

# Appendix A

## Addressing Sea Level Rise in Shoreline Master Programs

### Introduction

One widely accepted consequence of a changing climate is an increase in the rate of sea level rise (IPCC, 2007). Although there is scientific uncertainty about the precise amount of sea level rise by the end of this century, projections for Puget Sound range from 6 to 50 inches (Mote et al, 2008). Sea level rise will have significant effects on both human and natural systems (Shipman, 2009), increasing the risk from coastal hazards and the pressure on shoreline resources. These effects present a serious challenge to shoreline planning and coastal management.

The Shoreline Management Act (SMA) and the Shoreline Master Program (SMP) Guidelines currently contain no explicit references to climate change or sea level rise. However, they require local jurisdictions to take into account scientific and technical information pertinent to shoreline management issues. The Guidelines require local governments use “the most current, accurate and complete scientific and technical information available” (WAC 173-26-201(2)(a)).

RCW 90.58.100 (1)(c):  
Consider all plans, studies, surveys, inventories, and systems of classification made or being made by federal, state, regional, or local agencies, by private individuals, or by organizations dealing with pertinent shorelines of the state;

SMPs provide a direct opportunity for you to incorporate preparing for sea level rise into a broader planning framework. This SMP Handbook appendix presents background information on projected sea level rise in Washington State, potential impacts of sea level rise, and suggestions for local governments to address sea level rise in their SMP updates. As our knowledge about climate change and sea level rise grows, we will update this appendix accordingly.

This appendix addresses only sea level rise, but climate change may also result in other environmental impacts that will affect shorelines and the ecosystems they support. Some anticipated effects of climate change include:

- Altered hydrological cycles that may affect flooding and water resources.
- Increased sediment in glacier-fed rivers that may result in increased aggradation, flooding and channel movement.
- Increased landslides, which may result in more sediment and wood inputs to streams, potentially increasing flooding, channel movement, and transport of wood to hazardous positions (Beason and Kennard, 2006).

- Changes in ocean chemistry driven by higher levels of atmospheric carbon dioxide that will impact marine ecosystems.
- The potential for invasive species to increase their ranges as the ocean warms.



Figure A – 1: An unusually high tide in January 2010 caused water to spill over the seawall at Alki Beach in Seattle. Even modestly higher sea levels will cause the frequency of events such as this to increase, along with the potential for associated damage. Photo by Hugh Shipman.

More information about the anticipated effects of climate change on Washington’s coasts, as well as a number of other sectors such as water resources, endangered species, and human health, can be found in *The Washington Climate Change Impacts Assessment*, written by the University of Washington’s Climate Impacts Group and located online at: <http://cses.washington.edu/cig/res/ia/waccia.shtml>

## Projected sea level rise in Washington State

In order to plan for sea level rise, it is important to understand the potential extent of sea level rise and the effects this will likely have on coastal areas in Washington State. Distinct regions of the Washington coast will experience different levels of sea level rise due to vertical land movement in those regions. This movement is driven primarily by tectonic forces such as those responsible for the formation of the Olympic Mountains. Western Washington is located on the

edge of the North American continental plate, and as the Juan de Fuca oceanic plate moves underneath it a gradual uplift in the northwestern part of the state is produced.

A report co-authored by the University of Washington’s Climate Impacts Group and Ecology explains these variations and provides high, medium, and low sea level change projection scenarios for three broad regions of Washington’s coasts. That report, entitled *Sea Level Rise in the Coastal Waters of Washington State*, is available at <http://www.cses.washington.edu/db/pdf/moteetalr579.pdf>.

The table below summarizes the report’s projections:

**Table A-1: Sea level rise projections**

|             | <b>Puget Sound</b>               | <b>NW Olympic Peninsula</b>      | <b>Central &amp; Southern Outer Coast</b> |
|-------------|----------------------------------|----------------------------------|---|
| <b>2050</b> | Low 3”<br>Medium 6”<br>High 22”  | Low -5”<br>Medium 0”<br>High 14” | Low 1”<br>Medium 5”<br>High 18”           |
| <b>2100</b> | Low 6”<br>Medium 13”<br>High 50” | Low -9”<br>Medium 2”<br>High 35” | Low 2”<br>Medium 11”<br>High 43”          |

Table A-1: Sea level change projections for 2050 and 2100 in Washington's coastal regions. Note that the low projections for the NW Olympic Peninsula are negative values due to vertical land movement. Adapted From: *Sea Level Rise in the Coastal Waters of Washington State*.

## Environmental impacts of sea level rise

Sea level rise will have a variety of impacts on Washington state coastal areas. Increased sea level will allow high tides to reach farther into low-lying areas and higher against flood control structures such as dikes and tide gates. Coastal flooding will persist longer and will be more difficult to drain due to higher sea level. Higher water levels will result in faster rates of erosion on beaches and coastal bluffs (Shipman, 2009).

An important consequence of higher sea level will be increased frequency of high-tide flooding and the potential for storm damage. A rise in sea level of one foot might lead to as much as a ten-fold increase in the frequency of any particular flood event. This means that events that currently occur only once every decade may become annual events, increasing the severity and frequency

of flood and storm-related damages to coastal development (Shipman, 2009). These events could pose an increasing threat to coastal development and infrastructure.

The prospect of more flooding, erosion, and storm damage may lead communities and property owners to build seawalls, dikes, and tidal barriers. The construction and placement of these structures will have a direct and immediate impact on natural shoreline environments. These structures will also lead to the progressive loss of beach and marsh habitat as those areas are squeezed between the rising sea and a more intensively engineered shoreline. Predicted decreases in size or transitions in tidal marshes, salt marshes, and tidal flats will affect the species these habitats support. It is predicted that while some species may be able to locate alternate habitats or food sources, others will not (Glick, 2007).

Shellfish, forage fish, shorebirds, and salmon are among those identified as examples of species at risk (Glick, 2007). Sea level rise will also lead to other changes in coastal ecosystems, such as shifting of stream mouths and tidal inlets, reconfigured estuaries and wetlands, and more frequently disturbed riparian zones.

## **Coastal landforms and impacts**

The impacts of rising sea level will differ substantially between locations, based on landform (bluff, estuary, spit), the character of development (urban, agricultural, rural), and the capacity of the shoreline to adjust to changing conditions. Below is a list of areas particularly vulnerable or resilient to the impacts of sea level rise and anticipated impacts to these areas.

- Low-lying areas – river deltas, historically filled lands, spits and barrier beaches. These areas will experience more frequent and more persistent flooding and damage to infrastructure. In developed low lying areas, there will be an increased need for more robust dikes and drainage systems if the existing uses are to continue.
- Coastal bluffs. In general, sea level rise will result in higher erosion rates and greater instability of landslide prone areas. Demand for seawalls will increase, as will the adverse effects of such structures on shoreline habitat and on erosion patterns on nearby beaches.
- Spits and other barrier beaches. These low-lying features will be subject to increased flooding during storms and high tides and in many situations will experience more rapid erosion.
- Tidal environments – beaches and tide flats. These areas are expected to experience additional inundation and either be lost or undergo conversion to another habitat type.
- Marshy shorelines found in small estuaries and river deltas. These areas will be subject to increased flooding and increased erosion. Loss of salt marsh and related habitats may be significant in systems constrained by surrounding development.
- Developed shorelines – ports, marinas, roads and railroads, urban and residential shorelines. Typically, these are heavily armored with seawalls and riprap. Their level of vulnerability may be largely a function of their elevation. Developed shorelines of all types in low-lying areas will be vulnerable to losses from erosion, storms, or flooding.
- Rocky shorelines. Fairly resilient to modest increases in sea level.

## **Addressing sea level rise in SMPs**

In the absence of good planning, human reaction to sea level rise will likely be driven by our incremental responses to damaging storms and floods, not by our desire to reduce the long-term impacts of a gradually rising sea. SMPs cannot prevent climate change or alter the rate of global sea level rise, but they are essential tools in assuring the wise development of coastal areas and the protection of public resources as sea level increases. Many potential problems associated with sea level rise will intensify existing management challenges such as development in flood prone areas, construction of shoreline armoring, protection of beaches and salt marshes, and siting a variety of shoreline uses.

You should consider the impacts of and potential ways to adapt to or prepare for rising sea levels while developing your SMP. The phases and tasks shown below are particularly relevant to consideration of sea level rise impacts.

### **Shoreline jurisdiction (Phase 1)**

One of the earliest steps in the SMP planning process is identifying shoreline jurisdiction. As sea level rises, the ordinary high water mark (OHWM) will move inland as well, altering the line from which shoreline jurisdiction is measured. Although the SMA does not specifically mention shifts in shoreline jurisdiction due to sea level rise, it does identify that the OHWM is located “as it may naturally change” (RCW 90.58.030 (2)(b).) The location of the OHWM often changes, even without sea level rise, due to erosion, accretion, or shoreline modification.

While it will not be possible to predict precise shifts in jurisdiction, the process of identifying current shoreline jurisdiction is an important tool to measure future sea level rise. The SMA requires local governments to revisit their SMPs every seven years. This review cycle will allow you to ensure that your updated mapped shoreline jurisdiction reflects changes due to sea level rise or other factors, and to adjust environment designations, policies, and regulations accordingly.

### **Public participation (All phases)**

Sea level rise has the potential to generate considerable interest among shoreline property owners and other interested citizens and organizations. Therefore, incorporate it into your public participation activities. Local information could be presented to the public along with options for addressing sea level rise in your SMP update. Sea level rise adaptation should be part of most if not all public participation activities.

For example, the City of Olympia presented technical information to the public about the anticipated impacts of climate change to hydrologic regimes and area sea levels. The meeting closed with a presentation by city staff about the SMP update process and their plans to incorporate climate change adaptation into the update process. Providing this information during the early stages of the SMP allows local governments to alert interested parties about potential ways the draft SMP can address sea level rise or other climate change adaptation elements.

## Shoreline inventory and characterization (Phase 2)

The inventory and characterization provides an opportunity to identify shoreline areas that will be particularly vulnerable or resilient to rising sea level. One fairly straightforward way to characterize vulnerability is to classify the shoreline according to coastal landform. Landform types include coastal bluffs, marshes, rocky shorelines, and armored shorelines. Each type of landform will experience different long-term effects of rising sea level (as described above in the “Coastal landforms and impacts” section).

Once the coastal landforms have been mapped, you can determine the level of vulnerability to sea level rise for the extent of your shoreline. This type of characterization does not require a precise estimate of the rate of sea level rise.

Some urban jurisdictions have used high resolution coastal topographic data to develop maps of low-lying areas subject to inundation by higher water levels. Such maps can be used to illustrate the consequences of different sea level scenarios and storm and tide combinations. This type of approach can be useful for identifying coastal areas subject to increased flooding and to help direct appropriate future land use or development types to appropriate locations. These maps and projections may be particularly helpful for guiding engineering questions, such as structural elevations, drainage requirements, construction techniques, and hazard mitigation measures.

For some local governments, including the City of Olympia and King County, detailed analysis of sea level rise predictions and potential effects have already been conducted and can be directly incorporated into the shoreline inventory and characterization. These local products have been produced by academic researchers, independent consultants, and local government public works departments or other agencies responsible for stormwater or wastewater infrastructure. For an example of a detailed local analysis, view the “Sea Level Rise” presentation found on the City of Olympia’s climate change web page at [www.olympiawa.gov/community/sustainability/Climate\\_Change/](http://www.olympiawa.gov/community/sustainability/Climate_Change/).

**Public access:** As part of the shoreline inventory and characterization, local governments identify existing physical and visual public access sites and opportunities. During this process, you can identify those sites where sea level rise may pose a threat to public access. For example:

- Parks in low lying areas may be subject to increased flooding.
- Public tidelands may become inaccessible if shoreline armoring prevents the tidelands from migrating inland.
- Publicly accessible spits may be lost to erosion.
- Visual access sites along coastal bluffs may become hazardous due to landslides.

If you identify existing public access sites vulnerable to sea level rise, you might also identify opportunities to preserve or replace those sites during the use analysis. For example, consider expanding the upland reach of coastal parks to accommodate shifting shorelines in low lying areas, or planning for new public access sites in areas less vulnerable to flooding or erosion. Additional potential techniques for ensuring that public access is provided in the future include:

- Building public docks and piers that are more resilient to sea level rise.
- Removing shoreline armoring or moving it inland to allow the public to walk on the beach even as the sea level rises.
- Locating boardwalks or trails above the elevation of projected sea level rise.

### **Shoreline use analysis:**

In conducting the shoreline use analysis, take into account the effects of rising sea levels on existing and projected development. During the use analysis, you will estimate the future demand for shoreline space and identify projected development trends and potential use conflicts. The objective is to ensure that shorelines are available for uses that are unique to or dependent on the shoreline. The use analysis will be helpful in identifying developed and undeveloped areas that may be vulnerable to sea level rise.

Where possible, use analyses should build upon the inventory and characterization to project areas where future infrastructure will be necessary to address sea level rise impacts. This might include corridors along developed shorelines for new or expanded flood control structures, elevation of structures, or locations for pump stations and larger storm drainage facilities. These types of efforts will require detailed planning beyond the SMP and large public and private investments.

Keep in mind that the seven-year review cycle will allow you to revisit and update your inventory and characterization. This review should include an analysis of any new scientific and technical information on sea level rise and its effects. New information will be incorporated into the inventory and analysis at that time, and policies updated accordingly.

## **Goals, policies, and regulations (Phase 3)**

The goals, policies, and regulations contained in the SMP can specifically address sea level rise adaptation. These sea level rise provisions can help to create awareness of the impacts of sea level rise and other climate change effects among shoreline property owners and development proponents. Enhanced awareness of impacts may in turn result in project designs that incorporate larger setbacks which will decrease the risk of flooding and storm damage to these developments as sea level rises.

Sea level rise adaptation can be incorporated into several different sections of the goals, policies, and regulations. Examples of goals and policies addressing sea level rise are provided below.

### **General goals, policies, and regulations**

Some local governments have addressed climate change adaptation in the statement of general goals for their SMPs. Following are examples from the King County, Jefferson County and city of Burien draft SMPs.

- **King County Draft SMP**  
King County Draft SMP contains an example of general goals and policies related to climate change.

*Preparing for Climate Change*

As discussed in Chapter 4 of the King County Comprehensive Plan, climate change has the potential for significant impacts on shorelines and shoreline habitats. Sea-level rise and storm surges may place at risk infrastructure, habitat restoration projects, and other development, including residential development. New development and maintenance or replacement of existing development should take into account the potential for harm that may result from sea-level rise.

*S-649 King County shall ensure that new projects for and major maintenance or replacement of utilities, roads, and other public infrastructure consider the impacts of sea-level rise in the location, design, and operation of the projects.*

*S-650 Habitat protection and restoration projects in the shoreline jurisdiction shall consider implications of sea-level rise and other climate change impacts to promote resiliency of habitats and species.*

- **Jefferson County Draft SMP**

More specific, but still overarching goals can be included as shoreline use goals. Jefferson County's draft SMP contains the following shoreline use goal:

*10. Encourage all use and development to address potential adverse effects of global climate change and sea level rise.*

SMPs must address flood hazards and seek to reduce the damage caused by floods. This provides another opportunity to address sea level rise and the increased threat from flooding that will accompany it. The Jefferson County draft SMP provides an example of a policy designed to reduce future flooding from sea level rise:

*Shoreline Setbacks and Height Policy #2. Proponents of a development on no-bank or low bank marine shorelines are encouraged to locate the bottom of a structure's foundation higher than the level of expected future sea-level rise.*

- **City of Burien Draft SMP**

The City of Burien's draft SMP also contains a sea level rise policy in their Flood Prevention element. This policy articulates their intention to incorporate updated sea level rise predictions in their future SMP updates and alter policies as needed:

*Pol. FLD 4 - Monitor sea level rise and accordingly adjust development standards such as building setbacks to minimize flooding potential.*



### **Environment designations (Phase 3)**

Environment designations should reflect the results of the inventory and characterization and take into account existing shoreline development. Undeveloped areas that are designated as “natural” will remain less developed and therefore less likely to contain infrastructure that may be damaged by storms or flooding exacerbated by sea level rise. These shorelines may also prove better able to shift and change in response to sea level rise than those in more highly developed areas.

Buffers and setbacks are often specific to environment designations. Shoreline buffers and setbacks can be an effective way to ensure that future development is not threatened by sea level rise. Buffers and setbacks along with restrictive building standards near low lying or erosion prone shorelines will help reduce flooding and the need for shoreline armoring. Environment designation regulations can also state where and what types of armoring are or are not acceptable.

In intensely developed urbanized settings, the likely policy response to sea level rise will be to defend the existing developed area. In these locations, it might be appropriate to establish a setback to accommodate a future dike or elevated sea wall. The level of investment and intended life of the improvement are important considerations in addressing long-term sea level rise issues.

### **Shoreline modifications policies (Phase 3)**

As sea level rises, some property owners may wish to install shoreline armoring. If you have determined there are particular sections of your shoreline where armoring is not appropriate and is prohibited, state this clearly in your shoreline modifications policies and regulations. Incorporate planning for sea level rise into permit conditions for shoreline modifications. Policies and regulations should recognize the role that shoreline erosion and accretion play in preserving ecological functions, and to encourage softer armoring techniques where appropriate.

King County’s draft SMP encourages developers to consider sea level rise in projects along marine shorelines. This policy will help to prevent future unnecessary shoreline armoring.

S-778 King County shall notify all prospective developers of new development along Vashon and Maury Islands that their development may be impacted by sea-level rise and should encourage all such new development to be set back a sufficient distance to avoid the need for shoreline protection during the expected life of the development.

### **Restoration plan (Phase 4)**

Developing a restoration plan for your jurisdiction provides an excellent opportunity to implement sea level rise adaptation measures. As part of your restoration plan, identify restoration actions that improve resilience to sea level rise. Projects that protect and restore natural geomorphic processes such as erosion, sediment transport, tidal flooding, and marsh accretion are likely to be more successful than those that target the creation of historic habitat configurations that may be inundated or sustain increased flood damage due to sea level rise.

In addition, sea level rise predictions should be factored into restoration planning, perhaps including larger inland areas in restoration or habitat protection efforts to accommodate for the increasing inundation and to allow the shoreline to shift farther inland.



Figure A -2: A high tide event at a restored beach in the City of Seattle. Restoration projects such as this pocket beach should be selected and designed in ways that accommodate rising sea levels. Photo by Hugh Shipman.

Jefferson County recognized the potential need to alter the restoration plan as the effects of sea level rise become more evident. The “Obstacles and Challenges” section of the draft SMP includes the following text:

Climate change: Rising temperatures and sea levels have the potential to dramatically alter Jefferson County’s shoreline jurisdiction, processes, and functions over time. Depending on the scale of change and time period over which changes occur, restoration priorities could shift substantially within a relatively short period of time.

Language such as this would allow local governments to alter their restoration plan over time to address emerging impacts from climate change.

### **No net loss of ecological functions (All phases)**

SMPs must achieve “no net loss” of shoreline ecological functions resulting from allowed development. Detailed guidance on no net loss can be found in Chapter 4 of the SMP Handbook, online at: <http://www.ecy.wa.gov/programs/sea/shorelines/smp/handbook/Chapter4.pdf>. Under the current guidelines, SMPs are not expected to address the loss of ecological functions that result from outside influences such as climate change. However, sea level rise will likely result in loss of ecological functions in several ways. It will reduce the availability of upper intertidal

habitats on shorelines prevented from naturally eroding by development and armoring, even if no new development occurs. Depending on the rate of sea level rise, habitat may not be able to move upland, even on natural shorelines.

Therefore, when selecting indicators of no net loss, you should take sea level rise into account. A measure of no net loss is a change in one or more indicators, such as impervious surface, riparian or marine vegetation, eagle or osprey nests, shoreline stabilization and others. If sea level rise is expected to adversely impact a particular species or habitat type, you may wish to select a different species or habitat type to measure as an indicator of how well your SMP is achieving no net loss. In this way you will be able to measure the impacts of your SMP and at least partially control for the external impact of sea level rise. For example, if sea level rise would eliminate significant areas of riparian vegetation along your shorelines, riparian vegetation would not be a good choice as an indicator of ecological function.

## References and resources

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