7. Adaptation Overview

Chapters 7 & 8 of the Sea Level Rise Vulnerability Assessment and Adaptation Project (2019) serve as the City's Adaptation Plan.

Adaptation is defined as a response to existing or anticipated climate-induced impacts, and can include policy, programmatic, and project-level measures. Good adaptation planning enhances community resilience to hazards and natural disasters and is based upon the understanding of the City's specific risks, projected timing of impacts, and existing and future coastal processes. As our understanding of climate science continues to evolve, it is important for the City to maintain flexibility and monitor sea level rise as part of adaptation planning and consider updated climate science, predictions, scenario probabilities, and diverse adaptation strategies. Adaptation planning provides the City with a toolbox of options to carry out its long-term vision for the community with consideration of sea level rise.

7.1 State of California Adaptation Guidance

The California Coastal Commission (CCC) and the Ocean Protection Council (OPC) have released sea level rise and adaptation planning guidance that can be used by local jurisdictions to update land use planning documents. The guiding principles and preferred adaption approaches are listed below. This information is useful for developing principles for the City's adaptation strategies.

CCC Sea Level Rise Policy Guidance (2018)

Sea Level Rise Policy Guidance (CCC 2018) outlines 20 guiding principles based on Coastal Act policies that address sea level rise in the coastal zone and fall under four categories:

- Use science to guide decisions (Coastal Act Sections 30006.5; 30335.5);
- Minimize coastal hazards through planning and development standards (Coastal Act Sections 30253, 30235; 30001, 30001.5);
- Maximize protection of public access, recreation, and sensitive coastal resources (Coastal Act Chapter 3 policies); and,
- Maximize agency coordination and public participation (Coastal Act Chapter 5 policies).

In November 2018, the CCC adopted the 2018 *Sea Level Rise Policy Guidance – Final Science Update* (CCC 2018b). The guidance update indicates that the *Report on Sea Level Rise* (National Research Council [NRC] 2012) guidance for assessing and modeling sea level rise

is no longer the best available science. The CCC currently recommends use of the *State of California Sea-Level Rise Guidance: 2018 Update* (OPC 2018) for sea level rise modeling. Both the CCC 2018 and OPC 2018 guidance documents are complimentary and are utilized across the state for developing planning and adaptation strategies. These documents are available online at: https://www.coastal.ca.gov/climate/slrguidance.html.

OPC State of California Sea-Level Rise Guidance (2018)

In March 2018, the California Natural Resources Agency and OPC released an updated *State of California Sea-Level Rise Guidance* including eight (8) preferred sea level rise planning and adaptation approaches:

- Adaptation planning and strategies should prioritize social equity, environmental justice, and the needs of vulnerable communities[1];
- Adaptation strategies should prioritize protection of coastal habitats and public access;
- Adaptation strategies should consider the unique characteristics, constraints, and values of existing water-dependent infrastructure, ports, and Public Trust uses;
- Consider episodic increases in sea level rise caused by storms and other extreme events;
- Coordinate and collaborate with local, state, and federal agencies when selecting sea level rise projections; where feasible, use consistent sea level rise projections across multi-agency planning and regulatory decisions;
- Consider local conditions to inform decision making;
- Include adaptive capacity in design and planning; and
- Assessment of risk and adaptation planning should be conducted at community and regional levels, when possible.

Natural Resources Agency Safeguarding California Plan (2018)

The *Safeguarding California Plan: 2018 Update* (Natural Resources Agency [NRA] 2018) describes the State's climate change adaptation plan and actions state agencies are taking to adapt communities, infrastructure, services, and the natural environment to climate change. This Plan outlines several programmatic and policy responses as well as examples of adaptation projects. In addition, the Plan includes metrics for monitoring and evaluation. Seven overarching principles provide the framework for this plan:

[1] Vulnerable communities refer to communities of color and/or low-income communities that experience heightened risk and increased sensitivity to climate change, and have less adaptive capacity to cope with, adapt to, or recover from climate impacts. These disproportionate effects are caused by one or more physical (built and environmental), social, political, and economic factors, which are exacerbated by climate impacts.

- Consider climate change in all functions of government;
- Partner with California's most vulnerable populations to increase equity and resilience through investments, planning, research, and education;
- Support continued climate research and data tools;
- Identify significant and sustainable funding sources to reduce climate risks, harm to people, and disaster spending;
- Prioritize natural infrastructure solutions that build climate preparedness, reduce greenhouse gas emissions, and produce other multiple benefits;
- Promote collaborative adaptation processes with federal, local, tribal, and regional government partners; and
- Increase investment in climate change vulnerability assessments of critical built infrastructure systems.

7.2 Approaches to Adaptation

According to CCC *Sea-Level Rise Policy Guidance*, sea level rise adaptation generally falls into five main categories: do nothing, protect, accommodate, retreat, or a hybrid approach (Table 7-1; Figure 7-1). These approaches are described below. For the purposes of implementing the Coastal Act, no one category or specific strategy is considered the "best" option. Different types of strategies may be appropriate depending on location, backshore type, hazard management approach, resource protection goals, development intensity, and time horizons. Strategies for addressing sea level rise hazards require proactive planning to balance protection of coastal resources with physical development. The effectiveness of different adaptation strategies varies across spatial and temporal scales.

Table 7-1. Adaptation Strategies

Strategy	Description
Do Nothing	Following a policy of non-intervention
Protect	Engineered structures (soft or hard) or other measures to protect existing development (or certain coastal resources) in its current location
Accommodate	Modify existing areas or design new developments or infrastructure to decrease hazard risks and tolerate lower levels of flooding
Managed Retreat	Relocate or remove existing development out of hazard areas and limit the construction of new development in vulnerable areas
Hybrid	Employ strategies from multiple categories

The City is actively pursing adaptation strategies; therefore, the do nothing approach is dismissed from further evaluation. The following discussion introduces the three main approaches; however, the City is investigating hybrid approaches as they would provide the broadest array of adaptation measures and preserve the City's flexibility to implement strategies through time as science continues to advance and the physical settings change.

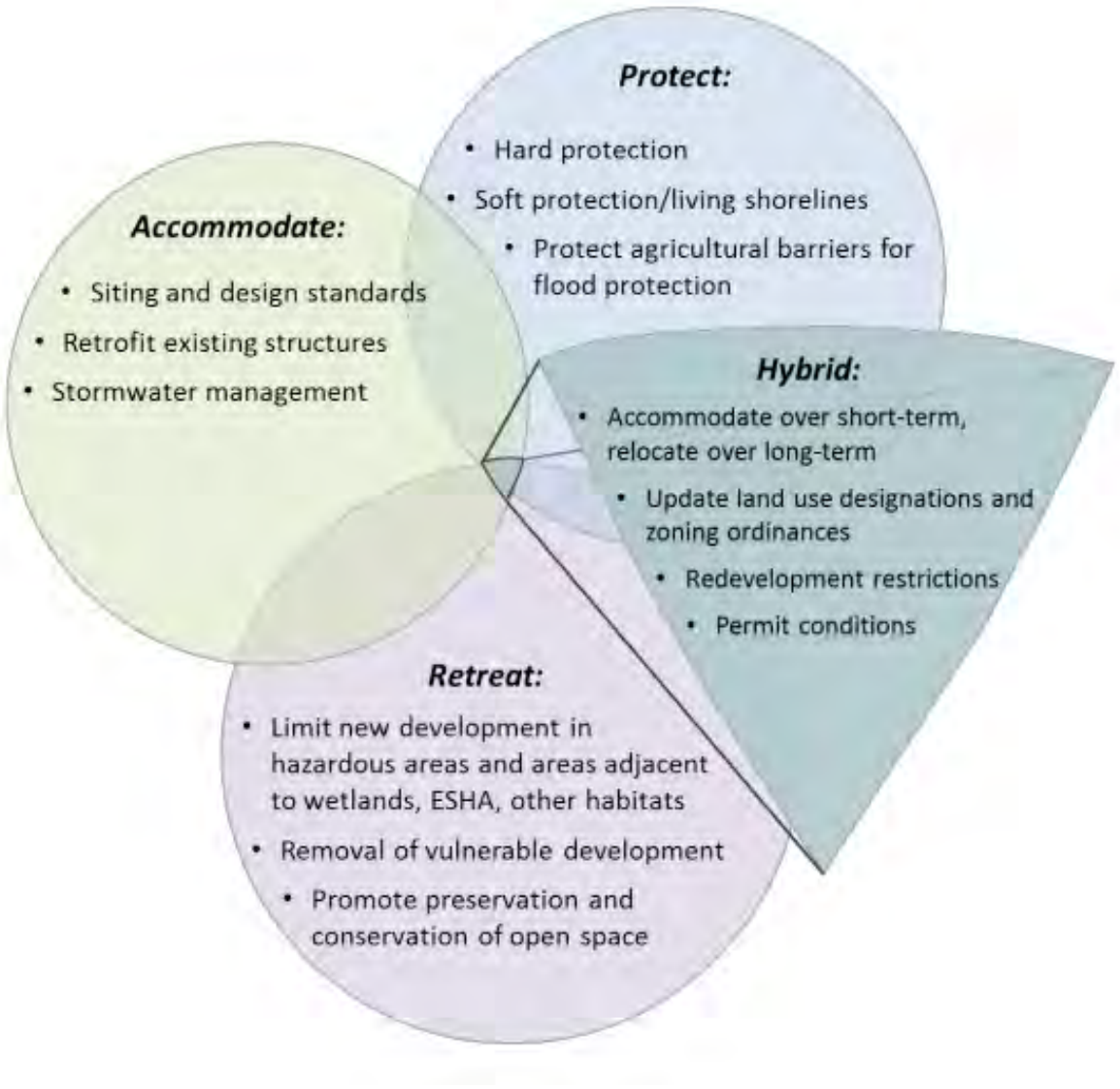


Figure 7-1. *Examples of General Adaptation Strategies. Source: CCC 2015.*

Protection

Protection strategies typically employ engineered structures or other measures to act as a barrier for existing development (or certain coastal resources) in its current location.

In accordance with the Coastal Act and *Safeguarding California Plan* (NRA 2018), priority should be given to options that protect, enhance, and maximize coastal resources and access. Protection strategies can range from "grey" to "green" and include either "hard" or "soft" defensive measures. A "soft" protection approach may be to nourish beaches with fine sand or natural sediments. A "green" soft approach may

be to establish vegetated sand dunes, or to develop a "living shoreline", which entails creation of a stabilized sand and cobble complex vegetated with local, native species. Dune systems are dynamic interfaces that act as a natural coastal defense by providing sand storage to buffer erosion and dissipate wave energy during extreme storm events. Successful implementation of such strategies may require some form of sand retention (e.g., enhanced headland or point to slow sand movement) to increase the longevity of such projects, as well as longer-term repeated nourishment of beaches or dunes. A "grey" and "hard" approach refers to an engineered structure and can be located either alongshore such as a seawall, revetment, or offshore breakwater, or cross-shore (i.e., shore-perpendicular) such as a groin, groin field, or jetty. Cross-shore structures are implemented to trap sand and widen the beach upcoast of the structure and must incorporate a downcoast pre-fill to prevent erosion. In most cases, "hard" structures must be accompanied by "soft" defensive measures such as beach nourishment and/or dune restoration to ensure efficacy in protecting the shoreline.

Although the Coastal Act provides for potential protection strategies when required to serve coastal dependent uses or for "existing development" in danger of erosion (i.e., California Coastal Act Section 30235), it also directs that new development be sited and designed to not require future protection that may alter a natural shoreline (California Coastal Act Section 30253). It is important to note that most protection strategies are costly to construct, require increasing maintenance costs, and may result in consequences to recreation, habitat, and natural defenses. The following options are considered protection strategies and are listed within the CCC *Sea Level Rise Policy Guidance*:

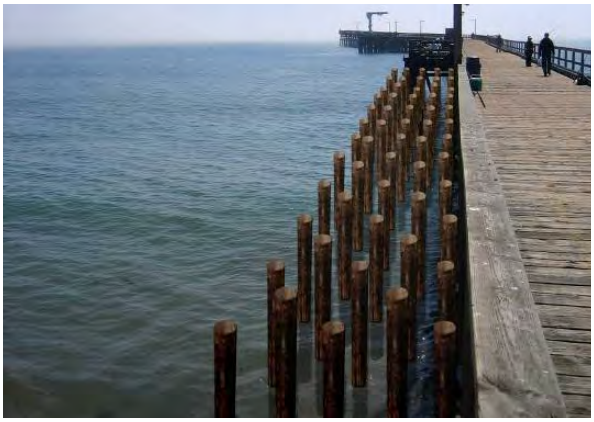
Example of hard shoreline protection. Portions of San Francisco's Ocean Beach is partially armored by a concrete seawall and supplemented with regular beach nourishment.

- Beach nourishment to widen the beach.
- Living shorelines, or other soft, green solutions to protect development and resources.
- Restoration of natural dune processes to provide a buffer against erosion and flooding by trapping wind-blown sand, storing excess beach sand, and protecting inland areas.
- Regional sediment management programs that consider the entire watershed system and restore natural sediment supply.
- Beneficial reuse of sediment through dredging and placement on beaches.
- Use of hard protection such as seawalls or revetments under special considerations to preserve the function of critical facilities.

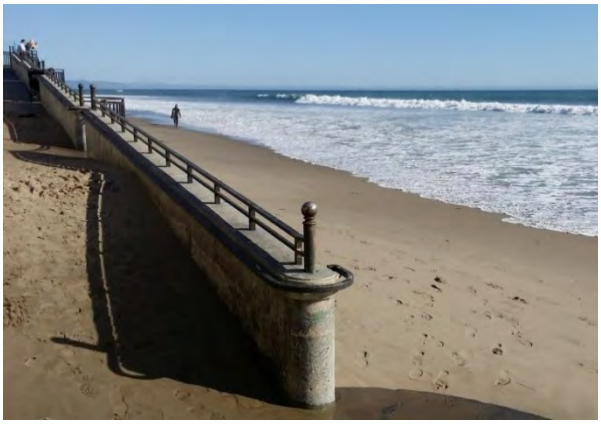
Other types of protection strategies include sand retention structures such as groins and recreational piers used for a cross-shore approach. Groins are thin and long structures perpendicular to the shoreline extending into the surf zone and slightly beyond the low water line. A recreational pier with a dense or impermeable set of support piles near the shoreline may be used to entrap sand while providing recreational benefits. Offshore artificial reefs are used to dissipate wave energy and consist of fill in the surf zone that reduces wave energy and anchors sand to the beach, slowing the rate of transport; kelp bed restoration may have similar effects. Many shoreline protective devices (e.g., flood control levees, revetments, etc.) can adversely affect a wide range of coastal resources and uses that the California Coastal Act protects. Placement of a "hard" shoreline protective device on the landward side of a beach ultimately leads to loss of the beach. Furthermore, hard shoreline protective devices often exacerbate erosion on adjacent unarmored beach areas. They often impede or degrade public access and recreation along the shoreline by occupying beach area or tidelines, by accelerating erosion, and reducing shoreline sand supply. Shoreline protective devices also raise serious concerns regarding marine resources and biological productivity and can degrade the scenic qualities of coastal areas and alter natural landforms.

Sand dunes act as a natural coastal defense by providing extra sand storage. Carpinteria State Beach currently has low-lying sand dunes that buffer the park.

Rock revetments are considered a "hard" coastal protection structure that fix the shoreline in place and buffer coastal resources from severe storm events.



Conceptual design for a permeable pier consisting of timber piles adjacent to a new or existing pier, which would trap sand from drifting downcoast.



Ramps connecting elevated walkways to the sand at Butterfly Beach in Montecito increase beach access and provide a safe path to traverse the seawall.

Accommodation

Accommodation strategies employ methods that modify existing areas or design new developments or infrastructure to decrease hazard risks and therefore increase the resiliency of development to the impacts of sea level rise.

On a community-scale, accommodation strategies include amendments to land use and zoning designations, or land use policy and zoning ordinance measures that require the above types of actions, as well as strategies such as clustering development in less vulnerable areas or requiring mitigation actions to provide for protection of natural areas. On an individual project scale, these accommodation strategies include standards such as elevating structures, performing structural retrofits, or using materials to increase the durability of development from additional coastal process impacts, building structures that can easily be moved and relocated, or using additional setback distances to account for acceleration of erosion. The following options are considered accommodation strategies and are listed within the CCC *Sea-Level Rise Policy Guidance*:

- Consider sea level rise in site-specific development proposals.
- Update development siting, code, and design standards to avoid, minimize, or reduce risks from coastal hazards and extreme weather events. Limit basements and first floor habitable space.
- Elevate structures above base flood elevations using caissons.
- Design coastal dependent infrastructure to withstand coastal hazards.
- Increase the capacity of stormwater infrastructure.
- Retrofit outfalls and wastewater treatment systems that could damage water quality. Realign or retrofit transportation infrastructure to better withstand sea level rise impacts.

Example of accommodation approach. The Santa Barbara Yacht Club is elevated above the shoreline using caissons, water-tight pier structures. The parking lot and beach flooded during the 1983 El Niño event. Photo credit: Gary Griggs

Example of managed retreat approach. Surfer's Point Managed Shoreline Retreat Project in Ventura, CA relocated the parking lot away from the shoreline and restored the beach area with cobbles and sand. Photo source: Surfrider Foundation 2013.

Managed Retreat

Managed retreat is considered a long-term adaptation measure that removes or relocates at-risk infrastructure to allow for natural retreat of the shoreline.

Managed retreat strategies prioritize proactive approaches to relocate or remove existing development out of hazard areas and limit the construction of new development in vulnerable areas. These strategies include amending land use designations and zoning ordinances to encourage siting and building in less hazardous areas, or gradually removing and relocating existing development outside of hazardous areas. Repetitive loss programs, development setbacks, and modification or removal of structures where the right to protection is waived (i.e., permit conditions) are examples of strategies designed to manage retreat from areas with existing and projected coastal hazards.

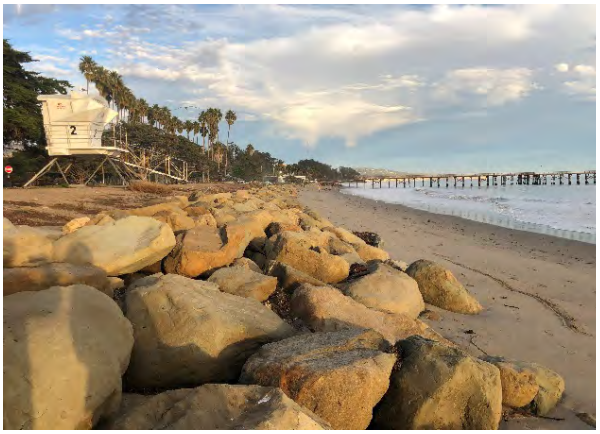
The following options are considered managed retreat strategies and are listed within the CCC *Sea-Level Rise Policy Guidance*:

- Establish mapped hazard zones or overlays that limit new development in current and future coastal hazard zones.
- Create shoreline management plans that address long-term shoreline changes due to sea level rise.
- Develop adequate setbacks for new development.
- Limit subdivisions in areas vulnerable to sea level rise.
- Develop a plan to remove or relocate structures that become threatened to coastal hazards.
- Plan to replace loss of land uses that could be lost to inundation or damage associated with sea level rise.
- Work with Caltrans and transportation agencies to identify alternative transportation routes.
- Coordinate planning and regulatory decisions with other appropriate local, state, and federal agencies.

Adaptation Trade-offs

Within each adaptation approach, adaptation measures have varying cost and benefit trade-offs. Consideration of trade-offs and impacts of different strategies and implementation mechanisms assists decision-makers and the public in determining the most effective policies and project-level adaptation strategies to advance. Factors to consider when

prioritizing strategies include: public health and safety, economic, ecological, recreational, and visual resources, environmental justice[2], political will, and community support.



Rock revetments at Goleta Beach have become exposed following severe winter storms, impeding vertical beach access while protecting the Park.

A selected adaptation measure may reduce risks to one asset or resource but may affect another resource or lead to unintended consequences (Table 7-2). One of the most controversial trade-offs of adaptation is associated with the long-term preservation of a beach, which often pits private and public interests against each other with strong overtures to social justice and community inequality. Adaptation trade-offs could include significant alterations to the shoreline and costs, resulting in the loss of beach following construction of a revetment but protection of landward development. Such impacts can result in major alteration or loss of public resources, public facilities, and other infrastructure; the severity of impacts is also dependent upon adaptation planning variables, including selected actions, available funding resources, and implementation timeframes. Good adaptation planning considers these trade-offs and how adaptation measures implemented to alleviate vulnerability in one sector may affect other sectors.

Table 7-2. Examples of Adaptation Trade-offs

Strategy	Trade-off Examples
Protect – Rock Revetment	Loss of public beach following construction of the revetment; protects landward development and infrastructure.
Accommodate – Elevate Buildings	Change in visual character and public views; allows private development to adapt in place.
Managed Retreat – Limit New Development in Hazardous Area	Places additional restrictions or eliminates use on private development; leaves room for public beach to migrate inland, maintaining recreational and ecological benefits.

Maladaptation

Adaptation measures that reduce the ability of people and communities to address and respond to climate change over time are called maladaptation. Maladaptation has several

[2] Environmental Justice refers to the fair treatment of people of all races, cultures, and incomes with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies (Government Code 65040.12[e]).

characteristics that help identify when it is occurring. One of the most significant concerns with maladaptation is that it reduces incentives to adapt while it simultaneously diminishes the capacity to adapt in the future. Maladaptation measures may:

- Result in sustained or increased hazardous conditions;
- Result in additional vulnerabilities, loss of property, and resources;
- Create a more rigid system with a false sense of security and severe consequences;
- Increase GHG emissions; and/or
- Reduce incentives to adapt.

Maladaptation occurs when efforts intended to protect communities and resources result in increased vulnerability, often realized indirectly or too late after a direction has been set. For instance, previously unaffected areas can become more prone to climate-induced hazards if the system that is being altered is not sufficiently understood. Likewise, if too much focus is placed on one-time period—either the future or the present—effects on the other can be ignored, resulting in an increased likelihood of impacts from climate-induced hazards. Avoiding maladaptation is critical to a successful climate adaptation strategy. To do so, the City must first be able to make informed decisions based on an accurate vulnerability assessment, and to determine its own level of tolerance to risk and vulnerability. Flexibility and a precautionary approach are key to avoiding maladaptation in the adaptation planning process.

7.3 Adaptive Capacity and Risk Tolerance

Adaptive capacity is the ability of a system to respond to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, and to address consequences. For purposes of this discussion adaptive capacity is categorized as:

- **High** – Strategy, asset, or resource can easily be adapted or has the ability and conditions to adapt naturally.
- **Moderate** - Strategy, asset, or resource can be adapted with minor additional cost or effort
- **Low** - Strategy, asset, or resource has limited ability to adapt without significant changes, cost, or additional engineering.

A guiding principle of adaptation planning is to limit the risk of coastal hazards to vulnerable assets. Risks to the City's vulnerabilities increase with sea level rise. The City must choose what level of risk it is willing to tolerate. Risks that present the most serious consequences and are projected to occur first should be elevated to top priorities for the City. Risks can be

addressed by reducing vulnerability or exposure. Given limited resources, it is important that risks be prioritized and phased to maximize the use of community resources while avoiding a costly emergency response to the maximum extent feasible (Figure 7-2).

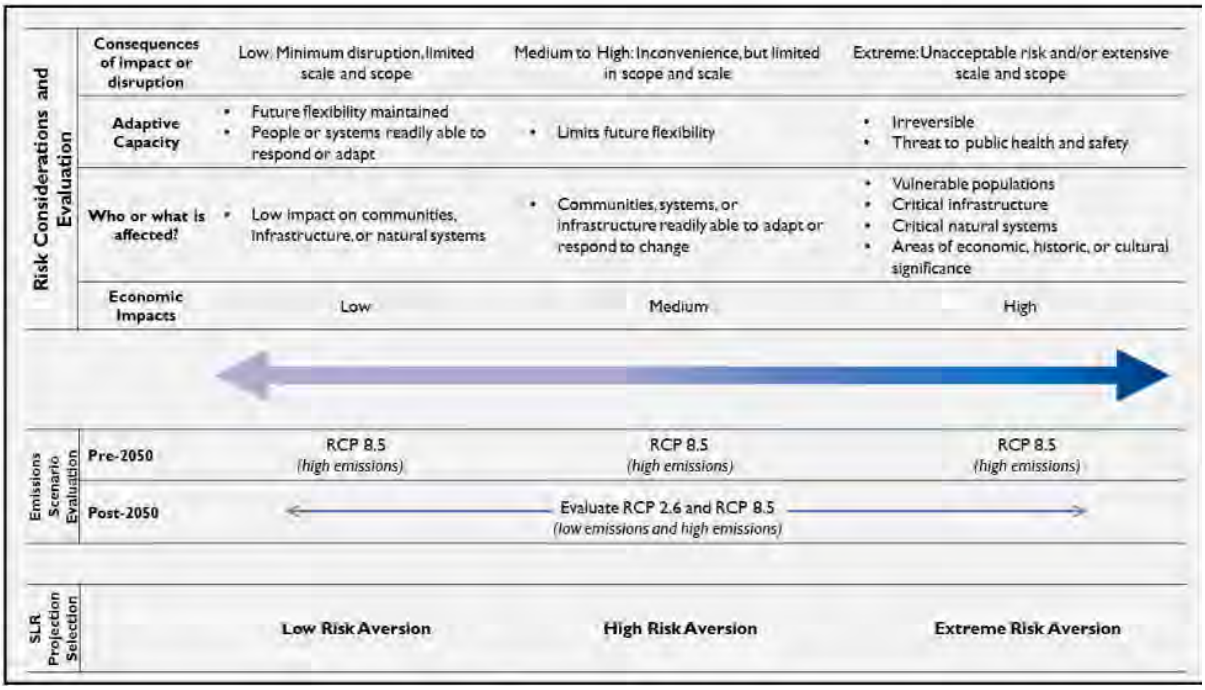


Figure 7-2. *Risk Tolerance Framework chart above includes factors to consider when prioritizing adaptation strategies. Source: OPC 2018.*

7.4 Triggers and Monitoring

Triggers represent a point in time when action must be taken to address coastal hazard-related vulnerabilities before impacts reach a critical mass. A trigger may be a shorter-term project such as a construction period associated with physical protection activities, or a longer-term program, such as a dynamic coastal adaptation overlay plan, which implements specific development regulations based on monitoring and assessment of need. Triggers are measurable indicators that serve as a catalyst or initiate planning, permitting, and/or the implementation process for adaptive measures. Triggers are useful in developing time-sensitive policies or actions and accommodate the required processes in advance of a needed adaptation measure. In cases where coastal hazards pose an existing threat, adaptation planning initiatives may be warranted regardless of future sea level rise, as adaptation can take several years to implement and any amount of sea level rise could exacerbate existing coastal threats. Each adaptation strategy has various lead times to plan, permit, finance, and implement. Updating the building code, for example, requires staff time to plan and develop

followed by decision-maker approval—a process that may at a minimum require a year or two. Removing a dam or relocating a railroad would take much longer.

An appropriate trigger would provide enough notice to implement before vulnerabilities become severe. Adaptation planning sets triggers such that adaptation measures can be implemented to reduce risks before they become critical. Potential triggers need to be monitored and assessed to inform adaptation decisions, and triggers should be reevaluated and updated in the future to capture advances in sea level rise science and changing conditions.

For the purposes of this Report, the **tipping point** is when sea level rise critically affects vulnerable assets, resources, or infrastructure, as indicated from the sector results of sea level rise modeling in Chapter 6. Triggers should occur in advance of the projected tipping point for adaptation to be successfully implemented.

Triggers should be related to actions that can be monitored or measured rather than related to uncertain projections given the importance of timing when abating or reducing effects of coastal hazards. There are several types of monitoring mechanism with examples that are useful to consider, such as:

- **By sea level rise elevation (or rate of sea level rise)** – trigger planning stages, study requirements, or changes in setback calculations. The City will follow sea level rise reports from the State and Scripps Institute of Oceanography, and National Oceanic and Atmospheric Administration tide gages. The City is already vulnerable to hazards that may occur from an El Niño event or individual storms; however, sea level rise would increase the severity and impacts of these storms. Monitoring sea level, and the rate it is rising allows the City to implement further actions in advance of projected sea level rise impacts.
- **By physical beach width distances** – identify an observable or measurable distance or threshold, such as when the beach width at the end of summer is less than 100 feet. This could trigger actions such as the pursuit of beach nourishment or sediment placement.
- **By planning year** – specify that by a future planning year (e.g., 2025), a long-range study identifying appropriate strategies must be complete (e.g., wastewater upgrade or transportation planning). The drawback of monitoring mechanisms based on planning year is that modeled projections of coastal hazards could occur sooner or later than a given year.
- **By storm exposure and frequency** – monitor the frequency of exposure to wave action (e.g., at Sandyland Road). To monitor the frequency of flooding, the City should track and record coastal and fluvial flooding, including the date, location, type, and severity. This would assess if the rate and frequency of flooding is increasing. An

increase in the rate and severity of storm damage should trigger the implementation of adaptation. Monitoring of storm damage frequency and exposure could be a collaborative effort with the County.

- **By damages** – identify available structural improvement that may occur to damaged buildings and facilities (e.g., repair if under 30 percent, upgrade building standards if damaged by >50 percent, or relocated if the structure has multiple damage claims >50 percent).
- **By bluff top offset** – monitor the distance of bluff erosion as a trigger for bluff adaptation measures. When erosion of the bluff edge reaches a certain distance that poses a safety risk to an asset or infrastructure, a trigger to relocate the infrastructure or asset would occur.

Triggers and timeframes to implement strategies are considered to identify high priority adaptation strategies. Implementing adaptation measures will require coordination, planning, permitting, engineering, and financing. Each strategy should identify a certain lead time from initial concept to implementation that varies depending on the scale and type of strategy, and the amount of sea level rise that the strategy can accommodate. These lead times should then inform policy triggers that are monitored through measurable objectives to act as a catalyst for the planning process.

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