heights, make assessing protection by levees difficult. See the Surging Seas Risk Zone Map for more information on the Climate Central sea level rise data.

CALIFORNIA SEA LEVEL RISE PROJECTIONS AND GUIDANCE

DISTRICT 11 | STORM SURGE FLOODS
DISTRICT 11 OFFICE FALL 2017

Ocean Protection Council Sea Level Rise Guidance

Various agencies and research institutions have developed sea level rise estimates for California. The OPC *State of California Sea Level Rise Guidance: 2018 Update* provides the most recent sea level rise scenarios for 12 locations across the California coastline. These projections were developed for tide gauges along the California coast based on global and local factors that drive sea level rise, such as thermal expansion of ocean water, glacial ice melt, and expected vertical land movement. See the OPC guidance document for more information and sea level rise projections for the 12 locations.[12] See the *Caltrans Climate Change Vulnerability Assessment* district reports for sea level rise projections for coastal districts.

The OPC guidance presents several sea level rise scenarios, including:

- A "likely" range (66% probability that sea level rise falls within this range)
- A median (50%) probability scenario
- A 1-in-20 (5%) probability scenario
- A low (0.5%) probability scenario
- An extreme (H++) scenario to be considered when planning for critical or highly vulnerable assets with a long lifespan

Each of these values are provided for low (RCP 2.6) and high (RCP 8.5) greenhouse gas concentration pathways to show a full range of potential projections over time. The OPC recommends using only RCP 8.5 for projects with a lifespan to 2050 and using both scenarios for projects with longer lifespans. Given inherent modeling input uncertainties, the OPC also recommends assessing a range of future projections to guide project decision-making. OPC guidance includes when to use certain projections based on the risks associated with various projects types. Currently, the OPC suggests that transportation projects are medium-high risk decisions that should consider these scenarios:

- **Medium to high-risk decisions**
  For projects with a long useful life (such as highway projects), the OPC recommends considering the low (0.5%) probability scenario.
- **High-risk decisions**
  For projects related to critical infrastructure, the OPC recommends considering (among other scenarios) the extreme (H++) scenario.

The OPC developed this guidance to help state and local governments understand future risks associated with sea level rise and incorporate these projections into work efforts, investment decisions, and policy mechanisms. The OPC recognizes that the science surrounding sea level rise projections is still improving and anticipates periodic guidance updates. New findings are inevitable, so Caltrans will use new guidance as it becomes available and further refine how to best incorporate it into capital investment decisions.

12 California Ocean Protection Council, State of California Sea-Level Rise Guidance: 2018 Update, March 14, 2018, http://www.opc.ca.gov/webmaster/ftp/pdf/agenda_items/20180314/Item3_Exhibit-A_OPC_SLR_Guidance-rd3.pdf

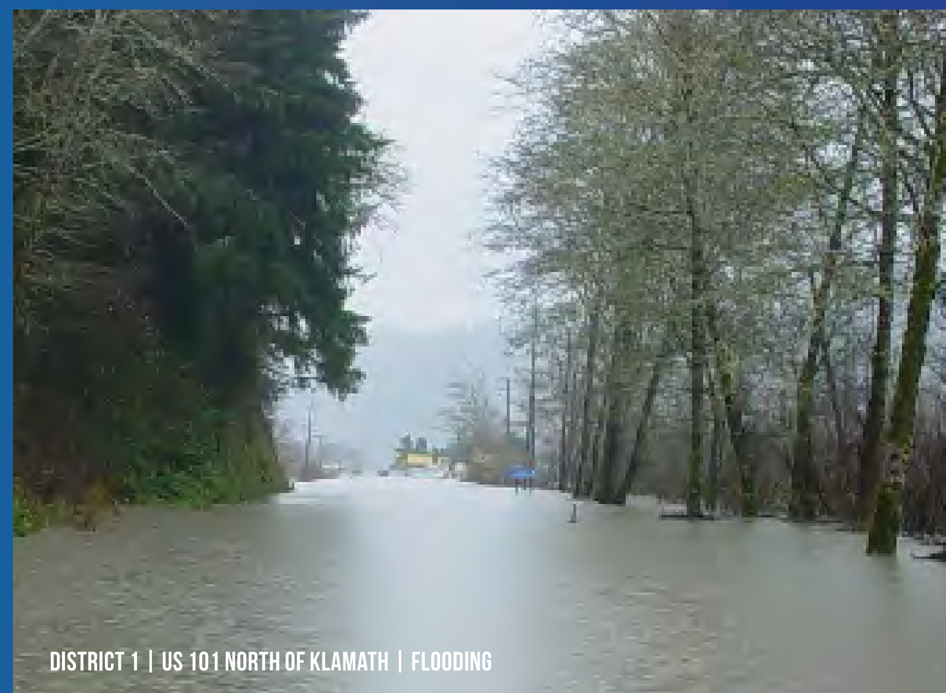
California Coastal Commission Sea Level Rise Guidance

The California Coastal Commission (Coastal Commission) Sea Level Rise Policy Guidance document was adopted in August of 2015 and updated following the OPC's release of its 2018 guidance.[1] The Coastal Commissions' document focuses on implementing the Coastal Act (the primary law governing coastal development) in a way that recognizes and responds to sea level rise. The guidance provides a step-by-step process using the latest science to determine a range of sea level rise projections in the project area, identify potential impacts, develop adaptation strategies, and incorporate those strategies into Local Coastal Programs (LCPs). Similar guidance applies to addressing sea level rise in Coastal Development Permits. The California Coastal Commission and local agencies with certified LCPs will evaluate how sea level rise was analyzed throughout the Caltrans project development process when Coastal Development Permits are required for Caltrans projects. Projects in the coastal zone must therefore consider sea level rise in all aspects of project delivery. Caltrans uses both Coastal Commission and OPC guidelines to ensure sea level projections are evaluated and properly accounted for.[2]

1 California Coastal Commission, "California Coastal Commission Sea Level Rise Policy Guidance: Interpretive Guidelines for Addressing Sea Level Rise in Local Coastal Programs and Coastal Development Permits," July 2018, https://www.coastal.ca.gov/climate/slrguidance.html

2 See the Caltrans "Sea Level Rise and the Transportation System in the Coastal Zone" webpage for more resources and information on project planning in the coastal zone: https://dot.ca.gov/programs/environmental-analysis/coastal-program/coastal-act-policy-resource-information/coastal-hazards/sea-level-rise

DISTRICT 12 | SR 1 | 2008 FLOOD EVENT



DISTRICT 1 | US 101 NORTH OF KLAMATH | FLOODING

STORM SURGE

Storm surge is defined as a rise of water "generated by a storm, over and above the predicted astronomical tide." The primary cause of storm surges are strong winds during storm events, which push water forward and cause "vertical circulation." In deep water the effect is minimal, but when the storm reaches the coastline, the circulation pushes water onshore.[13] Storm surge can significantly worsen coastal area flooding, which will become more damaging as sea levels rise. Even now, storm events expose coastal roads, bridges, and other transportation infrastructure to flooding, erosion, and wave run-up.

As with the sea level rise analysis, the *Caltrans Climate Change Vulnerability Assessment* used data from a variety of models to understand the potential impacts of sea level rise and storm surge on the State Highway System. The USGS CoSMoS data was used to assess sea level rise and storm surge impacts to the State Highway System in Districts 4, 7, 11, and 12. The model provides outputs for a variety of storm events, including an annual storm, 20-year storm, 100-year storm, and a King Tide. The model projects storm-event flooding using sea level rise heights ranging from 0.82 feet (0.25 meters) to 16.40 feet (5.00 meters). The assessment evaluated all sea level rise heights, but this report highlights only the results from the 100-year storm analysis and three sea level rise heights (1.64, 3.28, and 5.74 feet).

Data from the CalFloD-3D model data was used to assess sea level rise and storm surge impacts to the State Highway System in Districts 1, 3, 5, 10, and part of District 4 (in the Delta). UC Berkeley researchers developed the model to understand sea level rise and 100-year storm event risks to the California coast and the Delta. The model applies real water level data from past near-100-year storm events to better understand storm surge inland flows.[14]

See Figure 5 for a map of segments of the State Highway System exposed to sea level rise and a 100-year storm event for heights of 1.64 ft (0.50 m), 3.28 ft (1.00 m), and 4.62 ft (1.41 m)/5.74 ft (1.75) (depending on the model used). Table 3 provides a summary of the mileage of highway network exposed to flooding. The greatest length of exposed highway is in District 4, where even near-term sea level rise could lead to approximately 50 centerline miles of roadways flooded or otherwise affected. See the Climate Change Vulnerability Assessment: District 4 Summary Report for a map of sea level rise and surge impacts to Corte Madera Creek. District 1 is the next most affected district, with up to 20 centerline miles exposed to 4.62 feet (1.41 meters) of sea level rise with a 100-year storm.

Table 3: Centerline Miles of State Highway System Exposed to Sea Level Rise and a 100-Year Storm Event

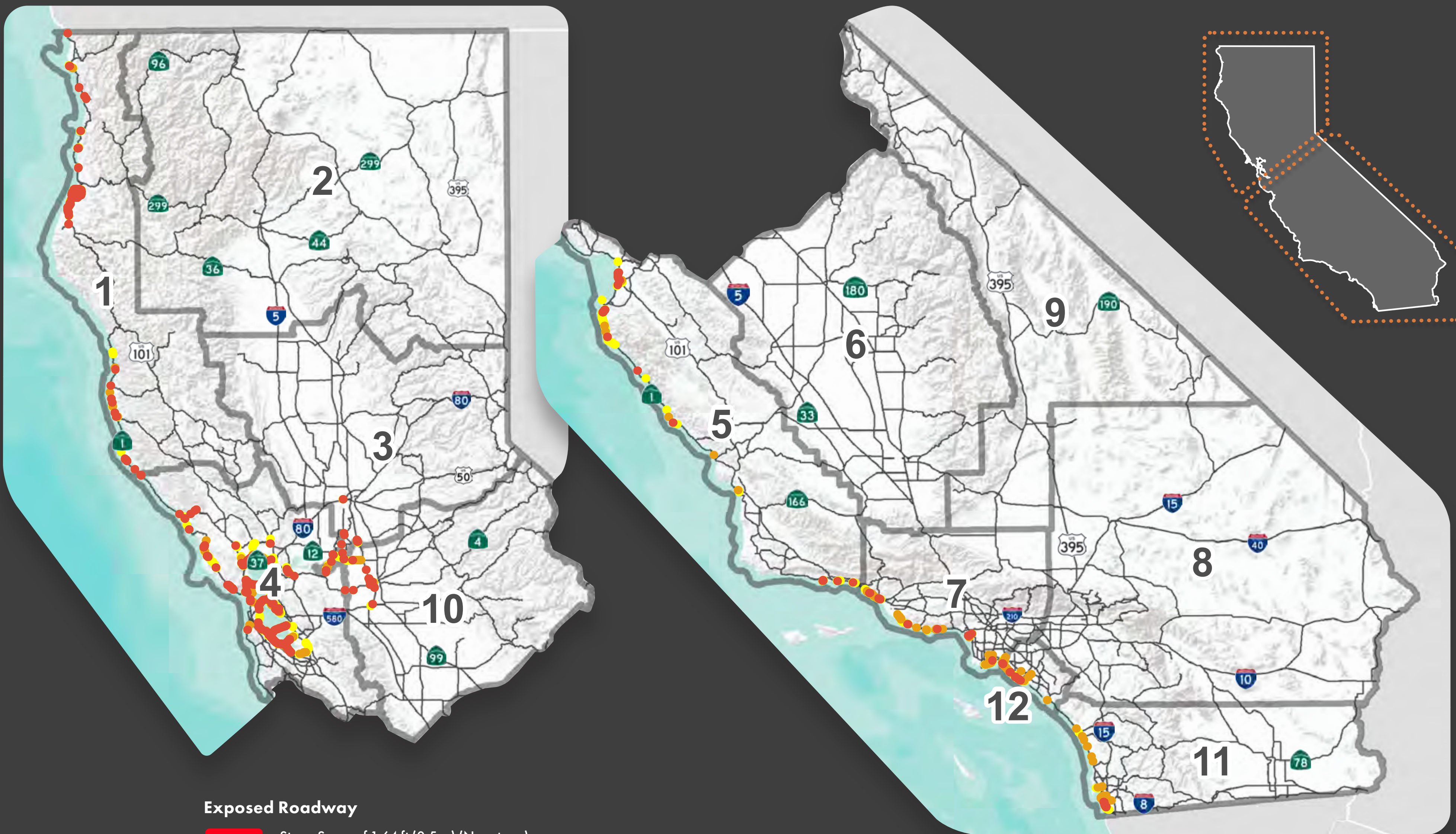
District	Sea Level Rise Height			
	1.64 ft (0.50 m)	3.28 ft (1.00 m)	4.62 ft (1.41 m)	5.74 ft (1.75 m)
1	11.6	17.0	20.5	–
3	1.8	2.3	10.7	–
4	49.2	68.9	–	110.2
5	2.7	3.6	13.9	–
7	5.7	8.7	–	17.2
10	0.8	5.3	10.5	–
11	2.7	4.9	–	7.7
12	3.7	6.2	–	11.9

Note: 4.62 ft (1.41 m) is only applied for districts that use the CalFloD-3D model (Districts 1, 3, 5, and 10). 5.74 ft (1.75 m) is only applied for districts that use the CoSMoS model (Districts 4, 7, 11, and 12). Centerline miles were not calculated for the Delta portion of District 4 in this assessment. Mileage includes bridges, which may not flood under sea level rise and surge but could be damaged by storm events.

13 "Introduction to Storm Surge," National Oceanic and Atmospheric Administration, last accessed May 21, 2019, https://www.nhc.noaa.gov/surge/surge_intro.pdf

14 John Radke, et al., (University of California, Berkeley), "Assessment of Bay Area Natural Gas Pipeline Vulnerability to Climate Change," California Energy Commission, Publication number: CEC-500-2017-008, 2016, accessed from https://cal-adapt.org/media/files/CEC-500-2017-008.pdf

FIGURE 5 | FLOODING FROM SEA LEVEL RISE AND STORM SURGE



Exposed Roadway

- Storm Surge of 1.64 ft (0.5 m) (Near term)
- Storm Surge of 3.28 ft (1 m)
- Storm Surge of 5.74 ft (1.75 m); 4.62 ft (1.41 m) Districts 1, 3, 5, and 10 (Long term)

Coastal sea level rise and storm surge (100-year storm) data applied is from the US Geological Survey, Coastal Storm Modeling System (CoSMoS). See Our Coast, Our Future and the USGS CoSMoS webpage for more information on the model. Districts 1 and 5, and the Delta districts (Districts 3, 10, and part of District 4) applied sea level rise and storm surge data from the 3Di modeling (CalFloD-3D) conducted by Dr. John Radke's team at the University of California, Berkeley, and featured on the Cal-Adapt website. CalFloD-3D is a three-dimensional hydrodynamic model that captures the dynamic effects of storm surge flooding.

CLIFF RETREAT

Accelerated beach and bluff retreat is another anticipated sea level rise impact. Cliff retreat occurs when waves impact the base of a cliff and hydraulic action carves out a portion of the cliff face. This loss of rock and soil increases over time and undermines support for the cliff itself, eventually resulting in the collapse of the cliff face. As this process continues, the cliff recedes, or "retreats," from its original position. Examples of this effect are seen throughout California, most notably (as described in a recent study of historic cliff retreat rates) in San Onofre, Portuguese Bend, Palos Verdes, Big Sur, Martins Beach, Daly City, Double Point, and Point Reyes.[15]

The USGS CoSMoS model was the main model used for the cliff retreat assessment. The CoSMoS data was available for the southern Bay Area to Southern California, and all districts except District 1 and the northern half of District 4 used it. The USGS CoSMoS cliff retreat data is provided in 0.82 feet (0.25 meter) increments from 0 to 6.56 feet (0 to 2.00 meters), and include a much higher 16.40 feet (5.00 meter) scenario (this analysis included all of these heights, but only three are presented here). The model's data uses two different assumptions—one which assumes that coastal armoring will be 100% effective at preventing cliff retreat ("hold the line"), and the other assumes that coastal armoring is ineffective, and cliff retreat continues past current protections ("do not hold the line").[16] For this analysis, the "do not hold the line" scenario was applied to assess the full potential of cliff retreat impacts. CoSMoS also provides a "shoreline erosion" dataset that this assessment did not incorporate due to its focus on cliff retreat.

UC Berekely developed the data used for the District 1 and northern District 4 assessments. The UC Berkeley researchers reviewed existing sea level rise and coastal erosion information developed by the Pacific Institute and USGS and used Google Earth to identify District 1 coastline areas currently experiencing active erosion. They also used NOAA elevation data to understand existing coastline conditions. The information collected helped identify which coastline sections are at risk from accelerated erosion and cliff retreat due to sea level rise.

The following characterizes concern levels for at-risk sites:

- **CRITICAL:** Signs of ongoing road distress to erosion (or erosion encroachment). Requires immediate attention and on-site inspections.
- **MEDIUM:** Signs of erosion and potential distress — they should be carefully reviewed and surveyed to create a baseline of current conditions.
- **LOW:** Should be monitored and periodically surveyed to track erosion.

Caltrans will consider the trade-offs between engineered coastline protection solutions and physical retreat strategies when responding to long-term cliff retreat. Coastal districts are already grappling with decisions on how to best protect the State Highway System from coastal erosion. For example, District 5 realigned State Route 1 from Point Piedras Blancas to North of the Arroyo de la Cruz Bridge in northern San Luis Obispo County due to years of erosion (see the District 5 Climate Change Vulnerability Assessment Summary Report for details). As sea level rise accelerates erosion and cliff retreat, Caltrans expects to implement other similar projects. The State Highway System in Districts 1, 5, and 7 is especially vulnerable to the impacts of oncoming cliff retreat (see Table 4 and Figure 6).

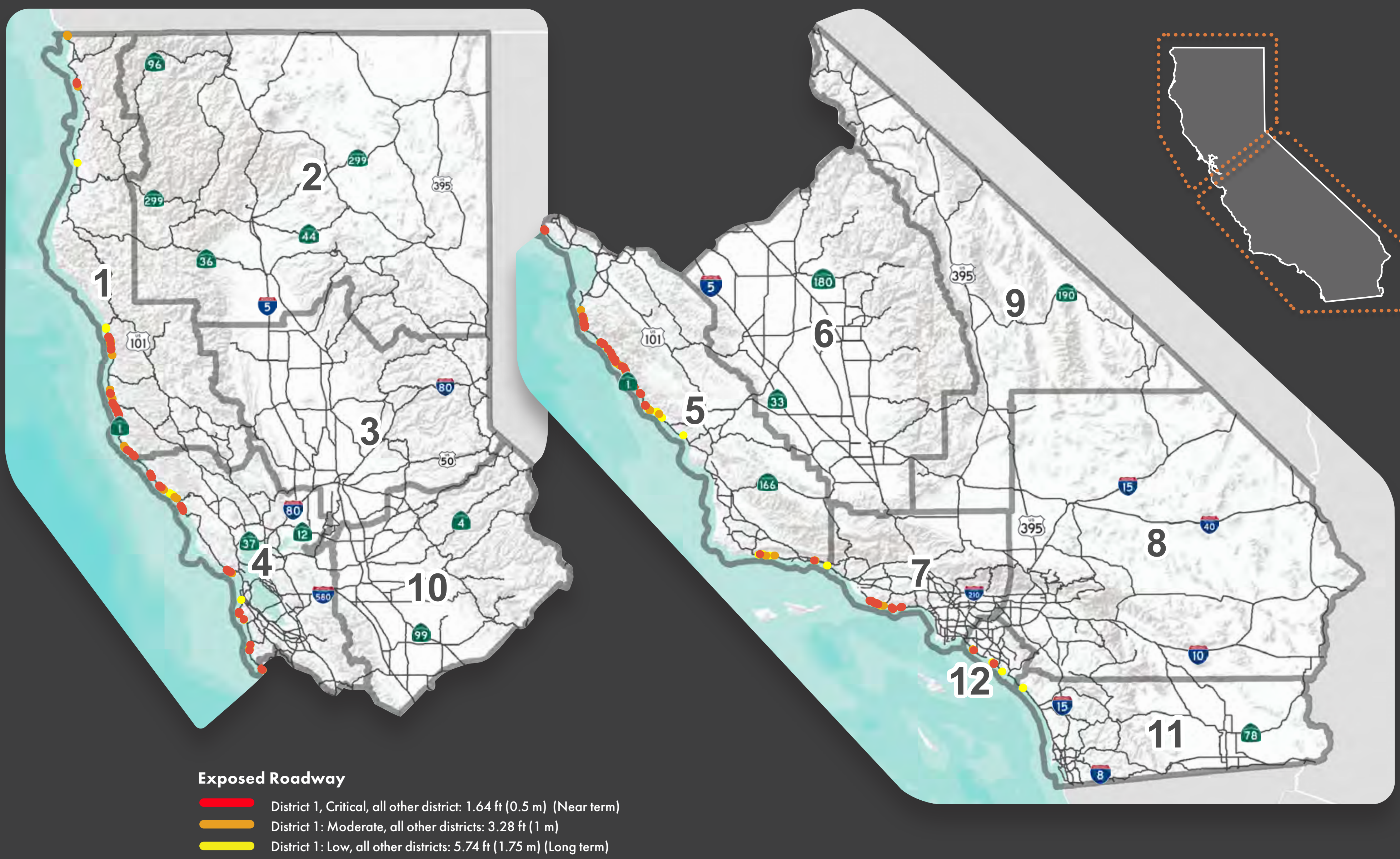
Table 4: Centerline Miles of State Highway System Exposed to Cliff Retreat

District	Sea Level Rise Height				
	0.82 ft (0.25 m)	1.64 ft (0.50 m)	3.28 ft (1.00 m)	5.74 ft (1.75 m)	6.56 ft (2.00 m)
1	7.5	-	12.3	-	13.2
4	4.4	-	8.9	-	9.9
5	2.5	5.5	9.1	12.4	13.2
7	2.5	4.3	5.3	5.6	5.7
11	0	0	0	0.1	0.1
12	0.1	0.3	0.4	0.6	0.7

Note: District 1 and the northern half of District 4 applied a qualitative model created by Dr. Nicholas Sitar at UC Berkeley, which defined cliff retreat hazard levels not tied to specific sea level rise heights. For the purposes of this assessment, the following sea level rise heights were used as proxies for each hazard level: "Critical" is 0.82 ft (.25 m), "Medium" is 3.28 ft (1.00 m), and "Low" is 6.56 ft (2.00 m). The other coastal districts and the southern half of District 4 used the USGS CoSMoS model. The centerline miles of exposure for northern and southern District 4 are summed together.

15 UC San Diego, "Study Identifies California Cliffs at Risk of Collapse," 2017, https://phys.org/news/2017-12-california-cliffs-collapse.html
16 "Coastal Storm Modeling System," ScienceBase-Catalog, Last modified July 12, 2019, https://www.sciencebase.gov/catalog/item/5633fea2e4b048076347f1cf

FIGURE 6 | ACCELERATED CLIFF RETREAT FROM SEA LEVEL RISE



Cliff retreat data is from the US Geological Survey, Coastal Storm Modeling System (CoSMoS). This data applies the "do not hold the line" management option, which assumes that cliff retreat continues unimpeded. See Our Coast, Our Future and the USGS CoSMoS webpage for more information on the model. The District 1 and northern District 4 (north of the Golden Gate Bridge) assessments of cliff retreat used data developed by UC Berkeley for the sole purpose of this study. The data identifies which sections of the District 1 and District 4 coastlines are at-risk from accelerated erosion and cliff retreat due to sea level rise. To develop this dataset, UC Berkeley researchers reviewed existing sea level rise and coastal erosion information developed by the Pacific Institute and USGS. Google Earth was used to identify areas along the coastline where there is active erosion today. Critical cliff retreat in District 1 and Northern District 4 is assumed to correspond to 0.82 ft (.25 m) of sea level rise.

APPLYING FINDINGS

DISTRICT 5 | SR 9 | BROOKDALE SLIPOUT | FINISHED VIADUCT

The *Caltrans Climate Change Vulnerability Assessment* created a new set of data points for the for Caltrans, including climate projections under a variety of models and scenarios and segments of the State Highway System exposed to these hazards. Caltrans is currently leveraging the assessment findings to prepare for current and future climate change challenges.

After the completion of the vulnerability assessment, Caltrans developed an *Adaptation Strategy Report*, which provides a list of agency-wide adaptation strategies recommended for implementation to increase agency resilience to climate change. These strategies include creating an organizational structure that integrates climate change adaptation into business operations, preparing design documents that use projected weather data (as opposed to historical data) and adjusting other project development and management processes to integrate climate change into decision-making across key aspects of the agency.

Caltrans also used the assessment's findings to develop an *Adaptation Priorities Report* for each district—the last reports will be finalized in 2021. The reports summarize a second stage of analysis that was completed to identify the most vulnerable assets for facility-level assessments and adaptations. By using the *Caltrans Climate Change Vulnerability Assessment* data, Caltrans developed an indicator-based scoring methodology to rank district assets by their vulnerability to climate hazards (e.g., exposure to sea level rise) and the potential consequences of impacts (e.g., detour distance around a damaged asset). Detailed facility-level assessments are recommended as a next step to focus on each district's highest priority assets to develop the best climate change adaptations. Caltrans would use an adaptation framework, such as the Federal Highway Administration's Adaptation Decision-Making Assessment Process (ADAP), for the facility-level assessments (see Figure 7).[17]

The prioritization effort helps Caltrans make initial decisions. First, because climate change projections vary across the state it would not make sense to implement change through a consistent standard. Caltrans is considering adapting certain design standards to account for future climate projections, but there are some cases where changing designs could lead to costly, unnecessary work, which needs to be avoided. Because projected precipitation and river flow changes are highly variable, they should not be addressed with a universal design standards, but rather with appropriate, cost-effective, customized solutions based in a determination of risk. Second, due to limited resources, Caltrans cannot evaluate all of its assets at once. Prioritizing the most vulnerable assets for further study allows Caltrans and each district to direct resources efficiently.

Caltrans is integrating its *Climate Change Vulnerability Assessment* into other agency reports and efforts, including:

- A high-level cost assessment of sea level rise and surge adaptation needs for the State Highway System
- A *Caltrans Climate Change Communication Guide* (2020) that provides Caltrans staff and their partners with a set of best practices for communicating the impacts of climate change and adaptation efforts[18]
- A *Caltrans Corridor Planning Process Guide* (in development)
- The *Caltrans Guidance on Incorporating Sea Level Rise: 2021 Update* (in development)

17 Adaptation Decision-Making Assessment Process," FHWA, last modified January 12, 2018, https://www.fhwa.dot.gov/environment/sustainability/resilience/ongoing_and_current_research/teacr/adap/index.cfm
18 Caltrans, Climate Change Communication Guide, (2020), accessed on January 1, 2021 from https://dot.ca.gov/-/media/dot-media/programs/transportation-planning/documents/caltransclimatecommunicationguidepdf-a11y.pdf

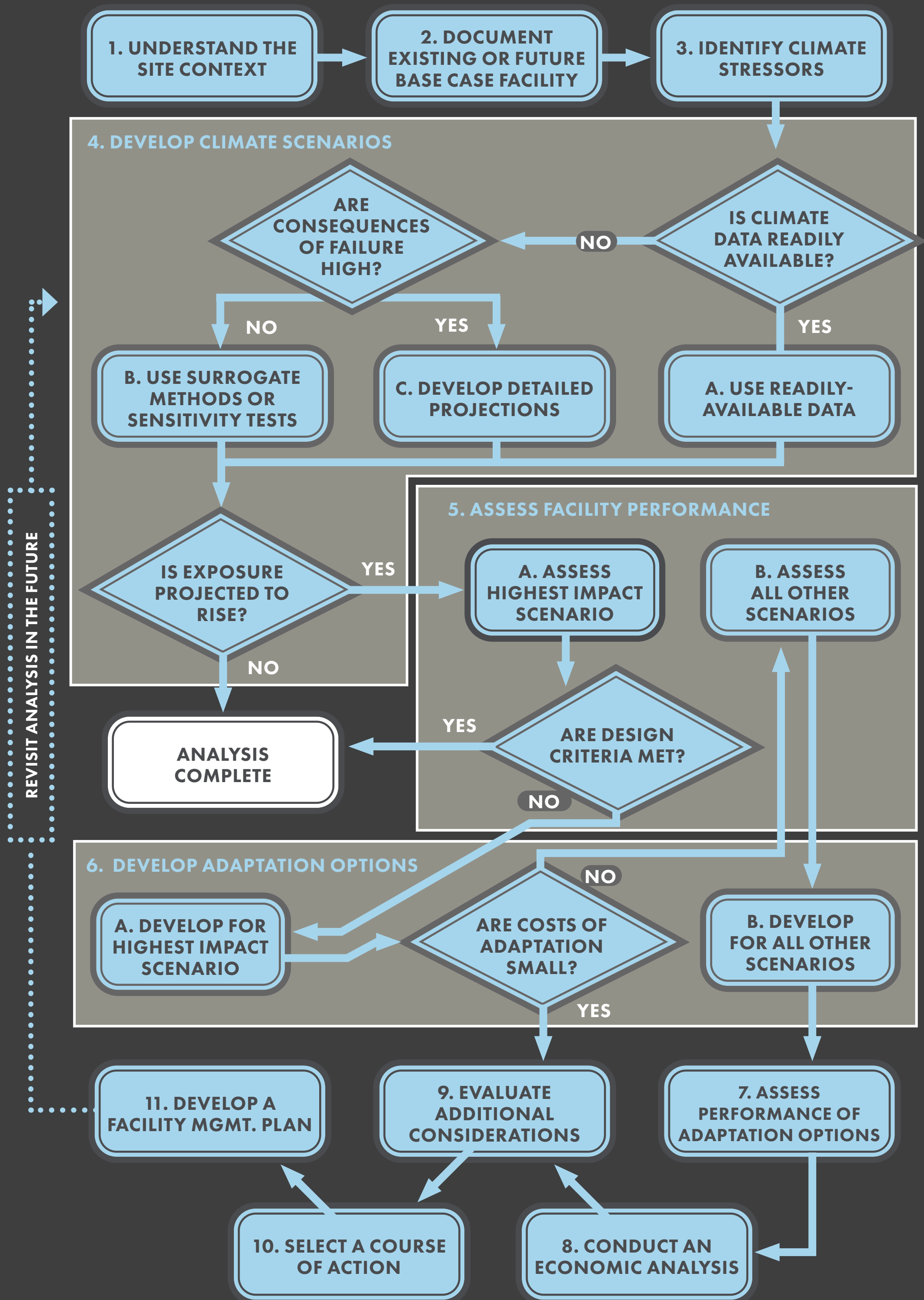


FIGURE 7 | FHWA'S ADAPTATION DECISION-MAKING ASSESSMENT PROCESS

NEXT STEPS

These efforts represent Caltrans' first actions to analyze and respond to climate change threats. Caltrans is beginning to outline a series of next steps to continue to assess State Highway System impacts, develop adaptation responses, and integrate climate change data and considerations into decision-making processes and agency practices. Caltrans plans to consider and progress the following next steps:

Asset Prioritization

- Create district Adaptation Priorities Reports that use an indicator-based scoring approach to rank State Highway System assets most vulnerable to the impacts of climate change. These reports will identify prioritized assets for detailed facility-level study of climate change and adaptation options. Other factors will also affect final prioritization and adaptations, including route criticality, population served, equity considerations, asset useful life, projects underway, funding availability, and cost considerations.

Facility-Level Assessments of Climate Change Impacts and Adaptation Options

- Use the *Caltrans Climate Change Vulnerability Assessment* and district *Adaptation Priorities Report* findings to begin conducting facility-level assessments of the State Highway System's most vulnerable, highest priority assets.
- Where needed, derive statewide, engineering-focused climate projections to inform facility-level assessments of climate change impacts and adaptation options.
- Evaluate potential funding streams for facility-level assessments of high priority assets.
- Use an existing (or develop a new) framework like ADAP to conduct facility-level assessments of top priority, vulnerable assets and evaluate adaptation options.

Incorporating Resilience into Project Development

- Develop an adaptation guidance document for how Caltrans will implement adaptation. The guidance should address:
  - How facility-level assessments and adaptation plans fit into the project development and delivery process.
  - How to incorporate stakeholder requirements and guidelines (such as Coastal Commission guidelines for Coastal Development Permits and the OPC State of California Sea Level Rise Guidance) into adaptation decisions
  - How to consider broader community needs and public input to ensure that adaptation responses are equitable and prioritize the needs of disadvantaged groups
  - How to develop adaptation strategies to make assets resilient to worsening future conditions (consider different strategies for different asset types and how to prioritize based on broader benefits)
  - How to understand the consequences of impacts from climate hazards, including the broader costs to State Highway System users
  - How to evaluate the cost-effectiveness of adaptation strategies before implementation

Asset Management

- Consider how climate change may affect future asset maintenance, rehabilitation, and replacement.
- Create a database (or leverage the asset management system) to monitor adaptations and document recurring impacts and changes in maintenance frequency.
- Evaluate cost of present day capital investments versus long term operations and maintenance needs.

Influence Decision-Making

- Integrate risk-based considerations of climate change into agency decision-making by evaluating consequences and costs of climate change in investments.
- Identify data gaps needed for decision-making. For example, detailed maintenance cost information may be needed to understand the consequences of climate impacts in the long term.
- Pursue agreed upon strategies as identified in the *Caltrans Adaptation Strategy Report*, which provides recommendations for different Caltrans departments (such as engineering and capital planning).
- Consider changing *Caltrans Highway Design Manual* designs to better account for future projections (as opposed to historical conditions). For example, it may be strategically beneficial to adjust pavement design requirements based on temperature projections to mitigate long-term pavement impacts statewide.

Stakeholder Coordination

- Coordinate with stakeholders involved in the Caltrans project development process, including state agencies and local entities, to ensure early and streamlined coordination on climate change impacts to a project. For example, the California Coastal Commission and local agencies with certified LCPs should be involved in the Caltrans project development process when Coastal Development Permits are required.
- Incorporate community needs and concerns into projects through public engagement. Wherever possible, Caltrans will develop adaptation strategies that provide broader community benefits equitably, by prioritizing the needs of disadvantaged or disproportionately vulnerable groups.

Create Tools to Implement Adaptation

- Create document templates and tools for benefit/cost analysis, cross-scenario decision-making, and climate projection acquisition to streamline facility-level assessments and implementation of the proposed adaptation guidance document.

Staff Training

- Train Caltrans staff on facility-level assessment of climate change impacts and adaptations and using the adaptation framework and proposed guidance. Periodically update the training to address the most current and important topics.

CALTRANS STATE HIGHWAY SYSTEM REPAIRS

DOOLEY CREEK BANK EROSION REPAIR | US 101

DISTRICT CLIMATE CHANGE VULNERABILITY ASSESSMENT ONLINE MAPPING TOOL

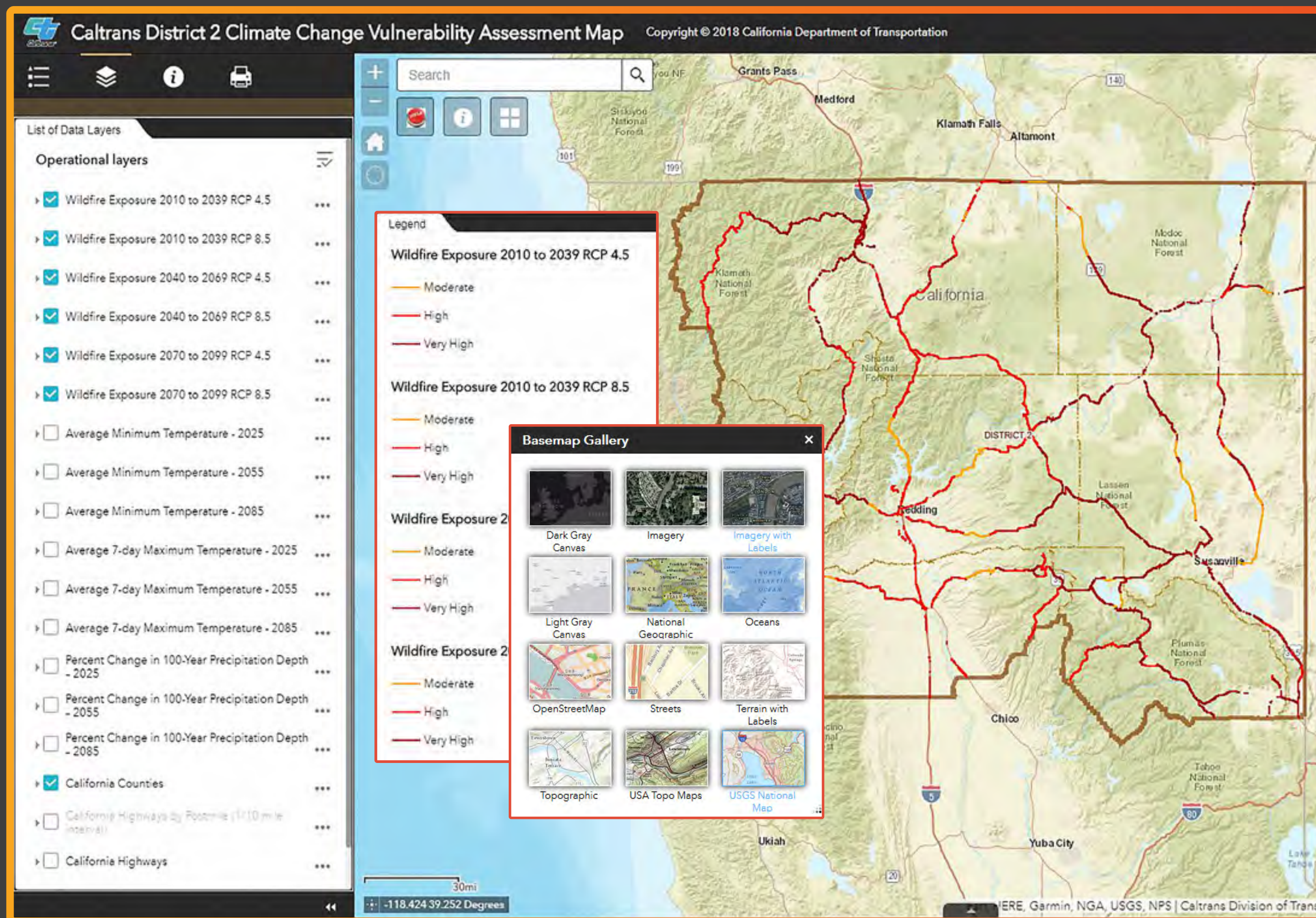
Caltrans created a ArcGIS Online mapping tool that allows users to view the data applied in the *Caltrans Climate Change Vulnerability Assessment*. Each district has its own vulnerability assessment map which can be accessed on the Caltrans website.

This tool enables Caltrans staff, stakeholders, policymakers, and California residents to view different climate change projections and identify the State Highway System's exposed areas. The map viewer is dynamic and incorporates new data as it is obtained from various Caltrans projects.

Identifying which Caltrans assets are exposed to threats from temperature rise, sea level rise, storm surge, cliff retreat, and wildfire events required complex geospatial analyses. The typical approach included:

- Collect or create stressor data: The first step in each GIS analysis was to obtain or create maps showing the climate stressor data for different models and RCPs over the coming century.
- Determining critical thresholds: To highlight areas affected by climate change, the geospatial analyses for certain stressors defined the critical thresholds for which the value of a hazard would be a concern to Caltrans.
- Overlaying the stressor layers with the Caltrans State Highway System to determine exposure: Once high hazard areas had been mapped, the next step was to overlay the Caltrans State Highway System centerlines with the climate stressor data to identify the segments of roadway exposed. State Highway System exposure was identified for temperature, wildfire, and coastal hazards, but not precipitation (see each stressor section for more information).
- Summarizing the miles of roadway affected: The final step in the geospatial analyses involved calculating the centerline miles of roadway affected by a given hazard.

After completing the geospatial analyses, the GIS data for each step was saved to a database, which will be a valuable tool for future Caltrans efforts. The data compiled is included in the online mapping tool.



Note: Caltrans makes no representation about the suitability, reliability, availability, timeliness, or accuracy of its GIS data for any purpose. The GIS data and information are provided "as is" without warranty of any kind. See the tool for more information.

DISTRICT 2 | DROUGHT-RESISTANT LANDSCAPING | ANTLERS BRIDGE, I-5 SHASTA COUNTY

DISTRICT 2 | HYDROSEEDING

CALTRANS CLIMATE CHANGE

VULNERABILITY ASSESSMENT

STATEWIDE SUMMARY REPORT