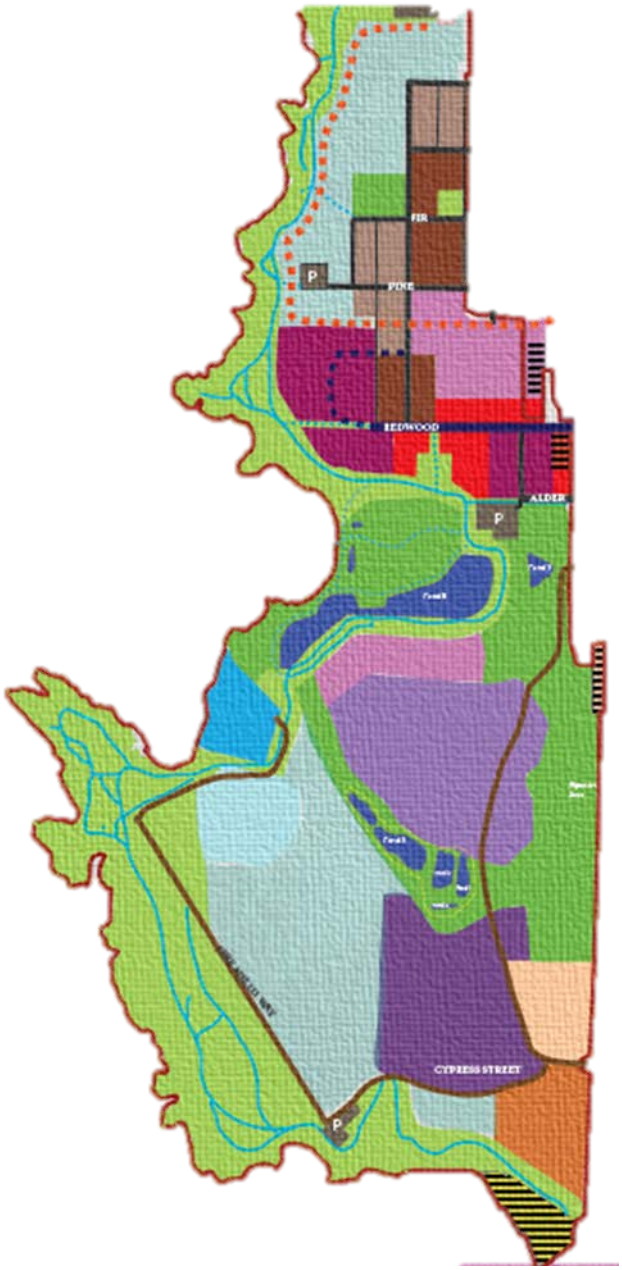
MILL SITE REUSE LCP AMENDMENT

SEA LEVEL RISE REPORT 2018



Marie Jones, Community Development Director

TABLE OF CONTENTS

1. PURPOSE

The City of Fort Bragg is updating its Local Coastal Program, a set of planning documents (Coastal General Plan, Coastal Zoning Ordinance and Coastal Zoning Map) that regulates development in the City's Coastal Zone and establishes a long-range vision for the community. The California Coastal Act, passed in 1976, provides for coastal jurisdictions to adopt a Local Coastal Program (LCP) to ensure local implementation of Coastal Act priorities. The City adopted its current LCP in 2008 and is currently preparing a Local Coastal Plan (LCP) Amendment to rezone 425 acres of the City, known as the Mill Site and update LCP policies to comply with State law.

City staff performed this Vulnerability Assessment to identify future vulnerability of both the City of Fort Bragg and the Mill Site to projected sea level rise, coastal flooding and erosion. The findings of this Assessment will enable Council and the Coastal Commission to develop and refine any adaptation policies for the LCP Amendment.

This coastal hazard analysis and vulnerability assessment is a planning-level assessment of the potential exposure Fort Bragg could face from sea level rise, flooding and erosion. The Vulnerability Assessment includes new LCP policies to improve community resilience and adaptation to Sea Level Rise. This assessment therefore relies on reasonable assumptions and engineering judgement to simplify the analysis where needed and utilizes available coastal hazard mapping products.

The purpose of this Vulnerability Assessment is to identify all potential assets at risk and understand where adaptation actions are needed, and provide adaptation policies to address these risks. For example, understanding the risk to the Pudding Creek Dam if the Dam were to fail due to sea level rise can make the case for adopting a policy in support of removing the dam (an adaptation alternative).

2. METHODOLOGY

Per the State of California Sea-Level Rise Guidance (2018), the following steps were undertaken to evaluate the sea level rise consequences and risk tolerance of the Mill Site Land Use Plan. This framework was used to: 1) guide selection of appropriate sea-level rise projections; 2) develop necessary adaptation policies to increase resiliency to sea-level rise and 3) develop contingency policies if projections are exceeded or reached prematurely.

STEP 1: *Identify the nearest tide gauge.*

STEP 2: Evaluate project lifespan.

STEP 3: *For the nearest tide gauge and project lifespan, identify range of sea-level rise projections.*

STEP 4: *Evaluate potential impacts and adaptive capacity across a range of sea-level rise projections and emissions scenarios.*

STEP 5: *Select sea-level rise projections based on risk tolerance and, if necessary, develop adapation pathways that increase resiliency to sea-level rise and include contingency plans if projections are exceeded.*

The Assessment uses the following mapping resources to develop scenario based sea level rise predictions.

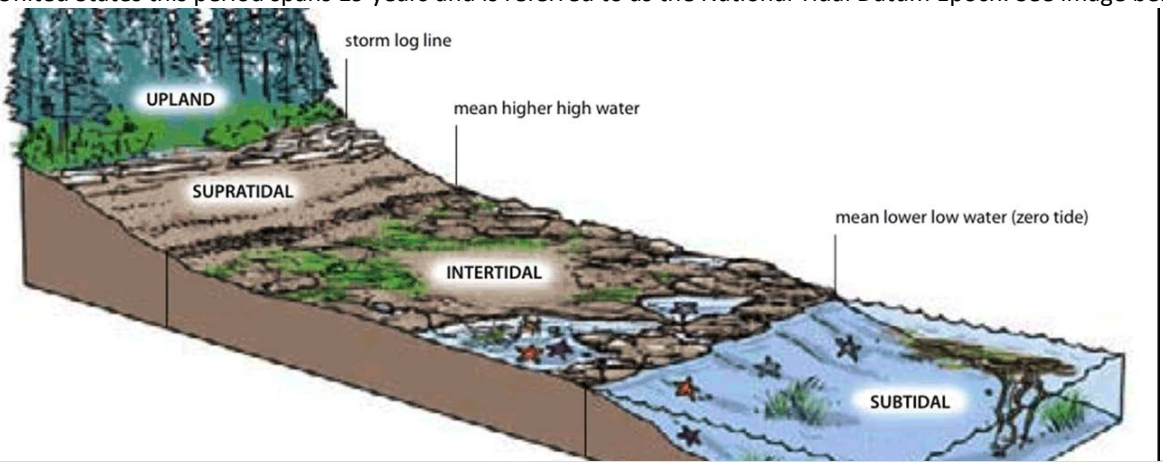
NOAA SEA LEVEL RISE VIEWER – SEA LEVEL RISE IMPACTS

The data and maps in NOAA's Sea Level Rise Viewer illustrate the scale of potential flooding, not the exact location, and do not account for erosion, subsidence, or future construction. Water levels are relative to Mean Higher High Water (MHHW) (excludes wind driven tides).[1] The data, maps, and information provided should be used only as a screening-level tool for management decisions. As with all remotely sensed data, all features should be verified with a site visit. The data and maps in this tool are provided "as is," without warranty to their performance, merchantable state, or fitness for any particular purpose. The entire risk associated with the results and performance of these data is assumed by the user. This tool should be used strictly as a planning reference tool and not for navigation, permitting, or other legal purposes.

SURGING SEAS RISK FINDER

Surging Seas Risk Finder is a multi-part public web tool that provides local sea-level rise and flood risk projections, interactive maps, and exposure tabulations from zip codes and up. Projections integrate extreme flood statistics with dozens of sea-level rise models and scenarios to choose from. Maps are based on the same modified bathtub model used by NOAA's Sea-Level Rise Viewer and consider static sea-level rise up to 10 feet above mean higher high water (MHHW). Maps illustrate which areas are or are not hydrologically connected to the ocean at each one-foot increment, and have layers for population, social vulnerability, property value, point features and more. Exposure assessments tabulate over 100 demographic, economic, infrastructure and environmental variables for every zip code and municipality, as well as planning, legislative and other districts. Additional features include heat maps showing wide-area exposure comparisons, and extensive data downloads including localized fact sheets, reports, and PowerPoint slides. Tutorial videos and step-by-step guides are also available

[1] The Mean High Water (MHW) is the average of all the high water heights (each day) observed over a period of several years, in the United States this period spans 19 years and is referred to as the National Tidal Datum Epoch. See image below



FORT BRAGG GIS AND TOPOGRAPHY ANALYSIS – SEA LEVEL RISE IMPACTS

This analysis includes a detailed analysis of the specific topography in Fort Bragg and the corresponding Sea Level Rise maps related to Fort Bragg. This analysis includes all Sea Level Rise scenarios for Fort Bragg and is the most site specific and accurate for Fort Bragg. Future Sea Level Rise was mapped across the Mill Site using current topography.

OUR COAST OUR FUTURE (OCOF) (PENDING COMPLETION 2019)

Our Coast Our Future (Ballard et al. 2016) is a collaborative project that provides online maps and tools to help users understand, visualize and anticipate vulnerabilities to sea level rise (SLR) and storms. The project maps 40 different SLR and storm scenarios that were developed by the United States Geological Survey (USGS) using their Coastal Storm Modeling System[1] (CoSMoS 2.0, North-central California (outer coast)). The hazard maps are hosted in an interactive web environment that includes layers for flooding extent, depth, duration, wave heights, current velocity, as well as various infrastructure and ecology layers. ESA used various OCOF hazard mapping products to evaluate existing and future coastal flooding hazards due to SLR (for regular tidal inundation) and storm flooding (considering a 100-year coastal event) for this Vulnerability Assessment. The modeling uses recent (2013) topography that includes existing features. This modeling will be completed for Northern California sometime in 2019 or 2020. If it comes available, staff will revise this analysis and include the findings from this model.

3. SEA LEVEL RISE ANALYSIS

Amounts of SLR were selected for the study planning horizons (2100 and 2150) following updated State guidance (CalNRA & OPC 2017). For any given year (planning horizon), State guidance recommends analyzing a range of SLR projections:

Because future projections of sea-level rise along California's coastline are uncertain (due to uncertainty associated with modeling and the trajectory of global emissions), it is critical to consider a range of projections to understand the consequences of various decisions, determine the tolerance for risk associated with those decisions, and to inform adaptation strategies necessary to prepare for change in the face of uncertainty.

In general, decision makers may have a higher tolerance for risk (or lower risk aversion) when considering projects with a shorter lifespan, minimal consequences, flexibility to adapt, or low economic burden as a result of sea-level rise. However, for longer lasting projects with less adaptive capacity and medium to high consequences should sea-level rise be underestimated, we suggest that decision makers take the more precautionary, more risk averse approach of using the medium-high sea-level rise projections across the range of emissions scenarios. We further recommend incorporating the extreme scenario in planning and adaptation strategies for projects that could result in threats to public health and safety, natural resources and critical infrastructure.

STEP 1: IDENTIFY THE NEAREST TIDE GAUGE

The nearest Tide Gauge is Arena Cove, CA, which was used for all sea level rise predictions in this report. See figure 1.

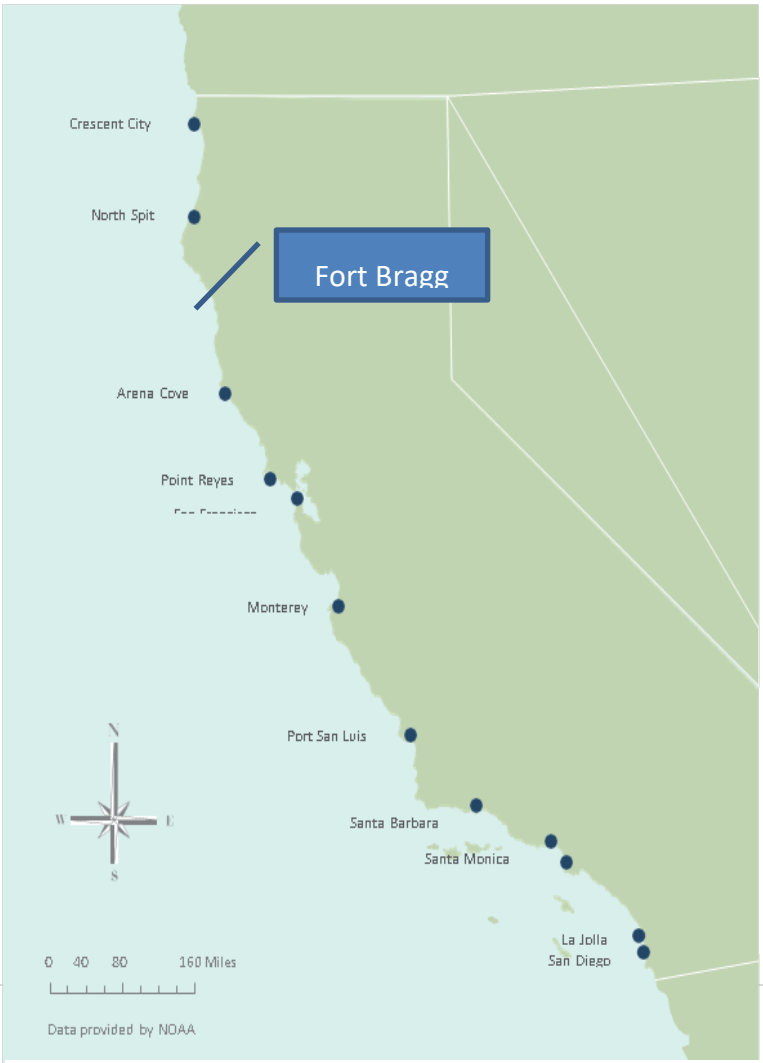


Figure 1: Tidal Gauges, California

STEP 2: EVALUATE PROJECT LIFESPAN.

Table 2 identifies project life expectancy for a range of assets that could be effected by sea level rise under various probabilistic projections.

For the former Mill Site, the City anticipates that the buildout timeframe would be from 25 to 30 years depending on market demand. Once constructed the structures would have a life expectancy of 50 to 100 years (depending on type of construction) The City has conservatively calculated that the "project" lifespan is 130 years or the year 2150 (30 years for buildout + 100 years useful structural life). This is a conservative and very risk averse calculation of project lifespan. The Life Expectancy for the low land build assets on the Mill Site) Beach Berm, Mill Pond Dam, hazardous materials sites is set for 150 years as this is the furthest in the future for which there are Sea Level Rise predictions.

STEP 3: FOR THE NEAREST TIDE GAUGE AND PROJECT LIFESPAN, IDENTIFY RANGE OF SEA-LEVEL RISE PROJECTIONS.

Table 2 below illustrates the probabilistic sea level rise projects for Arena Cove California, which is the closest tide gauge to the City of Fort Bragg. These data are from Kopp et al, 2014 and Sweet et al (2007) per State of California Sea Level Rise Guidance (2018).

Table 1: Life Span Estimates for Assets Potentially Impacted by Sea Level Rise

	Project Life Expectancy [1]
Sea Level Rise (ft)	
Build Assets -Outside of City Limits but within the City's Municipal Services District (Noyo Harbor)	
Wood Buildings: Hotels, Restaurants, Retail, Residential Rentals, Industrial facilities, etc.	75+
Concrete Buildings	30
Mobile home park	30
Roads (local harbor)	50
Transmission lines (Harbor)	15
Water distribution pipelines (harbor)	50
Sewer lines (harbor)	50
Built Assets - Inside City Limits	
Ocean Lake Senior Housing -Manufactured Homes	50
GP Mill Site	130
WWTF	60
Madson Hole: raw water supply	30
Sewer Lift Station at Pudding Creek	50
Storm drains	15
Pudding Creek dam	50
Hazardous material sites - Ponds 6, 7 & 8	150
Mill Pond Dam - upon seismic retrofit	150
Fort Bragg Landing Beach Berm	150
Natural Assets	
Pudding Creak Beach, Noyo Beach, Fort Bragg	NA
Streams & Rivers – Pudding Creek, Noyo River	NA
Steelhead habitat	NA
Wetlands	NA
Access and Recreation	
Pudding Creak Beach, Glass Beach, Noyo Beach, Fort Bragg Landing Beach	NA
Noyo Headland Park (Coastal Trail), Pomo Bluffs Park, MacKerricher Park	30
Pudding Creek Beach parking, Noyo Beach Parking	30
Highway bridges – Pudding Creek Bridge, Noyo Harbor Bride, Hare Creek Bridge	100
Highway 1	100
Fishing area at jetty	50
Surfing areas	NA

There is substantial agreement between sea level models in the Sea Level Rise (SLR) projections through 2050. However, after 2050, the differences in the projections vary greatly across both emission scenarios and individual scientific assessments. Therefore, there is uncertainty associated with any SLR projections for the later half of this century and beyond. Thus, per the State Guidelines, when assessing longer-term risk after 2050, multiple sea level rise predictive models should be used for SLR or extreme SLR should also be considered (e.g., discrete, non-probabilistic scenarios), particularly if the timeframe is closer to 2100 or beyond. The H++ Scenario represents the most conservative discrete **non-probabilistic** scenario and assumes

a very rapid loss of the Antarctic ice sheet; in other words we know that the likely of this scenario coming to pass is extremely low (less than 0.5% likely) but we don't know how low it is.

High Emissions Analysis. Based on Table 2, in the high emissions scenario, the most likely range of sea level rise is between 2.3 feet and 5.4 feet by 2150. Likewise there is about a 5% probability that SLR could reach 7.3 feet and a 0.5% chance of sea level rise exceeding 12.6 feet by 2150. If high emissions result in the extreme H++ scenario (Sweet et al 2007), which is extremely unlikely and assumes a very rapid loss of the Antarctic ice sheet, sea level rise by 2150 could be as high as 21.5 feet.

Low Emissions Analysis. Based on the table above, in a low emissions Scenario Fort Bragg has a 50% probability of experiencing at least 1.9 feet of sea level rise by 2150. Furthermore the most likely range of sea level rise is between 0.9 feet and 2.3 feet by 2150. Likewise there is about a 5% probability that SLR could reach 5.1 feet and a 0.5% chance of sea level rise exceeding 10.7 feet by 2150. The H++ scenario is not possible in a low emissions scenario.

Table 2: Projected Sea Level Rise (in feet) for Arena Cove/Fort Bragg, CA

		Probabilistic Projections (in feet) (based on Kopp et al. 2014)					*H++ scenario (Sweet et al. 2017) *Single scenario*
		MEDIAN	**LIKELY RANGE**		**1 - IN-20 CHANCE**	**1 - IN-200 CHANCE**	
		50% probability sea-level rise meets or exceeds…	*66% probability sea-level rise is between…*		*5% probability sea-level rise meets or exceeds…*	*0.5% probability sea-level rise meets or exceeds…*	
				Low Risk Aversion		**Medium - High Risk Aversion**	**Extreme Risk Aversion**
High emissions	2030	0.3	0.2	0.5	0.5	0.7	1
	2040	0.5	0.3	0.7	0.9	1.2	1.6
	2050	0.7	0.5	1	1.2	1.8	2.6
	2060	1	0.6	1.3	1.7	2.5	3.7
	2080	1.5	1	2.2	2.8	4.3	6.4
	2100	2.1	1.3	3.1	4.1	6.7	9.9
	2120	2.6	1.8	3.8	5	8.2	13.9
	2140	3.2	2.1	4.8	6.5	11.1	18.7
	2150	3.6	2.3	5.4	7.3	12.6	21.5
Low emissions	2080	1	0.6	1.6	2.1	3.6	
	2100	1.3	0.7	2.1	3	5.4	
	2120	1.5	0.9	2.5	3.6	7.1	
	2140	1.8	0.9	3.1	4.6	9.4	
	2150	1.9	0.9	3.4	5.1	10.7	

**Most of the available climate model experiments do not extend beyond 2100. The resulting reduction in model availability causes a small dip in projections between 2100 and 2110, as well as a shift in uncertainty estimates (see Kopp et al. 2014). Use of 2110 projections should be done with caution and with acknowledgement of increased uncertainty around these projections.*

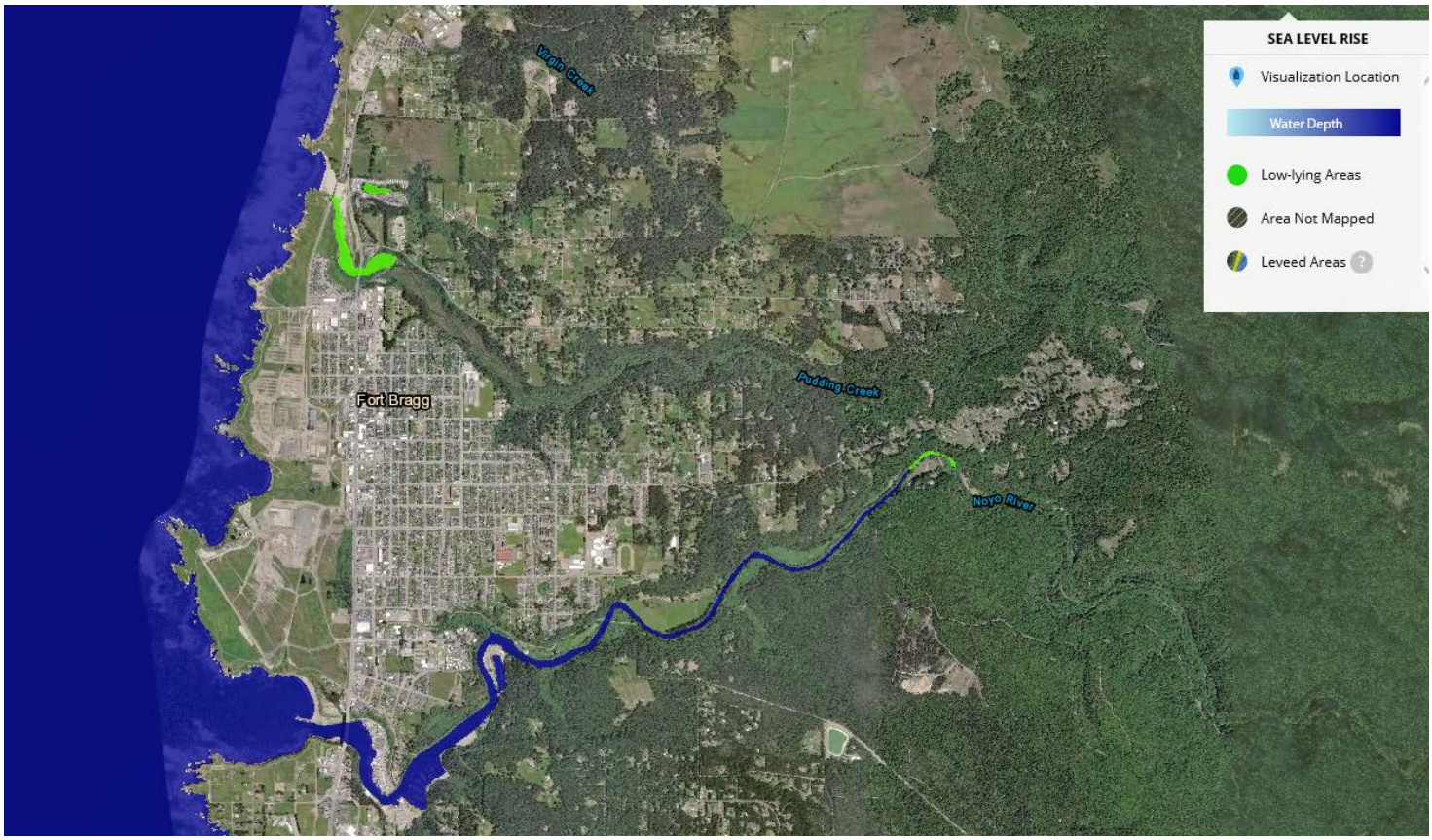
STEP 4: EVALUATE POTENTIAL IMPACTS AND ADAPTIVE CAPACITY.

NOAA SEA LEVEL RISE VIEWER ANALYSIS: HIGH EMMISSION AND 5% SCENARIOS

The following maps and narrative evaluate the effects of sea level rise impacts on Fort Bragg and the Mill Site, across a range of sea level rise projections and emissions scenarios, as follows:

- Map 1: Illustrates current sea level conditions, Fort Bragg CA
- Map 2: Illustrates the Likely Range of sea level rise by 2150 (5.4 feet) given the high emissions scenario, Fort Bragg CA
- Map 3: Illustrates the 1 in 20 or 5% probability level of sea level rise by 2150 (7 feet) given the high emissions scenario, Fort Bragg CA

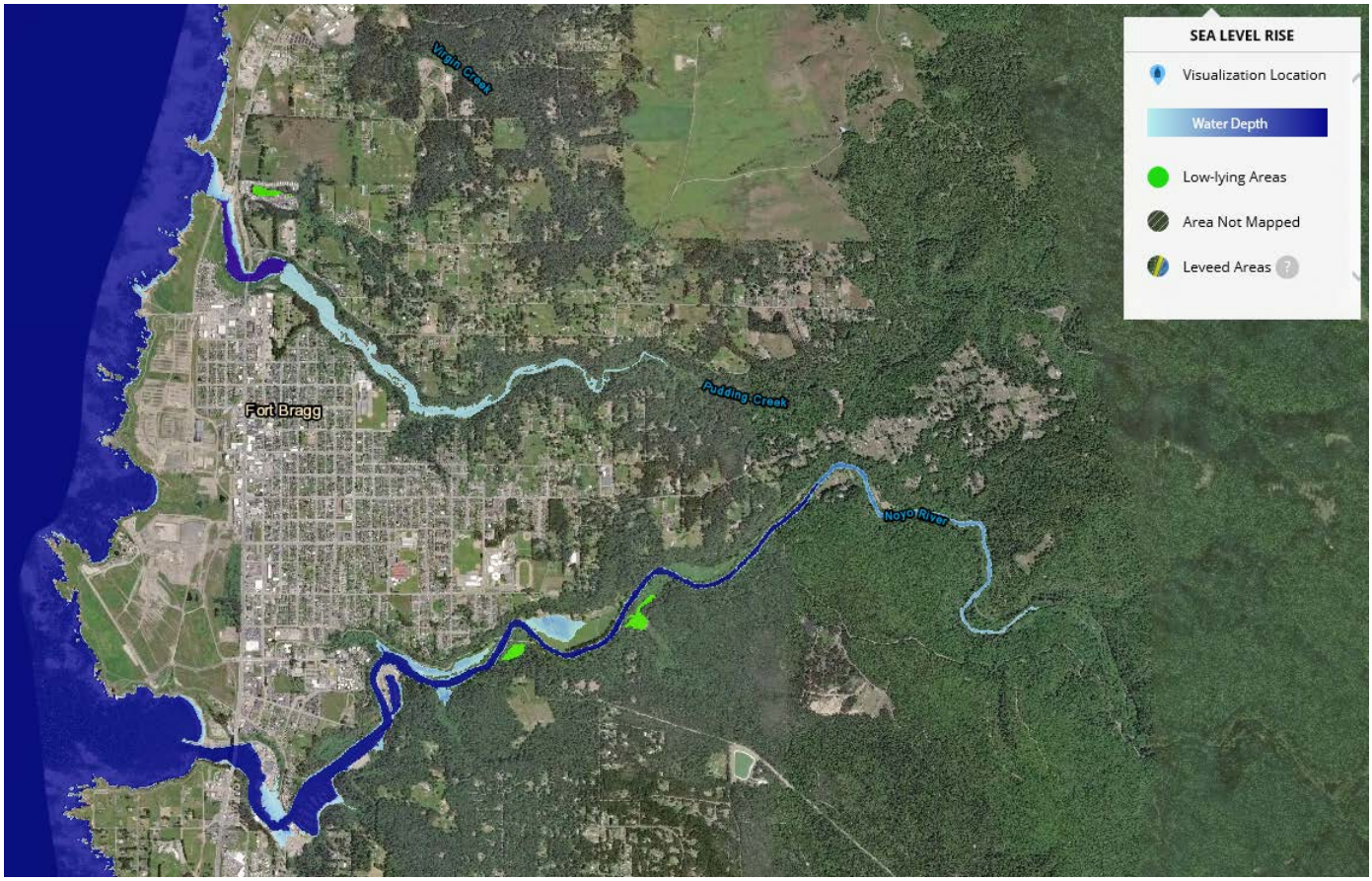
MAP 1: CURRENT SEA LEVEL CONDITIONS



As illustrated by the Current Sea Level map, the pudding creek wetlands and beach, located just below the Pudding Creek Dam, is the only area that is currently subject to flood conditions during high tides and storm surge. The Current Conditions Sea Level map also illustrates the existing tidal influences on the Noyo River, which results in salt water intrusion fairly high up the river. Although not generally as high as illustrated in the map because water flows from the Noyo Push the salt water out to sea.

MAP 2: HIGH EMISSIONS "LIKELY RANGE" SEA LEVEL RISE, 2150 (5.4 FEET OF SEA LEVEL RISE)

Projection for decisions with low risk aversion: This map uses the upper value of the "likely range" for the 2150 project lifetime timeframe. This SLR estimate is fairly risk tolerant, as it represents an approximately 17% chance of being overtopped, and as such, provides an appropriate projection for adaptive, lower consequence decisions (e.g. unpaved coastal trail) but will not adequately address high impact, low probability events. Additionally, it is important to note that the probabilistic projections may underestimate the likelihood of extreme sea-level rise, particularly under high-emissions scenarios.



As illustrated in the Likely Range Sea Level Rise scenario for 2150 (Map 2), 5.4 feet of sea level rise will impact some low risk, low lying areas of Fort Bragg including: Noyo Beach, the beach at Fort Bragg Landing (aka Soldiers Bay beach), Pudding Creek Beach, the estuary below the Pudding Creek Dam and some wetland areas along the Noyo River.

The map also illustrates potential impacts of Sea Level Rise to three high risk areas including:

1) Increased flooding of the Ocean lake senior homes project located just north of Pudding Creek Bridge, with high tides and storm surge which according to surging seas data would directly impact five homes.
2) Flooding of the pudding creek dam and estuary, possibly causing dam failure.
3) Flooding of developed portions of Noyo Harbor, including the southern most portion of North Harbor. While located outside of City Limits the flooding of this area would have significant economic impacts

for Fort Bragg residents and businesses. Additionally the flooding would eliminate road access to the entirety of the North Harbor and make it very vulnerable to storm surge and high tides.

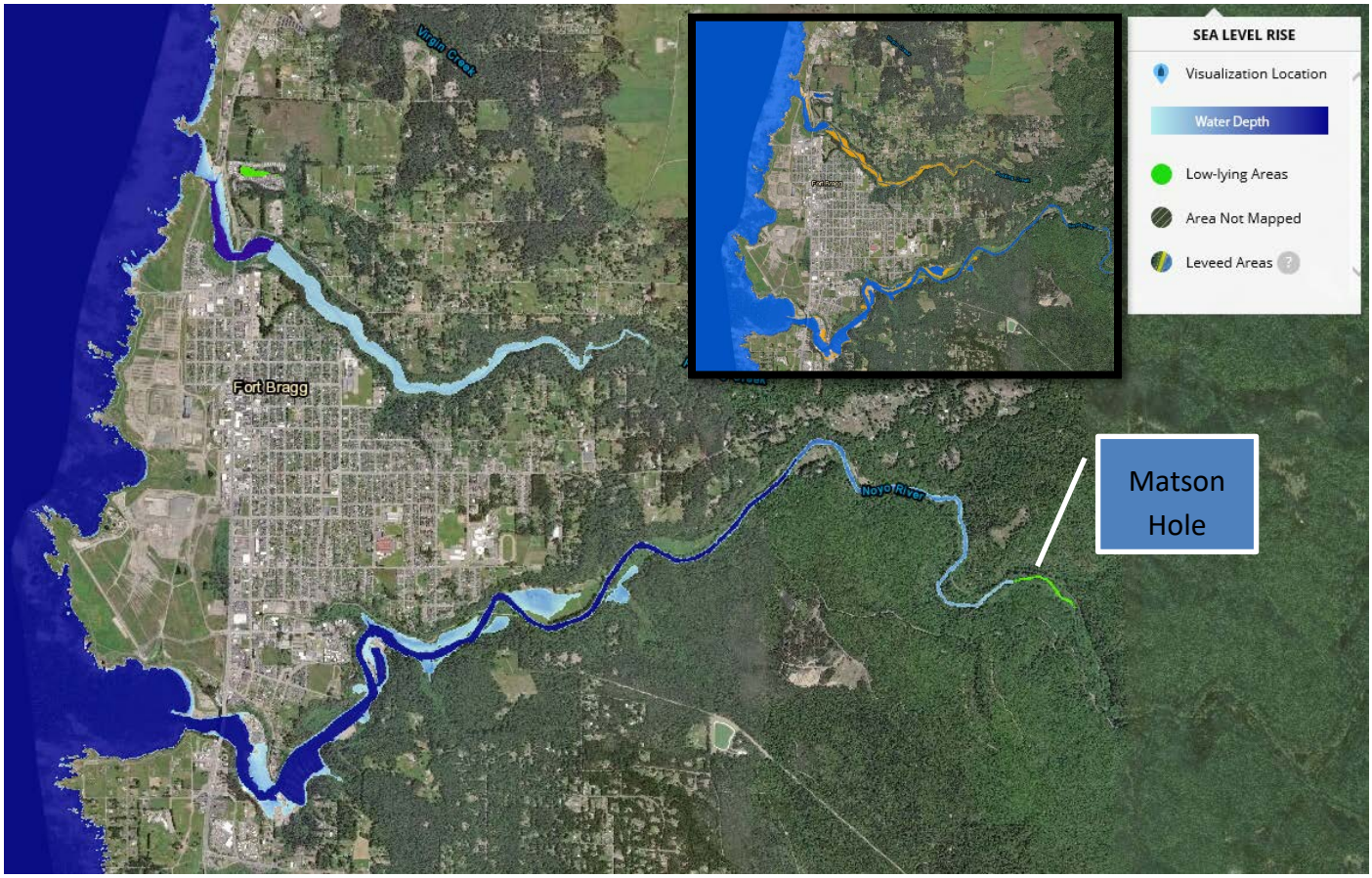
For detailed images of these locations please see maps 2.1 and 2.2 below:

Map 2.1: Pudding Creek Senior Home Project and Pudding Creek Reservoir Areas of Sea Level Inundation (Light Blue), and Periodic Flooding (Light Green)

Map 2.2: Noyo Beach and Noyo Harbor areas of Sea Level Rise inundation (Light Blue)

MAP 3: 1 IN 20 (5% PROBABILITY) LEVEL OF SEA LEVEL RISE BY 2150 (7 FEET) GIVEN THE HIGH EMISSIONS SCENARIO

Map 3 illustrates the 1-in-20 chance SLR projection of 7 feet for 2150. The likelihood that sea- level rise will meet or exceed this value is extremely low (5%), providing a precautionary projection that is recommended for less adaptive, more vulnerable projects or populations that will experience medium to high consequences as a result of underestimating sea-level rise. If this less likely scenario comes to pass, there would be additional and catastrophic sea inundation along the Noyo River resulting in: 1) permanent inundation of properties in both the north and south Noyo Harbor, 2) flooding in undeveloped lowland areas along the Noyo River; and 3) potential sea level rise impacts to the City's water intake station (Matson Hole) on the Noyo River, possibly necessitation the relocation of the water intake station further up river.

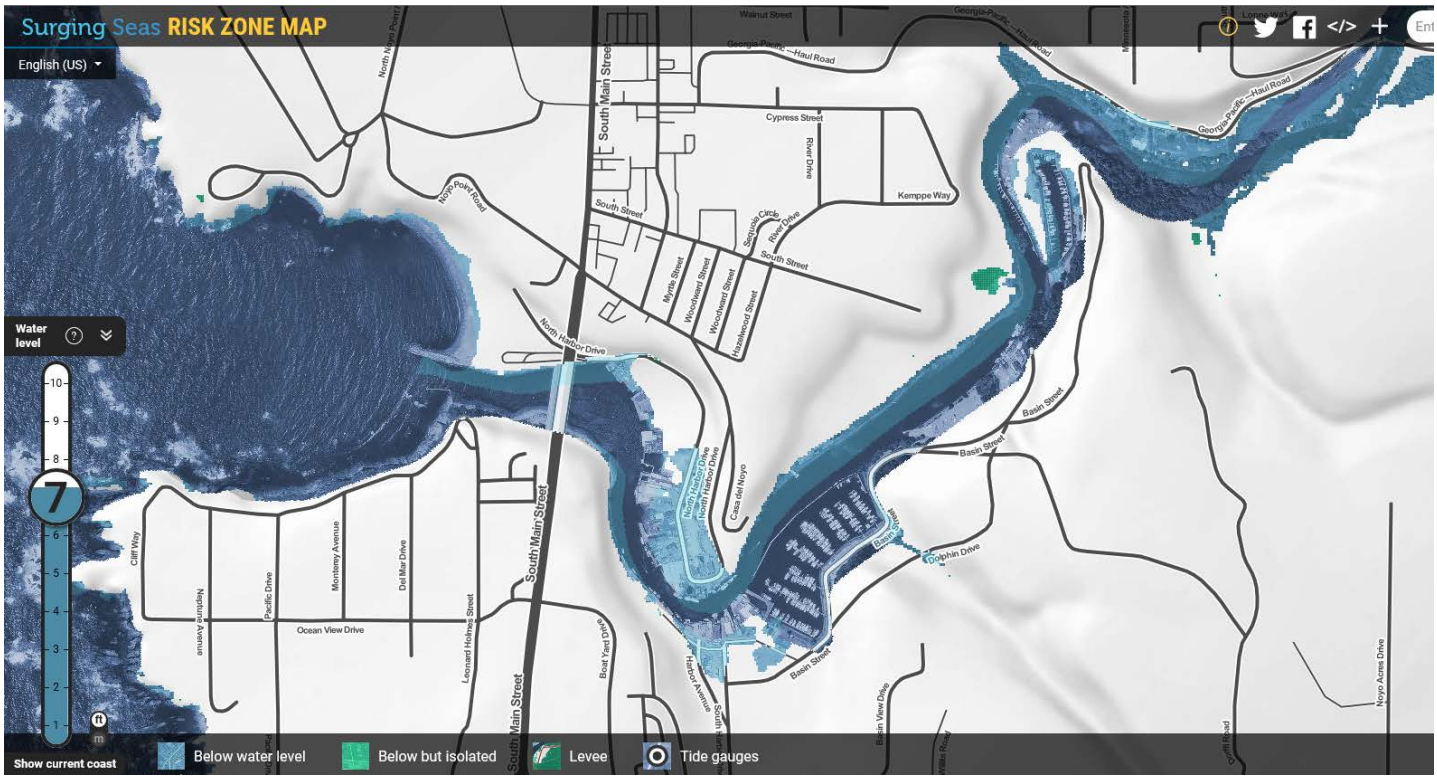


The inset map illustrates that the confidence level (yellow) for sea level rise into pudding creek is low.[2]

[2] Data Confidence: The inundation areas depicted in the Sea Level Rise tab are not as precise as they may appear. There are many unknowns when mapping future conditions, including natural evolution of the coastal landforms (e.g., barrier island overwash and migration), as well as the data used to predict the changes. The presentation of confidence in these maps only represents the known error in the elevation data and tidal corrections. Blue areas denote a high confidence of inundation, orange areas denote a high degree of uncertainty, and unshaded areas denote a high confidence that these areas will be dry given the chosen water level. In this application 80% is considered a high degree of confidence such that, for example, the blue areas denote locations that may be correctly mapped as 'inundated' more than 8 out of 10 times. Areas with a high degree of uncertainty represent locations that may be mapped correctly (either as inundated or dry) less than 8 out of 10 times.

Map 3a and 3b below illustrate this same level of (7 feet) of sea level rise with the Surging Seas Risk Zone map, which illustrates the significant impact that this level of sea level rise would have on Fort Bragg's Noyo Harbor. Specifically the map illustrates the inundation of many properties along North and South Harbor Drive within the Harbor. This level of sea level rise would result in the closure of docks, hotels, restaurants, and other facilities in the harbor, and therefore precautionary planning is recommended regarding approvals of new development after 2100, however this area is outside of the City's jurisdiction.

Map 3a: 1 in 20 (5% probability) level of sea level rise by 2150 (7 feet) given the high emissions scenario.



Map 3b: illustrates that 7 feet of sea level rise will directly impact seven homes (per surging seas dataset) in Ocean Lake Senior Housing with isolated flooding (green) and would inundate the pudding creek reservoir with sea water (Blue).

FORT BRAGG EXTREME SEA LEVEL RISE ANALYSIS (H++)

The following map and narrative evaluate the effects of sea level rise impacts on the Mill Site for the H++ extreme sea level rise scenario by 2150 (21.5 feet) which assumes Antarctic ice sheet loss. The probability of this outcome is undetermined, but deemed to be extremely low, however there is uncertainty in the rate of emissions reductions and the stability of some of the larger artic ice sheets, and this analysis is recommended by the Coastal Commission for SLR projections for decisions with extreme risk aversion.

This H++ Sea Level Rise Analysis is appropriate for high consequence projects with a design life beyond 2150 that have little to no adaptive capacity, would be irreversibly destroyed or significantly costly to relocate/repair, or would have considerable public health, public safety, or environmental impacts should this level of sea-level rise occur. Although estimating the likelihood of the H++ scenario is not possible at this time (due to advancing science and the uncertainty of future emissions trajectory), the extreme sea- level rise projection is physically plausible and provides an understanding of the implications of the worst case scenario. However the probability of H++ occurring is certainly much less than 0.5% chance of occurring.

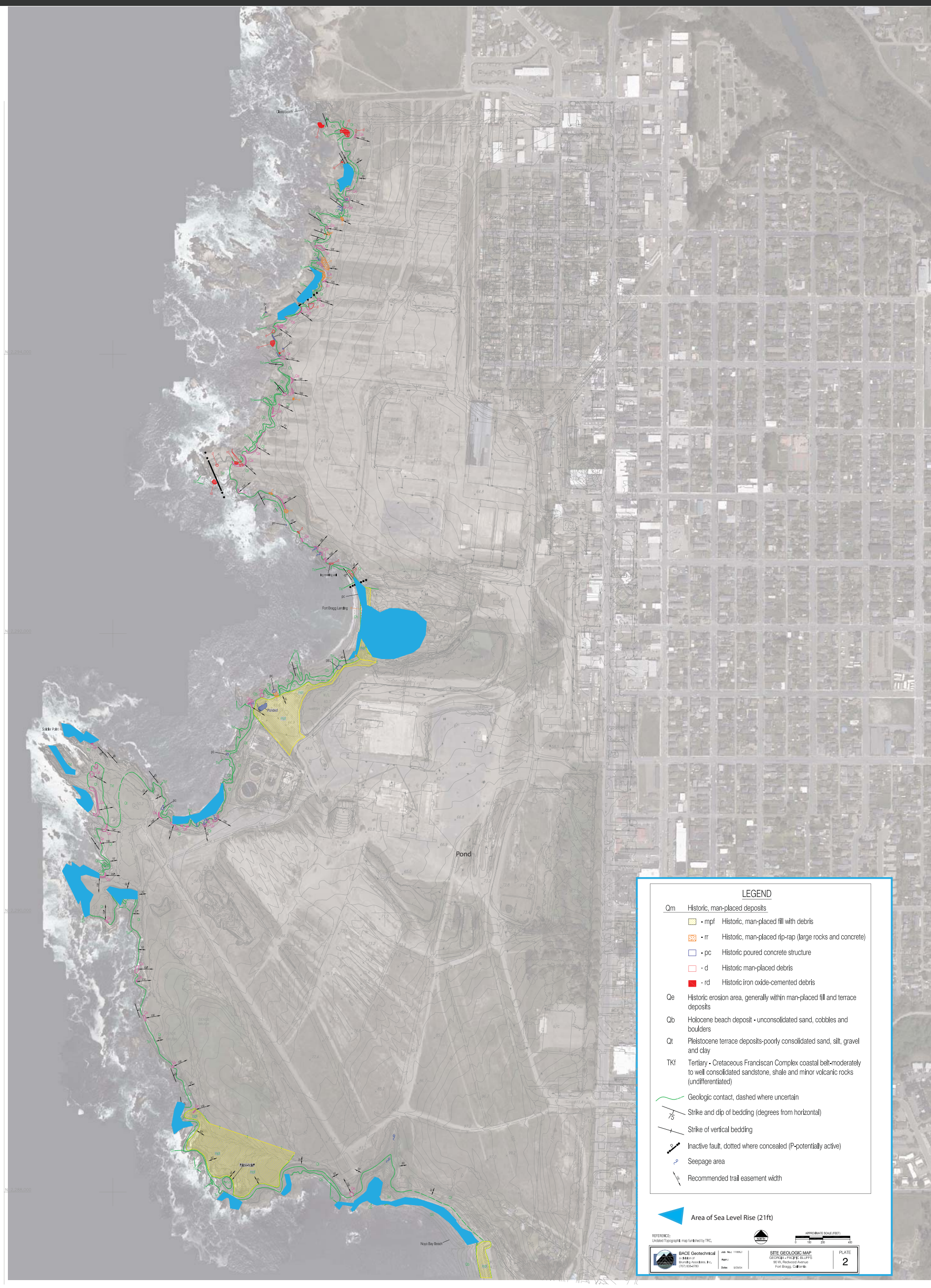
The Mill Site is located on a coastal bluff top that ranges in height from 20 feet (at the rip rap wall) to 110 feet in height. The topography is generally lower on the coastal bluff, 30 to 60 feet, and higher inland 50 to 110 feet. The Mill Site includes a bay in the middle of the site with an inland "low land area" that is located behind a pre 1972 shore protection devise (beach berm) composed of earth and concrete rubble. The berm is 20 feet in height. As illustrated in Map 4, the H++ Scenario sea level rise in the 2150 timeframe has the potential to impact four unique areas of the Mill Site, including:

1. The Lowland Area, which includes the Mill Pond Dam, Beach Berm and Ponds 6 and 7. These features would be costly to repair and replace and if damaged could have an impact on public safety and environmental health, and thus are deserving of future analysis with regard to the H++ sea level rise scenario.
2. Glass Beach and other smaller beaches. These features are natural areas and SLR would impact public safety only in so far as they would not longer be beaches.
3. An upland portion of the Native American Preserve and a portion of the South Gulch (south of the runway). These areas are natural features and would result in public safety issues in so far as public access to these areas would be limited.

The potential impacts of extreme sea level rise on each of these areas is illustrated in the map 4 below. Map 4 uses the H++ scenario for the 2150 timeframe to explore potential threats to these areas. As Illustrated extreme sea level rise, while very unlikely, has the potential to erode the beach berm and sediment located behind the beach berm. The subsequent introduction of wave action in this area may stress the dam and the north embankment of the Mill Pond. If H++ Sea Level Rise occurs, adaptive strategies (removal or strengthening) for the Mill Pond and the Beach Berm may be necessary.

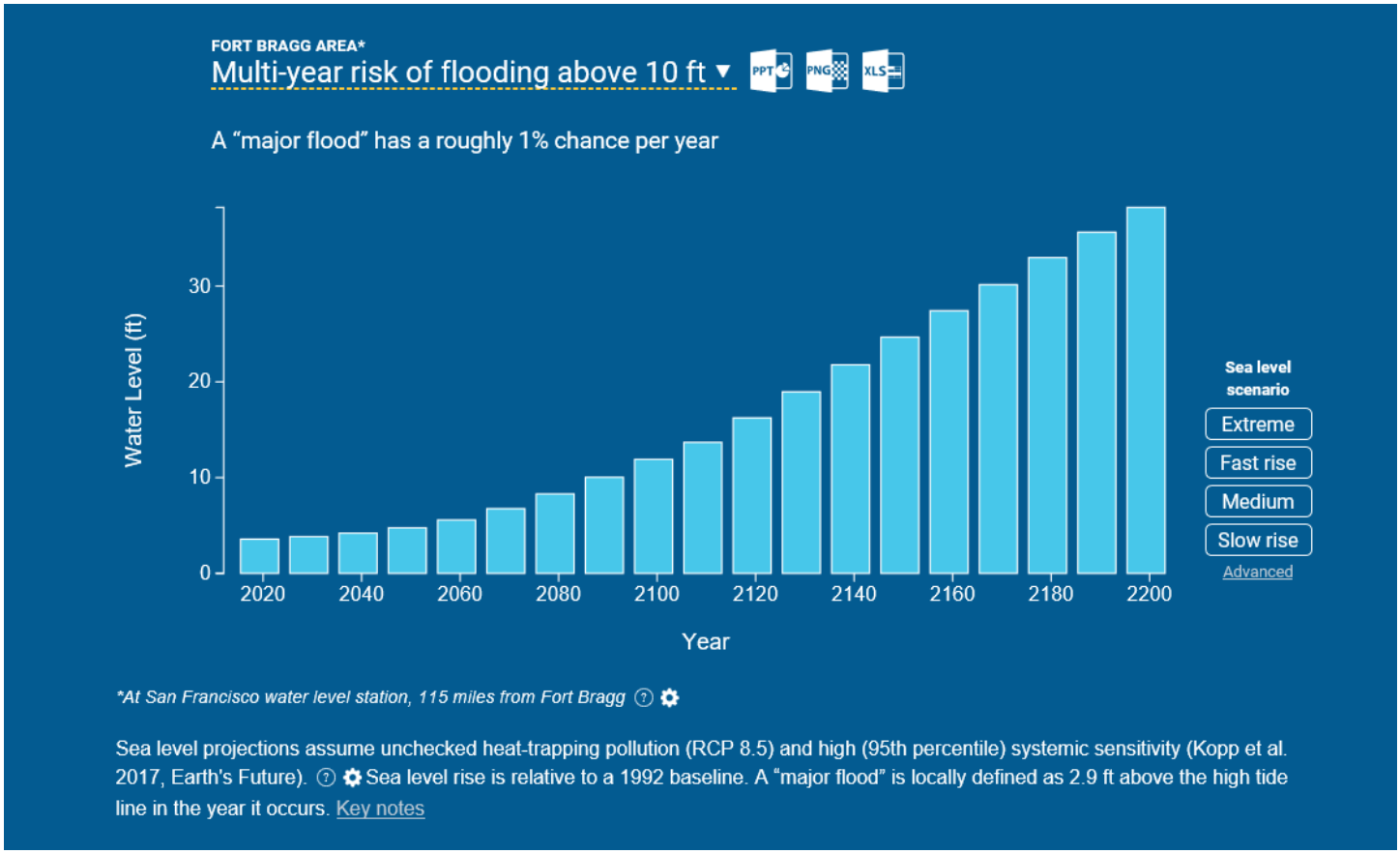
Unfortunately the City does not have access to topology for the Noyo River or the Pudding Creek that shows 10 foot or lower topo interval lines and staff in unable to complete a similar map for the entire Fort Bragg area. However, it is clear that 21 feet of sea level rise would have greater impacts on many of the locations identified under the 7 foot sea level rise scenario.

MILL SITE TOGOGRAHPY AND SEA LEVEL RISE (21 FEET)



THE CHART BELOW ILLUSTRATES THE RISE IN SEA LEVEL UNDER THE H++ EVENT WITH LOSS OF THE ICE CHEETS IN ANTARTICA.

This anlaysis comes from on Kopp et al. (2017): With Antarctic dynamics. Local sea level projections from Kopp et al. 2017 (Earth's Future), which incorporates new Antarctic physics from DeConto and Pollard 2016 (Nature). Based on different Representative Concentration Pathways (RCPs) of heat-trapping pollution over time, and on different sensitivities of climate and sea level to pollution. The chart is from Climate Central which has combined sea level projections with local data to make local flood risk projections.



A review of the chart reviels that the extreme H++ scenario could result in sea level rise of 40 feet by the year 2200, which would impact the northern side of the Mill Site, as some area are located between 35 and 45 feet in elevation.

VULNERABILITY ANALYSIS

Table 3, below, illustrates the vulnerability of various physical assets given different sea level rise scenarios. **Green squares** indicate that the asset will not be affected by sea level rise within the timeframe specified in the column. **Yellow squares** indicate that the asset has an increased risk of episodic flooding due to SLR combined with storm surge and or kind tides. **Red squares** indicate that the asset could be inundated within the timeframe specified given the probability that the scenario occurs. The "**X**" indicates the likely life expectancy of the asset.

Table 3: Sea Level Rise Valnerability: Proect Life Expectancy, Sea Level Rise Timing Under Different Scenarios & Probabilities

		High Emmissions SLR Scenario					H++ Scenario
	Project Life Expectancy [1]	Likely Range (83% chance)			1:20 Chance	0.5% Chance	
		2050	2100	2150	2150	2150	2150
Sea Level Rise (ft)		1	3.1	5.4	7.3	12.6	21.5
Build Assets -Outside of City Limits but within the City's Municipal Services District (Noyo Harbor)							
Wood Buildings: Hotels, Restaurants, Retail, Residential Rentals, Industrial facilities, etc.	75+		X				
Concrete Buildings	30	X					
Mobile home park	30	X					
Roads (local harbor)	50		X				
Transmission lines (Harbor)	15	X					
Water distribution pipelines (harbor)	50		X				
Sewer lines (harbor)	50		X				
Built Assets - Inside City Limits							
Ocean Lake Senior Housing -Manufactured Homes	50		X				
GP Mill Site	150			X	X	X	X
WWTF	60		X				
Sewer Lift Station at Pudding Creek	50		X				
Storm drains	15	X					
Pudding Creek dam	50		X				
Hazardous material sites - Ponds 6, 7 & 8	150+			X	X	X	X
Mill Pond Dam - upon seismic retrofit	150			X	X	X	X
Fort Bragg Landing Beach Berm	150			X	X	X	X
Natural Assets							
Pudding Creak Beach, Noyo Beach, Fort Bragg	NA						
Streams & Rivers – Pudding Creek, Noyo River	NA						
Steelhead habitat	NA						
Wetlands	NA						
Access and Recreation							
Pudding Creak Beach, Glass Beach, Noyo Beach, Fort Bragg Landing Beach	NA						
Noyo Headland Park (Coastal Trail), Pomo Bluffs Park, MacKerricher Park	30	X					
Pudding Creek Beach parking, Noyo Beach Parking	30	X					
Highway bridges – Pudding Creek Bridge, Noyo Harbor Bride, Hare Creek Bridge	100		X				
Highway 1	100		X				
Fishing area at jetty	50		X				
Surfing areas	NA						

[1] *Survey on actual service lives for North American buildings*, Jennifer O'Connor Forintek Canada Corp. 2004

As illustrated in Table 3, much of the Noyo Harbor may begin to be affected by Sea level Rise in 2100, with significant permanent flooding by 2150, if CO2 emissions are not curbed (83% probability model). While the Noyo Harbor is located outside of City Limits, the North Harbor is served by City water and sewer and is an important economic and jobs driver for our community.

Within City Limits, Noyo Beach, Pudding Creek Beach, Fort Bragg Landing & Glass Beach, Pudding Creek Dam and Noyo Harbor Jetty are threatened by permanent Sea level inundation by 2150, in the most likely sea level rise scenario (83% confidence), if CO2 emissions are not curbed.

In the 1 in 200 scenario (12.6 feet of sea level rise) the beach berm would start to be impacted by sea level rise, especially during surging storms and king tides.

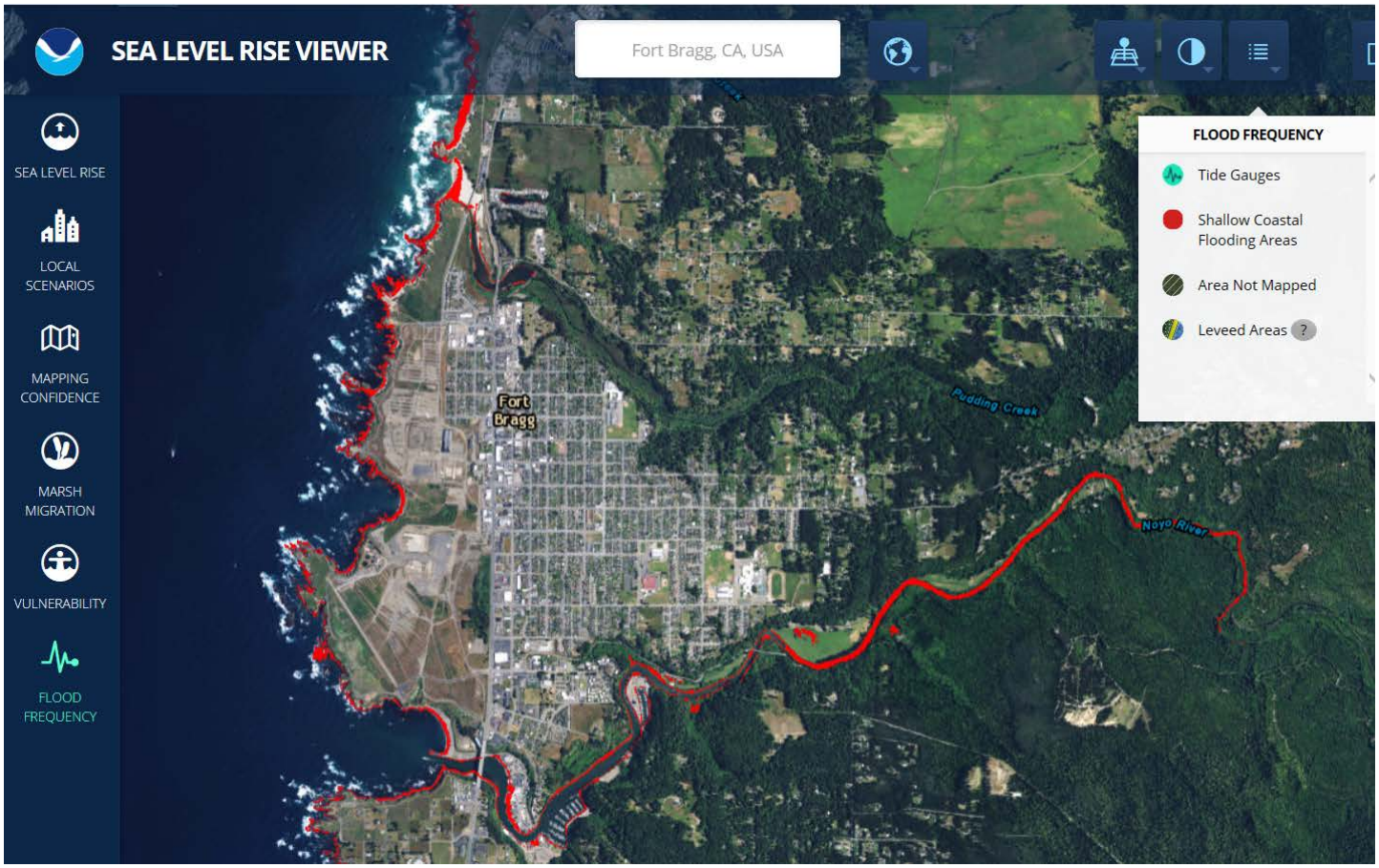
In the least likely and most catastrophic scenario, the H++ scenario, the Mill Pond Dam, Fort Bragg Landing Beach Berm and Ponds 6, 7 and 8 could be impacted and possibly even inundated by SLR, necessitating an adaptive strategy for this area. An adaptive strategy could include: 1) removal of ponds 6 & 7; and 2) removal of Pond 8 or dam stabilization for Pond 8 which could effectively withstand sea level rise.

EPISODIC EVENTS

Episodic events, such as king tides, storm surge, El Niños may cause acute increases in sea level heights for short periods of time. It is difficult to predict and map the cumulative impact of these short episodic events, but they will result in increased episodic flooding in low lying areas in and around Fort Bragg, including: Pudding Beach, Pudding Creek & Dam, Fort Bragg Landing (on the Mill Site), Noyo Beach and the Noyo Harbor and River.

King Tides. King tide" is a colloquial term for an especially high spring tide, such as a perigean spring tide. "King tide" is not a scientific term, nor is it used in a scientific context. The king tides occur when the Earth, Moon and Sun are aligned at perigee and perihelion, resulting in the largest tidal range seen over the course of a year. So, tides are enhanced when the Earth is closest to the Sun in January. In January 2019, the King Tide will be able 7.1 feet in Fort Bragg. The King Tide (occurring predictably each year) can exacerbate sea level rise episodically, however it is only a couple of inches over the Mean Higher High Water, which is the base water level for all sea level rise analyses in this report.

El Niños and Storm Surge. An accurate maps of interaction of storms, El Ninos and storm surge with SLR, the City will become available with OUR COAST OUR FUTURE (OCOF) SLR maps for the Northern Coast of California are completed in late 2019. In the meantime, staff has utilized Sea Level Rise Viewer to illustrate where flooding may be exacerbated prior to 2050. Sea level rise will make flooding more frequently and last for longer durations of time in low elevation areas that are influenced by the sea level. Increased flooding will likely occur at Pudding Creek Beach and the base of the pudding creak dam, possibly at the Noyo Beach parking lot and portions of North Noyo Harbor, as illustrated in the map.



Erosion. Large sections of the Pacific coast, especially those with rocky headlands or sea cliffs, are not vulnerable to flooding, but are highly susceptible to erosion. In areas where the coast erodes easily, higher sea levels are likely to accelerate shoreline erosion due to increased wave attack. The Fort Bragg Headlands are fairly resistant to erosion from wave action and sea level rise, due to their rocky base. A geotechnical study completed for the Mill Site in 2009, determined that bluff erosion has occurred at an average rate of about 1 to 2 inches per year over the past 95 years. The report also found that most of the upper bluff erosion that has taken place was due to runoff from the many hard surfaces of the site. Thus the removal of asphalt and other impervious surfaces along the bluff edge and replacement with the coastal trail and a system of berms and swales has virtually illuminated bluff erosion on the Mill Site.

However the erosion of dams such as the Pudding Creek Dam and the Beach Berm may expose previously protected areas to sea water flooding and further erosion.

Please see appendix 1 to review detailed photos of the Mill Site illustrating the unlikely H++ scenario and corresponding areas vulnerable to sea level rise related erosion. As previously noted most of the Mill Site is located on bluff tops which range from 40 feet to 60 feet in elevation. Impacts of H++ scenario are limited to the beach berm and the Noyo Beach dredge spoils site.

STEP 5: ADAPATION PATHWAYS TO INCREASE RESILIENCY TO SEA-LEVEL RISE

The State of California Sea Level Guidance provides eight Sea level Rise planning and adaptation recommendations as follows:

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

Staff recommends the following adaptation strategies to address these recommendations and the assets at risk in Fort Bragg from Sea Level Rise.

4. POLICY RECOMMENDATIONS

Policy SLR 1.1 - Planning for Noyo Harbor SLR Resilience. Work with the County of Mendocino to improve harbor resilience to Sea Level Rise and discourage long term investment after 2100, through the following activities:

1. Analysis the feasibility of establishing an alternative access road to the North Harbor; and
2. After the year 2100 consider a moratorium on new water and sewer connections in the North Harbor to discourage future development; and
3. Consider rezoning portions of the Urban Reserve on the Mill Site with “Ocean Dependent” zoning, to provide an upland area suitable for harbor activities such as fish processing, boat building, etc.

Policy SLR 1.1 – Collaborations for Noyo Harbor for SLR Resilience. On a regular basis, work with Mendocino County and resource agencies to establish collaborative approaches to develop adaptive strategies to address the effects of Sea Level Rise in the Noyo Harbor.

Policy SLR 2.1 – Water Supply SLR Resilience. When considering upgrades to the Noyo River fresh water intake and/or pumping station, consider the cost benefit analysis of the project location given predictions of future sea level rise. Consider and explore fresh water pumping locations further up the river, if the combination of sea level rise and low flows on the Noyo will result in a compromised water supply within the life expectancy of the proposed improvement.

Policy SLR 3.1 – Mill Site Lowland Area Project Review for SLR. Consider the effects of long term SLR (150 year time horizon) and project life expectancy for all projects located within the Lowland Area of the Mill Site, including projects related to creek daylighting, mill pond dam removal or stabilization, beach berm stabilization or removal, trail access, infrastructure improvements, etc.

Policy SLR 4.1 – Ocean Lake Senior Housing Resilience. Consider the effects of sea level rise and the risks associated with periodic flooding of Ocean Lake when considering proposals for new development at this location.

N 2,294,000

N 2,292,000

N 2,290,000

N 2,288,000

Glass Beach

Fort Bragg Landing

log retaining wall

Ponded

Soldier Point

'blow-hole'

Noyo Bay Beach

PILE

DENSE BRUSH

MARSH

W/L 62.3

W/L 40.7

W/L 40.8

W/L 52.9

U/C

GNV

LEGEND

Qm Historic, man-placed deposits

- mpf — Historic, man-placed fill with debris
- rr — Historic, man-placed rip-rap (large rocks and concrete)
- pc — Historic poured concrete structure
- d — Historic man-placed debris
- rd — Historic iron oxide-cemented debris

Qe Historic erosion area, generally within man-placed fill and terrace deposits

Qb Holocene beach deposit - unconsolidated sand, cobbles and boulders

Qt Pleistocene terrace deposits-poorly consolidated sand, silt, gravel and clay

TKf Tertiary - Cretaceous Franciscan Complex coastal belt-moderately to well consolidated sandstone, shale and minor volcanic rocks (undifferentiated)

Geologic contact, dashed where uncertain

75 — Strike and dip of bedding (degrees from horizontal)

Strike of vertical bedding

Inactive fault, dotted where concealed (P-potentially active)

Seepage area

100 — Recommended trail easement width

REFERENCE:
Undated Topographic map furnished by TRC.

NORTH

APPROXIMATE SCALE (FEET)
0 100 200 400

BACE Geotechnical
a division of
Brunsing Associates, Inc.
(707) 838-0780

Job No.: 11886.1
Appr.:
Date: 9/29/04

SITE GEOLOGIC MAP
GEORGIA - PACIFIC BLUFFS
90 W. Redwood Avenue
Fort Bragg, California

PLATE 2