Climate Change Emphasis Area Guidance for Corridor Planning

MARCH 2022

CONTENTS

KEY TERMS **3**
INTRODUCTION/OVERVIEW **4**
POLICY/LEGISLATION **6**
STEP 1: SCOPE EFFORT **10**
Climate Hazards to Consider in a Corridor Plan 10
Potential Tools for Climate Change Analysis 14
Potential Partnerships and stakeholders to Consider 16
Internal Caltrans Functions 18
Existing Plans and Guidance to Consider in All Districts 19
Plans and Guidance to Consider in Coastal Areas 21
STEP 2: GATHER INFORMATION **24**
Climate Change Data Sources To Consider 24
Corridor Planning in Coastal Areas 29
Regional GHG Reduction Strategies 31
Social and Public Health Considerations Relating to Climate Change 32
STEP 3: CONDUCT BASELINE PERFORMANCE ASSESSMENT **32**
Assessing Where a Corridor is Vulnerable to Climate Change 32
STEP 4: IDENTIFY POTENTIAL PROJECTS AND STRATEGIES **35**
Appendix A of the Caltrans Adaptation Strategy Report 35
Addressing Changes in Precipitation and Riverine Flooding on a Corridor 36
Addressing Wildfire Risk on a Corridor 37
Addressing Landslide Risk on a Corridor 39
Strategies for Adapting to Extreme Heat Events 41
Addressing Sea Level Rise on a Corridor 42
Strategies for Reducing VMT & GHG Emissions Along a Corridor 47
STEP 5: ANALYZE IMPROVEMENT STRATEGIES **49**
Consider Design Life and Climate Projection Years 49
Local and Regional Planning and Adaptation Strategies 50
Adaptation Costs and Benefits 51
STEP 6: SELECT AND PRIORITIZE SOLUTIONS **53**
GHG Emissions and VMT 53
STEP 7: PUBLISH/IMPLEMENT CORRIDOR PLANS **54**

Communicating Climate Change to a Non-Scientific Audience 54
STEP 8: MONITOR AND EVALUATE PROGRESS 55
APPENDIX..... 56
Climate Change Goals For the Corridor Planning Process.....56
Examples of Existing Plans.....58

KEY TERMS

BCDC	San Francisco Bay Area Conservation & Development Commission
CALFIRE	California Department of Forestry and Fire Protection
CalOES	California Governor's Office of Emergency Services
CARB	California Air Resources Board
CCC	California Coastal Commission
CDP	Coastal Development Permit
CGS	California Geologic Survey
CoSMoS	USGS Coastal Storm Modeling System
DEA	Caltrans HQ Division of Environmental Analysis
DOTP	Caltrans HQ Division of Transportation Planning
DSC	Delta Stewardship Council
FHWA	Federal Highway Administration
GHG	Greenhouse Gases
GIS	Geographic Information System
LCP	Local Coastal Program
NOAA	National Oceanic and Atmospheric Administration
OPC	Ocean Protection Council
OPR	California Governor's Office of Planning & Research
SHS	California State Highway System
SLR	Sea Level Rise
USGS	United States Geological Survey
VMT	Vehicle-Miles Traveled
ZEV	Zero-Emission Vehicle

INTRODUCTION/OVERVIEW

Climate change refers to long-term changes in temperature, precipitation, wind patterns, and other elements of the earth's climate system. An ever-increasing body of scientific research attributes these climatological changes to greenhouse gas (GHG) emissions, particularly those generated from the production and use of fossil fuels. While climate change has been a concern for several decades, the establishment of the Intergovernmental Panel on Climate Change (IPCC) by the United Nations and World Meteorological Organization in 1988 led to increased efforts devoted to GHG emissions reduction and climate change research and policy. Following this initial report, the IPCC has released multiple reports of increasing concern as new science becomes available, with the most recent report being released in 2021. These efforts are primarily concerned with the emissions of GHGs generated by human activity, including carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), tetrafluoromethane, hexafluoroethane, sulfur hexafluoride (SF_6), and various hydrofluorocarbons (HFCs). While CO_2 is a naturally occurring component of Earth's atmosphere, it is the most abundant GHG and fossil-fuel combustion is the main source of additional, human-generated CO_2. Currently, the transportation sector is the leading contributor to statewide GHG emissions.

Two terms are typically used when discussing how we address the impacts of climate change: "mitigation" and "adaptation." GHG mitigation covers the activities and policies aimed at reducing GHG emissions to limit or "mitigate" the impacts of climate change, as well as the removal and/or storage of GHG utilizing biologic and geologic processes through carbon sequestration. Adaptation, on the other hand, is concerned with planning for and responding to impacts resulting from climate change. Executive Order B-30-15 obligates Caltrans, and all other state agencies to consider climate change through both adaptation and mitigation in all planning & investment decisions.

As Caltrans prepares for the future of mobility, climate change represents a challenge towards infrastructure and economics that not only needs to be considered in project scoping, but also needs to be a significant influence in the transportation planning process. Preservation and optimization of the system through identifying and recommending projects and strategies that achieve Caltrans goals and objectives in a collaborative manner is the primary concern of System Planning. Goals and objectives have been established requiring and recommending that the Department recognizes and addresses the climate challenges that California faces. Caltrans planning functions have responded by developing climate change related documents identifying climate change issues as well as strategies and protocols to make the State's transportation system more resilient. System Planning must synthesize information and data from a variety of sources, from local to a federal level to develop a long-range corridor vision that meets the current and future mobility needs of the people of California.

Corridor Planning is a multimodal transportation planning approach that recognizes that transportation needs are based on the complex geographic, demographic, economic, and social characteristics of communities. The Climate Change Emphasis

Area Guidance may contain summaries of other reports and plans, but the source documents are available for review for additional information as well. Consideration of climate change adaptation and mitigation must be included in the corridor planning process and this guidance was developed with the Caltrans Corridor Planning Process Guide in mind, and similarly follows the same 8-step process with a stated goal and objectives at the beginning of each step, though necessary steps may vary from corridor to corridor. Corridor planning is a valuable step in Caltrans' climate change goals, where planners may deploy a more holistic approach in addressing the climate change needs of both the transportation system and its users. As a "living" document, this Climate Change Emphasis Area Guidance may be updated to reflect significant updates to policies, procedures, and data, as well as the best available science.

POLICY/LEGISLATION

Listed below are all relevant state and departmental policies that will guide the incorporation of climate change into corridor planning. These policies are divided into four categories: guiding policies, GHG mitigation policies, climate adaptation & resilience, and coastal resources & sea level rise. Though these policies may reflect different aspects of climate change, all relevant climate change legislation and policies should be considered in the corridor planning process.

GUIDING POLICIES

AB 32, Global Warming Solutions Act: Air Pollution: Greenhouse Gases (2006): Requires reducing GHG emissions to 1990 levels by 2020 and then an 80% reduction below 1990 levels by 2050. Mandates California's GHG reduction target to be 40% below 1990 levels by 2030, and the development of a State Climate Change Scoping Plan which identifies transportation strategies to reduce VMT and must be updated at least every 5 years by CARB.

SB 32, California Global Warming Solutions Act: Emissions Limit (2016): Ensures statewide GHG emissions are reduced to 40% below the 1990 level by 2030.

EO B-55-18 (2018): Establishes statewide goal to achieve carbon neutrality no later than 2045.

SB 743, Environmental Quality: Transit-Oriented Infill Projects, Judicial Review Streamlining for Environmental Leadership Development Projects (2013): Requires OPR to revise CEQA guidelines and establishes criteria for determining transportation impacts of projects within transit priority areas.

SB 1, Transportation Funding (2017): Requires transportation funding be used where feasible to preserve, protect, and reduce environmental impacts using project features that promote adaptation to withstand the negative impacts of climate change.

Director's Policy (DP) – 30, Climate Change (2012): Outlines roles and responsibilities for coordinated efforts to incorporate climate change and GHG reduction efforts into Departmental decisions and activities. Climate change adaptation efforts shall include development of methods to protect people, places, and resources from impacts of climate change including consideration of SLR and planning and implementing appropriate design changes to bridges and other transportation infrastructure.

EO N-19-19 (2019): Directs State government agencies to increase efforts to reduce GHG emissions and mitigate the impacts of climate change while building a sustainable and inclusive economy.

DP-37, Complete Streets (2021): Establishes Caltrans' organizational priority to encourage and maximize walking, biking, transit, and passenger rail as a strategy to not

only meet state climate, health, equity, and environmental goals but also to foster socially and economically vibrant, thriving, and resilient communities.

GHG MITIGATION POLICIES

Executive Order (EO) B-30-15 (2015): Requires the consideration of climate change in all state investment decisions using full life cycle cost, the prioritization of adaptation actions that reduce greenhouse gases (GHG), the consideration of the state's most vulnerable populations, the prioritization of natural infrastructure solutions, and the use of flexible approaches where possible.

SB 1386, Resource Conservation: Natural and Working Lands (2016): Directs state agencies to consider the carbon sequestration potential of natural and working lands when revising, adopting, or establishing policies, regulations, expenditures, or grant criteria relating to their protection and management. Identifies the protection and management of natural and working lands as a key strategy towards meeting ambitious state GHG reduction goals.

SB 375, Transportation Planning: Travel Demand Models: Sustainable Communities Strategy: Environmental Review (2008): Requires Metropolitan Planning Organizations (MPOs) to include Sustainable Communities Strategies (SCSs) in their Regional Transportation Plans (RTPs)for the purposes of reducing GHG emissions, aligning planning for transportation and housing, and creating incentives for the implementation of strategies.

CLIMATE ADAPTATION & RESILIENCE POLICIES

AB 1482, Climate Adaptation (2015): Requires all state agencies and departments prepare for climate change impacts by continued collection of climate data, considering climate in state investments, and the promotion of reliable transportation strategies.

AB 2800, Climate Change: Infrastructure Planning (2016): Requires state agencies to consider potential climate impacts during planning, design, building, operations, maintenance, and investments on infrastructure.

EO B-52-18 (2018): Establishes a goal of treating 500,000 acres of vegetation per year to reduce wildfire risk.

EO N-82-20 (2020): Directs the State to accelerate and expand use of nature-based solutions while mitigating greenhouse gas emissions to adapt and become more resilient to the impacts of climate change through conserving 30 percent of California's land and coastal waters by 2030.

SB 379, Land Use: General Plan: Safety Element (2015): Requires local General Plans to include climate change vulnerability assessment, measures to address vulnerabilities, and a comprehensive hazard mitigation and emergency response strategy.

COASTAL RESOURCES AND SEA LEVEL RISE POLICIES

AB 1282, Transportation Permitting Task Force (2017): Establishes the Transportation Permitting Task Force. The Task Force is charged with developing and implementing recommendations to meet these transportation project delivery goals for projects within jurisdiction of other state or public entities: Develop a structured process for early engagement of all parties; Reduce permit processing time; Establish reasonable deadlines for permit approvals; Provide for greater certainty of permit approval requirements; and Improve environmental outcomes. Relevant goals of from this bill include Goal 2.2 which calls for the incorporation of sustainability and climate change adaptation features in corridor planning, and Goal 4.3 which calls for resilience to, or avoidance of climate change impacts during project development and implementation.

EO S-13-08 (2008): Requires all planning and construction projects by state agencies in areas vulnerable to future sea level rise to consider a range of sea level rise scenarios for the years 2050 and 2100 in order to assess project vulnerability and reduce risks and resiliency to sea level rise.

Government Code Title 7.2, McAteer-Petris Act (1965): The San Francisco Bay Conservation and Development Commission (BCDC) administers permits for projects in the coastal zone—which includes most transportation projects—along the Bay's nine-county shoreline wherein projects must demonstrate consistency with the Bay Plan's 8 Policies; expectations for climate change including SLR is provided in the 2021 BCDC Climate Change Policy Guidance. This includes requiring "major shoreline projects" to be resilient to 2050 and adaptable to 2100. BCDC also coordinates with local governments, regional councils of government, and other agencies and interested parties in development of regional climate change adaptation strategies as part of the Adapting to Rising Tides program.

Public Resources Code Division 20, California Coastal Act (2021): The California Coastal Commission and local agencies with certified Local Coastal Programs (LCPs) will evaluate how SLR was analyzed throughout the Caltrans project development process when Coastal Development Permits (CDPs) are required for Caltrans projects. The Coastal Commission bases its standard of review for CDPs on the Chapter 3 policies of the California Coastal Act; Sections 30235, 30236, and 30253 focus on coastal hazards and shoreline development, and provide the primary basis for how the California Coastal Commission considers SLR and coastal resource impacts by proposed Caltrans projects. Newer Sections 30270 and 30421 have taken effect in 2022 and mandate the consideration of SLR in planning and management policies. Specific to transportation, section 30253(c) requires consistency with state air resources board requirements and

CARB mandates reductions in GHG, and section 30253(d) requires that VMT be minimized.

SB 1, Coastal Resources: Sea Level Rise (2021): Requires transportation funding be used where feasible to preserve, protect, and reduce environmental impacts using project features that promote adaptation to withstand the negative impacts of climate change. Requires state agencies to identify, assess, and, to the extent feasible and consistent with their statutory authorities, avoid, minimize, and mitigate the impacts of sea level rise; grants the Coastal Commission policy authority over identification, assessment, and, to the extent feasible, avoidance and mitigation of the adverse effects of sea level rise.

Water Code Division 35, Delta Reform Act (2009): The Delta Stewardship Council (DSC) holds appellate authority over the Legal Delta for "covered actions"—wherein most transportation projects aside from routine maintenance—must submit certifications that demonstrate consistency with the Delta Plan's 14 regulatory policies. Certification must include documentation of best available science (Policy G P1(b)(3)); and transportation projects should consider the recent Delta Adapts SLR vulnerability assessment which characterized exposure and adaptive capacity for both highways and rail as the Delta Plan addresses "the effects of climate change and sea level rise on the three state highways that cross the (Sacramento-San Joaquin) Delta".

STEP 1: SCOPE EFFORT

Goal: Identify comprehensive climate change mitigation and adaptation goals for the corridor. Include the consideration of exposure to potential climate change hazards as well as the mitigation of GHG and VMT as part of the planning scope. An initial list of such hazards should be included in the scope, along with appropriate analysis methods to assess the related risks. Include climate change mitigation goals for the corridor that identify strategies which reduce VMT and contribute to the statewide GHG reduction goal of 40% below 1990 levels by 2030 and achievement of carbon neutrality by 2045.

- ☑ Turn on all relevant layers in the Caltrans Climate Change Vulnerability Assessment webmaps to determine which climate change stressors affect the corridor.
- ☑ Corridors that include segments that are situated in terrain that features slopes, cliffs, or heavy undulations, use the Deep-Seated Landslide Survey (MS58) data from the California Department of Conservation to determine if there are any areas surrounding the corridor that are susceptible to landslide.
- ☑ Consider all relevant partnerships, stakeholders, plans, and existing guidance needed to be considered along the corridor as well as internal Caltrans functions that may need to be consulted.

CLIMATE HAZARDS TO CONSIDER IN A CORRIDOR PLAN

To address potential hazards associated with climate change, planners should identify, and list climate stressors affecting a corridor either now or in future climate scenarios and describe the potential impacts from the hazards associated with those stressors. Climate change stressors that may impact a corridor include changes in temperature, changes in precipitation, increased wildfire risk, and sea-level rise. If a segment of the SHS, or its companion facilities such as bridges, culverts, parking lots, or multi-modal assets such as transit routes or rail, or any areas surrounding these assets are exposed to multiple climate stressors, the hazards may compound to present additional hazards such as landslide, rock fall, or flooding. **Any climate stressors included in the table on pages 9-10 of this guide that are projected to impact a corridor should be listed in the corridor plan.**

To determine the risk of any of these stressors along the SHS or surrounding areas, access the Caltrans District Climate Change Vulnerability Assessment online webmaps and turn on layers for all stressors to determine which ones are predicted to affect the corridor. The layers in the Vulnerability Assessments follow representative concentration pathways (RCPs) which are projections that assume global emission behaviors through the year 2100.

- Planning for both RCP 4.5 and 8.5 should be considered in this initial overview, though it should be noted that California is currently on pace for a high-emissions scenario (RCP 8.5), and this scenario should be emphasized both in the analysis and in the final corridor plan.
- Sea-Level Rise requires a more complex analysis using the H++ extreme scenario that will be elaborated upon in steps 2-3. (Corridors in Districts 2, 6, 8, & 9 can skip this step altogether).
- If a corridor has segments within a hilly or mountainous area and has steep slopes adjacent or near the roadway or surrounding communities, the Deep-Seated Landslide Survey (MS58) webmap from the California Department of Conservation may be used to assess landslide susceptibility as well. If you are unsure of the corridor's susceptibility to potential impacts from landslides, more information is available for local hazard assessments in a Local Hazard Mitigation Plan or a safety element of a general plan. More information on these resources will be available in step 2.
- Temperature and precipitation changes are expected to be seen in all parts of California. Areas expected to see significant changes to either temperature (>4°F change in Average 7-day maximum temperature) or precipitation (>5% change in 100-year precipitation depth) should be included in a corridor plan.

Table 1 - Climate change-related hazards that may affect a corridor.

Climate Stressor	Potential Consequence	Impacts
Changes in Temperature	Road buckling/pavement heaving	Fluctuations in air temperatures cause pavements to expand and contract, creating pressures that can cause these pavements to buckle or crack.
	Rail track buckling	High temperatures may cause rails to expand, resulting in extreme compression and buckling which can lead to prolonged periods of closure for repairs which typically must wait for air temperatures to return to more manageable levels.
	Decrease in soil moisture	Increased temperatures may cause more rapid evaporation of moisture from soils, leading to changes in stability and the viability of vegetation.
	Increase in plant/vegetation mortality	Higher air temperatures coupled with decreased soil moisture that are both less suitable for native vegetation over time may lead to large die offs or damaged root structures, potentially increasing the risk of large, damaging wildfire.
	Impacts to health and safety to pedestrians, bicyclists, transit riders, underserved & disadvantaged communities, and wildlife	Extreme heat events are known to be dangerous to vulnerable populations and can result in hospitalization from heat-related illnesses as well as cardiovascular and respiratory disorders. These effects are felt even more in urban areas where the urban heat island effect can increase air temperatures higher than surrounding areas.
Changes in Precipitation	Increased risk of riverine/fluvial flooding	Natural and engineered drainage into perennial and intermittent streams may result in overtop of streambanks as dramatic rainfall events may dump more water than the stream channel can carry.
	Prolonged periods of drought affecting the availability of water for landscaping and other needs	Expected changes in the length of rainy seasons in California are also projected to be coupled with prolonged dry seasons which will affect Californians in multiple ways.
	Heavy rain events potentially leading to roadbed collapse	Precipitation can increase the potential for water to infiltrate the base and subbase layers of pavement and create saturated conditions, thereby weakening their structural strength and increasing their susceptibility to erosion.
	Increases in snowpack and/or accelerated snowpack runoff	Increases in snowpack coupled with warmer temperatures later in the year can result in rapid runoff events that are known to cause significant flooding events to communities along rivers and streams, particularly in the Sierra Nevada mountains, as well as contribute to debris on the roadway and in drainage facilities.

Increased Wildfire Risk	De-vegetation and exposure of slopes	The burn-off of fuels on sloped terrain decreases the stability of soils, potentially leading to a significantly increased risk of landslide or other geomorphic hazards.
	Culverts made of plastic or other materials in danger of melting or being damaged beyond functionality	Culverts made from non-inert materials are at risk of melting or becoming damaged from extreme heat during wildfire events, potentially leading to flooding events due to diminished peak flow capacity of drainage as well as a loss of the road prism during this flooding.
	Corridor inaccessibility during wildfire events	Closures and evacuations due to wildfire events are expected to increase over time.
	Significant, and far-reaching impacts to air quality and visibility	Smoke from wildfires can travel hundreds of miles to impact areas in different parts of the state. Smoke from wildfires can result in diminished air quality beyond safe levels for sensitive populations.
	Negative impacts to public safety	Wildfires may result in an immediate danger to structures, infrastructure, and populations residing in or passing through areas at risk of wildfire.
Sea Level Rise (SLR)	Problem flooding caused by the rise and fall of tides or storm surge	As the sea-level rises, an increased expanse of flooding from rising tides may overtop levees and other protective structures to flood coastal areas including segments of the SHS and other transportation infrastructure which may also lead to corrosion as salty water more regularly comes in contact with structural surfaces.
	Storm Surge	Storm events can temporarily cause an abnormal rise in seawater level that may result in rapid and potentially significant damage to coastal infrastructure.
	Groundwater Rise	Projected sea-level rise will raise coastal water tables, resulting in groundwater hazards that threaten shallow infrastructure and coastal ecosystem resilience.
	Cliff Retreat/Coastal Erosion	Rising sea-levels will exacerbate tidal flooding and storm surge conditions along the California coastline, leading to wave run up, coastal erosion and cliff retreat and scour, and potentially impacting coastal infrastructure.
Increased Landslide Susceptibility	Earth flows, debris flows, landslides, rockslides, and rockfalls	Landslides along the SHS may result in damaged roadways, prolonged closures, and hazards to public safety.
	Increases risk associated with wildfire, intense, short-term rainfall, prolonged rainfall, and rapid snowmelt	Climate change is expected to affect landslide risk as changes in precipitation and wildfire risk alter the stability of slopes in mountainous areas. Slopes exposed by wildfire lose the stability gained from vegetation and short- and long-term rain events may saturate soils, resulting in a looser, less stable slope surface.

POTENTIAL TOOLS FOR CLIMATE CHANGE ANALYSIS

To examine the level of exposure to future climate scenarios as well as corridor-wide adaptation and mitigation strategies, careful consideration for the analysis methods must be taken. Climate change analysis should be done on not only on the roadways, but also on the bridges and culverts as well.

District Climate Change Vulnerability Assessments

District-specific summary reports, technical reports, and ArcGIS webmaps visualizing the data behind the development of the Vulnerability Assessments that cover the SHS's susceptibility to temperature, precipitation, wildfire, sea-level rise, storm surge and cliff retreat. **The data used in these assessments should be the initial data used to determine the vulnerability of segments of a corridor to climate-driven hazards.** To determine the vulnerability of other transportation facilities such as bridges, and culverts, other data sources may be used in tandem with the Vulnerability Assessments to gain a more complete view of the level of impact projected at specific locations. If segments of a corridor are within the coastal zone, BCDC, or DSC jurisdiction, the Coastal Commission's SLR Policy Guidance and BCDC's Climate Change Policy Guidance documents should be consulted for those areas, and OPC recommended data sources should supplement the exposure assessment. Link

District Climate Change Adaptation Priorities Reports

District-specific reports build upon the vulnerabilities identified in the District Vulnerability Assessments by assessing which vulnerable Caltrans assets along the SHS are expected to require the most immediate adaptation measures. These reports utilize an indicator approach which considers an array of exposure and consequence metrics to calculate a prioritization score between 1 and 5, with Priority 1 assets requiring the most immediate attention. For a given corridor, all vulnerable assets should be identified, with the highest priority assets requiring the most attention in a corridor plan. This work should also be supplemented by additional analysis to reflect different adaptation responses and priorities by stressor. While this data is helpful in recognizing impacts on an asset by asset basis, further analysis will be necessary to determine the holistic impacts to a corridor that these individual vulnerabilities may represent. Link

Caltrans Division of Environmental Analysis GIS Library

This GIS library is available on OnRamp as a webmap which includes the Vulnerability Assessment data layers as well as GIS layers from the Caltrans Adaptation Priorities Reports, NOAA SLR projections, USGS SLR mapping, coastal habitats vulnerable to "coastal squeeze" between transportation infrastructure and SLR, and other relevant datasets. Click here to select your District or region for which you would like data, or click here to access all statewide datasets (the most relevant data will be under the "Climate" tab on GIS Library pane on the right side of the interface).

California Geological Survey Landslide Hazard Maps

The CGS has developed highway corridor landslide hazard maps to meet the needs of engineers, geologists, planners, and maintenance staff. The maps provide an inventory

of landslide activity along the selected highway corridors. Each of the reports prepared under this project includes a description of the geologic materials along the highway corridor, the distribution and types of landslides, and the potential impacts of landslides on the highway. Geologic and landslide inventory maps are included in each report. Click here to access the available maps and reports.

GIANT Database
This GIS database includes a statewide webmap of planning relevant information from across Caltrans' functions and programs to assist planners with comprehensive corridor planning activities. This tool is currently under development but will be available in the future to assist in planning activities.

Transportation Asset Management Map Viewer
Caltrans asset web map allows viewers to geographically visualize various assets and their current conditions, including pavement, bridges, culverts, TMS, lighting, Commercial Vehicle Enforcement Facilities (CVEF), and Weigh in Motion (WIM), among others. This is a useful tool to identify assets exhibiting a poor state of repair located in your project area. Link.

FHWA ADAP Facility-Level Analysis
A pilot study completed by Caltrans in 2021 using the Adaptation Decision-Making Assessment Process (ADAP) developed by the Federal Highway Administration. This study included a detailed engineering-level analysis performed using available District Climate Change Vulnerability Assessments and Adaptation Priority Reports to determine best available adaptation options for impacted assets. These assessments can be performed on single assets or a series of assets all the way up to a corridor-level. These assessments have not yet been performed in most of California, and this level of analysis may be too complex for a corridor plan; however, the need for such assessments may be recognized in a corridor plan to better assess the next steps for identifying impacts and consequently identifying future projects at locations exposed to climate change. The pilot Caltrans Facility-Level Assessment performed on a culvert along SR-70 in District 2 can be found here.

Cal-Adapt
Provides access to the wealth of data and information that have been, and continue to be, produced by the State of California's scientific and research community as State-endorsed climate projections. The data available on this site offer a view of how climate change might affect California at the local level. This information was used in the Caltrans Vulnerability Assessments but exploring Cal-Adapt will offer a more in-depth analysis of each climate impact separately. Cal-Adapt can be accessed here.

POTENTIAL PARTNERSHIPS AND STAKEHOLDERS TO CONSIDER

Developing consensus by aligning the goals of State, regional and local planning entities – while meeting existing regulations and mandates – is crucial to preparing for climate change. Effective public and stakeholder outreach is essential in ensuring that local governments and community organizations are informed and heard in this process. External partners may also be helpful in providing data and previous analysis that can inform the corridor planning process. Additional information on effective coordination with partner agencies can be found in the Caltrans Climate Change Communication Guide here.

Caltrans Interagency Agreement with California Coastal Commission – Integrated Planning Team

Caltrans' Division of Environmental Analysis has established a Coastal Program to assist District staff in understanding the requirements and complexities of the Coastal Act, how it relates to the coastal permitting process, and supports coordination on transportation planning as it relates to coastal resources. Caltrans and the Coastal Commission signed the *Plan for Improved Agency Partnering* in 2016 which contains recommendations to increase and improve coordination and communication on sea level rise. Statewide transportation liaisons at the Coastal Commission as well as local points of contact for Local Coastal Programs are available to Caltrans for engagement on corridor plan development. In 2022 Caltrans and the Coastal Commission also renewed their partnership agreement which outlines 5 key focus areas for interagency coordination and outlines commitments that will guide our work. The current Interagency Agreement is effective through 2025.

Metropolitan Planning Organizations (MPOs) and Regional Transportation Planning Agencies (RTPAs)

Outreach with regional agencies such as MPOs and RTPAs should be done early and with regularity throughout the corridor planning process. Regional Transportation Plans (RTPs) developed by these agencies often include information on climate change adaptation needs for a region, as well as suggestions for adaptation regional transportation infrastructure to the effects of climate change. Additionally, MPOs may have a Sustainable Communities Strategy that will outline GHG reduction goals for the region. Regional agencies may have their own or multi-county climate action, extreme weather, local hazard mitigation, or wildfire adaptation plans that can further contribute to addressing climate change in corridor planning. CARB also sets regional GHG reduction targets and measures to reduce emissions, which are included in many RTPs and should be highlighted in a corridor plan as well due to their potential influence on the types of projects that would most align with these goals. Link. The California Rural Counties task force consists of 26 rural county RTPAs which may advise on issues unique to rural areas along a corridor. Link

California Department of Forestry and Fire Protection (CALFIRE)

CALFIRE may provide a combination of resources, tools, and expertise on the susceptibility of areas along the SHS to wildfire and wildfire related hazards, as well as

suggest potential strategies to mitigate damage to Caltrans infrastructure and surrounding communities from wildfire. CalFire also is the key steward of the California Strategic Fire Plan.

California Air Resources Board (CARB)
CARB has a critical role in setting and tracking GHG reduction targets. The AB 32 State Scoping plan includes linkages between the transportation sector and climate change. CARB also conducts significant research on land use and transportation, and can provide insight to potential GHG emissions reduction strategies.

Local Fire Districts/ Wildfire Task forces, etc.
Local fire districts may assist in understanding wildfire risks along a corridor and identifying potential strategies. Urban and rural areas will have different factors playing into their potential wildfire threat. Local Fire Districts can often be located on a county's website, or within a Community Wildfire Protection Plan (CWPP). Local Fire Districts should be consulted in tandem with CALFIRE staff including local CALFIRE Operational Units to gain the most comprehensive wildfire information for state infrastructure available for a corridor. Link

Local and Tribal Planning/Transportation Agencies
Local and tribal agencies should be included on a corridor planning team. Datasets and plans from local agencies, as well as their expertise on local geography, can provide valuable contributions to a corridor plan.

Local Coastal Programs
Identification of Local Coastal Program jurisdictions that intersect with segments of the corridor should be identified, with particular attention given those that are in the process of updating or amending plans or policies. Collaboration with local governments that develop these plans and programs would be critical for corridor planning in Coastal Zones. A regularly updated list of these plans/programs with points of contact can be found on the internal Caltrans Coastal Plan Dashboard developed by DEA. Link

Non-Profit and Advocacy Groups
Californians are on the forefront of the fight against the impacts of climate change, and many non-profit and advocacy groups may have input on climate change resiliency measures that should take place along a corridor.

Underserved Public and Disadvantaged Communities and Community Organizations
The impacts of climate change will affect Californians statewide. The Caltrans Strategic Plan 2020-2024 calls for engagement with communities most vulnerable to climate change impacts in both adaptation and mitigation activities. Underserved and disadvantaged communities will face greater difficulty in adapting to these conditions, and therefore these needs should be considered in the corridor planning process.

Local and Regional Transit Agencies
Local and regional transit agencies may provide information on their transit service, as well as providing insight to the characteristics of their riders. Adapting transit along a corridor to future climate scenarios including increased precipitation and extreme heat events will be beneficial to regional GHG and VMT, and to public health. Some transit agencies may also have conducted vulnerability assessments or other resiliency planning activities for their network which should be considered in a corridor plan. If necessary, contact the HQ Division of Rail and Mass Transportation for more information on local transit and rail providers along a corridor.

INTERNAL CALTRANS FUNCTIONS

Two-way engagement between Headquarters and the Districts will enable staff at all levels to talk about climate change, share their unique perspectives and concerns, and remain invested. It will also facilitate more cross-divisional collaboration. Meetings and workshops provide opportunities for Headquarters to share updates about the latest climate change policy and science, discuss current and upcoming Caltrans work, and answer questions. Lessons learned at these engagements could also be used to customize climate change measures in a corridor plan for maximum impact. The Caltrans Climate Change Communication Guide provides guidance for effective communication with internal Caltrans functions. Link

Caltrans HQ Division of Maintenance, Office of Vegetation & Wildfire Management
The HQ Office of Vegetation & Wildfire Management manages efforts pertaining to roadside resilience and fuels reduction along the SHS. Planners may need to consult this program regarding stretches of highway that are currently at risk of wildfire or are projected to be exposed to wildfire in the future. Often times, maintenance operations are the among the first to identify vulnerable highway stretches through on the ground operations. Link

Caltrans HQ Division of Environmental Analysis, Coastal Program
Segments of highway exposed to SLR, cliff retreat, or storm surge may consult with the Caltrans Coastal Program. This program maintains expertise in coastal resources and policy that will be helpful in navigating the regulatory environmental of the Coastal Zone. Link

Caltrans HQ Division of Pavement
When a segment of a corridor is at risk of significantly higher temperatures, the characteristics of the pavement play a key role in the SHS's ability to withstand those temperatures. Current pavement design standards are required to maintain different pavement types depending on expected climate in a region. Currently, the department uses the Caltrans Pavement Climate Regions to determine the design standards for each region of California, however it is important to note that this method for differentiating between geographic regions was developed in 2005 and may require additional consultation from the Caltrans Division of Pavement and other experts on pavement design. Link

Caltrans Division of Engineering Services, Geotechnical Services Program
If a corridor may be susceptible to landslides, the HQ Office of Geotechnical Services may provide technical assistance on suggested actions. Services from this office includes geotechnical engineering and engineering geology products such as soil and rock field investigations, geophysics, and the development of geotechnical recommendations for structures and earthwork projects. Geotechnical Services provides emergency response to landslides, rockfall, bridge scour, and earthquake damage. Geotechnical Services maintains statewide policy, standards, and procedures for geotechnical engineering and engineering geology products and services. Link

Caltrans Division of Design, Office of Hydraulics and Stormwater Design
This Office in the Division of Design may provide District engineers with technical assistance in drainage design in locations that may be prone to coastal or riverine flooding. Link

Caltrans Office of Race & Equity
The Caltrans Office of Race & Equity (CORE) may provide insight into disadvantaged and low-income communities, as well as how to identify underrepresented groups and perform outreach. CORE also contains the Native American Liaison Branch, which could provide assistance in identifying and reaching out to tribes and tribal groups relevant to a corridor. Link

EXISTING PLANS AND GUIDANCE TO CONSIDER IN ALL DISTRICTS

Incorporating climate change policies and strategies into corridor plans will require leveraging existing methods and plans to achieve climate adaptation goals. Understanding the regulatory environment set forth by existing plans and policies will allow for a greater chance of strategies proposed in later steps to avoid unforeseen barriers to climate adaptation.

California Transportation Plan 2050 (CTP 2050)
California's long-range transportation plan that creates a vision and serves as a framework to articulate and implement the strategic goals, policies, and recommendations to improve multimodal mobility, accessibility, help improve housing, and combat climate change through GHG reduction and adaptation planning strategies. For more information, click here.

California Climate Action Plan for Transportation Infrastructure (CAPTI)
Details how the state recommends investing billions of discretionary transportation dollars annually to aggressively combat and adapt to climate change while supporting public health, safety, and equity. CAPTI builds on executive orders signed by Governor Gavin Newsom in 2019 and 2020 targeted at reducing GHG emissions in transportation, which account for more than 40 percent of all emissions, to reach the state's ambitious climate goals. For more information, click here.

2017 Climate Change Scoping Plan
AB 32 mandates the reduction of GHG emissions to 1990 levels by the year 2020 and 40% below 1990 levels by 2030. The Climate Change Scoping Plan is also a central requirement of AB 32 and must be updated every 5 years by CARB. The transportation sector is responsible for the largest share of emissions (41%), and a reduction of VMT must occur to meet the 2030 goal. Options for state transportation infrastructure investments should be included in corridor planning, see strategies here. For more information on the Scoping Plan, click here.

Planning and Investing for a Resilient California
Introduces a four-step process for building resilience and a set of resilient decision-making principles for state agencies when considering climate-informed infrastructure investments. These steps include identifying how climate change could affect a project or plan, conducting an analysis of climate risks, making a climate-informed decision, and tracking and monitoring progress. Link

Local Climate Action/Adaptation Plans and Strategies
Local agencies along a corridor may have existing plans that include strategies or insight on potential approaches to implementing climate change considerations on the transportation network. CARB has created a webmap that can be used to identify along a corridor possible plans created, GHG inventory information, GHG reduction targets, the local strategies planned to meet these targets, and more. For more information on local climate action plans, click here. To view the California Climate Action Portal Map, click here.

Caltrans Climate Change Adaptation Strategy Report
Through this report, Caltrans is aiming to adopt a leadership role in the process of climate change adaptation through developing a "how to" guide for integrating climate change adaptation into agency activities and decision-making. This Adaptation Strategy Report initially outlines an overall "pathway" for adopting recommendations on how Caltrans should mainstream adaptation strategies throughout functional areas and develop an approach to coordinate with partner agencies. Recognizing the important role of transit and active transportation facilities and routes, this report will develop solutions for all modes of transportation. This report also has a section focused on the incorporation of climate change considerations into System Planning documents. The Caltrans Adaptation Strategy Report can be found here.

Local Vulnerability Assessments
If local vulnerability assessments have been developed along a corridor, their data may be interwoven with the Caltrans Climate Change Vulnerability Assessments for more granular analysis of specific local areas, particularly those in more densely populated areas or with a high density of affected transportation assets. Many of these assessments and case studies can be found on the Integrated Climate Action and Resiliency Program (ICARP) Case Studies and Examples search page. Some transit and rail providers in California have also developed vulnerability assessments for their

networks as well, which may contain detailed analysis that could be useful in a corridor plan. The Caltrans SB1 Adaptation Planning Grants program has also assisted local agencies in development of local vulnerability assessments, a link to the deliverables from this program for each District can be found here.

Regional Transportation Plans
RTPs (or sometimes called Metropolitan Transportation Plans, or MTPs) are prepared by regional agencies every four years to identify a 20-year vision for transportation priorities and investments. Local MPO's, RTP's and Caltrans during the update of an RTP are required to outreach to the public and hold public hearings during processing and approval of the RTP. Corridor plans will need to implement and/or incorporate the requirements identified and adopted by the RTP. For more information, click here.

ResilientCA Adaptation Planning Map (RAP-Map)
The Integrated Climate Adaptation and Resiliency Program (ICARP)—supported through the Governor's Office of Planning & Research—contains a statewide inventory of local government adaptation and resiliency planning efforts. It is an open data tool, to inventory local government climate risk, adaptation, and resiliency planning efforts across the state and track progress towards statewide adaptation planning goals. Link.

Sustainable Communities Strategies
Demonstrates how each MPO will reach their GHG reduction target through integrated land use, housing, and transportation planning. Under SB 375, the development and implementation of SCSs, which link transportation, land use, housing, and climate policy at the regional level, are designed to reduce per capita GHG emissions. This is partially accomplished through reductions in per capita VMT. For more information, click here.

2018 California State Hazard Mitigation Plan
The 2018 California State Hazard Mitigation Plan represents the state's primary hazard mitigation guidance and is composed of comprehensive and valuable input provided by State Hazard Mitigation Team members and stakeholders. The 2018 Plan continues to build upon the state's commitment to reduce or eliminate potential risks and impacts of natural and human-caused disasters to help communities with their mitigation and disaster resiliency efforts. Link

PLANS AND GUIDANCE TO CONSIDER IN COASTAL AREAS

Understanding the regulatory environment of coastal areas will require identifying the jurisdictional boundaries that segments of a corridor may lie within. Jurisdictions that have regulatory authority over coastal areas include the California Coastal Commission, the San Francisco Bay Area Conservation & Development Commission, and Local Coastal Programs. The Division of Environmental Analysis GIS library is a helpful tool in locating the boundaries of these jurisdictions.

Local Coastal Programs
Identification of the specific LCP jurisdictions that the Corridor goes through should be identified, with particular attention given to SLR Vulnerability Assessments or Adaptation

Plans that have been completed, and relevant transportation policies for transportation. For more information, click here.

State of California Sea Level Rise Guidance (2018 Update)
If segments of the corridor could be exposed to tidal influence and SLR, this guidance provides a step-by-step decision framework to evaluate the risk tolerance of various planning decisions which could be applied to System Planning's project level functions, as well as to establish long-term strategies on corridors within the coastal zone. This guidance is also useful in determining the best SLR projections to use based on project characteristics determined in later steps in the corridor planning process. This document is intended to assist decision makers at state and local levels in planning for, and making decisions about, sea-level rise and related coastal hazards on projects considering the current state of climate change science. Link

California Coastal Commission (2018) Sea Level Rise Policy Guidance
SLR vulnerability assessments should evaluate—in alignment with the OPC State of California Sea-Level Rise Guidance: 2018 Update—the medium-high and extreme (H++) SLR projections in conjunction with the combined effects of the coastal hazards that have the potential to affect the site (i.e., wave run-up, flooding, erosion) and 100-year storm activity. Corridor plans should identify long-term adaptation strategies—in collaboration with local governments—that avoid or minimize risks to Caltrans' transportation system and avoids or minimizes and mitigates impacts on coastal resources. Coastal resources include wetlands, environmentally sensitive habitat areas, agriculture, public access, and water quality and groundwater. Adaptation strategies can include nature-based solutions, active management strategies, relocation, elevation, and short- or potentially longer-term armoring. To access the guidance, click here.

Coastal Adaptation Planning Guidance for Critical Infrastructure
This guidance from the California Coastal Commission addresses two main types of infrastructure – transportation and water – and presents six key considerations for successful adaptation planning. These considerations are accompanied by recommendations for stakeholders on how to plan effectively for the impacts of sea level rise on coastal infrastructure, a description of the regulatory framework that applies to adaptation planning for infrastructure. The Guidance can be accessed here.

BCDC San Francisco Bay Climate Change Policy Guidance
The guidance provides non-regulatory, but interpretive, information to assist in the development of prospective projects in relation to the requirements of the Climate Change policies with permit applicants, local jurisdictions, and the public at large. The Guidance can be accessed here.

Delta Adapts: Creating a Climate Resilient Future
Completed in 2021, this vulnerability assessment included an analysis of transportation infrastructure in the Sacramento/San Joaquin Delta (see page 5-42) which included 80 miles of highway, 48 miles of rail; which notes in terms of adaptive capacity:

"Transportation infrastructure (in the delta) has moderate adaptive capacity, because there may be built-in redundancy in routes (although some routes provide sole points of ingress/egress to islands) and traffic could use alternate routes during flood events. It is also possible to elevate roadways and rail above projected flood elevations to maintain access – particularly for those routes on existing levees; however, this is likely to be associated with high costs or infeasible for routes that traverse subsided Delta islands." Link

STEP 2: GATHER INFORMATION

Goal: Collect information on potential climate change hazards in the corridor, and the relationship of such an assessment to other transportation and non-transportation plans. Identify adopted GHG reduction plans and outline the strategies listed for implementation to align with these goals.

- ☑ Research and locate available data sources for all climate change stressors affecting a corridor, while considering social and public health aspects of climate change affecting a corridor and with an understanding that disadvantaged and low-income communities will face greater difficulty in adapting to climate change.
- ☑ If the corridor is within the coastal zone, BCDC, DSC, or a Local Coastal Program jurisdiction, carefully consider the regulatory environment for the respective jurisdiction and how proposed strategies will align with guidance for infrastructure located in these jurisdictions.
- ☑ Identify plans and documents that outline regional GHG reduction strategies for the areas around the corridor.

CLIMATE CHANGE DATA SOURCES TO CONSIDER

To identify the level of potential exposure to any of the climate stressors and disturbances defined in Step 2, some of the below data sources and tools can be used. **The Caltrans Climate Change Vulnerability Assessments should be the initial starting point for considering data sources as they will likely be the most encompassing of the impact of relevant climate hazards on the SHS.** More granular data for any climate stressor should be used when available at the local, regional, or academic level.

Caltrans District Climate Change Vulnerability Assessments

As of 2019, all twelve Caltrans Districts have a vulnerability assessment. These reports include a summary report, technical report, and ArcGIS interactive Webmap. Through these assessments, Caltrans identified six climate stressors that will have considerable impacts to the SHS. The climate stressors identified include:

- **Changes in Temperature**
- **Changes in Precipitation**
- **Wildfires**
- **Sea Level Rise**
- **Storm Surge**
- **Cliff Retreat**

Within these reports, assets including roadways segments which are vulnerable to each climate stressor are identified with their level of vulnerability.

For use in a corridor plan, all stressors described in the Vulnerability Assessments should be analyzed, and the level of exposure to each climate stressor should be listed in the plan. A corridor plan should identify clustering of assets that are at a high level of risk, or

individual assets that are at severe risk, and will require future assessment. Potential performance measures can include the level of exposure or the projected impact year.

The Caltrans Climate Change Vulnerability Assessment reports and webmaps for each Caltrans district can be found at the Caltrans internal and external websites. You can access each District Vulnerability Assessment here.

- Please note that with respect to SLR, while the Vulnerability Assessments provide a useful starting place for understanding exposure risk, there are shortcomings to be aware of. For example, SLR exposure was not evaluated for scenarios that correspond to the expected asset life given current state SLR guidance from OPC and CCC for most Districts. For example, in the District Vulnerability Assessments, H++ is only available for District 1 and the southern portion of Santa Barbara in District 5. In addition, cliff erosion risk is not available north of San Francisco in the data used in these assessments. In addition, groundwater SLR was not included in exposure. Lastly, exposed roadway segments were the only Caltrans asset that were evaluated—and exposure of other asset types like culverts, bridges, and rail are not included, and these should be accounted for in corridor plans. To account for these shortcomings regarding SLR, **Vulnerability Assessment data used for coastal areas should be supplemented with other data listed in the "OPC Recommended SLR Data" section below.**

The Caltrans District Adaptation Priorities Reports

Developed as a follow-up to the Vulnerability Assessments, the District Adaptation Priorities Reports calculate the level of risk of each Caltrans asset in each district using a standardized set of scoring criteria. The priorities reports can be used to identify high-priority assets that are most vulnerable to climate-driven hazards. A corridor plan should identify clustering of assets that are at a high level of risk, or individual key assets that are at severe risk, and will require future assessment. While these reports provide a useful starting point for determining climate change impacts, there are a few caveats to consider:

- The Adaptation Priority Reports do not identify all assets exposed to SLR or cliff erosion along coastal routes.
- They do not consider overall long-term exposure as characterized by the H++ scenario, an analysis necessary to understand overall asset risk and help inform short, medium and long term corridor strategies and subsequent projects permits by CCC, BCDC, DSC, or a Local Coastal Program.
- These reports do not consider the whole corridor, rather they focus on individual assets along the SHS.
- These reports do not consider groundwater SLR exposure or prioritization.
- The priorities reflect a merging of climate stressors (i.e. wildfire / SLR) and require further analysis as the adaptation treatment would likely vary according to stressor.

- The scoring in these reports do not consider coastal resources, adjacent land-uses or local or regional priorities, or other local considerations like equity or the community.
- The Adaptation Priority Reports do not consider projects that are already programmed or in development.

To compensate for discrepancies in SLR data, the data sources recommended by the OPC (below) should be used. Each District Adaptation Priorities Report can be found here. To view the Adaptation Priorities Report data in an ArcGIS webmap, use the DEA GIS Library here (the dataset is listed as CT APR in the layers pane on the right).

OPC Recommended Sea Level Rise Data

Caltrans' Climate Change Vulnerability Assessments are largely based on global climate data compiled by the Intergovernmental Panel on Climate Change (IPCC) and California research institutions such as the Scripps Institution of Oceanography. Other data sources recommended by the Ocean Protection Council (OPC) also can provide a clearer picture when assessing risk to facilities in the coastal zone. The following sources provide down-scaled, scientific data pertaining to SLR that could be used in tandem with the 2018 State of California Sea Level Rise Guidance:

- **Coastal Storm Modeling System (CoSMoS):** Model developed by the USGS which allows for more detailed predictions of coastal flooding due to both future sea level rise and storms. The two are integrated with long-term projections of coastal evolution such as beach changes and cliff/bluff retreats. This data can also be viewed in conjunction with varying levels of storm surge data as well. This data is available in several locations including the Division of Environmental Analysis GIS Library (to access CoSMoS data, in the pane on the right side of the screen, click the "Climate" tab, and then click the "USGS CoSMoS" tab).
- **Cal-Adapt 2.0:** Provides projections and analyses available as a basis for understanding local climate risks, resilience options and connects with supporting resources such as the Integrated Climate Adaptation and Resiliency Program (ICARP) by the Governor's Office of Planning & Research. Includes selected results from the CoSMoS model as well as projections modeling inundation associated with an extreme storm event for the Delta, San Francisco Bay, and the entire California coast. Link
- **The Nature Conservancy Coastal Resilience tool:** Visualization and decision support platform where ecological, social, and economic information can be viewed alongside sea-level rise and storm surge scenarios to develop risk reduction solutions. Link.
- **Coastal Flood Exposure Mapper – NOAA:** Visualization tool for assessing coastal hazard risks and vulnerabilities. Link
- **BCDC Flood Explorer:** Specific to District 4, The regional flooding and shoreline overtopping analysis maps provided in the ART Bay Shoreline Flood Explorer website

capture permanent and temporary flooding impacts from sea level rise scenarios from 0- to 108-inches above MHHW (mean higher high water) and storm surge events from the 1-year to the 100-year storm surge. Link

For a comparison of available SLR data in California, the Sea Level Rise and Coastal Flood Web Tools Comparison Matrix for California provides a side by side comparison of several available SLR viewers. To access this tool, click here.

Generally, when performing analysis for sea level rise, the extreme H++ scenario should be used in tandem with other projections to satisfy jurisdictional requirements in coastal areas.

Potential Wildfire Data

The following resources include analysis of projected changes in future wildfire risk that account for climate change in California. Climate change data sources such as these should be included in wildfire risk assessment.

- **Caltrans Climate Change Vulnerability Assessments:** Includes data that provides a statewide view of wildfire risks. Like the Sea Level Rise data, they provide an authoritative source for climate data when making local decisions. For more granular information pertaining to a particular corridor, facility, or segments of facilities, it may be necessary to utilize data from outside agencies for further analysis. Link. The following resources provide a good snapshot of current wildfire risk, but should be used in tandem with other sources that include climate change in their analysis such as the Caltrans Vulnerability Assessments to provide a more complete understanding of future wildfire risk along a corridor.
- **Caltrans Division of Maintenance, Forest and Wildfire Management Program:** Contains the mapped priority segments from the Caltrans Wildfire Vulnerability Analysis (2020-2030), there is also the Caltrans Vegetation and Wildfire Management Map Viewer and the Onramp webpage on Roadside Fire Fuels Reduction here. This tool contains a layer that displayed priority vegetation reduction treatments along the SHS. For more information on these efforts, contact the Office of Vegetation & Wildfire Management.
- **Fire Hazard Severity Zones:** CALFIRE is required by law (GCS 51179) to map areas of significant fire hazards based on fuels, terrain, weather, and other factors. The maps are developed using a science-based and field-tested model that assigns a hazard score based on the factors that influence fire likelihood and fire behavior. Many factors are considered such as fire history, existing and potential fuel (natural vegetation), predicted flame length, blowing embers, terrain, and typical fire weather for the area. There are three levels of hazard in the State Responsibility Areas: moderate, high, and very high. Link
- **Tree Mortality Viewer:** Developed as a response to severe drought in 2015, High Hazard Zones are updated on a yearly basis, generally around March/April by the Forest Management Task Force, comprised of rural stakeholders, CALFIRE, Bureau of

Land Management, Caltrans and other interest groups such as logging. The areas impacted are primarily rural and wouldn't be highly populated corridors. Link

- **Tier One High Hazard Zones:** These zones represent areas of tree mortality in direct proximity to assets determined to be important to life and property (including communications, transportation, recreation, communities, and utilities). Dead trees represent a direct threat to public safety and identify areas to be prioritized for hazardous tree removal. Link
- **CALFIRE GIS Page:** Includes downloadable and webmaps of GIS data for current and past fires in California. Link
- **CALFIRE Incidents Webpage:** This webpage shows a status of active fires for the current fire season, as well as fires from past fire seasons. This will be useful when researching past wildfire impacts affecting a corridor. Link

Identifying Riverine Flooding Risk Along a Corridor

- FEMA National Flood Insurance Program (NFIP) Maps: Caltrans is required to use NFIP maps to determine if highway alternatives encroach into flood plain base – if so – ensure Caltrans construction does not raise the base flood plain. Current design is based on historic data which may lead to many current and future assets being undersized, resulting in increased flooding, washouts, scour, erosion, bridge and culvert failure. To better understand future flood risk, these maps should be used in tandem with climate change precipitation data (and sea level rise information in coastal areas) to better understand future storm conditions and how they will affect the flood risk along a corridor. Precipitation data should be examined for segments of a stream that are near or intersect with the corridor, as well as within the watershed for the stream. Significant increases in precipitation (>5%) may contribute to an increased risk of flooding in conjunction with the expected 100-year floodplain in the NFIP maps. Another resource that may be helpful in locating these same floodplains is the Best Available Map (BAM) created by the California Department of Water Resources in response to SB 5. This tool can provide visual information on an interactive map for FEMA Effective 100-year floodplains, as well as other special studies if desired. The BAM can be accessed here.

Identifying Landslide Hazards Along a Corridor

These data sources provide a snapshot of current susceptibility to landslides based on characteristics of the geology surrounding these areas. Landslides are often triggered by external forces such as saturation from heavy precipitation events that loosen the binding of slopes, or wildfire events drying and burning vegetation that stabilized the slope structure. To gain a better understanding of how climate change will affect the susceptibility of landslides, these landslide data sources should be used in tandem with climate change data sources such as the Caltrans Vulnerability Assessment precipitation and wildfire data. Special attention should be given to areas that have a high susceptibility to landslide, but also are projected to see a significant increase in

both precipitation and wildfire risk as these stressors may compound with one another to increase risk even further.

- **California Geologic Survey Deep-Seated Landslide Survey (MS58) Data:** This data shows areas of California that are most vulnerable to landslide based on an industry standard scale that combines measurements for past landslide inventory, rock strength, annual rainfall, and slope steepness. To view a webmap of the Deep-Seated Landslide Risk, click here. To download GIS data, view the California Department of Conservation Geologic Hazards Data and Maps page here.
- **The California Geological Survey Corridor Landslide Mapping Reports:** A pilot project between the California Department of Conservation and Caltrans, selected highway corridors are divided into sections based on similarities in the bedrock geology, slopes, and size, type, and activity of landslides. The California Geological Survey Corridor Landslide Mapping Reports can be accessed on the California Department of Conservation website here.

Other Available Data Sources

- **DEA GIS Library:** The DEA GIS Library provides an internal, statewide collection of relevant spatial datasets. Relevant data includes SLR datasets from NOAA, USGS, and Humboldt-specific data, as well as boundaries of the Coastal Zone and Local Coastal Program jurisdictions. Link
- **Cal-Adapt Extreme Heat & Warm Nights Tool:** With this tool you can explore how the frequency and timing of extreme heat days and warm nights is expected to change under different emission scenarios. Link
- **Local Vulnerability Assessments:** Many local jurisdictions have received state funding from Caltrans or other agencies to perform their own vulnerability assessments that could include information and/or data that may be applicable to corridor planning.

CORRIDOR PLANNING IN COASTAL AREAS

In the 2021 State Highway System Management Plan (SHSMP), sea level rise has been associated with an $11 billion adaptation need. The California Coastal Management Program (CCMP), approved by the National Oceanic and Atmospheric Administration (NOAA) in 1978, is a combination of Federal, State, and local planning and regulatory authorities for uses of land, air, and water resources along the coast. The CCMP includes two state land use permitting agencies, the California Coastal Commission (CCC) and the San Francisco Bay Conservation and Development Commission (BCDC). The California Coastal Commission manages development within the Coastal Zone, which is a strip of land and water along the coast from the Oregon border to Mexico. While the specific location of the Coastal Zone boundary is defined in the Coastal Act, the Coastal Zone generally extends 1,000 yards inland from the mean high tide line of the sea. In some areas with significant coastal estuarine or recreational areas, this boundary may extend further inland, while in major urban areas the

boundary may extend less than 1,000 yards. The Coastal Zone does not include San Francisco Bay, which is separately regulated by BCDC. Additionally, while not part of the California Coastal Management Program, the Sacramento-San Joaquin Delta is protected and managed by the Delta Stewardship Council (DSC) through the Delta Reform Act. Collectively, the Coastal Zone, San Francisco Bay, and the Delta are all subject to sea level rise. As such, corridor plans in these areas should always consider sea level rise and other associated impacts.

In general, coastal resources in proximity to the transportation system that are exposed to SLR now or in the future have strong regulatory protections through existing law, and corridor plans should identify adaptation strategies that altogether avoid or in special cases minimize and mitigate impacts on coastal resources including wetlands, environmentally sensitive habitat areas, sandy beaches, agriculture, public access, water quality, and groundwater. Adaptation strategies can include nature-based solutions, active management strategies, relocation, elevation, and short- or potentially longer-term armoring, however there is a strong regulatory preference for strategies that do not include hard armoring and they are only allowed in certain circumstances where other options are infeasible.

For information on the documents listed in this section, as well as further guidance on addressing sea-level rise along a corridor, visit the Sea Level Rise and the Transportation System in the Coastal Zone webpage developed by the Division of Environmental Analysis.

Determining if Portions of a Corridor are Within Regulatory Coastal Jurisdictions
Corridors that cross these boundaries should consider the respective jurisdictional policies of the CCC, BCDC, DSC, or a Local Coastal Program. To determine if portions of a corridor fall within this boundary, the DEA GIS library has GIS layers that shows where these boundaries are. The DEA GIS Library can be found here (to access the Coastal layers, on the GIS Library pane on the right of the screen, select the General Tab and then within that tab, select the Coastal tab). While the DEA GIS Library is a helpful tool to get started, it will be most beneficial to work with Coastal Commission staff to determine if your corridor is within the Coastal Zone as the Commission reserves the right to make final Coastal Zone boundary determinations.

California Ocean Protection Council (OPC) Sea Level Rise Guidance
This guidance provides information on how to determine which Sea Level Rise scenario to select depending on strategies and projects proposed in later steps. **If a proposed project is within coastal areas like the external coast, SF Bay, or Delta—the OPC SLR guidance will be a helpful starting point for applying the necessary analysis once potential projects and strategies are proposed for the corridor plan that will be necessary for future Coastal Development Permit, BCDC permit, or DSC certification of consistency applications.** During this phase of the corridor planning process, it is advisable to satisfy step 1 of this OPC Guidance, which is to locate the nearest tide gauge(s) for the corridor to establish SLR projections for projects along the corridor. If a proposed project along the corridor falls relatively equidistant between two tide

gauges, it is appropriate to take the mean SLR projection from the two gauges. Tide gauge locations can be found within the document in Appendix 2.

SLR vulnerability assessments should evaluate the medium-high and extreme (H++) SLR projections in conjunction with the combined effects of the coastal hazards that have the potential to affect the site (i.e., wave run-up, flooding, erosion) and 100-year storm activity. Corridor plans should identify long-term adaptation strategies—in collaboration with local governments—that avoid or minimize risks to Caltrans' transportation system and avoids or minimizes and mitigates impacts on coastal resources. Adaptation strategies can include nature-based solutions, active management strategies, relocation, elevation, and short- or potentially longer-term armoring. The OPC State of California SLR Guidance can be found here.

Outstanding and Potential Sea Level Rise Planning Permit Requirements
Relevant Coastal Commission SLR recommendations for planning activities can be found in Chapter 5 of the 2018 CCC Sea Level Policy Guidance, as well as the Coastal Commission's Critical Infrastructure at Risk: SLR Planning Guidance for California's Coastal Zone. In general, identification of long-term adaptation strategies that avoid or minimize risks to Caltrans' transportation system should be identified that also avoid or minimize and mitigate impacts on coastal resources. Chapter 6 of the Coastal Commission's 2018 Sea Level Rise Policy Guidance outlines information and specific recommendations for addressing SLR in Coastal Development Permit applications and outlines a five-step process to address SLR in the project design and permitting process in cases where SLR may contribute to or exacerbate hazards or affect coastal resources. These considerations should be taken into account when proposing and analyzing projects and strategies in later steps.

REGIONAL GHG REDUCTION STRATEGIES

California has established an ambitious goal of carbon neutrality by 2045, with significant milestone of 40% below 1990 levels by 2030. While contributing to regional GHG emissions reduction goals should be a priority, interim goals should also be established leading up to those benchmarks.

Regional Plans
CARB sets regional targets for California's 18 MPOs to use in their Regional Transportation Plan/Sustainable Communities Strategy (RTP/SCS) to plan future projects that will cumulatively achieve GHG reduction goals. Targets are set at a percent reduction of passenger vehicle GHG emissions per person from 2005 levels. Regional Plan Climate Targets may be viewed here.

Areas Outside MPOs That Do Not Have a Sustainable Communities Strategy
An RTP, climate action plan, greenhouse gas reduction plan, or General Plan element may contain GHG-related goals and plans. Examine these plans to establish whether the proposed project conflicts with an applicable plan, policy, or regulation adopted for the purpose of reducing the emissions of GHGs. Climate action plans can be found at California Climate Adaptation Portal interactive map here.

SOCIAL AND PUBLIC HEALTH CONSIDERATIONS RELATING TO CLIMATE CHANGE

CDPH Climate Change and Health Profile Reports
The Climate Change and Health Profile Reports are designed to help counties in California prepare for the health impacts related to climate change through adaptation planning. The reports present projections for county and regional climate impacts, the climate-related health risks, and local populations that could be vulnerable to climate effects. The information is based on available science compiled from previously published, state-sponsored research, reports, and plans. Link

CalEnviroScreen Disadvantaged Communities and AB 1550 Low-Income Communities
Disadvantaged and low-income communities are projected to be disproportionately affected by climate change and climate-related hazards. At the same time, these communities will also face more pressing obstacles when adapting to climate change than other communities might. These communities should be identified in a corridor plan. Information about CalEnviroScreen can be accessed here. A map of both Disadvantaged and Low-Income communities can be accessed here.

STEP 3: CONDUCT BASELINE PERFORMANCE ASSESSMENT

Goal: Compile and document past system performance disruptions and potential characteristics of future disruptions in the performance assessment. This should include such factors as estimated potential economic costs of such disruptions, the impact on potential evacuation routes, and the feasibility of potential adaptation strategies that consider the surrounding environmental resources.

- ☑ Use best available data described in Step 2 to determine vulnerability of portions of the corridor to climate change stressors for multiple climate scenarios while noting the projection years of expected impacts.
- ☑ Highlight stressors that have affected the corridor in the past and, if possible, compile impacts from those past events to the operation and performance of the corridor.
- ☑ Use available resources to consider a "whole corridor" aspect that identifies impacts from climate change to all aspects of a corridor including social, environmental, and economic factors.

ASSESSING WHERE A CORRIDOR IS VULNERABLE TO CLIMATE CHANGE

Caltrans District Climate Change Adaptation Priorities Reports
The Climate Change Adaptation Priorities Reports build off the Climate Change Vulnerability Assessments by using a prioritization scoring matrix developed through a

combination of technical analysis and input from District staff. **The normalized scoring of each Caltrans asset in each District will allow planners to identify and prioritize the order in which assets found to be exposed to climate hazards.** If clustering of high priority assets is found along a corridor, the cluster may need to be identified in a corridor plan. The prioritization in these reports considers, amongst other things, the timing of the climate impacts, their severity and extensiveness, the condition of each asset (a measure of the sensitivity of the asset to damage), the number of system users affected, and the level of network redundancy in the area. Prioritization scores are generated for each potentially exposed asset based on these factors and used to rank them. This prioritization can be helpful for identifying and prioritizing projects, as it identifies assets that are most at risk to climate change-related impacts right now and in the future.

This tool should be used in conjunction with other visualization tools and local stakeholder engagement that reflect the characteristics of the surrounding area. Notable details about the surrounding areas that need to be considered might include adjacent land uses, rail lines, transit routes, and active transportation facilities. As described in Step 2, there are caveats in using the Adaptation Priority Report data, for example, priorities reflect a merging of climate stressors—and depending on climate stressor, both priorities and potential strategies to mitigation the risk would adjust accordingly (i.e. wildfire adaptation approaches would likely be different from those considered for SLR). Each of the District Adaptation Priorities Reports can be found here, while the Adaptation Priority Report webmaps are available on the DEA GIS Library here.

Corridor Performance with Sea Level Rise

Corridor plans should consider the "whole corridor" aspect when conducting a performance assessment—or how different assets including roadway segments, bridges, and culverts (as a start) operate in concert together over the short, medium, and long-term to provide or not provide continual corridor-level service. As described above, the District Climate Change Adaptation Priority Reports identify priorities on an asset-by-asset basis—meaning that additional analysis and interpretation is required in order to characterize how those assets collectively would perform in delivering transportation service throughout the corridor over time given SLR.

Assets expected to have impacts on coastal resources due to "coastal squeeze"—or where transportation infrastructure like roadways will inhibit landward migration and cause tidal wetlands and beaches to drown in the short, medium, and long-term—were not part of the Adaptation Priority Reports, and should form part of the performance assessment in terms of identification adaptation needs along a corridor. Areas containing resources projected to be impacted by coastal squeeze can be found on the DEA GIS library (on the selection pane on the right, click Climate > Coastal > USGS CoSMoS to access layers that identify impacts from coastal squeeze).

Local Climate Vulnerability Assessments

As a supplement to the Caltrans District Vulnerability Assessments, some local, regional, and tribal agencies may have developed climate vulnerability assessments that use

more granular data or analyze climate stressors that were not included in the Caltrans District Vulnerability Assessments. Whenever possible, the best available data should be used when determining climate vulnerabilities on a corridor. Coordination with local, regional, and tribal agencies who have conducted vulnerability assessments may be necessary to ensure that the data they have developed is available and is being used properly. Some rail and transit operators have also developed Vulnerability Assessments, which should also be considered on a corridor.

The Climate Access Portal Map (CAP-Map) was developed by the California Air Resources Board to allow users to quickly access the climate action planning details of local jurisdictions including links to climate plans created, GHG inventory information, GHG reduction targets, the local strategies planned to meet these targets, and more. The Governor's Office of Planning and Research developed the Resilient CA Adaptation Planning Map (RAP-Map), an open data tool, to inventory local government climate risk, adaptation, and resiliency planning efforts across the state and track progress towards statewide adaptation planning goals. Local vulnerability assessments may be found using either of these tools.

CALFIRE Historical Fire Data

The CALFIRE GIS data page allows users to view fire hazard severity zones, fire threat, and vegetation status across California. To view past fires affecting a corridor, there is a dataset that displays past fires from as far back as the 1950's. Any relevant fires, particularly larger fires along a corridor should be represented in a corridor plan to demonstrate potential impacts from wildfire to the corridor and surrounding areas, as well as to inform future needs for fuels reduction along a corridor and prepare for future potential disruptions to service caused by these events. Link

FEMA National Flood Insurance Program Maps

Caltrans is required to use the NFIP maps to determine if highway alternatives encroach into flood plain base – if so – ensure Caltrans construction does not raise the base flood plain. These maps provide a useful method for determining portions of the SHS that are susceptible to flooding events during a 100-year storm. These maps also provide context for surrounding areas that may be affected by flooding and will need to reroute along the SHS or use the corridor as an evacuation route. Link

Incorporating Past Climate Hazards

Local agencies may be consulted for more information regarding past impacts from climate-related hazards. A general overview of past hazards is often included in Local Hazard Mitigation Plans, as well as actions taken since those impacts took place. The climate change section in a corridor plan should highlight especially severe events such as major wildfires, floods, or landslides as well as the impacts of those events on the surrounding communities and the operability of the SHS. The CALFIRE data site includes a webmap of fire perimeters through 2020 that features incidents from as far back as the 1950s. When using this tool, focus on wildfire perimeters that intersect with the corridor or into surrounding communities, particularly if they are large and/or recent wildfire events. Another potential strategy for incorporating past climate hazards into a

corridor plan would be to include a list of past emergency projects relating to climate change that have occurred along a corridor.

Address Outstanding Emergency Permits Requirements
Coastal highways are and will continue to be increasingly exposed to wave action and cliff erosion which erode and undermine the roadway foundation. Over the past decades, Caltrans has conducted emergency repairs to address these issues and obtained what are known as Emergency Coastal Development Permits (ECDPs). By Statute, all these ECDPs contain requirements for Caltrans to follow-up with a long-term project solution and permit. Stated more simply, Caltrans is out of compliance in programming resources for permanent restoration projects that address these chronic wave-action or cliff erosion issues and submitting those projects for a permit. Districts should work with their Coastal Liaisons to ensure those chronic issue areas are considered in identification of potential projects for the corridor.

STEP 4: IDENTIFY POTENTIAL PROJECTS AND STRATEGIES

Goal: Consider strategy characteristics and stand-alone adaptation and mitigation projects and strategies that could be considered in the corridor to reduce climate change-related risks and impacts. This includes noting where incremental project changes could be made to make a project meeting primarily other goals to improve corridor system resiliency. When identifying adaptation solutions, where feasible, strategies and projects that avoid or minimize impacts to environmental resources should be identified. Appropriate GHG and VMT reduction measures should also be identified for the corridor.

- ☑ Identify and catalog a full suite of potential strategies to address impacts at each exposed location along the corridor in the short-, medium-, and long-term while considering the impact to all aspects of the corridor and surrounding systems if implemented.
- ☑ Consider nature-based and less-environmentally damaging solutions wherever feasible.
- ☑ Identify appropriate GHG and VMT reduction strategies that can be implemented along the corridor.

APPENDIX A OF THE CALTRANS ADAPTATION STRATEGY REPORT

This section of the Adaptation Strategy Report provides more detailed information on the representative types of projects that can be implemented to combat hazards posed by climate change and associated changing weather patterns. The intent of this section is to illustrate the types of hazards and/or threats represented by different climate stressors, the potential impacts to the SHS caused by these stresses, and the

types of adaptation actions or strategies that should be considered to avoid or minimize the impacts. **This should be the starting point for Step 4, with subsequent guidance and potential strategies, projects, and guidance for each potential hazard listed below.** Appendix A begins on page 100 of the Adaptation Strategy Report and can be found here.

ADDRESSING CHANGES IN PRECIPITATION AND RIVERINE FLOODING ON A CORRIDOR

Changing temperatures will change the overall behavior of weather in California. Climate-driven changes in precipitation may cause a rapid increase in peak flows along streams, potentially leading to pooling or riverine flooding. Transportation assets passing nearby or over these streams can be heavily impacted by flooding events, whether by disrupting traffic or damaging infrastructure.

- **Floodplain Conservation/Preservation:** Generally, wetlands are an effective option for reducing disaster risk in riverine environments in which semi-aquatic plants slow down the flow of floodwaters, soak them up, and hold soil in place. This is a very passive and non-invasive strategy that has very little cost associated with it.
- **Drainage Improvements:** Drainage improvements may assist in mitigating events where transportation facilities are overwhelmed by high flows from precipitation or runoff. Drainage can be improved through a variety of methods including widening the capacity of culverts, elevating road surfaces, and improving permeability. Designing and building with less permeable surfaces can cause a significant increase in surface runoff, so incorporating permeable surfaces into design may improve the overall drainage capabilities of facilities.

Potential Flooding and Heavy Precipitation Projects

Chapter 890 of the Highway Design Manual provides a high-level overview of potential strategies to improve surface drainage, with references to more detailed overview of these strategies. To view this chapter of the Design Manual, click here.

Table 2- Example strategies and projects for addressing heavy precipitation and riverine flooding impacts along a corridor.

Strategy	Project	Project Details
Floodplain Conservation/ Preservation	Floodplain Management	• The most efficient and inexpensive natural infrastructure strategy for riverine flooding protection due to its passiveness and doesn't require any construction.
Drainage Improvements	Bioswales/ Bioretention Ponds	• These strategies mitigate stormwater flooding impacts by serving as an absorbent catchment for the stormwater. Plants act to attenuate water flows and hold soil in place, while the permeable groundcover allows infiltration into the soil. • Can assist with ground water recharge – addressing ground subsidence issues in the area which may help protect the facility. In dry and arid areas, dry swales may be more appropriate. Bioswales can improve water quality of runoff compared to other strategies by catching and breaking down pollutants in stormwater, such as heavy metals. • These facilities require regular upkeep to maintain their beneficial functions over long periods of time.
	Detention Ponds	• Typically, these are engineered with hardened, less permeable shorelines. These ponds act as a temporary water storage to reduce peak flow periods and allow for more gradual runoff when flow levels recede.
	Culvert Expansion/ Bridge Elevation	• The redesign of a culvert or bridge to allow for higher peak flow levels. • Current design standards are for 100-year flood standards, however, with projected shorter and more intense wet seasons, this may result in an underestimation for potential flows.

ADDRESSING WILDFIRE RISK ON A CORRIDOR

Wildfire is a very rapid and costly climate-driven hazard affecting Californians every year. While many fires are preventable altogether, projected increases in temperature coupled with decreases in precipitation will likely generate more severe annual wildfire seasons in California in the future. Some measures can be taken to prevent the generation and uncontrollable spread of wildfire and mitigate potential damage to transportation facilities and their surrounding communities.

Division of Maintenance, Office of Forest & Wildfire Management

If a corridor is expected to be affected by wildfire, the Office of Forest & Wildfire Management will be a helpful internal resource for obtaining information on how to address wildfire risks along the corridor. Link

Evacuation Routes

To date, evacuation routes have not been explicitly defined or mapped statewide. Nevertheless, a county sheriff, in conjunction with city officials having jurisdiction over the community has the discretion to designate evacuation routes for that community.

Consulting with CALFIRE to determine potential actions to streamline evacuation along key routes would be useful in planning and designing the physical roadway to handle such events more readily. Some possible strategies to develop more efficient evacuation routes along a corridor include:

- Considering class II bike lanes instead of Class IV along a corridor to provide unobstructed pavement width for improved egress/ingress in emergency events.
- Making barriers easily visible during emergency situations including at night and in smoky conditions.
- Wider shoulders for potential use as another lane in emergency situations

More information can be found in Design Information Bulletin #93 – Evacuation Route Design Guidance (2020).

The Caltrans Climate Change Adaptation Strategy Report Recommended Wildfire Adaptation Strategies

The strategies outlined in Appendix A.7 of the Adaptation Strategy Report provide information on strategies for wildfire prevention and adaptation. Wildfire adaptation strategies are grouped into 3 categories: defensible space, fire-resistant landscaping, and hardening. The Caltrans Adaptation Strategy Report can be found here.

- **Defensible Space:** Caltrans can avoid the ignition of a wildfire, and prevent damages in the event of a wildfire, by maintaining defensible space. Defensible space is a buffer that's created between a building and the vegetation surrounding it. This space slows or stops the spread of wildfire and additionally protects the building from radiative heat impacts. More information on Defensible space can be found on the CALFIRE website here.
- **Fire Resistant Landscaping:** Caltrans can use fire-resistant landscaping along its right-of-way and outside of its facilities to prevent fire ignition, and slow or stop the spread of an existing wildfire.
- **Hardening:** Caltrans can take actions to prevent ignition and damage to Caltrans buildings and assets by using ember- and heat-resistant materials. Some of these changes are straightforward and are already being implemented by Caltrans across the State.

Table 3 - Example strategies and projects for addressing wildfire impacts along a corridor.

Strategy	Project	Project Details
Defensible Space	Fuels Reduction	• Clearing of vegetation along the SHS to protect SHS users from approaching wildfire, as well as protection from the ignition of fuels by SHS activity. • Allows for the SHS to act as a fire break in wildfire events, potentially slowing the advance of wildfire and improving conditions for fire suppression in such wildfire events.
Fire-Resistant Landscaping	Landscape Management	• Planting and maintaining vegetation that is known to be tolerant to fire, or less likely to die off from higher projected temperatures, and prolonged periods of drought. • Water conservation is another benefit to using fire-resistant landscaping, as plants that are fire-resistant are typically drought-tolerant natives.
Hardening	Culvert Replacement	• Replace plastic culverts with culverts made from inert materials such as corrugated steel pipe (CSP).
	Guardrail and Signpost Replacement	• Replace wooden guardrail posts and signposts with metal or other inert material that are less likely to be affected by wildfire.

ADDRESSING LANDSLIDE RISK ON A CORRIDOR

Landslides are a hazard that is typically driven by a combination of climate stressors. Precipitation, temperature, and the occurrence of wildfire all have an influence on the level of risk that landslides may occur. While Caltrans does not currently have climate change vulnerability assessments that assess climate change impacts on landslide risk directly, understanding the typical causes of landslides and necessary actions will be critical in preparing for future damage or disruptions.

The Caltrans Geotechnical Manual Recommended Landslide Mitigation Strategies
Landslide mitigation strategies are grouped into four categories: Avoidance, Stabilization, Protection, and Management. These categories trend from higher to lower cost, effectiveness, planning, and design effort; and from projects that are generally performed as Capital Improvement to SHOPP to Maintenance. The strategies are often used in combination, and the measures can overlap from one category to another. For more information on these strategies, view the Caltrans Geotechnical Manual module on Landslides here.

Table 4 - Example strategies and projects for addressing landslide impacts along a corridor.

Strategy	Project	Project Details
Avoidance/ Relocation	Roadway Realignments	• Rerouting the roadway to alignments that are less at risk from landslide or other geotechnical hazards.
	Bridge/ Viaduct	• Separating a roadway from adverse impacts of potential landslides by raising or moving roadway to another location, allow landslide movements to continue but without affecting the highway.
	Tunnels	• Rerouting the roadway to travel below where landslide movements may potentially affect the roadway. Known to be a very cost and labor-intensive project that would only be considered if there is no other strategy available.
Stabilization	Earthwork	• This strategy can be both costly and environmentally harmful if done incorrectly. Before making this recommendation in the plan, the Caltrans Geotechnical Manual should be referenced. Due to the relatively high impact and cost of material excavation, transport, and disposal, projects involving earthwork should strive to adhere to the principles of reduce, reuse, recycle, replenish, and dispose.
	Dewatering/ Drainage	• Influence the stability of a slide mass by both decreasing the driving force and increasing the resisting force by reducing the quantity of water entering a slide with drainage systems placed/graded near the head scarp to divert surface water elsewhere. Remove groundwater from within a potential slide mass or surrounding terrain using vertical wells or horizontal drains.
Protection	Rock Sheds	• Structures that enclose the SHS overhead to provide protection to travelers from landslides activity above the roadway.
	Barriers/ Draperies/ Catchment Ditches	• Proactive mitigation method based on topographic contours to catch debris lifted and transported during an increased precipitation event. • Debris Flow Catchments can be implemented in burn scars that are susceptible to high amounts of runoff. These catchments prevent clogged culverts and subsequent damage to roads from water overflow.
Management	Slope Management	• Involves measures such as monitoring systems, patrols, planned road closures, signing, periodic maintenance, and minor rebuilding to allow operation of the highway within a tolerable amount of movement and disruption. • Management measures are often practical for large, slow moving slides when the obstacles to other mitigation strategies prove insurmountable.

STRATEGIES FOR ADAPTING TO EXTREME HEAT EVENTS

Extreme heat events are projected to become more frequent and severe in the future, affecting both the transportation infrastructure and its users. In hot weather, unshaded roofs and pavements in urban and heavily paved locations can be heated to temperatures far above that of the surrounding air, creating what is called a "heat island." Heat islands increase summertime peak energy demands, air conditioning costs, air pollution, GHG emissions and heat-related illnesses. Wherever feasible, planners should consider these conditions when planning for streetscapes at a human-scale.

Impacts to Pavement and Infrastructure

High and low temperatures cause pavements to expand and contract, creating pressures that can cause pavements to buckle or crack with binders in flexible pavements also becoming softer at higher temperatures. If locations are projected to see a large increase in temperatures due to climate change, planners should consult the Division of Design to consider the types of pavements that may be necessary to maintain efficiency of the roadway along a corridor.

Complete Streets

Designing transportation facilities that remain usable for a variety of modes of transportation during extreme heat events would be an equitable approach for addressing impacts to non-auto users. Extreme heat is known to contribute to a variety of health risks that can affect non-vehicular travelers who have limited access to travel options that feature air conditioning. When considering complete streets projects, coordinate active transportation representatives and partner agencies to consider complete street options that consider extreme temperatures.

Table 5 - Example strategies and projects for addressing extreme heat events along a corridor.

Strategy	Project	Project Details
Complete Streets	Street Trees	Trees shade pavements and roof tops, which helps maintain more comfortable summertime temperatures. Trees also cool the air via evapotranspiration, which alone or in combination with shading, can help reduce peak summer air temperatures and heat islands.
	Cooling Pavements	Used in lieu of conventional black asphalt, cooling pavements either reflect more solar radiation (thereby absorbing less heat) or are permeable surfaces which cool the pavement through water evaporation and air circulation. Decreasing the amount of heat absorbed by pavements can be achieved by using lighter materials such as concrete or using a lighter colored aggregate in asphalt paving mixes.
	Improved Active Transportation Safety	Protected active transportation infrastructure will allow cyclists to move at slower, safer speeds during extreme heat events rather than higher speeds when sharing the road with cars, potentially reducing the risk of exhaustion during extreme heat events.
Improved Transit	Transit Shelters	Shaded areas where transit users can wait for transit in more comfortable conditions during extreme heat events.
	Increased Transit Service	Reducing wait times for transit service will provide benefits to transit riders with improved service as well as reduced exposure to extreme heat conditions.

ADDRESSING SEA LEVEL RISE ON A CORRIDOR

Planners must consider the regulatory environment when identifying potential projects and strategies for the transportation system in tidally influenced areas which extend from the exterior coast to the San Francisco Bay and Delta. In general, this step provides the opportunity for corridor plans to consider coastal resources through identification of a set of strategies and projects that will be easier to permit as impacts to those coastal resources were avoided or minimized from this planning and programming stage. For a high-level overview of sea level rise impacts in California, view the California Coastal Commission's Sea Level Rise in California: Planning for the Future ArcGIS storymap. For a more detailed overview of coastal zone background pertaining to the transportation system, visit the Sea Level Rise and the Transportation System in the Coastal Zone webpage developed by DEA.

Division of Environmental Analysis, Coastal Program

Caltrans' Division of Environmental Analysis has established a Coastal Program to assist Caltrans District staff and other interested parties in understanding the requirements and complexities of the California Coastal Act and coastal permitting process. The Coastal Program trains, educates, and coordinates with Caltrans staff working on projects in the California coastal zone.

Sea-Level Rise Adaptation Strategy Considerations

Adaptation strategies generally fall into three main categories– protect, accommodate, and retreat.

- **Protect:** Protection options include those strategies in which a physical barrier is constructed to essentially keep water (either from flooding or from short and long-term erosion) away from a structure. This includes both hard shoreline protective devices—such as seawalls, rock revetments, bluff retaining devices, groins, levees, and so on—as well as "soft" or "green" strategies—those features that rely on natural components and processes to provide protection, such as constructed or restored dunes, beach nourishment, vegetation, oyster beds, and the like.
- **Accommodate:** Accommodation strategies are those in which the asset itself is designed to better withstand the impacts from coastal hazards. This could include engineering structures to be physically stronger, such as building with stronger materials (cement, steel, etc.), or using caissons or foundations that ensure stability. It also includes options that allow structures to work with changing water conditions. For example, roads, bridges, various components of wastewater treatment plants, and other infrastructure can be elevated above a certain flood level, generally to protect against storm conditions or extreme tides, while piers and docks can be designed to float up and down as the tide changes throughout the day.
- **Retreat:** Retreat strategies are those in which assets are moved out of harm's way. This includes both removing or relocating existing structures that are in danger from hazards, as well as siting new development to avoid hazardous areas so that it will be safe over its anticipated lifetime without requiring additional adaptation measures. Due to the connectivity and linkages of most infrastructure systems, retreat strategies may need to address not just the portions that will be at-risk, but also adjacent segments so that the whole system can continue to function.
- **Hybrid Approaches:** In practice, hybrid approaches may be taken in which strategies from each category are used together on a single site to address different levels of risk, or different strategies may be phased and implemented over time to address changing conditions.

Adaptation strategies that are most appropriate for particular segments of the transportation corridor will depend on the specific circumstances for each location, each type of strategy—including protection, accommodation, retreat, and hybrid strategies—generally has benefits and impacts that can help guide decision-making around when each one should be used. There are two general take-aways for corridor plans:

- New transportation infrastructure should avoid areas where sea level rise will affect the infrastructure over its expected life.
- For transportation infrastructure that is already established, a "phased" or "adaptation pathways" approach which recognizes that adaptation options will

need to change over time to account for planning timelines, changing conditions, and uncertainty. In general, planning for relocation of the infrastructure to safe areas or elevation to avoid the need for hard shoreline protection that harms coastal resources is prioritized from a regulatory perspective. In some cases, it may be feasible and appropriate to employ nature-based adaptation strategies as a more environmentally friendly way to minimize the impacts associated with sea level rise over the short- to medium-term while planning for relocation, and if feasible, should be the preferred approach.

For more information on natural or nature-based solutions in a coastal area, and for an overview of project types, refer to the FHWA *Nature-Based Solutions for Coastal Highway Resilience Implementation Guide*. For more information on Nature-Based coastal infrastructure in a California context, refer to the report for California's Fourth Climate Change Assessment titled "Toward Natural Shoreline Infrastructure to Manage Coastal Change in California" as well as the Coastal Commission's "Critical Infrastructure at Risk: Sea Level Rise Planning Guidance for California's Coastal Zone".

Adaptation Phases in Corridor Plans

Phased adaptation—also known as an adaptation pathway approach or trigger-based adaptation—is the use of different adaptation strategies over time as certain sea level rise thresholds are met. For example, adaptation phases can start with protection strategies, such as sand replenishment, or accommodation strategies, such as floodproofing and elevation, and lead to eventual relocation in the longer term as protection and accommodation strategies become infeasible due to increasing hazards and costs.

Phased adaptation will be an essential approach for protecting the transportation system in California given the complexity of adapting infrastructure and the significant vulnerability that is expected. Phasing allows for incremental changes that can ease costs, creates additional time needed for planning future phases of adaptation, and is adaptive to the timing of future conditions. Phasing also allows for the alignment of long-term land use and infrastructure adaptation, so that development and infrastructure in hazardous areas can be phased out concurrently, as hazards become more extreme. Given the significant costs of adapting critical infrastructure, annual funding cycles, large project scopes, the uncertainty over the timing of sea level rise, and other factors that make it infeasible to adapt an entire infrastructure network all at once, this adaptive approach will often be the best method for systematically addressing sea level rise vulnerability.

State guidance recommends analyzing an extreme rate of sea level rise to inform adaptation planning for critical infrastructure. In the current best available science, this scenario is called the extreme or H++ scenario. While it may make sense to address the H++ scenario in a single adaptation project for certain pieces of critical infrastructure, *in other cases it may be appropriate to use a phased approach to adaptation*. Planners can design multiple phases of adaptation measures, each for an incremental amount of sea level rise, up to and including the H++ scenario. By linking each phase to a

particular amount of sea level rise or a particular physical impact of sea level rise, phasing allows adaptation measures to be triggered when they are necessary. This allows the adaptation pathway to be responsive to changes in the observed rate of sea level rise and other changing conditions over time.

Phased adaptation can be incorporated into corridor plans by including strategies that are specifically directed to addressing the near-term risks, or Short and Medium Term Adaptation Strategies, as well as strategies that more generally describe future adaptation phases, or Long Term Adaptation Strategies, and the need for periodic corridor plan updates to track progress on incorporating adaptation into existing projects, ensuring segments work together within a corridor, and developing a plan to continue adaptation implementation over time. Importantly, whenever shoreline armoring is used to ensure safety for transportation infrastructure—an approach that may be common in the short term—because there will likely be coastal resource impacts associated with hard shoreline protection, the corridor plan should clearly identify that coastal resource mitigation will be needed when using those adaptation approaches. By the same token, Medium- and Long-term strategies should minimize coastal resource and community impacts.

Building upon outcomes from Step 3 in the performance assessment for the "whole corridor", strategies identified here in Step 4 should also reflect the interconnected nature of the different assets along the corridor including roadways, bridges, and culverts—as well as the presence of coastal resources in the area.

Lastly, as Corridor Plans identify future project needs for each route on the SHS that are not captured within SHOPP for submission to the MONSTER Project List, the assets within the APRs that are already in Project Delivery or the 10-year SHOPP book need to be evaluated and potentially removed in this step of the Corridor Plan development process if not already done so in Step 2 as data were gathered.

Potential Sea Level Rise Projects and Strategies

When selecting strategies, projects must be carefully considered. Hard shoreline protective strategies such as seawalls, rock revetments, bluff retaining devices, and levees can exacerbate erosion and contribute to the loss of coastal resources like beaches or wetlands, necessitating mitigation for impacts and likely receiving permit conditions requiring development of long-term plan to avoid impacts. Under the California Coastal Act, hard armoring devices and strategies are only allowable under specific, limited circumstances as a last resort for protecting at-risk existing (pre-1976) development when no other alternatives are feasible. Such devices are designated with an asterisk in Table 6.

Table 6 - Example strategies and projects for addressing sea-level rise along a corridor.

Strategy	Project	Project Details
Protect	Sea Walls and Bulkheads*	• A site-specific solution built to protect assets including transportation and other community assets that generally resists the forces of wave erosion. These types of devices need to be thoughtfully placed to not induce further stress on the local communities or surrounding environment if the performance of the device is diminished. • Sea walls are capable of withstanding higher levels of erosive forces than bulkheads. Consequently, sea walls are typically implemented on a large scale, and incorporation into a given site requires consideration from the Division of Design and the Division of Environmental Analysis.
	Revetments and Slope Armoring*	• The most common engineered solutions used to protect a specific facility from erosion caused by persistent wave and tidal flows. Design parameters for these types of facilities are well established (scour depth, wave energy etc.). Large boulders, stones, or "rip-rap" break up and absorb wave energy to protect slopes which may support facilities (ex. Hwy 1.) or areas where the SHS acts as a dike (US101 Humboldt County).
	Soft Shoreline Protection	• Projects that incorporate or rely upon naturally occurring features and processes to protect the shoreline. • Beach nourishment is another viable option that may reduce the risk of wave run up and cliff retreat, as well as reducing impacts from storm surge.
Accommodate	Living Shorelines/ Nature-Based Solutions	• Use of "natural infrastructure," such as site-specific or native vegetation to stabilize shorelines through dissipating wave energy, reducing flood depth and minimizing storm surge risk. • The FHWA Nature-Based Solutions for Coastal Highway Resilience Implementation Guide includes details about specific nature-based strategies that can be used on coastal highways including potential costs and level of effort required for implementation and management. To view this guide, click here.
Retreat	Realignment/ Relocation	• Realignment away from the at-risk location is a potential strategy, that may be most appropriately explored as part of the long-term adaptation. Planned retreat can be utilized by predicting SLR through scientific models, though this option is often highly costly. All considerations for Design and ROW is necessary if realignment is needed.
Hybrid Approaches	Combination of At Least 2 Other Strategies	• Solutions involving strategies from each category are used together on a single site to address different levels of risk, or different strategies may be phased and implemented over time to address changing conditions.

STRATEGIES FOR REDUCING VMT & GHG EMISSIONS ALONG A CORRIDOR

Senate Bill 743 changed the way agencies analyze transportation improvements and development projects in our communities so Californians can drive less. The goal was to encourage the growth of more communities that allow for traveling shorter distances for daily routines, and spending less time driving. The transportation sector is responsible for the largest share of emissions (41%), and a reduction of vehicle miles traveled (VMT) must occur in order to meet the 2030 goal set by AB 32 and the California Climate Change Scoping Plan. Transportation and non-transportation strategies for reducing GHG and VMT have been established by CARB and can be viewed here. Additionally, the State Climate Action Plan for Transportation Infrastructure (CAPTI) also supports a robust economic recovery following the COVID-19 pandemic by revitalizing transit, supporting ZEV deployment, and expanding active transportation investments. While more details for incorporating the following strategies into a corridor plan may be further elaborated upon in other emphasis areas, each of these strategies may provide positive impacts to both VMT and GHG emissions along a corridor.

Improved Equitable Access to Transit

Transit has the capability of moving many people using far fewer vehicles, reducing congestion, GHG emissions, and VMT. Strategies for implementing transit to reduce GHG and VMT include:

- Supporting an expanded and integrated transit network.
- Supporting increased transit capacity and levels of service.
- Implementing viable bus rapid transit, and separated rail and bus guideways to offer service that will in many cases be faster than car trips.
- Exploring transit pass subsidies or other ways to reduce transit fares, particularly for disadvantaged communities, students, seniors, the disabled, and other transit-dependent users.
- Exploring ways to implement transit system improvements that increase the safety, attractiveness, reliability, and convenience of transit.

Improved Active Transportation Infrastructure

Viable access to equitable active transportation infrastructure is a key strategy for reducing vehicles on the road while providing positive impacts to public health & quality of life and reducing dependency on vehicle travel. Strategies for implementing active transportation to reduce GHG emissions and VMT include:

- Supporting the expansion and improvement of active transportation infrastructure.
- Exploring ways to implement active transportation system improvements that increase the safety, attractiveness, reliability, and convenience of active transportation.
- Explore ways to expand education on multimodal road safety for bicyclists, pedestrians, and drivers.

Expanded ZEV Infrastructure and Access

To reduce vehicular GHG emissions, supporting the deployment of charging or fueling infrastructure such as battery electric, fuel cell (hydrogen) electric, and other zero-emission technologies should be considered, with this infrastructure potentially being placed within the Caltrans right of way. This type of strategy should be considered particularly along trade corridors and adjacent to disadvantaged communities to achieve the largest benefits. Expanding ZEV infrastructure will also prepare a corridor for a rapid electrification of on-road vehicles due to EO N-79-20 which requires that 100% of all in-state sales of new passenger cars and trucks will be zero-emission, with a future goal of all medium and heavy-duty vehicles be zero-emission by 2045.

Encouraging Efficient Land Use

More efficient land use can expand mobility options, reduce travel times and VMT, and limit GHG emissions, all while addressing California's housing shortage. The CTP 2050 supports improving accessibility by bringing origins and destinations closer together, such as housing, schools, shopping, parks, and recreation. As such, planners should discuss opportunities for local agencies to repurpose antiquated land uses such as gas stations, parking lots, and large shopping centers to support compact, mixed-use development and sustainable mobility options. It is also beneficial to reduce emissions through reducing the vehicular right of way to increase the right of way for other modes of transportation, or other land uses.

STEP 5: ANALYZE IMPROVEMENT STRATEGIES

Goal: Include adaptation and GHG mitigation strategies and projects in the analysis, both as stand-alone projects and as part of other project scopes.

- ☑ Consult local and regional agencies and plans to determine if proposed projects and strategies comport to plans such as RTPs, SCSs, LCPs, and General Plans.
- ☑ Consider GHG and VMT impacts from proposed projects.

CONSIDER DESIGN LIFE AND CLIMATE PROJECTION YEARS

When assessing strategies, consider the projection years where impacts are expected to occur. Proposed strategies that are expected to feature a longer design life should consider later projection years, whereas shorter-term solutions must consider near-term projections. In general, corridor plans should maintain the following analysis horizons:

- **Short Term:** 1-4 Years
- **Medium Term:** 5-10 Years
- **Long Term:** Up to 25 Years

While these horizons may be relevant for the needs of corridor planning, considering the design life of resilient transportation assets will also be key. All strategies (short, medium, and long term) must consider assets that have a design life to end of century in coastal areas, and it is strongly recommended to do the same in other non-coastal areas as well. Longer-term investments will require more strategic partnerships designed to achieve consensus and mutual benefits necessary to make such investments feasible. Consult with the necessary Caltrans and partner functions to determine design life of proposed actions and to work towards these mutually beneficial long-term strategies.

CONSIDERATIONS FOR STATE CLIMATE CHANGE PRIORITIES

California is a leader in advancing climate action through a variety of policies and initiatives. Developing adaptation strategies that are consistent with state priorities will be imperative for their implementation at later stages of the planning process.

Climate Action Plan for Transportation Infrastructure (CAPTI)
CAPTI identifies investment principles for transportation infrastructure to promote projects that do not increase VMT, protect natural and working lands, and maximize social and racial equity.

California Climate Adaptation Strategy
The State Adaptation Strategy compliments the principles set forth in CAPTI by identifying priorities that:

1.) Strengthen protections for climate vulnerable communities;

2.) Bolster public health and safety

3.) Build a climate resilient economy

4.) Accelerate nature-based climate solutions & natural system resilience

5.) Make decisions using best available science, and

6.) Partner to leverage resources.

Ocean Protection Council Sea Level Rise Guidance
For sea level rise, the OPC SLR Guidance identifies priorities for adaptation planning and strategies to:

1.) Prioritize social equity, environmental justice and the needs of vulnerable communities and

2.) Prioritize protection of coastal habitats and public access.

LOCAL AND REGIONAL PLANNING AND ADAPTATION STRATEGIES

After identifying improvement strategies, local governments may have established methodologies for planning for climate change. These strategies should be assessed using available resources and should be incorporated

Local Climate Adaptation Plans/Strategies
Local agencies along a corridor may have existing plans that include strategies or insight on potential approaches to implementing climate change in the transportation network. CARB has created a webmap that can be used to identify possible climate action plans created, GHG inventory information, GHG reduction targets, the local strategies planned to meet these targets, and more. For more information on local climate action and adaptation plans and other potential actions taken by local governments to be considered, click here. To view the California Climate Action Portal Map, a webmap published by CARB that shows jurisdictions with published local Climate Action Plans and other climate-related plans and reports, click here.

OPR has also developed the Resilient Adaptation Planning MAP that includes a variety of key adaptation resources for communities across California. To access the RAP-Map, click here.

Local Coastal Programs may also be a source of identified adaptation strategies to consider. A regularly updated list of these plans/programs with points of contact can be found on the internal Caltrans Coastal Plan Dashboard developed by DEA. Link

Regional Transportation Plans & Sustainable Communities Strategies
Beginning in 2010, RTPs must incorporate a SCS, a regional growth strategy that provides the basis for transportation investments in the region, in accordance with SB 375. The goal of the SCS is to reduce greenhouse gas emissions from transportation in the region

sufficiently to meet a regional target set for the years 2020 and 2035 by CARB. To do this, the SCS identifies the general location of land uses, residential densities, and building intensities within the region, including areas sufficient to house all economic segments of the projected regional population, as determined by the California Department of Housing and Community Development (HCD).

Local Hazard Mitigation Plans/ Community Wildfire Protection Plans/ General Plans
Local Hazard Mitigation Plans may recommend strategies to respond to hazards that are influenced by climate change. These plans typically include information for all significant hazards that a community may face in the future, and sometimes include information for the role of the transportation network and the SHS in such events.

Evacuation and Lifeline Routes
Local Hazard Mitigation Plans, as well as Community Wildfire Protection Plans (CWPP) and the Safety element in General Plans may also provide information regarding potential evacuation routes during wildfire and other emergency events. These routes are typically designated by the county sheriff in conjunction with city officials. CALFIRE is also often well-versed in locating evacuation routes for communities. Under AB 747 (2019), beginning in 2022, evacuation routes must be identified within the next revision of a LHMP, CWPP, or the safety element of a General Plan.

It is also worth noting that "Lifeline Routes" are an older term that is typically applied in the case of seismic events; however, these routes can also be used in other emergency situations such as wildfire and flooding events. CalOES defines a lifeline as any spatially continuous engineered system that delivers essential services which includes, among other things, transportation.

Planners should consider this information and the impacts to such routes in the analysis of proposed strategies.

ADAPTATION COSTS AND BENEFITS

In general, the costs associated with damage to transportation infrastructure from climate change-driven impacts—and the costs associated with any adaptation strategy for the transportation system—will be significant. However, planning ahead and avoiding hazards may reduce long term costs. There is also uncertainty involved in calculating the full costs and benefits of different climate change adaptation approaches. Importantly, many of the benefits of adaptation strategies which accommodate or avoid impacts to surrounding social and natural resources are difficult to quantify in economic terms. For example, the value of preserving a beach area includes both market values, such as benefits to the local tourism industry and property tax revenues, as well as non-market values, such as providing habitat for wildlife—both of which can be difficult to calculate. In addition, although the construction cost of projects can be estimated, any work done in a current or future hazard area will be subject to uncertain future hazards, making it very difficult to predict future maintenance and repair or replacement costs.

Regardless of these uncertainties, attempts should be made within the Corridor Plan to characterize the costs and benefits associated with the different projects and strategies identified through Steps 4 and 5. This should include the costs anticipated from maintaining the status quo over time, the entire life cycle of the infrastructure, and analysis of costs of damage to facilities, need for upgrades, and loss of recreational areas, habitats, and natural protective coastal features.

Analyzing Cost and Benefit Tradeoffs

At a very basic level, there are finite public resources available for the transportation system to mitigate and adapt to climate change. For example, the costs associated with damage to transportation infrastructure from sea level rise and any adaptation strategy will be enormous and much beyond state and local resources. Therefore, as planning ahead and avoiding hazards may reduce the total, overall long-term costs and maximize the value of public investments—it is critical in this Step of the corridor plan to characterize the costs and benefits associated the short, medium, and long-term projects and strategies. Specifically, this means anticipated maintenance costs associated with the entire life cycle of the infrastructure including emergency repairs, needs for upgrades, and loss of recreational areas, habitats, and natural protective features. To be clear, resources allocated for a short-term strategy or project mean that less is available for longer-term solutions—and in this step of the corridor plan, costs and benefits should be clearly laid out for each of the various strategies and projects that have been identified in the preceding Step 4; this will support prioritization and trade-off decision-making activities in subsequent efforts in Step 6.

Furthermore, it should be acknowledged many of the benefits of adaptation strategies which avoid hazards and accommodate or avoid impacts to coastal resources can be difficult to quantify in economic terms that can outweigh expensive costs. For example, the value of preserving a beach area includes both market values—such as benefits to the local tourism industry and property tax revenues—as well as non-market values like providing habitat for wildlife, both of which should be characterized.

STEP 6: SELECT AND PRIORITIZE SOLUTIONS

Goal: Include climate change adaptation and system resiliency as part of the prioritization criteria. New coastal transportation infrastructure should avoid areas where sea level rise will affect the infrastructure over its expected life. For transportation infrastructure that is already established in areas projected to be affected by sea-level rise, a "phased" or "adaptation pathways" approach which recognizes that adaptation options will need to change over time to account for planning timelines, changing conditions, and uncertainty. In general, planning for relocation of the infrastructure to safe areas or elevation to avoid the need for hard shoreline protection that harms coastal resources should be prioritized. Natural or nature-based strategies should be prioritized, if feasible, given statutory mandates to state agencies.

- ☑ Consider GHG, VMT, and environmental impacts in prioritization criteria with the greatest priority being given to the least environmentally damaging options wherever feasible given statutory mandates to state agencies.
- ☑ Determine the costs and benefits to SHS users, habitats, communities, and any other stakeholders when prioritizing improvement strategies.

GHG EMISSIONS AND VMT

In the selection and prioritization process, there should be a strong preference against projects that would likely increase GHG emissions and/or VMT wherever possible. SB 743 requires the assessment of VMT changes in CEQA documentation, a measurement that may go up with capacity-increasing projects due to the phenomenon of induced demand. Projects that may cause an increase in VMT or GHGs may need to be reconsidered in favor of strategies that will limit that increase. Conversely, strategies that may work to decrease GHG emissions and/or VMT such as improved transit, active transportation, solar, and ZEV infrastructure should be given a strong preference and should have their climate and/or emissions benefits referenced in the final corridor plan. For more information on SB 743, click here.

STEP 7: PUBLISH/IMPLEMENT CORRIDOR PLANS

Goal: Highlight in the plan the potential benefits of the improvements to system resiliency from the adaptation strategies being recommended.

- ☑ Consider the potential users of the corridor plan when communicating climate change vulnerabilities and impacts to the corridor while highlighting potential benefits of adaptation strategies being recommended.
- ☑ Include helpful images that provide real-world context to the information being presented in the plan.

COMMUNICATING CLIMATE CHANGE TO A NON-SCIENTIFIC AUDIENCE

Caltrans Climate Change Communication Guide

The Climate Change Communication Guide articulates best practices that District corridor planners can use to educate, inform, and strengthen collaboration within Caltrans, among external partners, and with the public on the topic of climate change within corridor plans. Different audiences have different communication needs, the guide presents two distinct (though similar) sets of tools:

- Strategies for communicating with internal staff and partner agencies
- Strategies for communicating with the broader public

Providing context between the information included in the climate change section in a corridor plan and the real-world situation requires careful consideration. The following strategies are helpful in communicating climate change vulnerability and adaptation strategies within the climate change section of the corridor plan:

- Highlight the damage of past hazards affecting the corridor, possibly including images of the impacts to bring real-world context to the hazards expected to affect the corridor.
- Provide images and maps that are useful for describing the vulnerabilities to the corridor that are easily readable for the viewer to know specifically where the corridor is vulnerable.
- Provide images that help to describe potential strategies for addressing climate change along the corridor.

To access the Climate Change Communication Guide, click here

STEP 8: MONITOR AND EVALUATE PROGRESS

Goal: Include system resiliency performance metrics in the monitoring, which include revisiting corridor planning assumptions concerning future disruptions.

- ☑ Include both adaptation and mitigation performance metrics in monitoring.
- ☑ Continue to monitor impacts of climate change along the corridor using the best available data to determine what adaptation measures are working and where new measures may need to take place.

APPENDIX

CLIMATE CHANGE GOALS FOR THE CORRIDOR PLANNING PROCESS

Below are each of the outcomes that are stated in the blue boxes at the beginning of each step. It is important to note that while these goals are important for considering climate change in the corridor planning process, not all goals will result in items that will be included in the climate change section of a corridor plan.

Step 1: Scope Effort

- ☑ Turn on all relevant layers in the Caltrans Climate Change Vulnerability Assessment webmaps to determine which climate change stressors affect the corridor.
- ☑ Corridors that include segments that are situated in terrain that features slopes, cliffs, or heavy undulations, use the Deep-Seated Landslide Survey (MS58) data from the California Department of Conservation to determine if there are any areas surrounding the corridor that are susceptible to landslide.
- ☑ Consider all relevant partnerships, stakeholders, plans, and existing guidance needed to be considered along the corridor as well as internal Caltrans

Step 2: Gather Information

- ☑ Research and locate available data sources for all climate change stressors affecting a corridor, while considering social and public health aspects of climate change affecting a corridor, with an understanding that disadvantaged and low-income communities will face greater difficulty in adapting to climate change.
- ☑ If the corridor is within the coastal zone, BCDC, DSC, or a Local Coastal Program jurisdiction, carefully consider the regulatory environment for the respective jurisdiction and how proposed strategies will align with guidance for infrastructure located in these jurisdictions.
- ☑ Identify plans and documents that outline regional GHG reduction strategies for the areas around the corridor.

Step 3: Conduct Baseline Performance Assessment

- ☑ Use best available data to determine vulnerability of portions of the corridor to climate change stressors for multiple climate scenarios while noting the projection years of expected impacts.
- ☑ Highlight stressors that have affected the corridor in the past- including emergency repairs - and, if possible, compile impacts from those past events to the operation and performance of the corridor.
- ☑ Use available resources to consider a "whole corridor" aspect that identifies impacts from climate change to all aspects of a corridor including social, environmental, and economic factors.

Step 4: Identify Potential Projects and Solutions

- ☑ Identify and catalog a full suite of potential strategies to address impacts at each exposed location along the corridor while considering the impact to all aspects of the corridor and surrounding systems if implemented.
- ☑ Consider nature-based and less-environmentally damaging solutions wherever feasible.
- ☑ Identify appropriate GHG and VMT reduction strategies that can be implemented along the corridor.

Step 5: Analyze Improvement Strategies

- ☑ Consult local and regional agencies and plans to determine if proposed projects and strategies comport to plans such as RTPs, SCSs, LCPs, and General Plans.
- ☑ Consider GHG and VMT impacts from proposed projects.

Step 6: Select and Prioritize Solutions

- ☑ Consider GHG, VMT, and environmental impacts in prioritization criteria with the greatest priority being given to the least environmentally damaging options wherever feasible given statutory mandates to state agencies.
- ☑ Determine the costs and benefits to SHS users, habitats, communities, and any other stakeholders when prioritizing improvement strategies.

Step 7: Publish/Implement Corridor Plans

- ☑ Consider the potential users of the corridor plan when communicating climate change vulnerabilities and impacts to the corridor while highlighting potential benefits of adaptation strategies being recommended.
- ☑ Include helpful images that provide real-world context to the information being presented in the plan.

Step 8: Monitor and Evaluate Progress

- ☑ Include resiliency metrics in the performance monitoring that consider both adaptation and mitigation.
- ☑ Continue to monitor impacts of climate change along the corridor using the best available data to determine what adaptation measures are working and where new measures may need to take place.

EXAMPLES OF EXISTING PLANS

Wherever available, the following sections include at least an example document for one or several of the following geographies in California: A large metropolitan area, a town or city, a rural area, a coastal area, an inland area. All links are to where the documents are hosted on their respective agency's website.

Local and Regional Climate Action/Adaptation Plans and Strategies

- City of Gonzales Climate Action Plan (2018) – D5
- Contra Costa County Climate Action Plan (2015) – D4
- San Bernardino Regional Greenhouse Gas Reduction Plan (2021) – D8

Local Coastal Programs

- City of Santa Monica Local Coastal Program Update Land Use Plan (2018) – D7
- Plan Morro Bay (2021) – D5
- Marin County Local Coastal Program (2021) – D4

Local Vulnerability Assessments

- Climate Change Vulnerability Assessment for the Sacramento County Climate Action Plan (2017) – D3
- Marin Shoreline Sea Level Rise Vulnerability Assessment (2017) – D4
- Placer County Vulnerability Assessment Report (2018) – D3

Regional Transportation Plans & Sustainable Communities Strategies

- Butte County Association of Governments RTP/SCS (2020) – D3
- Connect SoCal (2020) – D7
- Madera County Transportation Commission RTP/SCS (2018) – D6

Local Hazard Mitigation Plans

- City of Los Angeles Local Hazard Mitigation Plan (2018) – D7
- Mariposa County Local Hazard Mitigation Plan (2020) – D10
- Santa Barbara County Multi-Jurisdictional Hazard Mitigation Plan (2017) – D5

Community Wildfire Protection Plans

- City of Santa Rosa Community Wildfire Protection Plan (2020) – D4
- Humboldt County Community Wildfire Protection Plan (2019) – D1
- Santa Clara County Wildfire Protection Plan (2016) – D4