

C-SMART ASSET PROFILES

PARCELS & BUILDINGS

Asset Profile: Parcels & Buildings

Properties and the buildings on them are significant assets along the Marin coast that provide for homes, goods and services providers, public facilities, worship, education and the ability to create equity and income in some cases. While a majority of the parcels feature buildings, many others are agricultural or natural in use and have unique vulnerabilities (see Working Lands and Natural Resources Profiles). The first threats to buildings will likely be the drinking water and disposal systems these buildings depend on (see Utilities Profile). In addition, road closures could prevent needed access to and from homes, schools, businesses, and public open spaces (see Transportation Profile). Ultimately, in low lying coastal locations, the structures themselves will likely face severe storm damage, and, eventually, near daily flooding at high tides.

As exposed buildings and land become increasingly vulnerable, property owners will be faced with deciding how to respond. The following are general key issues related to building vulnerability:

- Almost all buildings along Marin’s open coast are vulnerable to storms, though some property owners are at higher risk due to construction materials, elevation, and location over or directly bordering waterways, and subject to forces of moving water (FEMA A and V zones) (see
- According to utility managers, the earliest threats of flood damage may be to non-structural building component such as utility and mechanical systems and equipment at or below grade. Malfunctions could make a home unlivable.
- According to Stinson Beach and Bolinas asset managers, oceanfront and bluff properties are subject to erosion, and have seen erosion impacts and restructuring expenses in the past.
- Properties untouched by rising ocean water may still become isolated and cut off from essential services and access routes could be compromised if roads become flooded, blocked with mudslides, or wash out).
- A few public facilities, including Stinson Beach Fire Station No. 2, are vulnerable in the near to medium-term. Most others, such as the post offices in Inverness and Bolinas, are vulnerable nearing the end of the century.

IMPACTS AT-A-GLANCE

1,100 homes, businesses, & institutions	3,000 people
Storm and tidal impacts already occur	Regional
Billions of dollars’ worth of built assets exposed	Property Owners County CDA



Pier-based buildings on Wharf Road, Bolinas. Credit: Wong

Table 7. Exposed Parcels & Buildings by Scenario

	Parcels		Buildings	
	#	%	#	%
Scenario 1	824	16%	372	8%
Scenario 2	1,046	20%	588	10%
Scenario 3	1,085	21%	680	11%
Scenario 4	1,150	21%	853	14%
Scenario 5	1,298	25%	1,076	18%

Source: Marin Map, OCOF

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Throughout the study area, nearly 1,300 parcels (25 percent of all parcels) and 1,100 buildings, (20 percent of all buildings), could be exposed to average higher high tide flooding or storm flooding at 80 inches of sea level rise with a 100-year storm, the high end of the long-term scenarios. At the low end of the long-term scenarios, 40 inches with a 20-year storm, about 15 percent of all homes in Stinson Beach are exposed, and around 10 percent are affected in the near- and medium-term scenarios (scenarios 1-3). All coastal communities have public and private properties that could be impacted by sea level rise, increased storm surges, higher water table, sub-surface saltwater intrusion, beach erosion, high winds, waves, and several others to bluff erosion. These threats could damage the structural integrity of buildings and the land they rest on.

Table 8 breaks down the exposed residential and commercial parcels for Scenarios 1 (near-term), 3 (medium-term), and 5 (long-term, high end) by number and percent of the total within that community. By far, a majority of the parcels are residential. However, ten to twenty percent of residential parcels, and twenty to just over thirty percent of commercial parcels on the Marin coast are exposed under these scenarios. In this regard, a twenty to thirty percent loss of existing parcels would be significant across both land uses. At the

community scale, Stinson Beach has the highest number of residential parcels exposed across all three scenarios with nearly half of the parcels west of Shoreline Highway exposed in the short-term and nearly all in the mid-term (scenario 3). Of note, the Seadrift Association owns 26 potentially exposed parcels on the spit of Stinson Beach. The East Shore and Inverness are next, with a majority of the exposed buildings located on or between Tomales Bay and the main road. By percentage, the East Shore could see the greatest proportion of impacted residential and commercial parcels across all scenarios.

In the overall study area,, approximately 241 residential and 5 commercial parcels do not have structures and are less vulnerable than those with structures and active uses. Note however, this may not be as straightforward with agricultural parcels where often unimproved land is used for production. For information on the agricultural parcels see the Working Lands Profile. For more information on parks and open lands, see the Recreation Profile.

Residential parcels include multi-family and single-family housing. Overall, there are 28 multi-family parcels with 71 living units, and 706 single family parcels with 710 living units. Across both, there is likely a mix of owner-occupied and rental units, especially given the large portion of vacation rentals in West Marin.

Table 8. Exposed Parcels by Community and Land Use

	Scenario 1				Scenario 3				Scenario 5			
	Residential		Commercial		Residential		Commercial		Residential		Commercial	
	#	%	#	%	#	%	#	%	#	%	#	%
Stinson Beach	295	36%	6	21%	556	68%	6	21%	566	69%	6	21%
Bolinas	27	2%	1	7%	53	5%	4	27%	94	8%	13	87%
Inverness	38	3%	7	37%	72	6%	8	42%	108	9%	10	53%
Pt. Reyes Station	9	2%	3	8%	11	3%	3	8%	30	8%	4	11%
East Shore	66	49%	9	90%	105	78%	9	90%	114	84%	10	100%
Dillon Beach	0	0%	1	4%	1	0%	1	4%	6	1%	3	10%
TOTAL	435	10%	27	20%	798	19%	31	23%	918	22%	46	33%

Source: Marin Map Parcel Layer Land Use Description 2014

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Exposed government facilities include: Inverness and Bolinas Post Offices, Bolinas-Stinson school sites, Bolinas and Stinson Libraries, Bolinas Lift Station, and Stinson Fire Station No. 2. The Audubon Canyon Ranch facilities also have vulnerable farm buildings (offices, research, and education facilities).

Most of the buildings in the coastal zone are wooden single-story or two-story buildings, and are susceptible to water damage from flooding and structural damage from wind and waves. Buildings built prior to 1970 typically have T-footing foundations that extend 18 inches deep. Such buildings are prone to scouring from water hitting above their foundations, and their wooden floors are more likely to slide off the foundation. Older buildings in downtown Bolinas feature these foundation types. Homes built after 1970, most common in Stinson Beach, are secured to drilled piles 20-30 feet deep with reinforced steel cages and concrete to connect the homes to the foundation. These buildings are engineered to resist settling and earthquake impacts, and could withstand lateral forces from water and wind during storms. The majority of exposed buildings were built after 1980, with concentrations of older buildings in Downtown Bolinas and a few in Stinson Beach and Inverness. Many of the exposed buildings in Inverness and Marshall are on pier foundations or directly on the shoreline.



Sedrift neighborhood, Stinson Beach. Credit: CDA

Table 9. Physical Vulnerabilities of Buildings

Factors	Influence
Elevation	<ul style="list-style-type: none"> At or Below Grade – If the lowest floor is as high as or below the flood level, it is susceptible to water and salt. Mechanical or electrical equipment, pumps, utilities, heat, ventilation, power, openings (e.g. windows, entryways, or ventilation grates), etc. can be vulnerable if at or below grade.¹ Bluff top developments are highly vulnerable to erosion and scouring of the bluff toe.
Materials	<ul style="list-style-type: none"> Wooden buildings tend to be lighter and low-rise, and can incur structural damage.^{2, 3} Cinder block, brick, and reinforced concrete built buildings are heavier, taller, and less vulnerable to damage.⁴ Brick foundations are able to withstand up to 3 feet of flooding (highly unlikely unless building is very old).⁵ Mobile and manufactured homes tend to be susceptible to flooding and may suffer in storm and high tide events.
Building Codes	<ul style="list-style-type: none"> Buildings built before modern building codes and FEMA requirements for flood prone areas will be more susceptible.⁶
Surrounding environment	<ul style="list-style-type: none"> Buildings in areas without or failing coastal armoring are more vulnerable.

¹ The City of New York, *A Stronger, More Resilient New York* (2013), 75.

² Ibid.

³ Bay Conservation and Development Commission, *Housing Indicators Table*. Unpublished document.

⁴ The City of New York, *A Stronger, More Resilient New York* (2013), 75.

⁵ Bay Conservation and Development Commission, *Housing Indicators Table*. Unpublished document.

⁶ The City of New York, *A Stronger, More Resilient New York* (2013), 76.

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Many, though not all, cement foundation homes have an 18 inch crawl space containing electrical wires, pipes, mechanical ducts, and furnaces that could become flooded and trap debris. Additionally, septic leach fields could shrink and change chemical requirements as salt water saturates the sand. Disrupted access to drinking water could also reduce a building's functionality.

Commercial structures, except for those on piers, and a few other wooden structures, tend to be cinder block construction with stucco or paint sealing. Cinder block buildings built over twenty years ago are likely unreinforced and more vulnerable than newer reinforced buildings. Forty-two commercial parcels contain structures amounting to approximately 40 buildings with businesses and 29 living units. Vulnerable businesses are concentrated in downtown Bolinas (Bolin Market, Smileys Schooner Saloon and Hotel), and the shores of

Tomales Bay in Inverness (Brock Schreiber Boat House) and Marshall (East Shore; Hog Island Oyster, Tomales Bay Oyster, Marshall Boat Works, Tony's Restaurant).

Exposed government facilities include: Inverness and Bolinas Post Offices, Bolinas-Stinson school sites, Bolinas and Stinson Libraries, Bolinas Lift Station, and Stinson Fire Station No. 2. The Audubon Canyon Ranch facilities also have vulnerable office and research buildings.

Table 10 lists some of the vulnerable buildings, and the parcels they rest on, in the study area. This list shows onset and tidal mean higher high water (MHHW) and any additional extreme event flood depths for groups of buildings, and in some cases specific buildings were assessed. This list is not exhaustive of all the buildings that could be exposed to sea level rise and storm impacts in the study area.

Table 10. Building Assets Ranked by Onset and Flood Depth

Community	Asset (not exhaustive)	Tidal & Extreme Event Flooding Depth Estimates (Underlined values indicate daily tidal flooding at mean higher high water (MHHW) based on one geographic point placed at the landward limit of the first scenario where it overlaps the asset. Values not underlined represent temporary extreme event flooding. For groups of buildings, a maximum is provided.)					Vulnerability TF: Temp. Flooding during extreme events; I: Inundated at MHHW; E: Erosion; WS: Wave Surge; HW: High Wind
		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	
Stinson Beach	Patios and Calles Buildings	<u>10"</u> +1'4"	<u>10"</u> +6"3"	<u>1'6"</u> + 7'	<u>4'9"</u> +5'10"	<u>6'5"</u> + 6'8"	I, WT, WS, TF, E
Inverness	Inverness Yacht Club	<u>3'2"</u>	<u>4'1"</u>	<u>4'11"</u>	<u>6'10"</u>	<u>10'1"</u>	I, WS, HW
Inverness	Brock Schreiber Boathouse	<u>2'7"</u>	<u>3'6"</u>	<u>4'</u>	<u>5'10"</u>	<u>9'2"</u>	I, E
East Shore	Hog Island Oyster	<u>2'1"</u>	<u>2'1"</u>	<u>2'10"</u>	<u>4'10"</u>	<u>8'1"</u>	I
Inverness	Shoreline Buildings	<u>2'+1'2"</u>	<u>2'+2'</u>	<u>2'10"</u> +2	<u>4'8"</u> +2'	<u>8'+8'8"</u>	I, WT, WS, TF
East Shore	Shoreline Buildings	<u>1'9"</u> +1'	<u>1'9"</u> +1'11"	<u>2'6"</u> +2'	<u>4'3"</u> +2'2"	<u>7'8"</u> +2'2"	I, WT, WS, TF
Stinson Beach	Sadrift Buildings	<u>2'5"</u>	<u>4'11"</u>	<u>4'10"</u>	<u>3'4"</u> +8'3"	<u>6'1'</u> + 5'9"	I, WT, WS, TF, E
Bolinas	Downtown Buildings	<u>1'8"</u> +1'5"	<u>1'8"</u> +2'2"	<u>2'7"</u> +2'	<u>4'5"</u> +2'1'	<u>7'9"</u> +1'7"	I, WT, WS, TF
East Shore	Tony's Restaurant	<u>8"</u>	<u>1'8"</u>	<u>2'6"</u>	<u>4'5"</u>	<u>7'9"</u>	I
East Shore	Tomales Bay Oyster Company	<u>8"</u>	<u>1'5"</u>	<u>2'3"</u>	<u>4'1"</u>	<u>7'5"</u>	I, TF
Stinson Beach	Water District Office	<u>7"</u>	<u>3'3"</u>	<u>4'8"</u>	<u>6'6"</u>	<u>8'8"</u>	TF, I
Dillon Beach	Lawson's Landing Facilities	<u>2"</u>	<u>1'1"</u>	<u>2'11"</u>	<u>3'10"</u>	<u>7'3"</u>	I, E, WS, HW
Bolinas	Historic District		<u>3'10"</u>	<u>4'8"</u>	<u>6'4"</u>	<u>10'</u>	I, E
Dillon Beach	Bluff-top buildings	X	X	X	X	X	E

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Community	Asset (not exhaustive)	Tidal & Extreme Event Flooding Depth Estimates (<u>Underlined values</u> indicate daily tidal flooding at mean higher high water (MHHW) based on one geographic point placed at the landward limit of the first scenario where it overlaps the asset. Values not underlined represent temporary extreme event flooding. For groups of buildings, a maximum is provided.)					Vulnerability TF: Temp. Flooding during extreme events; I: Inundated at MHHW; E: Erosion; WS: Wave Surge; HW: High Wind
		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	
Bolinas	Bluff-top buildings	X	X	X	<u>X</u>	<u>X</u>	E
Muir Beach	Bluff-top buildings	X	X	X	<u>X</u>	<u>X</u>	E
Stinson Beach	Fire Station #2		3'6"	5'3"	6'10"	<u>9'1"</u>	I, TF, WT
East Shore	Inn on Tomales Bay		2"	11"	<u>2'10"</u>	<u>5'5"</u>	I
Bolinas	Sewage Lift Station			3'3"	<u>5'</u>	<u>8'7"</u>	TF, I
Inverness	Inverness Store			2'5"	<u>4'4"</u>	<u>7'6"</u>	TF, I, WT
Bolinas	Bolinas Super Market			8"	<u>2'6"</u>	<u>6'1"</u>	I, E, SI
Inverness	Motel Inverness				<u>2'9"</u>	<u>5'10"</u>	I, WS, HW
East Shore	Nick's Cove				<u>2'6"</u>	<u>5'10"</u>	
East Shore	Historic District				<u>2'5"</u>	<u>4'5"</u>	I
Inverness	Historic District				<u>2'1"</u>	<u>5'1"</u>	TF
Bolinas	Bolinas Library				1'8"	<u>5'3"</u>	I, TF
Bolinas	Bo-Gas Station				1'7"	<u>5'3"</u>	I
Bolinas	Gospel Flats				1'7"	<u>5'3"</u>	I, WT, SI, TF
Bolinas	Community Center Emergency Shelter				1'7"	<u>5'2"</u>	I, E
Bolinas	Community Land Trust Housing				1'2"	<u>4'10"</u>	I
Bolinas	Church: Calvary Presbyterian					<u>5'10"</u>	I, TF
Inverness	Tomales Bay Resort					<u>4'</u>	TF
Inverness	Inverness Post Office Building					<u>3'7"</u>	TF, I, WS, E
Bolinas	Bolinas People's Store					<u>3'</u>	I, TF
Bolinas	Bolinas Post Office					2'9"	TF, I
Bolinas	Bolinas Stinson School					2'2"	I, TF, E, WS
Pt. Reyes Station	Buildings along Lagunitas Creek					<u>1'8"-3'2"</u>	TF, I

Source: Marin Map, OCOF Exposure and Flood Depth data, Asset Manager Interviews

If a structure is purchased using a federally-backed loan, the owner is required to maintain flood insurance through FEMA to provide financial relief to recover from damages caused during storm events. To meet FEMA requirements, homes in FEMA mapped flood zones (Flood Insurance Rate Maps or FIRMs) are required to meet construction standards, to reduce flood risks and impacts. FEMA designates two flood zones that define the building

requirements that one needs to meet for new or substantially rebuilt structures. The v-zone is characterized by high velocity waves over 3 feet. The a-zone has smaller waves and less flooding under the 1% annual exceedance probability (AEP)⁷

⁷ Since hurricane Katrina, agencies changed to Annual Exceedance Probability from the year based flood description, for example "100-year flood." The latter has misled people to

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flow. Homes that do not meet these requirements pay more for their annual flood insurance premiums. Over the years, requirements have changed; therefore homes on the coast are built to the varying standards. Nevertheless, with storms combined with sea level rise, homes that meet current standards could become vulnerable because FEMA standards are based on historic trends and do not incorporate future sea levels.

Several homes in Stinson Beach are subject to the FEMA requirements and have flood insurance with a maximum claim of \$250,000. Only a handful of homes are raised and constructed to meet the FEMA v- and a-zone requirements. Based on data provided by FEMA, approximately 26 repetitive loss properties exist on the outer coast.⁸ The overall unincorporated Marin County total is 78 repetitive loss properties.⁹ Major storms may result in unaffordable claims for flood damages, as has already happened during recent storms on the East Coast. FEMA will likely continue to raise flood insurance premiums, may start limiting payouts, and strengthen their construction standards in response.

Table 11 provides estimates for the cost of damages to buildings and their contents according to the FEMA scale used in post-disaster assessments (assuming every building exposed in Scenario 5 suffers the same amount of damage).¹⁰ According to the *Structure Debris Estimates: Hazus Level 1 Flood and Wind Losses*,¹¹ building damage is assigned as:

- Yellow Tag
 - Affected: Full Verified Loss (FVL) is \$0 to \$5,000, or water depth greater than 0 to 2 feet (2.05 tons of debris per 1,000 square feet)
 - Minor: FVL is \$5,001 to \$17,000, or water depth greater than 2 to 5 feet (4.1 tons of debris per 1,000 square feet)

interpret that such a storm only should happen once every 100 years when, in fact, it is a flood that has a 1% probability of happening in any given year and a 30% chance of happening over the course of a 30-year mortgage. (See Methods for more details).

⁸ Defined by FEMA as “a property for which two or more flood insurance claims of more than \$1,000 have been paid within any 10-year period since 1978”

⁹ Flood insurance is required for all federally backed home mortgages.

¹⁰ ArcGIS. FEMA Modeling Task Force (MOTF)-Hurricane Sandy Impact Analysis. Last update June 22, 2015. <http://www.arcgis.com/home/item.html?id=307dd522499d4a44a33d7296a5da5ea0>

¹¹ Federal Emergency management Agency (FEMA) Website. Hazus. Last updated July 8, 2015. <http://www.fema.gov/hazus>

- Orange Tag: FVL greater than \$17,000 or water depth greater than 5 feet (8 tons of debris per 1,000 square feet).
- Red Tag: Destroyed as defined by the FEMA inspector.

To determine how many buildings could face storm hazards strong enough to destroy the building, FEMA v-zone criteria for flood depth and wave velocity was assessed for each building under the sea level rise and storm scenarios. Table 12, shows how many buildings could see destructive forces.

Table 13 provides monetary figures for buildings that would be exposed to hazardous conditions, meaning that they could be destroyed in a severe storm. Over \$250 million in assessed building (improvement) value could occur at the scenario 5 sea level of 80 inches and a 100-year storm. And once a home cannot be safely rebuilt, the land assessment value will also decline. Market values would be impacted in similar ways, though at much higher potential losses.

Figure 7. FEMA Guidelines for Construction in Flood Zones

	A ZONE		V ZONE
FLOOD PROTECTION STRATEGY	DRY FLOOD-PROOFING WATERTIGHT STRUCTURE e.g. FLOOD SHIELDS	WET FLOOD-PROOFING WATER TO RUN IN/RUN OUT e.g. FLOOD VENTS	ELEVATED STRUCTURE VIRTUALLY OPEN STRUCTURE e.g. OPEN LATTICE BREAKAWAY WALLS
GROUND FLOOR CONFIGURATION	<p>FLOOD SHIELDS PREVENT WATER FROM ENTERING</p> <p>NON-RESIDENTIAL SPACE ONLY</p> <p>LOWEST OCCUPIED FLOOR ALLOWED TO BE EXCAVATED BELOW GRADE. NOT PERMITTED FOR ENTIRELY RESIDENTIAL BUILDINGS</p>	<p>LOWEST OCCUPIED FLOOR TO BE AT OR ABOVE DESIGN FLOOD ELEVATION</p>	<p>OPEN LATTICE BREAKAWAY WALL</p> <p>VERTICAL FOUNDATION MEMBER</p> <p>BOTTOM OF LOWEST STRUCTURAL MEMBER TO BE AT OR ABOVE DESIGN FLOOD ELEVATION</p>
PERMITTED USE BELOW DFE	<ul style="list-style-type: none"> ✓ PARKING ✓ ACCESS ✓ STORAGE ✓ NON-RESIDENTIAL ✗ RESIDENTIAL 	<ul style="list-style-type: none"> ✓ PARKING ✓ ACCESS ✓ STORAGE ✗ NON-RESIDENTIAL ✗ RESIDENTIAL 	<ul style="list-style-type: none"> ✓ PARKING ✓ ACCESS ✓ STORAGE ✗ NON-RESIDENTIAL ✗ RESIDENTIAL

Source: *The City of New York, A Stronger, More Resilient New York (2013), 75.*

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Table 11. FEMA Damage Levels Applied to Buildings in SLR Scenario 5

	Buildings	Yellow Tag-Minor (\$5,000-17,000)	Orange Tag \$17,001+	Red Tag (County assessed improvement value)
Stinson Beach	660	\$3,070,000-10,438,000	\$10,438,001+	\$220,778,456
Bolinas	98	\$490,000-1,666,000	\$1,666,001+	\$23,114,950
Inverness	75	\$375,000-1,275,000	\$1,275,001+	\$10,155,532
East Shore	163	\$840,000-2,856,000	\$2,856,001+	\$18,035,996
Pt. Reyes Station	36	\$180,000-612,000	\$612,001+	\$5,480,520
Dillon Beach	5	\$50,000-85,000	\$85,001+	\$282,597
TOTAL	1,037	\$5,105,000-17,357,000	\$17,357,001+	\$293,856,687

Source: FEMA Hazuz applied to Marin Map and OCOF

Table 12. Buildings Potentially Facing Hazardous Conditions

	Scenario 1		Scenario 2		Scenario 3		Scenario 4		Scenario 5	
	#	%	#	%	#	%	#	%	#	%
East Shore	43	13%	59	18%	61	18%	56	17%	125	38%
Stinson	27	2%	48	4%	89	8%	239	21%	582	51%
Bolinas	3	<1%	6	<1%	15	1%	25	1%	98	5%
Inverness	4	<1%	4	<1%	4	<1%	14	1%	36	2%
Pt. Reyes Station									36	4%

Source: Marin Map, OCOF

Table 13. Assessed Value for Land and Improvements Exposed to Hazardous Conditions in Scenario 5

	Parcels	Land Assessment Value ^a	Improvement Assessment Value ^a	Total
Bolinas	61	\$13,074,598	\$14,781,273	\$27,855,871
East Shore	87	\$18,261,732	\$15,209,504	\$33,471,236
Inverness	45	\$14,437,134	\$10,884,967	\$25,322,101
Muir Beach	1	\$34,300	\$0	\$34,300
Pt. Reyes Station	14	\$2,370,960	\$2,229,076	\$4,600,036
Stinson Beach	492	\$403,489,417	\$217,439,909	\$620,929,326
Total	700	\$451,668,141	\$260,544,729	\$712,212,870

Source: Assessor Data 2014/2015 Tax Year

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Table 14. Buildings Vulnerable to Accelerated Erosion

	Bluff top Erosion (Muir Beach, Bolinas, Dillon Beach)	Shoreline Erosion (Stinson Beach)	Total
Scenarios 1&2*	60	0	60
Scenario 3*	143	5	148
Scenario 4*	332	51	383
Scenario 5*	435	284	719

* This analysis does not include storms. Source: Marin Map, OCOF

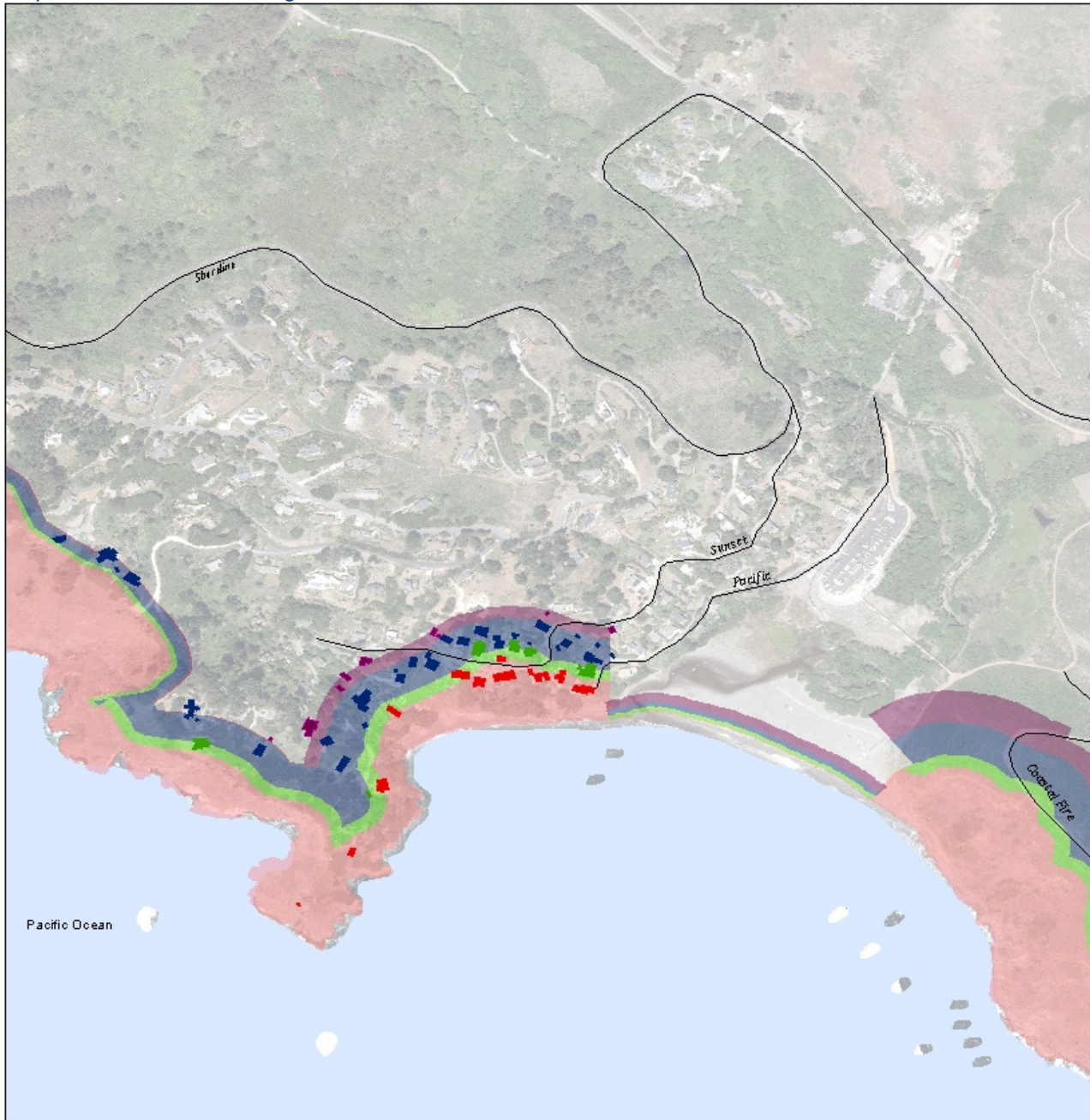
In addition to damage from flooding and storms several bluff top homes could be vulnerable to accelerated erosion, or erosion rates that take in to account higher sea levels. Nearly 450 additional buildings could be impacted at the high end of the long-term scenarios, scenario 5, as seen in [Table 14](#). Note that this analysis only use the sea level component, and not the storms, of each scenario.

The following maps highlight the parcels and buildings that could be exposed to average higher

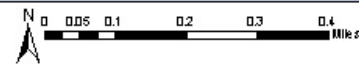
high tide and storm activity across the 5 scenarios. Maps also illustrate the additional buildings (typically residences) vulnerable to accelerated bluff erosion. The maps focus on the areas with the highest number of impacted properties including: Stinson Beach, Bolinas, Inverness, Pt. Reyes Station, and East Shore/Marshall (not Muir Beach nor Dillon Beach).

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Map 10. Muir Beach Buildings Vulnerable to Accelerated Erosion



Accelerated Erosion		Buildings Exposed	
 Scenarios 1 & 2	 Scenarios 1 & 2	 Scenario 3	 Scenario 3
 Scenario 4	 Scenario 4	 Scenario 5	 Scenario 5
	 Exposed Roads		

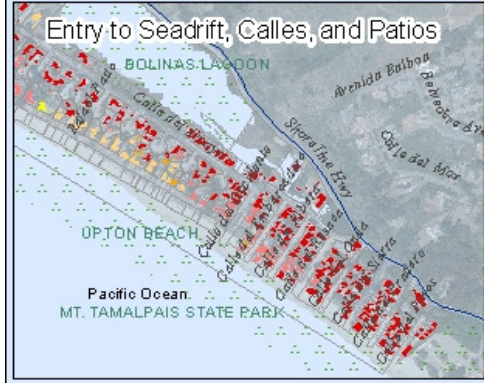
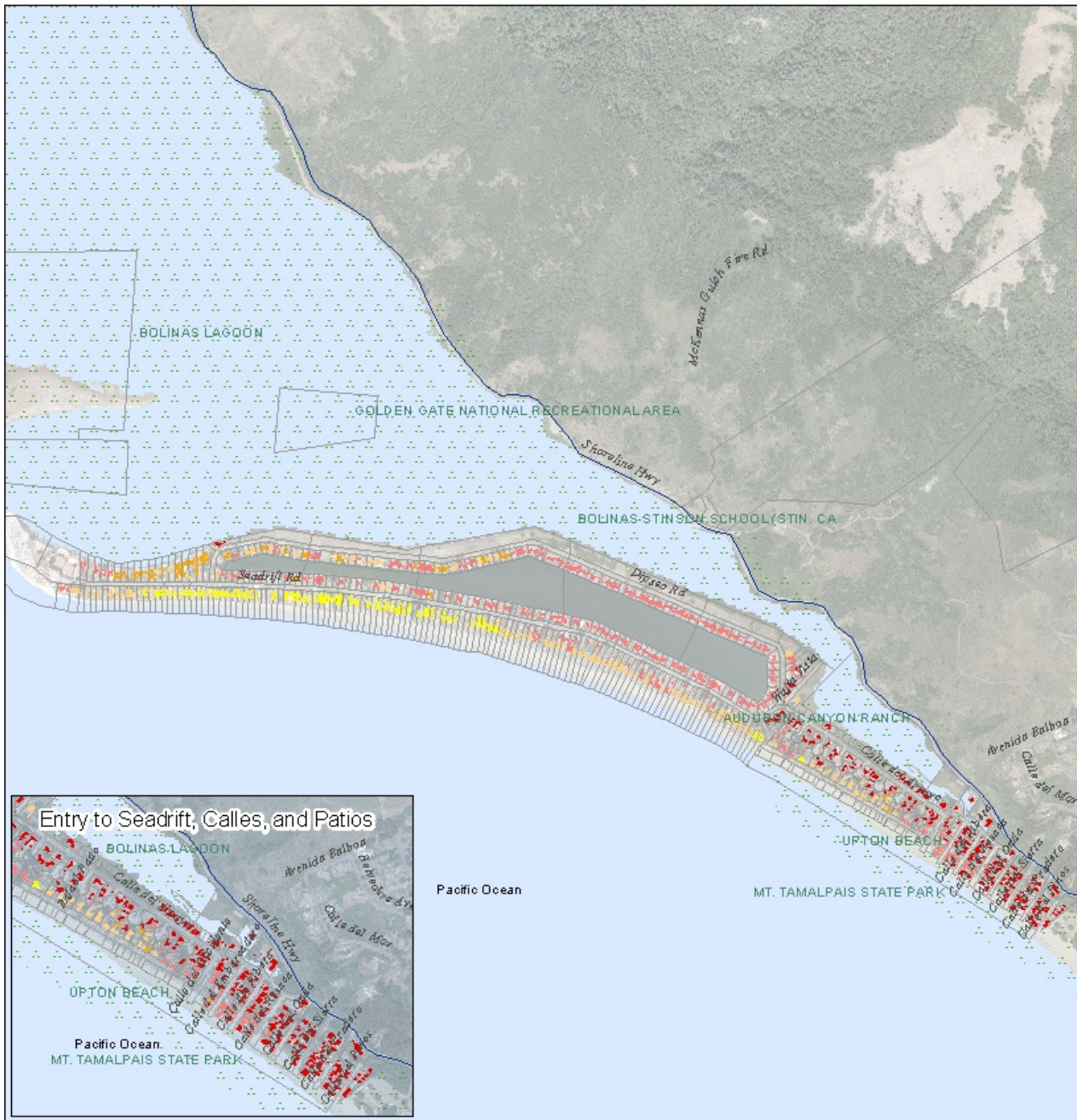


Source: Marin Map, Our Coast Our Future, CA Coastal Commission
 Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revisions. Local site conditions must be examined. Commercial use prohibited.

Date: 10/2/2015
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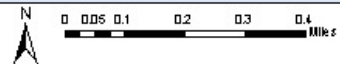
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Map 11. Stinson Beach Vulnerable Parcels & Buildings



Exposed Buildings

- Scenario 1
 - Scenario 2
 - Scenario 3
 - Scenario 4
 - Scenario 5
- Parcels
 - Park Parcels



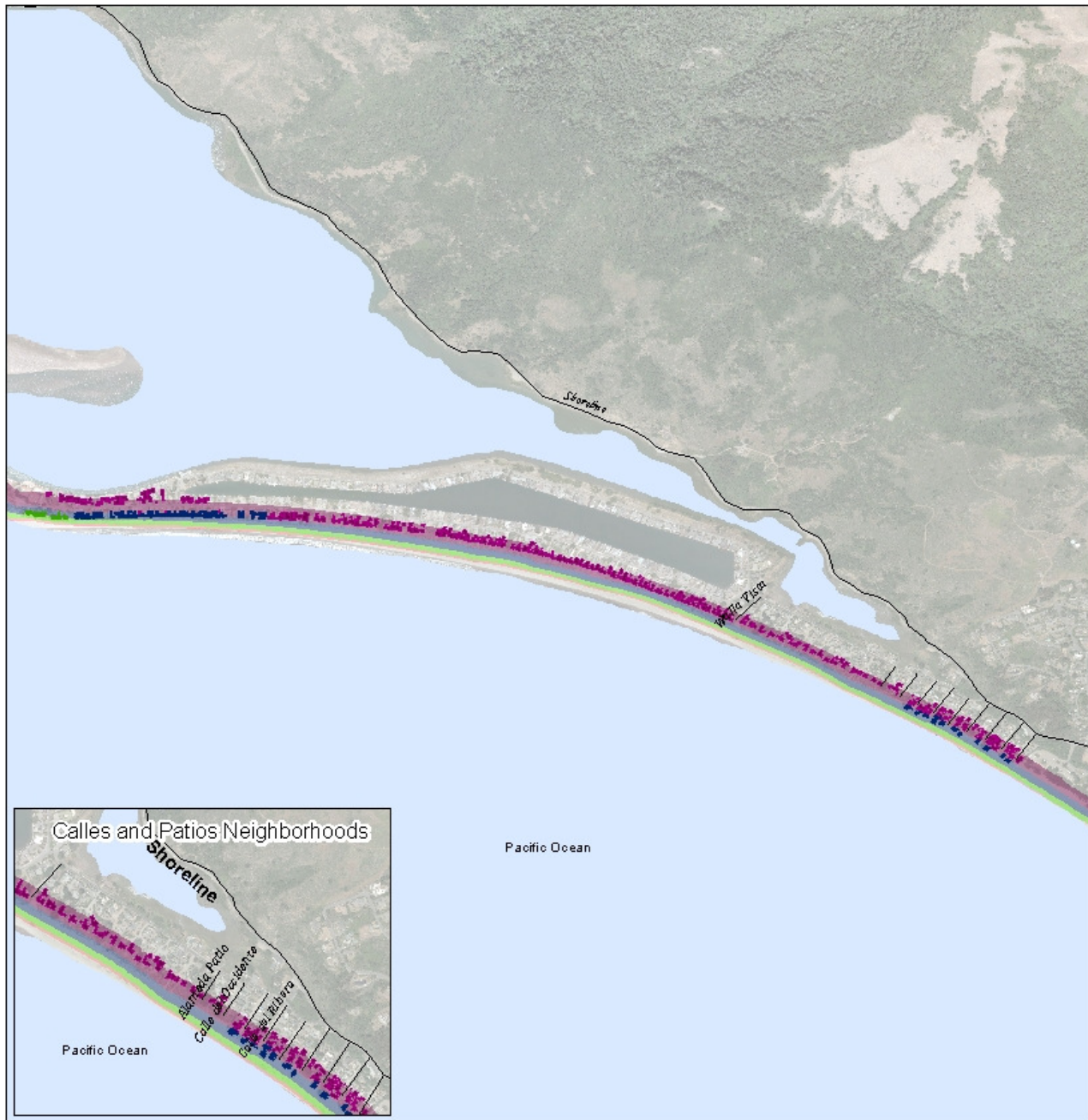
Source: Marin Map, Our Coast Our Future
 Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representations and are subject to the real world. Local site conditions must be examined. Commercial use is prohibited.


Date: 10/14/2015

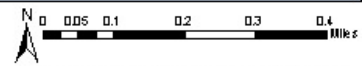


PARCELS & BUILDINGS

Map 12. Stinson Beach Buildings Vulnerable to Accelerated Erosion

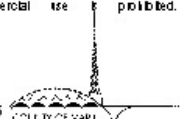


Accelerated Erosion		Buildings Exposed		
	Scenarios 1 & 2		Scenarios 1 & 2	 Exposed Roads
	Scenario 3		Scenario 3	
	Scenario 4		Scenario 4	
	Scenario 5		Scenario 5	



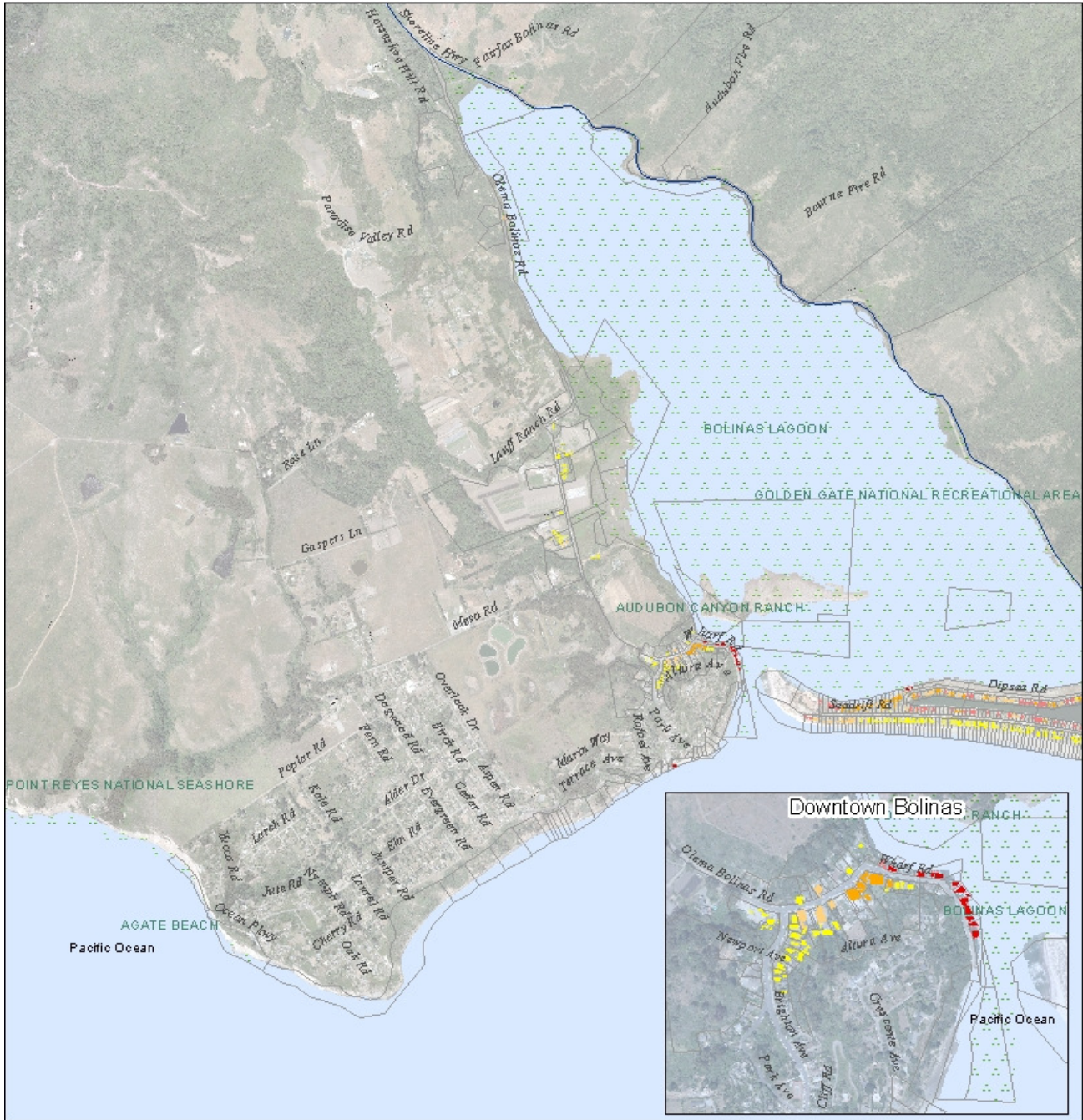
Source: Marin Map, Off-Coast Off-Fire, CA Coastal Commission
 Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use prohibited.

Date: 10/2/2015



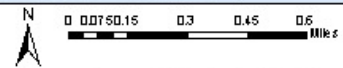
PARCELS & BUILDINGS

Map 13. Bolinas Vulnerable Parcels & Buildings



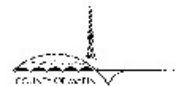
Exposed Buildings

- Scenario 1
 - Scenario 2
 - Scenario 3
 - Scenario 4
 - Scenario 5
- Parcels
 - Park Parcels



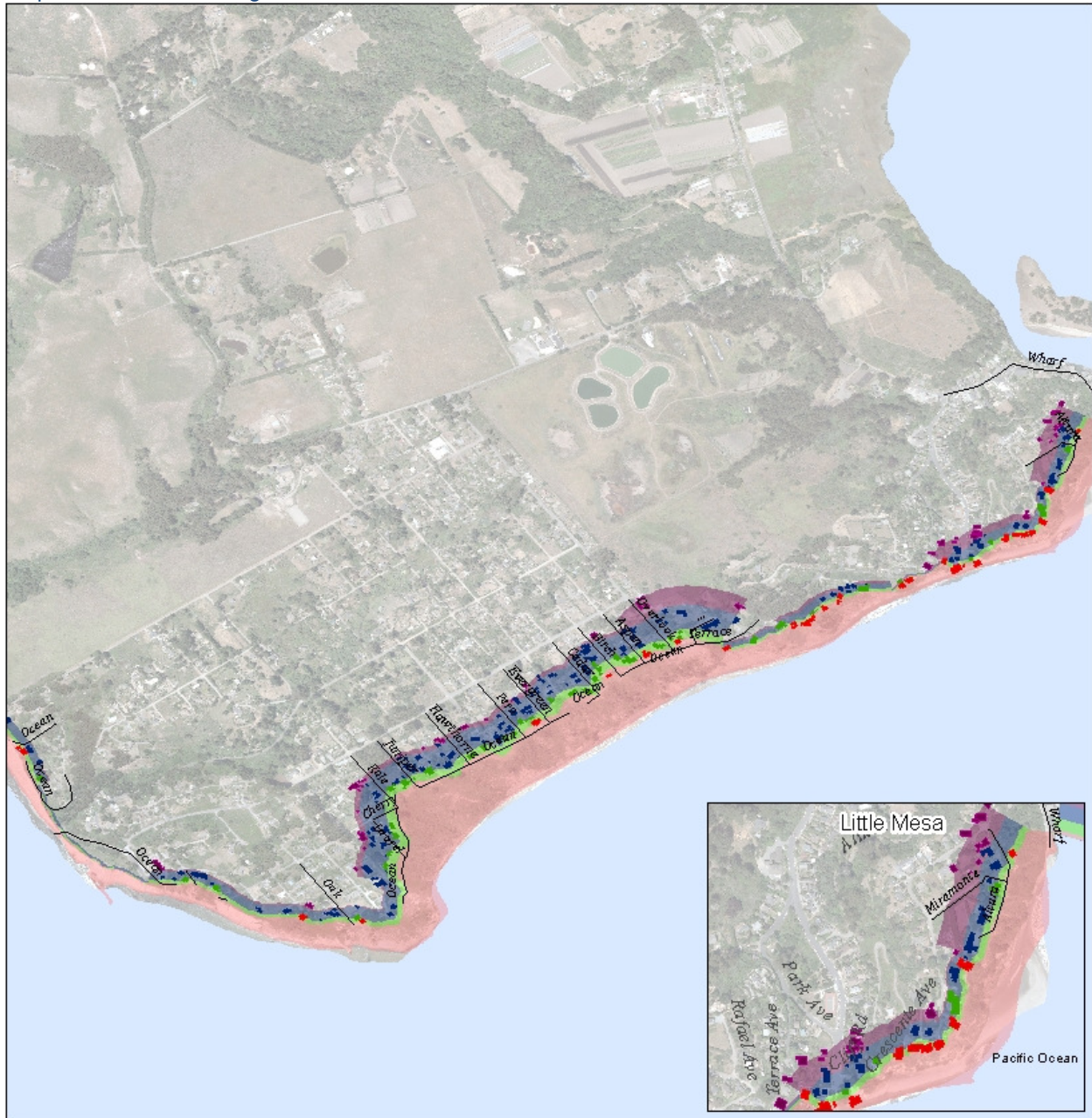
Source: Marin Map, Our Coast Our Future
 Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here, make no warranties of the accuracy or completeness of maps and data. Maps are for general informational purposes only and should not be used for legal or financial purposes. Local conditions must be examined. Commercial use is prohibited.

Date: 10/14/2015

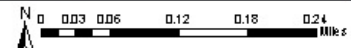


PARCELS & BUILDINGS

Map 14. Bolinas Buildings Vulnerable to Accelerated Erosion



Accelerated Erosion	Buildings Exposed	Exposed Roads
Scenarios 1 & 2	Scenarios 1 & 2	—
Scenario 3	Scenario 3	
Scenario 4	Scenario 4	
Scenario 5	Scenario 5	

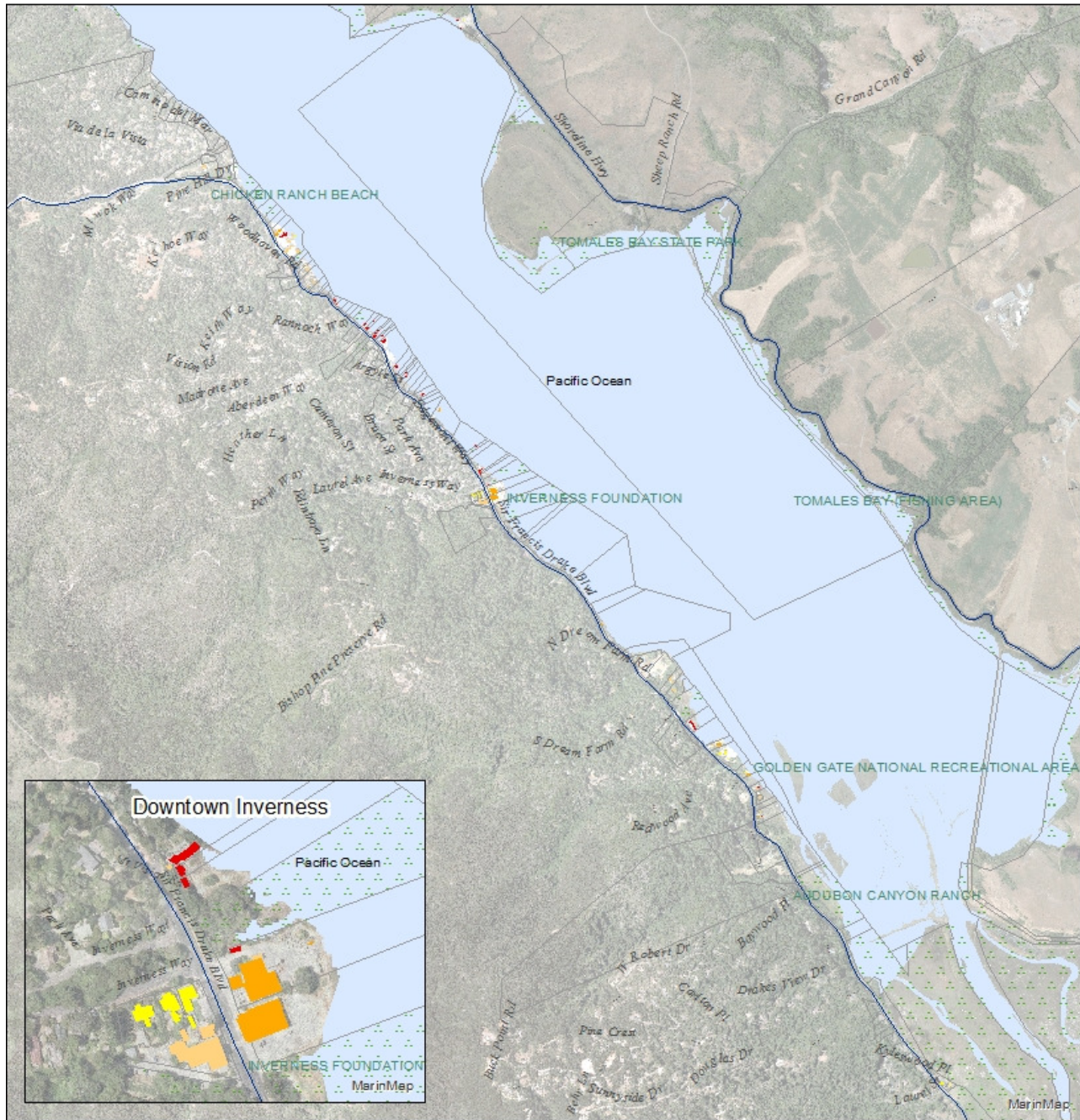


Source: Marin Map, Our Coast Our Future, CA Coastal Commission
 Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

Date: 10/2/2015

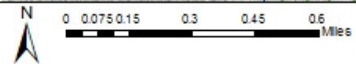
PARCELS & BUILDINGS

Map 15. Inverness Vulnerable Parcels & Buildings



Exposed Buildings

- Scenario 1
- Scenario 2
- Scenario 3
- Scenario 4
- Scenario 5
- Parcels
- Park Parcels



Source: Marin Map, Our Coast Our Future
 Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

Date: 11/2/2015



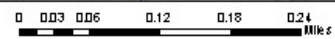
PARCELS & BUILDINGS

Map 16. Point Reyes Station Vulnerable Parcels & Buildings



Exposed Buildings

- Scenario 1
 - Scenario 2
 - Scenario 3
 - Scenario 4
 - Scenario 5
- Parcels
 - Park Parcels



Source: Marin Map, Our Coast Our Future
 Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here, make no warranties of the accuracy or completeness of maps and data. Maps are representative and subject to future revision. Local field conditions must be examined. Commercial use is prohibited.

Date: 10/14/2015



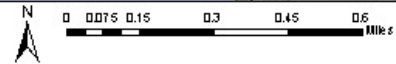
PARCELS & BUILDINGS

Map 17. East Shore Vulnerable Parcels & Buildings



Exposed Buildings

- Scenario 1
 - Scenario 2
 - Scenario 3
 - Scenario 4
 - Scenario 5
- Parcels
 - Park Parcels



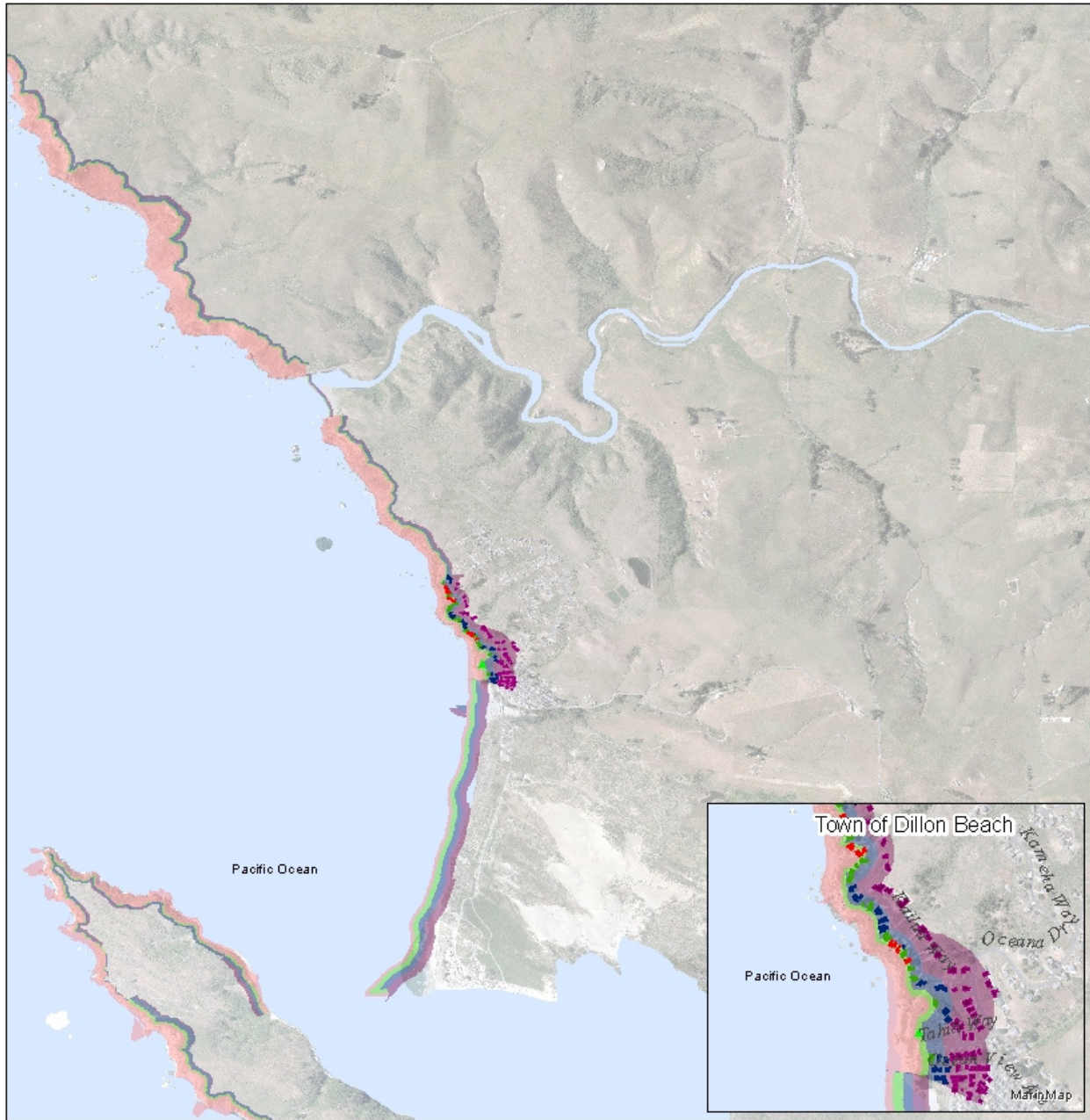
Source: Marin Map, Our Coast Our Future
 Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here, make no warranties of the accuracy or completeness of maps and data. Maps are representations and subject to future revision. Local conditions must be examined. Commercial use is prohibited.

Date: 10/14/2015

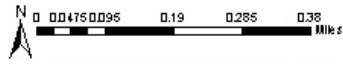


PARCELS & BUILDINGS

Map 18. Dillon Beach Buildings Vulnerable to Accelerated Erosion



Accelerated Erosion		Buildings Exposed	
 Scenarios 1 & 2	 Scenarios 1 & 2	Exposed Roads	
 Scenario 3	 Scenario 3		
 Scenario 4	 Scenario 4		
 Scenario 5	 Scenario 5		



Source: Marin Map, City Coastal Permit, CA Coastal Commission
 Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County and data providers herein make no warranties of accuracy or completeness of maps and data. Maps are representative and subject to future revisions. Local site conditions must be examined. Commercial use prohibited.

Date: 10/2/2015

PARCELS & BUILDINGS

Existing Policies

Coastal Act policies Sections 30210, 30240, and 30251 dictate that new development shall be safe from hazards and recognize that shoreline protective devices, such as seawalls may be appropriate in certain instances, to serve coastal-dependent uses or to protect existing structures or public beaches in danger from erosion. However, shoreline protective devices must be designed to eliminate or mitigate adverse impacts on the sand supply of surrounding natural shorelines. Other relevant Coastal Act policies include:

- Section 30210: Development shall not interfere with the public's right of access to the sea including the use of beaches.
- Section 30240: Environmentally Sensitive Habitat Areas (ESHA) shall be protected.
- Section 30251: The scenic and visual qualities of coastal areas shall be considered and protected as a resource of public importance.

The Board adopted Marin County Local Coastal Program (LCP) also contains policies to regulate development, particularly in areas vulnerable to environmental hazards. The Draft LCP Environmental Hazards policies are intended to "enhance the safety of residents and visitors in potentially hazardous areas, while allowing carefully designed and sited development to proceed" (Marin County DLCP C-EH-22.a.2, p. 40). The Environmental Hazards policies proposed by the County through its DLCP Amendment process have yet to be certified by the Coastal Commission and local stakeholders.

The County of Marin recently adopted higher regulatory standards than those established by both FEMA and MCC §23.09 for construction in the FEMA special flood hazard areas (SFHA). The Marin County Code refers to the California Residential Code (CRC), which requires construction in the FEMA special flood hazard areas to be 1 foot above the base flood elevations (BFE) with utilities above the lowest floor elevations, including freeboard. Marin County adopted the 2013 California Building Standards Code in 2013, and it became effective and enforceable in 2014.

Other Considerations

Economic

The more than 1,000 exposed properties, many with homes and businesses, account for \$7.2 million in annual tax revenue (Marin County total levy is about \$500 million) that could be impacted. As a portion of this, West Marin tourism generates nearly \$800,000 in transient occupancy taxes, which is 80 percent of the transient occupancy tax countywide. If vacation rentals sustain damages, this area could see a significant decline in tourism, impacting whole communities and economies, not just the owners or users of individual assets. The West Marin region accounts for millions of dollars in economic activity. Additionally, the study area's jobs and employment opportunities could diminish and compromise the viability of Marin's coastal communities as they exist today.

Table 15. Economic Impacts on Exposed Buildings Sea Level Rise Scenario 5

	Assessment Value ^a (Land+Improvements)	Property Tax Generation ^b	Tourism Tax Generation ^b	Median Market Household Value ^c
Muir Beach	\$121,461,219	-	-	No homes exposed
Stinson Beach	\$807,643,088	-	-	\$1,821,553,200
Bolinas	\$336,878,134	-	-	No data
Pt. Reyes Station	\$187,847,319	-	-	\$39,713,700
Inverness	\$477,136,109	-	-	\$82,467,300
East Shore	\$63,184,727	-	-	No data
Dillon Beach	\$187,659,869	-	-	No homes exposed
TOTAL	\$2,181,810,465	7,226,058	762,871	> \$1,943,734,200

Sources: ^aAssessor Data 2014/2015 Tax Year, ^b Marin County Department of Finance (2014/2015 tax year), Zillow

PARCELS & BUILDINGS

Several existing buildings are protected with coastal armoring, such as seawalls, revetment, bulkheads, bluff walls, and other hard engineering structures, to impede flooding and erosion. These protective structures may become compromised and require increased maintenance or replacement, or relocation. Some may already be in need of repair. For example, while the seawall in front of the Seadrift neighborhood in Stinson Beach is inspected by a qualified engineer every two years and maintained at no cost to the County, it is rated as low quality by FEMA. Maintaining this structure could come at increasing cost to homeowners in the future.

Additionally, regulations could diminish an individuals' capacity to maintain and retain their properties in the most cost effective ways. The equity held in these properties could be lost; negatively impacting a major contributor to wealth.

Environmental

Storm damage could result in debris that could pollute the ocean. When homes are repaired or rebuilt, resource consumption will occur. As homes are demolished and relocated, additional consumption could occur and degradation of the relocation site is likely to occur. Additionally, using seawalls and other shoreline protective devices to protect buildings could result in the loss of beaches, wetlands, and other habitats and recreational areas by impeding the ability of these areas to migrate inland.

Social Equity

If residents are unable to maintain their homes, deterioration could have negative impacts on community pride and sense of place. Temporarily or permanently relocating residents can sever neighborhood relationships, reducing neighborhood cohesion and breaking down emergency preparedness networks. Neighborhoods without these social networks are especially vulnerable to sea level rise and storm threats.

People living with scarce financial resources, with health or mobility constraints, who do not own a home or car, or are not proficient in the English language may be disproportionately burdened by sea level rise and storms. Vulnerable groups may lack access to information and resources to stay safe during storm events, and may not have the ability to take proactive steps to prepare for sea level rise

impacts. With long-term sea level rise, displaced residents may not have access to equivalent or affordable housing near the jobs, schools, and facilities they rely on. Equity questions may arise regarding who should pay for adaptation or recovery related to sea level rise impacts. Coastal access may also be diminished as public spaces become inundated, impacting recreational opportunities for everyone.

The vulnerable libraries and community centers in Bolinas and Stinson serve a critical role in their communities. The Bolinas library is extremely busy, offering several services, the most popular, aside from book borrowing, is internet use and DVD borrowing. These serve as cultural centers and are the main source of information dissemination for these small communities. Losing these centers or access to them could negatively impact the social fabric of West Marin communities.

Management

Potential state boundary changes could occur as waters rise. This could significantly impact private property rights when flooded land becomes lands of the State. As necessary, road alterations, or other public infrastructure relocations, are planned and implemented, and acquisition of private property may be required. Moreover, as housing opportunities on the coast diminish, so could political representation. Additionally, as public service facilities become threatened, they will need to relocate using public funds. Some examples are Stinson Beach Fire Station No. 2, roads, and utilities in Stinson Beach and Bolinas. In addition, several assets are part of national and state systems, such as Shoreline Highway, that will be competing for political attention and funding, with several other regional roadways threatened by sea level rise. As the planning process moves forward it is likely laws and regulations will need to be modified to permit individuals to implement protective and restorative measures without incurring significant expenditures for permits and regulatory compliance.

TRANSPORTATION

Asset Profile: Roads & Waterways

Low lying roads and other ground transportation infrastructure in Marin's coastal communities are already susceptible to flooding at high tides, especially king tides and storms. Storms can damage roads, even those at higher elevations, enough to close them for days. At worst, some roadways will become completely inundated most hours of the day or eroded beyond repair. If the road network becomes compromised, coastal communities will be extremely vulnerable due to reduced access to supplies essential for daily living (gas, food, etc.). Postal service could be interrupted, schools closed down, and tourism capacity significantly reduced. Water travel will likely be able to adapt, however during storms boats and boat launches, marinas, and piers could see significant damage. The following are key issues related to transportation vulnerability:

- The road network acts as a lynch pin, such that, if disrupted or destroyed, several other assets, or their usefulness, will also be disrupted or destroyed. While temporary shut downs during high tides and storms could be tolerated, chronic flooding could render road segments permanently impassable.
- In most West Marin communities, alternative routes are not available.
- A few roadways serve as emergency evacuation routes and severe storms could flood these routes when residents need them most. Moreover, during high tide and storm events, emergency vehicles may not be able to reach locations in time, or at all.
- Vulnerable roadways can also cover and protect critical utility lines.
- As access to the roads and parking areas becomes increasingly limited, so will the carrying capacity for visitors that contribute greatly to the regional economy.
- Not all residents have cars. Several residents travel by bike or depend on others, or transit, and may not be able to evacuate in emergencies.
- While roads and parking areas can tolerate infrequent storm flooding, erosion susceptible areas, and those exposed to frequent flooding, could see recurring damage and capacity reductions. Lighting systems in parking lots could be impacted and could cause electrical hazards.

IMPACTS AT-A-GLANCE

Over 20 miles of road exposed	3,000+ people
Everyday living, tourism	Regional
Several hundred dollars million needed	Caltrans Department of Public Works Private Road Owners and HOAs



Flooded roads block access Est. date, 1990's. Credit: CDA

- Roadways are also compromised by flooding from freshwater creeks during storms. This can exacerbate flooding impacts.
- Transit services could be interrupted during high tides and storms impacting local residents and visitors shuttling to popular destination along Shoreline highway and to and from Mill Valley on the Marin County's Bayside.

TRANSPORTATION

Table 16. Miles of Exposed Road Segments

	Shoreline Hwy	Sir Francis Drake Blvd.	Local & Private
Scenario 1	0.68 (2%)	0.02 (0.1%)	1.77 (> 1%)
Scenario 2	1.24 (4%)	0.02 (0.1%)	3.08 (1%)
Scenario 3	1.79 (5%)	0.15 (1%)	3.30 (2%)
Scenario 4	2.30 (7%)	0.53 (4%)	4.82 (2%)
Scenario 5	6.70 (19%)	2.35 (17%)	10.4 (3.5%)

Source: Marin Map

The most vulnerable roads are Shoreline Highway (several locations), Sir Francis Drake Blvd. (Inverness), Calle del Arroyo (Stinson Beach) and Olema-Bolinas Road (Bolinas). Shoreline Highway (State Route or Highway 1), the main road connecting every coastal community to the rest of the state, country, and world has seen several closures in the past years during high tides and storms. Bolinas-Olema Road is the primary access route to Bolinas from Shoreline Highway and is especially critical between Mesa Road and Horseshoe Hill. Sir Francis Drake Boulevard provides access to all of Inverness from Shoreline Highway. **Error! Reference source not found.** summarizes how many miles of these arterial roadways are exposed in each sea level rise scenarios. **Error! Reference source not found.** shows the cumulative lengths of roads and trails exposed in each community.



Washed out parking lot, Stinson Beach. Credit: Marin County DPW

TRANSPORTATION

Table 17. Exposed Roads by Community (Scenarios 2-5 include roads in previous scenarios)

	Scenario 1 ~2.5 miles (0.2%)	Scenario 2 ~4.3 miles (1%)	Scenario 3 ~5.2 miles (3%)	Scenario 4 ~7.7 miles (3%)	Scenario 5 ~19.5 miles (7%)
Muir Beach					Coastal Fire Rd. Pacific Wy. ^M
Stinson Beach	Alameda Patio ^P Calle del Arroyo ^M Calle del Embarcadero ^P Calle del Occidente ^P Calle del Onda ^P Calle del Pinos ^P Calle del Pradero ^P Calle del Resaca ^P Calle del Ribera ^P Calle del Sierra ^M Dipsea Rd. ^P Francisco Patio ^P Joaquin Patio ^P Jose Patio ^P Rafael Patio ^P Sacramento Patio ^P Seadrift Rd. ^P Shoreline Hwy. ^C Sonoma Patio ^P		McKennis Gulch Fire Rd.		
Bolinas	Shoreline Hwy. ^C Wharf Rd. ^M		Bolinas Wye ^C	Olema Bolinas Rd. ^M Fairfax Bolinas Rd. ^M	Brighton Ave. ^M Newport Ave. ^P Park Ave. ^M
Inverness	Sir Francis Drake Blvd. ^M			Vision Rd. ^M Rannoch Wy. ^P Argyle St. ^M Duck Cove Rd. ^P	Inverness Wy. ^P Woodhaven Rd. ^P
Pt. Reyes Station	Shoreline Hwy. ^C				Bear Valley Rd. ^M
East Shore	Shoreline Hwy. ^C Willow Wy. ^P				Grand Canyon Rd. ^P
Dillon Beach	Bay Dr. ^P Estero Trl. Valley Ford Frank Sch Rd. ^M Middle Rd. ^M				

P- Private Road, M- Marin County, C- Caltrans. Source: Marin Map, OCOF

lists some of the potentially vulnerable transportation related assets in the study area. This list measures onset and tidal mean higher high water (MHHW) and extreme event flood depths for a high and low value along a vulnerable road segment. In these scenarios a roadway may be impacted for just short periods of high tide, be

submerged on a daily basis at mean higher high water, or somewhere in between. This list is not exhaustive of all the transportation assets that could be exposed to sea level rise and storm impacts in the study area.

TRANSPORTATION

Table 18. Transportation Assets Ranked by Onset and Flood Depth (feet and inches)

Community	Asset (not exhaustive)	Tidal & Extreme Event Flooding Depth Estimates					Vulnerability TF: Temp. Flooding during extreme events; I: Inundated at MHHW; E: Erosion; WS: Wave Surge; HW: High Wind,
		(Underlined values indicate tidal flooding at mean higher high water (MHHW) based on one geographic point placed at the landward limit of the first scenario where it overlaps the asset. values not underlined represent temporary extreme event flooding. Roads received a high, used for ranking, and low value along the line segment.)					
		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	
Stinson Beach	Calle del Arroyo	<u>7"-6'11"</u>	<u>3"-6'8"</u>	<u>8"-9'6"</u>	<u>2'5"-12'2"</u>	<u>5'11"-13'9"</u>	I, TF
East Shore	Walker Creek Access Point	<u>2'4"</u>	<u>3'3"</u>	<u>4'2"</u>	<u>6'1"</u>	<u>9'3"</u>	I
Bolinas	Wharf Road	<u>6"-2'1"</u>	<u>3"-2'4"</u>	<u>2"-2'9"</u>	<u>1"-5'4"</u>	<u>10"-7'4"</u>	I, TF
East Shore	Shoreline Hwy	<u>3"-1'7"</u>	<u>3"-2'4"</u>	<u>3"-3'</u>	<u>2'-4'6"</u>	<u>6"-8'1"</u>	I, TF
Stinson Beach to Bolinas	Shoreline Hwy	<u>0"- 1'8"</u>	<u>0"-2'3"</u>	<u>0"-3'1"</u>	<u>0.4"-4'10"</u>	<u>0.4"-8'6"</u>	I, TF
East Shore	Marconi Boat Launch	<u>1'1"</u>	<u>2'</u>	<u>2'11"</u>	<u>4'10"</u>	<u>8'2"</u>	I
Stinson Beach	Walla Vista Walkway	<u>3"</u>	<u>1'8"</u>	<u>2'</u>	<u>4'4"</u>	<u>10'4"</u>	I, E
Dillon Beach	Lawson's Landing Facilities	<u>2"</u>	<u>1'1"</u>	<u>2'11"</u>	<u>3'10"</u>	<u>7'3"</u>	I, E, WS, HW
Pt. Reyes Station	Green Bridge	No depth data	No depth data	<u>2"</u>	<u>2'</u>	<u>9'10"</u>	I, TF
Inverness	Sir Francis Drake Blvd.			<u>1"-3'6"</u>	<u>1"-4'6"</u>	<u>1"-7'10"</u>	I, TF, WS
Bolinas	Olema-Bolinas Road			<u>2'8"</u>	<u>4"-4'4"</u>	<u>2"-7'11"</u>	I, TF
Pt. Reyes Station	White House Pool/Trail			<u>2'5"</u>	<u>2'3"</u>	<u>5'11"</u>	I
Pt. Reyes Station to Inverness	Shoreline Hwy			<u>6"</u>	<u>3"-1'5"</u>	<u>1'9"-9'7"</u>	I, TF
Inverness	Dana Marsh Beach Access				<u>3'</u>	<u>6'2"</u>	I, E, SI
Bolinas	Bo-Gas Station				<u>1'7"</u>	<u>5'3"</u>	I
Stinson Beach	CA Coastal Trail				<u>0.4"</u>	<u>1'3"</u>	TF, E
Bolinas	Bob Stewart Trail					<u>4'8"</u>	I, TF
East Shore	Shoreline Hwy					<u>3'5"</u>	I, E
Point Reyes Station	Olema Marsh Trail					<u>2'9"</u>	I
Dillon Beach	Dillon Beach Resort Parking Lot					<u>1'6"</u>	I

Source: Marin Map, OCOF Exposure and Flood Depth data, Asset Manager Interviews

TRANSPORTATION

Table 19. Transportation Asset Vulnerabilities

Elevation	<ul style="list-style-type: none"> Roads at grade are vulnerable to inundation, scouring, and erosion. During storms, roads above grade, on bluffs, or adjacent to hill sides, are also vulnerable to severe erosion.
Soils	<ul style="list-style-type: none"> Most soils in the study area are erodible soils and are susceptible to slides and scouring.
Materials	<ul style="list-style-type: none"> Asphalt exposed to frequent flooding and high levels of salt could deteriorate faster than in drier times. Lighting in parking lots could be vulnerable to flooding.

In the low and high ends of the long-term scenarios, roads in every community are exposed. As seen in the maps at the end of this profile, the majority of the roads exposed in scenario 1 are in Stinson Beach and Shoreline Highway between Stinson Beach and Bolinas. All of the exposed households and businesses in the Calles, Patios, and Seadrift neighborhoods in Stinson Beach could be isolated if Calle del Arroyo and its intersection with Shoreline Highway flood in the near-term. Green Bridge in Point Reyes, Pine Gulch Creek Crossings in Bolinas, and bridge crossings on Valley Ford Franklin School Road and Middle Road north of Dillon Beach are also vulnerable in the near-term.

In the medium-term, if Olema-Bolinas Road floods between Mesa Road and Lauff Ranch Road, nearly

1,600 Bolinas households could be isolated at home or prevented from returning home. In Inverness, if Sir Francis Drake Blvd. is compromised near Shoreline Highway, over 1,600 households could be without ingress and egress options. In scenario 5, the East Shore could also see nearly all 100 buildings isolated by the high end of the long-term scenarios, plus tens of others dependent on Shoreline Highway to head inland or along the coast. In the long-term, Muir Beach residents along Lagoon Road could be isolated by flooding on Pacific Way.

Participants at community workshops cited existing high tide and storm flooding at (south to north):

- Highway 101 and State Route 1 at Manzanita (Sausalito)
- Pacific Way, Muir Beach
- Shoreline Highway between Stinson Beach and Bolinas
- Bolinas-Olema Road, Bolinas
- Shoreline Highway at and up Sir Francis Drake, Inverness
- Green Bridge, Point Reyes Station
- Shoreline Highway at Walker Creek, Marshall

In addition to roads vulnerable to flooding, several are also vulnerable to bluff top and shoreline erosion when measured at rate accelerated by higher sea levels associated with the C-SMART scenarios as shown in [Table 20](#).

Table 20. Roads Vulnerable to Accelerated Erosion

	Bluff top (Muir Beach, Bolinas, Dillon Beach)		Shoreline (Stinson Beach)
Scenario 4*			Calle Resaca
Scenario 5*	Altura Ave. Aspen Rd. Birch Rd. Cedar Rd. Cherry Rd. Coastal Fire Road Evergreen Road Fern Rd. Hawthorne Rd. Juniper Rd. Kale Rd. Laurel Rd.	Miramonte Ln. Mitchell Rd. Oak Rd. Ocean Pkwy. Overlook Dr. Pacific Wy. Poplar Road Rosewood Rd. Sunset Wy. Terrace Ave. Wharf Rd.	Alameda Patio Calle del Embarcadero Calle del Occidente Calle del Onda Calle del Pinos Calle del Pradero Calle del Resaca Calle del Ribera Calle del Sierra

* This analysis does not include storms. Source: Marin Map, OCOF, ESA

TRANSPORTATION



Olema-Bolinas Rd. King Tide Dec. 2014. Credit: BPUD

Caltrans is the asset manager for Shoreline Highway, and the Marin County Department of Public Works manages the remaining public roads. Several private roads, especially in the Seadrift, Calles, and Patios neighborhoods in Stinson Beach, are also vulnerable to flooding. The maintenance and repair of private rights-of-way (ROW) is the responsibility of each landowner owning the easement.

Caltrans is in the early stages of developing sea level rise analysis for the state, with varying degrees across the different districts. Marin County is in Caltrans District 4 with Sonoma, Solano, Napa, Contra Costa, Alameda, San Mateo, and San Francisco Counties (see [Map 19](#)). Retrofitting and adapting the District 4 systems for near-term exposure levels could cost billions of dollars. According to the *Caltrans Guidance on Incorporating Sea Level Rise*, the State Highway System is limited in adaptive capacity because of the numerous services it facilitates, its permanent location, longitudinal nature, long lifespan, and uncertain resources.¹²

¹² Caltrans Climate Change Workgroup, and the HQ Divisions of the Transportation Planning, Design, and Environmental Analysis. *Guidance on Incorporating Sea Level Rise: For use in planning and development of Project Initiation Documents*. May 26, 2011.

Caltrans asks three questions in assessing sea level rise planning:

- Is the project located on the coast or in an area vulnerable to sea level rise?
- Will the project be impacted by the stated sea level rise (as determined by a range based on several models and adopted by the Ocean Protection Council in March 2011)?
- Is the design life of the project beyond year 2030?

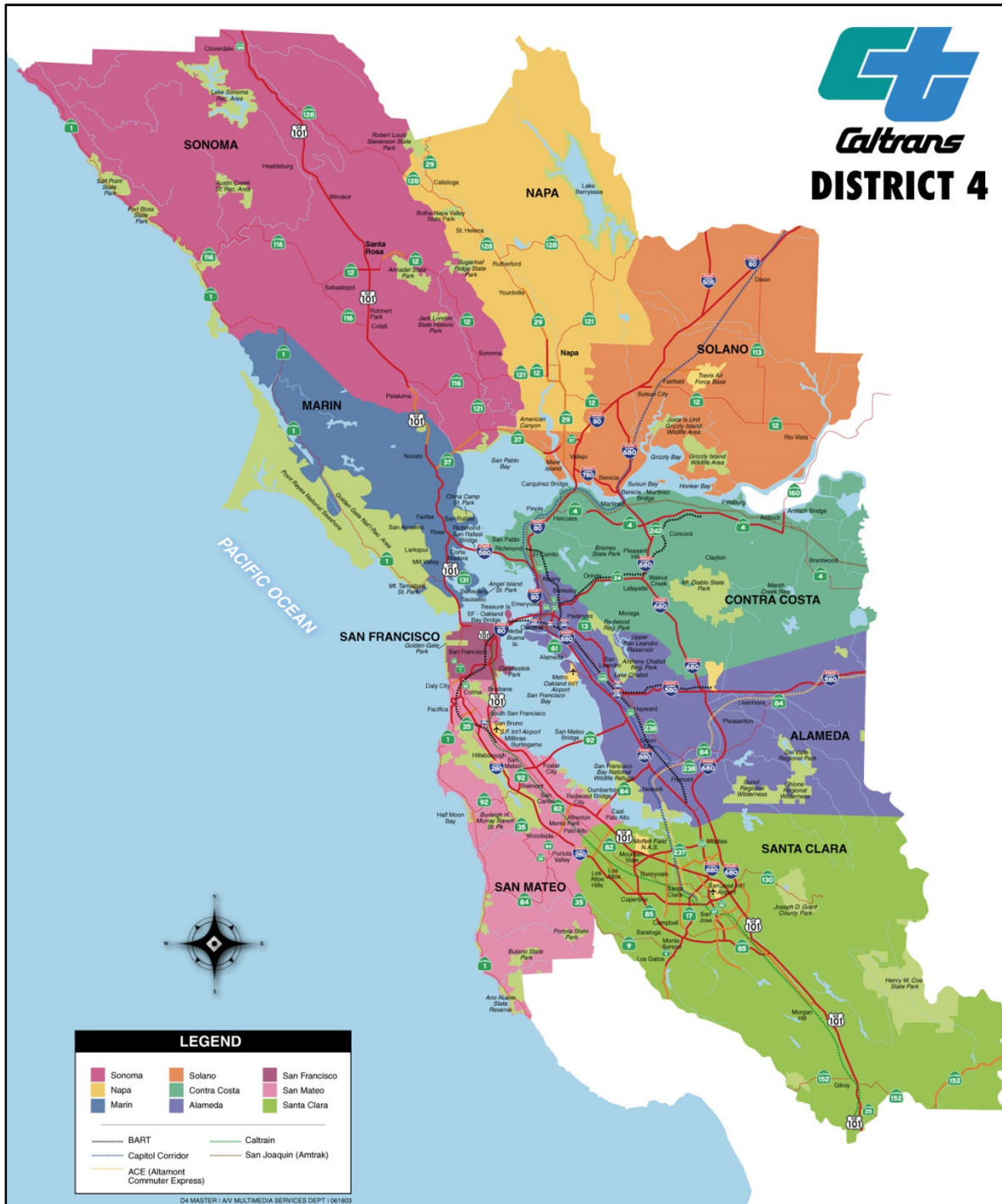
Other factors include anticipated travel delays, goods movement, emergency evacuation, travel safety, burden on public funds, impacts on connecting streets, and environmental constraints.

Caltrans is working with Marin County Public Works, the Greater Farallones National Marin Sanctuary, the Golden Gate National Recreation Area, and other property owners to resolve several challenges facing Shoreline Highway and Bolinas-Olema Road. Preliminary conversations with Caltrans confirm that this four-mile stretch of State Route 1 is susceptible to flooding and has submerged in past extreme storms.¹³ Elevating this portion of the road to a causeway platform designed to allow drainage of the surrounding hillsides could exceed several hundred million and is very environmentally sensitive.

¹³ Sea Level Rise Vulnerability Assessment Interview. Caltrans. April 30, 2015. J. Peterson. D. Fahey. Marin County Development Agency. B. Van Bellegem

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Map 19. Caltrans District 4



Several roads fall under Marin County jurisdiction including major arterials such as Sir Francis Drake, Olema-Bolinas Rd., and Olema-Fairfax Rd., to some less traveled roads such as Valley Ford Franklin School Rd. north of Dillon Beach. Another critical

road that is vulnerable in the near-term is Calle del Arroyo. This road provides access to the majority homes in the Calles, Patios, and Seadrift neighborhoods. Further north, though far from the coast line, Valley Ford Franklin School and Middle

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Roads already suffer from Estero Americano Creek over-topping bridges at high tide. This occurrence is expected to continue and become more frequent.

County Public Works stressed that roadway impacts from water, an incompressible liquid, entering a roadway base will severely degrade a roadway as the base and surface materials deteriorate and erode from the weight of vehicle traffic breaking up the roadway. The goal to limit water intrusion and avoid damage to the roadway system, including the roadway drainage facilities, is not easily met. Raising a road, pumping water, adding a seawall/levee system, or developing an alternate route are possible solutions usually involving land acquisition and or work outside of existing road right of way. In addition, measures to ensure that adjacent properties are not impacted by the proposed improvements must also be identified. Additional environmental review and permits from federal wildlife and state fish and game agencies would also likely be required to implement any of the above alternatives. Identifying cost effective and environmentally feasible solutions will require an engineering study with partnerships from local stakeholders and permitting agencies. Without detailed engineering studies, preparation of cost estimates is not possible, although it is anticipated

that the cost to implement these alternatives will be very high. County Public Works estimates the cost for a feasibility study for each roadway asset is between \$50,000 to \$100,000 to identify an appropriate solution/improvement to sea level rise impacts and to prepare a cost estimate. Developing solutions will involve public dialogue and funding that is yet to be determined.

Marin Transit runs two transit routes to the coast from the Manzanita Park-and-Ride in Sausalito to West Marin. Route 61, the West Marin Stage Coach, to Stinson Beach and Bolinas travels the most vulnerable route in West Marin. The northern Route could be vulnerable at its destination points of Point Reyes and Inverness. Transit here depends on accessible and safe road conditions on the coast and bayside at the junction of Shoreline Highway and Highway 101.

The maps on the following pages present vulnerable transportation assets in the most impacted communities. The C-SMART scenarios are not shown to improve visibility of the exposed roadways.






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Map 20. Stinson Beach Vulnerable Transportation Assets



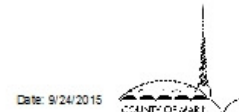
Exposed Roadway

- 10" + Annual storm
- 10" + 20-year storm
- 20" + 20-year storm
- 40" + 100-year storm
- 80" + 100-year storm

-  Boat Launch
-  Fishing Pier
-  Access Point
-  Port
-  Marina



Sources: Our Coast Our Future, Marin Map
 Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data provide is here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.



TRANSPORTATION

Map 21. Bolinas Vulnerable Transportation Assets



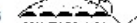
Exposed Roadway

- 10" + Annual storm
 - 10" + 20-year storm
 - 20" + 20-year storm
 - 40" + 100-year storm
 - 80" + 100-year storm
-  Boat Launch
 -  Fishing Pier
 -  Access Point
 -  Port
 -  Marina



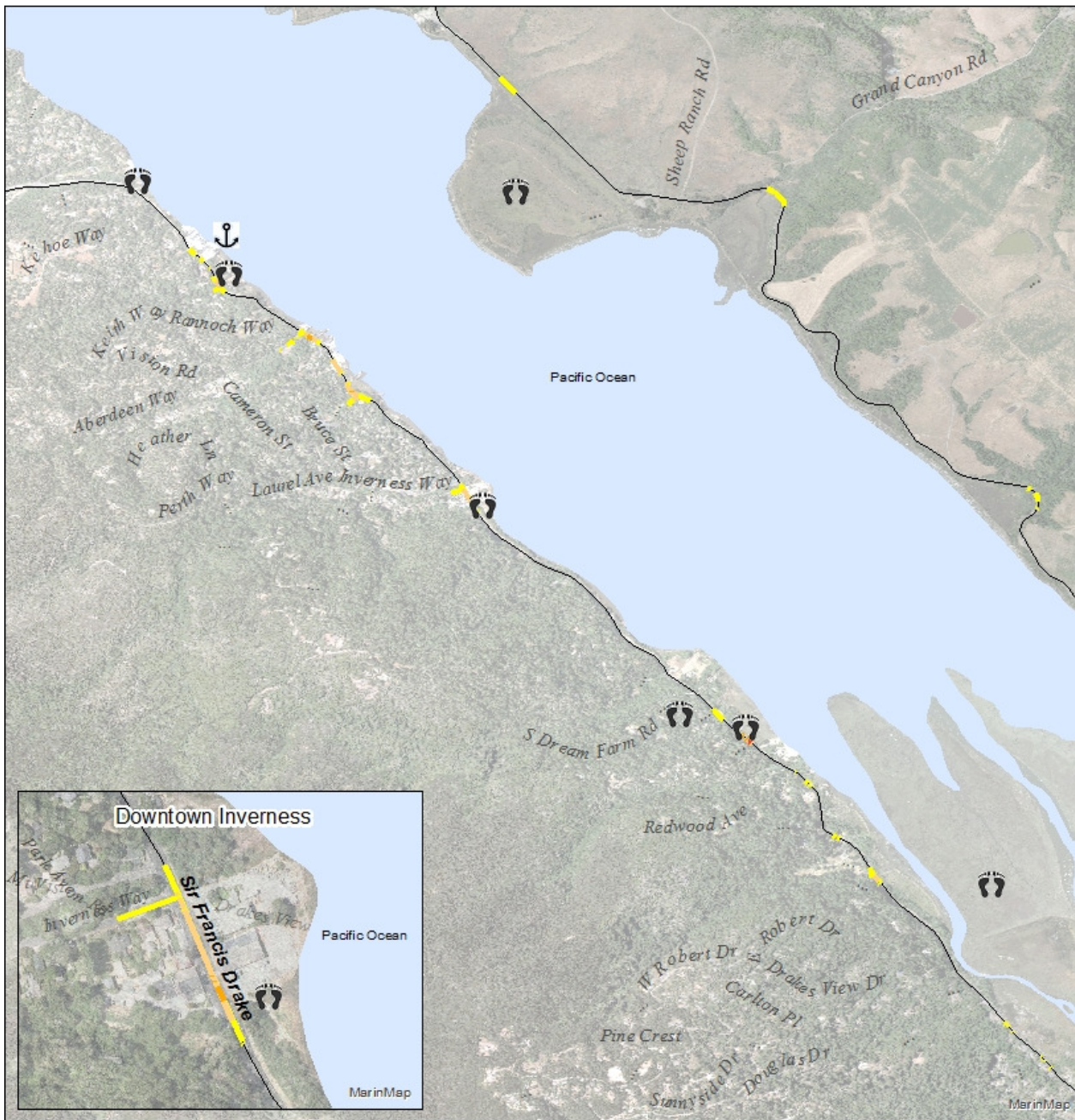
Sources: Our Coast Our Future, Marin Map
 Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

Date: 9/24/2015



TRANSPORTATION

Map 22. Inverness Vulnerable Transportation Assets

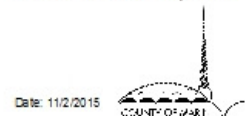


Exposed Roadway

- 10" + Annual storm
 - 10" + 20-year storm
 - 20" + 20-year storm
 - 40" + 100-year storm
 - 80" + 100-year storm
-  Boat Launch
 -  Fishing Pier
 -  Access Point
 -  Port
 -  Marina



Sources: Our Coast Our Future, Marin Map
 Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.



Date: 11/2/2015

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Map 23. Point Reyes Station Vulnerable Transportation Assets



Exposed Roadway

- 10" + Annual storm
 - 10" + 20-year storm
 - 20" + 20-year storm
 - 40" + 100-year storm
 - 80" + 100-year storm
-  Boat Launch
 -  Fishing Pier
 -  Access Point
 -  Port
 -  Marina



Sources: Our Coast Our Future, Marin Map
 Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

Date: 9/24/2015



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Map 24. East Shore Vulnerable Transportation Assets



Exposed Roadway

- | | | | |
|--|----------------------|--|--------------|
| | 10" + Annual storm | | Boat Launch |
| | 10" + 20-year storm | | Fishing Pier |
| | 20" + 20-year storm | | Access Point |
| | 40" + 100-year storm | | Port |
| | 80" + 100-year storm | | Marina |



Source: Our Coast Our Future, Marin Map
 Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

Date: 9/24/2015



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Existing Policies

The Draft Local Coastal Program (DLCP) policies prohibit the construction of additional highway lanes and ensure road improvements are limited and undertaken in a way that respects their environment. Instead of providing for an increase in vehicular traffic, the DLCP encourages reduction of congestion through alternative means, such as limiting local parking and providing shuttle service to popular destinations. As a condition of new development, the DLCP also encourages the designation of new trails, roadways or paths. The DLCP policies recognize and seek to minimize the impacts of sea level rise on Shoreline Highway using the least environmentally damaging means. [Figure 8](#) shows select transportation policies from the Draft LCP.

Other Considerations

Economic

Road access to the Marin Coast is critical for all economic activity, whether it is supply transport for daily needs, commuting to work, getting to school, or access for the several million tourists that visit the Marin Coast annually.

Funding for elevating roads will likely be difficult, straining limited county funding sources, at the same time other counties will be competing for state and federal resources. Moreover, state funding reductions have drastically impacted the County's overall road maintenance work program.

Several road segments are protected by coastal armoring, such as seawalls, revetments, bulkheads, bluff walls, and other hard engineering solutions to prevent flooding and erosion. These structures may become compromised and require increasingly costly maintenance or replacement. In some cases where retreat is selected, the roads and protecting structures may be closed and abandoned in place, and relocated. If seawalls and bulkheads in Bolinas fail, repairs to the road and utilities underneath will be very costly to the community. New alternative routes may require acquiring private property. If access to these local communities becomes compromised, tourist oriented businesses could lose potential revenues.

Figure 8. Draft Marin County LCP Transportation Policies (abridged)

C-TR-1 Roads in the Coastal Zone. Limit roads to two lanes. Work with state and federal agencies and local communities to enhance road safety, improve pedestrian, bicycle, and transit access, and stabilize or reduce congestion...projects will not be undertaken to increase the motorized vehicular capacity of these roads.

C-TR-3 Impacts to Highway One from Sea Level Rise. Consult with the California Department of Transportation to protect access to the coast and to minimize impacts of sea level rise on Highway 1.

C-TR-6 New Bicycle and Pedestrian Facilities. Encourage, and where appropriate, require new development to provide trails or roadways and paths for use by bicycles and/or on-street bicycle and pedestrian facilities. Consider facilities that...Connect to the existing bikeway or trail system, including linkages to and between communities and recreation areas...Provide diverse recreational and aesthetic experiences.

C-TR-8 Expansion of the Countywide Trail System. Acquire additional trails to complete the proposed countywide trail system, providing access to or between public lands and enhancing public trail use opportunities for all user groups, including multi-use trails.

*Reflects California Coastal Commission Suggested Modifications to Marin County DLCP Amendment (May 2014). **Subject to change.***

Environmental

Road repair and reconstruction can have significant environmental impacts. When roads completely fail, sediment and asphalt can enter into the surrounding properties and habitat. Constructing new roadways as alternative routes can have even greater impacts and could alter habitats significantly.

Social Equity

According to the Healthy Marin Partnership, 2013 Community Health Needs Assessment, nearly 25 percent of Marin's coastal residents pay more than 15 percent of their income towards transportation

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costs.¹⁴ This is considered a major cost burden. For those of lesser means, for example the nearly 30 percent of residents who have an annual household income under \$35,000,¹⁵ increases in these costs could be significant. Combined with housing cost burden, the needs assessment reveals that between 50 and 70 percent of Marin Coast residents pay more than 45 percent of their incomes on housing and transportation combined. The affordability standard is 30 percent of income on housing, 15 percent on transportation. This indicates that a large portion of residents are already overburdened by these basic expenses, leaving less income available for other necessities such as emergency preparedness, medical care, healthy food, child care, or education.

Moreover, the costs of owning a personal vehicle could increase if damaged in storm events. And if the Bo-Gas Station in Bolinas halts operation due to frequent flooding, the gas station in Pt. Reyes Station would be the last remaining gas station in Marin's Coastal Zone.

Residents dependent on bus routes 61 or 68 for travel along the coast or to other transit lines at the Manzanita Park-and-Ride to access Marin's bay side could face disruptions in service. Youth and other residents from Mill Valley often use the weekend service to access the beach communities. Those without personal vehicles may not be able to reach higher ground and may not be able to leave the area to replenish needed supplies.

Management

Efforts to proactively reengineer existing routes will require collaboration amongst several land owners, private and public. Emergency services should be considered to ensure roadways are wide enough as responders depend on accessibility to any affected areas. Coordination is critical to ensure consistent access and wise use of financial resources. Environmental and land condemnation processes can be extremely political, lengthy, and expensive. Planning and implementing adaptation measures for the extent of the roadways in the study area for higher water levels could span several electoral cycles and will require continuous leadership and action across them with respect to sea level rise preparation.

¹⁴ Healthy Marin Partnership. Community Health Needs Assessment Sub-county Health Indicators. 2013.
¹⁵ 2010 US Census.

UTILITIES

Asset Profile: Water, Wastewater, Stormwater, Gas, Electricity, & Telecommunications

Most habitable buildings depend on several utility systems including: water supply, onsite wells, septic systems (regulated as onsite wastewater treatment systems (OWTSs)), shared community waste systems, electricity, propane, communications, and stormwater infrastructure. These systems are significant assets and can be disrupted or destroyed before a building's structure—reducing the building's functionality and livability. Stormwater drainage failures could also impact roadways. West Marin residents have weathered temporary disruptions before; however, at some point in the coming decades, these occurrences could become unbearable and costly.

Where buildings are vulnerable to surface flooding, underground water, wastewater, and communications utilities are also likely threatened, and potentially before the built assets on the ground level. A few other utility components are threatened by bluff and road erosion. The following are key vulnerabilities for exposed utilities:

- Electricity, propane, water supply, and wastewater management systems are lynch pin assets. If severely compromised, even dry properties and buildings could become unusable.
- Wells are vulnerable to saltwater intrusion, elevating freshwater table, erosion, and salt water corrosion of distribution lines (East Shore, Dillon Beach).
- Most aging OWTS were installed deeper than current systems and are vulnerable to flooding and ground water intrusion. All systems are vulnerable to inundation and erosion. Flood waters could come in contact with waste water from saturated disposal fields and pollute surrounding ocean and fresh water resources (Stinson Beach, Inverness, Point Reyes Station, East Shore).
- Temporary threats for overland power and communication lines include high winds that fell trees.
- Many homes depend on propane tanks that could become “floating bombs.”¹⁶

¹⁶ Sea Level Rise Interview with Bolinas Public Utilities District, Chief Operator Bill Pierce. March 25, 2015.

IMPACTS-AT-A-GLANCE

~1,100 buildings	Public Utilities Districts Property Owners PG&E AT&T
3,000 people affected	
\$477 million in assessed value	



Inverness Yacht Club septic system covers. Credit: S. Callow

Several utility districts provide drinking water and/or wastewater management, and a few private companies provide electricity, propane, and communication technology to residents in several of Marin's coastal communities including:

- North Marin Water District for Point Reyes Station and Inverness Park,
- Inverness Public Utilities District, Inverness Ridge,

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- Bolinas Public Utilities District,
- Stinson Beach Water District,
- Muir Beach Community Services District,
- Estero Mutual, Dillon Beach,
- AT&T, all communities,
- PG&E, all communities, and
- Private propane providers (McPhails, ProFlame, DiCarli's, Blue Rhino, etc.).

These agencies are aware of, and where necessary, prepared for sea level rise in most cases.

Table 21 lists some of the potentially vulnerable utility related assets in the study area. This list measures onset, tidal mean higher high water (MHHW), and extreme event flood depths; however many utilities assets are underground. This list is not exhaustive of all the utility assets that could be exposed to sea level rise and storm impacts in the study area.

Potable Water

According to asset manager interviews, water distribution lines are the most vulnerable in the lower

areas of Stinson Beach, Bolinas, and all of Inverness. In the Calles, Patios, and Seadrift neighborhoods in Stinson Beach, the water lines are underneath every road, and nearly every road could be exposed with ten inches of sea level rise and an annual storm (scenario 1). If the road washes out, these utilities will also be impacted. California law dictates that water pipes and other system components can be safely buried 24 inches above the underground water table. The pipes also have to be a certain distance below the road to avoid damage from driving pressure.

Depending on location, a property gets potable water from a privately owned well or a small community water system. The asset managers are Stinson Beach Water District, Bolinas Public Utilities District, Inverness Public Utilities District, North Marin Water District, State Small Water Systems, and private well owners. Public water systems in Bolinas, Inverness, Pt. Reyes, and Dillon Beach are regulated by the State. Wells can pull water from areas as large as the parcel and at great depths. As the water rises closer to the surface further inland, this useable underground space becomes increasingly limited.

Table 21. Utility Assets Ranked by Onset and Flood Depth (feet and inches)

Location	Asset (not exhaustive)	Tidal & Extreme Event Flooding Depth Estimates (Underlined values indicate tidal flooding at mean higher high water (MHHW) based on one geographic point placed at the landward limit of the first scenario where it overlaps the asset. values not underlined represent temporary extreme event flooding.)					Vulnerability TF: Temp. Flooding; I: Inundated at MHHW; E: Erosion; WT: Water Table; SI: Saltwater Intrusion; WS: Wave Surge
		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	
Stinson Beach	Septic Systems West of Shoreline Hwy.	<u>4.5'</u>	<u>4.5'</u>	<u>6'</u>	<u>7.5'</u>	<u>10.5'</u>	I, WT, WS, TF
		underground resource					
Stinson Beach	Water Lines	<u>4.5'</u>	<u>4.5'</u>	<u>6'</u>	<u>7.5'</u>	<u>10.5'</u>	E, WS, TF, I, SI
		underground resource					
Inverness to Pt. Reyes Station	NMWD Pipeline	underground resource (see Shoreline Highway Point Reyes Station to Inverness for depths)					WT, SI, E
Stinson Beach	Water District Office	7"	3'3"	4'8"	6'6"	<u>8'8"</u>	TF, I
Pt. Reyes Station	Gallagher Well					underground resource	SI
Dillon Beach	Sewage Pump Station	bluff top asset					E

Source: Marin Map, OCOF Exposure and Flood Depth data, Asset Manager Interviews

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Table 22. Potable Water Vulnerabilities

Depth	<ul style="list-style-type: none"> ▪ Wells: Saltwater intrusion into groundwater will contaminate freshwater. ▪ Water distribution: Pipes must maintain 24" of space from the groundwater table, and 32" below ground. As the water table rises, pipes will be exposed to saltwater and shift underground.
System Upgrades	<ul style="list-style-type: none"> ▪ Wells: Adjustments to well withdrawal when groundwater shifts from fresh to salt water. ▪ Water Distribution: Pipes will need to be upgraded.

The mainline to Inverness was installed underneath Sir Francis Drake Blvd. in 1974. During the 1982 storms, the road eroded and damaged the pipeline interconnection enough to disrupt water service for one week until a temporary overland pipe was installed. Two weeks lapsed before the underground pipe was fully repaired. If storms of the magnitude of the 1982 storm become more likely, as studies predict, the threat to these pipes could increase. In Bolinas, waterlines are vulnerable on eroding cliff sides and in downtown. The Bolinas Public Utilities District has worked with property owners and Public Works to relocate water lines on the eroding bluffs; however, the issue remains in some locations.

Dillon Beach has two water systems, Estero Mutual owned mutually by Oceana Marin homeowners and Coast Springs owned by CalWater. Estero Mutual seasonally pumps water up hill to an open reservoir. The pumping station and pond that collects water are close to the estuary and vulnerable to saltwater intrusion.¹⁷ The main well for Coast Springs, though not exposed on the surface, is vulnerable to storm surges and extreme high water along Dillon Creek.¹⁸ Further south, two wells next to Tomales Bay serving Hog Island Oysters and another property are experiencing salt water intrusion already. East Shore property owners recently obtained approval to draw from a well on a neighboring property at a higher elevation. Marshall Boat Works' wells are at low elevation and the main well is adjacent to a creek. Private springs serving homes near the Marconi

¹⁷ S. Callow. Marin County Public Works. Email correspondence. April 8, 2015.
¹⁸ Ibid.

Center are near sea level elevation. The NMWD Gallagher well in Pt. Reyes Station may be threatened at scenario 5 water levels. Other vulnerable wells included Audubon's Bolinas Lagoon Preserve wells in canyon floors adjacent to creeks.

According to the National Park Service and Muir Beach CSD, Muir Beach water supplies are far enough inland to avoid sea level rise impacts. This is also the case for Bolinas and Stinson Beach.

Wastewater

Coastal residences and businesses dispose of their wastewater through privately owned OWTS; small waste water systems with Waste Discharge Permits from the State Regional Water Quality Control Board or public wastewater systems. An OWTS leach field for a typical three-bedroom home is 500-5,000 square feet either beneath or above the ground surface, depending on the system, soil, ground water levels, and site constraints.¹⁹ Some OWTS require pumps and electrical components that could be affected during power outages.



Bolinas Lift Station extends 25 feet below ground. Credit: Van Belleghem

Public wastewater systems exist in Bolinas and Oceana Marin (next to Dillon Beach). In Oceana Marin, the lift station is on an eroding terrace and could be susceptible if erosion rates increase with

¹⁹ Alegria, A. Asset Manager Interview. May 2015. Environmental Health Services. Marin County CDA.

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storm severity. In downtown Bolinas, the collection system serves 141 residential, 20 commercial, and 2 institutional properties. Low lying downtown Bolinas depends on a gravity fed lift station at sea level that is highly vulnerable in the long-term to sea level increases. Uplands in Bolinas are also vulnerable to continued road erosion with underground distribution lines. In several locations, sewage pipes were relocated landward and on the Little Mesa, homeowners were required to buy, install, and run pumps to get their effluent to the lift station.

With respect to OWTs, the most common wastewater management systems on the Marin Coast, projected sea level rise could raise the level of subsurface ground water causing flooding of disposal fields and contamination of groundwater. Even newly installed systems that are shallower or above ground could be impacted by flood waters and affected by power outages. Erosion could also reduce the land area. If ground water rises under septic tanks it could have enough pressure to cause tanks to pop out of the ground. These systems are privately managed by the land owner and regulated by Marin County Department of Environmental Health Services, Stinson Beach Water District, or Regional Water Quality Control Board.

According to district managers and Marin County Environmental Health Services, OWTs vary in age, size, and type of system. Additionally, through existing programs and private investment, upgrades on individual properties are made as needed. In the Calles, Patios, and Seadrift neighborhoods in Stinson Beach, approximately 20 of the 700 systems per year are upgraded to turn off when flood waters are too high. Some systems have manual diverter switches, and all but 12 of the septic systems have holding tanks that leach underground and are vulnerable to rising ground water and flood waters. The Seadrift neighborhood was built over a sand spit and is susceptible to flood water erosion. In downtown Bolinas there about 163 connections to the public wastewater system. In Inverness and Marshall, several pier based or shoreline buildings could also be vulnerable to septic system malfunction. A community wastewater system was recently installed in Marshall to relocate several independent leach fields to a shared leach field east of Shoreline Highway due to Tomales Bay water quality violations. However, individual septic tanks and the pipes connecting these homes to the

community system will still be vulnerable to corrosion in the long-term.

Septic systems in Marin's coastal zone are regulated by the Marin County Draft Local Coastal Program (DLCP), the Marin County Development Code, and the State Water Control Board's Onsite Wastewater Treatment Systems Policy. Two categories exist—'standard' and 'alternative' (see [Figure 9](#)). A permit must be obtained from the Marin County Community Development Agency's Environmental Health Services Department before constructing, repairing, replacing, or modifying a septic system. [Figure 10](#), Draft Marin County LCP Public Facilities & Services (PFS) Policies (abridged) lists relevant Local Coastal Program policies. More information on regulations can be found at <http://www.marincounty.org/depts/cd/divisions/environmental-health-services/septic-systems>.

Figure 9. Sewage Disposal System Regulations

Marin Co. Code Ch. 18.06 Design, Construction, and Repair of OWTs

Conventional/Standard System: Sewage from the structure flows by gravity into a septic tank. Effluent is discharged to the soil via gravity or pumps or dosing siphons.

Alternative System: Any OWTs with a supplemental treatment unit and/or a standard septic tank, and/or does not include standard leaching trenches for effluent disposal.

Figure 10. Draft Marin County LCP Public Facilities & Services (PFS) Policies (abridged)

C-PFS-6 Sewage Disposal and Water Quality Protection.

C-PFS-7 Adequately Sized Disposal Systems.

C-PFS-8 Disposal Systems Requirements for New Lots.

C-PFS-9 Preference for On-Site Sewage Disposal Systems.

C-PFS-10 Adequate On-Site Sewage Disposal Systems.

C-PFS-11 Alternative On-Site Disposal Systems.

*Reflects CCC Suggested Modifications to Marin County DLCP Amendment. **Subject to change.***

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Table 23. Wastewater System Vulnerabilities

Depth	OWTS: Erosion can reduce the land area available to percolate waste. Saltwater intrusion into the leach field could impact percolation rates and reduce useable area. Shared Wastewater: Lift stations below grade are vulnerable (Bolinás).
Materials/ Models	Septic: Older single field gravity septic systems are more susceptible to storm flooding than newer (year) systems, as newer systems are equipped with “flip” switches that turn off percolation when groundwater levels are too high to prevent contamination. Drip dispersal tubing is also being used in newer systems. Newer systems are sensitive to power outages during storm events.
Codes	Septic: OWTS State regulations Public Wastewater: State Water Resources Control Board adopted statewide Order No. 2006-0003-DWQ requires a Sewer System Management Plan (Bolinás PUD Plan).
System Upgrades	Septic: Upgrades are conducted on an ongoing basis (about 20 annually) to include automatic flip switches and close contaminant boxes. Shared Wastewater: Vulnerable to erosion, pipes may need to be relocated inland.

Fuels (Home and Automotive)

Residents in West Marin use individual propane tanks for heat, hot water, and cooking. According to asset managers, propane tanks are highly vulnerable to sea level rise and storm impacts. Propane tanks are stored outside typically at or slightly above grade. While tanks are typically stored on the landward side of a building, this may not be feasible on every property, and in severe flooding, this precaution may not be sufficient. If a property floods, and waves and water dislodge the propane tank, the tank becomes a floating bomb. Propane is transported to the area through private contractors. Route blockages could prevent residents from refilling tanks in a timely manner. With the most severe storms and high tides in the winter, these disruptions could occur when residents need the propane most.

With respect to liquid fuels, one automotive gas station is located in the flood area in downtown Bolinas and has experienced storm flooding in the past. More frequent flooding here may make continued operations challenging. The next nearest gas station is in Pt. Reyes Station and is not exposed to sea level rise.

Electricity

According to Pacific Gas and Electric (PG&E), few electrical system components are vulnerable to sea level rise and storms on the Marin Coast. The features exposed are poles, transmission wires, and the individual wires dropping down to each home. The tall large wooden poles are vulnerable, currently and into the future, to falling tree branches; however they can withstand some degree of flooding. Excessive or permanent flooding could weaken the poles over time, warranting replacement. Poles are also vulnerable to erosion and roadway collapse because the poles are often located in the right-of-way alongside roads. The Bolinas and Olema substations are well outside the area exposed to sea level rise and storms.

Several buildings, especially government facilities (i.e., Bolinas lift station, Inverness Fire Department) use back-up generators. If not elevated on an adequate cement pedestal, these expensive generators could be powerless.

Telecommunications

The asset manager of all shared telecommunications assets is AT&T. In general, according to AT&T asset managers, telecommunication assets are not vulnerable on their own as they are designed to withstand wet weather and tidal impacts. In addition, consistent level of service is a primary goal of the company; therefore, the company would anticipate and prepare for potential impacts. The most vulnerable assets are the communication cables under vulnerable roads. In addition, poles, as discussed above, are vulnerable during storms to tree falls.

Storm Drains

Storm drains, such as culverts and outfalls, are also a critical utility aligned with or under the road. Sediment build-up and sea level rise can block gravity flow through stormwater drainage paths that

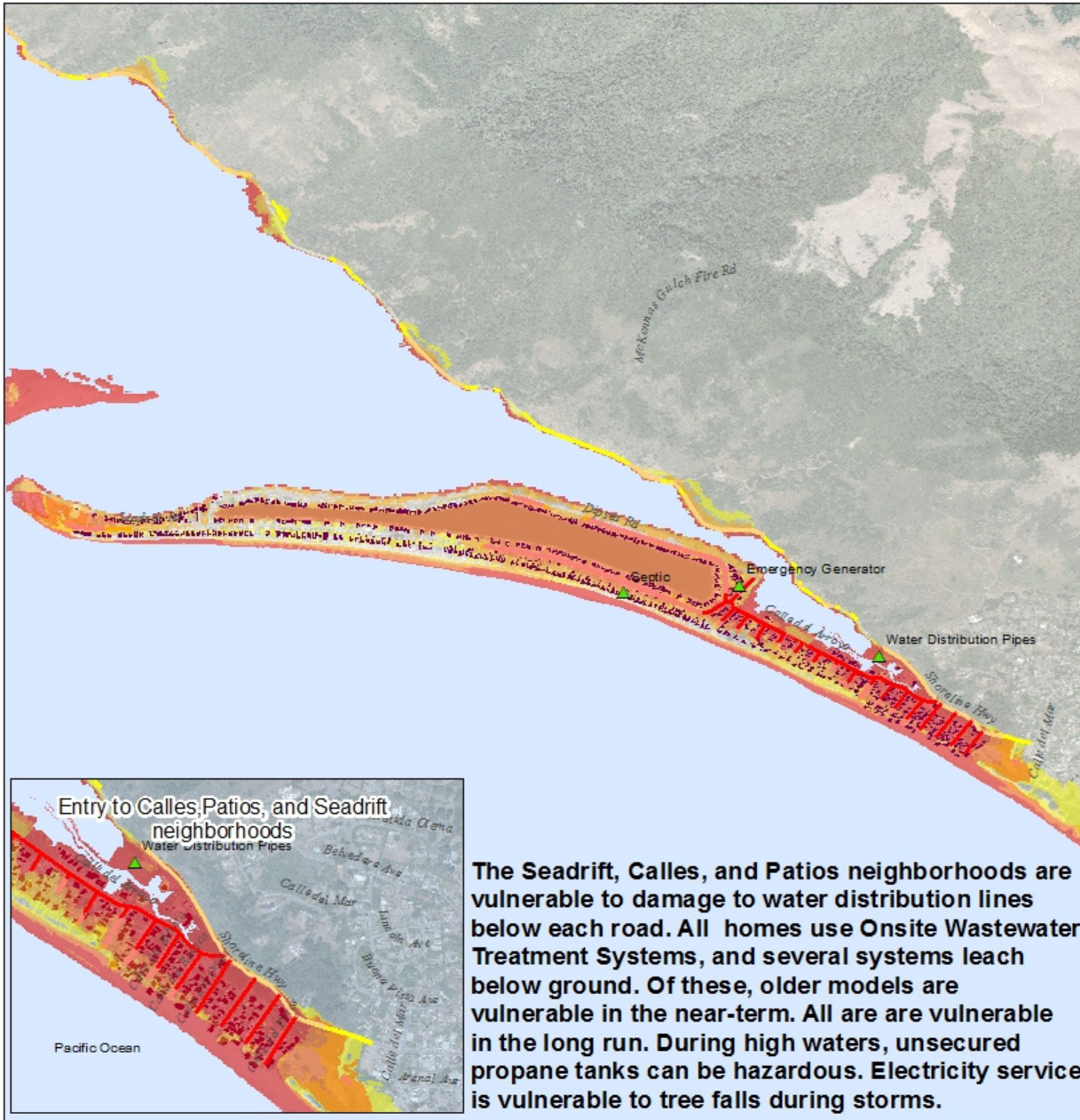
UTILITIES

travel under the roads, for example around Bolinas Lagoon. If the storm drains are unable to function, upstream flooding could occur and potentially weaken and erode the road. Stormwater infrastructure along private properties is typically managed by the property owner. Some public drainage facilities are maintained by Marin County along Bolinas-Olema Rd. and Sir Francis Drake Blvd., while those along Shoreline Highway are managed by Caltrans.

The maps on the following pages highlight vulnerable utility based assets. Since several utility assets are underground and could be exposed to sea level rise and storm threats before surface flooding shown in the maps occurs, supplemental information is provided with each map to describe these vulnerabilities. In addition, specific well and septic system locations are not available in the County GIS database, Marin Map. Building footprints are shown on the maps as a proxy for where these systems exist and may be vulnerable (except Bolinas because systems are public).

UTILITIES

Map 25: Stinson Beach Vulnerable Utilities



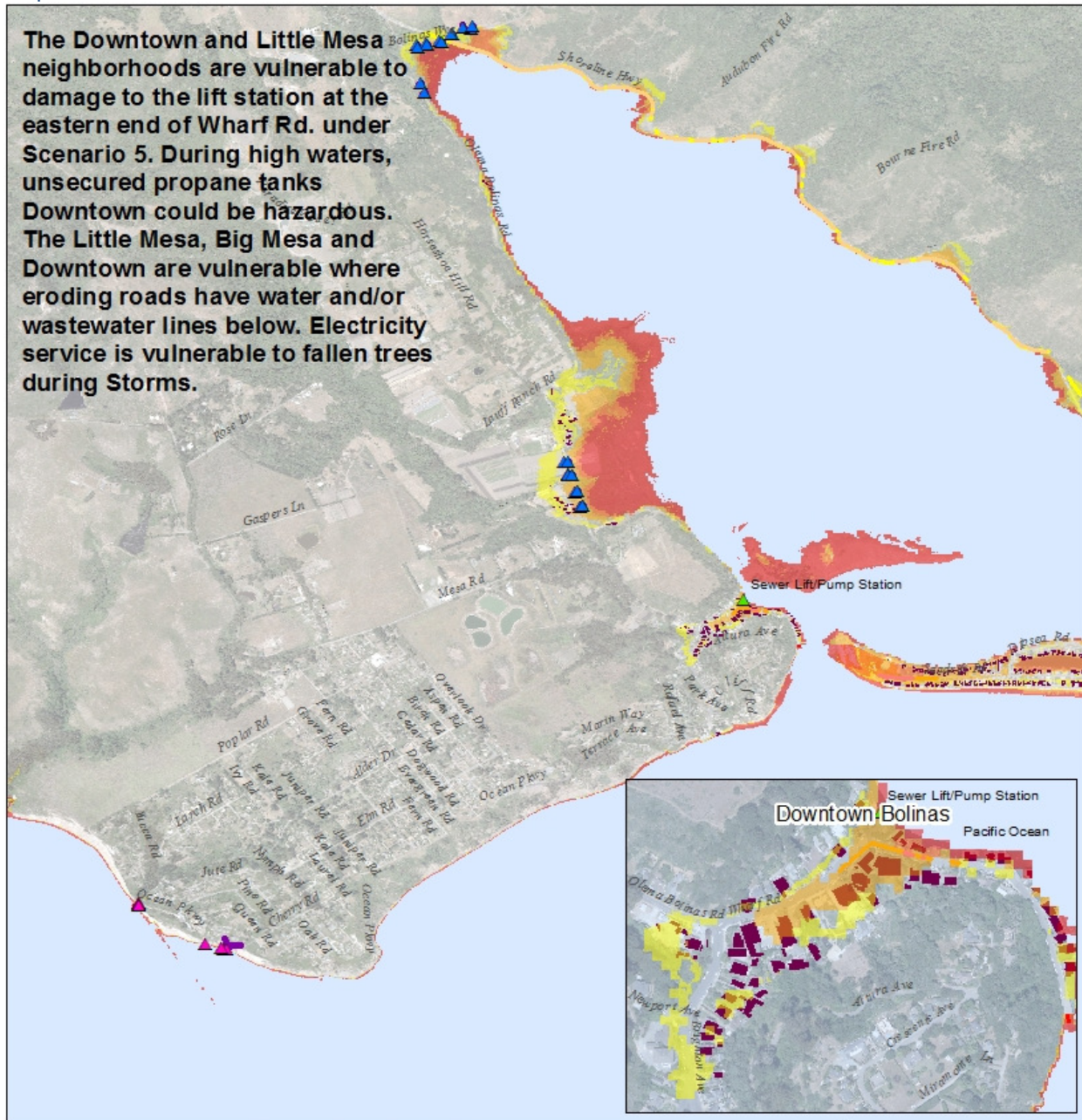
Scenarios	Exposed roads w/ utility lines beneath	
1 10" SLR + Annual Storm	Scenario 1	Buildings
2 10" SLR + 20-year Storm	Scenario 2	Utilities
3 20" SLR + 20-year Storm	Scenario 3	Culverts
4 40" SLR + 20-year Storm	Scenario 4	Culvert Lines
5 80" SLR + 100-year Storm	Scenario 5	Man Hole, Catch Basin Grate
		Road Side Ditches

Sources: Our Coast Our Future (2014), Marin Map Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers herein, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

Date: 9/28/2015
 COUNTY OF MARI

UTILITIES

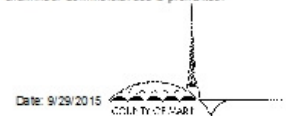
Map 26: Bolinas Vulnerable Utilities



Scenarios	Exposed roads w/ utility lines beneath	
1 10" SLR + Annual Storm	Scenario 1	Buildings
2 10" SLR + 20-year Storm	Scenario 2	Utilities
3 20" SLR + 20-year Storm	Scenario 3	Culverts
4 40" SLR + 20-year Storm	Scenario 4	Culvert Lines
5 80" SLR + 100-year Storm	Scenario 5	Man Hole, Catch Basin Grate
		Road Side Ditches

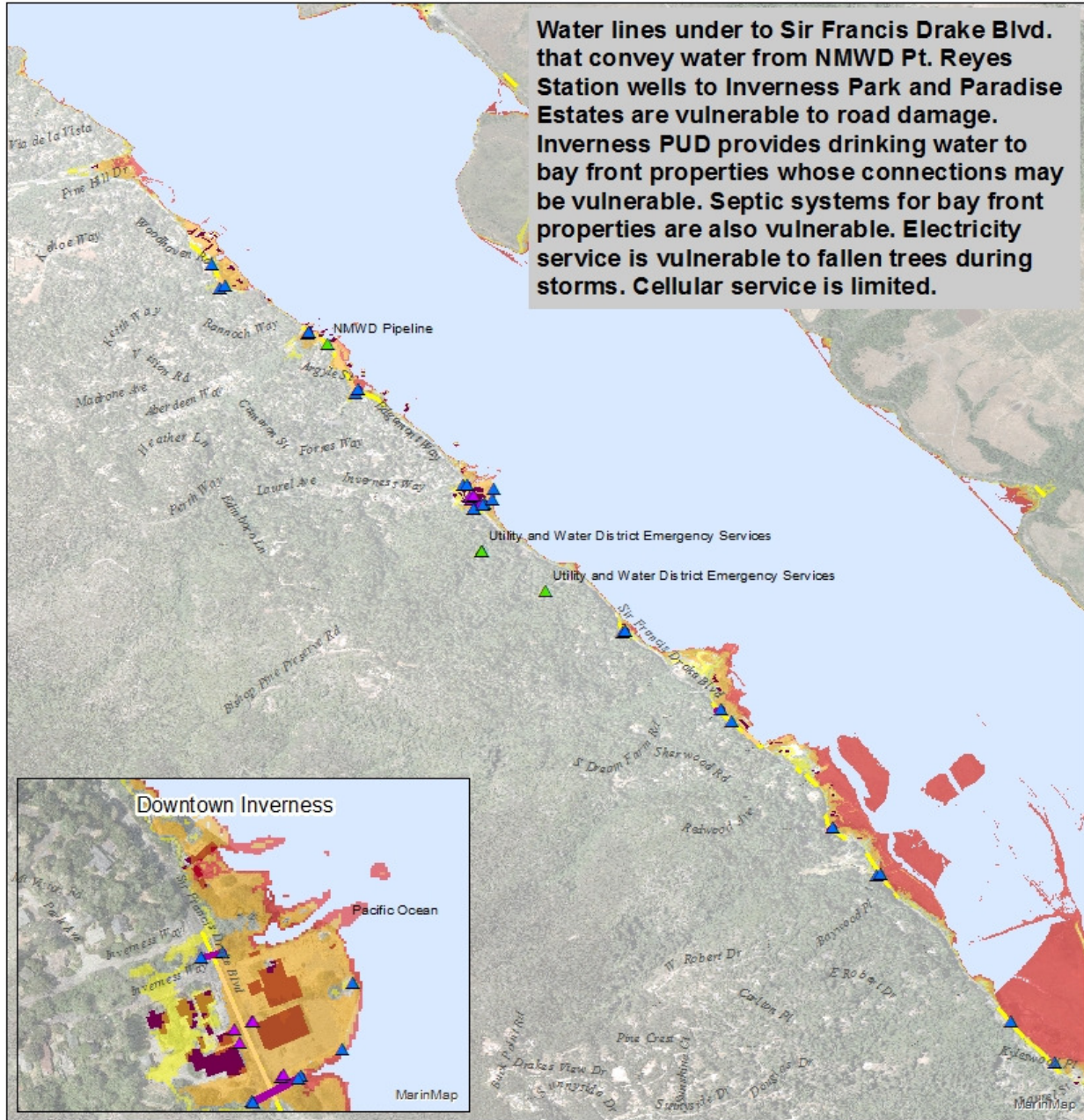


Sources: Our Coast Our Future (2014), Marin Map
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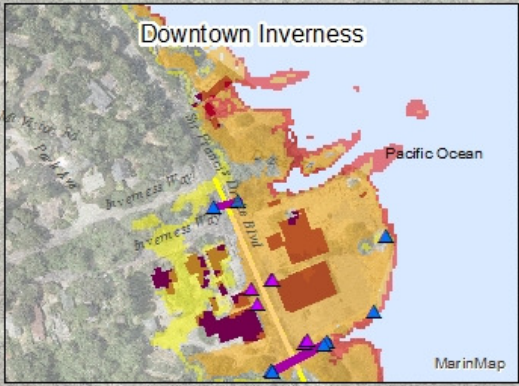


UTILITIES

Map 27: Inverness Vulnerable Utilities



Water lines under to Sir Francis Drake Blvd. that convey water from NMWD Pt. Reyes Station wells to Inverness Park and Paradise Estates are vulnerable to road damage. Inverness PUD provides drinking water to bay front properties whose connections may be vulnerable. Septic systems for bay front properties are also vulnerable. Electricity service is vulnerable to fallen trees during storms. Cellular service is limited.



Scenarios		Exposed roads w/ utility lines beneath		
1	10" SLR + Annual Storm	Scenario 1	Buildings	■ Buildings
2	10" SLR + 20-year Storm	Scenario 2	Utilities	▲ Utilities
3	20" SLR + 20-year Storm	Scenario 3	Culverts	▲ Culverts
4	40" SLR + 20-year Storm	Scenario 4	Culvert Lines	— Culvert Lines
5	80" SLR + 100-year Storm	Scenario 5	Man Hole, Catch Basin Grate	▲ Man Hole, Catch Basin Grate
			Road Side Ditches	— Road Side Ditches

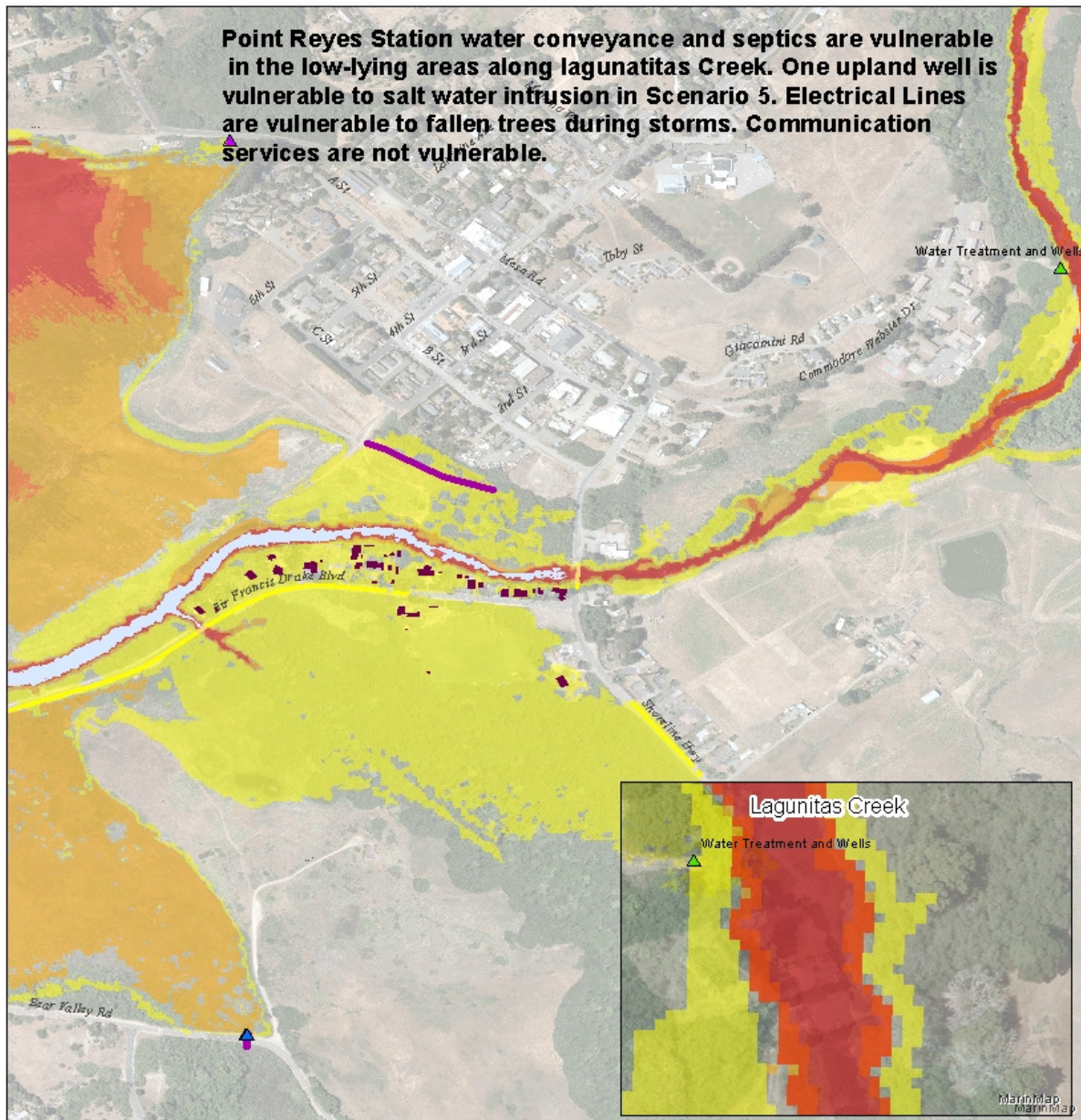
0 0.100 0.200 0.300 Miles

Sources: Our Coast Our Future (2014), Marin Map
 Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

Date: 11/2/2015

UTILITIES

Map 28: Pt. Reyes Station Vulnerable Utilities



Point Reyes Station water conveyance and septics are vulnerable in the low-lying areas along lagunitas Creek. One upland well is vulnerable to salt water intrusion in Scenario 5. Electrical Lines are vulnerable to fallen trees during storms. Communication services are not vulnerable.

Scenarios	Exposed roads w/ utility lines beneath	
1 10" SLR + Annual Storm	Scenario 1	Buildings
2 10" SLR + 20-year Storm	Scenario 2	Utilities
3 20" SLR + 20-year Storm	Scenario 3	Culverts
4 40" SLR + 20-year Storm	Scenario 4	Culvert Lines
5 80" SLR + 100-year Storm	Scenario 5	Man Hole, Catch Basin Grate
		Road Side Ditches

Scale: 0 600 61 62

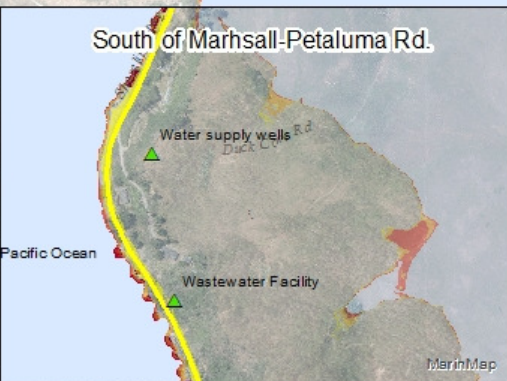
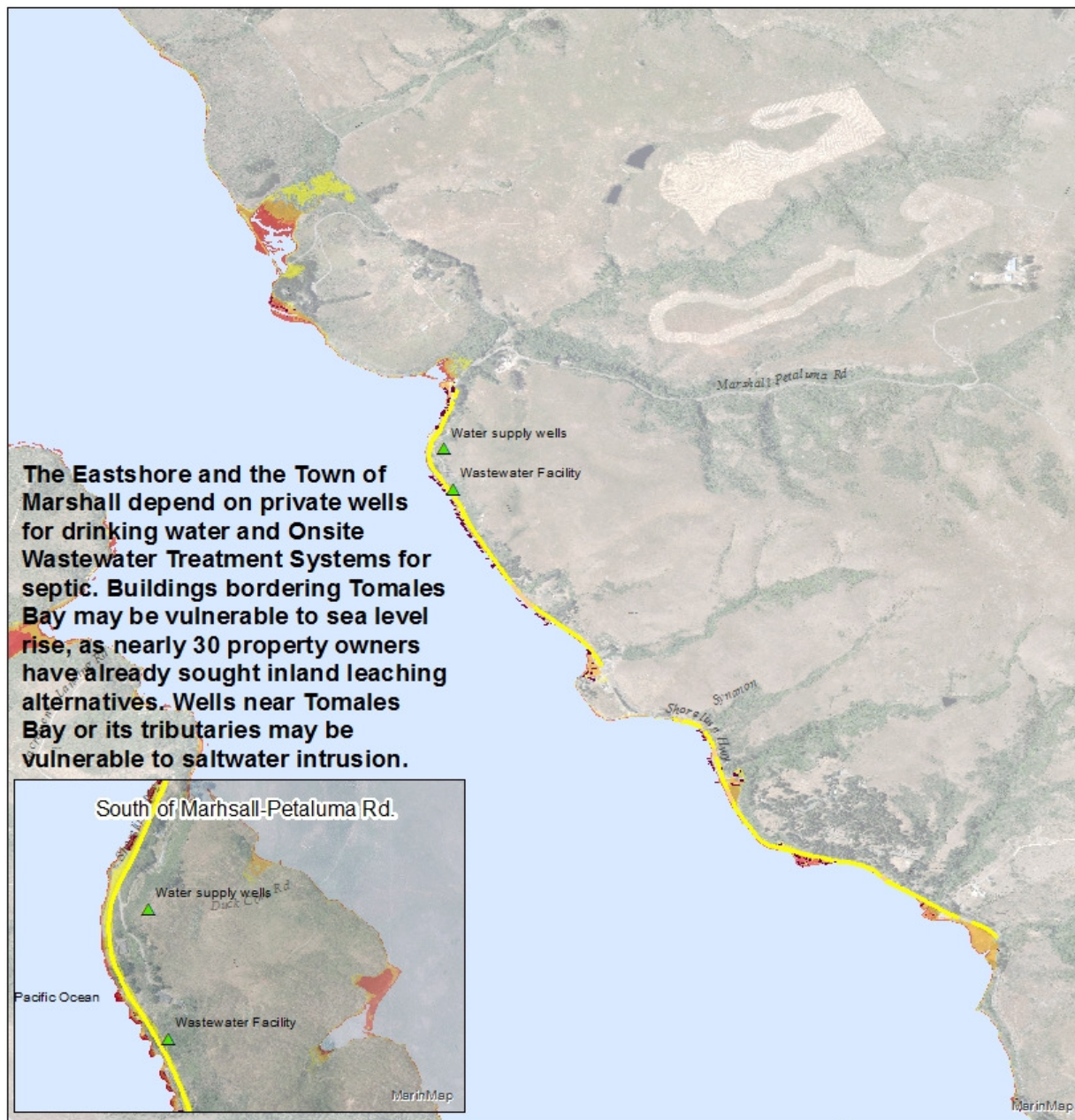
Sources: Our Coast Our Future (2014), Marin Map Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here, make no warranties of the accuracy or completeness of maps and data. Maps are presented as a guide only and are not to be relied on. Local officials should examine the examined. Commercial use is prohibited.

Date: 10/14/2015

COUNTY OF MARI

UTILITIES

Map 29: East Shore Vulnerable Utilities



Scenarios	Exposed roads w/ utility lines beneath	Buildings
1 10" SLR + Annual Storm	Scenario 1	Buildings
2 10" SLR + 20-year Storm	Scenario 2	Utilities
3 20" SLR + 20-year Storm	Scenario 3	Culverts
4 40" SLR + 20-year Storm	Scenario 4	Culvert Lines
5 80" SLR + 100-year Storm	Scenario 5	Man Hole, Catch Basin Grate
		Road Side Ditches

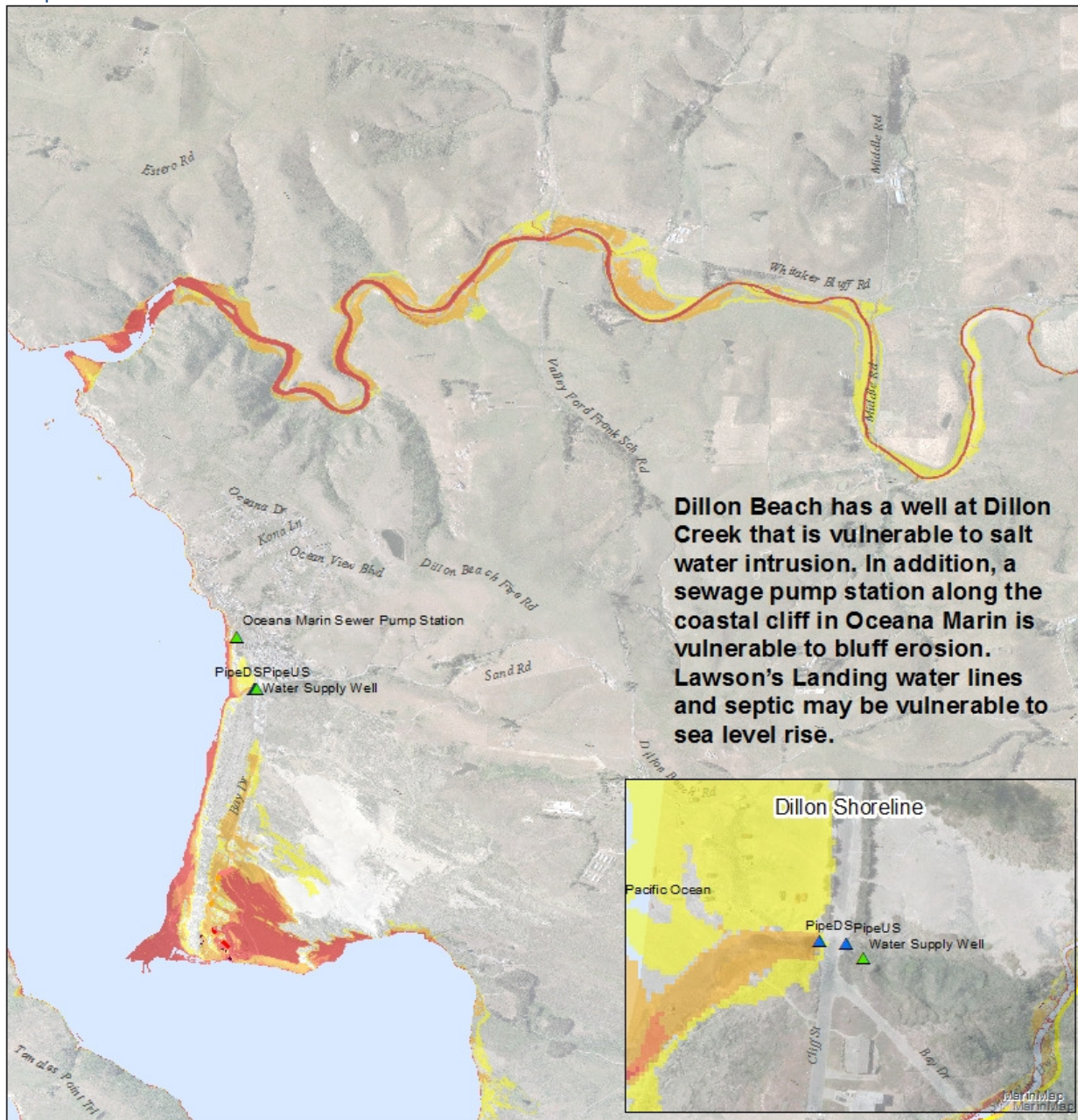
N
0 0.125 0.25 0.5 Miles

Sources: Our Coast Our Future (2014), Marin Map
Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers herein, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

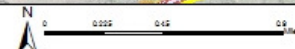
Date: 9/28/2015
CCLP Tr. of MARI

UTILITIES

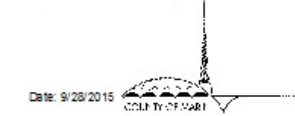
Map 30: Dillon Beach Vulnerable Utilities



Scenarios		Exposed roads w/ utility lines beneath		
1	10" SLR + Annual Storm	Scenario 1	Buildings	▲ Utilities
2	10" SLR + 20-year Storm	Scenario 2	▲ Utilities	▲ Culverts
3	20" SLR + 20-year Storm	Scenario 3	▲ Culverts	▲ Culvert Lines
4	40" SLR + 20-year Storm	Scenario 4	▲ Culvert Lines	▲ Man Hole, Catch Basin Grate
5	80" SLR + 100-year Storm	Scenario 5	▲ Man Hole, Catch Basin Grate	▲ Road Side Ditches



Sources: Our Coast Our Future (2014), Marin Map
 Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.



UTILITIES

Other Considerations

Economic

If these essential utility systems fail and residences become unlivable, depopulation could have significant impacts on the local year-around economy. If vacation homes are no longer able to offer essentials or amenities, such as internet, tourists could begin to find the area undesirable and seek other destinations. Visitor serving vacation rentals, bed and breakfasts, inns, and restaurants could see significant declines in patronage as well. Repairs to the community and private systems could be costly.

Repairs and relocations can be very costly, and in recent years a few multi-million dollars projects were implemented in Bolinas and the East Shore.

Environmental

If wastewater systems fail due to sea level rise, environmental contamination is highly likely and could become a hazard to people and wildlife exposed to the flood waters. Negative impacts to water quality are a major concern and are governed by the Clean Water Act.

Social Equity

Those on well and septic without financial means to update their utility systems to account for higher water levels are more vulnerable than those who can. Typically, unless financed via special assessment, funding measures are community wide, and in many of the coastal communities not all homes and businesses are directly impacted and may not be willing to share the cost burden for those who are directly impacted. This community separation could divide the community into factions, increase tension, and reduce community cohesion and resiliency.

Management

Several asset managers indicated that utility lines are often placed under and along roads. Right-of-way to move the roads and utility assets is inadequate and would need to be acquired from public and private land owners. Utility systems are often managed or regulated by state agencies, such as the Regional Water Quality Control Board and the California Public Utilities Commission and any improvements would require their involvement.

WORKING LANDS

Asset Profile: Agriculture & Aquaculture

Working lands host cultivation and livestock activities. The majority of land based operations exposed to sea level rise on the Marin Coast are ranches, dairies, and small produce farms. Ocean-based operations in Tomales Bay cultivate a variety of shellfish, while fishing and crabbing vessels leave from several boat launches in Bolinas, Inverness, and Marshall. All are major economic and cultural contributors to West Marin. The following are key issues related to working lands' vulnerability:

- Loss of vehicular access to and from working lands and processing facilities during storms and, eventually, on a daily basis threatens the viability of agricultural operations. Heavy vehicles may lose access as roadways become increasingly compromised by flooding. Bridges crossing Middle Road and Frank Valley School Road, north of Dillon Beach, already flood seasonally.
- Fishing vessels and aquaculture operations will face new challenges and may need to adjust practices and adapt their facilities.
- Aquaculture and land-based operations depend on access to local, regional, and worldwide markets.
- Lack of vehicular access for agri-tourism operations and bus tours could have negative tourism impacts on the region.

Agriculture

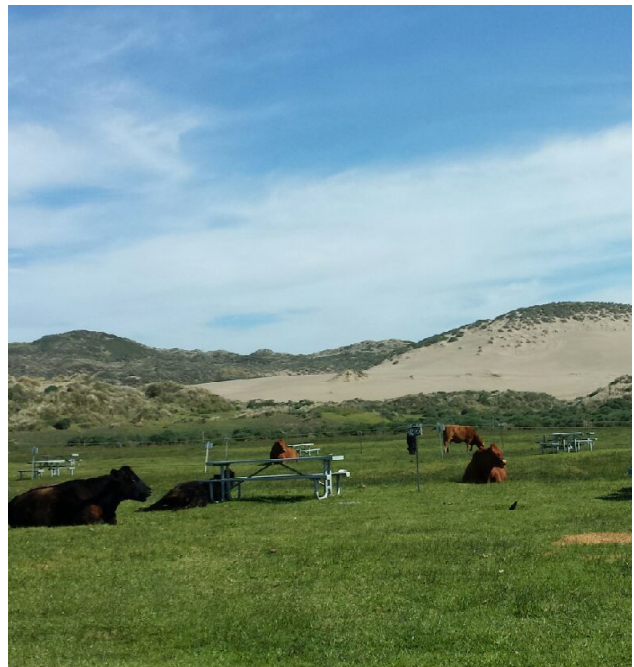
Under scenario 5, over 450 acres across forty-five parcels are exposed to sea level rise and storm conditions. Exposed agricultural parcels are concentrated north of Pt. Reyes Station with the exception of the Green Gulch Zen Center organic farm near Muir Beach and lagoon side fields in Bolinas. North of Pt. Reyes Station, a cluster of four grazing operations could be affected, including the Blake Family Farm and Giacommini Dairy. Exposed grazing parcels are also concentrated along Walker Creek in Marshall and extend a few miles inland (10 parcels, 8 property owners). According to local community members, this area is impassable during storm and high tide events. Additional grazing parcels are located along Stemple Creek (14 parcels, 10 property owners) and along the Americano Creek (9 parcels, 7 property owners).

IMPACTS AT-A-GLANCE

457 agricultural acres (mostly ranch)	30 land owners
569 aquaculture acres	Site specific
Economic impact unknown	Property Owners



Oyster farm on Tomales Bay at low tide. Credit: CDA



Grazing at Lawson's Landing. Credit: Van Belleghem

WORKING LANDS

Most farm operation buildings are set back far enough from the coast and creeks and are not exposed the sea level rise. However, coastal land based farming operations could see increases in brackish water conditions in creeks and erosion along the creeks and shoreline. In the area north of Dillon Beach and in Pt. Reyes Station, bridges are vulnerable to flooding, leaving farm products and transport vehicles stuck on one side or the other of the creek. Many of the exposed agricultural parcels are large and the land area exposed on the property is a small portion of the total parcel acreage. Bolinas has a few parcels with small scale agriculture that are shielded from coastal flooding by earthen berms. Muir Beach's Green Gulch farm operation was not deemed vulnerable based on a site visit and property owner consultation. However, all agricultural operations in West Marin could be vulnerable to breakdowns in the transportation network, whether maritime or land based, or local, regional, or statewide. Transportation disruptions would also impact the farm tour, or agri-tourism, based economy that depends on vehicular access to the areas wine, cheese, and other agricultural products.

Table 24. Exposed Agricultural Parcels and Acreage (ac.) by Community

	Scenario 1		Scenario 3		Scenario 5	
	#	Ac.	#	Ac.	#	Ac.
Muir Beach					4	13
Pt. Reyes Station					2	5
East Shore	6	8	8	11	15	34
Dillon Beach	18	100	21	159	25	405
Total	32	110	32	172	46	457

Source: Marin Map, Parcels. 2014

Aquaculture (Mariculture)

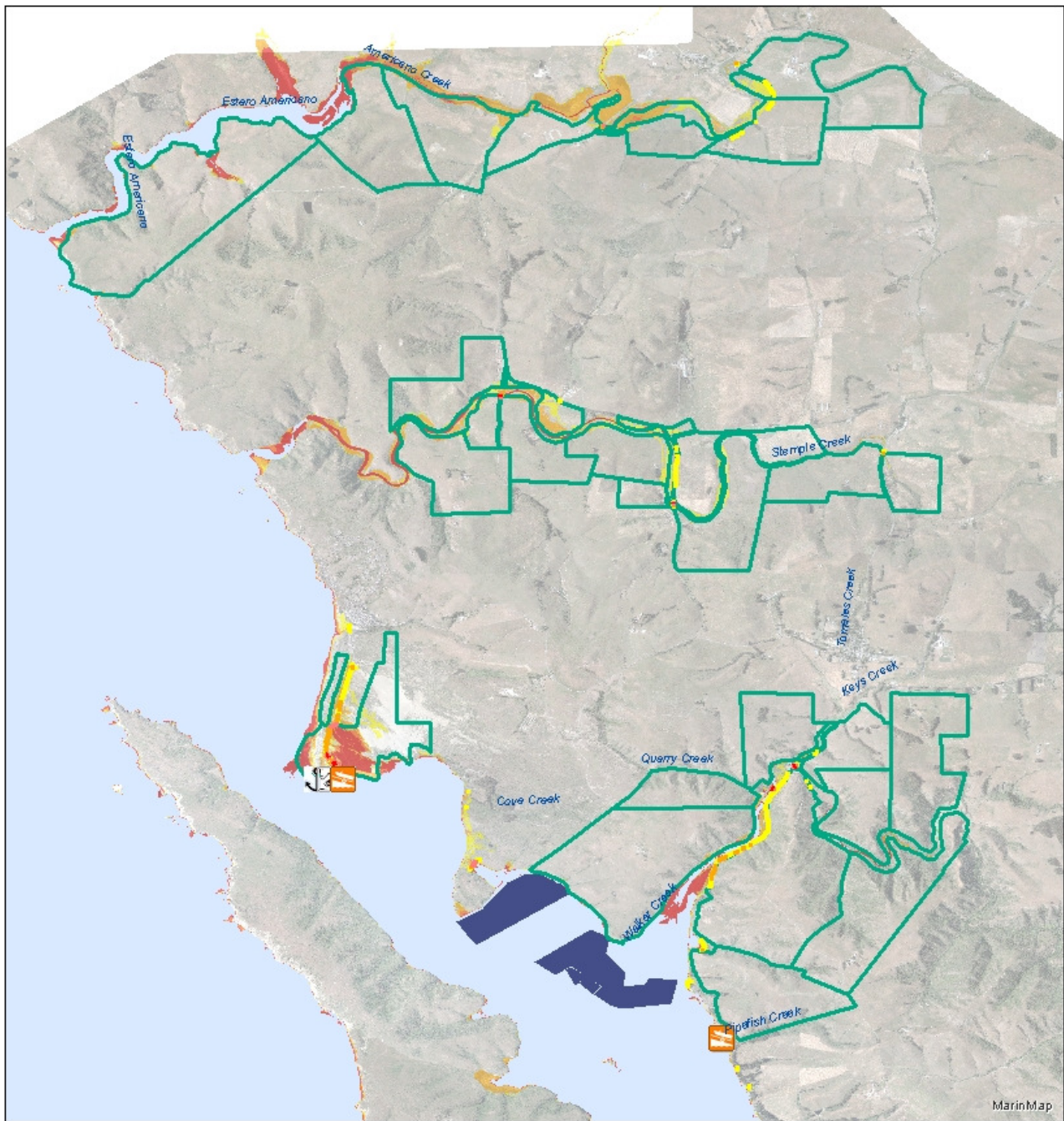
By their nature, aquaculture operations are exposed at existing water levels. Current practice depends on low tide for harvesting. As tides push landward, these operations could become inundated, causing a shift in practices. The hard edge along the bay shore will prevent inland flow and create dramatic conditions during storms. Unlike most land based operation's buildings, aquaculture buildings could see structural damage from storms and inundation. And much like with agri-tourism for land-based products, vehicular access could also be a hindrance on the thriving oyster tours that depend on fully functioning roadways in the Coastal Zone.

Aquaculture, or mariculture, operations are located on the East Shore of Tomales Bay. Twelve parcels, totalling nearly 600 acres, cultivate 10 oyster (Pacific, Kumamoto, Pacific Giant, Eastern flat, European, eastern, flat, native, Olympia, suminoe), 4 clam (manila, Northern Quahog, native littleneck, Japanese littleneck), 3 mussel (bay, California sea, blue), and 2 scallop (rock, Japanese) varieties, and red abalone. According to the 2014 Agriculture and Livestock Report, these parcels contributed \$10.6 million in economic activity that year (10 percent of the total Marin agricultural economy).²⁰ In addition, crabbing and fishing are popular commercial activities in Bolinas and Tomales Bay.

²⁰ Carlsen, Stacy. 2014 Marin County Agriculture and Livestock Report, Marin County department of Agriculture, Weights and Measures.- <http://www.marincounty.org/~media/files/departments/ag/crop-reports/2014.pdf?la=en>

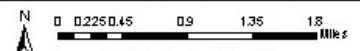
WORKING LANDS

Map 31. North of Nick's Cove (East Shore) Vulnerable Working Lands



Scenarios	Exposed Roads	
1 10" SLR + Annual Storm	10" + Annual storm	Aquaculture
2 10" SLR + 20-year Storm	10" + 20-year storm	Agricultural Parcels
3 20" SLR + 20-year Storm	20" + 20-year storm	Boat Launch
4 40" SLR + 20-year Storm	40" + 100-year storm	Fishing Pier
5 80" SLR + 100-year Storm	80" + 100-year storm	

- Port
- Marina

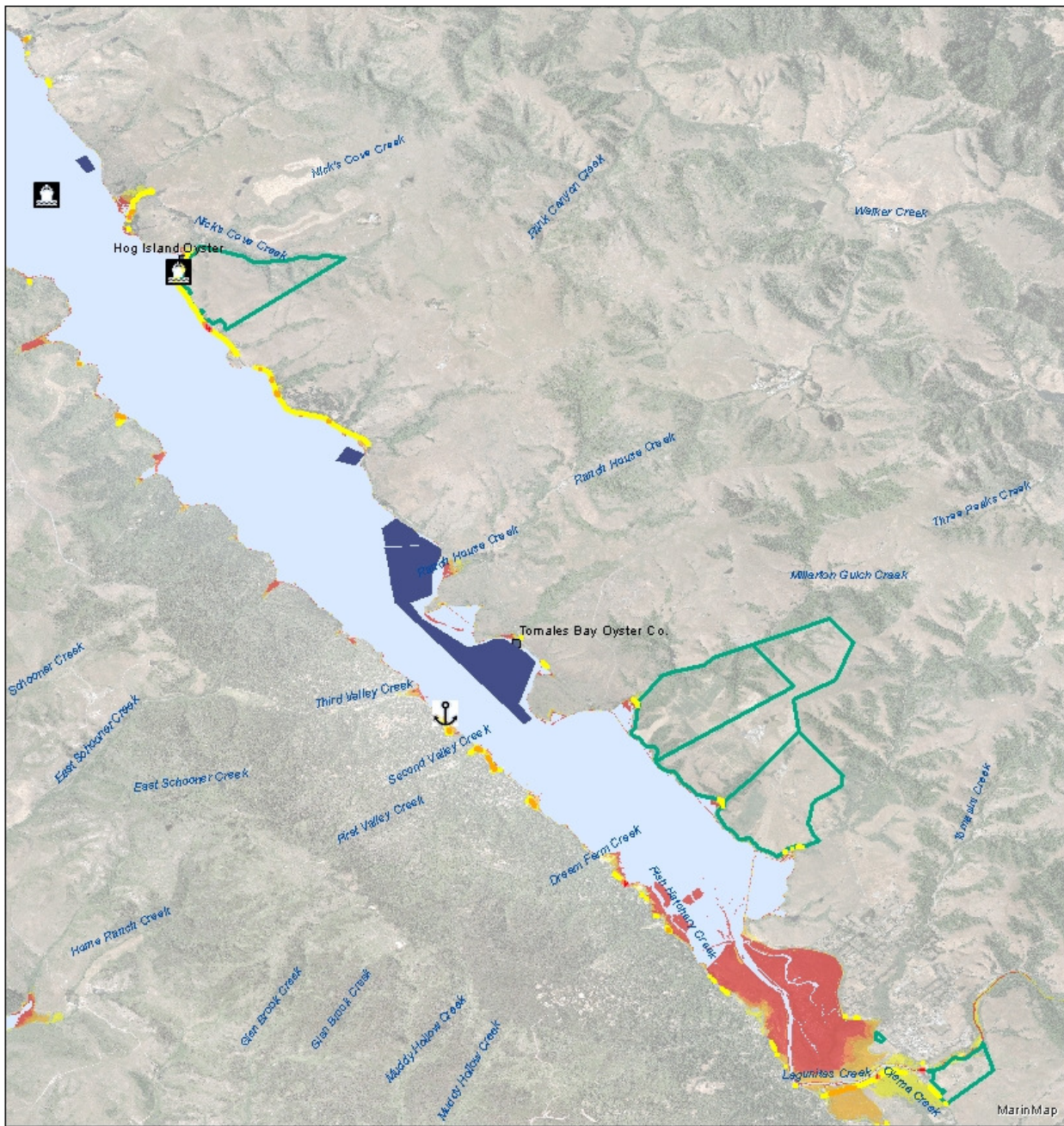


Source: Marin Map, Our Coast Our Future. Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County and data providers herein make no warranties of the accuracy or completeness of maps and data. Maps are representative and subject to future revision. Local sites could be as much as 10% higher. Commercial use is prohibited.

Date: 7/29/2015

WORKING LANDS

Map 32: South of Nick's Cove (East Shore) Vulnerable Working Lands



Scenarios

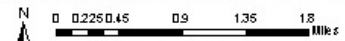
- 1 10" SLR + Annual Storm
- 2 10" SLR + 20-year Storm
- 3 20" SLR + 20-year Storm
- 4 40" SLR + 20-year Storm
- 5 80" SLR + 100-year Storm

Exposed Roads

- 10" + Annual storm
- 10" + 20-year storm
- 20" + 20-year storm
- 40" + 100-year storm
- 80" + 100-year storm

- Aquaculture
- Agricultural Parcels
- Boat Launch
- Fishing Pier

- Port
- Marina



Source: Marin Map, Our Coast Our Future
 Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here, make no warranties of the accuracy or completeness of maps and data. Maps are prepared for informational purposes only. Local officials should be consulted for more information. Commercial use is prohibited.

Date: 7/29/2015



WORKING LANDS

Existing Policies

The Draft Local Coastal Program (DLCP) strongly supports continued diversified agricultural and aquaculture uses. The Coastal Agricultural Production Zone (C-APZ) district comprises nearly two-thirds of the Coastal Zone, and contains the majority of Marin's agricultural lands. The Coastal Agriculture, Residential Planned (C-ARP) district is also present in the study area.

Because mariculture operations in Marin County are in submerged areas, they are under the permit jurisdiction of agencies such as the Coastal Commission and the Department of Fish and Wildlife. The DLCP gives general support for mariculture, while avoiding site specific policy provisions.

Other Considerations

Economic

Exposed land based operations account for \$7,146,200 in assessed land value that could see losses as lands newly under water become waters of the State. Aquaculture operations may need to adjust their harvesting practices in the near- to medium-terms to adjust to higher water levels and higher low tides by switching from tidal harvest to over water harvesting. Contamination from vulnerable wastewater systems could prevent safe production and prevent export. Exports and agritourism are contributors to the coastal Marin economy. If exporting agriculture and aquaculture goods becomes an ever increasing challenge on flooded roads, economic impacts could be incurred, including the loss of jobs. Finally, if tour routes are flooded during times of operation, reductions in tours, tourists, and their economic contributions could occur.

Environment

Intrusion of brackish water could change the ecological conditions of the ranchlands and ranch management practices. Invasive species are already a growing concern in the agricultural community, and warming conditions, with a weakening in the native flora, could increase the extent of some heat loving invasive plant species.

Social Equity

Employees of these operations could be disproportionately impacted if operations need to reduce labor costs. Local restaurants and markets along the East Shore that vend West Marin agricultural products provide places for social gathering and jobs for local youth. Losing businesses and jobs could have significant impacts on social outcomes.

Management

Agriculture is a highly regulated industry at nearly all levels of government. For example, at the federal level is the Clean Water Act (Sections 401 and 404)²¹ and the resulting Tomales Bay Conditional Grazing Waiver and Tomes Bay/ Stemple Creek/ Estero de San Antonio total maximum daily [sediment] loads (TMDLs) that farmers must comply with to reduce erosion and sediment loads to creeks. In several cases, to comply and improve water quality, farmers have fenced off creeks from livestock wading, installed new stream crossings and restored riparian areas that could be compromised under these sea level rise scenarios. Habitat changes prompted by sea level rise could require new conservation management plans and improvements in the coming decades to ensure water quality standards are upheld. The Coastal Commission may also impose regulations for farmland use that Marin County would be required to administer through the Local Coastal Plan

Aquaculture operations, in addition to the Clean Water Act, are subject to the Public Lands Doctrine and lease land from the State to conduct their cultivation efforts. These leases are associated with tides and as the tides change, the permits will need to adjust.

²¹ US Environmental Protection Agency. Water: Clean Water Act. *Water Quality and 401 Certification* . http://water.epa.gov/lawsregs/guidance/cwa/waterquality_index.cfm

NATURAL RESOURCES

Asset Profile: Habitats & Wildlife

Marin County is known and treasured for its beaches, estuaries, wetlands, marshes, creeks, national and state park lands, marine sanctuaries, wildlife preserves, and unique landscapes.

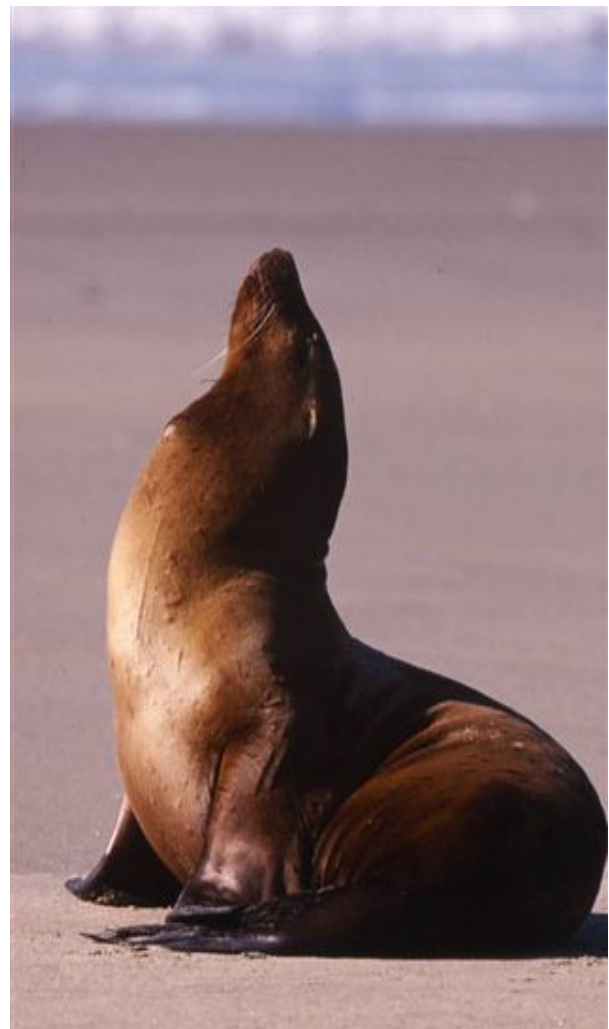
Over 50 natural resource assets on the Marin Coast could be exposed to sea level rise and storms. Several are managed by state and federal agencies for public use. Major examples include: Golden Gate National Recreation Area (includes Muir Beach Park), Stinson Beach Federal Park, Mt. Tamalpais State Park, Point Reyes National Seashore, Tomales Bay State Park, and Tomales Bay Wetland Reserve. The Greater Farallones National Marine Sanctuary is located in the coastal waters and islands off the Marin County Coastline. Others are preserved as county parks, such as Bolinas Lagoon Park, Agate Beach, and Duxbury Reef. Finally, some are held by non-profit organizations such as the Nature Conservancy and Audubon Canyon Ranch. Audubon Canyon Ranch manages the Martin Griffin Preserve and Livermore Cypress Grove.

A majority of these habitats and their wildlife inhabitants are already exposed to sea water during times of high tide, or always. What will change is the extent and nature of the sea water moving landward, and, in some cases, into freshwater habitats. The following are key issues related to natural resources and wildlife habitat vulnerability:

- Where space exists, sea level rise may push coastal beaches and marshes inland and shift existing tidal areas to standing water and or flood inland areas with saltwater.
- Roads, storm drains, and development greatly restrict the ability of habitats to migrate landward and could completely transform them. Inadequate maintenance, for example clogged culverts, could reduce drainage capacity and cause flooding (Bolinas, East Shore, and Inverness).
- Increases in salinity in freshwater and brackish water habitats can impact habitat suitability for existing species.
- Endangered species and special habitats are especially vulnerable.
- Ecosystem services, such as water filtration and flood protection, may be compromised.

IMPACTS AT-A-GLANCE

Several land and water species		GFNMS DFW CCC CA Wildlife Conservation Board
Site specific		
Beaches Estuaries Rocky Intertidal Areas	Western snowy plover Black oystercatcher Black Rail California Mussel Red Abalone	



Sea lion sunbathing. Credit: Drumm

NATURAL RESOURCES

Table 25 lists some of the potentially vulnerable natural resource related assets in the study area. This list provides onset and tidal mean higher high water (MHHW) and extreme event flood depths; however many natural resource assets are shoreline

based or water features. This list is not exhaustive of all the natural resource assets that could be exposed to sea level rise and storm impacts in the study area.

Table 25. Natural Resource Assets Ranked by Onset and Flood Depth (feet and inches)

Community	Asset (not exhaustive)	High Tide & Extreme Event Flooding Depth Estimates <small>(Underlined values indicate tidal flooding at mean higher high water (MHHW) based on one geographic point placed at the landward limit of the first scenario where it overlaps the asset. values not underlined represent temporary extreme event flooding.)</small>					Vulnerability <small>TF: Temp. Flooding during extreme events; I: Inundated at MHHW; E: Erosion; WT: Water Table; WS: Wave Surge; HW; HS: Habitat Shift</small>
		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	
Stinson Beach	Upton Beach	<u>4'7"</u>	<u>6'2"</u>	<u>7'5"</u>	<u>9'8"</u>	<u>14'9"</u>	I, E
East Shore	Walker Creek Access Point	<u>2'4"</u>	<u>3'3"</u>	<u>4'2"</u>	<u>6'1"</u>	<u>9'3"</u>	I
Bolinas	Brighton Beach	<u>2'2"</u>	<u>3'5"</u>	<u>4'11"</u>	<u>6'</u>	<u>9'11"</u>	E, WS
East Shore	Livermore Marsh Cypress Grove	<u>2'1"</u>	<u>3'1"</u>	<u>3'11"</u>	<u>5'10"</u>	<u>9'2"</u>	I, HS
Inverness	Chicken Ranch Beach	2'	3'1"	3'9"	<u>5'5"</u>	<u>8'</u>	I, E, HS
Inverness	Martinelli Park	<u>1'1"</u>	<u>2'</u>	<u>2'2"</u>	<u>4'1"</u>	<u>7'3"</u>	I, E
Bolinas	Agate Beach	2'1"	1'11"	2'8"	4'8"	<u>9'3"</u>	I, HS
Inverness	Tomales Bay State Park (low lying areas)	10"	1'10"	<u>2'8"</u>	<u>4'7"</u>	<u>7'10"</u>	I, HS
Dillon Beach	Lawson's Landing	2"	1'1"	<u>2'11"</u>	<u>3'10"</u>	<u>7'3"</u>	I, E, WS, HW, HS
Pt. Reyes Station	White House Pool/Trail			<u>2'5"</u>	<u>2'3"</u>	<u>5'11"</u>	I, HS
Inverness	Dana Marsh & Beach Access				<u>3'</u>	<u>6'2"</u>	I, E, SI, HS
East Shore	Millerton Point				<u>2'5"</u>	<u>5'8"</u>	I, E
Inverness	Shell Beach Tomales Bay SP				5"	<u>3'4"</u>	TF, I, WT
Point Reyes Station	Olema Marsh Trail					<u>2'9"</u>	I
Dillon Beach (north)	Stemple Creek Recreation Area	X	X	X	X	X	HS
Stinson Beach / Bolinas	Bolinas Lagoon	water resource					HS
Inverness / East Shore	Tomales Bay	water resource					HS
North of Dillon Beach	Estero Americano	water resource					HS

Source: Marin Map, OCOF Exposure and Flood Depth data, Asset Manager Interviews

NATURAL RESOURCES

The *Climate Change Vulnerability Assessment for the North-central California Coast and Ocean*, identifies how and why habitats and species across the North-central California coast and ocean region are likely to be affected by future climate conditions.²² Consultation with the authors enabled isolating sea level rise findings from other climate change impacts.

As described in the Methods section, this interagency study used different methods to assess vulnerability than this Assessment to examine sensitivity, adaptive capacity, and exposure. The interagency study employed 80 scientists to provide overall vulnerability and confidence scores for each habitat and species. Scores for the exposure were weighted less than scores for the sensitivity and adaptive capacity components of vulnerability by a factor of 0.5 due to uncertainty about the magnitude and rate of future change. Sensitivity, adaptive capacity, and exposure scores were combined into an overall vulnerability score calculated as follows:

$$\text{Vulnerability} = (\text{Climate Exposure (0.5)} + \text{Sensitivity}) / \text{Adaptive Capacity}$$

The assessment concludes that the most vulnerable habitats are beaches (including dunes), estuaries, and rocky intertidal areas. These habitats are primarily vulnerable to sea level rise, wave action from storms, and erosion. Beach and dune habitat was scored as having the highest vulnerability to sea level rise, due to high exposure, high sensitivity, and moderate adaptive capacity. Cliff habitats were scored with the lowest vulnerability due to moderate sensitivity and low to moderate exposure.

Beaches

Sea level rise can inundate existing beach and dune systems and increase rates of shoreline erosion. This could potentially force beach and dune habitats inland.²³ However, in many cases along the Marin

Coast, beachside development, roads, or steep slopes and bluffs, limit landward migration, causing beaches to shrink.²⁴ This habitat shift could affect many species, including pinnipeds (elephant seals, harbor seals, sea lions), shore birds, and smaller coastal species. In addition, shifts and losses in ecological zones within beach habitats could disrupt the food web²⁵ and ecosystem dynamics and quality.²⁶ Winter increases in wave action shape beaches, contribute to erosion, and affect key species. Late winter El Niño events (3 to 5-year storm),²⁷ occur when beaches are at their narrowest widths.^{28,29} Waves in combination with high tides could lead to significantly eroded beaches.



Stinson Beach from Shoreline Highway. Credit: CDA

²² Hutto, S.V., K.D. Higgason, J.M. Kershner, W.A. Reynier, D.S. Gregg. 2015. *Climate Change Vulnerability Assessment for the North-central California Coast and Ocean*. Marine Sanctuaries Conservation Series ONMS-15-02. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries, Silver Spring, MD. 473 pp. <http://sanctuaries.noaa.gov/science/conservation/pdfs/vulnerability-assessment-gfnms.pdf>.

²³ Feagin, R.A., D.J. Sherman, and W.E. Grant. 2005. *Coastal erosion, global sea-level rise, and the loss of sand dune plant habitats*. *Frontiers in Ecology and the Environment* 7:359-364.

²⁴ Largier, J.L., B.S. Cheng, and K.D. Higgason, editors. 2010. *Climate Change Impacts: Gulf of the Farallones and Cordell Bank National Marine Sanctuaries*. Report of a Joint Working Group of the Gulf of the Farallones and Cordell Bank National Marine Sanctuaries Advisory Councils.

²⁵ Dugan, J.E., D.M. Hubbard, I. F. Rodil, D. L. Revell and S. Schroeter. 2008. *Ecological effects of coastal armoring on sandy beaches*. *Marine Ecology* 29: 160-170.

²⁶ Feagin, R.A., D.J. Sherman, and W.E. Grant. 2005. *Coastal erosion, global sea-level rise, and the loss of sand dune plant habitats*. *Frontiers in Ecology and the Environment* 7:359-364.

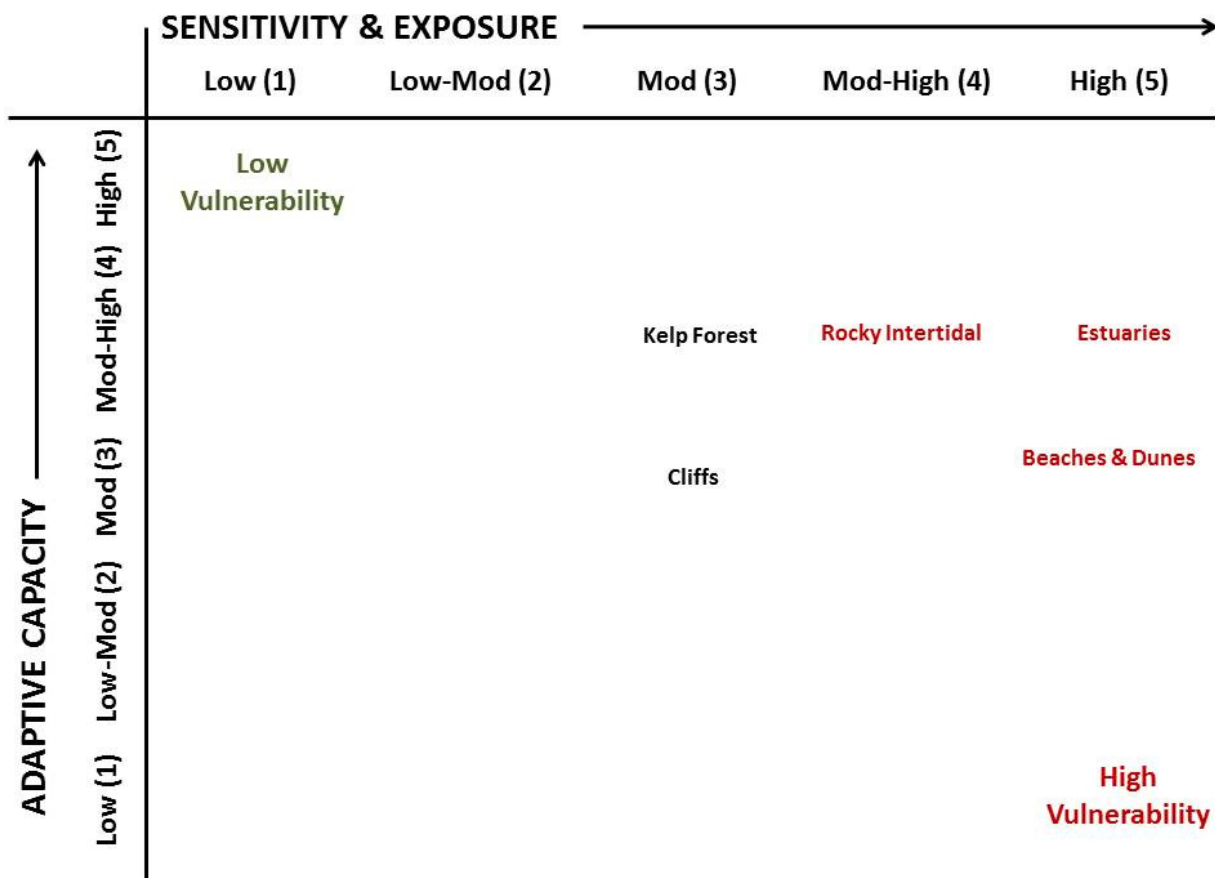
²⁷ Occur every 10-15 years. *A recent Nature Climate Change publication calculates an increase in the frequency of El Niño events*. Cai, W. et al. *Nature Clim. Change* <http://dx.doi.org/10.1038/NCLIMATE2100> (2014).

²⁸ Storlazzi, C. and G. Griggs. 2000. *Influence of El Niño-Southern Oscillation (ENSO) events on the evolution of Central California's shoreline*. *GSA Bulletin* 112 (2).

²⁹ Wingfield, D.K. and C.D. Storlazzi. 2007. *Variability in oceanographic and meteorologic forcing along Central California and its implications on nearshore processes*. *Journal of Marine Systems* v. 68.

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Figure 11. Sea Level Rise Vulnerability for the North-central California Coast and Ocean Habitats



Source: Hutto, S. Email Communication. Van Belleghem, B. 2015

Bluff erosion can have varying impacts on beach habitats. Eroding bluffs can be a major source of sediment allowing beaches to evolve.³⁰ Alternatively, beach loss due to bluff collapse can negatively impact sand crabs, wrack consumers, and species that depend on beach habitats for breeding and nesting.³¹ Major beaches include:

- Muir Beach
- Stinson Beach
- Nude Beach

- Brighton Beach
- Agate Beach
- Upton Beach
- Dillon Beach
- Lawson's Landing
- Shell Beach
- Heart's Desire Beach

Additional analysis for beaches in Stinson Beach, Bolinas, and the East Shore, calculated the resulting beach areas for each sea level rise amount. The resulting beach widths and associated vulnerability levels are presented in [Table 26](#).

³⁰ Baye, P. R., 2014. Memorandum: Bolinas Lagoon Restoration Project Design Review Group (DRG) Meeting San Francisco Bay Joint Venture (SFBJV) Meeting Summary And Synthesis Draft.

³¹ Largier, J.L., B.S. Cheng, and K.D. Higgason, editors. 2010. *Climate Change Impacts: Gulf of the Farallones and Cordell Bank National Marine Sanctuaries*. Report of a Joint Working Group of the Gulf of the Farallones and Cordell Bank National Marine Sanctuaries Advisory Councils.

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Table 26. Existing and Future Average Beach Widths and Corresponding Vulnerability Levels

	Width (meters) & Vulnerability					
	Base-line	Scen 1	Scen 2	Scen 3	Scen 4	Scen 5
Upton to Stinson Federal	53	48	48	32	9	2
	Low	Low	Low	Low	Med	High
Stinson (Seadrift)	38	29	29	14	0	0
	Low	Low	Low	Med	High	High
Bolinas	38	29	29	14	0	0
	Low	Low	Low	Med	High	High
Inverness/ East Shore	Beaches along are narrower than 10 meters.					
	High					

Source: ESA, 2015, OCOF

slightly wider patch of beach is in front of the cliff adjacent to the mouth of Bolinas Lagoon. The beaches at Bolinas are currently above the low vulnerability threshold mainly due to the existing condition (2010 LiDAR) of the wider east beach around the jetty; however, the beach width here fluctuates from year to year and has almost completely flooded out in years past. The west beach area is already narrow and increasingly vulnerable to loss with future sea level rise because the armored cliff and beachfront homes do not allow the beach to migrate landward.

Marshall

Beaches in the Marshall area are limited to a few small pockets either near creek mouths or tucked behind docks and armoring structures. These beaches are currently less than the 10 meter threshold for high vulnerability. Since most are backed by armor they will remain highly vulnerable as sea levels rise because they cannot migrate upland.

Stinson Beach (Upton to Stinson Federal)

Stinson is backed by a mix of armored homes, other beachfront structures, and unarmored dunes. The Federal area, is the widest, and the lack of armor on dunes may allow the beach to migrate inland, with sea level rise and storm erosion events. However, the beach areas and associated vulnerability levels for future years in Stinson assume no transgression of the backshore, effectively treating the back of the beach as armored. Allowing the beach to migrate inland may help sustain the beach as an ecological and recreational resource into the future, though likely at the expense of parking and other beachfront facilities.

Stinson Beach (length in front of Seadrift neighborhood)

The Seadrift neighborhood backing this segment of beach was armored after homes sustained significant damage from wave impact and inundation during the 1983 El Niño event.³² This stretch of beach is more susceptible to loss because it is narrower than Stinson and armored, preventing inland migration.

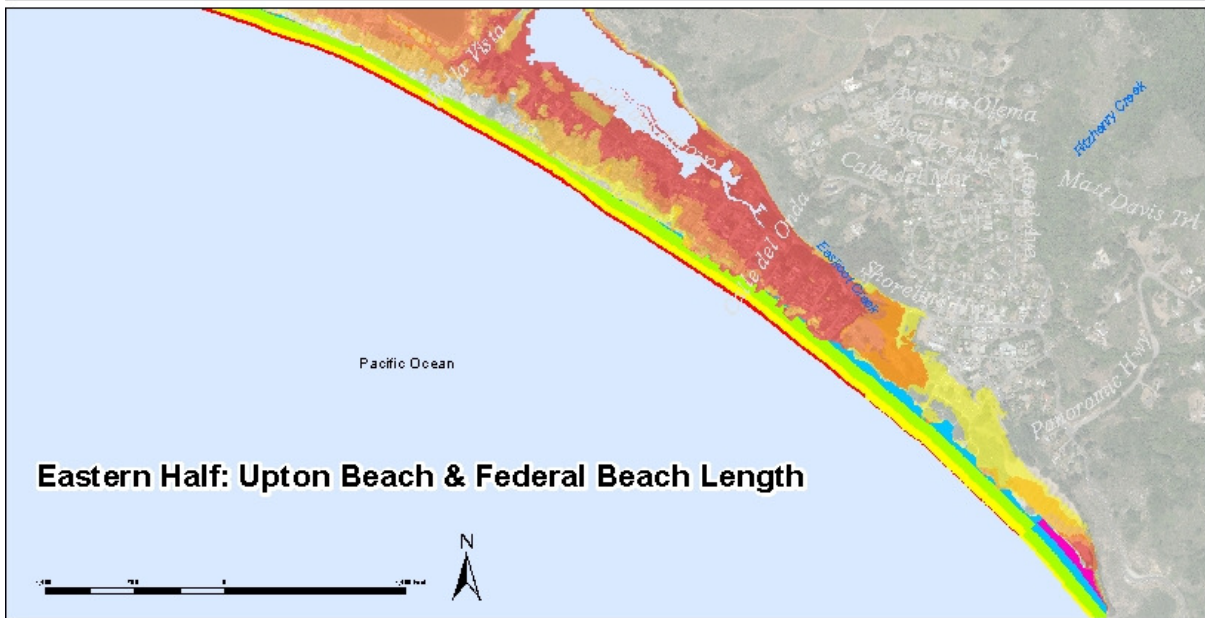
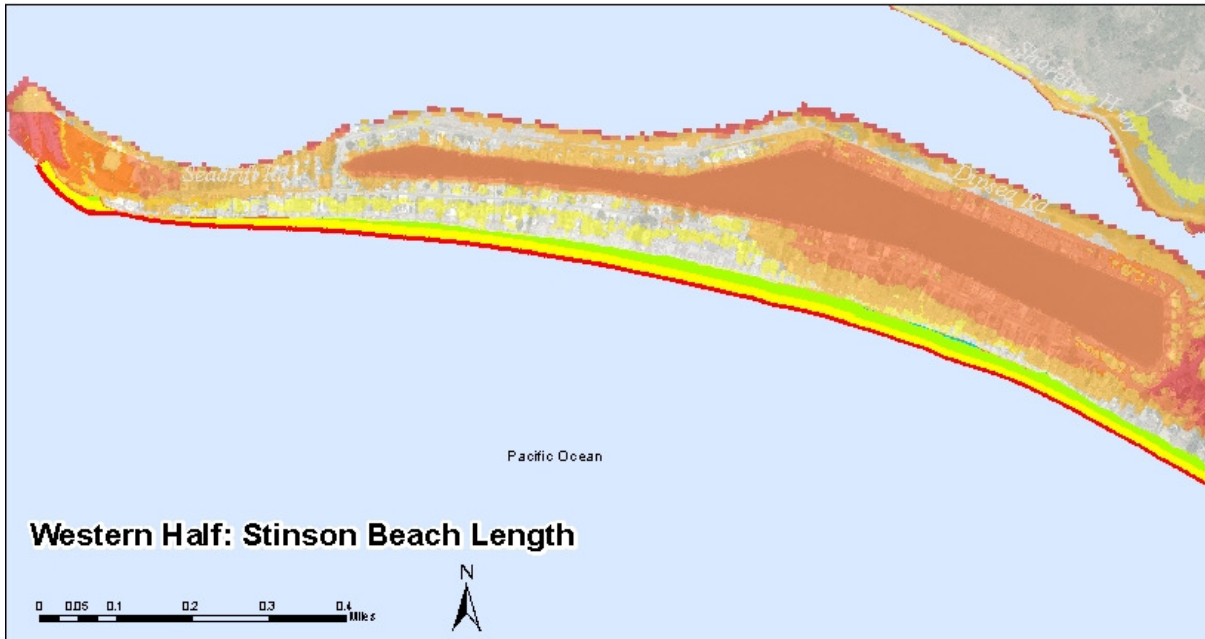
Bolinas

Bolinas is characterized by small patches of cliff-backed beaches with armored oceanfront homes. A

³² Griggs, G., Patsch, K., Savoy, L. 2005. Living With The Changing California Coast. University of California Press. Berkeley, CA. 551pp.

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Map 33. Stinson Beach Potential Beach Loss



Scenarios

- | | | |
|---|--------------------------|-------------------------------|
| 1 | 10" SLR + Annual Storm | Beach (around end of century) |
| 2 | 10" SLR + 20-year Storm | Beach Loss @ 80 inches SLR |
| 3 | 20" SLR + 20-year Storm | Beach Loss @ 40 inches SLR |
| 4 | 40" SLR + 20-year Storm | Beach Loss @ 20 inches SLR |
| 5 | 80" SLR + 100-year Storm | Beach Loss @ 10 inches SLR |

Source: Marin Map, OffCoastOffshore, ESA

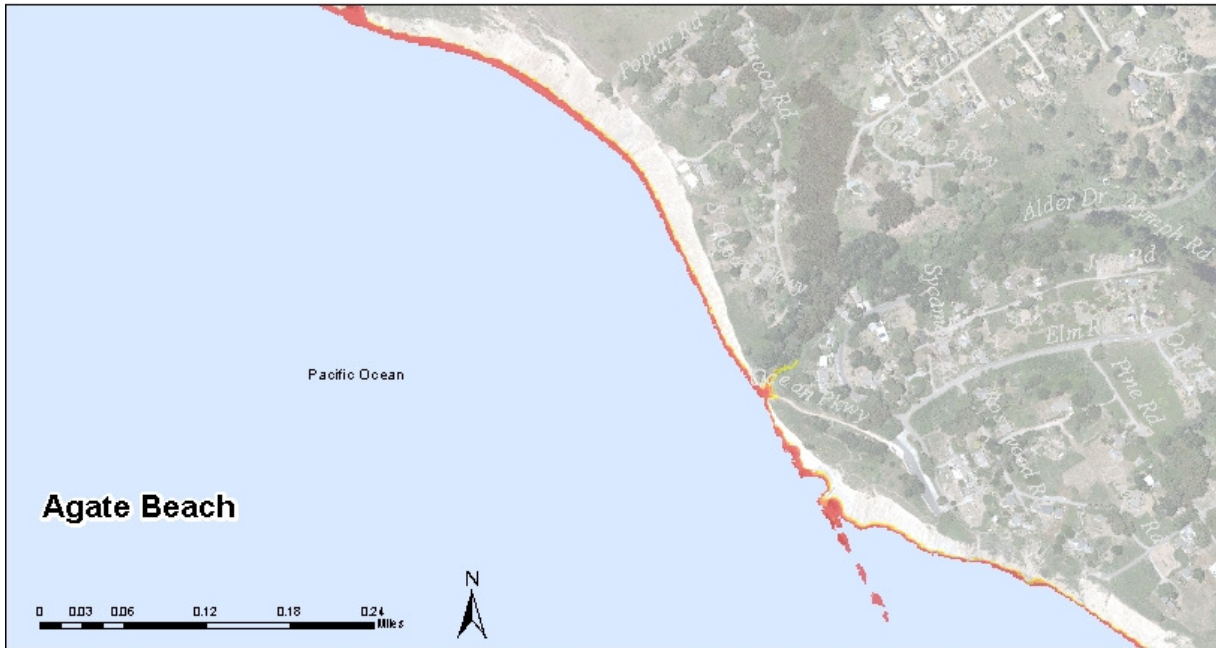
Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data provided here, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revisions. Local site conditions must be examined. Commercial use is prohibited.

Date: 9/1/2015



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Map 34. Bolinas Potential Beach Loss



Scenarios

- | | | |
|---|--------------------------|-----------------------------|
| 1 | 10" SLR + Annual Storm | Beach around end of century |
| 2 | 10" SLR + 20-year Storm | Beach Loss @ 80 inches SLR |
| 3 | 20" SLR + 20-year Storm | Beach Loss @ 40 inches SLR |
| 4 | 40" SLR + 20-year Storm | Beach Loss @ 20 inches SLR |
| 5 | 80" SLR + 100-year Storm | Beach Loss @ 10 inches SLR |

Source: Marin Map, Our Coast Our Future, ESA

Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers herein, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

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Estuaries, Marine Wetlands, & Marshes

An estuary is a partially enclosed coastal body of brackish water, or a mixture of fresh and salt water, with one or more rivers or streams flowing into it that mix with and transition to open ocean. Many of these connect with marine wetlands and marshes, though wetlands and marshes also occur along the coast unassociated with estuaries. Overlaying the C-SMART scenarios on this habitat data reveals there are roughly 9,000 existing acres in the estuaries of Tomales Bay, Bolinas Lagoon, and Esteros Americano and San Antonio. Approximately, 1,600 acres marshlands with established vegetation and an additional 200 acres of less vegetated wetland could be impacted to varying degrees across all of the scenarios.

Sea level rise will likely exacerbate shoreline erosion and potentially increase salinity.³³ Without a comparable increase in land elevation from sediment delivery, these coastal habitats will be unable to adjust and thus, flood more frequently.^{34,35} Much like beaches, these areas can be prevented from moving landward when backed by development, coastal armoring, or cliffs. Additionally, timing and extent of the rise and fall of the tide may be altered in estuaries and tidal rivers.³⁶ Increased storm activity could have significant implications for flooding of estuarine habitat and mouth.³⁷ Increased storm activity could also experience increased salinity of coastal wetlands and marshes.

The following are examples of the major estuarine, wetland, and marsh habitats that could be vulnerable to sea level rise and storms:

- Muir Beach Lagoon
- Bolinas Lagoon
- Giacomini Wetlands
- Olema Marsh
- Tomales Bay
- Shields Salt Marsh
- Estero San Antonio
- Estero Americano

Similar to beaches, a geomorphic assessment of marsh habitats was conducted and a metric was developed that links marsh vulnerability levels to future sea levels. In general vegetation occurs from just above mean sea level (MSL) to just above mean higher high water (MHHW). Cordgrass is found at lower elevations, and pickleweed is typically at the MHHW limit with a number of other species depending on local elevation, drainage, soils, site history and other factors.

Bolinas Lagoon

Bolinas Lagoon is a tidal embayment sheltered by Stinson Beach Spit and consists of approximately 1,000 acres of open shallow water, extensive mud and sand tidal flats, approximately 600 acres, flood and ebb tide shoals and deltas, small alluvial fans and deltas, and fringing tidal salt marsh. Kent Island within the Lagoon is an emergent flood tidal delta island with a thin cap of beach and dune sands.³⁸ The water is primarily marine and connects via a tidal inlet that has primarily remained open for 1,600 years (as suggested by the absence of freshwater pollen from soil cores).³⁹

Ten small seasonal drainages and Pine Gulch Creek contribute freshwater and coarse alluvial sediment, accounting for 25 percent of the sediment in the lagoon. Deltas at the mouth of these creeks are growing in response to increasing sediment load from channelization upstream. In the Pine Gulch Creek delta, this growth has converted intertidal estuarine habitats to upland riparian woodland. The Pine Gulch Creek delta and Kent Island shelter much of the western shoreline from wind and wave impacts and will facilitate mudflats converting to salt marsh. Tidal marshes are associated with deltas and alluvial fans, flood tidal delta shoals, and barrier beaches.

³³ Knowles, N. and D.R. Cayan. 2002. Potential effects of global warming on the Sacramento/San Joaquin watershed and the San Francisco estuary. *Geophysical Research Letters* 29:1891.

³⁴ Largier, J.L., B.S. Cheng, and K.D. Higgason, editors. 2010. *Climate Change Impacts: Gulf of the Farallones and Cordell Bank National Marine Sanctuaries*. Report of a Joint Working Group of the Gulf of the Farallones and Cordell Bank National Marine Sanctuaries Advisory Councils.

³⁵ Ackerly, D. D., R. A. Ryals, W. K. Cornwell, S. R. Loarie, S. Veloz, K. D. Higgason, W. L. Silver, and T. E. Dawson. 2012. *Potential Impacts of Climate Change on Biodiversity and Ecosystem Services in the San Francisco Bay Area*. California Energy Commission. Publication number: CEC-500-2012- 037.

³⁶ Largier, J.L., B.S. Cheng, and K.D. Higgason, editors. 2010. *Climate Change Impacts: Gulf of the Farallones and Cordell Bank National Marine Sanctuaries*. Report of a Joint Working Group of the Gulf of the Farallones and Cordell Bank National Marine Sanctuaries Advisory Councils.

³⁷ Largier, J.L., B.S. Cheng, and K.D. Higgason, editors. 2010. *Climate Change Impacts: Gulf of the Farallones and Cordell Bank National Marine Sanctuaries*. Report of a Joint Working Group of the Gulf of the Farallones and Cordell Bank National Marine Sanctuaries Advisory Councils.

³⁸ PWA, 2006. *Projecting the future evolution of Bolinas Lagoon*. Report prepared for Marin County Open Space District.

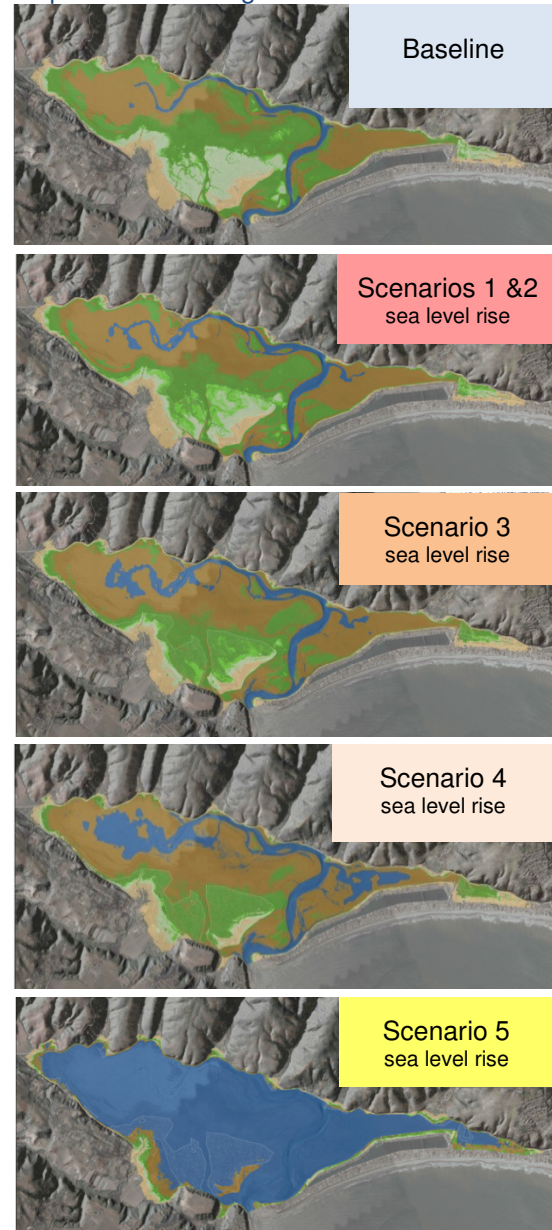
³⁹ Byrne, R., L. Reidy, D. Schmidt, D. Sengupta, A. Arthur, 2005. *Recent (1850-2005) and late Holocene (400-1850) sedimentation rates at Bolinas Lagoon*. Report prepared for Marin County Open Space District.

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Map 35 shows the existing and potential elevation capital in Bolinas Lagoon for each sea level associated with each scenario. The analysis assumes the best case of 6.8 mm/year of sediment inputs.

The most vulnerable areas in the Bolinas Lagoon are those without gradually sloping transitional uplands or are located away from the creek deltas. shows the increasing vulnerability of loss of marsh functions as sea level rises and marshes are squeezed against slopes. Approximately 50 percent of the high marsh is expected to be lost by mid-century; converting to low marsh, mud and sand flats; this will increase to 80 percent loss nearing the end of the century.⁴⁰ As sea level rises, the marshes will be restricted to the Pine Gulch Creek delta, Kent Island, Easkoot Creek and the Lewis and Wilkins Gulches at the head of the lagoon. Marshes close to the Pine Gulch Creek are also likely to survive longer due to the higher rate of vertical accretion associated with deltaic processes.

Map 35. Bolinas Lagoon Marsh Habitat Shifts



Elevation Capital

- 1.5 < z* < 3 (Transition)
- 1.0 < z* < 1.5 (High Salt Marsh)
- 0.75 < z* < 1.0 (Mid Salt Marsh)
- 0 < z* < 0.75 (Low Salt Marsh)
- 1.17 < z* < 0 (Intertidal Mudflats)
- z* < -1.17 (Subtidal Channels)



Note: Maps consider accretion rate of 6.8 mm/year. Dark and light brown color in the lagoon is an artifact of the aerial imagery and not a distinction in Intertidal habitat. Source: ESA, 2015

⁴⁰ This is a conservative estimate as there may be increases in accretion rates and changes from sand bodies in the lagoon such as Kent Island, which increases protection from wave action and enhance sedimentation rates.

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Table 27. Bolinas Lagoon Spatial Distribution of Marsh Habitat & Vulnerability at 6.8 mm/year Sedimentation

Habitat Type	Area (acres)					z* Range
	Baseline	Scenarios 1, 2	Scenario 3	Scenario 4	Scenario 5	
Transition zone	129	123	118	107	66	1.6-3
High salt marsh (salt grass)	164	95	478	42	27	1.1-1.5
Mid salt marsh (pickleweed)	35	76	42	14	9	0.85-1
Low salt marsh (cordgrass)	430	328	305	236	67	0-0.84
Intertidal Mudflats	387	497	581	600	126	-1.04 – 0
Subtidal Channels & Shallows	68	106	142	253	1,026	< -1.04
Vulnerability Level						
Low	255	184	140	115	49	1.1-2.5
Medium	257	234	221	78	77	0.3 – 1
High	662	772	849	1,048	1,180	< 0.3

Source: ESA, 2015

The *Memorandum: Bolinas Lagoon Restoration Project Design Review Group*⁴¹ provides a summary of the implications of higher sea level rise projections in Bolinas Lagoon:

- Accelerated sea level rise replaces the risk of excessive lagoon sedimentation and tidal prism loss as an overriding ecosystem concern. Long-term lagoon submergence due to accelerated sea level rise is a major challenge to the lagoon’s ecosystem health and resilience.
- Sediment values can be neutral, beneficial, or adverse depending on location, timing, magnitude, and context. Sedimentation is an asset to evolution of the lagoon, not just an impact.
- Accommodation space is a primary concern for the long-term health and stability of Bolinas Lagoon.
- Future changes in the lagoon’s barrier beach and tidal inlet will occur in response to accelerated sea level rise and coastal storms.

In addition, changes in salinity will affect vegetation. Lower salinities, common in winter and early spring, positively affect plant recruitment. Increases in salinity, especially during the summer growing season, negatively affect vegetation diversity, with a likely shift of more salt tolerant vegetation

⁴¹ Baye, P. R., 2014. Memorandum: Bolinas Lagoon Restoration Project Design Review Group (DRG) Meeting San Francisco Bay Joint Venture (SFBJV) Meeting Summary And Synthesis Draft.

establishing inland. However, in some locations, migration of vegetation inland may be limited by different soil conditions between freshwater tidal marshes to salt marshes.

Tomales Bay - Marshall Area

Tomales Bay is formed by the San Andreas Fault with an incomplete sand barrier at Dillon Beach. Fresh water and coarse sediment supplies from the relatively large Walker Creek and Lagunitas Creek watersheds create local estuarine gradients within the Bay. Similar to Bolinas Lagoon, the largest tidal marshes are associated with the alluvial deltas of these creeks. The bay margins are indented with coves and gulches with small deltas, beaches, and discrete pocket tidal marshes, riparian vegetation, and lagoons.

The Lagunitas Creek delta expanded in the 19th century due to sediment deposition from watershed erosion. Similarly, the Walker Creek delta has expanded rapidly in recent decades due to watershed erosion. At the south end of Tomales Bay are diked baylands, tidal flats, and tidal marshes including the Lagunitas Creek delta and Olema marshes.

Map 36 and Table 28 shows habitat shifts in Marshall lagoons for scenarios 1-5 for the average historic sedimentation rate of 1.6 mm./year.⁴² The

⁴² Smith, S. V. and J. T. Hollibaugh (1998). The Tomales Environment, University of Hawaii, School of Ocean and Earth

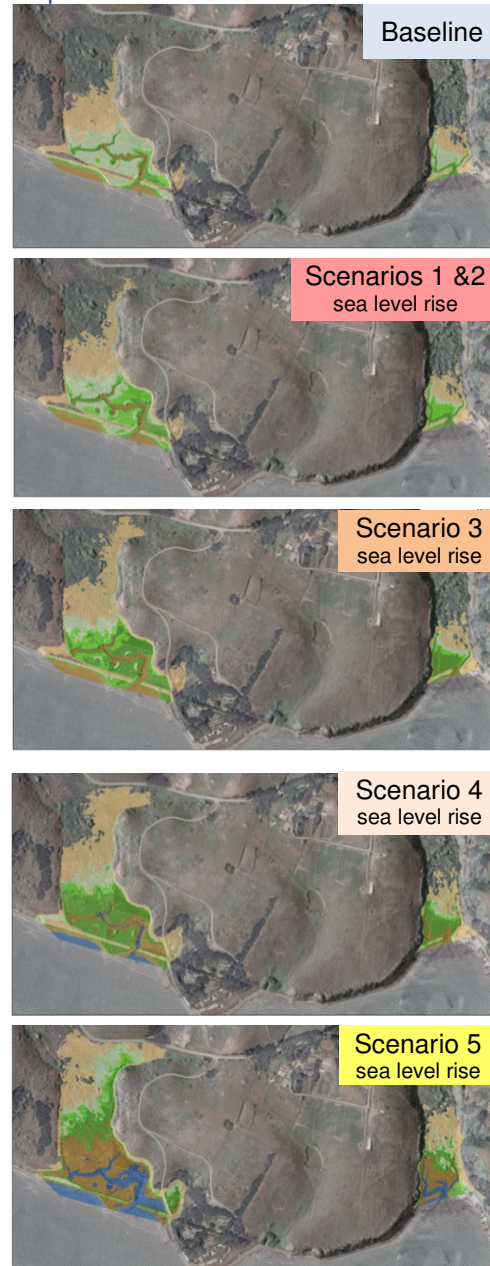
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most vulnerable marsh areas are those lowest in elevation. Relatively large areas of transition zone exist allowing the area of high and mid marsh to remain constant over time. The high marsh in 2100 is about the same acreage as in 2010. The acreage of mudflat does increase as the former low lying marsh areas are drowned. As sea level rises, the high marshes are able to transgress inland along the valley profile. While these are areas with gently sloping migrating transition zones, some realignment of infrastructure, such as roads and culverts, may be necessary.



Tomales Bay winter light. Credit: Silver

Map 36. Marshall Area Marsh Habitat Shifts



Elevation Capital

- 1.5 < z* < 3 (Transition)
- 1.0 < z* < 1.5 (High Salt Marsh)
- 0.75 < z* < 1.0 (Mid Salt Marsh)
- 0 < z* < 0.75 (Low Salt Marsh)
- 1.17 < z* < 0 (Intertidal Mudflats)
- z* < -1.17 (Subtidal Channels)



Source: ESA, 2015

Science and Technology and San Francisco State University,
Tiburon Center. <http://lmer.marisci.uga.edu/tomales/tomenv.html>

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Table 28. Spatial Distribution of Marsh Area & Vulnerability in the Marshall Area at 1.6 mm/year of Sedimentation

Habitat Type	Area (acres)					z* Range
	Baseline	Scenarios 1, 2	Scenario 3	Scenario 4	Scenario 5	
Transition zone	7	7	8	9	8	1.5-3
High salt marsh (salt grass)	5	4	2	2	4	1-1.5
Mid salt marsh (pickleweed)	1	3	2	1	2	0.75-1
Low salt marsh (cordgrass)	1	2	4	6	4	0-0.75
Intertidal Mudflats	1	2	2	3	8	-1.17-0
Subtidal Channels & Shallows	na	na	0	1	4	< -1.17
Vulnerability Level						
Low	9	8	7	9	9	1-2.5
Medium	2	4	6	3	4	0.3-1
High	2	2	3	8	13	below 0.3

Source: ESA, 2015

Rocky Intertidal

This area is the rocky substrate found between high and low tide water levels. Key sensitivities include salinity, wave action, and erosion. The ecosystem depends on the abundance, distribution, and interactions of the vulnerable California mussel and the ochre sea star. Salinity plays a strong role in rocky intertidal tide pools. Studies on the effect of salinity extremes indicate that, when combined with temperature stress, salinity can negatively impact rocky intertidal invertebrates through increased embryonic mortality^{43,44} and decreased adult aerobic performance.⁴⁵ In addition, projected increases in storm activity and wave action can remove larger intertidal organisms⁴⁶ and increase coastal erosion that may bury the habitat. If tides do not retreat as far as they currently do with sea level rise, these

areas could shift from intertidal to underwater habitats. Rocky intertidal areas on the coast can be found at Muir Beach, Duxbury Reef (Bolinias), and Estero Americano (north of Dillon Beach).

Freshwater Resources

The *North-central California Coast and Ocean Vulnerability Assessment*⁴⁷ does not address freshwater habitats inland from the coast. However, according to CoSMoS, these habitats are also likely to see impacts from sea level rise and storm surges. Nearly 622 acres of freshwater emergent wetlands, 90 acres of shrub and forested wetlands, 36 acres of ponds, 291 acres of lake, and 123 acres of riverine areas could face sea level rise and storm impacts. These areas face varying degrees of vulnerability, much like their coastal equivalents, depending on location and surroundings. In Scenario 5, with 80 inches of sea level rise and 100-year storm, saltwater can travel inland up to 2 miles, especially in Walker, Stemple, and Americano creeks. This could significantly impact the existing freshwater habitat and lead to brackish conditions. Creeks that

⁴³ Przeslawski, R., Davis, A. R. and Benkendorff, K. (2005), *Synergistic effects associated with climate change and the development of rocky shore molluscs*. *Global Change Biology*, 11: 515–522. doi: 10.1111/j.1365-2486.2005.00918.x

⁴⁴ Deschaseaux, E.S.M., A.M. Taylor, W.A. Maher, A.R. Davis. 2009. Cellular responses of encapsulated gastropod embryos to multiple stressors associated with climate change. *JEMBE* 383(2):130-136.

⁴⁵ Vajed Samiei, J., Novio Liñares, J.A., Abtahi, B. 2011. *The Antagonistic Effect of Raised Salinity on the Aerobic Performance of a Rocky Intertidal Gastropod Nassariusdeshayesianus* (Issel, 1866) Exposed to Raised Water Temperature. *Journal of the Persian Gulf* 2(6): 29-36.

⁴⁶ Largier, J.L., B.S. Cheng, and K.D. Higgason, editors. 2010. *Climate Change Impacts: Gulf of the Farallones and Cordell Bank National Marine Sanctuaries*. Report of a Joint Working Group of the Gulf of the Farallones and Cordell Bank National Marine Sanctuaries Advisory Councils.

⁴⁷ Hutto, S.V., K.D. Higgason, J.M. Kershner, W.A. Reynier, D.S. Gregg. 2015. *Climate Change Vulnerability Assessment for the North-central California Coast and Ocean*. Marine Sanctuaries Conservation Series ONMS-15-02. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries, Silver Spring, MD. 473 pp. <http://sanctuaries.noaa.gov/science/conservation/pdfs/vulnerability-assessment-gfms.pdf>.

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could be affected by the rising Pacific Ocean include:

- Redwood Creek (Muir Beach)
- Green Gulch Creek (Muir Beach)
- Easkoot Creek (Stinson Beach)
- Pine Gulch Creek (Bolinás)
- Walker Creek (Bolinás)
- Lagunitas Creek
- Keys Creek (East Shore)
- Stemple Creek (North of Dillon Beach)
- Americano Creek (North of Dillon Beach).

Wildlife & Endangered Species

Select mammal, fish, invertebrate, and plant species were examined in the *North-central California Coast and Ocean Vulnerability Assessment*. Of the 31 species assessed for climate impacts, twelve are identified as vulnerable to sea level rise. Of these, seven are bird species, four are intertidal invertebrates, and one is an intertidal alga. The two most vulnerable species, Western snowy plover and black oystercatcher, received high scores for sensitivity and moderate adaptive capacity scores. The most vulnerable species are those that use beaches, estuaries, coastal marshes, and rocky intertidal habitat.

Along the coast are several mammal and bird habitats. Mammal haul-outs are widely used by pinnipeds. According to the Department of Fish and Wildlife, the following are recorded locations marine mammal populations inhabit (does not include Federal Park locations):

- Estero Americano
- Tomales Point
- Tomales Bay Northwest
- Sand Point
- Toms Point Sand Bars
- Double Point South
- Bolinas Point
- Duxbury Point
- Bolinas Lagoon

Seabirds are known to frequent a much larger geography, however, live out critical life phases in these locations (does not include Federal Park locations):

- Dillon Beach Rocks
- Tomales Point
- Stinson Beach to Rocky Point
- Gull Rock Area

In addition to the habitats and species assessed in the *North-central California Coast and Ocean Vulnerability Assessment*, several endangered and threatened species, and sensitive habitats warrant mention. The Natural Diversity Database⁴⁸ records where species and their habitats are observed. Species potentially located within the geographic extent of scenario 5 are listed in [Table 29](#).

Finally several marshland plant species are also vulnerable. Bolinas marshes contain populations of rare annual plants, such as cordylanthus and dichondra donnelliana. The vegetation of Tomales marshes is similar to that of Bolinas Lagoon.⁴⁹ Tomales tidal marshes also support some of the largest populations of rare tidal marsh plants, such as cordylanthus and owl's-clover.

The maps on the following pages show only the available data sources. The *North-central California Coast and Ocean Vulnerability Assessment* does not provide digital geographic information for species and habitat locations, however, where known, this information is provided from other sources.



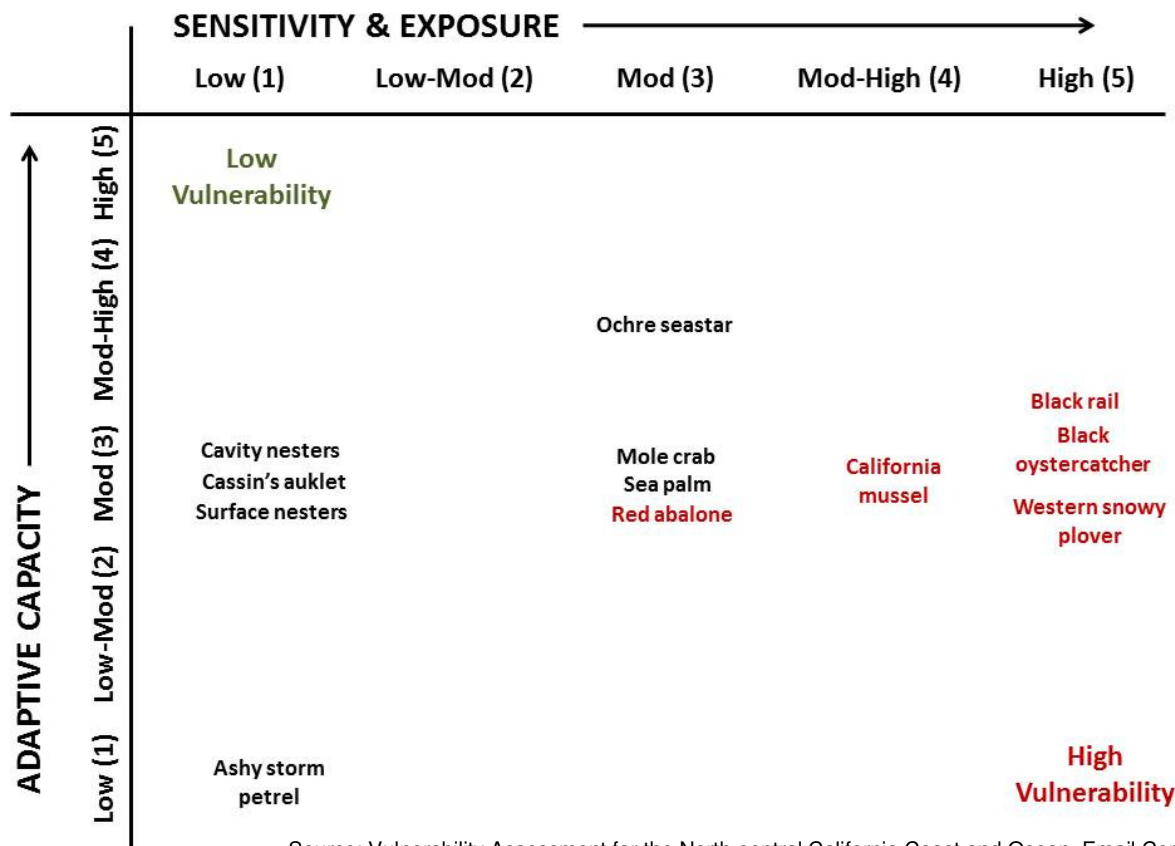
Black Oystercatcher. Credit: Drechsler

⁴⁸ Natural Diversity Database

⁴⁹ USFWS, 2013. Recovery plan for tidal marsh ecosystems of Northern and Central California. US Fish and Wildlife Service, Sacramento, California. xviii

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Figure 12. North-central California Coast and Ocean Vulnerable Species



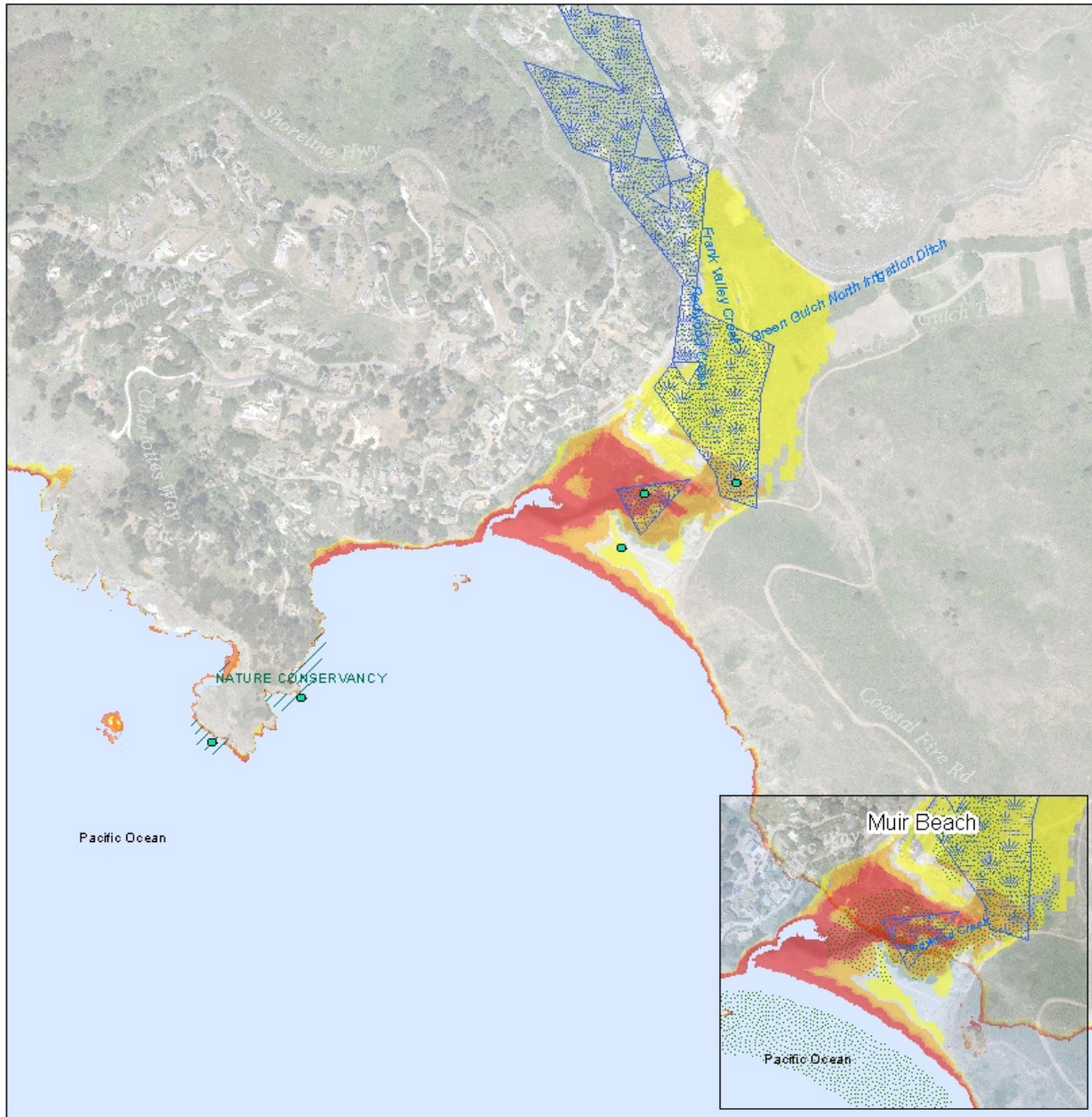
Source: Vulnerability Assessment for the North-central California Coast and Ocean. Email Communication.

Table 29. Threatened and Endangered Species Exposed to Sea Level Rise-Scenario 5

Endangered	Threatened	Candidate
<p>BIRDS</p> <ul style="list-style-type: none"> California clapper rail <p>PLANTS</p> <ul style="list-style-type: none"> Baker's larkspur Beach layia Golden larkspur Showy rancheria clover Sonoma shortawn foxtail Sonoma spineflower Tiburon paintbrush Tidestrom's lupine <p>INSECTS</p> <ul style="list-style-type: none"> San Bruno elfin butterfly <p>FISH/CRUSTACEAN</p> <ul style="list-style-type: none"> California freshwater shrimp coho salmon tidewater goby 	<p>BIRDS</p> <ul style="list-style-type: none"> Western snowy plover <p>AMPHIBIAN</p> <ul style="list-style-type: none"> California red-legged frog <p>FISH</p> <ul style="list-style-type: none"> Steelhead trout 	<p>FISH</p> <ul style="list-style-type: none"> Longfin smelt

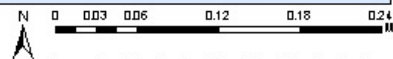
NATURAL RESOURCES

Map 37. Muir Beach Vulnerable Natural Resource Assets



Scenarios

- | | | | |
|---|--------------------------|-------------------------|-----------------|
| 1 | 10" SLR + Annual Storm | Natural Resource Assets | Seabird Colony |
| 2 | 10" SLR + 20-year Storm | Park Parcels | Mammal Haul Out |
| 3 | 20" SLR + 20-year Storm | Wetland | |
| 4 | 40" SLR + 20-year Storm | Estuary | |
| 5 | 80" SLR + 100-year Storm | Marsh | |



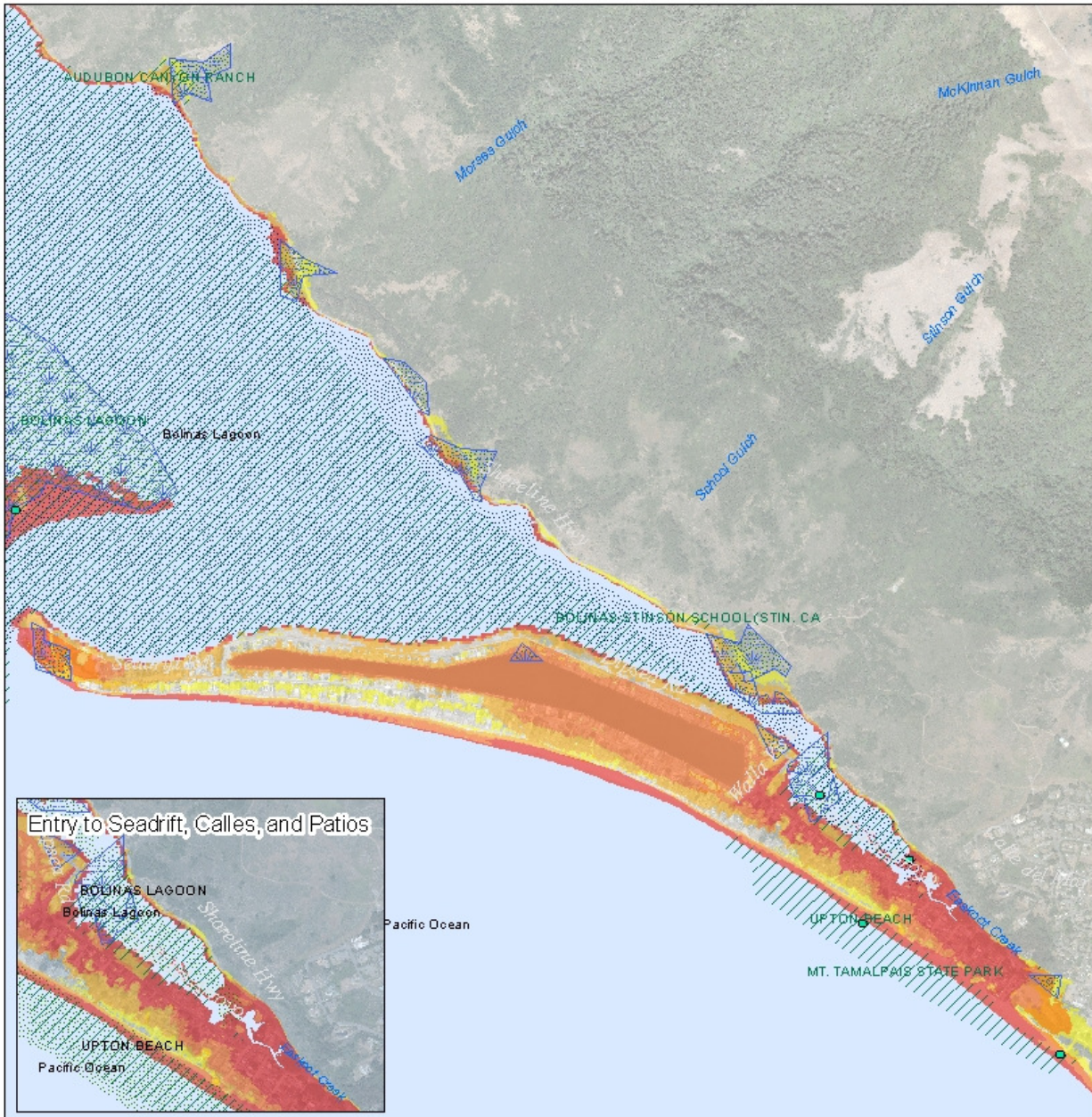
Source: Marin Map, Our Coast Our Future, Department of Fish & Wildlife
 Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazards areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are prepared for informational purposes only. Local officials should examine the map. Commercial use is prohibited.

Date: 7/29/2015



NATURAL RESOURCES

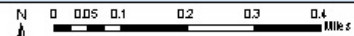
Map 38. Stinson Beach Vulnerable Natural Resources



Scenarios

- | | | | |
|---|--------------------------|---|-------------------------|
| 1 | 10" SLR + Annual Storm | ● | Natural Resource Assets |
| 2 | 10" SLR + 20-year Storm | ▨ | Park Parcels |
| 3 | 20" SLR + 20-year Storm | ▨ | Wetland |
| 4 | 40" SLR + 20-year Storm | ▨ | Estuary |
| 5 | 80" SLR + 100-year Storm | ▨ | Marsh |

- | | |
|--|-----------------|
| | Seabird Colony |
| | Mammal Haul Out |



Source: Marin Map, Our Coast Our Future, Department of Fish & Wildlife

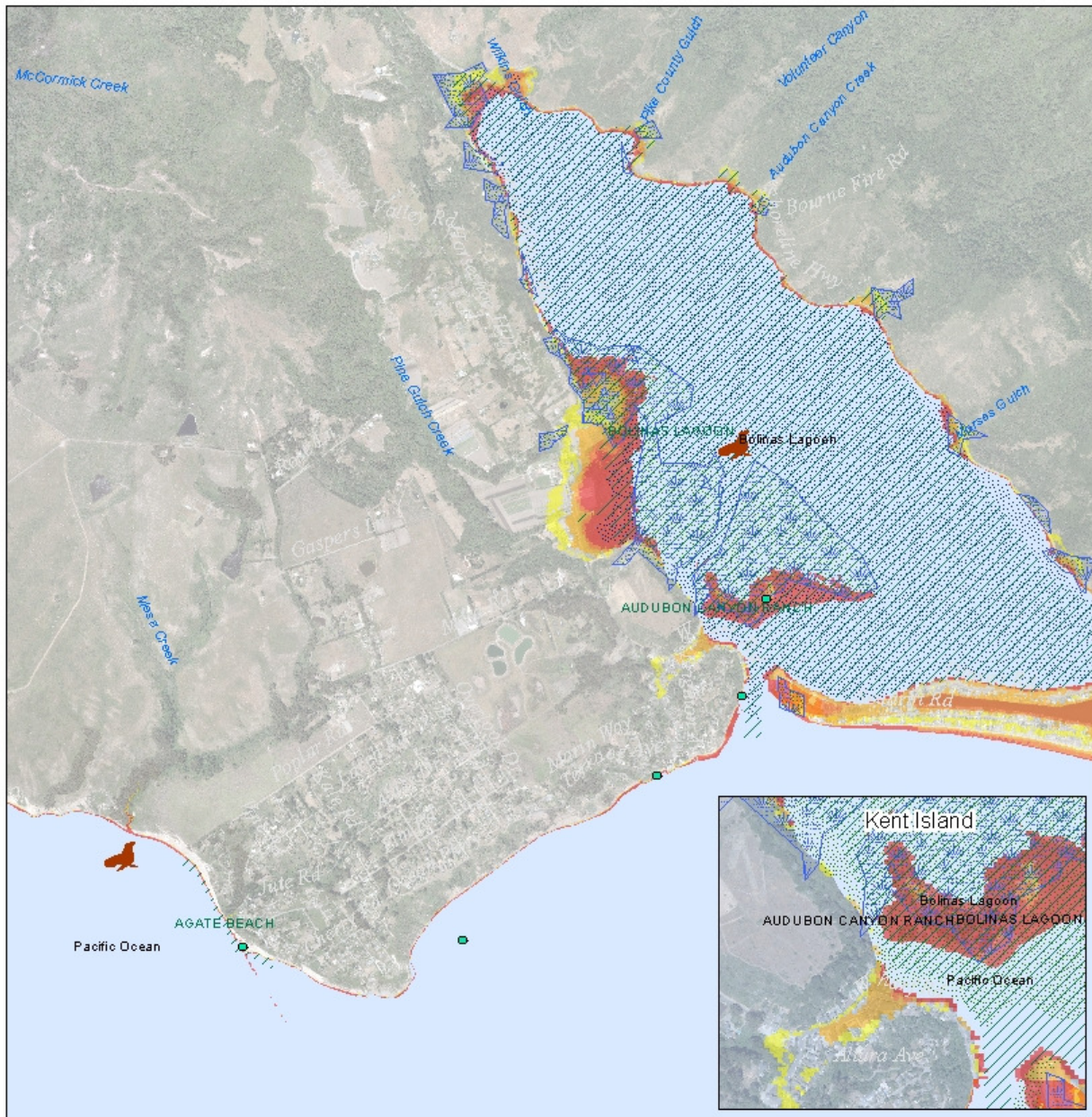
Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County and data providers here make no warranties of the accuracy or completeness of maps and data. Maps are presented as a guide to information only. Local site conditions must be examined. Commercial use is prohibited.

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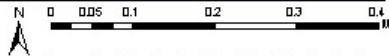
NATURAL RESOURCES

Map 39. Bolinas Vulnerable Natural Resources



Scenarios

- | | | | | | |
|---|--------------------------|---|-------------------------|---|-----------------|
| 1 | 10" SLR + Annual Storm | ● | Natural Resource Assets |  | Seabird Colony |
| 2 | 10" SLR + 20-year Storm |  | Park Parcels |  | Mammal Haul Out |
| 3 | 20" SLR + 20-year Storm |  | Wetland | | |
| 4 | 40" SLR + 20-year Storm |  | Estuary | | |
| 5 | 80" SLR + 100-year Storm |  | Marsh | | |



Source: Marin Map, Our Coast Our Future, Department of Public Works

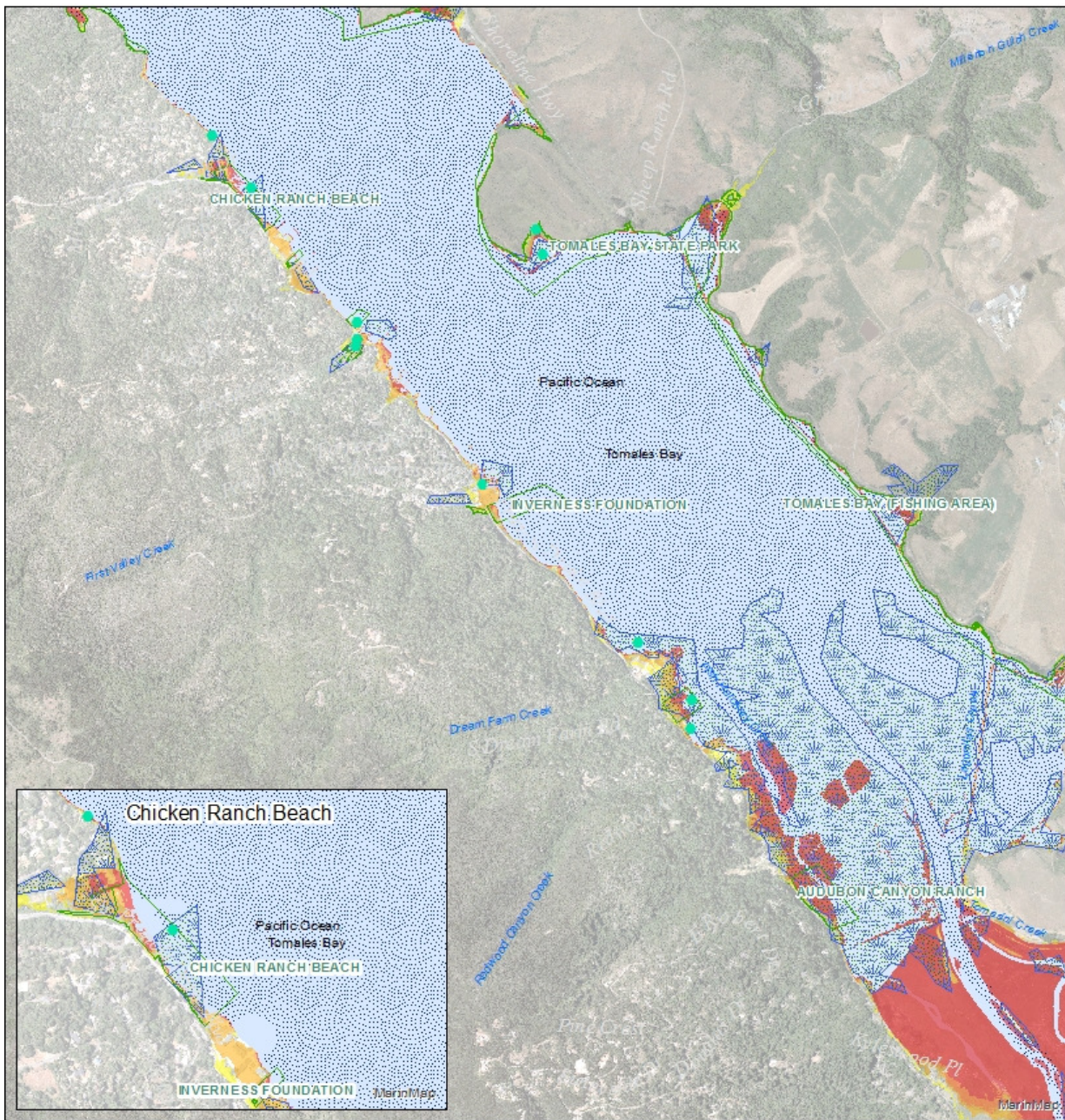
Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here, make no warranties of the accuracy or completeness of maps and data. Maps are presented for informational purposes only. Local site conditions must be examined. Commercial use is prohibited.

Date: 7/29/2015



NATURAL RESOURCES

Map 40. Inverness Vulnerable Natural Resources



Scenarios

- | | | | |
|---|--------------------------|---------------------------|---------|
| 1 | 10" SLR + Annual Storm | ● Natural Resource Assets | Wetland |
| 2 | 10" SLR + 20-year Storm | ▭ Parks | Estuary |
| 3 | 20" SLR + 20-year Storm | 🐦 Seabird Colony | Marsh |
| 4 | 40" SLR + 20-year Storm | 🐾 Mammal Haul Out | |
| 5 | 80" SLR + 100-year Storm | | |

0 0.1 0.2 0.4 0.6 0.8 Miles



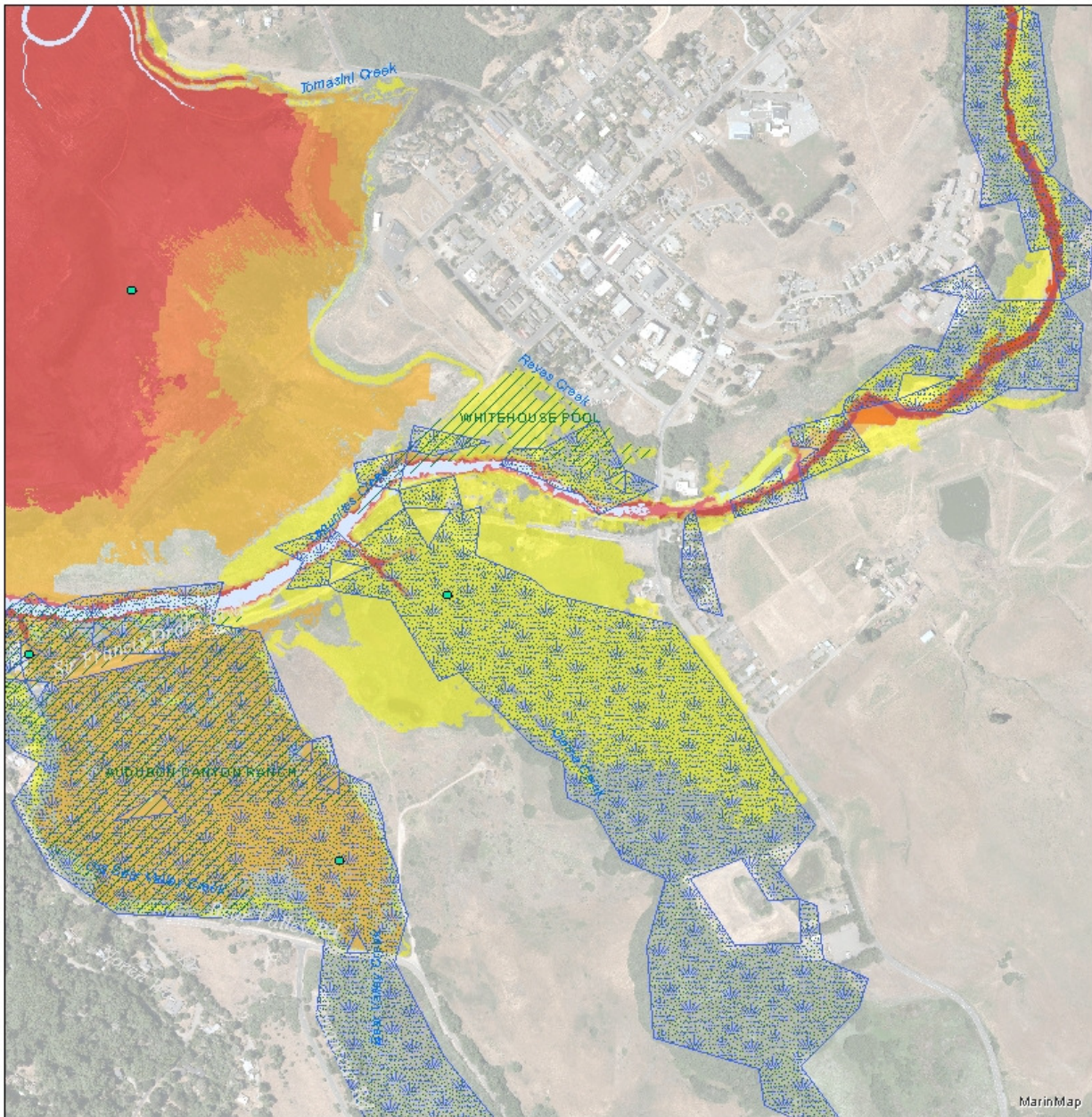
Source: Marin Map, Our Coast Our Future, Department of Fish & Wildlife
 Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

Date: 11/2/2015



NATURAL RESOURCES

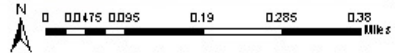
Map 41. Point Reyes Station Vulnerable Natural Resources



Scenarios

- | | | |
|---|--------------------------|-------------------------|
| 1 | 10" SLR + Annual Storm | Natural Resource Assets |
| 2 | 10" SLR + 20-year Storm | Park Parcels |
| 3 | 20" SLR + 20-year Storm | Wetland |
| 4 | 40" SLR + 20-year Storm | Estuary |
| 5 | 80" SLR + 100-year Storm | Marsh |

- | | |
|--|-----------------|
| | Seabird Colony |
| | Mammal Haul Out |



Source: Marin Map, Our Coast Our Future, Department of Fish & Wildlife

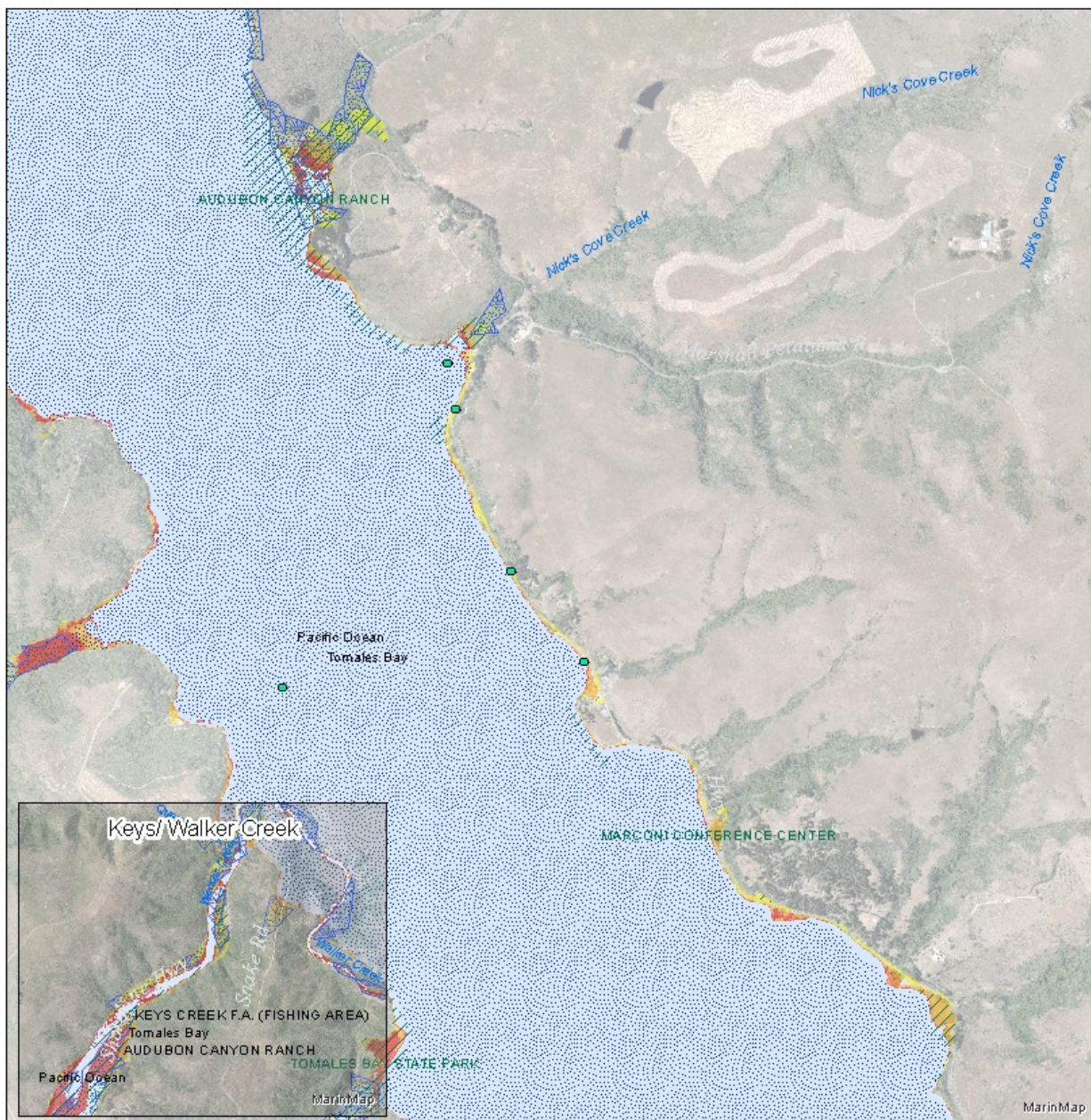
Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are prepared for informational purposes only. Local site conditions must be examined. Commercial use is prohibited.

Date: 7/29/2015



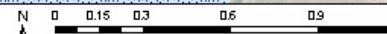
NATURAL RESOURCES

Map 42. East Shore Vulnerable Natural Resources



Scenarios

- | | | | | | |
|---|--------------------------|---|-------------------------|---|-----------------|
| 1 | 10" SLR + Annual Storm | ■ | Natural Resource Assets | 🦅 | Seabird Colony |
| 2 | 10" SLR + 20-year Storm | ▨ | Park Parcels | 🐾 | Mammal Haul Out |
| 3 | 20" SLR + 20-year Storm | ▨ | Wetland | | |
| 4 | 40" SLR + 20-year Storm | ▨ | Estuary | | |
| 5 | 80" SLR + 100-year Storm | ▨ | Marsh | | |



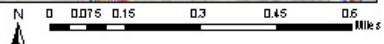
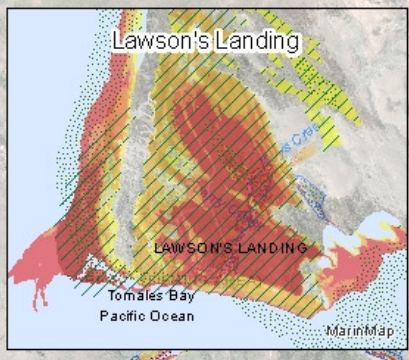
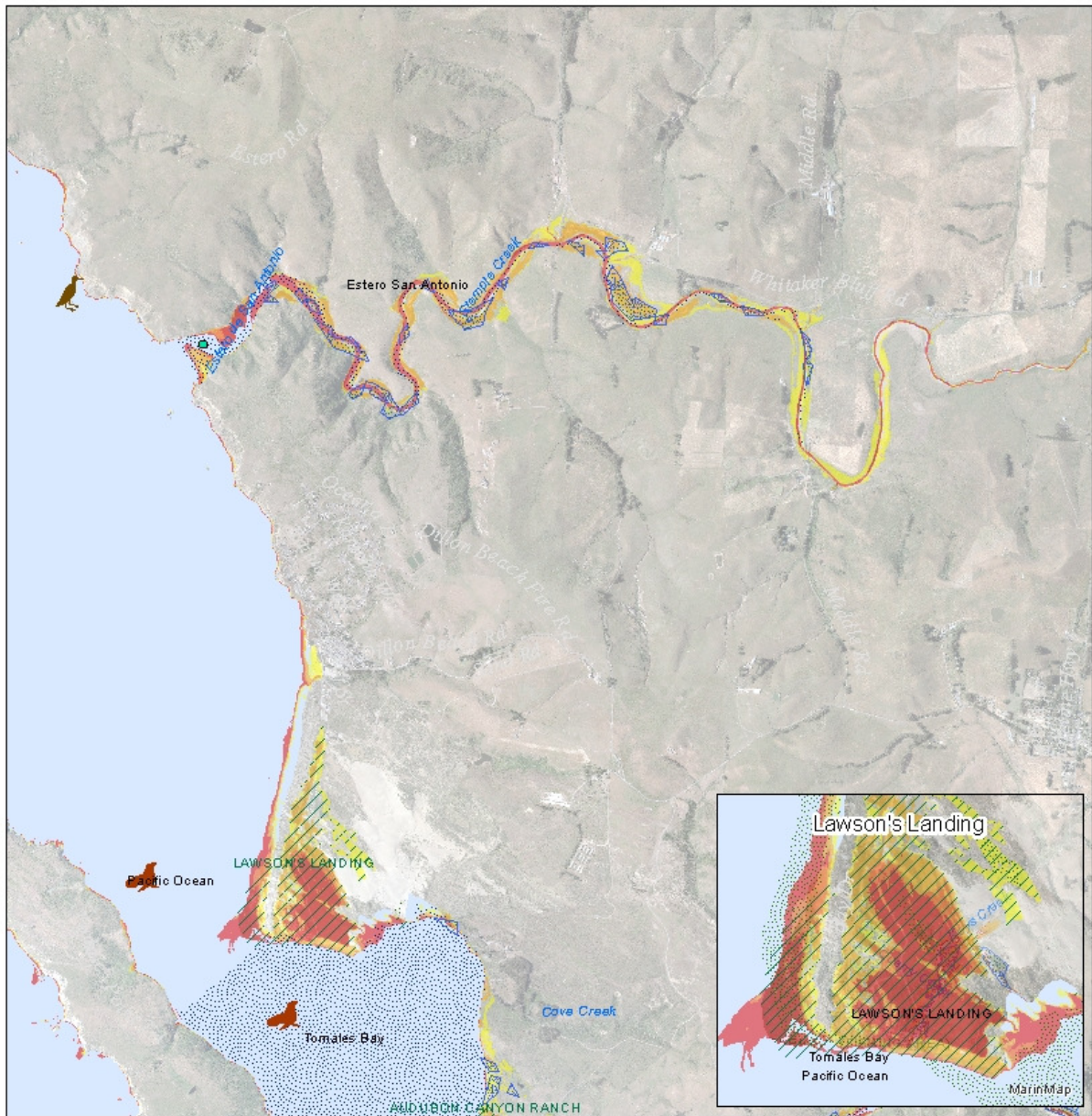
Source: Marin Map, Our Coast Our Future, Department of Fish & Wildlife
 Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a source to help identify potential hazardous areas and vulnerable assets. Marin County and data providers here, make no warranties of the accuracy or completeness of maps and data. Maps are presented and suitable to their resolution. Local site conditions must be examined. Commercial use is prohibited.

Date: 7/29/2015



NATURAL RESOURCES

Map 43. Dillon Beach Vulnerable Natural Resource Assets

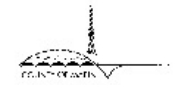


Scenarios

- | | | | |
|---|--------------------------|-------------------------|-----------------|
| 1 | 10" SLR + Annual Storm | Natural Resource Assets | Seabird Colony |
| 2 | 10" SLR + 20-year Storm | Park Parcels | Mammal Haul Out |
| 3 | 20" SLR + 20-year Storm | Wetland | |
| 4 | 40" SLR + 20-year Storm | Estuary | |
| 5 | 80" SLR + 100-year Storm | Marsh | |

Source: MarinMap, Our Coast Our Future, Department of Fish & Wildlife
 Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here, make no warranties of the accuracy or completeness of maps and data. Maps are presented as a guide only and do not constitute a guarantee. Local officials should examine. Commercial use is prohibited.

Date: 7/29/2015



NATURAL RESOURCES

Existing Policies

Protecting Marin County's natural environment is an overarching goal of Marin County. The Marin County Draft Local Coastal Program (DLCP) guides protecting natural resources and sensitive habitats when land is developed, preserving public access to the coast, and maintaining and enhancing coastal resources.

An environmentally sensitive habitat area (ESHA) is any area where plant or animal life, or their habitats, are either rare, of special nature, or perform a special role in an ecosystem that could be easily disturbed or degraded by human activities. ESHA consists of four general categories: wetlands, streams, riparian vegetation, and terrestrial ecosystems (dunes, roosting and nesting sites). Buffers are established to protect ESHAs from development impacts, and a coastal permit is required for the removal of major vegetation (not for agricultural purposes). Relevant natural resource policies from the Marin County DLCP are provided in [Figure 13](#).

Other Considerations

The coast's natural resources are among Marin's greatest assets. With a majority of coastal land preserved in national, state, county parks, and other easements, these assets are a major draw for visitors from around the world. Damage and destruction to these assets could have serious consequences across all aspects of coastal life in Marin.

Economic

Active and passive recreation on western Marin's miles of beaches, trails, and roads are critical economic contributors to Marin Coast and County residents (see the Recreation Profile for more information). Wildlife viewing is a major draw to the region and the inability to do so could significantly reduce tourism. At the same time, the public values recreation and tourism greatly, and will likely adjust the location of recreation and tourism activities.

Loss of fishing and aquaculture commercial trade that could have far reaching economic impacts. Employees, restaurants near and far, shipping companies, and other commercial sectors would bear the loss. For more information on these activities see the Working Lands profile.

Estuaries, beaches, bluffs, marine wetlands, and marshes also provide ecosystem services as buffers protecting development from waves and floods. Their loss could increase the cost of maintaining flood protection.

Figure 13. Marin County DLCP Natural Resource Policies

C-BIO-5 Ecological Restoration. Encourage restoring, enhancing, and creating ESHAs, and streamline regulatory processes.

C-BIO-7 Coastal Dunes. Prohibit development and non-emergency motor vehicles in coastal dunes.

C-BIO-8 Preventing Beach Encroachment. Where most lots are developed, no part of a proposed new development (other than an allowable shoreline protective device), shall be built farther onto a beachfront than the most seaward portions of the adjacent structures. Enclosed living space in a new unit or addition shall not extend farther seaward than a second line drawn between the most seaward portions of the enclosed living space of the adjacent structures.

C-BIO-9 Stinson Beach Dune and Beach Areas. Prohibit development west of Mira Vista, including fences, signs, or other structures. Pursue land trade between the lots seaward of Mira Vista and the street right-of-way. New development on shorefront lots in Stinson Beach consistent with LUP Policy C-BIO-7 (Coastal Dunes), where no dunes are evident, shall be set back behind the first line of terrestrial vegetation per Policy C-EH-2, avoid the need for protective works, protect sandy beach habitat, and provide a buffer area between private and public use areas.

C-BIO-14 Wetlands. Preserve and maintain wetlands.

C-BIO-15 Diking, Filling, Draining and Dredging. Strictly limited in coastal waters, wetlands, and estuaries.

C-BIO-29 Marin County Parks. Support Marin County Parks environmental conservation, land and easement acquisition, and habitat restoration efforts.

*Reflects CCC Suggested Modifications to DLCP Amendment. **Subject to change.***

NATURAL RESOURCES

Environmental

The complete or partial loss of tidal or managed marsh systems will increase the reliance on structural shoreline protection, and will place shoreline residents at a greater risk of flooding. Multiple utilities, including a telecommunications cable under the Bolinas Lagoon, transect these resources and habitats. Damage to these structures could damage the habitat and relocating them could have serious temporary environmental impacts. Finally, efforts to protect vulnerable built assets with new coastal armoring could have detrimental impacts on coastal habitats by reducing their ability to adapt.

Social Equity

Coastal beaches, estuaries, wetlands, and marshes offer opportunities to view wildlife, provide access to the shoreline, and offer scenic and aesthetic benefits. The loss of these functions could

negatively impact the people that use these areas for recreation, and could ultimately diminish the desirability of living in these coastal communities. As preparations are made to protect existing areas or create new public areas, costs could increase, therefore increasing entrance fees, or in some cases requiring new fees. These added costs could make visiting federal and state parks cost prohibitive for those of lesser means.

Management

Protecting natural resources and wildlife can be highly controversial. For example, protecting breeding areas may limit public access or economic activity. Limited financial resources could reduce priorities for wildlife protection, park maintenance, and investment. Developing and implementing large projects will require multiple agencies and private partners to coordinate and contribute financially.

RECREATION

Asset Profile: Recreation & Public Access

Marin County is treasured for its immense recreation opportunities. Vulnerable recreational assets are beaches and surfing locations in Stinson Beach, Bolinas, and Inverness where little room for beach retreat exists. Several other recreational activities, such as hiking trails, wildlife viewing, and kayaking may simply shift as sea level rises, or require minimal management actions. However, ensuring continued safe public access to existing recreation areas could be a challenge.

Most exposed recreation areas are managed by county, state, and federal agencies for public use. Major examples include: Golden Gate National Recreation Area (including the Marin Headlands, Muir Beach, and Stinson Beach), Mt. Tamalpais State Park, Point Reyes National Seashore, Tomales Bay State Park, and Tomales Bay Wetland Reserve. A few are held by non-profit organizations that require appointments.

The following are key issues related to public access and recreation asset vulnerability:

- Sea level rise may push coastal recreation opportunities inland where possible. Where not possible, the recreation asset could be lost.
- Access to recreational areas may be impeded as Shoreline Highway, local roads, and trails flood and erode.
- Tour buses could be impeded from visiting the area.
- Visitor serving business, such as restaurants, hotels and inns, boat rentals, oyster farms, and others, could be exposed to sea level rise and susceptible to storm damage.

Table 30 lists some of the potentially vulnerable recreational assets in the study area. This list measures onset and tidal mean higher high water (MHHW) and extreme event flood depths; however many recreational assets are shoreline based or water features. This list is not exhaustive of all the recreational assets that could be exposed to sea level rise and storm impacts in the study area.

IMPACTS AT-A-GLANCE

Thousands of residents, millions of visitors		
Site specific		Property Owners CSP County Parks & Roads Caltrans
8 Beaches	20 Parks	



Beach Access during King Tide. Credit: Rapaport

RECREATION

Table 30. Recreation Assets Ranked by Onset and Flood Depth (feet and inches)

Community	Asset (not exhaustive)	Tidal & Extreme Event Flooding Depth Estimates <small>(Underlined values indicate tidal flooding at mean higher high water (MHHW) based on one geographic point placed at the landward limit of the first scenario where it overlaps the asset. Values not underlined represent temporary flooding. Groups of buildings are ranked by maximum flood depth. Roads received a high and low value along the line segment.)</small>					Vulnerability <small>TF: Temp. Flooding during extreme events; I: Inundated at MHHW; E: Erosion; WT: Water Table; SI: Saltwater Intrusion; WS: Wave Surge; HW: High Wind, HS: Habitat Shift</small>
		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	
Stinson Beach	Calle del Arroyo	<u>7"-6'11"</u>	<u>3"-6'8"</u>	<u>8"-9'6"</u>	<u>2'5"-12'2"</u>	<u>5'11"-13'9"</u>	I, TF
Stinson Beach	Upton Beach	<u>4'7"</u>	<u>6'2"</u>	<u>7'5"</u>	<u>9'8"</u>	<u>14'9"</u>	I, E
Stinson Beach	Patios and Calles Buildings	<u>10"+1'4"</u>	<u>10"+6'3"</u>	<u>1'6"+7'</u>	<u>4'9"+5'10"</u>	<u>6'5"+6'8"</u>	I, WT, WS, TF
Inverness	Inverness Yacht Club	<u>3'2"</u>	<u>4'1"</u>	<u>4'11"</u>	<u>6'10"</u>	<u>10'1"</u>	I, WS, HW
Inverness	Brock Schreiber Boathouse	<u>2'7"</u>	<u>3'6"</u>	<u>4'</u>	<u>5'10"</u>	<u>9'2"</u>	I, E
East Shore	Walker Creek Access Point	<u>2'4"</u>	<u>3'3"</u>	<u>4'2"</u>	<u>6'1"</u>	<u>9'3"</u>	I
East Shore	Brighton Beach	<u>2'2"</u>	<u>3'5"</u>	<u>4'11"</u>	<u>6'</u>	<u>9'11"</u>	E, WS
East Shore	Livermore Marsh Cypress Grove	<u>2'1"</u>	<u>3'1"</u>	<u>3'11"</u>	<u>5'10"</u>	<u>9'2"</u>	I
East Shore	Hog Island Oyster	<u>2'1"</u>	<u>2'1"</u>	<u>2'10"</u>	<u>4'10"</u>	<u>8'1"</u>	I
Inverness	Martinelli Park	<u>1'1"</u>	<u>2'</u>	<u>2'2"</u>	<u>4'1"</u>	<u>7'3"</u>	I, E
Bolinas	Downtown Buildings	<u>1'8"+1'5"</u>	<u>1'8"+2'2"</u>	<u>2'7"+2'</u>	<u>4'5"+2'1'</u>	<u>7'9"+1'7"</u>	I, WT, WS, TF
Inverness	Shoreline Buildings	<u>2'+1'2"</u>	<u>2'+2'</u>	<u>2'10"+2'</u>	<u>4'8"+2'</u>	<u>8'+8'8"</u>	I, WT, WS, TF
East Shore	Shoreline Buildings	<u>1'9"+1'</u>	<u>1'9"+1'11"</u>	<u>2'6"+2'</u>	<u>4'3"+2'2"</u>	<u>7'8"+2'2"</u>	I, WT, WS, TF
Bolinas	Wharf Road	<u>6"-2'1"</u>	<u>3"-2'4"</u>	<u>2"-2'9"</u>	<u>1"-5'4"</u>	<u>10"-7'4"</u>	I, TF
East Shore	Shoreline Hwy	<u>3"-1'7"</u>	<u>3"-2'4"</u>	<u>3"-3'</u>	<u>2'-4'6"</u>	<u>6"-8'1"</u>	I, TF
Bolinas	Agate & Brighton Beaches	<u>2'1"</u>	<u>1'11"</u>	<u>2'8"</u>	<u>4'8"</u>	<u>9'3"</u>	I
Stinson Beach to Bolinas	Shoreline Hwy	<u>0"-1'8"</u>	<u>0"-2'3"</u>	<u>0"-3'1"</u>	<u>0.4"-4'10"</u>	<u>0.4"-8'6"</u>	I, TF
East Shore	Marconi Boat Launch	<u>1'1"</u>	<u>2'</u>	<u>2'11"</u>	<u>4'10"</u>	<u>8'2"</u>	I
Inverness	Tomales Bay State Park	<u>10"</u>	<u>1'10"</u>	<u>2'8"</u>	<u>4'7"</u>	<u>7'10"</u>	I, HS
East Shore	Tony's Restaurant	<u>8"</u>	<u>1'8"</u>	<u>2'6"</u>	<u>4'5"</u>	<u>7'9"</u>	I
East Shore	Tomales Bay Oyster Company	<u>8"</u>	<u>1'5"</u>	<u>2'3"</u>	<u>4'1"</u>	<u>7'5"</u>	I, TF
Stinson Beach	Walla Vista Walkway	<u>3"</u>	<u>1'8"</u>	<u>2'</u>	<u>4'4"</u>	<u>10'4"</u>	I, E
Dillon Beach	Lawson's Landing Facilities	<u>2"</u>	<u>1'1"</u>	<u>2'11"</u>	<u>3'10"</u>	<u>7'3"</u>	I, E, WS, HW, HS
East Shore	Inn on Tomales Bay		<u>2"</u>	<u>11"</u>	<u>2'10"</u>	<u>5'5"</u>	I

RECREATION

Community	Asset (not exhaustive)	Tidal & Extreme Event Flooding Depth Estimates (<u>Underlined values</u> indicate tidal flooding at mean higher high water (MHHW) based on one geographic point placed at the landward limit of the first scenario where it overlaps the asset. Values not underlined represent temporary flooding. Groups of buildings are ranked by maximum flood depth. Roads received a high and low value along the line segment.)					Vulnerability TF: Temp. Flooding during extreme events; I: Inundated at MHHW; E: Erosion; WT: Water Table; SI: Saltwater Intrusion; WS: Wave Surge; HW: High Wind, HS: Habitat Shift
		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	
Inverness	Sir Francis Drake Blvd.			<u>1"-3'6"</u>	1"- <u>4'6"</u>	<u>1"-7'10"</u>	I, TF, WS
Bolinas	Olema-Bolinas Road			2'8"	<u>4"-4'4"</u>	<u>2"-7'11"</u>	I, TF
Pt. Reyes Station	White House Pool/Trail			<u>2'5"</u>	<u>2'3"</u>	<u>5'11"</u>	I
Inverness	Inverness Store			2'5	<u>4'4"</u>	<u>7'6"</u>	TF, I, WT
Bolinas	Bolinas Super Market			8"	<u>2'6"</u>	<u>6'1"</u>	I, E, SI
Pt. Reyes Station to Inverness	Shoreline Hwy			6"	3"-1'5"	<u>1'9"-9'7"</u>	I, TF
Inverness	Dana Marsh & Beach Access				<u>3'</u>	<u>6'2"</u>	I, E, SI, HS
Inverness	Motel Inverness				<u>2'9"</u>	<u>5'10"</u>	I, WS, HW
East Shore	Nick's Cove				<u>2'6"</u>	<u>5'10"</u>	
East Shore	Millerton Point				<u>2'5"</u>	<u>5'8"</u>	I, E
Inverness	Shell Beach Tomales Bay SP				5"	<u>3'4"</u>	TF, I, WT
Stinson Beach	CA Coastal Trail				0.4"	1'3	TF, E
Bolinas	Bob Stewart Trail					<u>4'8"</u>	I, TF
Inverness	Tomales Bay Resort					<u>4'</u>	TF
East Shore	Shoreline Hwy					<u>3'5"</u>	I, E
Bolinas	Bolinas People's Store					<u>3'</u>	I, TF
Bolinas	Bolinas Post Office					2'9	TF, I
Point Reyes Station	Olema Marsh Trail					<u>2'9"</u>	I
Dillon Beach	Dillon Beach Resort Parking Lot					<u>1'6"</u>	I
Dillon Beach (north)	Stemple Creek Recreation Area	X	X	X	X	X	HS
Stinson Beach / Bolinas	Bolinas Lagoon	water resource					HS
Inverness / East Shore	Tomales Bay	water resource					HS
North of Dillon Beach	Estero Americano	water resource					HS

Source: Marin Map, OCOF Exposure and Flood Depth data, Asset Manager Interviews

RECREATION

The *Climate Change Vulnerability Assessment for the North-central California Coast and Ocean*, concludes that beaches and estuaries are vulnerable to sea level rise and erosion.⁵⁰ The sections below summarize the report's findings.

Beaches

Beaches are used for wildlife viewing, sunbathing, and accessing the ocean waters for swimming, surfing, kayaking, exercising, and fishing. Sea level rise could inundate existing beaches and increase rates of shoreline erosion. This could potentially force beach recreation opportunities inland where beaches are not impeded by development, roads, or bluffs.⁵¹ Beaches commonly used for recreation that could be vulnerable to sea level rise and storms include:

- Nude Beach (South of Stinson Beach),
- Brighton Beach (Bolinás),
- Agate Beach (Bolinás),
- Stinson Beach/ Upton Beach,
- Heart's Desire Beach (Inverness),
- Chicken Ranch Beach (Inverness),
- Lawson's Landing (Dillon Beach), and
- Dillon Beach.

For more information on beaches, including maps showing potential future beach widths at select locations, see the Natural Resources Profile.

Estuaries, Wetlands, & Marshes

Tomales Bay and Bolinas Lagoon are vulnerable. Primary recreational activities in estuarine areas are hiking, kayaking, paddle boarding, boating, bird watching, fishing/crabbing, swimming, and other passive forms of recreation. Without a comparable increase in land elevation from sediment delivery, these coastal habitats will flood.^{52,53} Like beaches,

estuaries can be prevented from moving landward when bordering development or cliffs. Vulnerable Marin coast estuaries, wetlands, and marshes include:

- Bolinas Lagoon,
- Giacomini Wetlands (may have room to retreat landward),
- Olema Marsh (may have room to retreat landward),
- Tomales Bay (may have room to retreat landward),
- Shields Salt Marsh,
- Estero San Antonio (may have room to retreat landward), and
- Estero Americano (may have room to retreat landward).



Brighton Beach, Bolinas. Credit: CDA

50 Hutto, S.V., K.D. Higgason, J.M. Kershner, W.A. Reynier, D.S. Gregg. 2015. *Climate Change Vulnerability Assessment for the North-central California Coast and Ocean*. Marine Sanctuaries Conservation Series ONMS-15-02. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries, Silver Spring, MD. 473 pp.

51 Feagin, R.A., D.J. Sherman, and W.E. Grant. 2005. Coastal erosion, global sea-level rise, and the loss of sand dune plant habitats. *Frontiers in Ecology and the Environment* 7:359-364.

52 Largier, J.L., B.S. Cheng, and K.D. Higgason, editors. 2010. *Climate Change Impacts: Gulf of the Farallones and Cordell Bank National Marine Sanctuaries*. Report of a Joint Working Group of the Gulf of the Farallones and Cordell Bank National Marine Sanctuaries Advisory Councils.

53 Ackerly, D. D., R. A. Ryals, W. K. Cornwell, S. R. Loarie, S. Veloz, K. D. Higgason, W. L. Silver, and T. E. Dawson. 2012. *Potential Impacts of Climate Change on Biodiversity and Ecosystem Services in the San Francisco Bay Area*. California Energy Commission. Publication number: CEC-500-2012- 037.

RECREATION



Wharf Road along Bolinas Lagoon. Credit: Ahern-Perchetti

Freshwater Resources

In scenario 5, with 80 inches of sea level rise and 100-year storm, saltwater can travel inland up to two miles, especially in Walker, Stemple, and Americano creeks. This could significantly alter the habitat and wildlife viewing opportunities. Creeks with recreational opportunities that could be impacted by sea level rise include:

- Redwood Creek (Muir Beach)
- Pine Gulch Creek (Bolinas)
- Walker Creek (Bolinas)
- Lagunitas River (Point Reyes Station)
- Keys Creek (East Shore)
- Stemple Creek (North of Dillon Beach), and
- Americano Creek (North of Dillon Beach)

Public Access

The Coastal and Bob Stewart trail, Olema Marsh Trail, White House Pool/Trail, Walker Creek Access Point, and several locations at Tomales State Park and a few in Stinson Beach and Bolinas are vulnerable. In general, exposed parks in the study area include:

- Agate Beach (Bolinas)
- Audubon Canyon Ranch sites (private)
- Bolinas Lagoon
- Chicken Ranch Beach (Inverness)
- Golden Gate National Recreational Area (federal)
- Inverness Foundation Park
- Keys Creek Fishing Area (East Shore)
- Lawson's Landing (private)
- Marconi Boat Launch (East Shore)
- Martinelli Park
- Miller Park Boat Launch
- Mt. Tamalpais State Park
- Nature Conservancy (private)
- Point Reyes National Seashore (federal)
- Stinson Beach Facility
- Tomales Bay Fishing Area
- Tomales Bay State Park (w/Millerton Point)
- Upton Beach
- Walker Creek Marsh, and
- Whitehouse Pool

The National Park Service released [*Adapting to Climate Change in Coastal Parks: Estimating the Exposure of Park Assets to 1 m of Sea-Level Rise*](#).⁵⁴

Note that the National Parks report uses a different methodology than this Assessment to determine vulnerability. While outside of the study area for this report, these federal park lands draw tourists and residents to Marin's Coast. Report highlights for Point Reyes National Seashore reveal that high sea level exposure could impact 614 national park assets (96 percent), including buildings and other facilities valuing \$704,396,200. High exposure to sea level rise could also impact 43 assets valued at \$57,870,724 in the Marin County portion of the Golden Gate National Recreation Area, for a combined value of nearly \$800 million.

Private Recreation

Several private entities support recreation activities on the coast that could be vulnerable. These include hotels, boat suppliers, surfing schools, restaurants, markets, tours, and other activities.

⁵⁴ McDowell Peek, Katie, R. S. Young, R. L. Beavers, C. Hawkins Hoffman, B. T. Diethorn, S. Norton. *Adapting To Climate Change in Coastal Parks: Estimating the Exposure of Park Assets to 1 m of Sea-Level Rise*. Natural Resource Technical Report NPS/NRSS/GRD/NRR—2015/916. http://www.nature.nps.gov/geology/coastal/coastal_assets_report.cfm.

RECREATION

- Inverness Yacht Club
- Tomales Bay Resort
- Motel Inverness
- Lawson's Landing Fishing Pier
- Lawson's Landing Marina
- Hog Island Oyster
- Nick's Cove
- Inn on Tomales Bay
- Marshall Boat Works
- Tony's Restaurant
- Love Athletic Field and Venue
- Brock Schreiber Boathouse
- Bolinas Super Market
- Bolinas People's Store
- Inverness Store
- Tomales Bay Oyster Co.
- West Marin Food & Farm Tours, and
- Dillon Beach Resort.

Existing Policies

The Draft Local Coastal Program (DLCP) seeks to preserve recreational opportunities for both coastal residents and visitors, and to maintain and expand opportunities for public access. The Coastal Commission retains Coastal Development Permit (CDP) authority over tidelands (below mean high tide), submerged lands, and public trust lands. The Coastal Open Area (C-OA) district provides for open space, outdoor recreation, and other open lands, including areas suited for park and recreational purposes, access to beaches, and areas that link major recreation areas.

Public Trust Lands

Public trust lands include submerged land and tidelands below the mean high tide level. As sea level rise advances, the boundary of public trust lands will also move inland. The California Coastal Act provides for the protection and mitigation of coastal hazards for existing and new development. However, some shoreline protection measures, such as coastal armoring, may have significant impacts to public trust resources, including public beach and shoreline access. If coastal armoring impedes or eliminates coastal access or recreational opportunities, the installation and ongoing

maintenance of the armoring could constitute a public trust violation.⁵⁵

A number of court cases throughout the U.S. are indicative of the tension between the right of the public to use open space and the right of homeowners to their property. To make public beaches accessible, perpendicular access is needed for people to get to the shore. Home owners and public agencies sometimes come into conflict over whether an access way is open for public use.⁵⁶

The *California Coastal Commission Sea Level Rise Policy Guidance: Interpretive Guidelines for addressing Sea Level Rise in Local Coastal Programs and Coastal Development*⁵⁷ encourages local governments to, “recognize that sea level rise will cause the public trust boundary to move inland. New shoreline protective devices should not result in the loss of public trust lands.” Homes in Stinson Beach and Bolinas are protected by existing shoreline armoring that could eventually impede public access or infringe on public trust lands. In other cases, such as Brighton Beach in Bolinas, sea walls protect the pedestrian access point, armoring can facilitate public access.

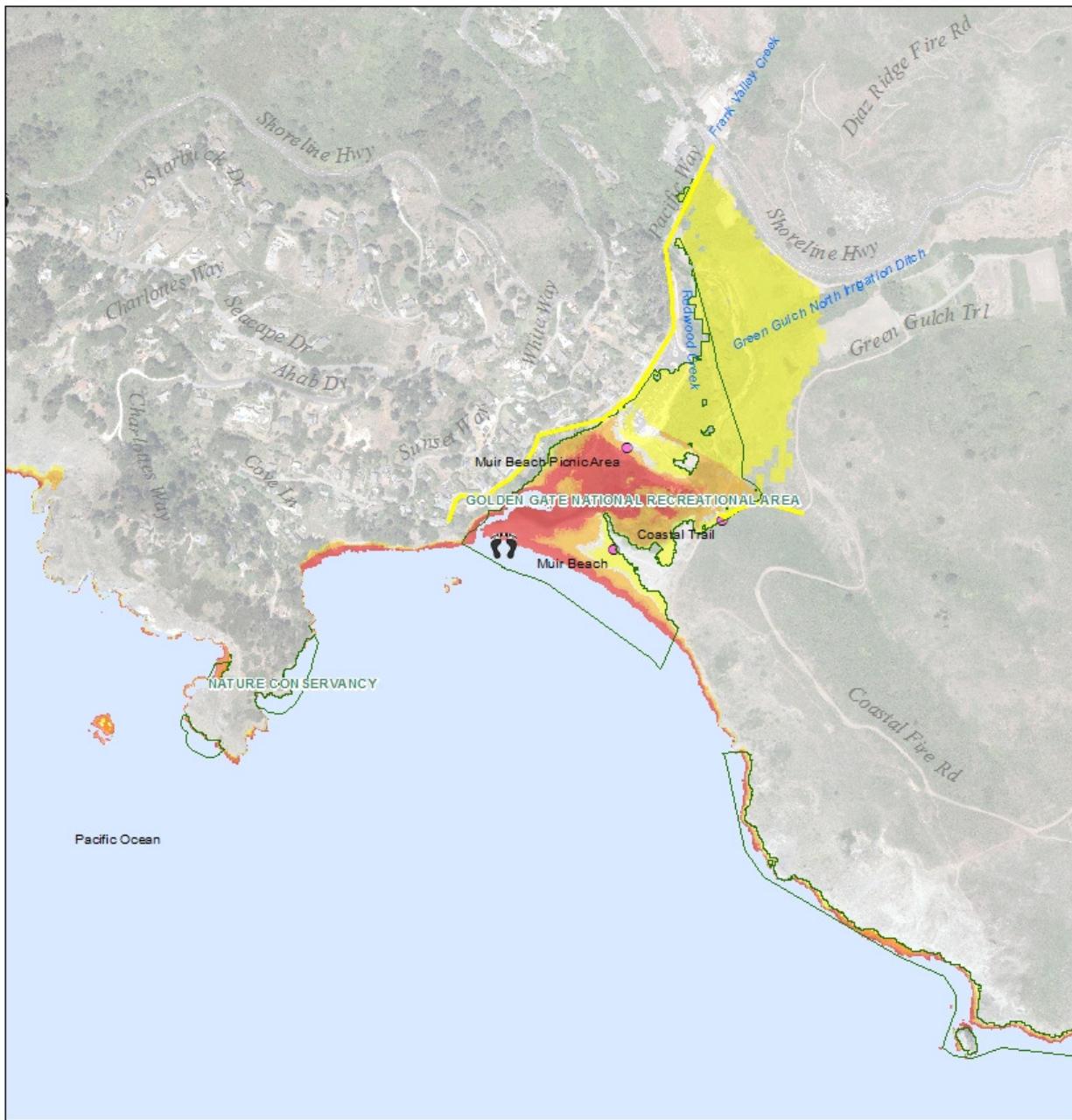
⁵⁵ Melius, Molly Loughner and Caldwell, Margaret R. *California Coastal Armoring Report: Managing Coastal Armoring and Climate Change Adaptation in the 21st Century*. Stanford Law School, Environment and Natural Resources Law & Policy Program. 2015.

⁵⁶ Boerner, Heather. *A Line in the Sand: What happens when the boundaries between private property and public space get washed away?* American Planning Association, June 2015.

⁵⁷ California Coastal Commission. *California Coastal Commission Sea Level Rise Policy Guidance: Interpretive Guidelines for addressing Sea Level Rise in Local Coastal Programs and Coastal Development*. August 12, 2015. <http://www.coastal.ca.gov/climate/slrguidance.html>

RECREATION

Map 44. Muir Beach Vulnerable Recreation Assets



Scenarios

- | | | |
|---|--|--------------------------|
| 1 | | 10" SLR + Annual Storm |
| 2 | | 10" SLR + 20-year Storm |
| 3 | | 20" SLR + 20-year Storm |
| 4 | | 40" SLR + 20-year Storm |
| 5 | | 80" SLR + 100-year Storm |

Exposed Roads

- | | |
|--|--------------------------|
| | 10" SLR + Annual Storm |
| | 10" SLR + 20-year Storm |
| | 20" SLR + 20-year Storm |
| | 40" SLR + 20-year Storm |
| | 80" SLR + 100-year Storm |

- Recreation Asset
- Public Boat Launch
- Public Fishing Pier
- Public Access Point
- Public Port
- Public Marina

0 0.02250.045 0.09 0.135 0.18 Miles
 Sources: Our Coast Our Future, Marin Map, California Coastal Commission

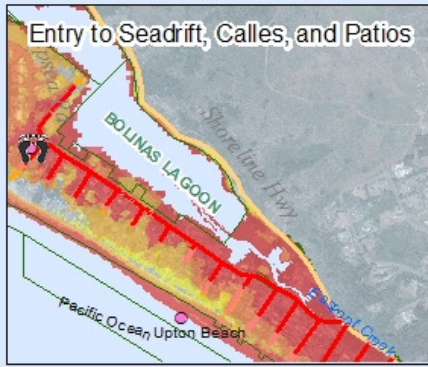
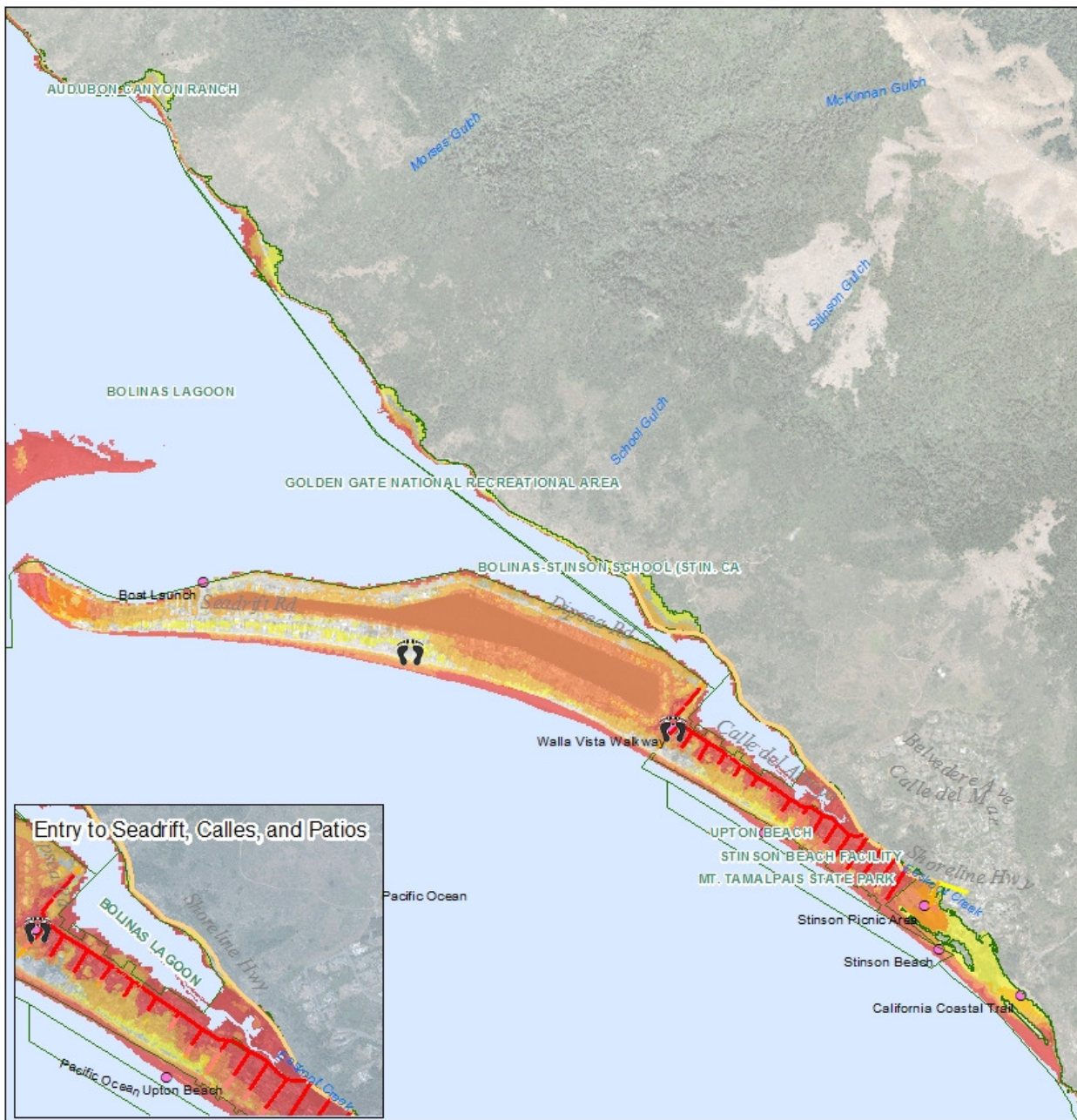
Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

Date: 10/19/2015



RECREATION

Map 45. Stinson Beach Vulnerable Recreational Assets



Scenarios

- | | | |
|---|--------------------------|--------------------------|
| 1 | 10" SLR + Annual Storm | 10" SLR + Annual Storm |
| 2 | 10" SLR + 20-year Storm | 10" SLR + 20-year Storm |
| 3 | 20" SLR + 20-year Storm | 20" SLR + 20-year Storm |
| 4 | 40" SLR + 20-year Storm | 40" SLR + 20-year Storm |
| 5 | 80" SLR + 100-year Storm | 80" SLR + 100-year Storm |

Exposed Roads

- | |
|--------------------------|
| 10" SLR + Annual Storm |
| 10" SLR + 20-year Storm |
| 20" SLR + 20-year Storm |
| 40" SLR + 20-year Storm |
| 80" SLR + 100-year Storm |

- Recreation Asset
- Public Fishing Pier
- Public Access Point
- Public Port
- Public Marina
- Public Boat Launch

0 0.05 0.1 0.2 0.3 0.4 Miles
 Sources: Our Coast Our Future, Marin Map, California Coastal Commission

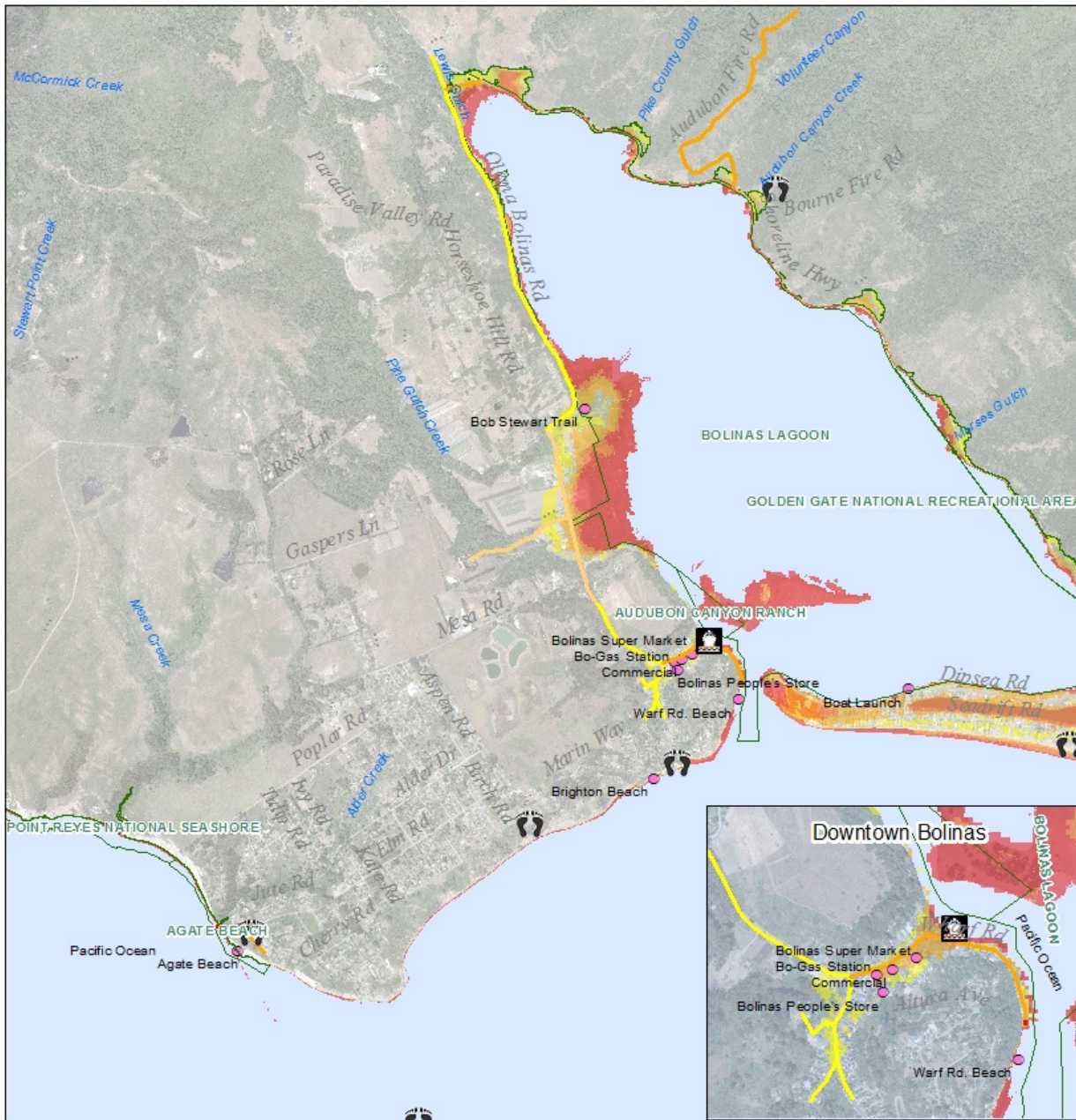
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Date: 10/19/2015



RECREATION

Map 46. Bolinas Vulnerable Recreational Assets



Scenarios

- | | | |
|---|--------------------------|--------------------------|
| 1 | 10" SLR + Annual Storm | 10" SLR + Annual Storm |
| 2 | 10" SLR + 20-year Storm | 10" SLR + 20-year Storm |
| 3 | 20" SLR + 20-year Storm | 20" SLR + 20-year Storm |
| 4 | 40" SLR + 20-year Storm | 40" SLR + 20-year Storm |
| 5 | 80" SLR + 100-year Storm | 80" SLR + 100-year Storm |

Exposed Roads

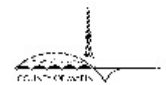
- | |
|--------------------------|
| 10" SLR + Annual Storm |
| 10" SLR + 20-year Storm |
| 20" SLR + 20-year Storm |
| 40" SLR + 20-year Storm |
| 80" SLR + 100-year Storm |

- Recreation Asset
- Public Fishing Pier
- Public Access Point
- Public Port
- Public Marina
- Public Boat Launch

Scale: 0 0.075 0.15 0.3 0.45 0.6 Miles
 Sources: Our Coast Our Future, Marin Map, California Coastal Commission

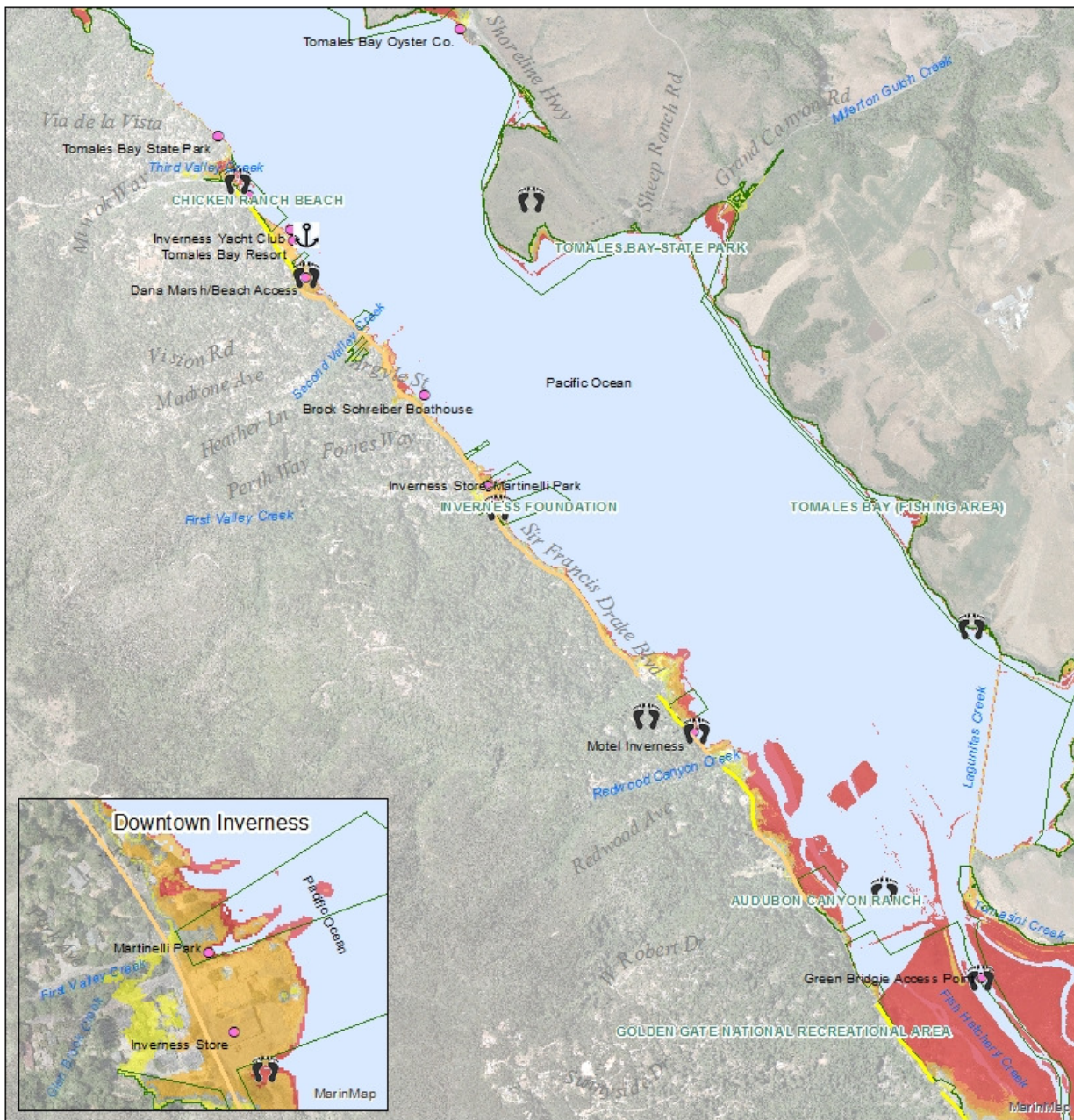
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Date: 10/19/2015



RECREATION

Map 47. Inverness Vulnerable Recreational Assets



Scenarios

- | | | |
|---|--------------------------|--------------------------|
| 1 | 10" SLR + Annual Storm | 10" SLR + Annual Storm |
| 2 | 10" SLR + 20-year Storm | 10" SLR + 20-year Storm |
| 3 | 20" SLR + 20-year Storm | 20" SLR + 20-year Storm |
| 4 | 40" SLR + 20-year Storm | 40" SLR + 20-year Storm |
| 5 | 80" SLR + 100-year Storm | 80" SLR + 100-year Storm |

Exposed Roads

- | |
|--------------------------|
| 10" SLR + Annual Storm |
| 10" SLR + 20-year Storm |
| 20" SLR + 20-year Storm |
| 40" SLR + 20-year Storm |
| 80" SLR + 100-year Storm |

- Recreation Asset
- Public Boat Launch
- Public Fishing Pier
- Public Access Point
- Public Port
- Public Marina

0 0.075 0.15 0.3 0.45 0.6 Miles
 Sources: Our Coast Our Future, Marin Map, California Coastal Commission

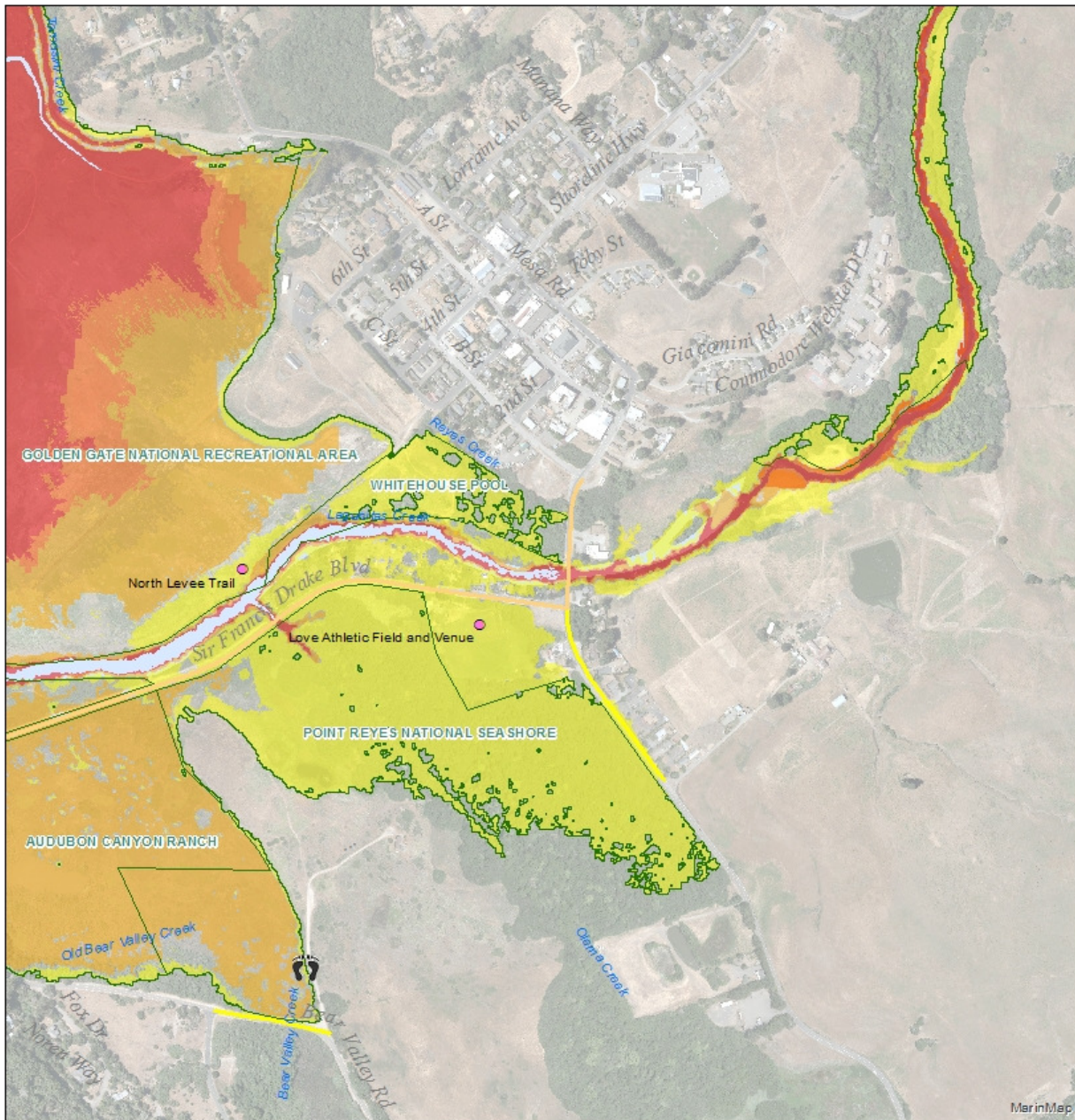
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Date: 11/2/2015



RECREATION

Map 48. Point Reyes Vulnerable Recreational Assets



Scenarios

- | | | | |
|---|--------------------------|---|--------------------------|
| 1 | 10" SLR + Annual Storm | 2 | 10" SLR + Annual Storm |
| 2 | 10" SLR + 20-year Storm | 3 | 20" SLR + 20-year Storm |
| 3 | 20" SLR + 20-year Storm | 4 | 40" SLR + 20-year Storm |
| 4 | 40" SLR + 20-year Storm | 5 | 80" SLR + 100-year Storm |
| 5 | 80" SLR + 100-year Storm | | |

Exposed Roads

- | | |
|-------------------------|--------------------------|
| 10" SLR + Annual Storm | 20" SLR + 20-year Storm |
| 40" SLR + 20-year Storm | 80" SLR + 100-year Storm |

- Recreation Asset
- Public Boat Launch
- Public Fishing Pier
- Public Access Point
- Public Port
- Public Marina

0 0.02750055 0.11 0.165 0.22 Miles
 Sources: Our Coast Our Future, Marin Map, California Coastal Commission

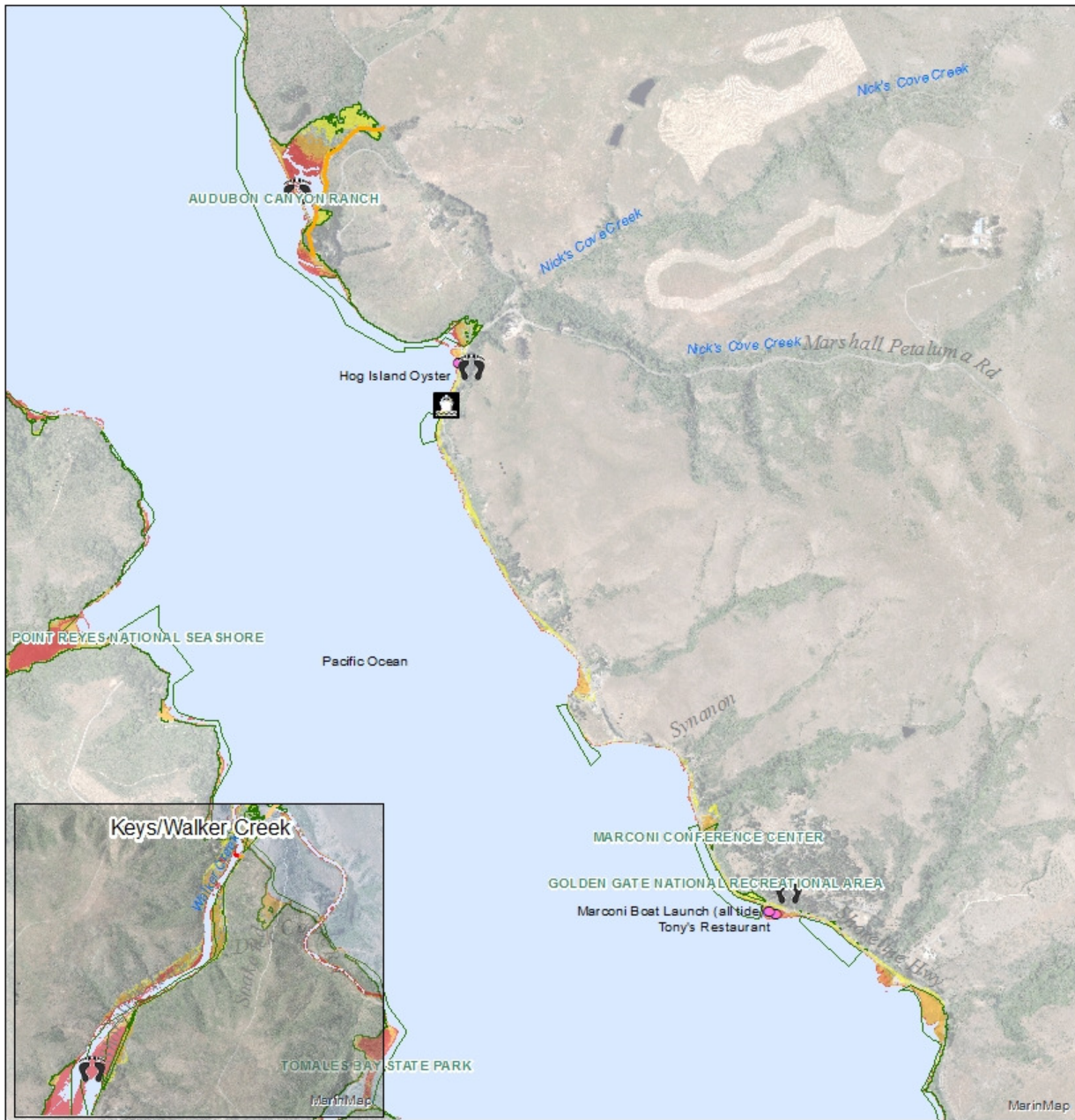
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Date: 10/19/2015



RECREATION

Map 49. East Shore Vulnerable Recreational Assets









Scenarios

- | | |
|---|--------------------------|
| 1 | 10" SLR + Annual Storm |
| 2 | 10" SLR + 20-year Storm |
| 3 | 20" SLR + 20-year Storm |
| 4 | 40" SLR + 20-year Storm |
| 5 | 80" SLR + 100-year Storm |

Exposed Roads

- | |
|--------------------------|
| 10" SLR + Annual Storm |
| 10" SLR + 20-year Storm |
| 20" SLR + 20-year Storm |
| 40" SLR + 20-year Storm |
| 80" SLR + 100-year Storm |

-  Recreation Asset
-  Public Fishing Pier
-  Public Access Point
-  Public Port
-  Public Marina
-  Public Boat Launch

0 0.05 0.1 0.2 0.3 0.4 Miles
 Sources: Our Coast Our Future, Marin Map, California Coastal Commission

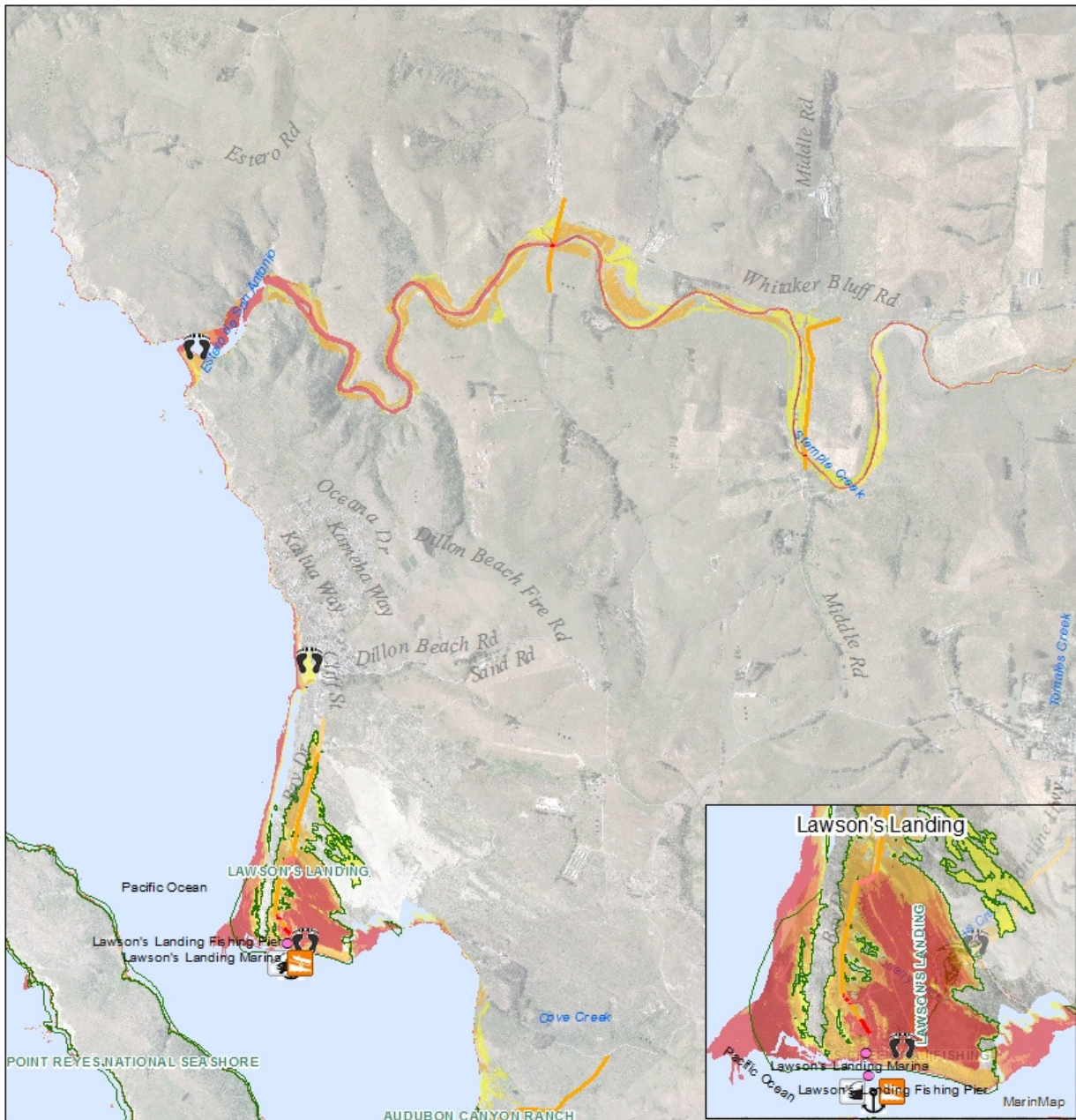
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Date: 10/19/2015



RECREATION

Map 50: Dillon Beach Vulnerable Recreation Assets



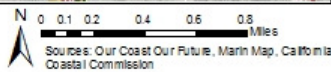
Scenarios

- 1 10" SLR + Annual Storm
- 2 10" SLR + 20-year Storm
- 3 20" SLR + 20-year Storm
- 4 40" SLR + 20-year Storm
- 5 80" SLR + 100-year Storm

Exposed Roads

- 10" SLR + Annual Storm
- 10" SLR + 20-year Storm
- 20" SLR + 20-year Storm
- 40" SLR + 20-year Storm
- 80" SLR + 100-year Storm

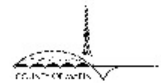
- Recreation Asset
- Public Fishing Pier
- Public Access Point
- Public Port
- Public Marina
- Public Boat Launch



Sources: Our Coast Our Future, Marin Map, California Coastal Commission

Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

Date: 10/19/2015



RECREATION

Other Considerations

Economic

Active and passive recreation on West Marin's miles of beaches and roads are critical economic contributors to the regional economy that could diminish with rising seas.

Environmental

Creating new access and activity areas could have serious temporary and long-term environmental impacts. Several species require buffers between their habitats and human activity, especially for breeding and nesting. Allowing human activity in new areas could greatly impact wildlife roosting and feeding habitats.

Social Equity

Coastal beaches, estuaries, wetlands, and marshes provide unique low cost opportunities for wildlife viewing, shoreline access, and scenic enjoyment that could be lost to sea level rise.⁵⁸ The losses could be felt unequally across income levels because as free or low cost public access points are lost to the rising sea there could be less capacity to accommodate lower income brackets.

Management

Protecting public access to natural resources and wildlife is a state and local priority. However, as Marin Coast residents' daily lives become more and more vulnerable, preserving recreation opportunities could become a lower priority. National priorities could also affect Marin public lands and sanctuaries under federal jurisdiction. The Public Trust Doctrine, as described in the Existing Policies section of this profile could also prompt regulatory issues coastal residents may have to face.



Marshall businesses between Tomales Bay and Shoreline Hwy. Credit: Drumm

⁵⁸ BCDC Vulnerability Assessment.

EMERGENCY SERVICES

Asset Profile: Emergency Services

West Marin is susceptible to earthquakes, tsunamis, fires, and more. Sea level rise and storms could create additional hazards and impede emergency response. In fact, primary vulnerability in West Marin’s emergency services sector is continued safe access to people and places needing aide.

The West Marin Disaster Council works with local fire departments in disaster planning and response, and is divided into four geographic zones: Pt. Reyes Station, Inverness Park, Olema, and Marshall; Inverness; Bolinas; and Woodacre. Additionally, Emergency Response Teams of trained volunteers for Dillon Beach, Inverness, and Muir Beach supplement public agencies’ capacity and help implement disaster response.

Tsunami Evacuation Routes

lists some of the potentially vulnerable emergency service assets related assets in the study area. This list measures onset and tidal mean higher high water (MHHW) or extreme event flood depths. This list is not exhaustive of all the emergency service assets that could be exposed to sea level rise and storm impacts in the study area.

Sheriff

While no sheriff facilities are exposed in the study area, lack of emergency access, power outages, and high demand could strain or disrupt service.

Fire Protection Districts

Fire departments could be vulnerable to station flooding, though losing transportation access could be the main vulnerability. Additionally, disruptions in water supply could compromise fire service.

Fire protection districts can provide a variety of services including ambulance, rescue and first aid, land clearing, fire prevention ordinances, and public education. West Marin fire protection districts include Bolinas, which serves 10.5 miles² and a population of 2,500, and Stinson Beach, which serves 6.75 miles² and a population of 1,200. Additionally, the Marin County Fire Station in Pt. Reyes serves over 100 square miles of parklands and rural areas, including Pt. Reyes Station, Marshall, Olema, and

Inverness Park. A flood evacuation boat also serves the area. Inverness has a volunteer fire department.

IMPACTS AT-A-GLANCE

Thousands of residents, millions of visitors

Emergency Access Routes Hydrants

Stinson Fire Station No.2

Property Owners Office of Emergency Services Fire Departments County Sheriff



Stinson Beach Fire Station No. 2 is vulnerable. Credit: Westhoff

Tsunami Evacuation Routes

Over the past century, six tsunamis have hit Marin County. The most impactful was the 1964 Tsunami that caused one death and \$100,000 in damage to boats and docks. Tsunami evacuation routes follow roads, and hence, their vulnerabilities reflect the road’s vulnerability. [Tsunami Evacuation Planning Maps](#) are available on the internet.⁵⁹ Vulnerable tsunami routes in West Marin include:

- Stinson Beach – Follows Dipsea Road and Seadrift Road out of Seadrift to Calle de Arroyo.

59 Marin County Sheriff’s Office of Emergency Services. January 2015. Tsunami Annex (Draft). <http://marinsheriff.org/uploads/documents/Marin%20Tsunami%20Annex%20Jan%202007.pdf>.

EMERGENCY SERVICES

Then to Shoreline Highway to Buena Vista Ave headed north.

- Bolinas – Follows Wharf Road to Olema Bolinas Road. Another road follows Olema Bolinas Road to Horseshoe Hill Road.
- Inverness – Two evacuation routes from Sir Francis Drake Blvd to upland areas west of Tomales Bay – Vision Road and Inverness Way.
- Dillon Beach – Follows Bay Drive out of Lawson's Landing, to Beach Avenue and Band Road out of Dillon Beach, to Dillon Beach Road.

The Marin County Sheriff's Office of Emergency Services also drafted a Tsunami Annex as part of the Marin Operational Area Emergency Operations Plan. This Operation Plan identifies evacuation routes for Tsunamis at higher sea levels. Additionally, tsunami-Response Playbooks are being developed by the State Office of Emergency Services for coastal counties.

Helicopter Landing Pads

The helicopter landing pad, or helispot in Inverness is vulnerable, but can be relocated easily.⁶⁰

The maps on the following pages highlight where vulnerable emergency facilities and routes exist. The subsequent sections detail these key vulnerabilities and others in greater detail.

⁶⁰ Ursula Hanks, Marin County Sheriff's Office of Emergency Services, personal communication – 3/9/15

EMERGENCY SERVICES

Table 31. Emergency Service Assets Ranked by Onset and Flood Depth (feet and inches)

Community	Asset (not exhaustive)	Tidal & Extreme Event Flooding Depth Estimates <small>(Underlined values indicate tidal flooding at mean higher high water (MHHW) based on one geographic point placed at the landward limit of the first scenario where it overlaps the asset. values absent the underline represent temporary extreme event flooding. Roads received a high, used for ranking, and low value along the exposed line segment.)</small>					Vulnerability <small>TF: Temp. Flooding during extreme events; I: Inundated at MHHW; E: Erosion; WT: Water Table; SI: Saltwater Intrusion; WS: Wave Surge; HW: High Wind, HS: Habitat Shift</small>
		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	
Stinson Beach	Calle del Arroyo	<u>7"-6'11"</u>	<u>3"-6'8"</u>	<u>8"-9'6"</u>	<u>2'5"-12'2"</u>	<u>5'11"-13'9"</u>	I, TF
Bolinas	Tsunami Evacuation Route	<u>2'4"</u>	<u>1'8"</u>	<u>2'5"</u>	<u>4'2"</u>	<u>7'9"</u>	TF, I, WS, E
Bolinas	Wharf Rd.	6"-2'1"	3"-2'4"	2"-2'9"	1"-5'4"	<u>10"-7'4"</u>	I, TF
East Shore	Shoreline Hwy.	3"-1'7"	3"-2'4"	3"-3'	<u>2'-4'6"</u>	<u>6"-8'1"</u>	I, TF
Stinson Beach	Stinson Fire Department #2		3'6"	5'3"	6'10"	<u>9'1"</u>	I, TF, WT
Inverness	Sir Francis Drake Blvd.			<u>1"-3'6"</u>	1"-4'6"	<u>1"-7'10"</u>	I, TF, WS
Bolinas	Olema-Bolinas Rd.			2'8"	<u>4"-4'4"</u>	<u>2"-7'11"</u>	I, TF
Pt. Reyes Station to Inverness	Shoreline Hwy.			6"	3"-1'5"	<u>1'9"-9'7"</u>	I, TF
Bolinas	Community Center Emergency Shelter				1'7"	<u>5'2"</u>	I, E
East Shore	Shoreline Hwy .					<u>3'5"</u>	I, E

Source: Marin Map, OCOF Exposure and Flood Depth data, Asset Manager Interviews

EMERGENCY SERVICES

Map 51: Stinson Beach Vulnerable Emergency Service Assets



**Exposed roads w/
evacuation routes**

- Scenario 1 ▲ Emergency Services
- Scenario 2
- Scenario 3
- Scenario 4
- Scenario 5



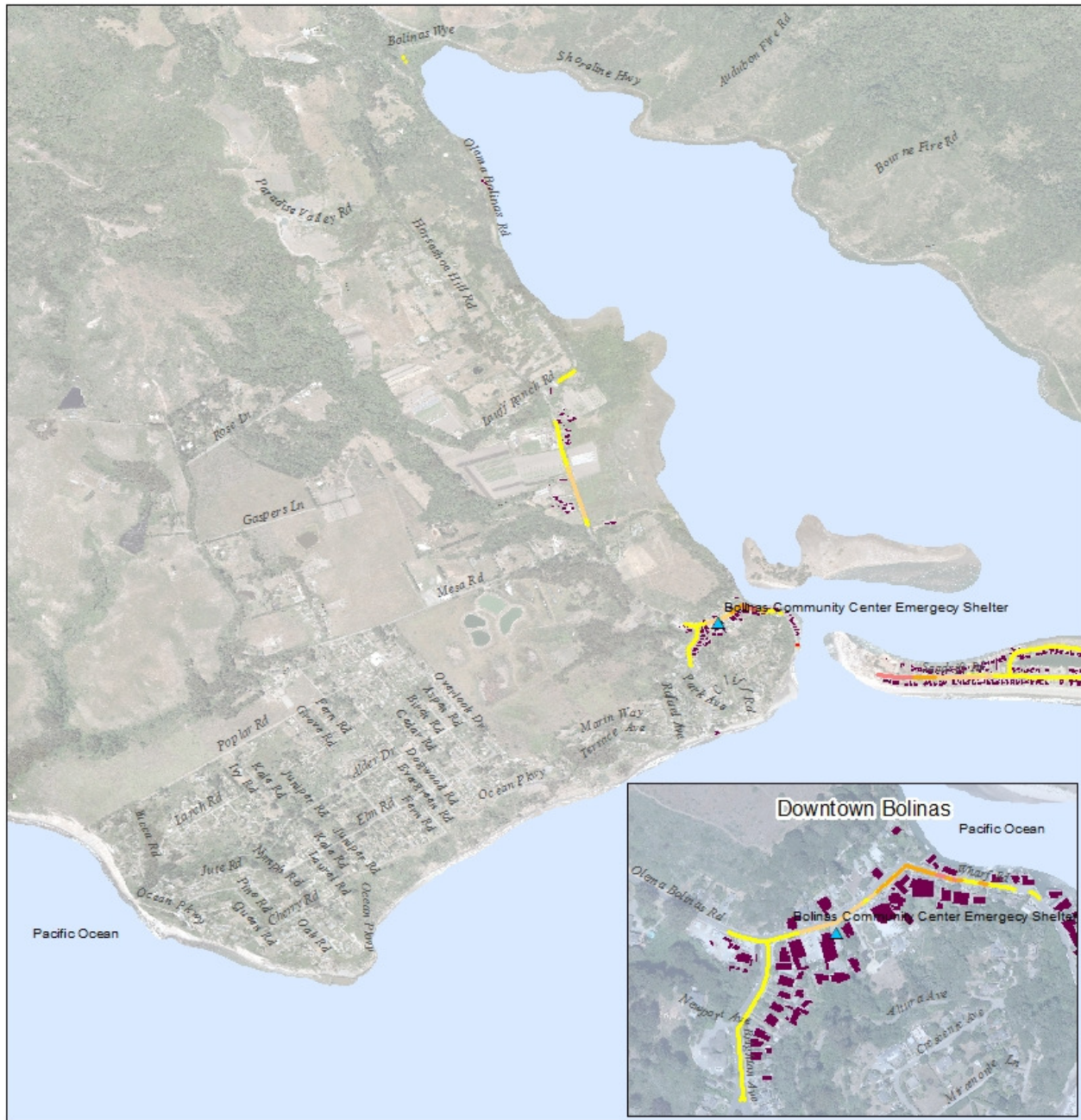
Sources: Our Coast Our Future Flood Map (2014), Marin Map, Marin County Tsunami Annex 01/15
 Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data provide is here in, make no warranties of the accuracy or completeness of maps and data. Maps are representation and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

Date: 9/30/2015



EMERGENCY SERVICES

Map 52: Bolinas Vulnerable Emergency Service Assets




**Exposed roads w/
evacuation routes**

- Scenario 1 ▲ Emergency Services
- Scenario 2
- Scenario 3
- Scenario 4
- Scenario 5

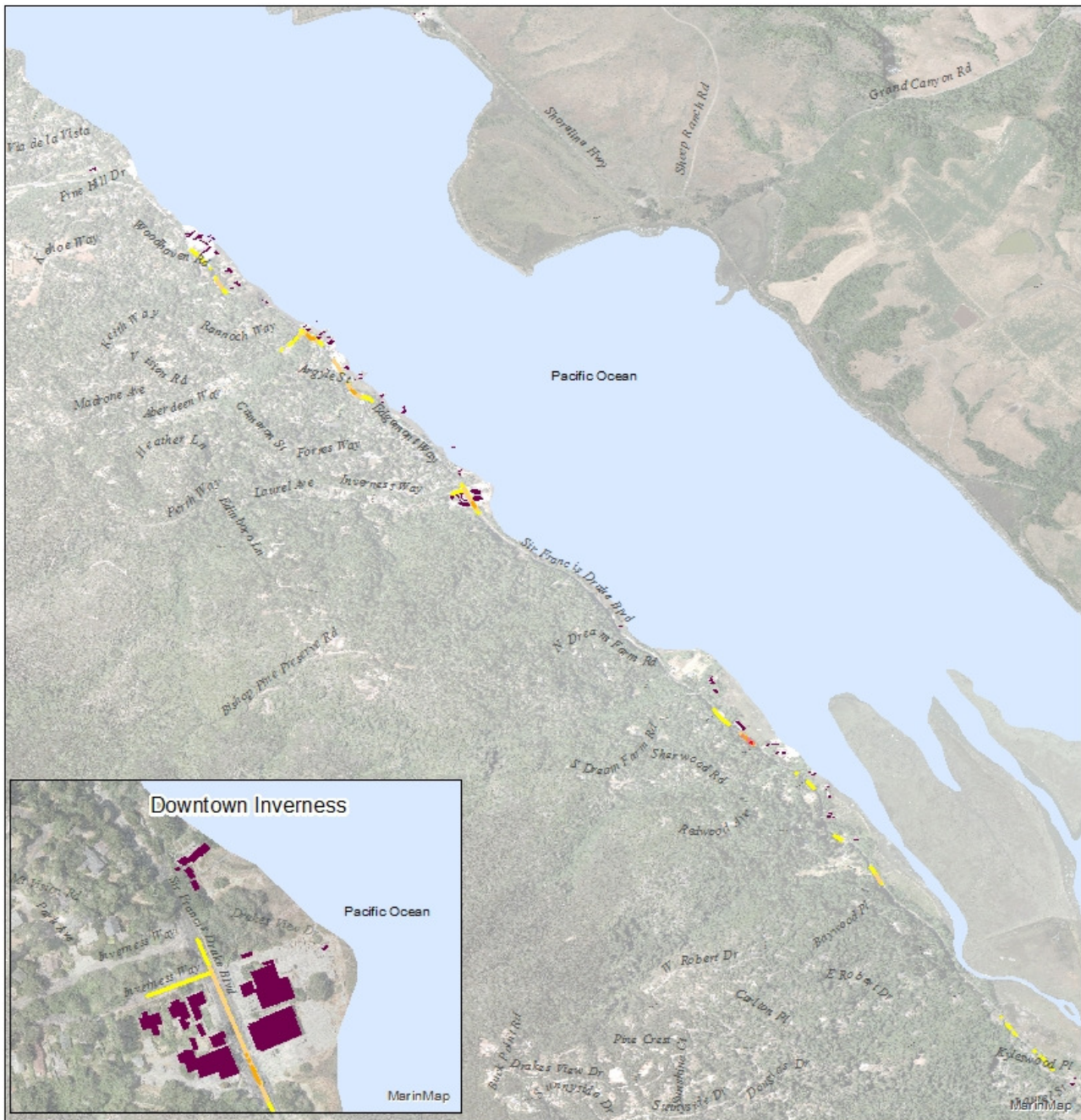


Sources: Our Coast Our Future Flood Map (2014), Marin Map, Marin County Tsunami Annex 01/15
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Date: 9/30/2015 

EMERGENCY SERVICES

Map 53: Inverness Vulnerable Emergency Service Assets



Exposed roads w/ evacuation routes

- Scenario 1
- Scenario 2
- Scenario 3
- Scenario 4
- Scenario 5
- ▲ Emergency Services
- Buildings



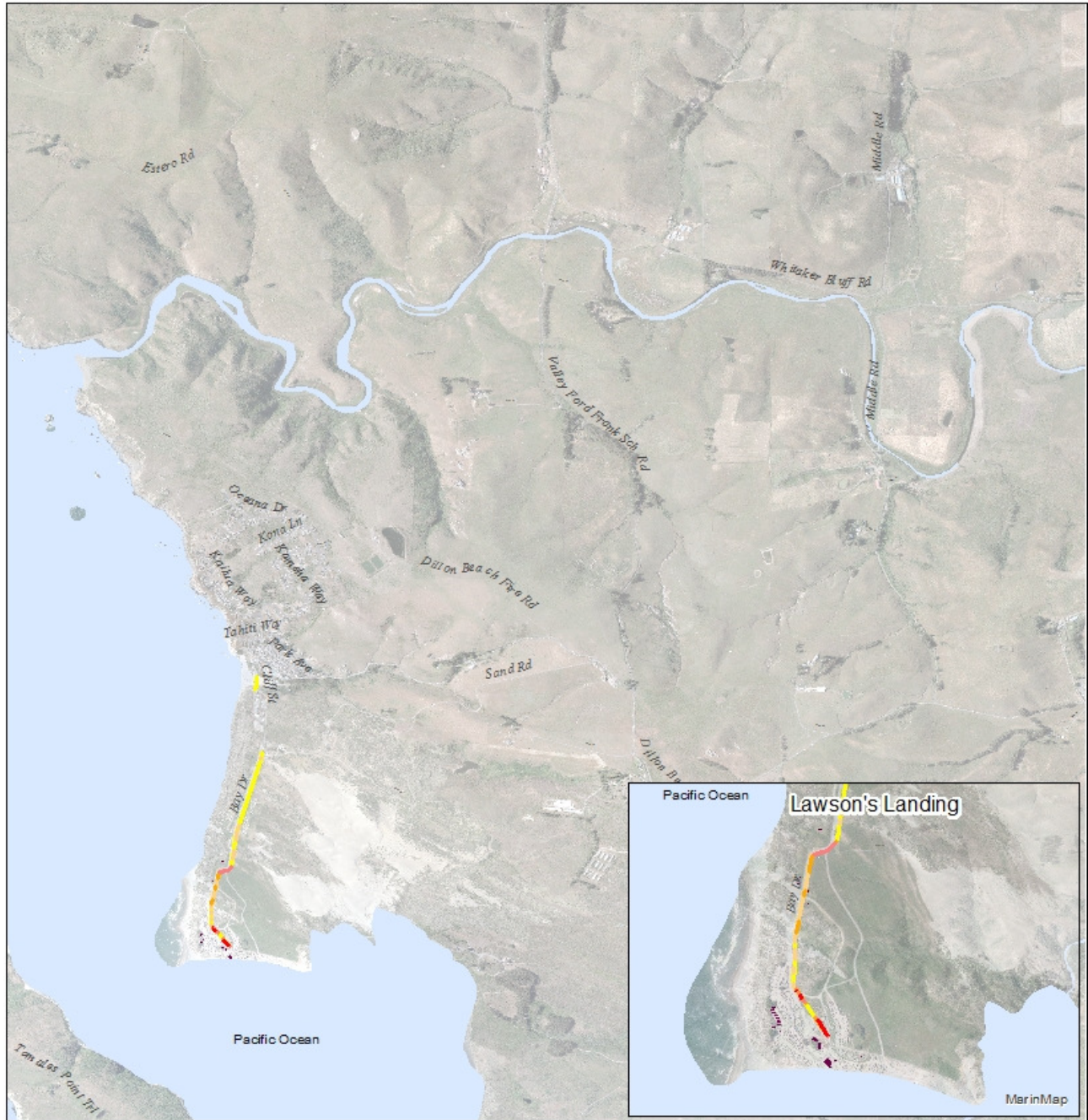
Sources: Our Coast Our Future Flood Map (2014), Marin Map, Marin County Tsunami Annex 01/15
 Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

Date: 11/2/2015



EMERGENCY SERVICES

Map 54. Dillon Beach Vulnerable Emergency Service Assets



Exposed roads w/ evacuation routes

- Scenario 1 ▲ Emergency Services
- Scenario 2
- Scenario 3
- Scenario 4
- Scenario 5



Sources: Our Coast Our Future Flood Map (2014), Marin Map, Marin County Tsunami Annex 01/15
 Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers herein, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

Date: 9/30/2015



EMERGENCY SERVICES

Existing Policies

The Marin County Sheriff's Department established the Office of Emergency Services (OES) to coordinate efforts to develop disaster-resistant communities and to educate residents on emergency preparedness. In the event of a major emergency or disaster, the OES has established a fully functional centralized Emergency Operations Center (EOC). The County maintains an [Emergency Operations Plan](#) to provide preparation and agency response to disasters that threaten the health or property of residents and businesses. Simultaneously, the plan recognizes that in the first 72 hours following a major event, community members must be self-sufficient.

In addition, the Marin County Local Hazard Mitigation Plan (LHMP), was developed to meet the requirements of the Disaster Mitigation Act of 2000 and maintain eligibility for certain FEMA hazard mitigation programs. Strategies focus on safety and protection during earthquakes, fires, floods, and other disasters with high priority mitigation projects identified. The LHMP is currently being updated with an effort to reflect the full scope of hazard issues including climate change impacts.

Relevant programs of the Marin Countywide Plan include: maintain effective communication systems, maintain adequate response resources, distribute public information, conduct disaster awareness efforts, promote community involvement, locate emergency facilities appropriately, promote agency emergency planning, and develop evacuation plans (Marin Countywide Plan, 2007).

Other Considerations

Economic

Lack of emergency services or access for emergency services could lead to injury or death, which could result in costly medical expenses, death related expenses and cause financial complications for dependents of the victims.

Environmental

Lack of fire services or access could prevent adequate protection of homes or entire communities. Wildfire may be able to consume greater acreages if local and fire roads are compromised.

Social Equity

Losing public emergency services could impact all residents and visitors regardless of socioeconomic status, though certain demographic factors may increase an individual's vulnerability in the face of an emergency. The Association of Bay Area Governments identifies several indicators that reduce a community's ability to prepare for, respond to, recover from major disasters. These include:

- Low educational attainment
- Transit dependence (persons without vehicles)
- Non-English speakers
- Young children and aging adults
- Significant housing cost burden
- Household income
- Home ownership.⁶¹

Loss or compromised emergency services could be more devastating to communities with higher populations that fall under such demographics, such as Bolinas.

Management

Protecting emergency services will require coordination amongst federal, state, county and local agencies. Sea level rise planning efforts should collaborate with Local Hazard Mitigation Plans and the Office of Emergency Services to ensure emergency response systems and amenities are planned with the consideration of sea level rise.

⁶¹ Bay Conservation and Development Commission and Association of Bay Area Governments. *Creating Safe Growth Strategies for the San Francisco Bay Area*. 2015

HISTORIC & ARCHEOLOGICAL RESOURCES

Asset Profile: Historic & Archeological Resources

Coastal Marin is rich with prehistoric and historic resources reflective of the area’s unique history and past inhabitants. Miwok Indians inhabited the area for thousands of years before being displaced by foreign settlers in the mid-1800’s.⁶² English explorer Sir Francis Drake’s most likely landing spot during his 1579 circumnavigation of the world was in West Marin. The Gold Rush and the 1875 completion of the North Pacific Coast Railway catalyzed population growth, and lumber, dairy, and agricultural industries. The following are key issues relevant to archaeological and historical resources:

- Archaeological sites can be vulnerable to sea level rise and erosion. Site disturbance can harm valuable historic information and intrinsic losses for Native Americans.
- Additional vulnerabilities lie in lack of comprehensive data about West Marin’s archaeological resources. Not all of the coastline is surveyed, and without a staff archaeologist, it is not possible to acquire existing confidential datasets.
- Several locally-identified historic districts and one national register site in the study area are vulnerable to sea level rise and storms. Their loss or degradation could lead to negative economic and sense of place impacts.
- Marin County’s Local Coastal Program Historic Study is 30 years old. An updated study could inventory additional sites to assess for sea level rise vulnerability.

IMPACTS AT-A-GLANCE

3 Historic Districts		Property Owners Marin County Society for CA Archaeology Federated Indians of Graton Rancheria
Archaeological Sites		
Irreplaceable	Intrinsic Values	

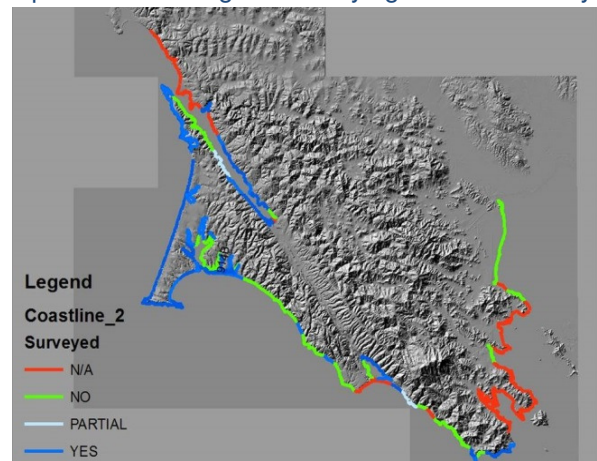


Point Reyes Shipwreck, Inverness. Credit: Klingel

Archaeological Resources

The State of California recognizes 630 archaeological sites in Marin County including permanent settlements, seasonal camps, hunting camps/special use sites, and petroglyphs covering thousands of years of Miwok Indian history. The Anthropological Studies Center at Sonoma State University is currently inventorying additional sites in anticipation of sea level rise and erosion. As depicted in [Map 55](#), a total of sixty-nine miles of public lands were surveyed, and eight miles are partially surveyed. Inventorying has not occurred on private property due to access restrictions.

Map 55. Archaeological Surveying in Marin County



Source: Anthropological Studies Center, 2015

⁶² Newland, M. 2015. The Potential Effects of Climate Change on Cultural Resources Within Point Reyes National Seashore (Public Final Release, 2015). Prepared for the National Park Service. p. 20.

HISTORIC & ARCHEOLOGICAL RESOURCES

Specific locations of archaeological sites must remain confidential and Marin County CDA does not have a staff archaeologist to maintain and protect this sensitive information. Given these restrictions, not all of the aforementioned data is available to the Marin County CDA, thus currently restricting CDA's capability to conduct a comprehensive vulnerability assessment of archaeological sites. However, based on the limited available spatial information, a total of 20 vulnerable sites fall within the purview of this assessment (non-federal land). Sites are considered vulnerable if they lie within the exposure zones, as impacts including temporary flooding, inundation and erosion could disturb the sites.

Table 32. Number of Known Vulnerable Archaeological Sites

Near Term	10
Medium Term	1
Long Term	9

Source: Marin County CDA (confidential dataset), OCOF Exposure and Flood Depth data

Sites will be impacted different depending on location. Vulnerable sites generally fall along cliff edges, adjacent to interior bays and in dune areas. While there is little research on the effects of rapid sea level rise on archaeological sites, the field of 'wet site archaeology' suggests that coastal sites threatened by large waves, long fetch and strong winds can be destroyed or significantly damaged.⁶³ Coastal cliff erosion may have the most detrimental impact, as it can completely destroy relevant site's archaeological contexts, through inundation dispersal across the ocean floor.⁶⁴ Finally, dune erosion can also be quite damaging, and cause the collapse of some sites while covering/concealing others.⁶⁵

Existing Policies

The Marin County Draft Local Coastal Program (DLCP) supports the inventorying and protection of archaeological and paleontological resources. Mitigation measures are required in cases that development would negatively impact such resources.

⁶³ Newland, M. 2015. The Potential Effects of Climate Change on Cultural Resources Within Point Reyes National Seashore. Prepared for the National Park Service.

⁶⁴ Ibid.

⁶⁵ Ibid.



Marin Coastal Archaeological Site – 2001 (above) and 2013 (below) Credit: Anthropological Studies Center.

Figure 14. Marin County DLCP Archaeological Resources Policies (abridged)

C-HAR-1 Maintenance of Information on Archaeological and Paleontological Resources. Maintain a file on known and suspected archaeological and paleontological sites in the Coastal Zone.

C-HAR-2 Potential Impacts of Development on Archaeological and Paleontological Resources. Prior to the approval of a coastal permit for any development proposed within an area of known or likely archaeological or paleontological significance require a field survey by a state-qualified archaeologist recommended by the Sacred Sites Protection Committee of the Federated Indians of Graton Rancheria or by a qualified paleontologist at the applicant's expense. Where development would adversely impact resources, require mitigation measures.

C-HAR-3 Monitoring of Construction on Archaeological Sites by Appropriate Experts. Require that new development on sites identified as archaeologically sensitive include on-site monitoring by a qualified archaeologist(s) and appropriate Native American consultant(s) of all grading, excavation, and site preparation that involves earth moving. Provide mitigation measures if significant resources are discovered.

Reflects California Coastal Commission Suggested Modifications to Marin County LCP Amendment (May 2014). Subject to change

HISTORIC & ARCHEOLOGICAL RESOURCES

Historic Resources

Historic sites are irreplaceable resources and may be used to interpret stories about past events, people, industries, and/or movements. Many historic buildings serve as commercial centers, supporting local businesses and integral to community fabric and character. Some historic sites have spiritual, or intrinsic importance valued by current and past residents.

Marin County's Local Coastal Program Historic Study (1981)⁶⁶, identifies historic districts based on architectural styles of pre-1930 structures. Communities' characters have changed little since, and this study can serve as a basis for a historic resources vulnerability assessment. However, it is difficult to fully assess historic resource vulnerabilities as other sites more recently could qualify as historic based on age (50+ years), or uniqueness beyond architecture (e.g., industry, government, settlement, etc.). If local interest/resources exist, an updated study could document additional vulnerable historic sites before they are negatively impacted by sea level rise.

Table 33 lists some of the potentially vulnerable historic assets related assets in the study area. This list measures onset and tidal mean higher high water (MHHW) and extreme event flood depth. This list is not exhaustive of all the historic assets that could be exposed to sea level rise and storm impacts in the study area.

Historic Sites

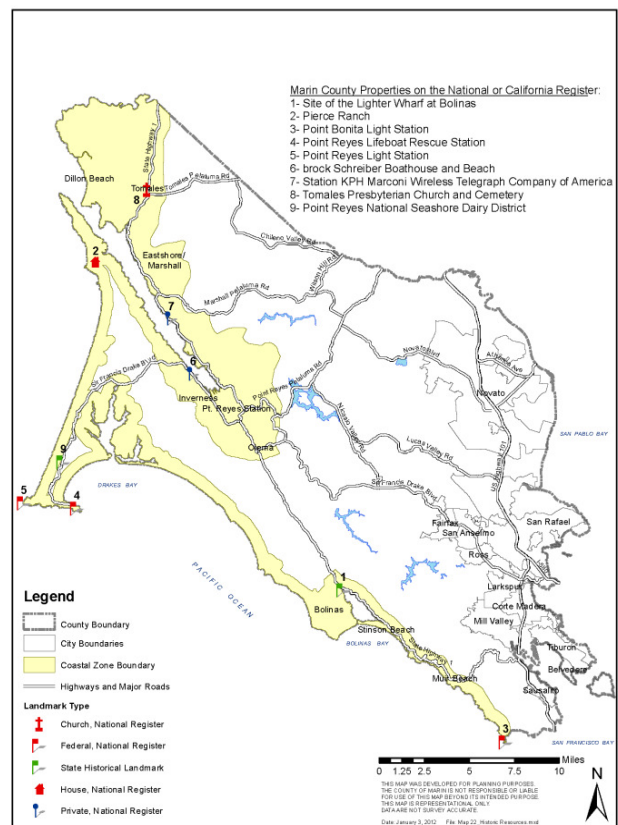
Map 56 depicts designated historic sites in West Marin. Several sites lie on federal land, and therefore not within the purview of this assessment. Two sites within the Study Area are exposed to the sea level rise and storm scenarios:

- *The Brock Schreiber Boathouse and Beach-National Register of Historic Places, Private.*
The boathouse lies within the Inverness Historic District, was built in 1913, and its significance lies in being one of the few surviving reminders of a time when row-boating was a major recreational activity.⁶⁷ The site falls directly on Tomales Bay, and

is therefore considered vulnerable in the near-term and has already sustained severed wave damage from a December 2014 storm.

- *Site of Lighter Wharf in Bolinas State Historic Landmark.* The Lighter Wharf was built in the 1850s to load lumber for transport to deeper water near the channel, where it was transferred to seagoing vessels for shipment to San Francisco. While it was significant in supporting Bolinas's historic lumber industry, the wharf decayed long ago, and no interpretive/commemorative marker exists.⁶⁸ The site is exposed, even at the baseline scenario, and more of the surrounding area will become permanently inundated as the seas continue to rise.

Map 56. Historic Resources



Credit: Marin County Local Coastal Program Land Use Plan Proposed Amendments, 2013

⁶⁶ Duthie, j. Williams, C., Bonos, N., Curry, D. Nov. 1981. *Marin County Historic Study*. Marin County Local Coastal Program.

⁶⁷ NoeHill Travels in California. *National Register Sites in Marin County*. <http://noehill.com/marin/nat1978000702.asp>. Accessed July 29, 2015.

⁶⁸ NoeHill Travels in California. *California Historical Landmarks in Marin County*. <http://noehill.com/marin/cal0221.asp>. Accessed July 29, 2015

HISTORIC & ARCHEOLOGICAL RESOURCES

Table 33. Historic Assets Ranked by Onset and Flood Depth (feet and inches)

Community	Asset (not exhaustive)	Tidal & Extreme Event Flooding Depth Estimates (Underlined values indicate tidal flooding at mean higher high water (MHHW) based on one geographic point placed at the landward limit of the first scenario where it overlaps the asset. Values not underlined represent temporary flooding.)					Vulnerability TF: Temp. Flooding during extreme events; I: Inundated at MHHW; E: Erosion
		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	
		Inverness	Brock Schreiber Boathouse	<u>2'7"</u>	<u>3'6"</u>	<u>4'</u>	
Bolinas	Historic District		3'10"	4'8"	<u>6'4"</u>	<u>10'</u>	I, E
Bolinas	Bolinas Super Market			8"	<u>2'6"</u>	<u>6'1"</u>	I, E, SI
East Shore	Historic District				<u>2'5"</u>	<u>4'5"</u>	I
Inverness	Historic District				<u>2'1"</u>	<u>5'1"</u>	TF
Bolinas	Church: Calvary Presbyterian					<u>5'10"</u>	I, TF
Inverness	Inverness Post Office					<u>3'7"</u>	TF, I, E

Source: Marin Map, OCOF Exposure and Flood Depth data, Asset Manager Interviews

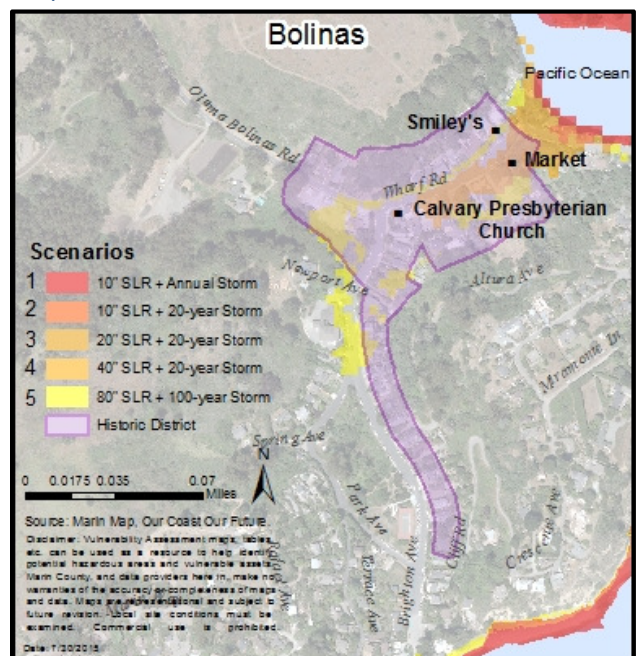
Historic Districts

The Local Coastal Program’s Marin County Historic Study delineated historic districts based on architectural styles; including Greek Revival, Italianate, Queen Anne, Shingle Style, Mission Revival, Western Stick Style, and California Bungalow. Of the seven study area communities, three historic districts (Bolinas, Inverness, and Marshall) may be exposed to sea level rise and increased storm impacts.

- ### Bolinas Historic District

Bolinas’s original ranch was established in 1837 as part of the Baulenes Mexican land grant. Once the original settler’s brother-in-law acquired property ownership, it became a logging operation with lumber shipped to San Francisco. By 1850, Bolinas was a large logging town, followed by dairy ranching once logging operations ceased. More settlers came to the area by stagecoach, and in the 1880’s summer homes were built. Historic structures vulnerable to sea level rise, all under mid to long term scenarios, include: the Bolinas Market, Smileys, and the Calvary Presbyterian Church.

Map 57. Bolinas Historic District



- ### Inverness Historic District

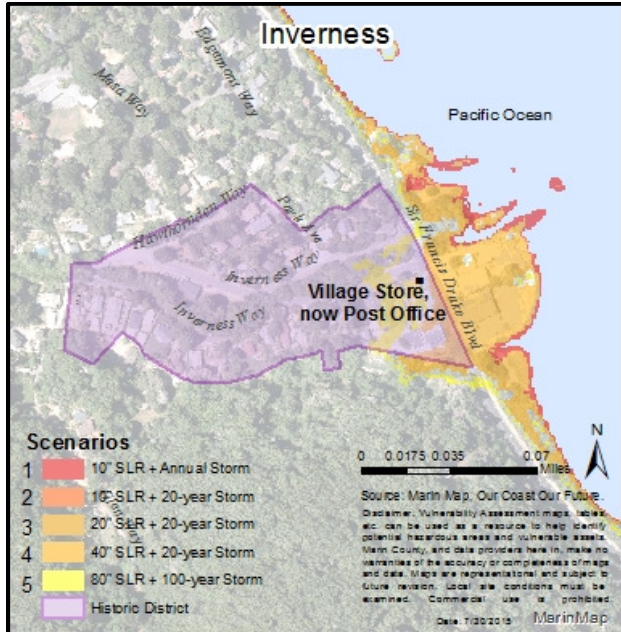
Inverness began as a planned subdivision of small lots intended for the wealthy founded by Superior Court Judge James McMillan Shafter in 1889. This would later become Inverness Ridge. Because of family ties to UC Berkeley, students prepared Marin County’s first master plan in 1949. Inverness’s post office in a building on one of the district’s two historic sites vulnerable

HISTORIC & ARCHEOLOGICAL RESOURCES

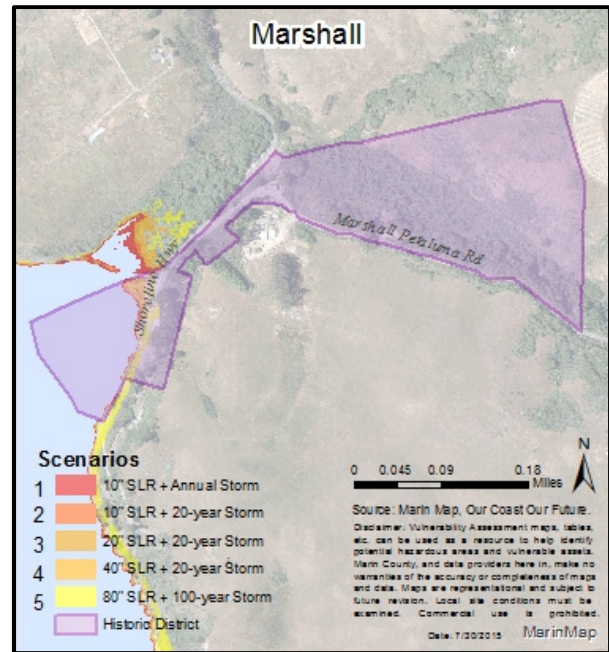
to long-term sea level rise. The Brock Schreiber Boathouse is the other vulnerable historic site and could be impacted at near-term scenarios.

district is particularly unique because of its sensitive siting of the strip of land between the Tomales Bay and Highway 1.

Map 58. Inverness Historic District



Map 59. Marshall Historic District



- Marshall Historic District**
 Marshall was primarily a fishing and dairy ranching community, named after four brothers from Ireland in the early 1860's, and was an important shipping center during the railroad days. Marshall's historic

Existing Policies

The Marin County Draft Local Coastal Program (DLCP) provides for protection of key Coastal Zone resources that reflect the legacy of the past. In furtherance of this goal, DLCP policies protect historic buildings and ensure that new development will be compatible with the existing character of the surrounding community (see [Figure 15](#)).

Figure 15. Marin County DLCP Historical Resources Policies

C-HAR-4 Structures of Special Character and Visitor Appeal. Preserve and restore structures with special character and visitor appeal in coastal communities.

C-HAR-6 Alterations and Additions to Structures of Special Character and Visitor Appeal. Require a coastal permit for substantial alterations or additions to any structure built prior to 1930 that would otherwise be exempt from a coastal permit, except for (a) maintenance or repair to any pre-1930's structure consistent with its original architectural character and (b) maintenance or repair that includes replacement-in-kind of building components.

C-HAR-7 Proposed Demolition of Structures of Special Character and Visitor Appeal. Review the proposed demolition of any structure built prior to 1930 for its impacts on community character.

C-HAR-8 Village Areas with Special Character and Visitor Appeal. Ensure that all new development conforms in siting, scale, design, materials and texture with surrounding community character within areas having special character and visitor appeal including mapped historic areas in Stinson Beach, Bolinas, Tomales, Marshall, Point Reyes Station, Olema, and Inverness.

Reflects CCC Suggested Modifications to Marin County DLCP Amendment. Subject to change.

HISTORIC & ARCHEOLOGICAL RESOURCES

Other Considerations

Economic

Historic preservation has proven to be an effective tool for small business sustainability, community development, renewal, and revitalization, heritage tourism development, and more.⁶⁹ Some of West Marin's vulnerable historic sites house local businesses important to local economic well-being. Loss or deterioration of these resources could lead to business closure, thus having negative impacts on the local economies; or force relocation which could be financially taxing on the owner. In instances which the historic building houses a civic use (e.g., the Inverness Post Office), the loss/compromise could require public money to support relocation. Additionally, West Marin's historic districts contribute to the communities' unique charm and character, adding to their appeal as tourism hubs, thus assisting with economic development through increased visitor spending and sales tax.

In the case of Marshall, historic buildings adjacent to Tomales Bay have the co-benefit of coastal armoring to protect State Highway 1 and other assets to the East. The loss or deterioration of these structures could therefore lead to increased flooding of the roadway causing costly repairs, maintenance, relocation, etc.

Environmental

In addition to valuable information on cultural history, some archaeological sites are valuable information sources on natural history, which may be of increased importance as global temperatures rise. Through analysis of elements such as pollen, seeds, shells, and bones, archaeological data can reveal which plants and animals thrived during past climactic periods (e.g., the mid Holocene) with land and water temperatures comparable to potential future conditions with climate changes, including secondary impacts such as increased ocean acidification.⁷⁰ Such data could be of great value to inform future ecosystem restoration and management plans.

Building reuse is almost always less taxing on the environment than new construction, and it can take decades for moderately more energy efficient new buildings to overcome climate change impacts from the construction process than average performing

existing buildings.⁷¹ Materials production/transport, building construction, and demolition waste disposal are all components of new construction which yield environmental impacts, which could be minimized through preserving/protecting existing buildings.

Social Equity

West Marin's Archaeological sites convey information on thousands of years of Miwok Indian history and many remain sacred to the Federated Indians of Graton Rancheria for recognition/commemoration of ancestors, while still contributing to current sense of place. The loss of these irreplaceable resources could represent an unprecedented loss of history and culture, and no established processes exist to protect/mitigate for their disappearance.

Management

The loss of archaeological sites can present management challenges including the need for increased documentation and protection of certain sites, particularly those of high intrinsic value. Close coordination with the Federated Indians of Graton Rancheria is critical to ensure that adaptation strategies protect vulnerable archaeological sites. Little guidance exists to inform the challenge of protecting historic integrity and community character.

⁶⁹ Rypkema, Donovan D., 2005. *The Economics of Preservation: A Community Leader's Guide*.

⁷⁰ Newland, Michael (Sonoma State Anthropological Studies Center). 2015. Personal Communications

⁷¹ National Trust for Historic Preservation. 2011. *The Greenest Building: Quantifying the Environmental Value of Building Reuse*.