CALIFORNIA DEPARTMENT OF TRANSPORTATION

Guidance on Incorporating Sea Level Rise

For use in the planning and development of Project Initiation Documents

Prepared by the Caltrans Climate Change Workgroup, and the HQ Divisions of Transportation Planning, Design, and Environmental Analysis

May 16, 2011

This guidance is intended for use by Caltrans Planning staff and Project Development Teams to determine whether and how to incorporate sea level rise concerns into the programming and design of Caltrans projects. Because of the evolving nature of climate change science and modeling, this guidance is subject to revision as additional information becomes available.

Caltrans

1. Sea Level Rise in California

Sea level rise (SLR) is perhaps the best documented and most accepted impact of climate change. Observations of sea levels along the California coast, and global climate models indicate that California's coast will experience rising sea levels over the next century and beyond (unless emissions of greenhouse gases are dramatically reduced from current levels). As the earth warms due to global climate change, two changes are occurring that are causing sea levels to rise: glacial melting and thermal expansion of the oceans. Data from tide gauges in the State collected over the past several decades indicates an upward trend of approximately 20 cm per century (which is similar to the change in global mean sea level). Climate models project rising rates that could far exceed any experienced "during modern human development on the California coast and estuaries." (Cayan, 2008)

The effects of SLR will have impacts on all modes of transportation located near the coast. Rising sea levels will significantly increase the challenge to transportation managers in ensuring reliable transportation routes are available. Inundation of even small segments of the intermodal transportation system can render much larger portions impassable, disrupting connectivity and access to the wider transportation network (Gulf Coast Study, Phase I, 2008).

SLR will likely lead to multiple changes to the physical environment beyond a simple increase in sea surface elevation. Higher water levels may increase coastal bluff erosion rates, change environmental characteristics that affect material durability (e.g., pH and chloride concentrations), lead to increased groundwater levels and change sediment movement both along the shore and at estuaries and river mouths. All of these factors will have to be addressed by the California Department of Transportation (Caltrans) at the planning and project level.

2. Why does Caltrans Need to Address SLR?

Future SLR poses a serious threat to residents and existing infrastructure along the coast of California; including transportation assets. In an effort to better understand potential amounts of rise and the associated impacts, then Governor Arnold Schwarzenegger signed Executive Order (EO) S-13-08 in November 2008[1]. The EO directs State agencies planning construction projects in areas vulnerable to SLR to begin planning for potential impacts by considering a range of SLR scenarios for the years 2050 and 2100. Although EO S-13-08 allows for some exemptions for routine maintenance projects and for projects programmed for construction through 2013, the intent is to plan ahead to assess project vulnerability and reduce anticipated risks associated with SLR. Other California State agencies, commissions, and climate action teams are already moving forward to implement guidance on how to address this issue. It should be noted that EO S-13-08 is

[1] A link to the executive order: http://www.climatechange.ca.gov/publications/EXECUTIVE_ORDER_S-13-08.pdf

still in effect until it is rescinded by a subsequent Governor. Executive Order S-13-08 directs the Natural Resource Agency, in cooperation with Caltrans and other State agencies to commission the National Academy of Sciences (NAS) through the Natural Resources Council to assemble a team of experts to produce a West Coast SLR assessment report for the states of California, Oregon, and Washington. This Pacific Coast SLR assessment is expected to be released in mid-2012. When released, the NAS report will include SLR scenarios for all three states, and will act as the official SLR estimate for State agencies.

Because of the extended release date of the NAS study, the California Ocean Protection Council established the SLR Task Force of the Coastal and Ocean Working Group. The working group is part of the California Climate Action Team (CO-CAT) which developed interim SLR scenarios for the State until the NAS study is completed. The SLR Task Force includes staff from 16 State agencies, including the Business, Transportation and Housing Agency, and Caltrans. The SLR Task Force developed and agreed upon recommendations for incorporating SLR projections into planning and decision making for projects in California. The SLR scenarios adopted by the CO-CAT (see Page 8, Table 2) are based on the values presented in the December 2009 *Proceedings of National Academies of Sciences* publication by Vermeer and Rahmstorf[2]. These scenarios were recommended by the California Ocean Science Trust and the Ocean Protection Council's Science Advisory Team.

Because of the requirements set forth for State agencies in Executive Order S-13-08, as well as increased interest by the public and regulatory agencies, Caltrans must be proactive in addressing SLR impacts on existing infrastructure and for future projects. Despite the long timeframe of the release of the NAS study, regulatory agencies such as the California Coastal Commission are urging Caltrans to incorporate SLR analysis into projects. If the impact analysis and related adaptation measures are not planned for in advance, there is risk of not being able to obtain necessary approvals and permits, which could potentially delay project delivery in the ready to list phase of a project. The public is also expressing its concerns about SLR in comments submitted during public circulation of our draft environmental documents. Climate change issues, including adaptation, have also been a cause of litigation on some transportation projects.

Planning for potential impacts to California's infrastructure due to SLR also requires addressing cost, scope and schedule in our project planning documents. Items that need to be considered, in addition to enhancing the design of structures, will be the potential increased costs of permit fees and mitigation to implement the enhanced design. To reduce the risk of impact on project delivery in the future, it is important to include these considerations into the project planning now.

[2] Martin Vermeer and Stefan Rahmstorf, "Global sea level linked to global temperature," *Proceedings of the National Academy of Sciences*, published online before print December 7, 2009; 10.1073/pnas.0907765106.

3. Determining and Documenting Whether to Incorporate Sea Level Rise into Project Programming and Design

Making a determination of whether to incorporate SLR adaptation measures into the programming and design of a project is a two-part analysis followed by documentation of the effort to be included into the Project Initiation Document (PID). The first step will be to determine whether there is the potential for the project to be impacted by an increase in SLR. The second step is to balance the potential SLR impacts with the level of risk and the potential consequences to the transportation system to determine whether the potential impacts warrant programming resources to include adaptation measures into the project.

Determining Potential Impact

To assess whether an individual project will potentially be impacted by SLR, a three-part screening criteria has been developed for use by members of the Project Development Team (PDT) (see Appendix A for detailed screening criteria). In brief, the screening involves examination for the following three questions:

1. Is the project located on the coast or in an area vulnerable to SLR?
2. Will the project be impacted by the stated SLR?
3. Is the design life of the project beyond year 2030?

If after using the screening criteria the determination is made that the project does not need to incorporate SLR in the PID, include a sentence or two in the PID to explain why the project does not warrant further consideration of SLR.

If the project requires further analysis, then the PID must include a more detailed discussion of SLR and adaptation. The PDT may decide that due to the nature of the project and the relative risk involved that the project does not need to have additional funds programmed for SLR adaptation (see discussion on balancing below). However, even then, the PID must contain a detailed discussion about how and why the PDT came to that conclusion. Similarly, if the decision is made to incorporate additional project funding for SLR adaptation measures, that decision must also be documented and explained.

Balancing Potential Impacts with the Level of Risk and Potential Consequences

Determining whether and to what extent to program funding for adaptation measures for SLR into a project requires balancing many factors. In the *Coastal-Ocean Climate Action Team Interim Sea-Level Rise Guidance Document*, state agencies are urged to consider timeframe, risk-tolerance and adaptive capacity when determining whether to adapt the project for potential SLR impacts. The discussion below is an excerpt from that guidance document:

> The timeframe identified for a project is important for sea level rise assessments and will affect the approach for assessing impacts. Until 2050, there is strong agreement among the various climate models for the amount of sea level rise that is likely to occur. After mid-century, projections of sea level rise become more uncertain, because the modeling results diverge and the sea level rise projections vary depending upon how quickly the international community reduces greenhouse gas emissions. Therefore, for projects with timeframes beyond 2050, it is especially important to consider adaptive capacity, impacts, and risk tolerance to guide decisions of whether to use low, medium, or high sea level rise projections.
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> Consequences = Adaptive Capacity + Impacts
> The consequences of failing to address sea level rise for a particular project will depend on both adaptive capacity and the potential impacts of sea level rise to public health and safety, public investments, and the environment.
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> Adaptive capacity is the ability of a system to respond to climate change, to moderate potential damages, to take advantage of opportunities, and to cope with the consequences.[3] A project that has high adaptive capacity and/or low potential impacts will experience fewer consequences. For example, an unpaved trail built within a rolling easement has high adaptive capacity (because the trail can be relocated as sea level rises) and therefore will experience fewer harmful consequences. In contrast, a new wastewater treatment facility located on a shoreline with no space to relocate inland has low adaptive capacity and high potential impacts from flooding (related to public health and safety, public investments, and the environment). The negative consequences for such a project of failing to consider sea level rise would therefore be high.
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> Risk tolerance is the amount of risk involved in a decision depends on both the consequences and the likelihood of realized impacts that may result from sea level rise. These realized impacts, in turn, depend on the extent to which the project design integrates an accurate projection of sea level rise. However, current sea level rise projections provide a range of potential sea level rise values and lack precision. Therefore, agencies must consider and balance the relative risks associated with under- and/or overestimating sea level rise in making decisions.[4]
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> Harmful impacts are more likely to occur if the project design is based upon a low projection of sea level rise and less likely if higher estimates of sea level rise are used. In situations with high consequences (high impacts and/or low adaptive capacity), using a low sea level rise value therefore involves a higher degree of risk.

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[3] Definition of adaptive capacity used in the 2009 California Climate Adaptation Strategy, based upon definition provided in Climate Adaptation: Risk, Uncertainty and Decision-making, UK CIP (2003), UKCIP Technical Report, Oxford, Willows, R. I. and R. K. Cornell (eds.).

[4] Examples of harmful impacts that might result from underestimating SLR include damage to infrastructure, contamination of water supplies due to saltwater intrusion, and inundation of marsh restoration projects located too low relative to the tides. Examples of harmful impacts that might result from overestimating SLR include financial costs of over-engineering shoreline structures, locating in-water development in too shallow a depth to avoid navigational hazards, and marsh restoration projects located too high relative to the tides.

Development of the screening criteria to determine whether to incorporate SLR in Project Programming and Design (Table 1)

Based on the concepts in the California Sea Level Rise Interim Guidance document, Table 1 was developed as an aid to help determine when SLR poses enough of an overall threat to warrant programming of additional funds in the PID to avoid or mitigate the identified risks. The table below is not an exhaustive list of factors; other factors may need to be balanced based on the nature and location of the project. As other factors are identified, this guidance will be updated.

In general, the State Highway System (SHS) is limited in its adaptive capacity because of the numerous services it facilitates (travel routes for the public, emergency evacuation etc.), its permanent location, longitudinal nature, long lifespan, and uncertain resources. However, new methods to increase the resiliency and adaptive capacity of the SHS must be developed in order to cope with the potential impacts of SLR.

Table 1: Factors to consider in whether to incorporate SLR into project programming and design				
		Towards incorporating SLR into project design		**Towards not incorporating SLR into project design**
1	Project design life	Long (20+ years)		Short (less than 20 years)
2	Redundancy/alternative route(s)	No redundant/alternative route		Redundant/alternative route
3	Anticipated travel delays	Substantial delays		Minor or no delay
4	Goods movement/interstate commerce	Critical route for commercial goods movement		Non-critical route for commercial goods movement
5	Evacuations/emergencies	Vital for emergency evacuations; loss of route would result in major increases to emergency response time		Minor or no delay in the event of an emergency or evacuation
6	Traveler safety (delaying the project to incorporate SLR would lead to on-going or new safety concerns)	Safety project in which little or no delay would result; non safety project		Safety project and delay would be substantial
7	Expenditure of public funds	Large investment		Small investment
8	Scope of project–"point" vs. "linear"	Project scope is substantial–e.g. new section of roadway		Project scope is substantial–e.g. new section of roadway
9	Effect of incorporating SLR on non-state highway (interconnectivity issues with local streets and roads)	Minor or no effect–adjacent local street and roads would not have to be modified	Medium to minor interconnectivity issues	Substantial interconnectivity issues
10	Environmental constraints	Minor or no increase in project footprint in Environmentally Sensitive Area (ESA)	Less than significant increase in project footprint in ESAs	Substantial increase in project footprint in ESAs

1. **Project design life:** Those projects that have a long design life of 20+ years should include further SLR analysis. These projects have a very high likelihood of being impacted by SLR at some point during their lifespan. The shorter lifespan projects may be less likely to face SLR impacts, and as a result be less inclined to incorporate SLR, depending on their proximity to the coast line.
2. **Redundancy/alternative route(s):** Looking at the SHS, as a system, there are, however, some locations that are serviced by multiple routes; for example, SR-99 and I-5 in Central and Northern California and I-5 and I-405 in Southern California. Even in cases where the SHS does have parallel routes, it is important to keep in mind that the need for traveler and goods movement necessitated the construction of those parallel routes.
3. **Anticipated travel delays:** What impacts will result if SLR impacts a roadway? For instance, if during high tides or a storm event a roadway is splashed by spray the travel delays would be minimal. However, if a roadway is inundated by waves, the delays will be substantial and should warrant further consideration of incorporating SLR.
4. **Goods movement /interstate commerce:** If the route is a high priority commercial goods movement route in the State, the cost of delays due to impacts from SLR will be high, and the project should incorporate SLR consideration.
5. **Evacuations /emergencies:** If the route is vital for emergency evacuations, and SLR impacts would greatly increase emergency response time, the project should incorporate SLR analysis.
6. **Traveler safety (delaying the project to incorporate SLR would lead to on-going or new safety concerns):** If incorporating SLR considerations will substantially delay a safety project getting to construction, then the risk to traveler safety must take precedent. However, it is important to also weigh the possibility that if the highway is not designed to incorporate SLR that the result could be flooding of the facility in the future and that inundation of the facility may prevent the route from being used in the event of an emergency or evacuation.
7. **Expenditure of public funds:** Future allocation of resources should consider SLR impacts on the SHS and Caltrans' facilities. Considerations include potential for increased facility maintenance costs and/or more frequent repair/rehabilitation needs due to SLR impacts.
8. **Scope of project–"point" vs. "linear":** If the scope of a project is a single "point" or single project task, it may be less necessary to incorporate SLR (given all other factors).
9. **Effect of incorporating SLR on non-state highway (interconnectivity issues with local streets and roads):** Consideration should be given to whether the infrastructure around Caltrans' facility (adjacent local streets and roads) is being adapted for SLR. For example, if Caltrans were to raise the grade of its roadway to what extent, if any, are the surrounding local entities raising their roadways? Will the two systems interconnect efficiently and effectively?
10. **Environmental constraints:** Adapting the project to SLR may mean an increase in the environmental impacts of the project due to design aspects of adaptation, such as more reinforced bridge structures, larger culverts, or alternative pavements. There is also the potential that adapting the project to SLR may mean

modifying the hydrology in the area in ways that could be beneficial to some species while doing greater harm to others. Incorporating SLR Impacts into Project Programming and Design.

Sea Level Rise Impacts Assessment

Once a determination has been made that SLR should be incorporated into a project, the PDT will need to conduct studies to estimate the degree of potential impact and assess alternatives for preventing, mitigating, and/or absorbing the impact.

The Ocean Protection Council adopted statewide SLR values (Table 2), and a SLR interim guidance Document in March 2011. Caltrans participated in the development of this first set of statewide SLR scenarios. Prior to the adoption of the SLR values, State agencies were individually responsible for determining what amounts of SLR to use for planning purposes. This common set of values allows all state agencies to plan for SLR with the same assumptions. This document will be revised when the NAS releases their final SLR values, but in the interim, provides a standardized set of assumptions to use when determining SLR impacts.

Table 2. Sea-Level Rise Projections[5] using 2000 as the Baseline

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

The SLR values provided in Table 2 reflect global scale changes to mean sea levels. There is often some variation to these values at specific locations. For the purposes of this guidance, local sea surface elevation changes will be ignored. Additionally, Table 2 values represent only the change in sea level in relation to a static land mass. In reality, it is common for subsidence (due to groundwater extraction, subsurface instability, etc.) or uplift (due to tectonic action or glacial rebound) to occur such that the relative change in elevation of the ocean level could be greater or lesser than the Table values for a given location. It will be important for the PDT to obtain data from District Surveys and geotechnical services to fully understand both current and future sea levels compared to project facility elevations. Designers must be aware that current survey benchmarks may or may not have an established relationship to sea level. As a result, the ability to provide

[5] For dates after 2050, Table 2 includes three different values for SLR - based on low, medium, and high greenhouse gas emission scenarios. These values are based on the Intergovernmental Panel on Climate Change emission scenarios as follows: B1 for the low projections, A2 for the medium projections and A1FI for the high projections.

precise correlation between project site elevations and changing sea levels may be limited until such time that an entire network of new datum can be developed.

Time vs. Risk

As indicated, SLR is variable with time. Facilities which are not at risk today may continue to be unaffected for many years. Even when assessing conditions 50 or more years into the future, the determination may be that there is limited risk of impact. Neither SLR nor ground subsidence or uplift are linear with time and the PDT should assess not only the future target date (e.g., 2050), but also, to the extent practicable, assess the timeframe from project completion to future date of interest for which impacts may be of significance. For example, while we may determine that we anticipate SLR impacts at 2050, for some locations the impacts may become significant in 2045, while in other cases the impacts may become significant in 2025. The facility risks, impacts to the public, and type of response selected should be commensurate with not only the magnitude of the SLR but the spatial and temporal aspects of the impacts.

It must be noted that the values of SLR indicated in Table 2 are tied to mean sea level in 2000. Future SLR estimates must be adjusted for this base line level–so a project where surveys are performed in 2013, for example, will need to use a slightly modified baseline for the estimated rise between 2000 and that future date. Similarly, a project that is in PID phase in 2014 would use a higher initial sea level elevation to determine estimated “rise” during the project life.

The projected values of SLR indicated in Table 2 show narrow ranges of rise for the relative short term and increasing ranges for time frames farther into the future. The ranges are estimates of SLR for multiple future climate scenarios. The scenarios predict fairly consistent values in the short term, but increasingly wide ranges of value in the longer term due to increasing uncertainty. There is no specific probability of occurrence for any of the projected scenarios–they simply represent different possible global climate conditions and the amount of projected SLR for the respective conditions.

Selecting Sea Level Rise Value(s) for Design

When selecting a future design life date up to and including year 2050, use the initial target value from the column titled “Average of Models.” For projects with design life consideration of 2070 or beyond, use the range of the three “Average of Models” values. For design life dates not specifically listed in Table 2 interpolate using an assumption of linear progression for dates between those listed in Table 2 (e.g. 2037 or 2080).

When using the range of the three average values for time periods of 2070 or beyond, it is up to the discretion of the PDT to determine a value to use for the project. There is no specific “right” or “wrong” value, and it is anticipated that as future climate research and studies are completed that these values will change. It is expected that most resource agencies will lean toward the higher indicated values, and expect entities seeking permits to show that such levels can be accommodated or addressed. The PDT will need to confer with the resource agencies in question and reach agreement on an appropriate target value for design purposes.

Choosing a future date from which to select a future SLR estimate should be based on the type of project being programmed. Projects with an estimated design life extending to year 2030 or earlier (e.g., temporary projects, detours, Capital Preventive Maintenance (CAP-M) or other simple overlay projects) should not assume impacts from SLR. SLR values for projects which include new bridge or other major structures should choose a future date commensurate with the life of the structure–meaning 75 years or more.

The PDT should understand that virtually all climate models for SLR indicate that sea levels will continue to rise–potentially for centuries beyond the year 2100. While we cannot accommodate any or all possible scenarios, understanding the extreme long term potential should encourage the PDT to seek opportunities that, for equivalent cost, provide the longest term of protection from impact.

Implementation

Once target values of SLR have been selected for the project, the following procedures should be followed:

1. Request information from District Surveys to evaluate existing vertical elevation data and benchmarks to determine the correlation between current sea level and planned facility elevations for the project.[6]

2. As part of the request for the project preliminary Geotechnical Design Report, request a preliminary assessment of local land subsidence or uplift for the period associated with the project design life.[7]

3. From the SLR Table and data from Surveys and Materials/Geotechnical Services, generate a plot of relative SLR for the project over the time period of concern. This plot will allow the PDT to estimate both the estimated future date for initial impact and the maximum impact at the end of the time period used for analysis.

4. Determine if relative SLR will have negative impacts on facility function or operation. Impacts could be associated with issues such as elevation of culvert

[6] Foundational information for all sea level rise predictions and impacts cannot be managed or planned without accurate vertical control and datum continuity between the tide stations and ground based benchmarks. Survey control and base mapping needed to generate highly accurate assessments of the actual project year sea level in relation to the assumed levels upon which Table 2 is based, may need updating to current standards.

[7] Detailed assessment of land subsidence or uplift may not be possible due to limited data and/or inability to predict past landform changes into the future. Under these circumstances, the PDT should apply the projected sea level rise value from Table 2 directly to the best available project design elevations to assess impact, and document the currency of data, and the risks and assumptions made.

outlets to revised estimates for foundation scour and/or erosion due to tidal action or exposure of materials to salt water inundation that would otherwise be unaffected. List the various impacts and roughly identify the time scale for these impacts to become problematic.

5. For the listed impacts, determine if adaptive measures will be necessary. In many cases, the project footprint may be impacted but no adaptive measure may be required. In other cases, the impact may be only temporary–such as wave splash during periods of high tide and storm surge. Not all adaptive measures require a physical alteration to the roadway facility. In particular, impacts of limited duration may be able to be addressed via operational modifications–such as short term road or lane closures or restrictions on access. Any proposal for operational mitigation must be approved by District Traffic Operations and District Maintenance.

6. Identify the cost of SLR mitigation in the estimate of project cost as a separate line item.

7. There will be instances where the relative SLR selected for the project cannot be accommodated due to cost or the creation of new impacts (e.g., raising a roadway could cause a larger fill slope to encroach onto environmentally sensitive areas or create impacts to designated scenic highways). The PDT should document the attempts made to address SLR in the PID and indicate what can be achieved and quantify that both in terms of cost as well as the degree of potential impact for the target future year.

8. Incremental or staged improvements to address SLR are also acceptable approaches, particularly where future projects are anticipated.

Other Considerations

SLR is not the only predicted climatic or weather induced change to the physical environment due to climate change. Various scenarios of future climate also include higher temperatures, more intense storms that can lead to increased storm surge and wave heights, as well as changes to precipitation patterns and intensities.

At this point in time, the level of uncertainty regarding these other aspects of future climate change is too great to assess with any degree of confidence. As such, Caltrans is continuing to partner with other State, federal and research entities to better understand and predict magnitudes and severity. For the purposes of this guidance document, it will be assumed that existing practices and policies will remain in effect and no change to future climate other than SLR will be addressed within our projects. At such time as more definitive information is available on both the severity of, and how to address these additional impacts of climate change, guidance will be issued.

Appendix A: Screening Criteria for Incorporating Sea Level Rise into Project Initiation Document

1. Is the project located in the coastal zone or in an area vulnerable to SLR? (If no, stop).

2. Using the SLR projections in Table 2 below, would the project be potentially impacted by an increase in sea level? (If no, stop).

Table 2. Sea-Level Rise Projections[8] using 2000 as the Baseline

Year		Average of Models	Range of Models
2030		7 in (18 cm)	5-8 in (9-17 cm)
2050		14 in (36 cm)	10-17 in (26-43 cm)
2070	**Low**	23 in (59 cm)	17-27 in (43-70 cm)
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	Medium	47 in (121 cm)	37-60 in (95-152 cm)
	High	55 in (140 cm)	43-69 in (110-176 cm)

3. If the project is located in the coastal zone, and could be potentially impacted by SLR, and it is determined that there are enough factors influencing the project to incorporate SLR, then the PID document must contain a discussion of SLR.

If the project is located in the coastal zone and could potentially be impacted by SLR and the design life is beyond 2030 then the PID document must contain a discussion of SLR.

[8] For dates after 2050, Table 2 includes three different values for SLR - based on low, medium, and high greenhouse gas emission scenarios. These values are based on the Intergovernmental Panel on Climate Change emission scenarios as follows: B1 for the low projections, A2 for the medium projections and A1FI for the high projections.

Appendix B: Additional Information Sources

1) U.S. Geological Survey report on shoreline changes for California's beach habitat
   http://pubs.usgs.gov/of/2006/1219/
2) U.S. Geological Survey report on shoreline changes for California's bluff habitat
   http://pubs.usgs.gov/of/2007/1133/.
3) National Oceanic and Atmospheric Administration (NOAA) data on historic sea level change on California's coast
   http://tidesandcurrents.noaa.gov/sltrends/sltrends_states.shtml?region=ca
4) FHWA Hydraulic Engineering Circular 25–Highways in the Coastal Environment, 2nd Edition
   http://www.fhwa.dot.gov/engineering/hydraulics/library_arc.cfm?pub_number=192&id=137
5) U.S. Army Corps of Engineers Coastal Engineering Manual, EM 1110-2-1100
   http://chl.erdc.usace.army.mil/cem
6) National Oceanic and Atmospheric Administration (NOAA) Tidal Information
   http://tidesandcurrents.noaa.gov/tide_predictions.shtml?gid=235
7) U.S. Environmental Protection Agency Climate Change Website
   http://www.epa.gov/climatechange/index.html
8) San Francisco Bay Conservation and Development Commission Climate Change Website
   http://www.bcdc.ca.gov/planning/climate_change/climate_change.shtml
9) California Natural Resources Agency Climate Adaptation Strategy
   http://www.climatechange.ca.gov/adaptation/index.html
10) Caltrans Climate Change Program