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Sea Level Rise Adaption Planning Report Addendum No 1 - City of Eureka

Bayview Consulting

SEA LEVEL RISE

ADAPTION PLANNING REPORT ADDENDUM No. 1

City of Eureka

December 15, 2016

Prepared By: Bayview Consulting

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PURPOSE:

The purpose of this Addendum is to provide additional clarification and analysis on the information that was presented in the Sea Level Rise Adaptation Planning Report dated December 2016. This report is not intended to supersede the original report, rather it is intended to provide decision makers additional details regarding:

1. Draft goals and policies that could potentially be included in the City's Local Coastal Plan.
2. Potential strategies that could be utilized to protect those priority assets.
3. How and why the City's selected a specific projected sea level rise elevation.
4. What are other issues to consider besides "best available science" when making policy decisions.
5. Compliance with specific Coastal Act sections that requires certain assets to be protected, as well as, local "common sense" priority assets.

II DRAFT GOALS, POLICIES, AND REGULATIONS:

The following draft Goals, Polices, and Regulations are not intended to be viewed as a stand-alone regulatory document. These draft regulations when adopted and certified by the Coastal Commission will be one section of the City's overall Local Coastal Program. The City's Local Coastal Program currently includes detailed policies and standards regarding wetlands and other environmentally sensitive habit areas. These draft regulations must be both horizontally and vertically consistent with the other sections, as well as, the implementing zoning standards. Therefore, it is unnecessary to include those policies and standards as they are already included in the existing Local Coastal Program and Coastal Act.

The following goals, policies, and regulations were developed based on the legislatures intention and the specific requirements that are outline in the Coastal Act. The Coastal Act is clear that there are urban areas and rural areas; developed areas and undeveloped areas; and existing development and new development on California's Coastline. The Coastal Act does not treat these areas the same and therefore, the City's policies treat them differently. The following facts should be carefully reviewed when developing sea level rise regulations:

1. *The ports of the State of California, including the Humboldt Bay Harbor, Recreation, and Conservation District, constitute one of the state's primary economic and coastal resources and are an essential element of the national maritime industry (Section 30701 (a).*
2. *Approval of a local coastal program shall not be withheld because of the inability of the local government to financially support or implement any policy or policies contained in this division; provided, however, that this shall not require the approval of a local coastal program*

allowing development not in conformity with the policies in Chapter 3 (commencing with Section 30200) (Section 30516(a)).

3. *The Legislature further finds and recognizes that conflicts may occur between one or more policies of the division. The Legislature therefore declares that in carrying out the provisions of this division such conflicts be resolved in a manner which on balance is the most protective of significant coastal resources. In this context, the Legislature declares that broader policies which, for example, serve to concentrate development in close proximity to urban and employment centers may be more protective, overall, than specific wildlife habitat and other similar resource policies. (30007.5).*
4. The City's Coastal Commission Certified Local Coastal Plan established the "urban and employment centers" in the City of Eureka (Section 1 Land Use and Community Design).
5. *The Coastal Act requires protection, and therefore, policies must be in place to protect:*
   a. *Public Access (Section 30210).*
   b. *Commercial Fishing and Recreational Boating (Section 30234, 30220, and 30703).*
   c. *Coastal Visitor Serving Uses (Section 30235).*
   d. *Coastal Dependent Uses and Existing Structures (Section 30235)*
   e. *Environmentally Sensitive Habitat Areas (Section 30240)*
   f. *Agricultural Lands (Section 30242).*
   g. *Cultural, Archeological and Paleontological Resources (section 30244).*
6. *Coastal-dependent developments shall have priority over other developments on or near the shoreline. Except as provided elsewhere in this division, coastal-dependent developments shall not be sited in a wetland. When appropriate, coastal-related developments should be accommodated within reasonable proximity to the coastal-dependent uses they support (Section 30255).*
7. *Revetments, breakwaters, groins, harbor channels, seawalls, cliff retaining walls, and other such construction that alters natural shoreline processes shall be permitted when required to serve coastal dependent uses or to protect existing structures or public beaches in danger from erosion, and when designed to eliminate or mitigate adverse impacts on local shoreline sand supply. Existing marine structures causing water stagnation contributing to pollution problems and fish kills should be phased out or upgraded where feasible (Section 30235).*

In addition the Coastal Commissions Strategic Plan for 2013 – 2018 under Goal # 3 states: *"Global sea level rise is accelerating and extreme storm events are increasing in intensity, both of which are exacerbating coastal shoreline hazards that the Commission must address, including coastal erosion and flooding. Public beaches and public access will be placed at increased risk in urban areas where there may be significant coastal armoring and little opportunity for natural retreat of the beach. Wetland protection and restoration decisions will need to account for changes in sea level rise. Coastal terrestrial and marine habitats are already changing with shifts in climate patterns."*

In Chapter 8: Legal Context of Adaptation Planning of the Coastal Commission's Sea Level Rise Guidance Document it states:

"Section 30235 of the Coastal Act provides that seawalls and other forms of construction that alter natural shoreline processes "shall be permitted when required to serve coastal-dependent uses or to protect existing structures or public beaches in danger from erosion, and when designed to eliminate or mitigate adverse impacts on local shoreline sand supply." Despite other Coastal Act provisions that could often serve as the basis for denial of shoreline protective devices (for example, new development requiring shoreline protection can also conflict with Coastal Act policies requiring protection of public access and recreation, coastal waters and marine resources, natural landforms, and visual resources), the Coastal Commission has interpreted Section 30235 as a more specific overriding policy that requires the approval of Coastal Development Permits for construction intended to protect coastal-dependent uses[47] or existing structures if the other requirements of Section 30235 are also satisfied.[48] The Commission thus will generally permit a shoreline protective device if (1) there is an existing structure, public beach, or coastal-dependent use that is (2) in danger from erosion; and (3) the shoreline protection is both required to address the danger (the least environmentally-damaging, feasible alternative) and (4) designed to eliminate or mitigate impacts on sand supply."

Chapter 7 of the Commission's document gives the following policy guidance regarding ports critical facilities and Coastal Dependent Infrastructure. We were unable to find any guidance on protecting commercial fishing, recreational boating facilities, and coastal dependent development.

A.26 Plan ahead to preserve function of critical facilities*: Addressing sea level rise impacts to critical facilities and infrastructure will likely be more complex than for other resources and may require greater amounts of planning time, impacts analyses, public input, and funding. To address these complexities, establish measures that ensure continued function of critical infrastructure, or the basic facilities, service, networks, and systems needed for the functioning of a community. Programs and measures within an LCP could include identification of critical infrastructure that is vulnerable to SLR hazards, establishment of a plan for managed relocation of at-risk facilities, and/or other measures to ensure functional continuity of the critical services provided by infrastructure at risk from sea level rise and extreme storms. Repair and maintenance, elevation or spot-repair of key components, or fortification of structures where consistent with the Coastal Act may be implemented through CDPs.*

A.26a Develop or update a long-term public works plan for critical facilities to address sea level rise*: Develop a long-term management plan to address the complexities of planning for sea level rise that incorporates any potential maintenance, relocation, or retrofits and structural changes to critical facilities to accommodate changes in sea level, and obtain Coastal Commission certification.*

A.27 Apply high sea level rise projections for siting and design of critical facilities: *Given the planning complexities, high costs, and potential impacts resulting from damage, there is reason to be particularly cautious when planning and designing new critical facilities and/or retrofitting existing facilities. Ensure that critical facilities are designed to function even if the highest*

projected amounts of sea level rise occur and that sites with hazardous materials are protected from worst-case scenario sea level rise impacts.

***A.27a Design coastal-dependent infrastructure to accommodate worst case scenario sea level rise**: Include policies that would require proposals and/or expansion plans to address sea level rise for coastal dependent infrastructure that must necessarily be sited in potentially hazardous areas, such as industrial, energy, and port facilities. Such facilities should be designed to withstand worst case future impacts while minimizing risks to other coastal resources through initial siting, design, and/or inclusion of features that will allow for future adaptation.*

***A.28 Site and design wastewater disposal systems to avoid risks from sea level rise**: Wastewater treatment and disposal systems are particularly challenging in that they are often located in areas that will be impacted by sea level rise. Ensure that these systems are not adversely affected by the impacts of sea level rise over the full life of the structure and ensure that damage to these facilities would not result in impacts to water quality or other coastal resources. Avoid locating new facilities in hazardous areas if possible. If complete avoidance is not possible, minimize elements of the system that are in hazardous areas (for example, locate the main facility on higher ground and only place pump stations in potentially hazardous areas), and design any facilities in hazardous areas to withstand worst-case scenario sea level rise impacts.*

***A.33 Incorporate sea level rise considerations into Port Master Plans and other port activities**: Ensure that ports and related infrastructure are designed to function given anticipated sea level rise. In some cases, this may mean initially designing structures to accommodate projected sea level rise impacts. Other options may include planning for and ensuring capacity for future adaptive actions.*

***A.33a Retrofit existing port infrastructure as necessary:** Given the coastal-dependent nature of many port structures, it may not be feasible to site or relocate development to avoid hazards. In these instances it may be more appropriate to include efforts to accommodate and withstand sea level rise during actions to repair or retrofit existing structures. Options may include using more robust designs or materials or elevating structures.*

***A.33b Minimize resource impacts that may result from future use of shoreline protective structures**: If existing, coastal-dependent port structures require shoreline protective structures, minimize resource impacts as feasible and consistent with Chapter 3 and/or Chapter 8 of the Coastal Act, as applicable, by encouraging inland expansion of protective devices rather than further fill of coastal waters.*

***A.33c Ensure that linkages to overland transportation networks are able to adapt to sea level rise impacts**: Coordinate with relevant stakeholders to ensure that linkages between port infrastructure and overland transportation networks will be resilient to future sea level rise impacts.*

EUREKA LOCAL COASTAL PROGRAM
LAND USE PLAN
SEA LEVEL RISE AND SHORELINE EROSION

GOAL SLR 1

Preserve, enhance, and restore the shoreline while protecting public access, scenic quality, natural resources, critical public infrastructure, and existing development from coastal hazards.

SLR 1.1 Structures. Shoreline structures (boardwalks, seawalls, revetments, piers, docks, marina's, dikes, levees, and other structures) shall:

a. be designed for multiple urban purposes such as flood protection, transportation, public access trails, wastewater management, recreation, wildlife, nature, and tourism wherever practical.
b. incorporate an interconnected system of public access trails, boardwalks, and viewpoints wherever practical.
c. assure shore stability and structural integrity, and neither create nor contribute significantly to erosion, geologic instability, or destruction of the site or surrounding area.
d. avoid, minimize, and mitigate impacts on environmentally sensitive habitat areas, public recreation, coastal access, and navigation.
e. incorporate soft coastal protection such as engineered "living shoreline" or fringe salt marshes where practical to reduce wave run up, coastal erosion, and reduce the height of hard shoreline structures. Soft coastal protection shall not diminish navigation or recreational activities on the bay.
f. include vegetation and other features designed to soften rock revetments, rock boulders rip rap, or other hard armoring structures and make them more atheistically pleasing wherever practical.

SLR 1.2 Preserving Undeveloped Shorelines: The City shall encourage the preservation and habitat enhancement of natural shoreline areas that were identified in the 2013 shoreline mapping assessment as these areas are vulnerable to future flooding and contain significant habitats or species and are especially suitable for ecosystem enhancement.

SLR 1.3 Fill Material in Bay. Safe fill material such as dredge spoils, rock, and oyster shells may be placed in the Bay to protect existing and planned development from flooding as well as erosion.

SLR 1.4 Adaptation Measures. As per the Coastal Act and common sense, the City shall prioritize developing and implementing adaptation measures to protect the following assets:

a. Public Coastal Access Points identified in the General Plan (Coastal Act Section 30210).
b. Eureka Waterfront Trail from the Elk River to Humboldt Bay Trail near Highway 101 (Coastal Act Section 30210).
c. Commercial Fishing and Recreational boating facilities (Coastal Act Section 30234 and 30220).
    1. Marina
        i. Woodley Island Marina
        ii. Eureka Public Marina
    2. Docks
        i. Humboldt Bay Rowing Association Dock (Samoa Bridge)
        ii. Bonnie Gool Dock (Adorni Center)
        iii. F Street Dock (Boardwalk)
        iv. Coast Guard Dock (Commercial Street)
    3. Boat Ramps
        i. Samoa Bridge Boat Ramp
        ii. Eureka Public Marina (500 W Waterfront Drive)
        iii. Montgomery Ward Boat Ramp (Behind Target)
d. Coastal Visitor Serving Uses (Coastal Act Section 30235)
e. Coastal Dependent Uses and Existing Structures (Coastal Act Section 30235).
    1. Coastal Dependent Industrial Uses.
    2. Waterfront Commercial.
    3. Use Existing Structures.
f. Environmentally Sensitive Habitat Areas (Coastal Act Section 30240)
g. Agricultural Lands (Coastal Act Section 30242).
h. Cultural, Archaeological and Paleontological Resources (Coastal Act Section 30244).
i. Wastewater Treatment Plant and Associated Facilities (Common Sense).
j. Highway 101 north and south (Common Sense).
k. Other Critical Infrastructure as established by the City Council (Common Sense).

SLR 1.5 **Removal of Shoreline Protective Structures**. If the "tipping point" is reached at a specific location and it is determined that it is no longer feasible to construct and maintain shoreline structures from the effects of sea level rise, the City may need to abandon certain developed areas. If currently developed areas are abandoned, and development is relocated outside of the coastal hazard areas, existing shoreline protective structures will either modified into a revised adaptation measure or be removed to allow natural processes and responses to sea level rise.

GOAL SLR 2:
Protect all lands currently developed with urban growth and all undeveloped lands designated for urban uses that provide valuable infill development opportunities until the magnitude of Sea Level Rise change is such that the protection management strategy can no longer be achieved.

SLR 2.1 **Existing Shoreline Structures.** To protect development located behind the shoreline from storm events, wave run-up, and coastal erosion; the existing shoreline structures (boardwalks, seawalls, revetments, piers, docks, marina's, dikes, levees, and other structures) shall be maintained and enlarged. To protect development from potential shoreline erosion and flooding hazards the City shall utilize the projected 2100 low intermediate model 100-year storm event projection of 2.7 feet (12.5 NAVD 88) plus a minimum of two additional feet (one foot for waves and one foot safety).

SLR 2.2 **Gaps in Lines of Defense.** Low points and gaps in the City's coastal flooding lines of defense shall be identified and tied into either higher existing land or be continued to avoid "back door" flooding.

SLR 2.3 **New Shoreline Structures.** New development along the shoreline shall assure stability and structural integrity, and neither create nor contribute significantly to erosion, geologic instability, or destruction of the site or surrounding area.

SLR 2.4 **Development Not Protected by Shoreline Structures:** New development and substantial improvements to existing development located in areas that are not protected from coastal flooding as established by Policy SLR 2.1 shall be designed and constructed to minimize risks to life and property due to flooding. These potentially unprotected structures shall have a finish floor elevation one foot above the following low intermediate model MMMW (NAVD 88) elevation:

Type	Elevation Established by SLR Model Year	RSLR (Feet)	NAVD 88 (Feet)	Structure "Expected Life"	Structure "Expected Life" Applies To These Structure Types
A	2050	0.5	8.6	Less than 25 years	Temporary structures, ancillary development, amenity structures, and other development with an expected life of less than 25 years. Also includes substantial improvements to existing structures.
B	2070	0.9	9.2	25 to 75 years	Permanent commercial, industrial, and other non-critical facilities type projects.
C	2100	2.7	10.4	Greater than 75 years	Permanent residential and critical facilities such as wastewater treatment facilities, arterial roadways, hospitals, power substations, police, and fire stations.

SLR 2.5 **Vulnerability Assessment, Adaptation Plans, and Mapping.** The City's Flood Administrator shall periodically update and amended, as necessary, the sea level rise vulnerability assessment, adaptation plans, and mapping periodically based on the best available science warranting significant adjustments to established projections.

GOAL SLR-3

Utilize the best available science, planning, and engineering to identify and disclose the potential for sea level rise impacts, well in advance, so that we can design and implement adaptation measures to minimize the risk of any actual future hazard.

SLR 3.1 **Safety of New Development.** The City will review projects and establish appropriate standards in the zoning code to:

a. Ensure that risks to life and property are minimized and that new development is safe from and does not contribute to flooding.
b. Assure stability and structural integrity, and neither create nor contribute significantly to erosion, geologic instability, or destruction of the site or surrounding area or in any way require the construction of protective devices that would substantially alter natural landforms along bluffs and cliffs. (NOTE CA Section 30253)

SLR 3.2 **Potential SLR Maps**. Potential Sea Level Rise Map: Sea level rise flooding areas are defined as those areas that have the "potential" to be subject to flooding as modeled utilizing the low intermediate greenhouse gas emissions scenario as determined by the Humboldt Bay: Sea Level Rise Hydrodynamic Modeling, and Inundation Vulnerability Mapping (Northern Hydrology and Engineering 2015) as recommended by the Coastal Commission in their Sea Level Rise Guidance Document 2016. The map shall be reviewed to determine if a proposed development is in an area of potential current or future high coastal flooding. The areas identified on the map are not an indication of a definite hazard on a specific parcel. It is possible that hazards may exist outside of the mapped area. If a specific study indicates that a hazard does not exist on a property that is within the mapped hazard area, development can proceed as if the property were not located within that mapped hazard area. The maps shall be based on the best available science and updated when new information warranting significant adjustments to projections becomes available. (Figure X).

SLR 3.3 **Specific Study Requirement.** For development proposed within a mapped hazard area, the zoning code will identify any specific study requirements that are needed to document any specific construction standards; minimum floor elevations; and to ensure that shoreline development will not create a hazard.

SLR 3.4 **Applicant's Assumption and Disclosure of Risk.** To ensure that future property owners are notified that their property is in a hazard area, development approval for projects located in hazardous areas shall be required to record on title a risk disclosure notice. The zoning code shall establish the minimum required risk disclosures requirements.

GOAL CH 4

Collaborate with other agencies and the public, to develop local and regional strategies to collectively improve our ability to adapt to sea level rise in ways that advance economic prosperity, social equality, and environmental protection.

CH 4 1 **Stakeholder Collaboration.** The City shall actively encourage, lead, and/or participate in collaborative stakeholder group(s) that includes critical asset owners, property owners, shoreline protective structure managers and business owners, regulatory agencies and interested public to develop bay wide, watershed, drainage basin, and project specific multipurpose sea-level rise adaptation strategies and measures.

CH 4.2 **Innovative Solutions.** The City will explore and encourage innovative solutions to reduce peak tidal and storm events thereby reducing the vulnerability and risk from tidal inundation. Potential regional solutions may include by are not limited to:

a. installing hard engineered tidal barriers at the Humboldt Bay entrance, Eureka Slough entrance, and/or between Indian, Woodley, and Daby Islands that allow continued navigation, fish passage, and sediment transport while allowing temporary sea gates, pump stations, and offshore structures to be put in place.
b. constructing soft engineered islands, reefs, marshes, living shorelines or other features which mimic natural process and shoreline protection by filling portions of Humboldt Bay.
c. utilizing oyster shells, navigation channel dredge spoils and other safe local waste material to implement adaptation measures inland, along the shoreline, and within the waters of Humboldt Bay.

CH 4.3 **Education.** The City will work with community partners to educate the community about sea-level rise hazards and property owners, land, and water managers about how to implement best management practices that reduce vulnerability and risk from sea-level rise and flooding hazards.

CH 4.4 **Research and Funding.** The City will encourage state and federal agencies to research and fund sea level rise projections, tidal inundation mapping for Humboldt Bay, and adaptation construction projects.

CH 4.5 **Flexibility in Decision Making Process.** The City will encourage the State Legislature to adopt revisions to the California Coastal Act and other laws which require

the California Coastal Commission and other agencies to implement a flexible approach to approving reasonable sea level rise adaption projects that are based on the best available science, but may not strictly meet every Coastal Act and/or other government regulation.

CH 4.6 **Beach and Dune Nourishment.** The City will encourage the U.S. Army Corps of Engineers and other State and federal agencies to develop and implement a beach nourishment programs to ensure that the region's beaches and dunes remain intact as they are our regions outer front line of defense.

CH 4.7 **North and South Harbor Entrance.** The City will encourage the Humboldt Bay Harbor, Recreation, and Conservation District, U.S. Army Corps of Engineers, and other State and federal agencies to maintain and enhance the North and South Jetty's to ensure that harbors entrance is safe for continued navigation.

CH 4.8 **Cultural Resources.** The City will work with our local tribes to protect the areas cultural resources from the effects of sea level rise and coastal flooding.

III CONCEPTUAL ADAPTION STRATEGIES.

The City could utilize the conceptual adaptation strategies to protect Eureka from the effects of Sea Level Rise. These conceptual strategies are intended to provide decision makers an overview of potential strategies, where the strategy may be appropriate to constructed, as well as the pros and cons of the strategy. It must be made clear that before any strategy could be implemented, a detailed site specific engineering/financial feasibility analysis, CEQA environmental review, public input/comment and permitting process would need to be completed.

The conceptual strategies are purposefully present with rough outlines illustrating where they could potentially be constructed. No engineering was completed nor were any feasibility study or environmental review completed.

These processes to select, design, permit, finance, and construct adaptation measures will take time. Local projects such as the construction of the Eureka Waterfront and Arcata McDaniel Slough levee projects in Arcata took years. One good thing about sea level rise adaptation measures is that we have time to plan, fund and build these measures. All projections indicate that most of Eureka's shoreline will remain protected through at least the 2040-time for the City's Local Coastal Program update.

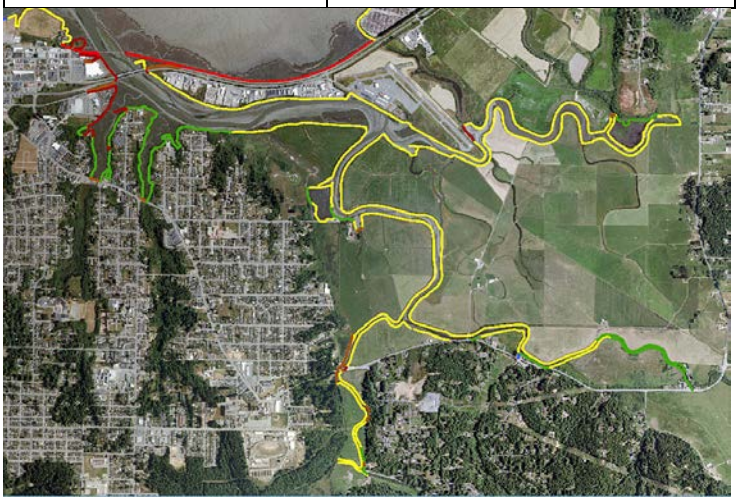
Concept 1. Perimeter Shoreline Levee Protection

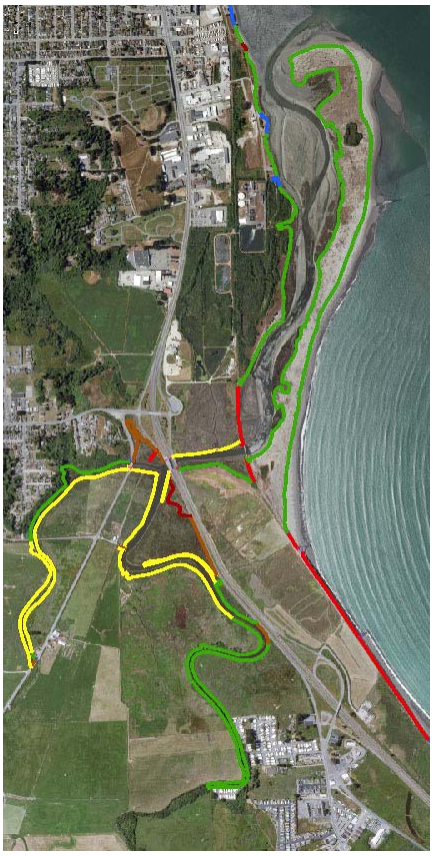
THE CONCEPT: Build, enlarge, or maintain a dike/levee along the existing shoreline.

POTENTIAL LOCATIONS STRATEGY COULD BE APPLIED:

- California Redwood Company on Highway 101
- Fay Slough, Jacobs Avenue and Murray Field levee complex
- Highway 101 Bridge behind Target to Highway 255 Bridge.
- Elk River Slough

PROS	CONS
Comparatively low cost alternative	Visual barrier along the waterfront
Limited space requirements	Piers and docks not protected
Easy to fit in existing infrastructure	Sets area up for a future below sea level
Robust: Limited failure risk	





The illustrations above are from the 2013 Humboldt Bay Shoreline Inventory, Mapping, and Sea Level Rise Vulnerability Assessment. These show the distribution of shoreline structure types on Eureka's shoreline: dike (yellow), natural (green), railroad (red), fill (maroon), fortified (blue), and roadway (brown).

Concept 2. Wide Levee Shoreline (elevate land surface behind levee with fill material)

THE CONCEPT: Create a wide multipurpose levee along the existing shoreline that provides opportunities for integrated development. The wide levee would be designed to accommodate sea level rise, and reduce inundation from storms and storm surge well beyond 2100. The shoreline structure could be a levee, boardwalk, seawall, or other structure. The area behind the shoreline would be a continuous raised landmass along the waterfront that serves as a levee. However, because the levee would be so wide, it would also support opportunities for development on top of the levee, including residential and commercial buildings, and could be integrated into the natural and urban fabric of the existing shoreline. This is not a new concept and in fact since the 1850's much of Eureka's shoreline was created using this method.

POTENTIAL LOCATIONS STRATEGY COULD BE APPLIED:

- Area between the Adorni Center and the raised area near the Blue Ox Mill.
- Waterfront between G to I Streets
- Coastal Dependent Industrial zoned lands from Wharfinger Building to Del Norte Street

PROS	CONS
Fail safe.	Requires large amounts of structurally sound fill material.
Creates opportunities for return on investment for dual functions (development and protection).	Expensive to implement.
New Bayfront development possible.	Need to integrate with existing buildings, roads, and infrastructure.

Concept 3 Maintain Eureka's Boardwalk and Working Waterfront Piers and Docks

THE CONCEPT: Three general adaption measures are to: 1) retrofit piers to either accommodate periodic flooding, modify existing structures to dampen tidal impacts; or raise the surface; 2) rebuild and raise above projected sea level rise elevation; 3) maintain the piers and docks for as long as practical and safe, then remove structure. Eureka's waterfront is an active working waterfront with a vibrant visitor serving commercial core along the shoreline. This shoreline is a mix of existing boardwalk and working piers and docks. To maintain these coastal dependent uses, a resilient pier adaptation strategy will need to be developed.

POTENTIAL LOCATIONS STRATEGY COULD BE APPLIED:

- Between Adorni Center and the Wharfinger building.
- Coastal Dependent Industrial zoned lands from Wharfinger Building to Del Norte Street

PROS	CONS
Working waterfront maintained (fishing, shipping, and tourism).	Expensive to implement.
Public access points maintained.	Need to integrate with existing buildings.
Visitor serving commercial and lodging facilities maintained.	

Concept 4 Elevated Street Behind Shoreline.

THE CONCEPT: Retreat to a street, trail, or other natural or manmade topographic feature as the main line of protection by connecting buildings, roads, and elevated land to create a line of protection. This adaptation concept will embrace how Eureka could be "living with water" by integrating structural and non-structural adaptation measures along the line of defense. Truesdale, Felt Street and Broadway would be the main line of flood protection by connecting buildings, roads, and elevated land to create a line of defense. This approach minimizes the scope and scale of sea level rise impacts - as opposed to entirely suspending them. Some buildings should be retrofitted with materials and uses that could adapt to potential flooding.

POTENTIAL LOCATIONS STRATEGY COULD BE APPLIED:

- Del Norte Felt Streets would be raised.
- Levee behind waste transfer station would be raised and a new levee would be constructed around Palco Marsh protecting Broadway (Hwy 101) and the Bayshore Mall.
- The railroad/waterfront trail from Del Norte to the Elk River could be raised to maintain public access and create an increase layer of protection.

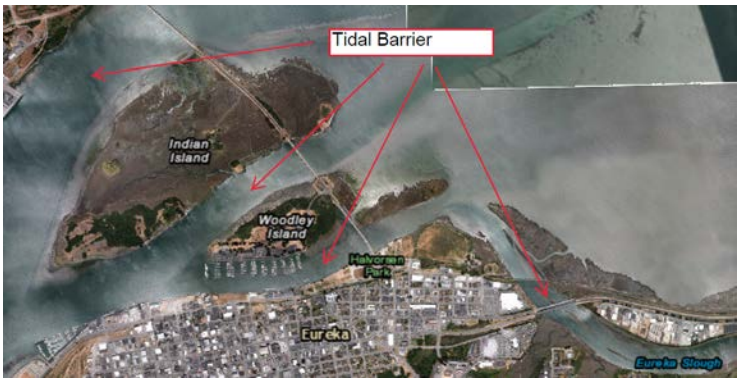
- Concept could also be feasible on Waterfront Drive from C Street to the Wharfinger Building behind the Eureka Marina.

PROS
Palco Marsh natural area retained.
Waterfront trail retained.
Three layers of defense (shoreline, railroad/ Waterfront trail levee, and raised road.)
Complete reconfiguration of uses can be embedded within elevated roadway-barrier.

CONS
Long line of defense.
Need for modification of Bay interior drainage behind Bayshore Mall.
Expensive.

Concept 5. Tidal Control.

THE CONCEPT: Outer layers are typically offshore and are large and expensive engineered systems such as tidal barriers at the mouth of a river, estuary, or bay. Outer layers are designed to keep the water out before it reaches the shore. On Humboldt Bay, such a tidal barrier might be designed similar to what is currently constructed on the Thames River near London. This barrier was originally planned to be closed once a decade. Today, the barrier closes the Thames River several times a year during high tidal events. These barriers are designed to allows navigation to continue, except when the barrier is closed. Failure to close during a high tide coupled with a storm event would likely result in flooding.



POTENTIAL LOCATIONS:

- Eureka Fay Slough
- Between Indian, Woodley, and Daby Island
- Mouth of Humboldt Bay

PROS
Reduced need to increase height of flood protection behind structure.
Tidal flows maintained most of the time.
Channel navigability, sediment transport, and fish migration maintained.

CONS
Expensive to implement.
More frequent closures as sea level rises.
Risk of operational failure.

Concept 6. Living Shoreline and Islands

THE CONCEPT: Create a new salt marsh in the Bay. The new salt marsh would be over the existing mudflats that are immediately adjacent to the shore. The new salt marsh would be fortified with logs and artificial reef on the outer edge and interior marsh. The artificial reef could be constructed with oyster shells or other natural materials. Dredge fill material would be deposited to elevate the existing mudflat to support salt marsh vegetation. The existing island that forms the mouth of the Elk River could also be fortified and raised with similar materials.

POTENTIAL LOCATIONS:

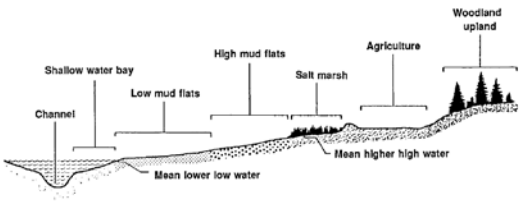
- Between Del Norte Street and Elk River Slough
- Potentially anywhere along the shoreline where there are existing mudflats

PROS:

- New habitat areas ecological transition zone.
- Public/private partnerships could potentially fund project.
- Piers could be protected.
- Failure risk low.
- Reduces storm wave run-up impacts.
- Tsumani protection

CONS:

- Permitting highly uncertain.
- Filling the Bay required.



Concept 7. New Waterfront or Islands

THE CONCEPT: Create a landmass in the Bay outboard and parallel to the existing shoreline, to be used for new habitat, recreation, development, and recreation. Much of Eureka's waterfront, along with many working waterfronts throughout the world were created through this method.

POTENTIAL LOCATIONS:

- Potentially anywhere along the shoreline.

PROS:

- New habitat areas ecological transition zone.
- Public/private partnerships could potentially fund project.
- New development opportunities.
- Piers could be protected.
- Failure risk low.
- Reduces storm wave run-up impacts.

CONS:

- Permitting highly uncertain.
- Expensive.
- Filling the Bay required.

IV COASTAL COMMISSION SEA LEVEL RISE POLICY GUIDANCE.

The Coastal Act does not specify either a "100-year protection level or establish a 2100-year threshold for sea level rise protection. The level of risk for flooding is established in the Coastal Act Section 30253. Minimization of adverse impacts. Section 20253 specifies that new development shall: "(a) Minimize risks to life and property in areas of high geologic, flood, and fire hazard.". The Coastal Commission's Sea Level Rise Guidance document states that the guidance is advisory and not a regulatory document or legal standard of review for the actions that the Commission or local governments must take under the Coastal Act."

The Guidance Document goes on to states that the "best available science" for establishing sea level rise projections is the 2012 NRC report and recommends that adaptation measures and policies should minimize risks throughout the "expected life" of the development. Pages 50 and 51 of the Coastal Commission's Sea Level Rise Guidance document recommends that jurisdictions:

- *"…identify a range of sea level rise scenarios including the high projection, low projection, and one or more intermediate projections".*
- *"For a Local Coastal Program (LCP), the general goal is to assess the potential impacts from sea level rise over the entire planning area and over a range of time horizons so that both short and long term adaptation strategies can be identified and implemented."*
- *"In practice, the process for choosing scenarios and performing scenario-based analysis will be slightly different for LCP planning and CDP applications due to the different planning goals and levels of technical detail required for each."*
- *"Similar to the recommendation in the OPC's 2011 State Sea-Level Rise Resolution, the Commission does not recommend using values solely in the lower third of the NRC's projections as this does not give a full picture of the risks. Looking instead at both the high and low projections allows users to build an understanding of the overall risk sea level rise poses to the region or site."*
- *"By exploring the range of future scenarios based on the best available science, users of this document can make decisions based on full understanding of possible future hazards, ultimately achieve outcomes that are safer for both development and coastal resources, and avoid costly damages to projects."*

Once the range of future sea level rise scenarios has been developed and different adaptation measures analyzed, the next step will be to take a broader perspective and develop goals policies to be amended into the City's Local Coastal Program. The City's Local Coastal Program is essentially the ground rules for regulating future development and protecting coastal resources. The Local Coastal Plan consists of a Land Use Plan which contains policies and an Implementation Plan which is essentially the zoning regulations within the coastal portion of the City. The City's Local Coastal Program requires certification by the Coastal Commission and must be consistent with the Coastal Act.

When developing goals, and polices which require certification from the Coastal Commission, it may be helpful to understand what the criteria the Commission will utilize to evaluate the City's proposed new policies and regulations.

Section 30512.2 Land use plan; criteria for decision to certify or refuse certification

The following provisions shall apply to the commission's decision to certify or refuse certification of a land use plan pursuant to Section 30512:

(a) The commission's review of a land use plan shall be limited to its administrative determination that the land use plan submitted by the local government does, or does not, conform with the requirements of Chapter 3 (commencing with Section 30200). In making this review, the commission is not authorized by any provision of this division to diminish or abridge the authority of a local government to adopt and establish, by ordinance, the precise content of its land use plan.

(b) The commission shall require conformance with the policies and requirements of Chapter 3 (commencing with Section 30200) ***only to the extent necessary to achieve the basic state goals specified in Section 30001.5.*** *(emphasis added)*

Section 30001.5 Legislative findings and declarations; goals

The Legislature further finds and declares that the basic goals of the state for the coastal zone are to:

(a) Protect, maintain, and where feasible, enhance and restore the overall quality of the coastal zone environment and its natural and artificial resources.

(b) Assure orderly, balanced utilization and conservation of coastal zone resources taking into account the social and economic needs of the people of the state.

(c) Maximize public access to and along the coast and maximize public recreational opportunities in the coastal zone consistent with sound resources conservation principles and constitutionally protected rights of private property owners.

(d) Assure priority for coastal-dependent and coastal-related development over other development on the coast.

Establishing goals and policies are a balancing act and the Coastal Act is not one dimensional. The protecting natural resources goal in Section 30005.1(a) must met along with the social and economic needs of the people of the state (30005.1(b); public access and recreation (30005.1(c); and coastal-dependent and coastal-related development (3005.1(d).

The legislature also found in Section 30001 (d): *"That existing developed uses, and future developments that are carefully planned and developed consistent with the policies of this division, are essential to the economic and social well-being of the people of this state and especially to working persons employed within the coastal zone."* Policies that protect the protect coastal access, commercial fishing, recreational boating, coastal dependent industries, visitor serving facilities, and the economic and social well-being of the people of Eureka are crucial to the core identity of Eureka.

V. SEA LEVEL RISE SCIENCE:

The Coastal Commission's guidance, as well as common planning practices, dictate that the policies surrounding sea level rise be made after considering the best available science. The City's adaptation planning efforts have utilized the best available science as recommended. To develop regional solutions to adapt to sea level rise, the Humboldt Bay Sea Level Rise Adaptation Planning Working Group (APWG) was formed by the Humboldt Bay Harbor, Conservation, and Recreation District and Humboldt County Public Works Department. The City of Eureka was an active member.

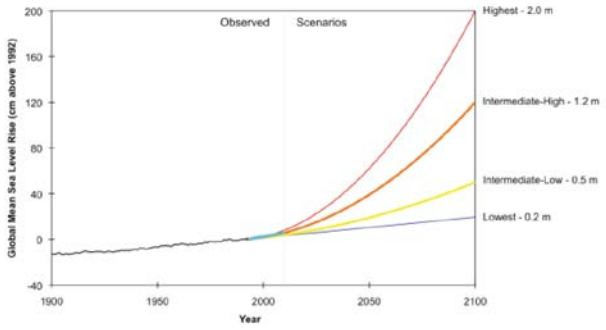
The APWG commissioned Northern Hydrology and Engineering (NHE) and Trinity Associates to develop the science utilized to determine sea level rise vulnerabilities in Humboldt Bay. As part of these efforts the following work products were completed:

1. Laird, Aldaron, Brian Powell. 2013. Humboldt Bay sea level rise adaptation planning project: Phase II report. Humboldt Bay shoreline inventory, mapping, and sea level rise vulnerability assessment, with an Addendum: Shoreline Vulnerability Ratings.
2. Laird, Aldaron. 2015. Humboldt Bay sea level rise adaptation planning project: Phase II report.
3. Laird, Aldaron. 2016. City of Eureka Sea Level Rise Assets Vulnerability and Risk Assessment.
4. Northern Hydrology and Engineering. 2014a. Estimates of local or relative sea level rise for Humboldt Bay region.
5. Northern Hydrology and Engineering. 2015. Humboldt Bay Sea Level Rise Hydrodynamic Modeling and Inundation Vulnerability Mapping.
6. Pacific Watershed Associates. 2014. A seamless topographic/bathymetric digital elevation model (DEM) of Humboldt Bay using the recent 2009-2011 California Coastal Conservancy LiDAR Project Hydro-flattened Bare Earth DEM (California Coastal DEM) and various subtidal bathymetric data sets to support the modeling efforts.
7. Dr. Robert Willis. 2014. A conceptual groundwater model to analyze the effects of SLR on groundwater levels and saltwater intrusion in the Eureka-Arcata coastal plain.

The science and planning efforts made by APWG were recognized by the Coastal Commission in the Commissions Sea Level Rise document when they specified that:

> *Humboldt Bay has not experienced the regional uplift that characterizes most of the coast north of Cape Mendocino, and instead has shown the highest subsidence recorded for the California coast. As a result, the projections for north of Cape Mendocino may not be appropriate for use in or near Humboldt Bay and the Eel River Estuary. Please see Humboldt Bay: Sea Level Rise Hydrodynamic Modeling, and Inundation Vulnerability Mapping (Northern Hydrology and Engineering 2015) for additional information on sea level rise projections for the Humboldt Bay region.*

Both the NHE 2015 sea level rise projections and the Coastal Commission recommended projections in their Guidance Document are based on the 2012 NRC report. Table 3 and Figure 5 from the Commission's Guidance document outlined a range of four global sea level rise scenarios. Per page 35 of the NHE 2015 report: *"The Highest Scenario of GMSL rise was based on the Pfeffer et al. (2008) estimate of maximum possible glacier and ice sheet loss by 2100, and should be used when there is little tolerance for risk. The Intermediate-High Scenario was based on the average of the upper end of semi-empirical model projections, and the Intermediate-Low Scenario was based on the upper end of the 2007 IPCC AR4 projections. The Lowest Scenario was based on a linear extrapolation of the 20th century GMSL rate of ~1.7 mm/yr. Given the range of GMSL rise projections used in developing the scenarios, the authors concluded that they have very high confidence (>9 in 10 chance) that GMSL will rise at least 20 cm and no more than 200 cm by 2100 (Parris et al., 2012)."*



Source: Figure 5 from SLR Guidance Document (NOTE 20 CM = 7.9 inches and 200 cm = 78.7 inches)

TIME PERIOD*	NORTH OF CAPE MENDOCINO[19]	SOUTH OF CAPE MENDOCINO	
by 2030	-2 – 9 in (-4 – +23 cm)	2 – 12 in (4 – 30 cm)	
by 2050	-1 – 19 in (-3 – + 48 cm)	5 – 24 in (12 – 61 cm)	
by 2100	4 – 56 in (10 – 143 cm)	17 – 66 in (42 – 167 cm)	

*with Year 2000 as a baseline

Source: Table 3 from SLR Guidance Document

To come up with a Humboldt Bay projections, the 2015 NHE Report took the mid-point in the NRC 2012 projected range and removed the upward vertical land motion assumption of 1 mm/yr from the 2012 NRC projection and replaced the value with the -2.33 mm/yr vertical land motion which Humboldt Bay is experiencing.

Like the San Francisco's 2016 Sea Level Rise Action Plan, and several other jurisdictions, the 2015 NHE report selected the midpoint as this represents the most *likely* projections for a moderate level of global greenhouse gas (GHG) emissions and continued accelerating land ice melt patterns. The "high" range estimates represent *unlikely, but possible* levels of sea level rise using very high greenhouse gas emissions scenarios with significant land ice melt.

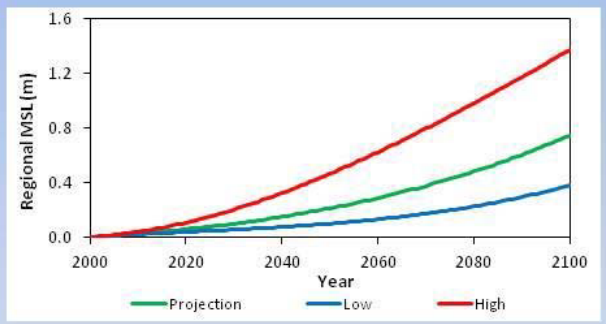
Based on Humboldt Bay's North Spit tide gage, relative sea level rise (i.e., the combination of regional sea level rise rates and local vertical land motion rates) was estimated to be approximately 7 inches by 2030, 13 inches by 2050, 22 inches by 2070 and 39 inches by 2100.

Sea-Level Rise Projections for Humboldt Bay Region

Sea-Level Rise Projections Based on National Research Council (2012) Study

Regional mean sea-level rise (ReSLR) projections for different scenarios in Humboldt Bay Region without vertical land motion effect

	ReSLR Projections Relative to Year 2000 (cm (in))		
Year	Low	Projection	High
2030	3.9 (1.5)	9.9 (3.9)	21.3 (8.4)
2050	10.9 (4.3)	21.4 (8.4)	46.2 (18.2)
2100	38.6 (15.2)	75.1 (29.6)	137.9 (54.3)



Relative mean sea level rise (RSLR) projections for different scenarios in Humboldt Bay with vertical land motion effect (VLM at North Spit gage = -2.30 mm yr^{-1} downward)

	RSLR Projections Relative to Year 2000 (cm (in))		
Year	Low	Projection	High
2030	12.5 (4.9)	16.8 (6.6)	27.3 (10.7)
2050	21.4 (8.4)	32.8 (12.9)	58.1 (22.9)
2100	61.2 (24.1)	97.7 (38.5)	160.4 (63.2)

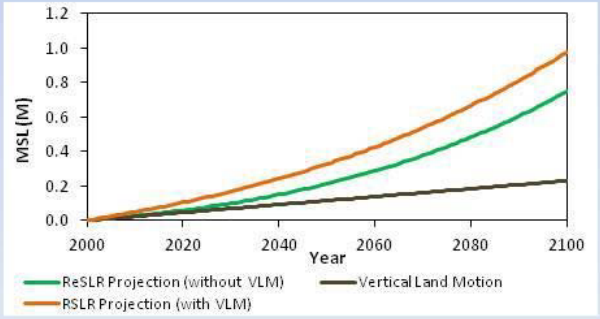


Figure 1. Regional and relative sea level rise projections for Humboldt Bay (NHE 2013).

The City of Eureka, its consultants and regional partners have done a great deal of research and have analyzed many scenarios over the last few years to determine the potential impacts associated with sea level rise. Because there is a significant range in sea level rise projections for 2050 (8.4 to 22.9 inches) and 2100 (24.1 to 63.2 inches), there will be uncertainty regarding the use of any projections for sea level rise 84 years into the future. This is especially true since these time horizons are well beyond the 2040 term of the City's proposed Local Coastal Program amendments.

After all the analysis is completed and science has presented their conclusions, it is always a good practice for decision makers to take a good step or two back from the nuances best available science, and organizational "agenda's" and opinions. Scientist, planners, boards, and commissions often get so far "into the weeds" that they overlook the social and economic needs of the community.

VI SEA LEVEL RISE ADAPTAION APPROACH:

The impacts associated with sea level rise generally include erosion, inundation, flooding, wave impacts, and saltwater intrusion. Adaptation planning in the original Sea Level Rise Adaptation Report was analyzed using three different approaches: assets, planning horizons/ water elevations, and specific geographic areas of the City most likely to be affected by sea level rise. The inundation mapping in the reports was not based on the NHE 2015 projection number, but instead was based on a 0.5, 1.0, 1.5, and 2.0-meter water sea level rise increase.

It is important to note that all mapping in the report assumes a "bathtub" model. The "bathtub' model assumes that there are no existing dikes, levees, tide gates or other adaptation measures currently protecting Eureka shoreline and that no adaptation measures or actions will be implemented in the future. In other words, the maps do not reflect the actual current conditions. The "bathtub" model assumes that not only will the City not take any additional action to protect the areas, it also assumes, that the existing adaptation measure currently in place will not be maintained and they fail.

This addendum builds upon the work of developing the three approaches in the original report as well as the Coastal Commissions Guidance document and takes a hybrid approach of simply looking at assets that are of such high value that the Coastal Act and common sense mandates that the City take every effort to protect them. The logic is that if you are going to protect these valuable assets, what other assets will automatically, and by default, receive some level of protected behind them.

The Coastal Act has several sections that focus on protecting coastal access, commercial fishing, recreational boating, coastal dependent industries, visitor serving facilities, and the social and economic vitality of a community. There is a big difference between developing sea level rise adaption measure for Eureka's urban waterfront and adaptation measures for undeveloped portion of the coast such as Clam Beach, Table Bluff, and the mouths of the Klamath, Mad, and Eel Rivers.

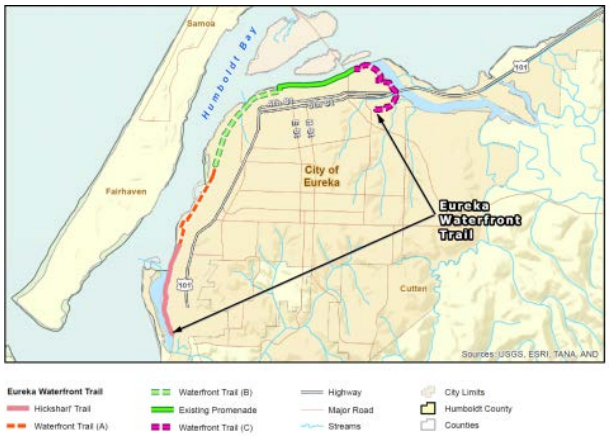
The following are the specific Coastal Act requirements and the assets which the Act specifies what you can and shall protect.

Coastal Act Section 30210 Access; recreational opportunities; posting: *In carrying out the requirement of Section 4 of Article X of the California Constitution, maximum access, which shall be conspicuously posted, and recreational opportunities shall be provided for all the people consistent with public safety needs and the need to protect public rights, rights of private property owners, and natural resource areas from overuse.*

Protected Assets:

1. The Coastal Zone Access points identified in Table 5-2 of the Eureka General Plan.
2. Waterfront Trail:

a. Section A: Hikshari' Trail running from Elk River to Truesdale St., runs behind the Bayshore Mall and along Humboldt Bay to the foot of Del Norte St., landing right at the Del Norte St. Fishing Pier.



b. Section B: Waterfront Drive Trail running directly adjacent to Railroad Ave. and Waterfront Dr., this portion of the Waterfront Trail begins at Del Norte St. and ends at the foot of C St., and

c. Section C: Boardwalk Trail running from C Street along the south shore of Humboldt Bay under Highway 255 and then follows the south side of the Eureka Slough, passing underneath the bridge decks of Highway 101, providing the only alternative route in the City for pedestrians and non-motorized vehicles to cross US 101 without having to physically attempt to cross through traffic**,** eventually ending at Tydd St.

Coastal Act Section 30234: Commercial fishing and recreational boating facilities: *Facilities serving the commercial fishing and recreational boating industries shall be protected and, where feasible, upgraded. Existing commercial fishing and recreational boating harbor space shall not be reduced unless the demand for those facilities no longer exists or adequate substitute space has been provided. Proposed recreational boating facilities shall, where feasible, be designed and located in such a fashion as not to interfere with the needs of the commercial fishing industry.*

Coastal Act Section 30220. Protection of certain water-oriented activities*: Coastal areas suited for water-oriented recreational activities that cannot readily be provided at inland water areas shall be protected for such uses.*

Coastal Act Section 30703. Protection of commercial fishing harbor space: *The California commercial fishing industry is important to the State of California; therefore, ports shall not eliminate or reduce existing commercial fishing harbor space, unless the demand for commercial fishing facilities no longer exists or adequate alternative space has been provided. Proposed recreational boating facilities within port areas shall, to the extent it is feasible to do so, be designed and located in such a fashion as not to interfere with the needs of the commercial fishing industry. (Section 30703).*

Protected Assets:

1. Marina
   a. Woodley Island Marina
   b. Eureka Public Marina

2. Docks
    a. Humboldt Bay Rowing Association Dock (Samoa Bridge)
    b. Bonnie Gool Dock (Adorni Center)
    c. F Street Dock (Boardwalk)
    d. Coast Guard Dock (Commercial Street)
3. Boat Ramps
    a. Samoa Bridge Boat Ramp (under Highway 255)
    b. Eureka Public Marina (500 W Waterfront Drive)

Coastal Act Section 30255 Priority of coastal-dependent developments: *Coastal-dependent developments shall have priority over other developments on or near the shoreline. Except as provided elsewhere in this division, coastal-dependent developments shall not be sited in a wetland. When appropriate, coastal-related developments should be accommodated within reasonable proximity to the coastal-dependent uses they support.*

Coastal Act Section 30235 Construction altering natural shoreline: *Revetments, breakwaters, groins, harbor channels, seawalls, cliff retaining walls, and other such construction that alters natural shoreline processes shall be permitted when required to serve coastal dependent uses or to protect existing structures or public beaches in danger from erosion, and when designed to eliminate or mitigate adverse impacts on local shoreline sand supply. Existing marine structures causing water stagnation contributing to pollution problems and fish kills should be phased out or upgraded where feasible.*

Protected Assets:
1. Coastal Dependent Industrial Uses.
2. Waterfront Commercial Uses.
3. Existing Structures.

Coastal Act Section 30240. Environmentally sensitive habitat areas; adjacent developments: *(a) Environmentally sensitive habitat areas shall be protected against any significant disruption of habitat values, and only uses dependent on those resources shall be allowed within those areas.*

Protected Assets:
1. Environmentally sensitive habitat areas.

Coastal Act Section 30242 Lands suitable for agricultural use; conversion: *All other lands suitable for agricultural use shall not be converted to nonagricultural uses unless (l) continued or renewed agricultural use is not feasible, or (2) such conversion would preserve prime agricultural land or concentrate development consistent with Section 30250. Any such permitted conversion shall be compatible with continued agricultural use on surrounding lands.*

Protected Assets:
1. Agricultural Lands until they are no longer economically viable.

Section 30244 of the Coastal Act (Archaeological or paleontological resources)*.*
Where development would adversely impact archaeological or paleontological resources as identified by the State Historic Preservation Officer, reasonable mitigation measures shall be required.

Protected Assets:
1. Cultural, archaeological, or paleontological resources.

General Common Sense Protection:

Protected Assets:
1. Wastewater Treatment Plant and associated facilities.
2. Highway 101 North of the Eureka Slough Bridge to Arcata
3. Highway 101 South from Broadway to Fortuna.
4. Other Critical Infrastructure

The adaptation strategies outline in this addendum assume that the Coastal Act and general common sense dictates that the assets listed above will be protected until the magnitude of Sea Level Rise change is such that the protection management strategy can no longer protect the asset. Once the tipping point is reached it does not mean that the asset will be abandoned or that the City will retreat. Rather, it requires that alternative strategies be considered and implemented.

VII LEVEL OF PROTECTION (TOLERANCE):

When developing an adaptation strategy, a primary starting point is "what level of protection" is appropriate, or, "how safe is safe enough" "and how high should it be?" Historically, emphasis in the United States has been on achieving a "100-year" level of protection. However, this was a standard for the National Flood Insurance Program and was not developed for safety or for what level of flooding and impacts would be considered tolerable. Rather, it was selected as the minimum threshold by which one not need to purchase federal flood insurance. "how safe is safe enough" needs to be made by the community and its stakeholders based on what frequency and impacts of flooding they consider tolerable.

The Guidance Document recommends that adaptation measures and policies should minimize risks throughout the "expected life" of the development. The local jurisdiction has the discretion to establish reasonable "expected life" timeframes. The Guidance Document gives examples of "expected life" timeframes of:

1. 25 years or less for temporary structures, ancillary development, amenity structures, or moveable or expendable construction;
2. 75 to 100 years for residential or commercial structures;

3. over 100 years for critical facilities such as infrastructure, bridges, or industrial facilities and
4. perpetuity for conservation or restoration projects.

Although, the SLR modeling utilizes the 2050 and 2100 thresholds, the Commission will likely require projects to documents that they "minimize risks to life and property" for a specific timeframe such as 25, 50, or 100 years from the date of approval. This will mean that the projected sea level rise elevations utilized to permit projects will need to be continually be revised throughout the life of the Local Coastal Plan. This also means that the City should consider carefully drafting policies and standards so that individual development projects are not overly burdened with preparing complicated and expensive sea level rise projections for each individual project.

VIII COASTAL HAZARDS:

Coastal hazards associated with sea level rise come in a variety of types. The magnitude and frequency of these events will likely increase over time unless adaptation measures are implemented.

1. Daily tidal inundation. As sea level rises, the elevation of average daily high tides will continue to increase. It is anticipated that the mean high higher water (MHHW) will increase from the current 6.7 feet to 7.3 feet in 2030, 7.8 feet in 2050 and to 10 feet in 2100.
2. 100-year Storm Event with King Tides. Eureka's shoreline experience daily tides, King Tides, and temporary "extreme" tides. Temporary "extreme" tides are thought to be the result of higher periodic water elevations of coastal waters, caused by storms, El Niño, or other factors. If these "extreme" tidal events happen concurrently with both King Tides and 100-year storm events water elevations can be up to 3 feet higher than the MHHW tidal events. As overall climate change continues and sea levels rise, the frequency and intensity of storms temporary coastal flooding will likely also increase. Coastal flooding is the result of ocean water (saltwater) inundation. If adaptation measures are not implemented, future coastal flooding issues may include damaged infrastructure, impacted sewage system, and road closures.
3. Urban flooding. Unlike coastal flooding, rainfall runoff causes urban flooding. When the Bay waters are high enough, streams and storm water infrastructure backs up and urban freshwater flooding occurs.
4. Shoreline erosion. Shoreline areas are susceptible to increased erosion associated with extreme tides and increased wave action. Without protective action, rising seas will increase erosion hazards. A clear consensus has not fully emerged regarding climate changes, but a commonly identified trend is a tendency toward increased wind speed and wave height along northern California. This may increase both erosion rates and extreme tide frequency within the Bay.

IX GUIDING PRINCIPALS FOR CONSIDERING ADAPTATION STRATEGIES:

1. Consider all options: even if they are expensive, difficult to permit, and not yet tried in other places.
2. Develop site specific solutions instead of a one size fits all approach.
3. Always remember that water can come in from all sides including up (rain) and down (groundwater).
4. Utilize multipurpose solutions that integrate flood protection into urban design that result in an attractive and economically viable city.
5. Where ever practical, incorporate natural and habitat development into urban waterfront protection design.

X SEA LEVEL RISE MAPPING:

As previously discussed, the mapping done previously projected a sea level rise elevation of 0.5, 1.0, 1.5, and 2 meters. Planners then utilized the mapped elevation that most closely matched the "projected" sea level rise elevation to represent sea level inundation. As an example, if sea level was "projected" to 1.1 feet by 2100, planners would use the 0.5-meter map. The "bathtub' is useful for planners and the community to get a general idea of inundation. However, in practice this method has several important flaws such as:

1. 0.5 meters equals 1.64 feet not the 1.1 feet of actual projected sea level rise.
2. The model assumes that there are no existing dikes, levees, tide gates or other adaptation measures currently protecting Eureka shoreline.
3. The model assumes that none of the adaptation measures will be implemented in the future.

The areas of the City that are vulnerable and at-risk from sea level rise by 2050, 2070 and 2100 are presented in the Potential Sea Level Rise map (PSLR). For long-range planning, environmental review and project approvals, this report recommends that decision makers establish four SLRHZ elevations. Decision makers would select an elevation in the range between the NRC intermediate low projection and the NHE 2015 projection. If the NHE 2015 projection were selected, Type "A" would reflect 1.1 feet of SLR for the year 2050. Type "A" would map the 2050 Mean Monthly Maximum Water (MMMW) elevation at 8.8 feet (NAVD 88) and is intended to be used for projects such as temporary structures, ancillary development, amenity structures, and other development with an expected life of less than 35 years. Type "B" would utilize the 2070 projection of 1.8 feet (9.5 feet NAVD 88). Type "B" is intended for permanent commercial, industrial, and other non-critical facilities type projects.

Type "C" would utilize the 2100 "High" projection of 3.3 feet MMMW (11.0 feet NAVD 88). Type "C" is intended to be used for permanent residential structures and critical facilities such as wastewater treatment facilities, arterial roadways, police, and fire stations. Type "D" would utilize the 2100 - 100-year storm event projection of 3.3 feet (13.1 NAVD 88). Type "D" is intended to be used for shoreline structures such as dikes, levees, sea walls, boardwalks, and

other features that are located on the immediate shoreline and intended to protect inland areas.

Type	Elevation Established by SLR Model Year	RSLR (Feet)	NAVD 88 (Feet)	Structure "Expected Life"	Structure "Expected Life" Applies to These Structure Types
A	2050	0.5	8.6	Less than 35 years	Temporary structures, ancillary development, amenity structures, and other development with an expected life of less than 35 years.
B	2070	0.9	9.2	35 to 75 years	Permanent commercial, industrial, and other non-critical facilities type projects.
C	2100	2.7	10.4	Greater than 75 years	Permanent residential and critical facilities such as wastewater treatment facilities, arterial roadways, hospitals, power substations, police, and fire stations.

XI ADAPTATION: MULTIPLE LAYERS AND MULTIPLE LINES OF DEFENSE:

Once it is determined what will be protected, for how long, and what elevation the water is projected to rise; the next key questions is where to put the line of defense? To put this another way, what will we allowed to be flooded and what not? Does the City want the protection to be along the existing shoreline, out into the bay, or pulled back from the current shoreline? Flood risk protection measures generally happens through an approach that utilizes not one but multiple lines of defense. These multiple layers of defense are coordinated into integrated solutions where each measure contributes to reduce overall flood risk. In general, coastal adaptation measures are classified as either Inner, middle, and outer layers.

Outer layers are typically offshore and are large and expensive engineered systems such as tidal barriers at the mouth of a river, estuary, or bay. Outer layers are designed to keep the water out before it reaches the shore. On Humboldt Bay, such a tidal barrier might be designed similar to what is currently constructed on the Thames River near London. This barrier was originally planned to be closed once a decade. Today, the barrier closes the Thames River several times a year during high tidal events. These barriers are designed to allows navigation to continue, except when the barrier is closed. If such a barrier was constructed, it could potentially be located between the north and south jetties of Humboldt Bay; between Woodley, Indian and Daby Islands or at the entrance to Faye Slough.

Middle layers are what most people think about when they imagine coastal protection solutions. These solutions typically include levees, seawalls, boardwalks, piers, strands, marshes, and estuaries as they are located right at the interface between the bay waters and the shoreline. The levees behind Jacobs Ave, Eureka Boardwalk, and the railroad levee along Highway 101 are local examples of these middle structures.

Inner solutions may include watershed protection, stream and estuary restoration, storm drains, pumps, and detention basins. Basically, anything that is behind the immediate shoreline is considered an inner solution. It should be noted that no matter what layer we are discussing; these lines of defense should tie into either higher existing land or be continued to avoid "back-door" flooding.

As was stated in the Guiding Principles section: always remember that water can come in from all sides including up (rain) and down (groundwater). High tides create backwater flooding that can get trapped behind levees and other shoreline structures. Storm water management is a critical element of sea level rise adaption.

Groundwater infiltration must also be closely considered. This will be most evident in the low-lying areas and especially in the former tidelands. As sea levels rise there is increased pressures from groundwater. This pressure comes in several forms, and includes but are not limited to:

1. saltwater intrusion into freshwater supplies;
2. higher groundwater tables;
3. inflow and infiltration of water into the wastewater collection system and other critical infrastructure; and
4. structural competency issues for building construction.

The first area to be significantly impacted by groundwater infiltration will likely be the low lying agricultural lands on the north and south entrances to the City. Groundwater tables will likely rise to the point that they no longer support the growth of grasses suitable for grazing. Adaptation measures can delay the groundwater intrusion. However, if sea levels continue to rise and the lands continue to sink, these areas will likely eventually convert to wetlands at some point in the future. For how long and at what cost will the community and property owners continue to protect those resources is unknown?

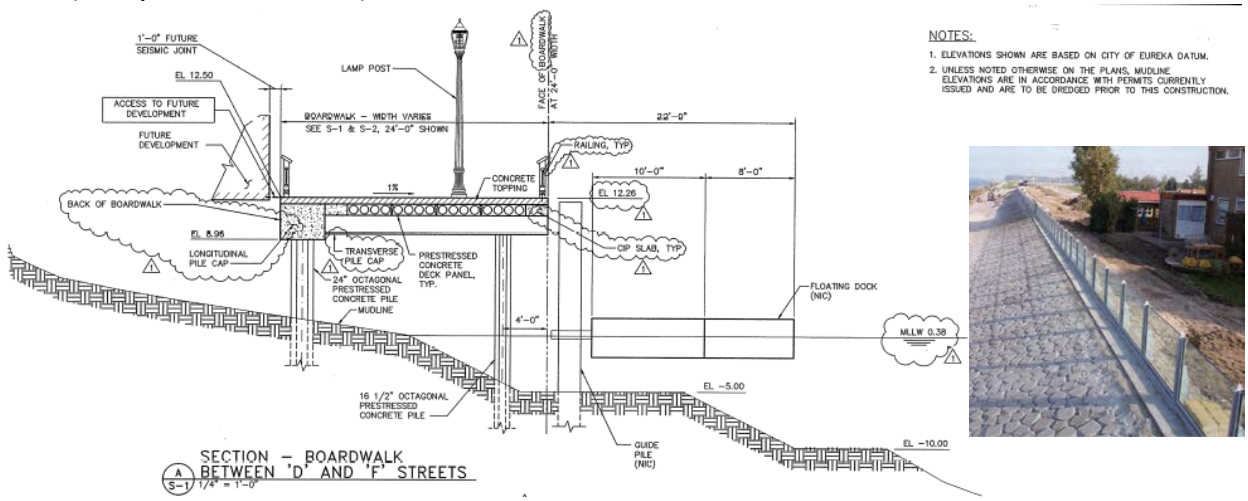
XII ADAPTATION GOALS:

The City's overall goal is to protect all lands currently zoned for urban growth until the magnitude of Sea Level Rise change is such that the protection management strategy can no longer protect all the lands zoned for urban growth. Once this "adaptive tipping point" is reached, an alternative adaption strategy will be needed. The concept of "adaptation tipping points", has been utilized in the Netherlands and other areas for years. Expressing uncertainty

in terms of the period that the existing strategy is effective (when will a critical point be reached) was found to be useful for the policy makers.

Per the Article Using adaptation tipping points to prepare for climate change and sea level rise, a case study for in the Netherlands: "An ATP analysis starts from the perspective that a water system provides the natural boundary conditions for living and working in this region, summarized as the boundary conditions for socio-economic activities. The system needs to be managed to maintain the proper conditions and achieve our objectives for living in the delta."

The adaptation tipping point approach could be useful for Eureka and the region to consider. An example, of this approach is the Eureka Boardwalk between D and F Streets. This section was designed with the top of the concrete at the end of the Boardwalk at an elevation of 12 feet 4 inches with the top of the railing approximately an additional 3 feet 8 inches. If at some point in the distant future the railing will be converted from bars to a heavy duty solid barrier designed to withstand wave run-up, the Boardwalk at this location would have 16 feet of protection. The adaptation tipping point method would tell you that this location on the Boardwalk with relatively small improvements could protect beyond the projected 13.1 feet 2100 (100-year storm event).



Glass or acrylic over-topping walls provide strong and safe resistance to periodic stormwater surges while avoiding view disruption.
Source: SF Mission Creek Adaptation Study

XIII Eureka's Shoreline:

As with almost all other coastal cities, Eureka, and the property owners along the bay, have a great deal of experience with managing the regular threat of coastal flooding and the regular the constant pounding shoreline structures take with every rising tide. Although we have not historically called them "Sea Level Rise Adaptation Measures", almost all of Eureka's shoreline is composed of man-made structures which have effectively "held back" and protected the City from the approximately eighteen inches of sea level rise which has already occurred over the last century. The City will need to continue to maintain existing, replace decaying, and construct new and improved adaptation measures over the next century to remain protected.

The type and condition of man-made shoreline is important when evaluating an area's vulnerability to erosion and future sea level rise. In January, 2013, Trinity Associates published the Humboldt Bay Sea Level Rise Adaptation Planning Project: Phase 1 Shoreline Inventory, Mapping, and Vulnerability Assessment. The 2013 Report was prepared to:

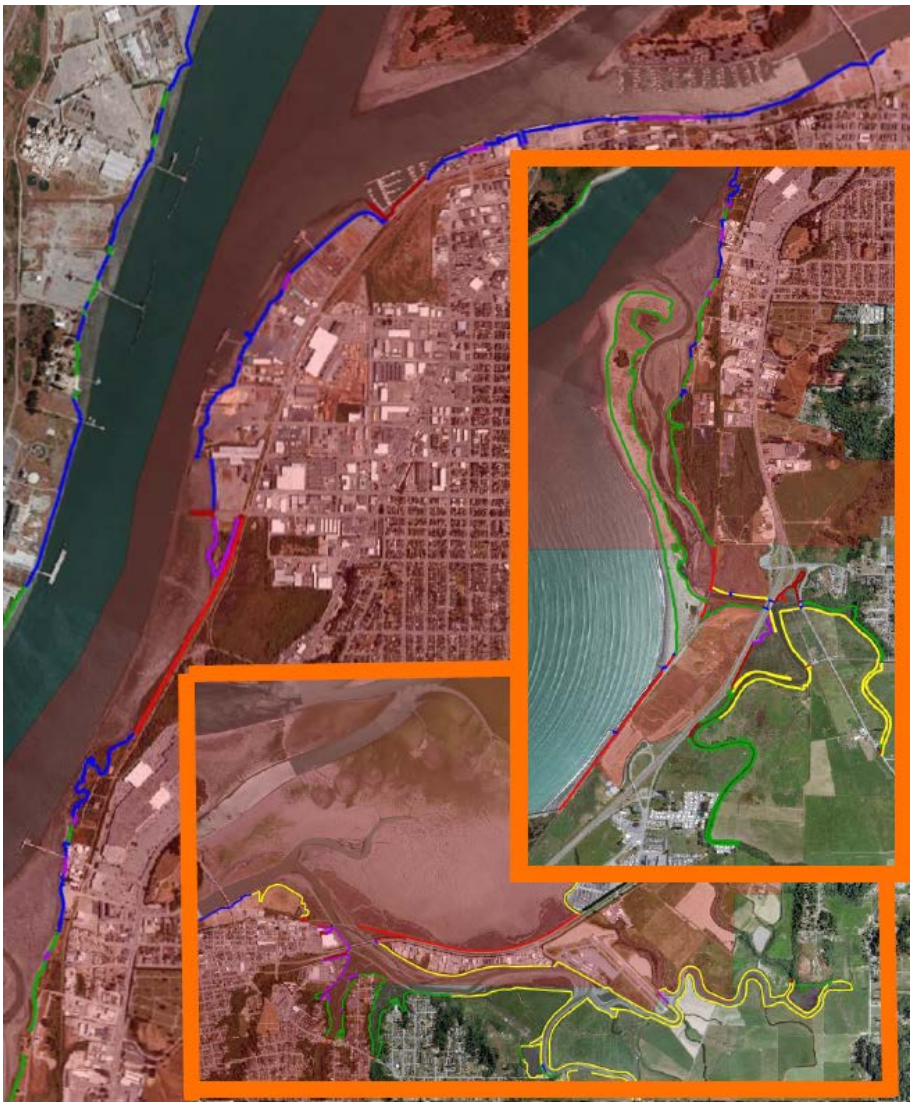
- Inventory and map existing shoreline conditions on Humboldt Bay;
- Assess existing shoreline vulnerability to breaching or overtopping, under current tidal and climatic conditions;
- Assess existing shoreline vulnerability to sea level rise; and
- Identify land uses and infrastructure that could be affected if the existing shoreline fails to retain the tides.

The 2013 Report provides the most detailed and current assessment available of the natural and man-made shoreline of Humboldt Bay, including those sections within the Eureka LCP Area. As such, the Eureka Local Coastal Plan Update is expected to rely extensively on the findings of the 2013 Report to establish appropriate policies and programs.

Man-made shoreline cover was categorized as either fortified or unfortified. Fortified shorelines consist of revetments or rip rap made of rock or concrete, or bulwarks of wood and steel. Unfortified shorelines include earthen levees that were either vegetated or exposed are more prone to erosion and failure. A substantial portion of the man-mad structures along Eureka's shoreline have not been properly maintained and the Report documents that sever erosion and failure have occurred.

The report states that: "The shoreline of Eureka Bay is 15.9 miles long and 71% of the shoreline is composed of artificial structures, but only 6% of the artificial shoreline is exposed (3,587 feet) (Figure 76). The two dominant artificial shoreline structures are fortified shoreline segments (49%, 29,657 feet) and the NCRA's railroad grade (15%, 8,794 feet). Other types of artificial shorelines are fill (10%), bulwarks (6 %), and roadways (6%). The railroad grade is mostly fortified (66%), 2,980 feet are vegetated, and none is exposed. There are 2,015 feet of exposed fill and 963 feet of exposed road way."

The following figure illustrates the sections of the Eureka's shoreline that are natural shoreline (green), dikes (yellow), railroad, (red), and the remaining colors represent other artificial shoreline types such as the Eureka Boardwalk, bulwarks, and roads. These Figures show how almost all of Eureka's shoreline is comprised of artificial man-made structures. To assist with analyzing potential alternative adaptation measures much of the information is available as GIS data files.



Natural shoreline (green), dikes (yellow), railroad, (red), and the remaining colors represent other artificial shoreline types such as the Eureka Boardwalk, bulwarks, and roads.

XIV WATERSHED BASINS:

There are several creeks traversing Eureka's urban area that drain into Humboldt Bay as well as several unnamed watershed sub basins in Eureka's urban core. It is critical that sea level rise adaptation measures be designed at the watershed and sub basin level. In Eureka's urban core these sub basins have been significantly altered and managed. Road, rail lines, levees and other man-made features form barriers to the natural flow of runoff and it is common that ditches, tide gates, and storm water collection lines artificially redirect the water that flows into the bay.

These man-made features serve multiple roles and are critical to not only direct and redirect storm water runoff, but also serve as barriers and reconveyance features to hold back or delay

Eureka's tidewaters. The elevations of the tiers, or barriers, that form may of the sub-basins adjacent to Eureka's shoreline. To plan and adapt to sea level rise, it will be essential for planners, engineers, and resource managers to drill down to the creeks, watershed sub-basin, levees, roads, rail lines, tide gates, storm water collection lines, and other natural and man-made features that form additional barriers behind the immediate shoreline.

XV Storm Water:

Critical infrastructure required to manage Eureka's storm water that is expected to be affected by sea level rise includes tide gates, levees, and storm water lines. Understanding the interrelationship and interface between Eureka's storm water runoff/floodwaters and the ever-rising tidewaters is fundamental to Eureka's efforts to adapt to sea level rise. As the tidewater continues to rise with sea level rise, we are also expected to see an increase in the frequency and intensity of storms that will generate rising floodwaters. Eureka's weather patterns typically bring the highest runoff at the same general season that we experience our highest tides. Eureka is the most vulnerable when these "king tides" occur at the same time that ocean storms generate the highest tidal surge, and inland storms result in coastal flooding.