115 S La Cumbre Lane
Suite 300
Santa Barbara, CA 93105
805.880.0922 phone
805.880.0923 fax

esassoc.com

memorandum

date	September 11, 2024
to	John Dinunzio, SLOCOG
cc	
from	Louis White PE, Amber Inggs PE, ESA
subject	FINAL Summary of Additional Guidance Memorandum for the Morro Bay Estuary Climate Transportation Plan

1 Introduction

This memo presents a preliminary assessment of sea level rise for the Morro Bay Estuary Climate Transportation Plan (The Plan) to be used by the ESA team under contract to the San Luis Obispo Council of Governments (SLOCOG). The sea level rise scenarios and planning horizons presented below will be used to provide analyses to explore a variety of strategies that could cultivate transportation and ecological resilience over a range of time horizons.

These sea level rise scenarios are consistent with the latest State guidance documents and available coastal hazard maps for the Port San Luis area, including the California Ocean Protection Council and United States Geological Survey (USGS) CoSMoS 3.0 (OPC, 2024; O'Neill, et al., 2018).

ESA recommends using a thresholds approach in the Morro Bay Estuary Climate Transportation Plan to examine the sea level rise impacts by incremental amounts. The method involves identifying specific amounts of sea level rise, or thresholds, at which assets become vulnerable. The sea level rise guidance, projections, and threshold approach are summarized in the following sections.

2 California State Sea Level Rise Policy Guidance

The California Ocean Protection Council (OPC) recently finalized the State of California Sea Level Rise Guidance: 2024 Science and Policy Update (OPC, 2024), which provides projections for sea level rise at various locations along the coast of California through 2150. OPC produced this guidance in partnership with the California Ocean Science Trust (OST) and a scientific Task Force. The guidance is based on the National Oceanic and Atmospheric Administration (NOAA) 2022 Global and Regional Sea Level Rise Scenarios for the United States (Sweet, et al., 2022), which provides updated sea level rise scenarios for the United States based on global projections from the Intergovernmental Panel on Climate Change (IPCC) 6th Assessment Report. The updated 2024 guidance **(Table 1)** presents five sea level rise scenarios and values that incorporate: (1) sea level rise observations, estimated and modeled projections, and uncertainties, and (2) a range of global greenhouse gas

emissions scenarios, which rely on shared socioeconomic pathways (SSPs).[1] The following summaries of each scenario are provided in the State of California Sea Level Rise Guidance (2024):

Low Scenario: Aggressive emissions reductions leading to very low future emissions; the scenario is on the lower bounding edge of plausibility given current warming and sea level trajectories, and current societal and policy momentum.

Intermediate-Low Scenario: A range of future emissions pathways; a reasonable estimate of the lower bound of most likely sea level rise in 2100 based on support from sea level observations and current estimates of future warming.

Intermediate Scenario: A range of future emissions pathways; could include contribution from low confidence processes. Based on sea level observations and current estimates of future warming, a reasonable estimate of the upper bound of most likely sea level rise in 2100.

Intermediate-High Scenario: Intermediate-to-high future emissions and high warming; this scenario is heavily reflective of a world where rapid ice sheet loss processes are contributing to sea level rise.

High Scenario: High future emissions and high warming with large potential contributions from rapid ice-sheet loss processes; given the reliance on sea level contributions for processes in which there is currently low confidence in their understanding, a statement on the likelihood of reaching this scenario is not possible.

Several changes were made from the previous State of California Sea Level Rise Guidance (OPC, 2018) (**Table 2)**. The updated 2024 Guidance removes the extreme sea level rise scenario (H++) that was included in the previous guidance. The H++ scenario assumed rapid ice sheet loss on Antarctica, which could drive rates of sea level rise 30-40 times faster than the sea level rise experienced over the last century. This scenario is not included in the 2024 update, as the rates and amounts of sea level rise are not supported by best available science. Additionally, the 2024 guidance provides a greater certainty of sea level rise through 2050, with a California statewide average of 0.8 feet. By 2100, the expected range of sea level rise is between 1.6 and 3.1 feet, although higher amounts cannot be ruled out. Beyond 2100, sea level rise uncertainty increases, with the potential for statewide sea levels to rise from 2.6 to 11.9 feet or greater by 2150.

The updated guidance recommends evaluation of the Intermediate, Intermediate-High, and High Scenarios in sea level rise planning and projects. The High Scenario is sufficiently precautionary for even the most risk averse applications. The High Scenario assumes high future greenhouse gas emissions. Note that future emissions are inherently uncertain because emissions depend on societal choices; therefore, it is not possible to estimate the probability that future emissions will be high. Assuming high emissions and considering the range of model projections for a high emissions scenario, the High Scenario's sea level rise estimates have less than a 1% chance

[1] SSP background from OPC 2024 guidance: *Developed more recently, the SSPs are a collection of narrative descriptions of alternative futures of socio-economic development in the absence of climate policy intervention. Five SSPs describe five different pathways that the world could take, drawing on data including population, economic growth, education, urbanization, and the rate of technological development. The SSPs are important inputs into the IPCC sixth assessment and are used to explore how societal choices will affect greenhouse gas emissions. Pathways 5-85 (SSP 585) assumes heavy fossil-fueled development with high percentage of coal and energy-intensive lifestyles worldwide and assumes a radiative forcing of 8.5 W/ m^2.*

of exceedance in 2100.[2] Each of the three recommended scenarios corresponds with low, medium-high, and extreme risk aversion applications:

- *Low risk aversion* is appropriate for adaptive, lower consequence projects (e.g., unpaved coastal trails). The *Intermediate Scenario* is recommended for consideration in low risk aversion applications.
- *Medium-high risk aversion* is appropriate as a precautionary projection that can be used for less adaptive, more vulnerable projects or populations that will experience medium to high consequences as a result of underestimating sea level rise (e.g., coastal housing development). The *Intermediate-High Scenario* is recommended for consideration in medium-high risk aversion applications.
- *Extreme risk aversion* is appropriate for high consequence projects with little to no adaptive capacity and which could have considerable public health, public safety, or environmental impacts (e.g., coastal airport, power plant, wastewater treatment plant, etc.). The *High Scenario* is recommended for consideration in extreme risk aversion applications.

The OPC guidance recommends utilizing data from one of twelve NOAA tide gauges that are located along the coast of California. Using the data from the nearest tide gauge to the project site can capture local variations due to tectonic activity or subsidence. The nearest NOAA tide gauge to Morro Bay Estuary is located at Port San Luis near Avila Beach.

[2] As stated in OPC (2024): "It is important to note that probabilistic projections do not provide actual probabilities of occurrence of sea level rise but provide probabilities that the ensemble of climate models used to estimate contributions of sea-level rise (from processes such as thermal expansion, glacier and ice sheet mass balance, and oceanographic conditions, among others) will predict a certain amount of sea-level rise." Also, note that the High Scenario has an 8% chance of exceedance when accounting for low confidence processes associated with Antarctica and Greenland ice-sheet loss.

Sea level rise projections for Port San Luis from the 2024 OPC Guidance and 2018 OPC Guidance are shown through 2150 for each risk aversion in **Figure 1**.

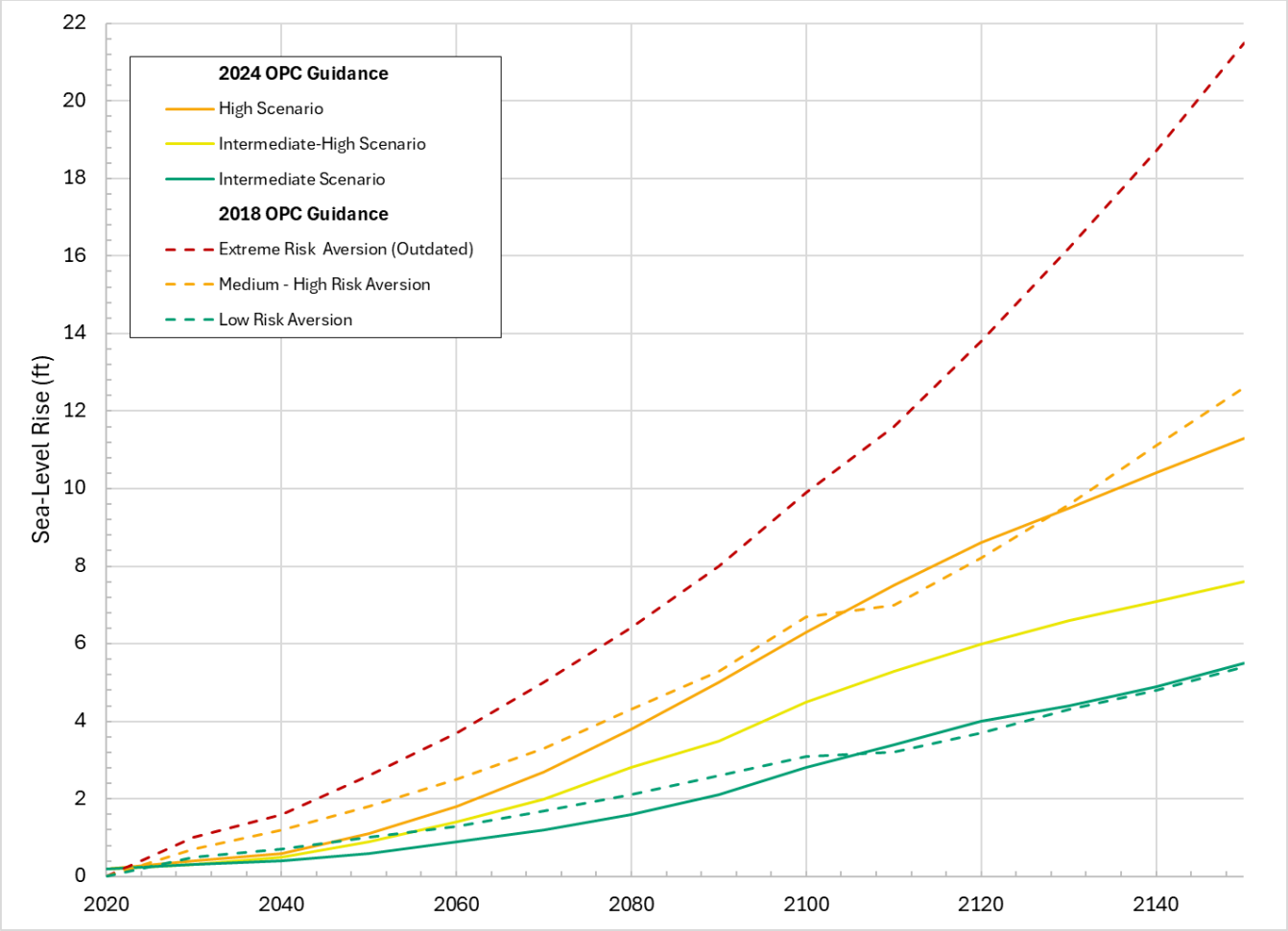

Figure 1
Sea level rise projections for Port San Luis from 2020 to 2150 from 2024 and 2018 CA OPC Sea Level Rise Guidance

While the OPC Guidance provides projections through 2150, it is important to note that sea level rise is expected to continue for centuries, because the earth's climate, cryosphere,[3] and ocean systems will require time to respond to the emissions that have already been released to the atmosphere. Although sea level rise is typically presented as a range in the amount of sea level rise that will occur by a certain date (e.g., 0.6-1.1 feet of sea level rise by 2050), it can also be presented as a range of time during which a certain amount of sea level rise is projected to occur (e.g., 1.6 feet of sea level rise between 2060 and 2080). Even if emissions are reduced to levels consistent with the low-emissions-based projections, sea level will continue to rise to higher levels, just at a later date.

[3] The cryosphere is the portions of the Earth's surface where water is in solid form, like glaciers and ice caps.

Table 1 presents State-recommended projections for the Morro Bay area in terms of Low, Intermediate-Low, Intermediate, Intermediate-High, and High Scenarios. The recommended scenarios for evaluation (Intermediate, Intermediate-High, and High) are outlined by the dark blue box.

TABLE 1
2024 OPC STATE GUIDANCE: PROJECTED SEA LEVEL RISE FOR PORT SAN LUIS AREA IN FEET

Year	Low	Int-Low	Intermediate (Low Risk Aversion)	Int-High (Medium-High Risk Aversion)	High (Extreme Risk Aversion)
2020	0.1	0.2	0.2	0.2	0.2
2030	0.2	0.3	0.3	0.3	0.4
2040	0.3	0.4	0.4	0.5	0.6
2050	0.3	0.5	0.6	0.9	1.1
2060	0.4	0.6	0.9	1.4	1.8
2070	0.5	0.7	1.2	2.0	2.7
2080	0.5	0.9	1.6	2.8	3.8
2090	0.5	1.1	2.1	3.5	5.0
2100	0.6	1.2	2.8	4.5	6.3
2110	0.6	1.4	3.4	5.3	7.5
2120	0.7	1.5	4.0	6.0	8.6
2130	0.7	1.7	4.4	6.6	9.5
2140	0.7	1.9	4.9	7.1	10.4
2150	0.8	2.0	5.5	7.6	11.3

NOTE:

Median values of Sea Level Scenarios, in feet, for each decade from 2020 to 2150, with a baseline of 2000. All median scenario values incorporate the local estimate of vertical land motion.

SOURCE: 2024 OPC Guidance

Table 2 presents the outdated 2018 State-recommended projections for the Morro Bay area in terms of Low, Medium-High, and Extreme Risk Aversion scenarios.

TABLE 2
2018 OPC STATE GUIDANCE: PROJECTED SEA LEVEL RISE FOR PORT SAN LUIS AREA IN FEET

Year	Low Risk Aversion	Medium-High Risk Aversion	Extreme Risk Aversion
2030	0.5	0.7	1.0
2040	0.7	1.2	1.6
2050	1.0	1.8	2.6
2060	1.3	2.5	3.7
2070	1.7	3.3	5.0
2080	2.1	4.3	6.4
2090	2.6	5.3	8.0
2100	3.1	6.7	9.9
2110	3.2	7.0	11.6
2120	3.7	8.2	13.8
2130	4.3	9.6	16.2
2140	4.8	11.1	18.7
2150	5.4	12.6	21.5

NOTE:

Median values of Sea Level Scenarios, in feet, for each decade from 2020 to 2150, with a baseline of 2000. All median scenario values incorporate the local estimate of vertical land motion. Projections after 2100 should be used with caution as there is increased uncertainty due to most available climate models at the time did not extend beyond 2100.

2.1 Critical Infrastructure Guidance for Sea Level Rise Adaptation Planning

In 2021, the California Coastal Commission (CCC) adopted the Critical Infrastructure Guidance for Sea Level Rise Adaptation Planning with specific guidance for sea level rise adaptation of at-risk critical infrastructure (CCC, 2021). The CCC Critical Infrastructure Guidance is based on the previous 2018 OPC California Sea Level Rise Guidance (OPC, 2018), which is superseded by the 2024 OPC guidance. The CCC Critical Infrastructure Guidance is summarized below for reference.

The CCC 2021 guidance document is focused on transportation and water/wastewater infrastructure and builds upon the 2018 science update to the CCC Sea Level Rise Policy Guidance (CCC, 2018). The purpose of the critical infrastructure guidance is to provide policy and planning information to inform sea level rise planning and adaptation decisions that are consistent with the California Coastal Act. The guidance presents key considerations for successful infrastructure adaptation planning with specific recommendations for each infrastructure category, describes the regulatory framework for infrastructure adaptation planning and provides model policies.

Consistent with direction from OPC 2018 guidance on the potential for extreme sea level rise, CCC recommended evaluating the extreme risk aversion (H++) scenario for critical infrastructure due to the long lifespans and significant consequences associated with extreme sea level rise and related hazard impacts. CCC guidance was to:

> *"understand and plan for the H++ scenario, not necessarily to site and design for the H++ scenario. In other words, in some cases it may not be appropriate or feasible to site or design a project today such that it will avoid the impacts associated with, for example, ~10 feet of sea level rise (the approximate H++ scenario in 2100 for much of the California coast). However, it is important to analyze this scenario to understand what the associated impacts could be and to begin planning options to adapt to this scenario if and when it occurs, and to ensure that the risks and benefits of economic investments in critical infrastructure are fully understood."*

Given that the 2024 OPC guidance is the best available science and does not include the H++ scenario, the superseded OPC 2018 guidance's extreme risk aversion (H++) scenario is not recommended for this study and the 2024 OPC guidance's High sea level rise scenario is used instead.

3 Suggested Approach for the Morro Bay Estuary Climate Transportation Plan

Sea level rise scenarios are recommended by considering the 2024 OPC guidance discussed above (which is based on the latest sea level rise science) and the availability of existing sea level rise hazard data for this study.

3.1 Thresholds Approach

ESA recommends using a thresholds approach in the Morro Bay Estuary Climate Transportation Plan to examine the sea level rise impacts by incremental amounts. The method involves identifying specific amounts of sea level rise, or thresholds, at which assets become vulnerable.

This approach differs from the chosen sea level rise scenario approach, which chooses three or so sea level rise amounts that are applied to the entire project. In the threshold approach, specific assets will have different sea level rise thresholds. For example, South Bay Blvd near Twin Bridges may have a different sea level rise threshold than the State Park Road bordering the bay in the Morro Bay State Park.

Sea level rise thresholds will be determined in the vulnerability analysis task of the Morro Bay Estuary Climate Transportation Plan. To determine the approximate timing of the sea level rise thresholds, the state recommended 2024 OPC projections for the Intermediate, Intermediate-High, and High will be used. Each projection is given an approximate year, and thus there will be a time range based on the risk level, Intermediate to High.

This is a different approach than what was used in the 2021 Plan Morro Bay, which analyzed sea level rise in the years 2030, 2050, and 2100, associated in the plan with 0.5 ft, 0.9 ft, and 3.1 ft of sea level rise, respectively. The timing of these sea level rise amounts corresponds to a superseded "low risk aversion" from the 2018 State of California Sea Level Rise Guidance (OPC, 2018).

Note that future global greenhouse gas emissions scenarios drive the sea level rise projections reported by the OPC. These emissions scenarios are influenced by societal choices and therefore their likelihood of occurrence is inherently uncertain. Sea level rise scenarios are determined by modeling a range of global emissions projections and considering a range of uncertainties in sea level rise processes. Due to the inherent uncertainty of future emissions scenarios, the probability of sea levels rising a specific amount by a specific date cannot be determined. Instead, the probability of exceedance of a particular sea level rise scenario provided by the 2024 OPC guidance is contingent or conditional on the assumption of a particular future emissions and warming scenario.

4 References

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