

C-SMART COMMUNITY PROFILES

MUIR BEACH

Community Profile: Muir Beach

Muir Beach, West Marin's southernmost community, is situated about 2 miles northwest of Muir Woods National Monument, along the lower portions of Redwood Creek and a ridge overlooking the Pacific Ocean. The following assets may be vulnerable:

- Bluff top homes could be impacted by erosion across all scenarios.
- Portions of Pacific Way could flood, limiting routine and emergency access for residents and visitors in the long-term.
- Emergency access through the Green Gulch Zen Center to Muir Beach public area could flood in the long-term.

Muir Beach is home to just over 300 people. The population is primarily Caucasian, with a small portion of Latino residents. They are upper-middle class with a household median income of roughly \$104,500¹ and a median age of 52.6 years.² The average household size is approximately 2.5 persons. Of the 162 homes, about 74 percent are owner-occupied.

Recently, the National Park Service completed the Redwood Creek Restoration at Muir Beach. The project objectives were to create a natural creek system, reconnect the floodplain, reduce flooding, improve access along Pacific Way, and create habitat for Coho salmon, steelhead trout, and red-legged frog.³ The beach and tidal lagoon were allowed room to migrate landward with sea level rise and the parking lot was reconfigured away from direct wave action to minimize storm surge impacts.⁴ Because this project occurred after the geographic baseline for the CoSMoS model was taken, sea level rise information may not be comparable to C-SMART scenarios. Map 60 depicts the project.

¹ U.S. Census Bureau, 2006-2010 American Community Survey, DP03.

² U.S. Census Bureau Profile of General Population and Housing Characteristics: 2010.

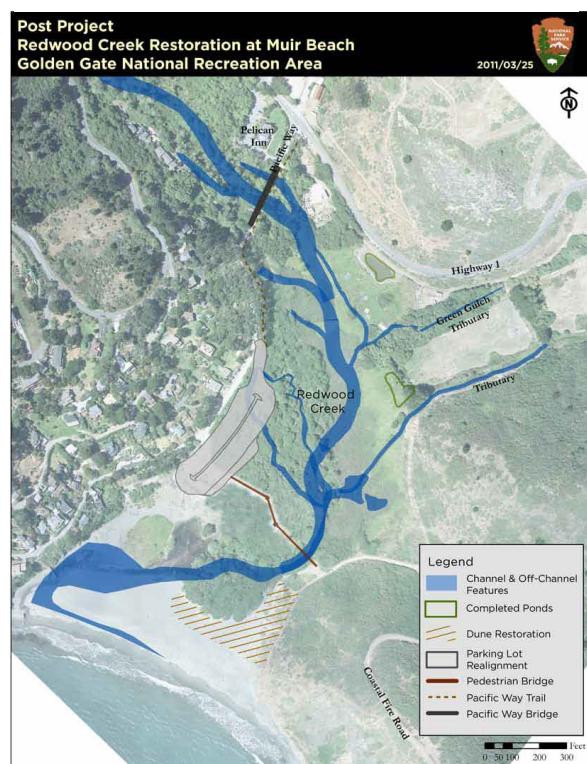
³ Redwood Creek Restoration and Muir Beach. www.nps.gov/goga/learn/nature/muir-beach.htm

⁴ Redwood Creek Restoration at Muir Beach, Frequently Asked Questions. Revised 2009.

IMPACTS AT-A-GLANCE

Beach access compromised	Property Owners MB HOA MB Fire Department
Extreme event impacts already occur	
1 business Tourism	

Map 60. Muir Beach Restoration Project



Source: NPS, 2011

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Vulnerable Assets

In the near- to medium-term, several homes are vulnerable to bluff top erosion. The most vulnerable assets in Muir Beach include portions of Pacific Way and emergency access through the Green Gulch Zen Center to the Muir Beach public area at the high end of the long-term scenario. Archaeological sites may also be present. [Table 34](#) shows the vulnerable assets in Muir Beach. [Maps 61, 62, and 63](#) at the end of this profile illustrate the developed and natural assets vulnerable to sea level rise and accelerated erosion areas.

Parcels & Buildings

The bluff wall beneath the oceanfront homes in Muir Beach could be susceptible to undercutting from strong wave activity during storms. Such damage could accelerate bluff erosion, increasing the vulnerability of oceanfront homes. An analysis was conducted using sea levels from C-SMART scenarios, revealing that just over 50 homes in Muir Beach could be vulnerable to future erosion trends.

Table 1. Muir Beach Blufftop Buildings Vulnerable to Accelerated Erosion

	Buildings
Scenarios 1&2*	12
Scenario 3*	17
Scenario 4*	49
Scenario 5*	53

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

Transportation

In the long-term, Pacific Way could be exposed from the coast to its intersection with Shoreline Highway, blocking access to the Muir Beach parking lot. This could result in fewer visitors to Muir Beach and cause complications for residents who depend on it for daily activities and emergency access.

Additionally, many Muir Beach residents and visitors use the Manzanita Interchange in Sausalito (outside the study area) for southerly access, which floods during current high tides and storms.



View south toward Muir Beach. Credit: LCP

Table 34. Muir Beach Vulnerable Assets

Asset (not exhaustive)	Tidal & Extreme Event Flooding Depth Estimates					Vulnerability TF: Temp. Flooding during extreme events; HS: Habitat Shifts:
	(Underlined values indicate tidal flooding at mean higher high water (MHHW) based on one geographic point located at the landward limit of the first scenario overlapping the asset. Values not underlined represent extreme event flooding.)					
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	
Bluff Top Buildings	X	X	X	X	X	E
Emergency Access (Green Gulch Center)					SLR + Creek Flooding	TF
Pacific Way					22"	TF
Green Gulch Creek	Water Resource					HS
Redwood Creek	Water Resource					HS

Source: Marin Map, OCOF, Asset Manager Interviews

MUIR BEACH

Utilities

Insufficient information.

Working Lands

Not vulnerable as determined in discussion with property manager.

Natural Resources

Beaches are among the most vulnerable local habitat types, susceptible to higher tide lines, flooding, erosion, and sand shift;⁵ however, the Redwood Creek restoration project created space for the beach and marsh to migrate landward. Despite this, ecosystem shifts could disturb habitats of shorebirds, wildflowers, and other species. While Redwood Creek may be able to tolerate higher water levels, some of the key species it provides habitat for, such as Coho salmon, steelhead trout, and California red-legged frog could be disturbed by increased salinity in the tidal areas and upstream.^{6,7}

Rocky intertidal habitats are vulnerable to increased salinity, flooding, erosion, wave action, and more standing water and less tidal flux. This could significantly impact species living in the zone, including the California mussel.⁸

Recreation

Based on the OCOF model results, access to the beach parking lot could be compromised at Pelican Way in the long-term scenarios.

However, it is possible that the restoration completed in 2013 could reduce the threats modeled by OCOF.



Rugged coastline near Muir Beach. Credit: CDA

Emergency Services

Emergency access through the Green Gulch Zen Center to Muir Beach public area and along Pacific Way could be compromised in the long term. Combined with creek flooding during storms, temporary disruption could occur at lower levels of sea level rise.

Fire and emergency protection is provided by the Marin County Fire Department, and the Sanitary District has a fully qualified volunteer fire department with EMT services.⁹

Historic & Archaeological Resources

Archaeological sites could be present in the exposure zones. The Sonoma State University's Anthropological Study Center is inventorying archaeological sites for much of California's

⁵ 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.

⁶ Botsford, L. and C. Lawrence. 2002. Patterns of co-variability among California Current chinook salmon, coho salmon, Dungeness crab, and physical oceanographic conditions. *Progress in Oceanography* 53 (2):283-305.

⁷ U.S. Fish and Wildlife Service. 2002. Recovery Plan for the California Red-legged Frog (*Rana aurora draytonii*). U.S. Fish and Wildlife Service, Portland, Oregon. viii + 173 pp.

⁸ 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.

⁹ Ostroff, M. 2007. The Muir Beach Community Services District Guidebook. www.muirbeachcsd.com/documents/MuirBeachGuidebook.pdf

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coastline in anticipation of sea level rise and coastal erosion.¹⁰

¹⁰ Newland, M. April 1, 2015. Sonoma State University, personal communication.

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Map 61. Muir Beach Vulnerable Developed Assets



Exposed Roads

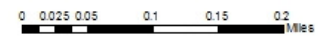
- 10" + Annual storm
- 10" + 20-year storm
- 20" + 20-year storm
- 40" + 100-year storm
- 80" + 100-year storm

* Roads may also have utility pipes underneath, are used for recreation, and serve as emergency access in some locations.

- Agricultural Parcels
- Aquaculture
- Buildings
- Parcels
- Parkland
- Historic District

- Commercial
- Education
- Emergency
- ▲ Food
- ▲ Government Service
- Historic
- Institutional
- Recreation
- Residential
- Transportation
- ▲ Utilities

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

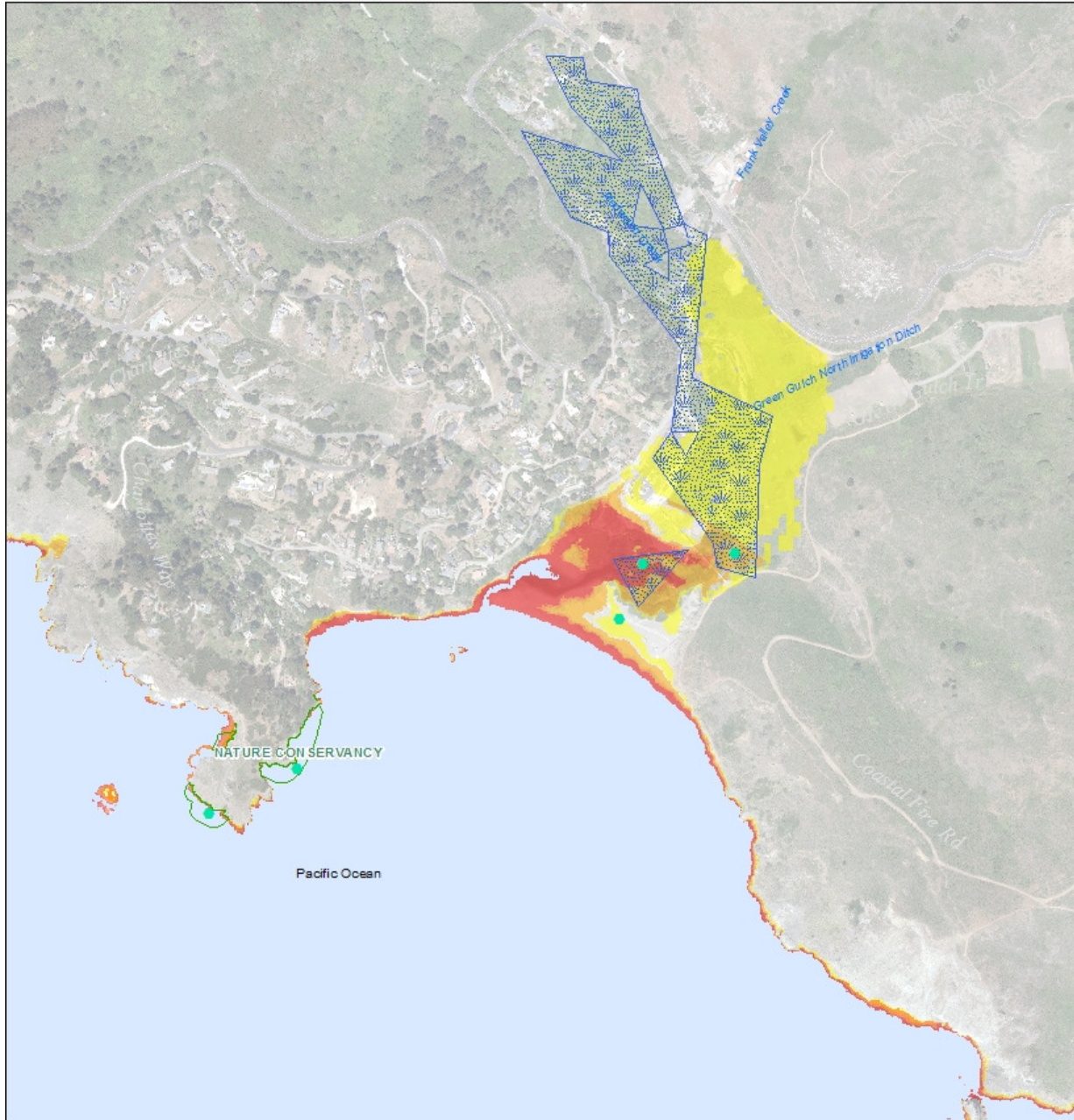


Source: Marin Map, Our Coast Our Future, CA Coastal Commission
 Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use prohibited.
 Date: 10/19/2015



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Map 62. Muir Beach Vulnerable Natural Resource Assets



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 0.03 0.06 0.12 0.18 0.24 Miles



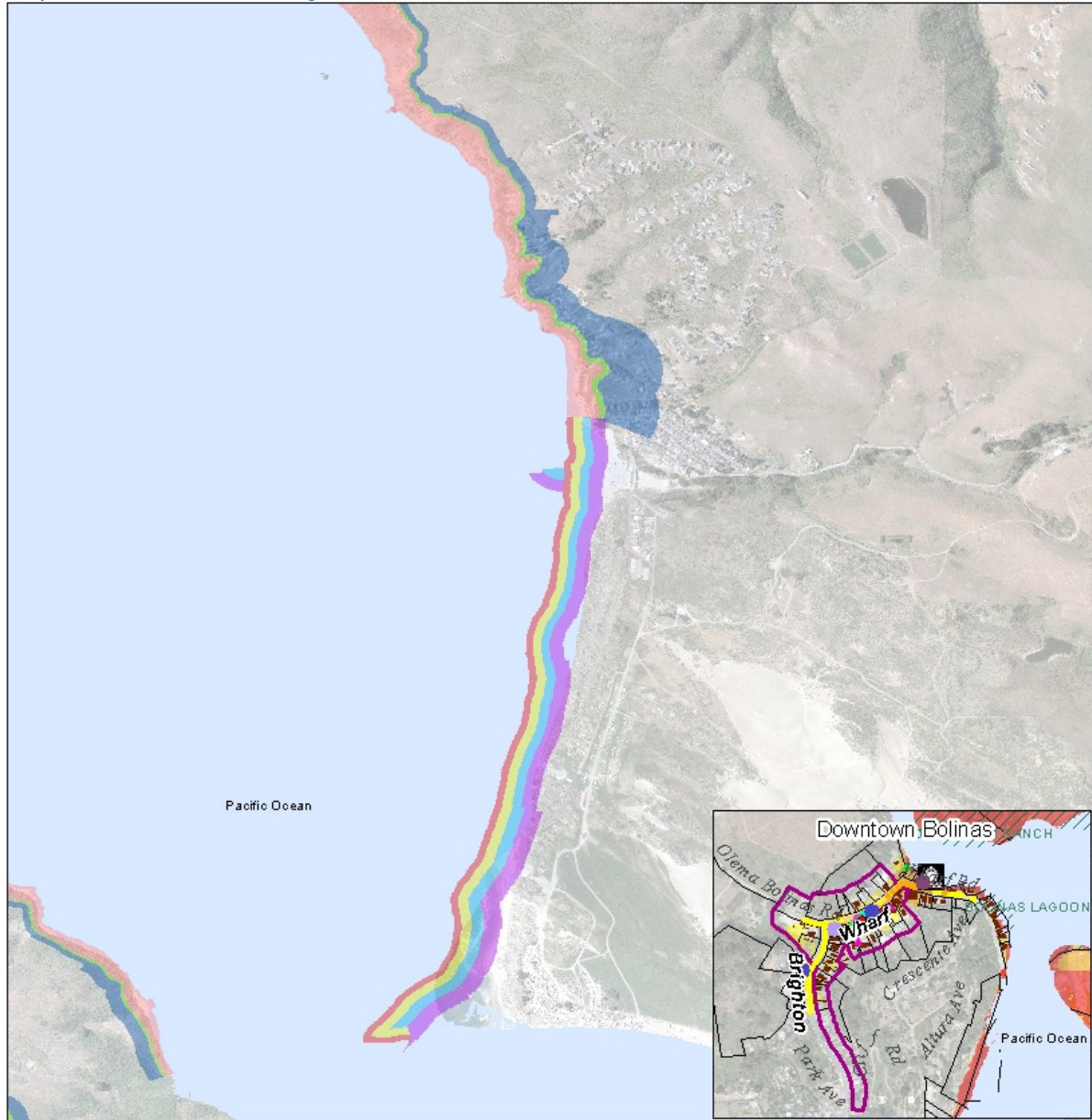
Source: Marin Map, Our Coast Our Future, Department of Fish & Wildlife
 Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness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

Date: 10/19/2015

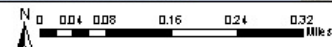


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Map 63. Muir Beach Buildings Vulnerable to Accelerated Erosion



Shoreline Erosion	Bluff Erosion
Scenarios 1 & 2	Scenarios 1 & 2
Scenario 3	Scenario 3
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 prohibited.

Date: 10/2/2015

STINSON BEACH

Community Profile: Stinson Beach

Nestled between the Pacific Ocean, Bolinas Lagoon, and Federal and State Parkland, the low-lying areas of Stinson Beach may include some of the most impacted built assets in West Marin. Key issues in Stinson Beach are:

- All homes, buildings, and facilities west of Shoreline Highway are vulnerable to storm impacts, OWTS failure, water distribution pipe failure, and flooding.
- Calle del Arroyo, a principal access road to the Calles, Patios, and Seadrift neighborhoods, is a vulnerable lynch pin asset.
- Flooding from Bolinas Lagoon and Easkoot Creek already occur and will likely worsen.
- Beach loss is likely to occur by the long-term scenarios.

Stinson Beach is a nearly 400-acre village with about half of its land area within Seadrift, a large privately managed subdivision along the sand spit.

The population of just over 630 is primarily Caucasian with a small portion of each Latino, Asian, American Indian and Alaska Native, African-American, Native Hawaiian and other Pacific Islander. The community is upper-middle class with a household income of roughly \$114,500¹¹ and a median age of 54 years old.¹² The average household size is slightly fewer than two persons. Of the 773 homes, 44 percent are occupied, with 28 percent owner-occupied,¹³ and the remaining 72 percent as rentals.

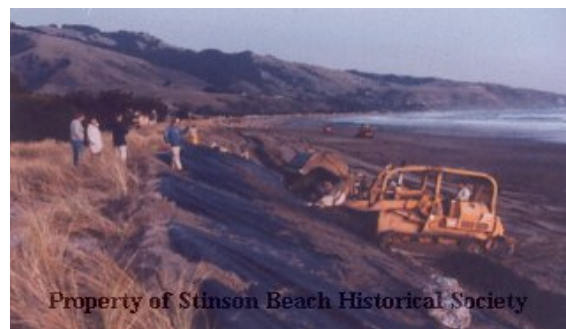
¹¹ U.S. Census Bureau, 2006-2010 American Community Survey, DP03

¹² U.S. Census Bureau Profile of General Population and Housing Characteristics: 2010

¹³ U.S. Census Bureau Profile of General Population and Housing Characteristics: 2010

IMPACTS AT-A-GLANCE

773 homes, 55 percent vacation rental	630 people
Storm and tidal impacts already occur	6 businesses
Nearly \$200 million of assessed value and \$1.5 billion in market value exposed	Residential Tourism
	Property Owners Seadrift Association SB Fire Department SB Water District County DPW



Property of Stinson Beach Historical Society

Building the Seadrift seawall. Credit: Stinson Beach Historical Society



Stinson Beach. Credit: CDA

STINSON BEACH

Vulnerable Assets

Stinson Beach's most vulnerable assets are buildings, Shoreline Highway, Calle del Arroyo and other local roads, the fire station, OWTS, water delivery systems, and the beach itself. All assets and their tidal and flood depths are presented in [Table 35](#) and described in the following sections. [Maps 67, 68, and 69](#) at the end of this profile illustrate the developed and natural assets vulnerable to sea level rise, and accelerated erosion areas.



Homes in the Stinson Beach Calles Neighborhood.
Credit: CDA

Table 35. Stinson Beach Vulnerable Assets

Asset (not exhaustive)	Tidal & Extreme Event Flooding Depth Estimates					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
	(Underlined values indicate tidal flooding at mean higher high water (MHHW) based on one geographic point located at the landward limit of the first scenario overlapping the asset. Values not underlined represent extreme event flooding. Groups of buildings are ranked by the maximum flood level. Roads received a high and low value along the line segment.)					
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	
OWTS 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					
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, ES
	underground resource					
Calle del Arroyo	<u>7"</u> - 6'11"	3" - <u>6'8"</u>	8" - <u>9'6"</u>	<u>2'5"</u> - <u>12'2"</u>	<u>5'11"</u> - <u>13'9"</u>	I, TF
Stinson/ Upton Beach	<u>4'7"</u>	<u>6'2"</u>	<u>7'5"</u>	<u>9'8"</u>	<u>14'9"</u>	I, E
Patios & 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
Seadrift Buildings	2'5"	4'11"	4'10"	<u>3'4"</u> +8'3"	<u>6'1"</u> + 5'9"	I, WT, WS, TF, E
Shoreline Hwy	0" - 1'8"	0" - 2'3"	0" - <u>3'1"</u>	0.4" - <u>4'10"</u>	0.4" - <u>8'6"</u>	I, TF
Water District Office	7"	3'3"	4'8"	6'6"	<u>8'8"</u>	TF, I
Walla Vista Walkway	3"	1'8"	2'	<u>4'4"</u>	<u>10'4"</u>	I, E
Stinson Fire Department #2		3'6"	5'3"	6'10"	<u>9'1"</u>	I, TF, WT
Coastal Trail				0.4"	1'3"	TF, E
Bolinas Lagoon	water resource					HS
Easkoot Creek	water resource					HS

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

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Parcels & Buildings

Relative to other West Marin communities, Stinson Beach has a high number of buildings exposed to sea level rise and storms. The percent of exposed buildings range from 15 percent in the near-term, to 60 percent in the high end of the long-term scenario at 80 inches of sea level rise and a 100-year storm. The most vulnerable buildings are in the Calles and Patios neighborhoods. Seadrift properties are at slightly higher elevations and protected by a rock revetment, and therefore not anticipated to be exposed to permanent inundation until the long-term scenarios. However, some properties could be exposed to storm flooding in the near- and medium-term, as storm waves combined with higher sea levels could overtop Seadrift armoring.¹⁴ [Table 36](#), [Table 37](#), and [Table 38](#) summarize parcel and building exposure, buildings by type and depth of flooding, and exposed residential and commercial parcels, respectively.

Table 36. Stinson Beach Exposed Parcels & Buildings By SLR Scenario

	Parcels	Buildings
Scenario 1	379	223
Scenario 2	590	429
Scenario 3	600	468
Scenario 4	608	589
Scenario 5	614	660

Source: OCOF, Marin Map

Most of Stinson Beach’s buildings are wood-framed. While it is unclear how many buildings are older than 30 years, newer buildings typically have drilled piles 20-30 feet deep with reinforced steel cages and concrete to connect the homes to the foundation. This feature can help homes withstand lateral forces from wind and water. However, even if buildings remain structurally intact, utility-related equipment could be vulnerable. Moreover, material and content damage from water and salt could occur, especially during storms.

Nearly 68 percent of all residential parcels in Stinson Beach could be vulnerable to 40 inches

of sea level rise and a 20-year storm (medium-term). This amounts to the near entirety of buildings west of Shoreline Highway, and the majority of buildings in the community overall. While most commercial properties are east of Shoreline Highway, the 20 percent of commercial parcels west of Shoreline Highway are all vulnerable in the near term. [Map 64](#) shows near term flood depths across lower Stinson Beach ranging from 0 to 12.6 feet.

[Table 39](#) estimates damage costs for buildings and their contents under Scenario 5, assuming every building experiences the same level of damage using FEMA tagging designations. Over \$3 million of damage could occur in the near term and over \$220 million at the high end of the long-term.

To determine how many buildings could be re-tagged under each scenario, buildings were evaluated for exposure to a combined wave velocity and flood depth significant enough to destroy them. This analysis shows that up to 582 buildings could be damaged beyond repair, destroying over \$220 million in assessed building value.

¹⁴ Erickson, L. 2015. USGS. Personal Communication.

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Table 37. Stinson Beach Building Permanent and Temporary Flood Depths
(Total number and the portion (%) of the buildings exposed in that scenario)

		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Buildings Exposed	#	223	430	466	591	660
Temporary Inundation	#	207	414	401	427	110
	%	93%	96%	86%	73%	17%
0 - 1.5 feet	#	106	184	186	114	32
	%	97%	99%	99%	93%	80%
1.5 - 3 feet	#	61	119	120	87	35
	%	92%	98%	91%	91%	56%
3 - 4.5 feet	#	35	57	61	72	22
	%	81%	97%	90%	78%	49%
4.5 - 6 feet	#	5	46	27	59	14
	%	100%	94%	84%	70%	12%
6 - 7.5 feet	#		8	7	61	4
	%		53%	18%	62%	5%
7.5 - 9 feet	#			0	25	2
	%			0%	42%	2%
9 - 10.5 feet	#				8	0
	%				22%	0%
10.5 - 12 feet	#				1	0
	%				100%	0%
12 - 13.5 feet	#					0
	%					0%
Permanent Inundation	#	16	16	65	164	549
	%	7%	4%	14%	27%	83%
0 - 1.5 feet	#	3	1	1	8	8
	%	3%	1%	1%	7%	20%
1.5 - 3 feet	#	5	3	12	9	27
	%	8%	2%	9%	9%	44%
3 - 4.5 feet	#	8	2	7	20	23
	%	19%	3%	10%	22%	51%
4.5 - 6 feet	#	0	3	5	25	105
	%	0%	6%	16%	30%	88%
6 - 7.5 feet	#		7	32	38	71
	%		47%	82%	38%	95%
7.5 - 9 feet	#			8	35	105
	%			100%	58%	98%
9 - 10.5 feet	#				29	117
	%				78%	100%
10.5 - 12 feet	#				0	80
	%				0%	100%
12 - 13.5 feet	#					14
	%					100%

Source: Marin Map, OCOF

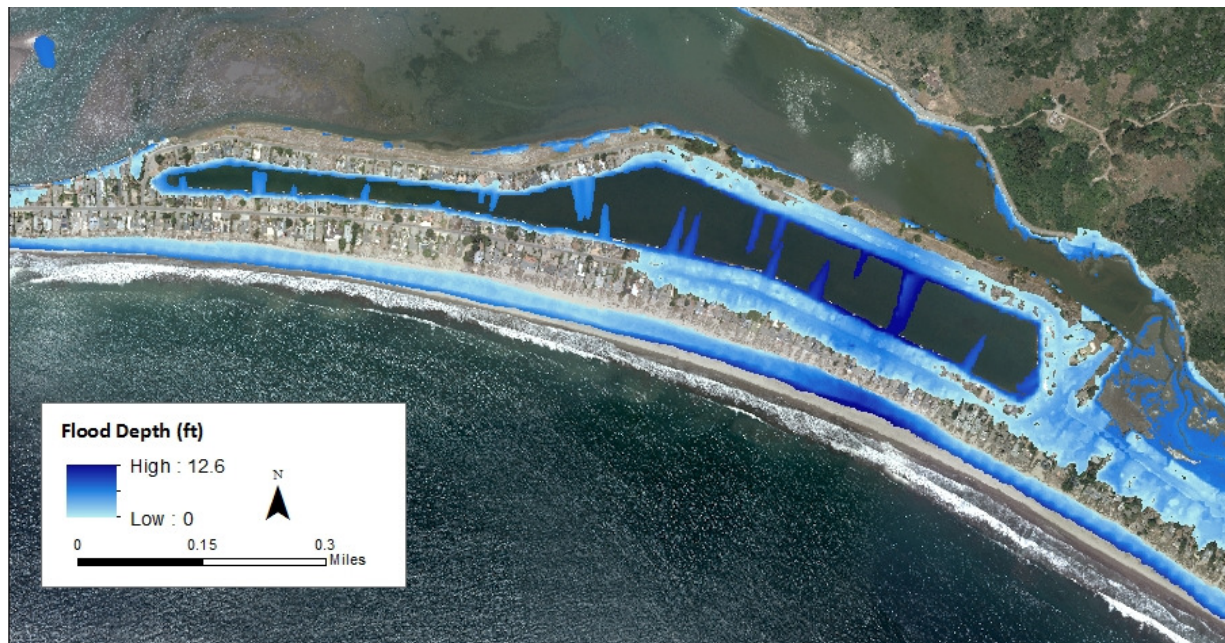
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Table 38. Stinson Beach Exposed Residential and Commercial Parcels by Scenario

Scenario 1				Scenario 3				Scenario 5			
Residential		Commercial		Residential		Commercial		Residential		Commercial	
#	%	#	%	#	%	#	%	#	%	#	%
295	36%	6	21%	556	68%	6	21%	566	69%	6	21%

Source: Parcel Layer Land Use Description 2014

Map 64. Stinson Beach at 20 inches Sea Level Rise & 20-Year Storm



Source: OCOF Flood Depth Layer

Table 39. Stinson Beach FEMA Damage Levels Applied to Buildings in Exposed in Scenario 5

Buildings	Yellow Tag-Minor (\$5,000-17,000)	Orange Tag (\$17,001+)	Red Tag-Destroyed (County assessed improvement value)
660	\$3,070,000-10,438,000	\$10,438,001+	\$220,778,456

Source: Marin Map, Assessor Data

Table 40. Stinson Beach Buildings Potentially Facing Hazardous Conditions (feet, inches)

Scenario 1		Scenario 2		Scenario 3		Scenario 4		Scenario 5		
#	%	#	%	#	%	#	%	#	%	Value*
27	2%	48	4%	89	8%	239	21%	582	51%	\$217,439,909

*Improvement Assessed Value Marin County Assessor 2014. Source: Marin Map

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Table 41. Buildings Vulnerable to Accelerated Erosion

	Buildings
Scenario 1&2*	0
Scenario 3*	5
Scenario 4*	51
Scenario 5*	284

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

The deterioration and destruction of Stinson Beach’s buildings would have devastating impacts on the local economy and sense of place. Having to rebuild or repair buildings after flood events could be traumatic and costly for local residents. Foreclosure and vacancy rates could increase, and the community’s population

could decline. Moreover, sales appeal to potential buyers could decline.

Transportation

Shoreline Highway is the only access road to Stinson Beach, and temporary or permanent flooding of this road, Calle del Arroyo, and other private Calles and Patios streets could have significant impacts on the residents and visitor-serving facilities. Without Shoreline Highway, residents who work out of the town will find it difficult to commute. Leisure travelers may be dissuaded from visiting, resulting in less economic activity. Finally, emergency services would be compromised west of Shoreline Highway.

Table 42. Stinson Beach Exposed Road Segments
(Scenarios 2-5 include roads in previous scenarios)

Scenarios 1 & 2	Scenario 3	Scenario 4	Scenario 5
Alameda Patio (Private) Calle del Arroyo (County) Calle del Embarcadero (Private) Calle del Occidente (Private) Calle del Onda (Private) Calle del Pinos (Private) Calle del Pradero (Private) Calle del Resaca (Private) Calle del Ribera (Private) Calle del Sierra (County) Dipsea Rd. (Private) Francisco Patio (Private) Joaquin Patio (Private) Jose Patio (Private) Rafael Patio (Private) Sacramento Patio (Private) Seadrift Rd. (Private) Shoreline Hwy. (Caltrans) Sonoma Patio (Private)	McKennas Gulch Fire Rd.		

Source: Marin Map, OCOF

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Beachgoers flock to Stinson Beach. Credit: CDA

Utilities

The underground water distribution pipes west of Shoreline Highway are vulnerable to pressure caused by higher groundwater levels. Salt in the groundwater could also increase the rate of pipe corrosion. Residents' livability, visitor services, and health and safety systems could all be negatively impacted if potable water service is disrupted for extended periods of time.

Several Stinson Beach homes use gravity-fed underground OWTS that could be significantly compromised when inundated. Older systems are prone to malfunction during high waters and could release contaminants into the ocean. According to the water district, about 20 older systems are replaced every year with systems that stop releasing effluent when water levels are high. However, all underground systems are vulnerable during power outages.

The Stinson Beach County Water District (SBCWD) provides water service and manages sewer and garbage disposal services for the community. SBCWD's 718 metered water connections include residential, commercial, and federal and state recreation uses. Development also relies on individual on-site wastewater treatment systems (OWTSs). Currently, the SBCWD monitors 700 OWTSs.

Natural Resources

Stinson's beach habitat is vulnerable to higher tide lines, inundation, flooding, erosion, and

sand shifts. Erosion could force beach and dune areas inland. However, where development abuts the beach in the Calles, Patios, and Seadrift neighborhoods, the beach could shrink offering less room for human and wildlife activity.

Average beach widths and levels of beach loss risk are tabulated in Table 43 for current and future sea levels. Seadrift's beach is currently narrow along this rock revetment and during seasonal fluctuations and coastal storm events the dry beach can completely disappear. This stretch of beach is vulnerable because it is armored and unable to migrate inland.

The rest of Stinson Beach is backed by a mix of individually armored homes, other beachfront structures, and dunes. This area is typically wider than Seadrift and has a lower vulnerability in the near-term, though the risk of beach loss increases at higher sea levels.

Table 43. Stinson Beach Beach Width and Vulnerability

	Width (meters) & Vulnerability				
	Base line	Scen 1 & 2	Scen 3	Scen 4	Scen 5
Stinson Beach	53	48	32	9	2
	Low	Low	Low	Med	High
Seadrift Beach	38	29	14	0	0
	Low	Low	Med	High	High

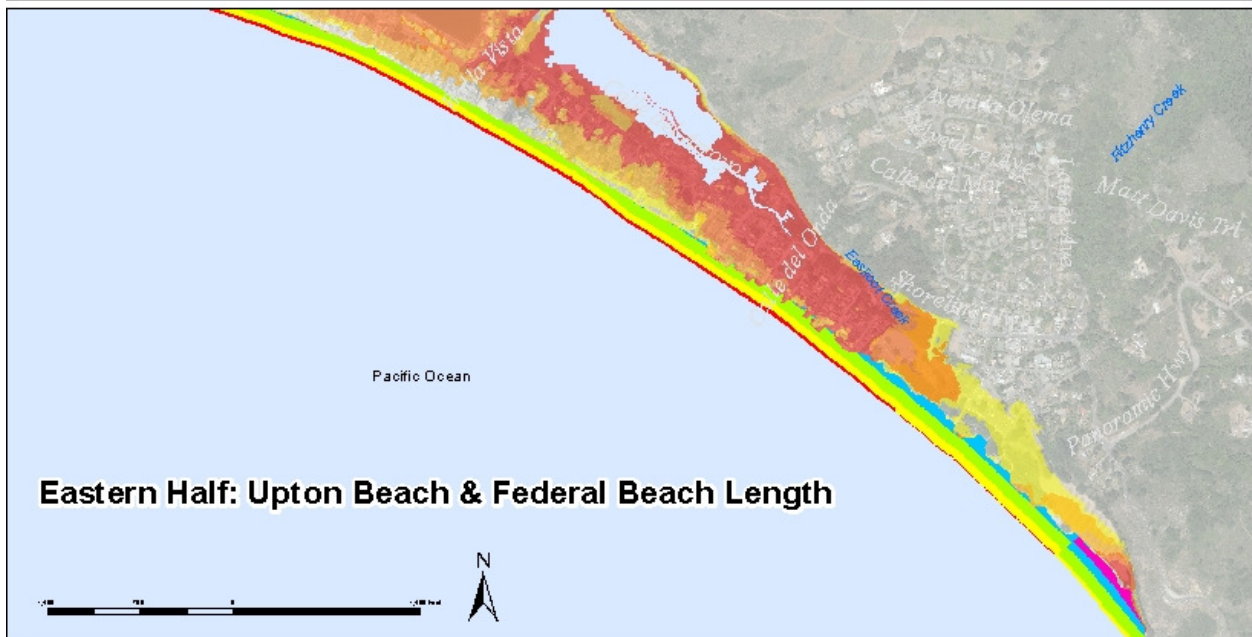
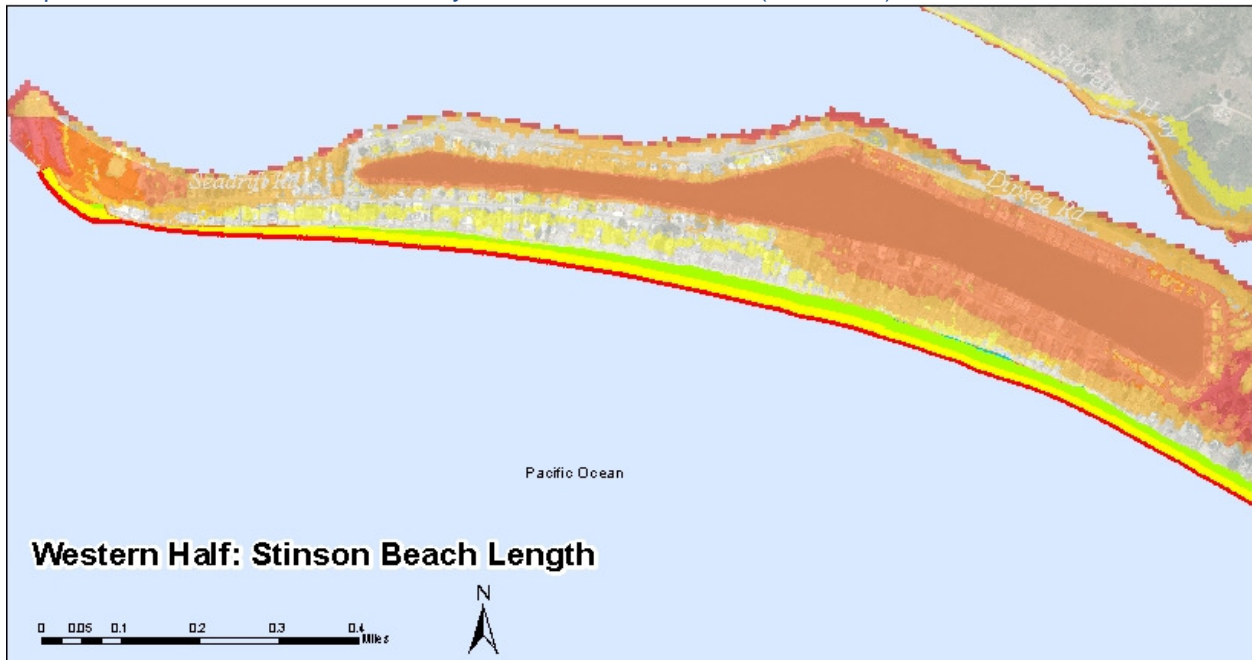
Source: ESA 2015, OCOF



Stinson Beach Seadrift neighborhood. March. 25, 2015. Credit: CDA.

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Map 65. Stinson Beach Beach Loss by Sea Level Rise Amount (no storms)



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, Off Coast Oil Field, 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 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: 9/1/2015



STINSON BEACH

According to the *Stinson Beach Watershed Program Flood Study and Alternative Assessment*, Easkoot Creek once flowed southerly into the ocean, and was altered northerly through NPS parkland to Bolinas Lagoon.¹⁵ The creek is prone to overflowing its banks; for example, in February 2014 a storm eroded the northwest stream bank. [Table 44](#) and [Map 66](#) show the results of the Flood Study's assessment of the area and buildings flooded for stimulated events.

Table 44. Easkoot Creek Storm and Sea Level Rise Impacts

Event	# of Flooded Buildings
2-yr	2
10-yr	34
100-yr	59
Jan. 2008	16
Dec. 2005	45
Dec. 2005 MHHW	24
Dec. 2005 MHHW + 2050 Sea Level Rise	27

Source: Stinson Beach Watershed Program *Flood Study and Alternative Assessment*. O'Connor Environmental Inc.

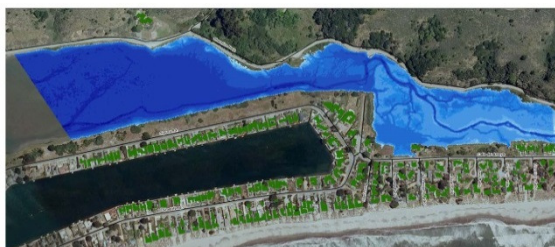
Map 66. Easkoot Creek Flood Extent Under Storm and Downstream Sea level Rise in Bolinas Lagoon Scenarios (no direct coastal flooding)



Maximum inundation depths, December 2005 (lower)



Maximum inundation depths, December 2005 (upper)



Maximum inundation depths 100-yr event (lower)



Maximum inundation depths, 100-yr event (upper)



Maximum inundation depths, 200-yr event (lower)



Maximum inundation depths, 200-yr event (upper)

¹⁵ Marin County Department of Public Works. 2014. Stinson Beach Watershed Program Flood Study and Alternatives Assessment

STINSON BEACH

Recreation

Stinson Beach is a popular recreational destination, and visitors can easily exceed 10,000 persons on a summer weekend. As discussed in the Natural Resources section, most of the beach area could be lost. This loss could have negative effects on the sense of place and local economy. The portion of Stinson Beach that falls within the Golden Gate National Recreation Area is federal land outside of the County (and C-SMART) jurisdiction. The National Park Service's [Adapting to Climate Change in Coastal Parks: Estimating the Exposure of Park Assets to 1 m of Sea-Level Rise](#),¹⁶ estimated over \$3 million in current replacement value for Stinson Beach's sand area, bridge and north parking lot. Additionally, the vulnerable portion of the California Coastal Trail that runs through the GGNRA property is vulnerable in its current path in the long term.

Emergency Services

Stinson Beach Fire Station No. 2 could face nuisance and structurally damaging flooding in the near- to medium-term. Emergency access to residents in the Calles, Patios, and Seadrift neighborhoods could be compromised. The loss or compromised function of tsunami evacuation routes along Shoreline Highway and Calle del Arroyo would be detrimental to the community's safety.

Historic & Archaeological Resources

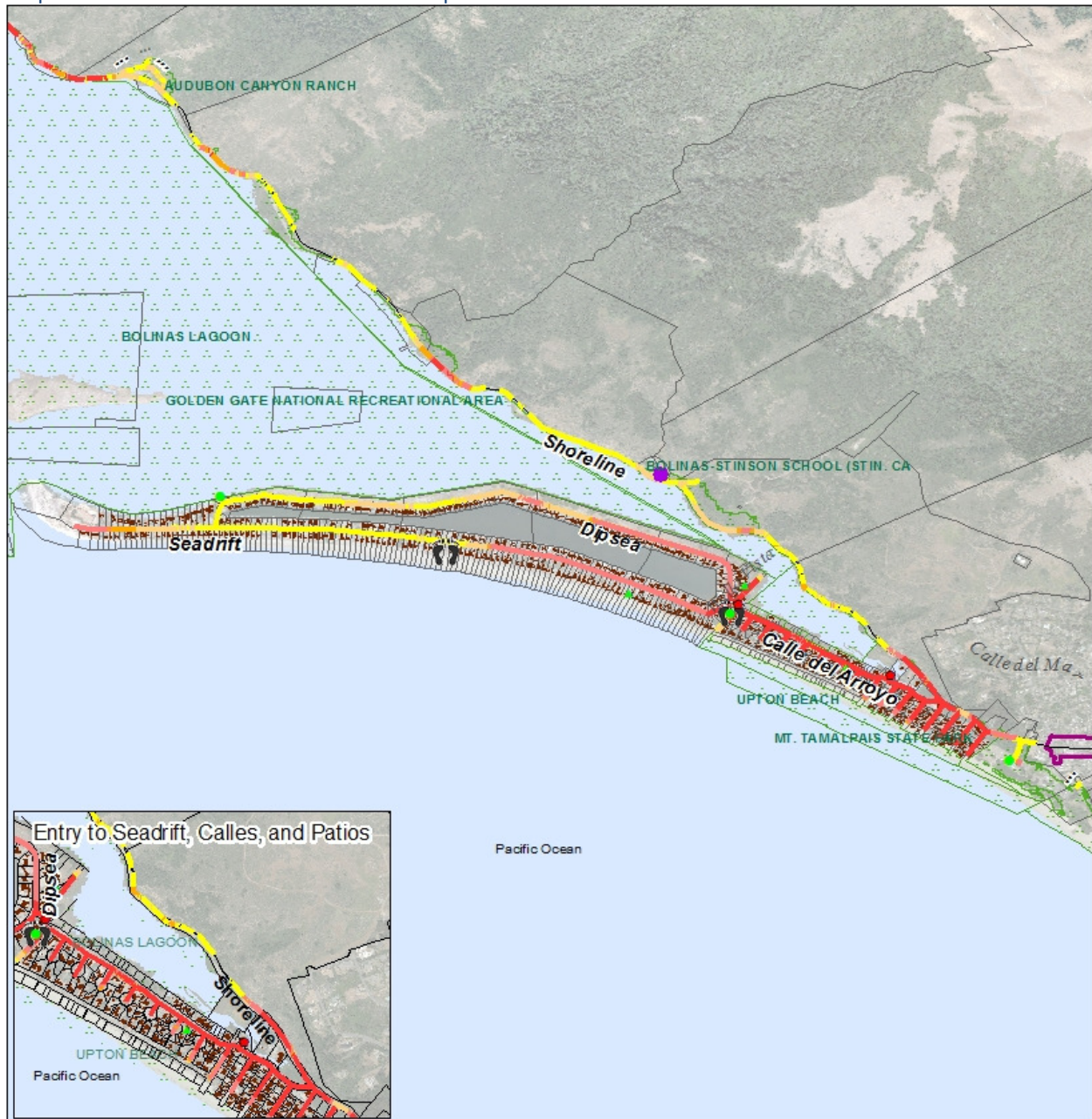
Archaeological sites could be vulnerable to sea level rise, storms, and erosion.¹⁷

¹⁶ 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.

¹⁷ Newland, M. April 1, 2015. Sonoma State University, personal communication.

STINSON BEACH

Map 67. Stinson Beach Vulnerable Developed Assets



Exposed Roads

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

- Agricultural Parcels
- Aquaculture
- Buildings
- Parcels
- Parkland
- Historic District

- Commercial
- Education
- Emergency
- Food
- Government Service
- Historic
- Institutional
- Recreation
- Residential
- Transportation
- Utilities

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

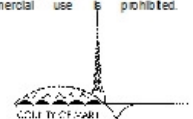
* Roads may also have utility pipes underneath, are used for recreation, and serve as emergency access in some locations.

0 0.05 0.1 0.2 0.3 0.4 Miles

Source: Marin Map, Our Coast Our Future, CA Coastal Commission

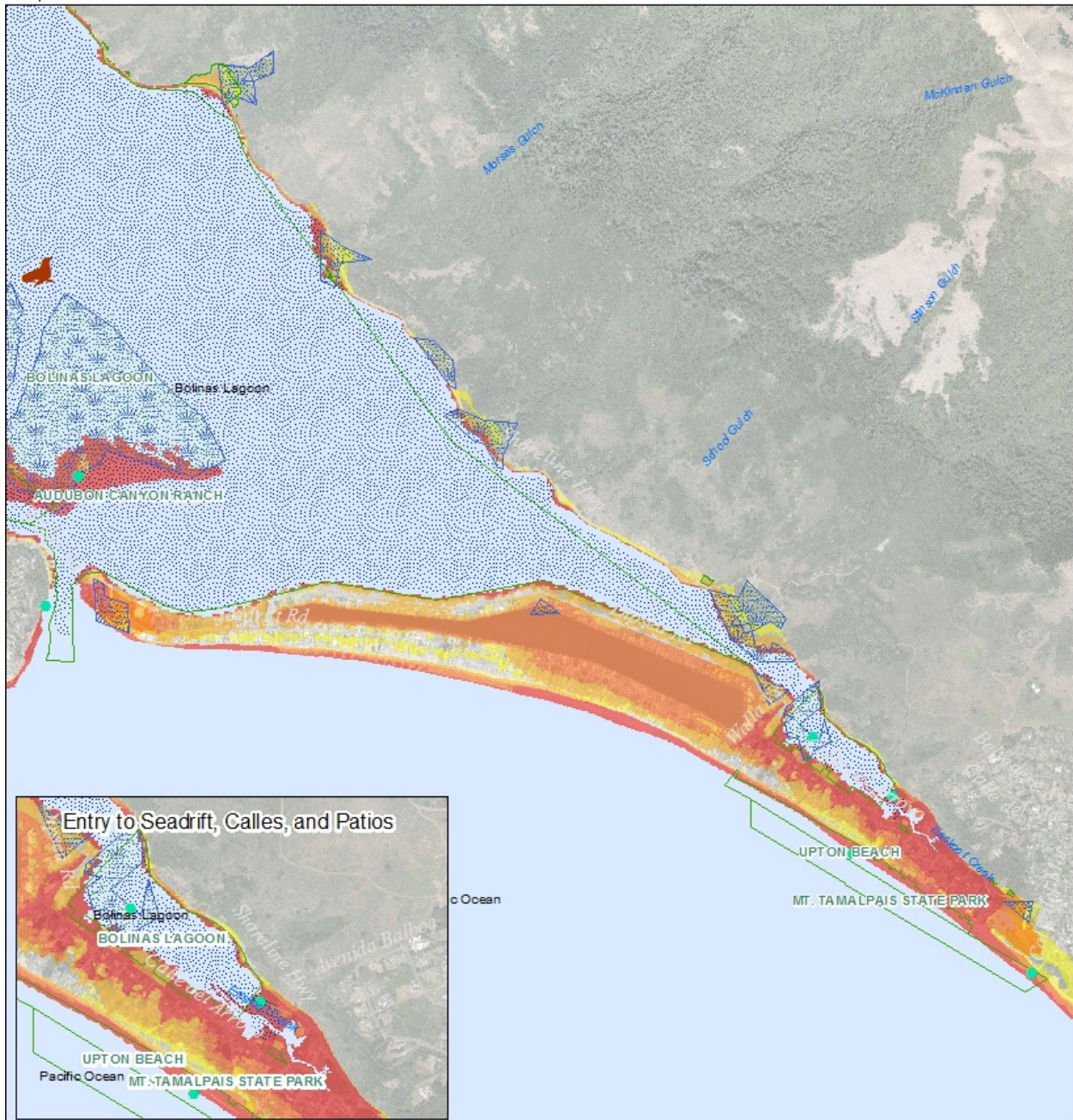
Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future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

Date: 10/19/2015



STINSON BEACH

Map 68. Stinson Beach Vulnerable Natural Resource Assets



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 0.075 0.15 0.3 0.45 0.6 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: 10/19/2015



BOLINAS

Community Profile: Bolinas

Bolinas is a unique coastal community, known for its mesas, lagoon, beaches and historic area. Bolinas is completely west of the San Andreas Fault, and is a relatively self-contained community with respect to public services. Key sea level rise vulnerability issues include:

- Downtown buildings and roads could be vulnerable during high tide and storm combinations in the near term.
- Increased bluff erosion potential as more intense storms and wave action reach new heights.
- Beaches trapped by armoring and development could disappear.
- Sea level rise and erosion could significantly impact sewage collection and water distribution systems in the downtown and Little Mesa neighborhoods.
- Only one access road to the community exists. If the Olema-Bolinas Road or its bridges are compromised for extended periods of time, Bolinas residents will be isolated.

Bolinas covers approximately 3,800 acres with development in four neighborhoods: the historic downtown, Little Mesa, Big Mesa and Gospel Flats. In 2010, the community was home to 1,620 people. The population was mostly Caucasian, with a moderate Latino population, and small portions of African-American, American Indian and Alaska Native, Asian, and Native Hawaiian and other Pacific Islander residents.¹⁸ The median age was 49 years.¹⁹ The average household size was approximately 2 persons. Of the 698 homes, 71 percent are owner-occupied and 29 percent are rentals, most of which are vacation rentals.²⁰

Vulnerable Assets

The assets most vulnerable to sea level rise and storms in Bolinas are Shoreline Highway, Bolinas-Olema Road, Gospel Flats homes, downtown Bolinas, and eroding cliffs on the Big and Little Mesas. The following sections detail these vulnerabilities and others presented in [Table 45](#), [Maps 71, 72, and 73](#) at the end of this profile illustrate developed assets vulnerable to sea level

rise, natural assets vulnerable to sea level rise, and buildings and roads vulnerable to accelerated erosion, respectively.

IMPACTS AT-A-GLANCE

98 buildings		1,620 people
Storm and tidal impacts already occur		12 businesses
18 million worth of assets exposed	Residential, crabbing, tourism	Property Owners BPUD County Public Works



Bolinas Lagoon. Credit: CDA

¹⁸ U.S. Census Bureau Profile of General Population and Housing Characteristics: 2010

¹⁹ Ibid.

²⁰ Ibid.

BOLINAS

Table 45. Bolinas Vulnerable Assets

Asset (not exhaustive)	Tidal & Extreme Event Flooding Depth Estimates					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
	<p><u>Underlined values</u> indicate tidal flooding at mean higher high water (MHHW) based on one geographic point located at the landward limit of the first scenario where it overlaps the asset. Values not underlined represent extreme event flooding. A maximum value is provided for groups of buildings. Roads received a high, used for ranking, and low value along the line segment.</p>					
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	
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
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
Wharf Road	6" - 2'1"	3" - 2'4"	2" - 2'9"	1" - 5'4"	<u>10" - 7'4"</u>	I, TF
Agate Beach	2'1"	1'11"	2'8"	4'8"	<u>9'3"</u>	I
Shoreline Hwy	0" - 1'8"	0" - 2'3"	0" - <u>3'1"</u>	0.4" - <u>4'10"</u>	0.4" - <u>8'6"</u>	I, TF
Historic District		3'10"	4'8"	<u>6'4"</u>	<u>10'</u>	I, E
Bluff Top Buildings	X	X	X	<u>X</u>	<u>X</u>	E
Sewage Lift Station			3'3"	<u>5'</u>	<u>8'7"</u>	TF, I
Olema-Bolinas Road			2'8"	<u>4" - 4'4"</u>	<u>2" - 7'11"</u>	I, TF
Bolinas Super Market			8"	<u>2'6"</u>	<u>6'1"</u>	I, E, SI
Bolinas Library				1'8"	<u>5'3"</u>	I, TF
Bo-Gas Station				1'7"	<u>5'3"</u>	I
Gospel Flats				1'7"	<u>5'3"</u>	I, WT, SI, TF
Community Center Emergency Shelter				1'7"	<u>5'2"</u>	I, E
Community Land Trust Housing				1'2"	<u>4'10"</u>	I
Church: Calvary Presbyterian					<u>5'10"</u>	I, TF
Bob Stewart Trail					<u>4'8"</u>	I, TF
Bolinas People's Store					<u>3'</u>	I, TF
Bolinas Post Office Buildings					2'9"	TF, I
Bolinas Stinson School					2'2"	I, TF, E, WS
Bolinas Lagoon	water resource					HS
Pine Gulch Creek	water resource					HS

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

BOLINAS

Parcels & Buildings

The most vulnerable buildings are those directly above the tidal marshlands on piers along Wharf Road. Current high tides reach the top of the bulkheads reinforcing the shoreline and Wharf Road.

Compared to other West Marin communities, Bolinas has a relatively high number of threatened properties. Overall, 57 parcels and 110 buildings could be exposed in the long-term, including the lift station, which would impact tens of other homes. Without armoring, eroding cliffs could undermine several additional homes on the mesa over the coming decades.

Several historic properties are vulnerable, including the Bolinas Stinson School and District Office and Smiley's Schooner Saloon & Hotel. Other vulnerable properties include Gospel Flats homes and farms, the Bolinas Community Center and Library, Bo-Gas Station, Community Land Trust Housing, Bolinas People's Store, Bolinas Post Office, and other locations in downtown Bolinas. [Table 47](#) organizes the exposed buildings by flood type and depth for the C-SMART scenarios.

Table 46. Bolinas Exposed Parcels & Buildings by Scenario

	Parcels	Buildings
Scenario 1	69	13
Scenario 2	73	16
Scenario 3	81	24
Scenario 4	91	30
Scenario 5	127	98

Source: Marin Map, OCOF



Bolinas Library. Credit: B. White

Table 47. Bolinas Temporary and Daily Tidal Flooding Depth Estimates for Building Footprints (Total number and the portion of the buildings exposed in that scenario)

		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Buildings Exposed	#	13	16	24	30	98
Temporary Flooding	#	5	8	24	6	17
	%	38%	50%	100%	20%	17%
0 - 1.5 feet	#	3	2	16	6	4
	%	33%	25%	100%	50%	44%
1.5 - 3 feet	#	1	4	2	1	12
	%	50%	100%	100%	13%	57%
3 - 4.5 feet	#	1	2	5	0	1
	%	50%	50%	100%	0%	3%
4.5 - 6 feet	#			1	0	0
	%			100%	0%	0%
Permanent Inundation	#	8	8	0	24	81
	%	62%	50%		80%	83%
0 - 1.5 feet	#	6	6	0	6	5
	%	67%	75%		50%	56%
1.5 - 3 feet	#	1	0	0	7	9

BOLINAS

		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
3 - 4.5 feet	%	50%			88%	43%
	#	1	2	0	4	34
4.5 - 6 feet	%	50%	50%		100%	97%
	#			0	5	16
6 - 7.5 feet	%				100%	100%
	#				1	9
7.5 - 9 feet	%				100%	100%
	#					7
9 - 10.5 feet	%					100%
	#					1

Source: Marin Map, OCOF

Table 48. Bolinas Exposed Residential and Commercial Parcels

Scenario 1				Scenario 3				Scenario 5			
Residential		Commercial		Residential		Commercial		Residential		Commercial	
#	%	#	%	#	%	#	%	#	%	#	%
27	2%	1	7%	53	5%	4	27%	94	8%	13	87%

Source: Marin Map Parcel Layer Land Use Description 2014

Table 48 shows that up to 90 percent of commercial parcels in Bolinas could be vulnerable, the majority of which are located in downtown Bolinas. Because most of the town's housing is located on the Big and Little Mesas, less than 10 percent of the residential buildings are vulnerable to temporary and permanent flooding.

Applying the FEMA damage tagging levels described in the Parcels & Buildings Profile reveals that minor damage could add to \$490,000-1,660,000, assuming every building exposed in Scenario 5 experiences the same amount of damage.²¹ If total destruction were to occur for each exposed building, over \$23 million in assessed building value²² could be lost. These figures are summarized in Table 49.

Buildings were also assessed for their potential to see storm forces strong enough to destroy them and lead to a red-tag. This revealed that all 98 buildings

exposed to sea level rise and storms could face destructive conditions. See Table 50. In addition, over two hundred buildings could see heightened erosion threats on the Big and Little Mesa neighborhoods by the long-term scenarios. See Table 51.

²¹ ArcGIS. FEMA Modeling Task Force (MOTF)-Superstorm Sandy Impact Analysis. Last update June 22, 2015. <http://www.arcgis.com/home/item.html?id=307dd522499d4a44a33d7296a5da5ea0>

²² Market value is likely significantly higher than assessed value.

BOLINAS

Table 49. FEMA Damage Levels Applied to Buildings in Bolinas Exposed in Scenario 5

Buildings	Yellow Tag-Minor (\$5,000-17,000)	Orange Tag \$17,001+	Red Tag (County assessed improvement value)
98	\$490,000-1,666,000	\$1,666,001+	\$23,114,950

Source: Marin Map, OCOF

Table 50. Bolinas Buildings Potentially Facing Hazardous Conditions

Scenario 1		Scenario 2		Scenario 3		Scenario 4		Scenario 5		
#	%	#	%	#	%	#	%	#	%	Value*
3	<1%	6	<1%	15	1%	25	1%	98	5%	\$23,114,950

*Improvement Assessed Value Marin County Assessor 2014. Source: Marin Map

Table 51. Bolinas Buildings Vulnerable to Accelerated Erosion

	Buildings
Scenarios 1&2*	30
Scenario 3*	84
Scenario 4*	227
Scenario 5*	275

* This analysis does not include storms

Source: Marin Map, OCOF

Table 52. Bolinas Exposed Road Segments (Scenarios 2-5 include roads in previous scenarios)

Scenarios 1& 2	Scenario 3	Scenario 4	Scenario 5
Shoreline Hwy. (Caltrans) Warf Rd. (County)	Bolinas Wye (Caltrans)	Olema Bolinas Rd. (County) Fairfax Bolinas Rd. (County)	Brighton Ave. (County) Newport Ave. (Private) Park Ave. (County)

Source: Marin Map, OCOF

Transportation

Several roadways already experience winter and tidal flooding, especially in combination with annual storms. As sea level rises and storm severity increases, these occurrences may become more severe. Major vulnerable roadways include Shoreline Highway (State Route 1) at the Bolinas Wye to the south, Fairfax-Bolinas Road, and Olema-Bolinas Road.

The Pine Gulch Creek bridge on Bolinas-Olema Road is the first vulnerable spot along the only access point to most of Bolinas. Bridge failure would prevent access in and out of the community. If the bridge and road are out for extended periods of time, the community would have limited access to

propane, food, and gasoline. Wharf Road, the main road in the small commercial downtown, could be impacted in the near-term. Brighton and Park Avenues could see impacts in the medium- and long-term. Finally, several bluff top roads could be eroded.

Water transportation for pleasure, fishing, and crabbing is a major use of the Bolinas Wharf area. As tides sea level rises, boating opportunities may improve. However, crabbing and fishing may shift significantly.

BOLINAS



Olema-Bolinas Road, December 2014. Credit BPUD

Utilities

Some of the biggest threats are to the water and waste systems. These utilities are typically under the road or property. Electricity and telephone communications, both above and underground, are vulnerable during storms.

Changes in water elevation and pressure in the ground could greatly impact the strength and function of potable water system distribution lines. With respect to wastewater removal, the most vulnerable asset in the long-term is the lift station that serves downtown and the Little Mesa. The collection system serves 141 residential, 20 commercial, and 2 institutional properties. This service could be severely disrupted at 6 feet of sea level rise (Scenario 5). This gravity-fed system leads into a lift station that reaches 25 feet underground with access points a few feet above sea level. The mechanical components at grade are elevated about one foot. If this system were to fail or be disrupted, hundreds of Downtown and Little Mesa homes and businesses would become unlivable.

Erosion is of particular concern and several improvements to the pipe system have helped to increase the longevity of the system. Three years ago, along Terrace Avenue at Overlook Drive, the bluff dropped roughly 50 feet, taking the road and water pipes with it. The water pipes were rerouted behind homes landward of the new road. The County funded the \$1.5 million bluff stabilization

project. Additionally, BPUD elevated the water lines at “surfer’s overlook” for \$500,000, and anticipate that moving the sewer lines could cost an additional \$300,000-400,000. Homeowners on the Little Mesa also had to buy and install pump stations costing \$15,000 each.

Bolinas residents use propane services for heating and cooking. If roadways are comprised, the supply line between the residents and propane purveyors is also cut off. If significant flooding occurs, the ground-based tanks downtown may be dislodged, becoming “floating mines.”²³



BPUD lift station and backup generators. The building extends 25 feet underground. Credit: Van Belleghem

Natural Resources

Brighton and Agate beaches and the Bolinas Lagoon are highly vulnerable to sea level rise and storm impacts (see [Table 53](#)). Agate and Brighton beaches are currently, and will continue to be, subjected to tidal and storm flooding. Both beaches are against the bluff and could disappear. Brighton Beach is backed by armoring that could prevent erosion sediment supply.

If intensifying wave action erodes the base of cliffs and protective beachfronts, existing vegetation regimes could shift and impact the greater food web. Finally, major landslides onto beaches could eliminate bird, mammal, and invertebrate habitat.

²³ B. Piece. Bolinas Public Utilities District Asset Manager Interview. Feb. 2015.

BOLINAS

Table 53. Brighton and Agate Beach Future Average Widths and Vulnerability

	Base-line	Scen 1 & 2	Scen 3	Scen 4 & 5
Width (meters)	22	9	3	0
Vulnerability	Low	High	High	High

Source: ESA, 2015, OCOF

Bolinas Lagoon

Bolinas Lagoon is a tidal embayment sheltered by the Stinson Beach sand spit. The lagoon consists of approximately 1,000 acres of open shallow water, 600 acres of extensive mud, and additional acreages of sand tidal flats, ebb tide shoals, small alluvial fans, deltas, and tidal salt marsh. The water is primarily saline and connects via a tidal inlet that has remained open for 1,600 years.²⁴ Ten small seasonal drainages and the perennial Pine Gulch Creek contribute freshwater and 25 percent of the coarse alluvial sediment in the lagoon.

Adaptive capacity is generally low because the lagoon is completely surrounded by roads and development. Water and sediment exchange occur through storm drains and culverts. The lagoon also has high sedimentation that exacerbates the risk of flooding. Public and private interests have participated in several years of studies and coordination to address lagoon management.

Error! Reference source not found. shows the existing and shifting habitats in Bolinas Lagoon for each sea level associated with each C-SMART scenario. The analysis assumes the best case of 6.8 mm/year of sediment inputs. 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 likely to survive longer due to the higher rate of vertical accretion associated with deltaic processes. All other marsh areas are likely to be inundated.

shows the increasing vulnerability of marsh functions as marshes are squeezed against slopes by sea level rise. Approximately 50 percent of high marsh is expected to be lost by mid-century;

²⁴ 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.

converting to low marsh, mud and sand flats; this will increase to 80 percent loss nearing the end of the century.²⁵

The *Memorandum: Bolinas Lagoon Restoration Project Design Review Group*²⁶ provides a summary of the implications of higher sea levels:

- Accelerated sea level rise replaces the risk of excessive lagoon sedimentation and tidal prism loss as an overriding ecosystem concern. Long-term lagoon submergence is a major challenge to the lagoon’s ecosystem health and resilience.
- Sediment values can be neutral, beneficial, or adverse, depending on the location, timing, magnitude, and context. Sedimentation is an asset to evolution of the lagoon.
- The lack of space to migrate into lowlands of stream and fault valleys as sea level rises is a concern for long-term health and stability.
- The barrier sand spit and tidal inlet are essential components of its evolution in response to sea level rise. 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, can negatively affect vegetation diversity and shift salt tolerant vegetation inland, soil conditions permitting.

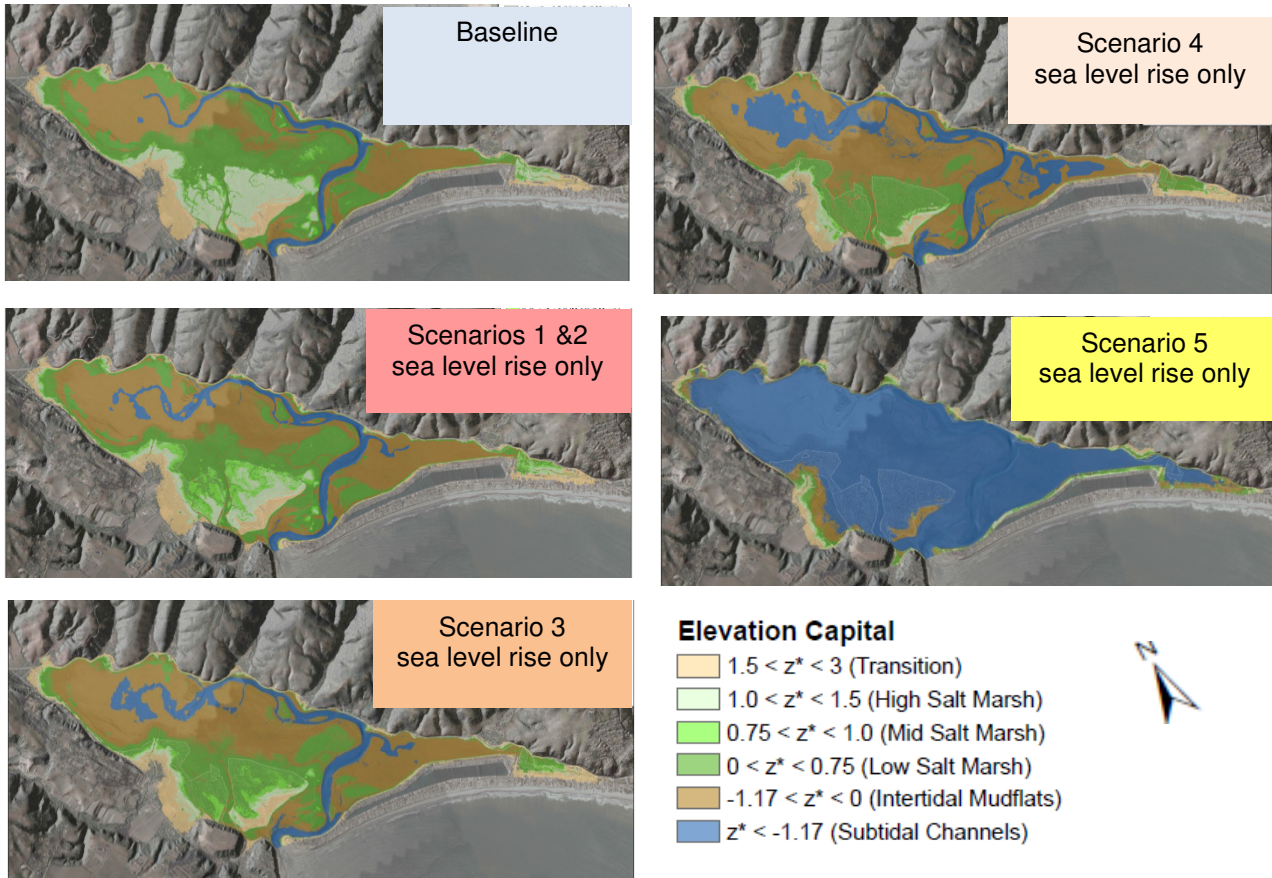


View from “Surfer’s Overlook,” Bolinas. March 25, 2015. Credit: Van Belleghem.

²⁵ 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.

²⁶ 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.

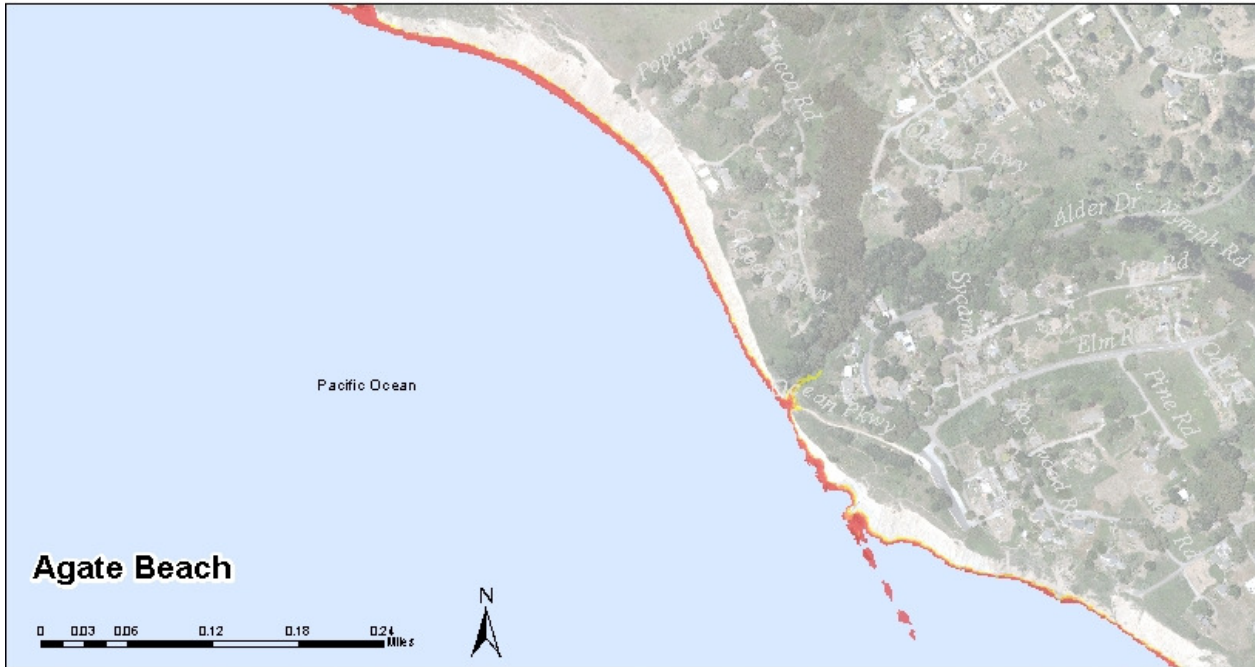
BOLINAS



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

BOLINAS

Map 69. Bolinas Beach Loss By Scenario



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, Department of FPA & Wildlife
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Date: 9/1/2015



BOLINAS

Working Lands

Permanent flooding and erosion threaten small agricultural operations in the lowlands of Gospel Flats, as protective earthen berms could give out. In the lagoon and off the coast, crabbing and other fishing activities may see a shift; or if habitat changes are significant enough, may be lost.

Recreation

If beaches are diminished and waters shift inland, beach and water recreation, such as surfing, could be severely diminished at Brighton Beach. The Bolinas County Park provides trails along the marsh that could be permanently inundated. Blocked by the road, the marshy area is prevented from migrating and could transition to unnavigable mudflat, reducing aesthetics and access. Residents and visitors use the roadway for bicycling and fishing access that could see increased water barriers. Visitors and residents use the Bob Stewart Trail that is sensitive with low adaptive capacity. Finally, the Bolinas People's Store and Bolinas Super Market could be inundated, greatly impacting residents and inconveniencing recreationists and tourists who depend on such facilities for water, food and other supplies to support their experiences.

Historic & Archeological Resources

Vulnerable buildings in Bolinas's historic district include the Bolinas Market, the two-story Smiley's, and the Calvary Presbyterian Church. Destruction and deterioration could impact the historic district's character, having potential negative impacts on sense of place and economy.

Archaeological sites could be present in the exposure zones. The Sonoma State University's Anthropological Study Center is inventorying archaeological sites for much of California's coastline in anticipation of sea level rise and coastal erosion.²⁷

Emergency Services

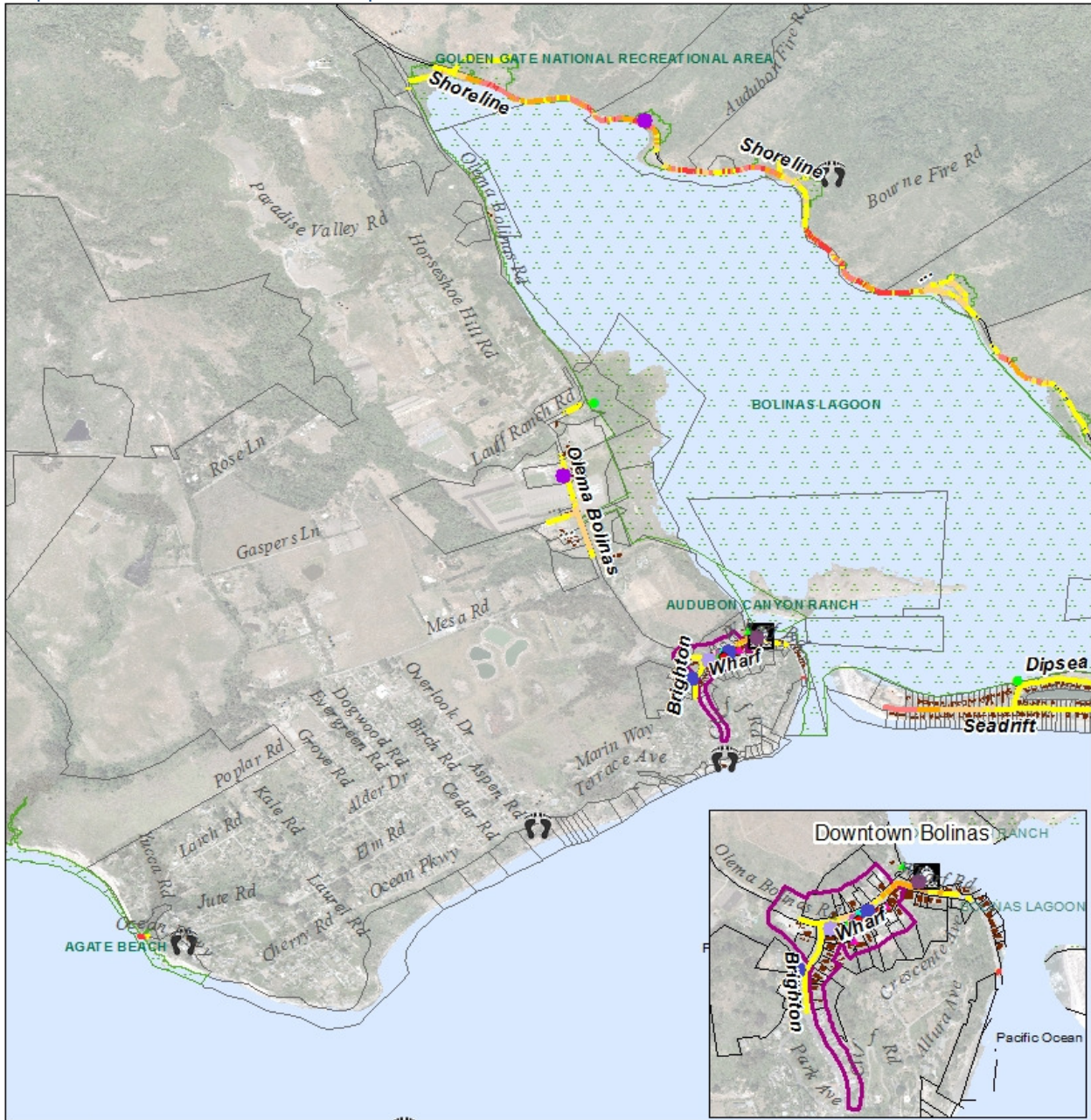
The largest threat to emergency services is loss of access to downtown when emergency vehicles are blocked by flooding at a time when they are needed

most. This is also the case for the evacuation route out of downtown.

²⁷ Newland, M. April 1, 2015. Sonoma State University, personal communication.

BOLINAS

Map 70. Bolinas Vulnerable Developed Assets



Exposed Roads

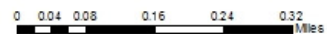
- 10" + Annual storm
- 10" + 20-year storm
- 20" + 20-year storm
- 40" + 100-year storm
- 80" + 100-year storm

- Agricultural Parcels
- Aquaculture
- Buildings
- Parcels
- Parkland
- Historic District

- Commercial
- Education
- Emergency
- Food
- Government Service
- Historic
- Institutional
- Recreation
- Residential
- Transportation
- ▲ Utilities

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

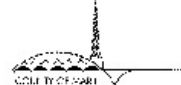
* Roads may also have utility pipes underneath, are used for recreation, and serve as emergency access in some locations.



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: 10/19/2015



INVERNESS

Community Profile: Inverness

Inverness is located on the southwest shore of Tomales Bay. Increased sea level rise and storm surges could significantly compromise this coastal community in the following ways:

- The main access road, Sir Francis Drake Blvd., could experience frequent flooding and erosion, impeding access for residents, tourists, and emergency responders.
- Erosion of Sir Francis Drake Blvd. could lead to damage and disruption to drinking water distribution pipelines beneath it.
- Several shoreline and pier developments are vulnerable to rising waters and storm impacts.

The community is primarily residential, with just over 1,300 people. The population is primarily Caucasian, with small portions of Latino, African-American, and Asian residents. The population is middle class with a median age of 57.3 years²⁸ and household income of roughly \$66,000.²⁹ The average household size is slightly below 2 persons. Of the 1,130 homes, 62 percent are occupied, and of those 40 percent are owner-occupied.³⁰ Recreational and small commercial boating facilities exist along Tomales Bay. A handful of hotels, inns, and visitor-serving facilities are spread throughout town.

Vulnerable Assets

Inverness's most vulnerable assets include Sir Francis Drake Blvd., the water distribution pipeline beneath Sir Francis Drake Blvd., and a number of shoreline developments of economic, civic, recreational, and/or historical value. Surrounding wetlands, Tomales Bay, and public lands to access the bay (Martinelli Park, Shell Beach) are also vulnerable. Archaeological sites may be present. The following sections provide greater detail on these vulnerabilities. [Table 54](#) lists the vulnerable assets in Inverness by onset and flood depth.

IMPACTS AT-A-GLANCE

1,130 buildings	1,304 people
Storm and tidal impacts already occur	10 businesses
11 million worth of assets exposed	Residential Tourism
	Marin DPW Inverness PUD NMWD Property Owners



*Inverness commercial area on Sir Francis Drake Boulevard.
Credit: CDA*

²⁸ U.S. Census Bureau Profile of General Population and Housing Characteristics: 2010

²⁹ U.S. Census Bureau, 2006-2010 American Community Survey, DP03

³⁰ U.S. Census Bureau Profile of General Population and Housing Characteristics: 2010

INVERNESS

Table 54. Inverness Vulnerable Assets

Asset (not exhaustive)	Tidal & Extreme Event Flooding Depth Estimates					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
	(Underlined values indicate tidal flooding at mean higher high water (MHHW) based on one geographic point located at the landward limit of the first scenario overlapping the asset. Values not underlined represent extreme event flooding. Maximum values are provided for groups of buildings. Roads received a high, used for ranking, and low value along the line segment.)					
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	
NMWD Pipeline	underground resource (see Shoreline Hwy., Pt. Reyes Station to Inverness)					WT, SI, E
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
Brock Schreiber Boathouse	<u>2'7"</u>	<u>3'6"</u>	<u>4'</u>	<u>5'10"</u>	<u>9'2"</u>	I, E
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
Martinelli Park	<u>1'1"</u>	<u>2'</u>	<u>2'2"</u>	<u>4'1"</u>	<u>7'3"</u>	I, E
Tomales Bay State Park	10"	1'10"	<u>2'8"</u>	<u>4'7"</u>	<u>7'10"</u>	I, HS
Chicken Ranch Beach						
Inn on Tomales Bay		2"	11"	<u>2'10"</u>	<u>5'5"</u>	I
Sir Francis Drake Blvd.			<u>1" - 3'6"</u>	1" - <u>4'6"</u>	1" - <u>7'10"</u>	I, TF, WS
Inverness Store			2'5	<u>4'4"</u>	<u>7'6"</u>	TF, I, WT
Shoreline Hwy			6"	3" - 1'5"	1'9" - <u>9'7"</u>	I, TF
Dana Marsh & Beach Access				<u>3'</u>	<u>6'2"</u>	I, E, SI, HS
Motel Inverness				<u>2'9"</u>	<u>5'10"</u>	I, WS, HW
Historic District				<u>2'1"</u>	<u>5'1"</u>	TF
Shell Beach Tomales Bay SP				5"	<u>3'4"</u>	TF, I, WT
Tomales Bay Resort					<u>4'</u>	TF
Tomales Bay	water resource					HS

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

Parcels & Buildings

Compared to neighboring coastal communities, Inverness has fewer buildings that will be exposed to sea level rise. Several homes and businesses between Sir Francis Drake and Tomales Bay are on piers and can tolerate tidal flooding and moderate storms. However, inundation and severe storms could impact lower-lying properties, such as the Inverness Yacht Club and the Brock Schreiber boathouse, which sustained severe wave damage in the December 2014 storm. Several OWTs and the

Table 56 delineates the exposed buildings by flood depth range, showing how many and what portions

of the exposed buildings are flooded within each range. water distribution system are also highly vulnerable and could impact homes and businesses, as well as those on the other side of Sir Francis Drake up into the ridge lands. **Error! Reference source not found.** shows how many parcels and buildings are impacted by scenario, with 20 to 34 buildings in the near- and medium-terms, respectively, and upwards to 60 and 75 buildings in the long-term scenarios. Up to 130 parcels – many with buildings – could also be vulnerable. Several of the parcels without buildings are state lands and other parklands.

INVERNESS

Table 55. Inverness Exposed Parcels & Buildings by Scenario

	Parcels	Buildings
Scenario 1	100	23
Scenario 2	101	23
Scenario 3	107	34
Scenario 4	120	61
Scenario 5	127	75

Source: Marin Map, OCOF



Flooding in Inverness commercial area during 2014 King Tides. Credit: Doherty

Table 56. Inverness Building's Daily Tidal & Temporary Extreme Event Flooding Depth Estimates

% represents the portion of the buildings exposed in scenario and water level.

		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Buildings Exposed	#	23	23	37	61	75
Temporary Inundation	#	6	6	10	3	0
	%	26%	26%	27%	5%	
0 - 1.5 feet	#	5	0	0	1	0
	%	56%	0%	0%	100%	
1.5 - 3 feet	#	1	6	6	3	0
	%	8%	35%	22%	12%	
Permanent Inundation	#	17	17	27	58	75
	%	74%	74%	73%	95%	100%
0 - 1.5 feet	#	4	0	1	0	0
	%	44%		100%		
1.5 - 3 feet	#	11	11	21	23	5
	%	92%	65%	78%	88%	100%
3 - 4.5 feet	#	2	6	7	28	16
	%	100%	100%	100%	100%	100%
4.5 - 6 feet	#			2	4	23
	%			100%	100%	100%
6 - 7.5 feet	#				2	23
	%				100%	100%
7.5 - 9 feet	#					6
	%					100%
9 - 10.5 feet	#					2
	%					100%

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

INVERNESS

Table 57. Inverness Exposed Residential and Commercial Parcels

Scenario 1				Scenario 3				Scenario 5			
Residential		Commercial		Residential		Commercial		Residential		Commercial	
#	%	#	%	#	%	#	%	#	%	#	%
38	3%	7	37%	72	6%	8	42%	108	9%	10	53%

Source: Marin Map Parcel Layer Land Use Description 2014

Table 58 outlines damage cost estimates for buildings and their contents under Scenario 5, using FEMA damage tagging levels and assuming every building would face the same level of damage. Over \$10 million of damage could occur with sea level and storm combinations in the long-term.

Alternatively, buildings were assessed for exposure to wave velocity and flood depths under each scenario to determine the buildings most likely to experience destructive conditions that would result in the buildings being red-tagged. This reveals that up to 36 of the 75 buildings exposed to sea level rise and storms could be destroyed, exceeding \$10 million in assessed building value.

Table 58. FEMA Damage Levels Applied to Buildings in Inverness Exposed in Scenario 5

Buildings	Yellow Tag-Minor (\$5,000-17,000)	Orange Tag \$17,001+	Red Tag (County assessed improvement value)
75	\$375,000-1,275,000	\$1,275,001+	\$10,155,532

Source: Marin Map, OCOF

Table 59. Inverness Buildings Potentially Facing Hazardous Conditions

Scenario 1		Scenario 2		Scenario 3		Scenario 4		Scenario 5		
#	%	#	%	#	%	#	%	#	%	Value*
4	<1%	4	<1%	4	<1%	14	1%	36	2%	\$10,155,532

*Improvement Assessed Value Marin County Assessor 2014. Source: Marin Map

INVERNESS

Transportation

Sir Francis Drake Blvd. is the main access road to the Point Reyes National Seashore and Tomales Bay State Park. Temporary and permanent flooding could negatively impact recreational opportunities, complicate residents' daily routines, and cut off access for emergency vehicles.

Table 60. Inverness Exposed Road Segments
(Scenarios 2-5 include roads in previous scenarios)

Scenarios 1 & 2	Scen 3	Scenario 4	Scenario 5
Sir Francis Drake Blvd. (County)		Vision Rd. (County) Rannoch Wy. (Private) Argyle St. (County) Duck Cove Rd. (Private)	Inverness Wy. (County) Woodhaven Rd. (Private)

Source: Marin Map, OCOF

Utilities

Water distribution pipes beneath marshland south of Tomales Bay and adjacent to Sir Francis Drake Boulevard are considered vulnerable. In addition, exposed buildings could also have vulnerable underground septic systems, as many are sited just off the shoreline. Like other communities, the loss of potable water and sanitary service would have significant negative impacts on public safety, quality of life, and the local economy. Additionally, Inverness depends on private propane services and could be cut off from suppliers if Sir Francis Drake Blvd. is compromised for an extended period.

Water service is provided by two different water companies, and several residents operate private wells. Inverness Park and Paradise Ranch estates are served by the North Marin Water District-West Marin with groundwater pumped from two wells adjacent to Lagunitas Creek through its Point Reyes Water System. The Inverness Public Utility District (IPUD) provides water service to around 1,600 acres, including the entire publicly owned portions watershed.³¹ IPUD and the North Marin Water District (NMWD) have an emergency water agreement that allows transfer of up to 40 gallons per minute water between the two district's water

systems in an emergency. The agreement expires in 2024.

Working Lands

Not Applicable.

Natural Resources

Tomales Bay, a Ramsar wetland of international importance, is highly vulnerable to increased salinity, inundation, and waves. Tomales Bay supports numerous species, including the California clapper rail and black rail, salmon and steelhead trout, whose populations could be impacted if the Bay's ecological functions shift dramatically.

All the marshes in Inverness are vulnerable because they are confined by the roadway. As sea levels rise, much of the low salt marsh will be converted to mud and sand flats. Because the Inverness shore is steep, marsh transition areas shrink with elevating sea levels. [Map 73](#) shows how the marsh habitats in Inverness could shift for each sea level rise scenario (not including storms) using sedimentation rate of 1.5mm/year. [Table 61](#) shows the corresponding area for each marsh habitat type. Approximately 50 percent of the high marsh is expected to be lost in the long-term (low end); converting to low marsh, mud, and sand flats. Existing low marsh is expected to lose 80 percent of area in the same period.

³¹ Inverness Area Sphere of Influence Update, May 2007, p. 3

INVERNESS

Map 73. Inverness Area Marsh Habitat Transitions by Scenario at 1.5mm/ year Sedimentation

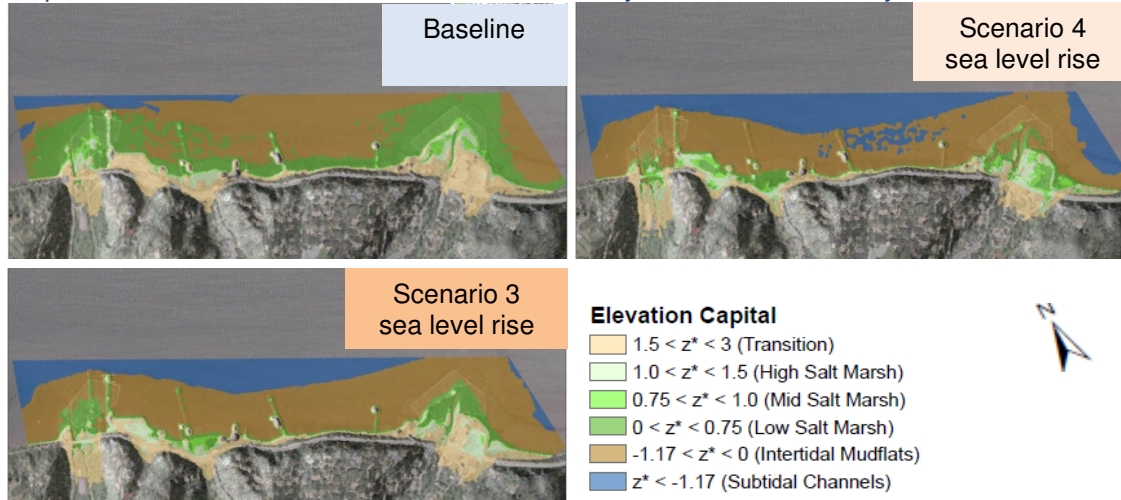


Table 61. Inverness Distribution of Marsh Vulnerability

Habitat Type	Area (acres)			z* Range
	Baseline	Scenario 3	Scenario 4	
Transition zone	10	9	7	1.5 - 3
High salt marsh (salt grass)	3	4	4	1 - 1.5
Mid salt marsh (pickleweed)	2	1	2	0.75 - 1
Low salt marsh (cordgrass)	20	6	4	0 - 0.75
Intertidal Mudflats	24	35	32	-1.17 - 0
Subtidal Channels & Shallows	3	13	20	< -1.17

Source: ESA, 2015, OCOF

Recreation

Inverness borders Point Reyes National Seashore and California State Parks along Tomales Bay. A variety of vulnerable recreational areas provide access to Tomales Bay including the Martinelli Park, Dana Marsh, and Tomales Bay State Park. These areas may shrink with rising waters, compromising public access to the bay, leading to negative economic and quality of life impacts for residents and visitors. A handful of private marinas are vulnerable, and property owners would need to decide if these assets should be protected or elevated. Loss of such businesses could have dramatic impacts on the tourism-based economy.

Emergency Services

The helicopter launch pad is vulnerable; however, it can be easily relocated.³² The tsunami evacuation route on Vision Road could be vulnerable in the medium- and long-term scenarios. Like other evacuation routes, the loss or compromised function of these routes would be detrimental to public safety. The Inverness Public Utility District (IPUD) provides fire protection to Inverness and while the station is not exposed to sea level changes, it is exposed to creek flooding. Access to those in need could be compromised when waters are high.

³² Hanks, Ursula. March, 9 2015 Marin Office of Emergency Services, personal communication.

INVERNESS

Historic & Archaeological Resources

The historic building in which the post office is located and the Brock Schreiber Boathouse are considered vulnerable, and their destruction or deterioration could impact the historic district's character. Archaeological Sites could be present in the exposure zones.³³

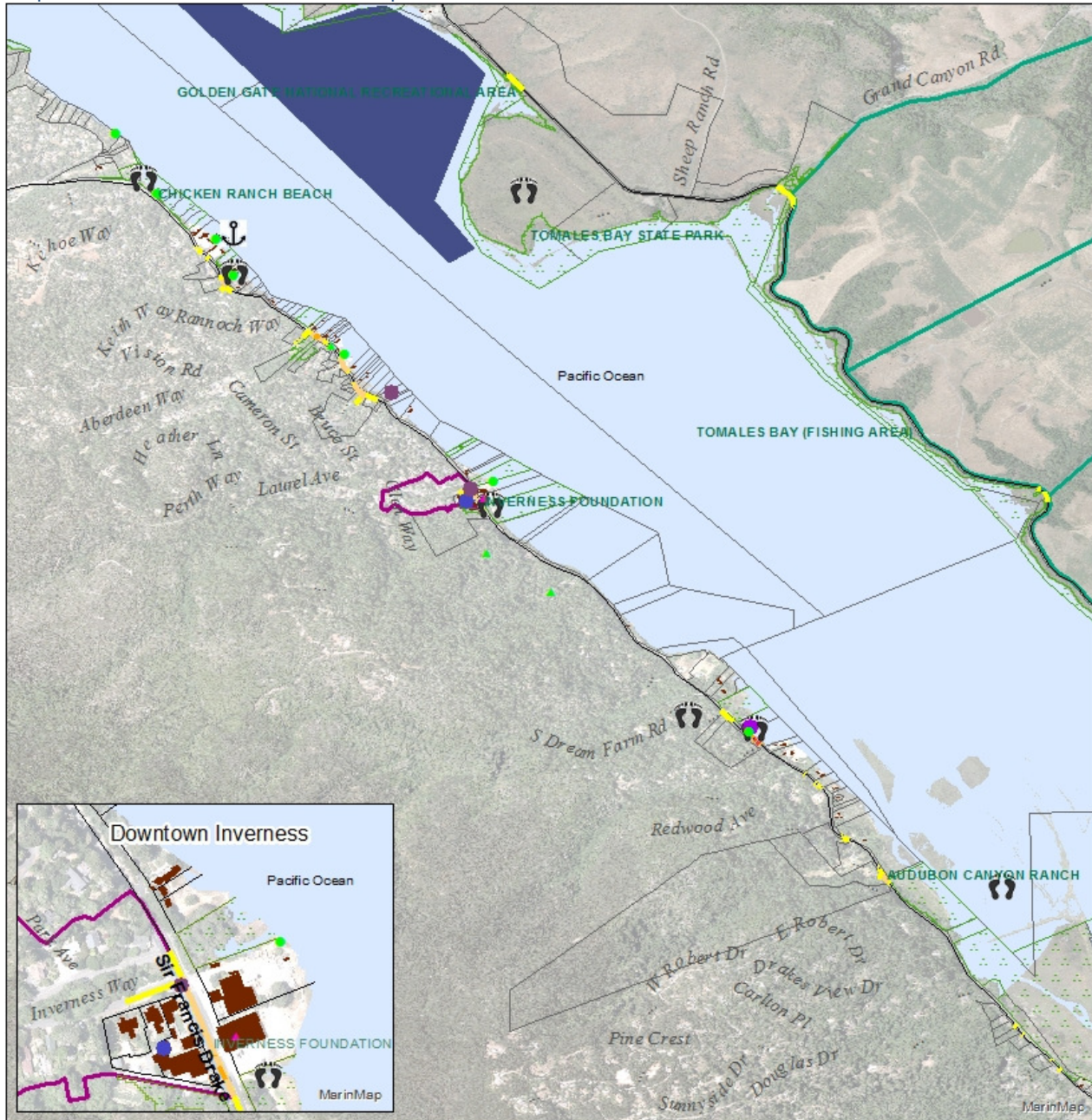


Historic Brock Schreiber Boat House. Tomales Bay from Inverness. Credit: CDA

³³ Newland, M. April 1, 2015. Sonoma State University, personal communication.

INVERNESS

Map 74. Inverness Vulnerable Developed Assets



Exposed Roads

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

- Agricultural Parcels
- Aquaculture
- Buildings
- Parcels
- Parkland
- Historic District

- Commercial
- Education
- Emergency
- Food
- Government Service
- Historic
- Institutional
- Recreation
- Residential
- Transportation
- Utilities

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

* Roads may also have utility pipes underneath, are used for recreation, and serve as emergency access in some locations.

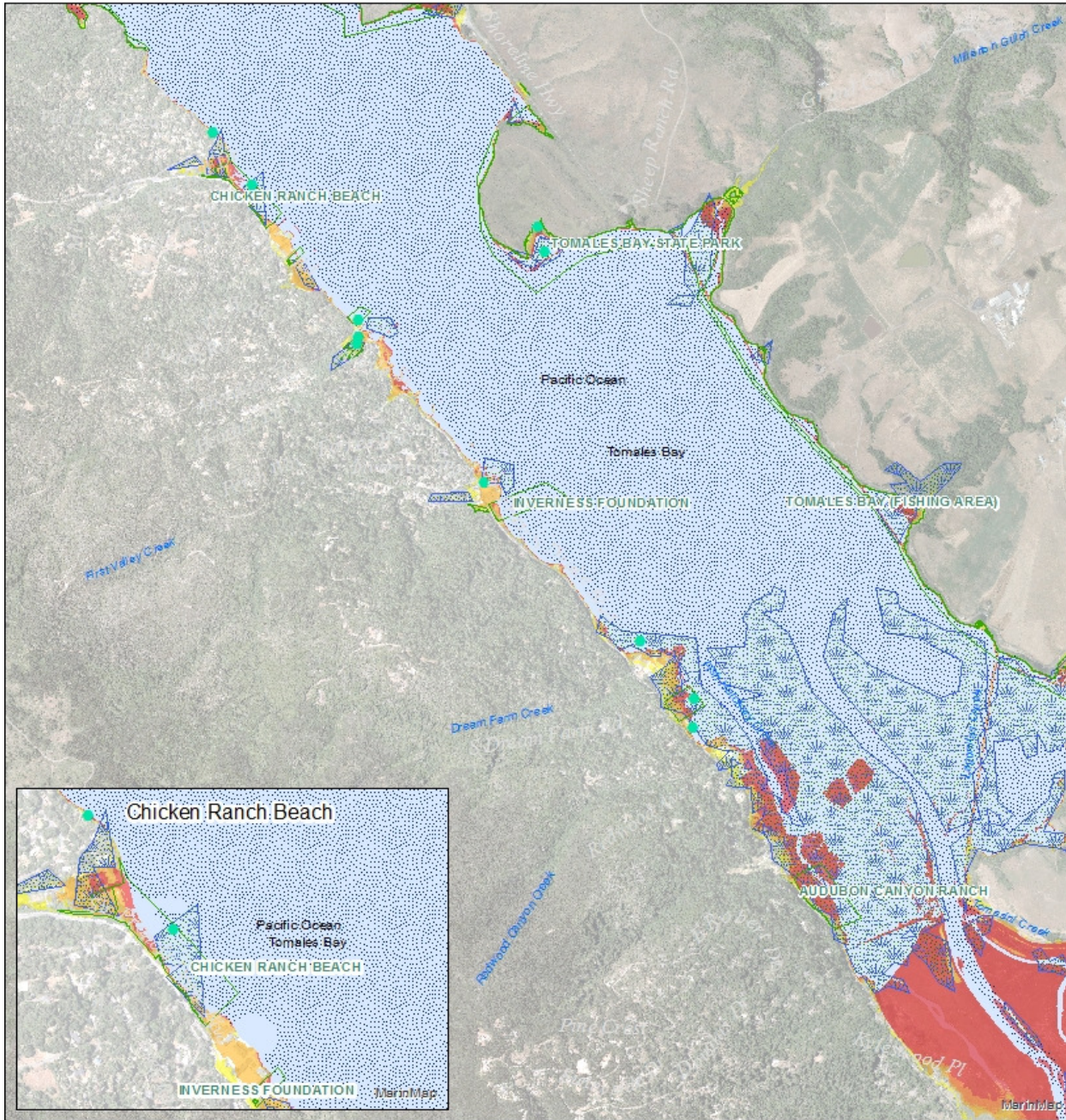
0 0.015 0.03 0.06 0.09 0.12 Miles

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: 11/2/2015



INVERNESS

Map 75. Inverness Vulnerable Natural Resource Assets



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 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: 11/2/2015



POINT REYES STATION

Community Profile: Point Reyes Station

At the southeast tip of Tomales Bay, Point Reyes Station is the gateway to the Point Reyes National Seashore. While most of the community lies outside of sea level rise exposure zones, some of Point Reyes Station's assets could be impacted. Key issues in Pt. Reyes Station include:

- Surrounding wetlands and marshes, including Giacomini Wetlands and Olema Marsh could be degraded by flooding, erosion, and increased salinity.
- Water district pipes traversing under the marsh and road could be damaged by higher groundwater.
- Flooding is probable on portions of Shoreline Highway in the long-term scenarios, however green bridge is vulnerable in the near-term.

Point Reyes Station is one of Marin County's oldest coastal communities. The approximately 1,500-acre town was home to 848 people in 2010. The population is primarily Caucasian, though it is one of the more diverse on the Marin Coast, with a 20 percent minority population of primarily Latino residents. The average resident is middle class with a median age of 51 years³⁴ and household income of roughly \$81,000.³⁵ The average household size is approximately two persons. Of the 490 homes, 412 are occupied.³⁶

Vulnerable Assets

Point Reyes Station's most vulnerable assets include water district pipelines that lead to Inverness, Green Bridge on Shoreline Highway, and the surrounding wetlands. In the long-term, roughly 30 homes along Lagunitas Creek could also see flooding. Table 62 lists assessed vulnerable assets in Inverness and the following sections provide further detail for each asset category.

IMPACTS AT-A-GLANCE

36 buildings	700 people
Storm and tidal impacts already occur	4 businesses
2 million worth of assets exposed	Residential Tourism
	Caltrans NMWD



Point Reyes Station. Credit: CDA

³⁴ U.S. Census Bureau Profile of General Population and Housing Characteristics: 2010

³⁵ U.S. Census Bureau, 2006-2010 American Community Survey, DP03

³⁶ U.S. Census Bureau Profile of General Population and Housing Characteristics: 2010

POINT REYES STATION

Table 62. Pt. Reyes Vulnerable Assets

Asset (not exhaustive)	Tidal & Extreme Event Flooding Depth Estimates					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	
	(Underlined values indicate tidal flooding at mean higher high water (MHHW) based on one geographic point located at the landward limit of the first scenario overlapping the asset. Values not underlined represent extreme event flooding. Maximum flood values are provided for groups of buildings. Roads received a high and low value along the line segment.)						
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5		
NMWD Pipeline	underground resource (see Shoreline Highway Point Reyes Station to Inverness for depths)					I, SI	
Green Bridge	No depth data	No depth data	<u>2"</u>	<u>2'</u>	<u>9'10"</u>	I, TF	
White House Pool/Trail			<u>2'5"</u>	<u>2'3"</u>	<u>5'11"</u>	I	
Shoreline Hwy			6"	3" - 1'5"	1'9" - <u>9'7"</u>	I, TF	
Olema Marsh Trail					<u>2'9"</u>	I	
Buildings along Lagunitas Creek					<u>1'8"-3'2"</u>	TF, I	
Gallagher Well					underground resource	SI	
Lagunitas Creek	water resource					HS	

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

Table 63. Pt. Reyes Station Exposed Parcels & Buildings by Scenario

	Parcels	Buildings
Scenario 1	31	0
Scenario 2	31	0
Scenario 3	30	0
Scenario 4	38	0
Scenario 5	60	36

Parcels & Buildings

Only a small percentage of the parcels and buildings fall within the exposure zone, and only at higher scenarios. Loss or degradation of these properties could have significant impacts for the residents, who reside within them.

Table 64. Pt. Reyes Station Flood Depths for Building Footprints

Number and portion of the buildings exposed in that scenario.

		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Buildings Exposed	#	0	0	0	0	36
Temporary Inundation	#	0	0	0	0	28
	%					78%
0 - 1.5 feet	#	0	0	0	0	22
	%					92%
1.5 - 3 feet	#	0	0	0	0	3
	%					33%
3 - 4.5 feet	#	0	0	0	0	1
	%					33%
4.5 - 6 feet	#	0	0	0	0	1
	%					100%
Permanent Inundation	#	0	0	0	0	8
	%					22%

POINT REYES STATION

		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
0 - 1.5 feet	#	0	0	0	0	2
	%					9%
1.5 - 3 feet	#	0	0	0	0	6
	%					67%
3 - 4.5 feet	#	0	0	0	0	2
	%					67%

Source: Marin map, OCOF

Table 65. FEMA Damage Levels Applied to Buildings Exposed in Pt. Reyes Station in Scenario 5

Buildings	Yellow Tag-Minor (\$5,000-17,000)	Orange Tag \$17,001+	Red Tag (County assessed improvement value)
36	\$180,000-612,000	\$612,001+	\$5,480,520

Source: Marin Map, OCOF, Marin County Assessor

Table 66. Pt. Reyes Station Buildings Potentially Facing Hazardous Conditions

Scenario 1		Scenario 2		Scenario 3		Scenario 4		Scenario 5		
#	%	#	%	#	%	#	%	#	%	Value*
								36	4%	\$2,229,076

*Improvement Assessed Value Marin County Assessor 2014. Source: Marin Map

Error! Reference source not found. estimates damage costs to for buildings and their contents under Scenario 5, with the assumption that every building would face the same level of damage using FEMA post-disaster tagging rankings. Over \$18 million of damage would occur at the high end.

To determine how many buildings could experience red-tag level destruction, buildings were analyzed for exposure to wave velocity and flood depths strong enough to destroy a building for each scenario. This reveals up to 36 buildings could be destroyed, resulting in over \$2 million in assessed building value losses.

Transportation

Highway 1 is vulnerable at Green Bridge in the near-term and along other segments south of the bridge in the long-term. This segment's loss would cut off south west access to Point Reyes Station. Lost or

compromised function could cut off access to Point Reyes Station, leading to negative economic impacts for local businesses that depend on the tourist economy, emergency accessibility impacts, and negative sense of place impacts for locals and visitors.

Table 67. Pt. Reyes Station Exposed Road Segments

(Scenarios 2-5 include roads in previous scenarios)

Scenarios 1 & 2	Scenario 3	Scenario 4	Scenario 5
Shoreline Hwy. (@ Green Bridge; Caltrans)			Bear Valley Rd. (County)

Source: Marin Map, OCOF

POINT REYES STATION

Utilities

NMWD's water distribution lines that run beneath the marshes south of Tomales Bay and adjacent to Sir Francis Drake Boulevard are of concern as pipe damage in Point Reyes Station or Inverness could disrupt flow and pressure throughout the system. The Gallagher Well, also managed by the NMWD, could be threatened by saltwater intrusion at the high end of the long-term scenarios. During times of low creek flow and/or high tides, seawater can be drawn into the wells and water supply, such as during the 1976-77 drought and the winters of 1980-81 and 1986-87. A salinity intrusion-avoidance pumping plan was developed to lessen water quality impacts.³⁷

The NMWD also serves the Point Reyes National Seashore Headquarters at Bear Valley, Silver Hills, and the U.S. Coast Guard Housing Facility. Preliminary review of Marin County's database of private drinking and irrigation wells indicates that 14 wells are in Point Reyes.³⁸ The NMWD West Marin service area and the neighboring Inverness Public Utility District (IPUD) have an emergency water agreement (expires in 2024) that allows for the transfer of water between the two district's water systems.³⁹

Point Reyes Station relies on OWTS, cesspools, mound systems, and other sewage disposal methods that discharge into the ground. This is an issue for the handful of homes exposed to sea level rise along Lagunitas Creek.

Working Lands

Not Vulnerable.

Natural Resources

Olema Marsh (Point Reyes National Seashore, Audubon Canyon Ranch) and Giacomini Wetlands (State Parks) are large marshes that support habitat for a variety of bird and plant species.

³⁷ Nichols Berman Environmental Planning. Nov. 2007. 2007 *Marin County Wide Plan Final Environmental Impact Report*. p. 4.9-14. State Clearinghouse No. 2004022076.

http://www.marincounty.org/~media/files/departments/cd/planning/currentplanning/publications/county-wide-plan/cwp_eir/cwpupdatefeir1107.pdf

³⁸ Marin County Local Coastal Program Amendment Land Use Analysis draft, June 2012, p. 44

³⁹ Nichols Berman Environmental Planning. Nov. 2007. 2007 *Marin County Wide Plan Final Environmental Impact Report*. p. 4.9-16. State Clearinghouse No. 2004022076.

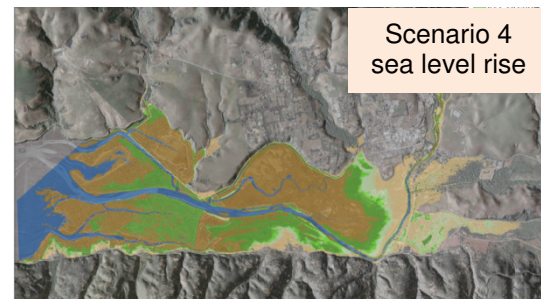
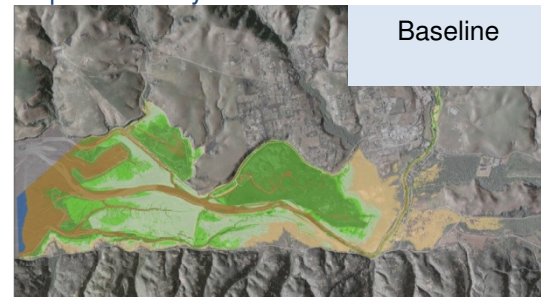
http://www.marincounty.org/~media/files/departments/cd/planning/currentplanning/publications/county-wide-plan/cwp_eir/cwpupdatefeir1107.pdf

POINT REYES STATION

Map 76 shows how the marsh habitats will shift by 2050 and 2100 using the average historic sedimentation rate of 1.6mm/year.⁴⁰ Downshifting from mid-marsh to tidal flats is anticipated, particularly in low-lying areas adjacent to Point Reyes Station. The area has relatively significant freshwater inputs and salinity changes could have significant impacts. The high marshes could transgress inland along the valley profile with some realignment of infrastructure such as roads and culverts.

Areas most vulnerable are those without gradually sloping transitional uplands. Table 68 shows the increasing vulnerability of marsh functions as sea level rises and marshes are squeezed against steeper upland slopes. This table does not take salinity impacts into account.

Map 76. Pt. Reyes Station Marsh Habitat Transition



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)



Recreation

Olema Marsh, Giacomini Wetlands, and the Whitehouse Pool provide access to trails and waterways. If altered by inundation, saltwater intrusion, erosion, habitat shifts, or other impacts, these areas may no longer support the diversity of wildlife or recreational functions, and may thus lose some of their recreational appeal. The privately held Love's baseball field already floods. Sea level rise will only exacerbate the depth and duration of standing water.

⁴⁰ Smith, S. V. and J. T. Hollibaugh (1998). The Tomales Environment, University of Hawaii, School of Ocean and Earth Science and Technology and San Francisco State University, Tiburon Center. <http://lmer.marsci.uga.edu/tomales/tomenv.html>

POINT REYES STATION

Table 68. Pt. Reyes Station Distribution of Marsh Vulnerability

Habitat Type	Area (acres)		
	Baseline	Scenario 3	Scenario 4
Transition zone	233	229	194
High salt marsh	255	73	81
Mid salt marsh	125	45	37
Low salt marsh	298	401	247
Intertidal Mudflats	233	464	521
Subtidal Channels	13	35	211

Source: ESA, 2015, OCOF

Historic & Archaeological Resources

No historic sites are exposed. Archaeological sites could be present in the exposure zones.⁴¹

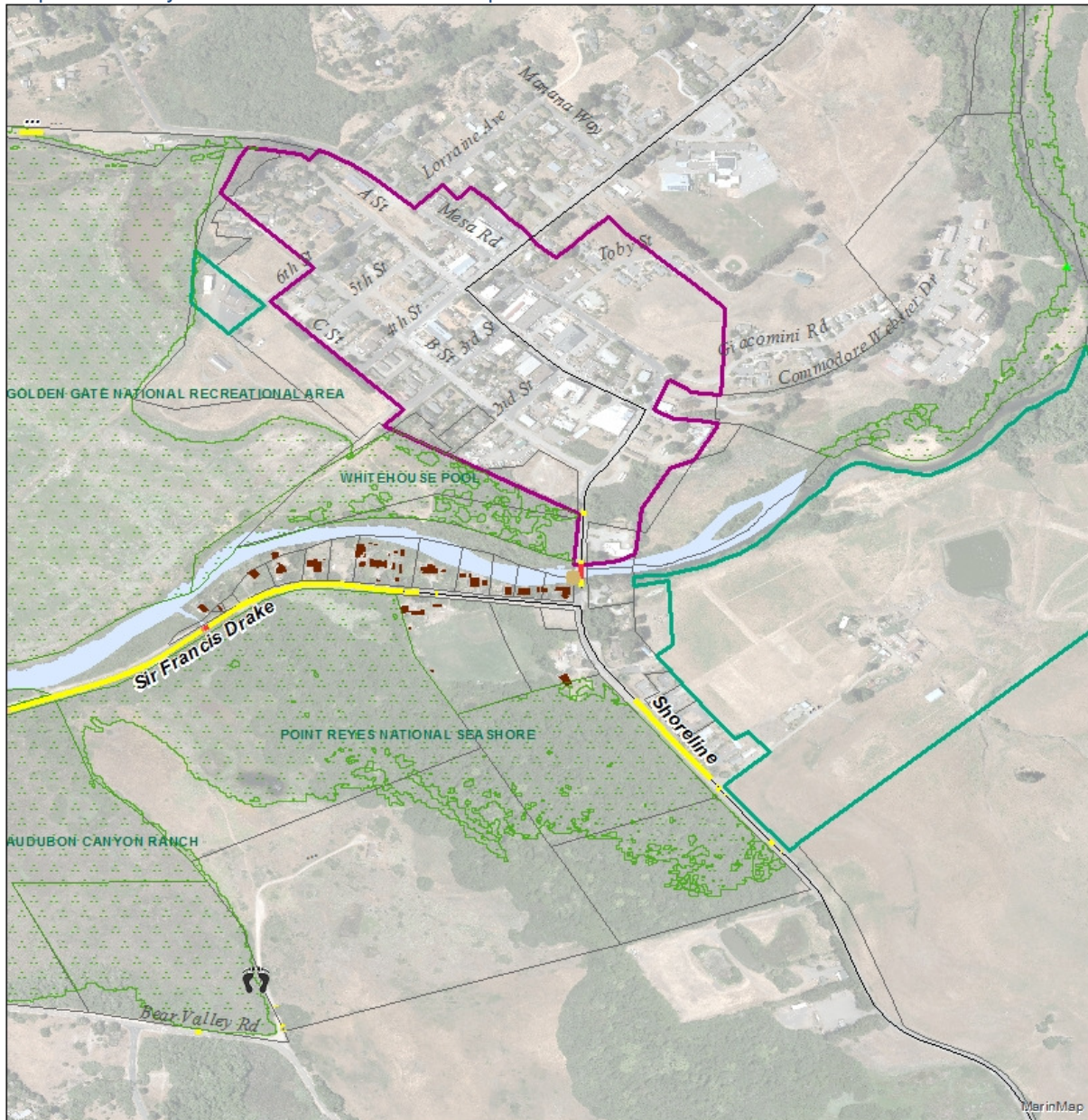
Emergency Services

Emergency service is not directly impacted in Point Reyes Station. However, sheriff and fire access to those living along Shoreline Highway south of the community may be challenging as storm waters reach these roadways in the long-term scenarios.

⁴¹ Newland, M. April 1, 2015. Sonoma State University, personal communication.

POINT REYES STATION

Map 77. Pt. Reyes Station Vulnerable Developed Assets



Exposed Roads

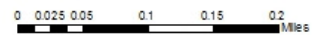
- 10" + Annual storm
- 10" + 20-year storm
- 20" + 20-year storm
- 40" + 100-year storm
- 80" + 100-year storm

* Roads may also have utility pipes underneath, are used for recreation, and serve as emergency access in some locations.

- Agricultural Parcels
- Aquaculture
- Buildings
- Parcels
- Parkland
- Historic District

- Commercial
- Education
- Emergency
- ▲ Food
- Government Service
- Historic
- Institutional
- Recreation
- Residential
- Transportation
- ▲ Utilities

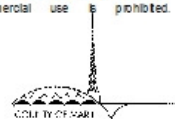
- Boat Launch
- Fishing Pier
- Access Point
- Port
- Marina



Source: Marin Map, Our Coast Our Future, CA Coastal Commission

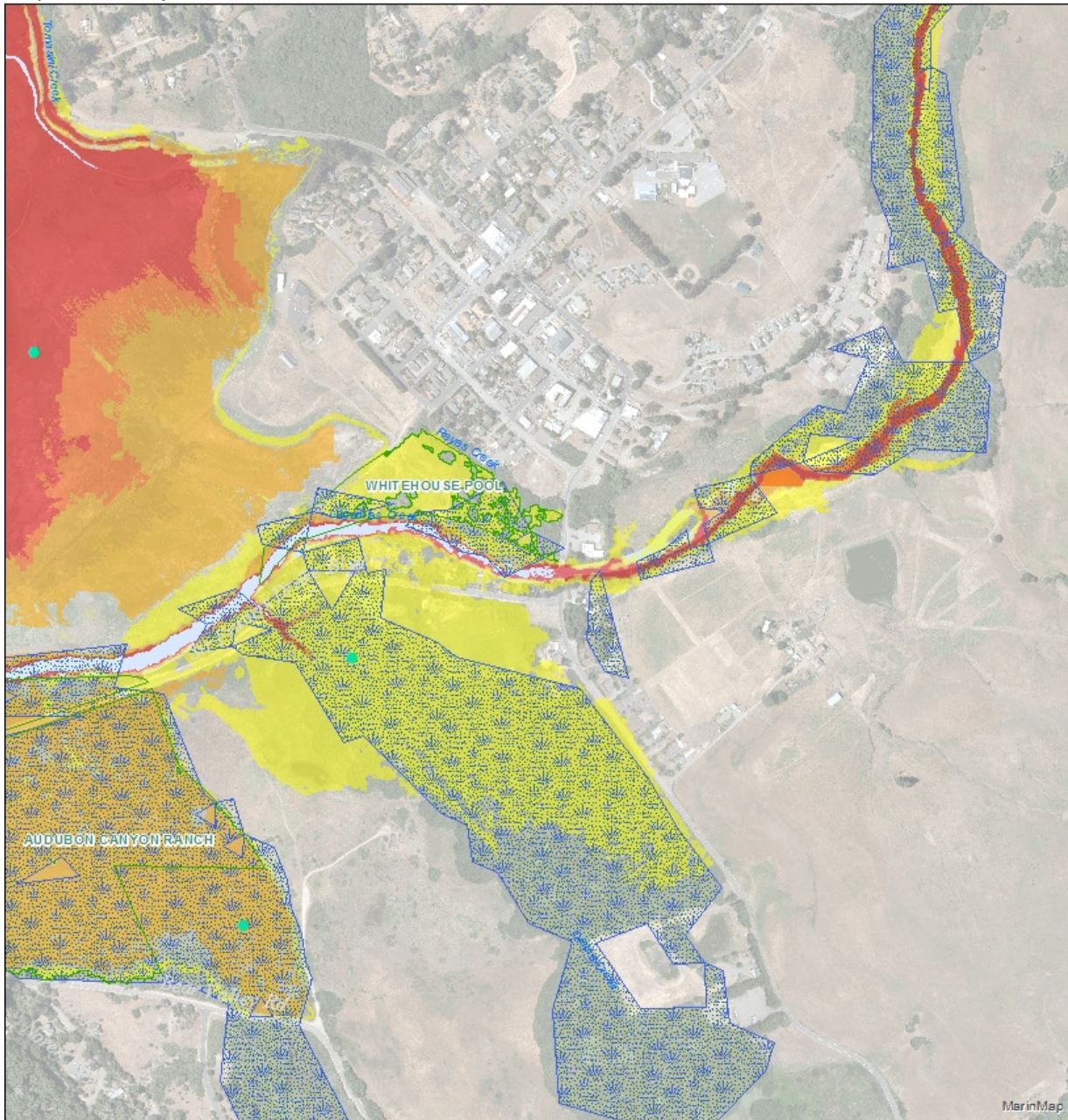
Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future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

Date: 10/19/2015



POINT REYES STATION

Map 78. Pt. Reyes Station Vulnerable Natural Resource Assets



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 0.0375 0.075 0.15 0.225 0.3 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: 10/19/2015



EAST SHORE

Community Profile: East Shore

The East Shore of Tomales Bay and the town of Marshall are vulnerable to sea level rise and storm surges. Key issues include:

- Access to, from and along Shoreline Highway. Major barriers include Walker Creek.
- Pier-based and shoreline housing, which act as a first line of defense for Shoreline Highway, are highly vulnerable.
- The public beach could be degraded by flooding.

The East Shore community covers approximately 4,250 acres on a very narrow strip of land along the eastern shoreline of Tomales Bay. Existing development is generally clustered west of Shoreline Highway. Between these developed clusters are stretches of undeveloped land.

Vulnerable Assets

The East Shore's most vulnerable assets include Shoreline Highway, private wells, septic systems, the Livermore Cypress Preserve, and a number of recreation and shoreline developments including visitor serving assets such as the Marconi Boat Launch, several restaurants, and the Inn on Tomales Bay. Vulnerable archaeological sites may also be present.

IMPACTS AT-A-GLANCE

163 buildings	10 businesses	
Storm and tidal impacts already occur		
14 million worth of assets exposed	Residential Tourism Aquaculture	Caltrans Property Owners



East Shore. May 30, 2008. Credit: CDA



Marshall Store Boat Launch, East Shore. July 19, 2009. Credit: CDA

EAST SHORE

Table 69. East Shore Vulnerable Assets

Asset (not exhaustive)	Tidal & Extreme Event Flooding Depth Estimates					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
	(Underlined values indicate tidal flooding at mean higher high water (MHHW) based on one geographic point located at the landward limit of the first scenario overlapping the asset. Values not underlined represent extreme event flooding. Maximum flood depths are given for groups of buildings. Roads received a high and low value along the line segment.)					
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	
OWTS and wells	Underground Resource					TF, I, SI
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
Brighton Beach	<u>2'2"</u>	<u>3'5"</u>	<u>4'11"</u>	<u>6'</u>	<u>9'11"</u>	E, WS
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
Hog Island Oyster	<u>2'1"</u>	<u>2'1"</u>	<u>2'10"</u>	<u>4'10"</u>	<u>8'1"</u>	I, TF
Shoreline Hwy	3" - 1'7"	3" - 2'4"	3" - 3'	<u>2' - 4'6"</u>	<u>6" - 8'1"</u>	I, TF
Buildings west of Shoreline Hwy.	<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
Marconi Boat Launch	1'1"	2'	<u>2'11"</u>	<u>4'10"</u>	<u>8'2"</u>	I
Tony's Restaurant	8"	1'8"	<u>2'6"</u>	<u>4'5"</u>	<u>7'9"</u>	I
Tomales Bay Oyster Company	8"	1'5"	<u>2'3"</u>	<u>4'1"</u>	<u>7'5"</u>	I, TF
Nick's Cove				<u>2'6"</u>	<u>5'10"</u>	I, TF, E, WS
Millerton Point				<u>2'5"</u>	<u>5'8"</u>	I, E
Historic District				<u>2'5"</u>	<u>4'5"</u>	I
Shoreline Hwy					<u>3'5"</u>	I, E
Tomales Bay	water resource					HS
Keys Creek (Fishing Area)	water resource					HS

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

Parcel & Buildings

The East Shore contains a high number of potentially vulnerable properties along the shoreline. Overall, 45 percent of the buildings were identified as exposed at the highest C-SMART scenario.

Error! Reference source not found. presents exposed parcels and buildings overall, revealing 154 to 168 parcels, and 103 to 163 buildings could be exposed across the five scenarios.

Table 71 breaks down the vulnerable buildings by the type and level of flooding for each scenario.

Table 70. East Shore Exposed Parcels & Buildings by SLR Scenario

	Parcels	Buildings
Scenario 1	154	103

	Parcels	Buildings
Scenario 2	155	109
Scenario 3	157	121
Scenario 4	159	135
Scenario 5	168	163

Source: Marin Map, OCOF

EAST SHORE

Table 71. East Shore Flood Depth Estimates for Exposed Building Footprints
Number and portion of the buildings exposed in that scenario.

		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Buildings Exposed	#	105	122	122	136	163
Temporary Inundation	#	20	37	16	11	2
	%	19%	30%	13%	8%	1%
0 - 1.5 feet	#	16	24	7	6	2
	%	32%	63%	44%	43%	25%
1.5 - 3 feet	#	0	11	7	1	0
	%	0%	15%	10%	5%	0%
3 - 4.5 feet	#		0	0	2	0
	%				3%	0%
Permanent Inundation	#	85	85	106	125	161
	%	81%	70%	87%	92%	99%
0 - 1.5 feet	#	34	14	9	8	6
	%	68%	37%	56%	57%	75%
1.5 - 3 feet	#	55	62	61	19	17
	%	100%	85%	90%	95%	100%
3 - 4.5 feet	#	-	11	36	64	18
	%	-	100%	100%	97%	100%
4.5 - 6 feet	#	-	-	2	32	25
	%	-	-	100%	100%	100%
6 - 7.5 feet	#	-	-	-	4	53
	%	-	-	-	100%	100%
7.5 - 9 feet	#	-	-	-	-	37
	%	-	-	-	-	100%
9 - 10.5 feet	#	-	-	-	-	5
	%	-	-	-	-	100%

Source: Marin Map, OCOF

Table 72. FEMA Damage Levels Applied to Buildings Exposed in East Shore in Scenario 5

Buildings	Yellow Tag-Minor (\$5,000-17,000)	Orange Tag \$17,001+	Red Tag (County assessed improvement value)
163	\$840,000-2,856,000	\$2,856,001+	\$18,035,996

Source: Marin Map, OCOF

Table 73. Pt. Reyes Station Buildings Potentially Facing Hazardous Conditions

Scenario 1		Scenario 2		Scenario 3		Scenario 4		Scenario 5		
#	%	#	%	#	%	#	%	#	%	Value*
43	13%	59	18%	61	18%	56	17%	125	38%	\$15,209,504

*Improvement Assessed Value Marin County Assessor 2014. Source: Marin Map

EAST SHORE

Table 72 outlines damage cost estimates for buildings and their contents under Scenario 5, assuming that every building would face the same level of damage. Over \$18 million of damage would occur at the high end. Damage levels are associated costs are derived from FEMA. See the Parcels & Buildings Profile for more information).

Table 73 shows how many buildings could experience destructive enough storms to be destroyed, or red-tagged. This analysis uses velocity and flood depth thresholds and applies them to each building for the five C-SMART scenarios. This analysis reveals that up to 36 of the 163 buildings could be exposed to sea level rise and storms, resulting in over \$15 million in assessed building value losses.

Transportation

Shoreline Highway is vulnerable on the East Shore in the near-term near creek crossings, such as Walker Creek. Flooding in this location, and others, could worsen in the long-term scenarios. This would limit north to southern travel along the East Shore, leading to potential economic, quality of life, sense of place, and emergency access impacts for locals and visitors alike.

The East Shore faces unique challenges because the bayside houses inadvertently serve to armor Shoreline Highway from flooding impacts. The loss or compromise of shoreline houses would impact the highway as well.

Table 74. East Shore Exposed Road Segments
(Scenarios 2-5 include roads in previous scenarios)

Scenario 1 & 2	Scenario 3	Scenario 4	Scenario 5
Shoreline Hwy. (Caltrans) Willow Way (County)			Grand Canyon Rd. (County)

Source: Marin Map, OCOF

Utilities

Several OWTSS are located on the bay side of the highway and are vulnerable to high tides and storms in the near-term. Privately owned wells are vulnerable to saltwater intrusion. Both septic and

water systems have already been compromised in some locations, prompting community members to join together and work with Environmental Health Services to establish news systems east of the highway. However, even these homes' pipe connections could still be vulnerable to corrosion.

Working Lands

Aquaculture, particularly oyster production, is integral to the East Shore. Mariculture buildings and facilities to process and vend their harvest are vulnerable to flooding, failed septic, and wave impacts. Losses in this sector could have economic impacts locally and for importers across the globe. Land based operations, such as dairies, could see saline conditions reaching higher along creeks and greater extents of flooding. This may warrant revisions to the operation's conservation management plan. However, the primary concern is transportation access along Shoreline Highway. Finally, agri-tourism along this route could be compromised if the roads are closed due to flooding or erosion.



Aquaculture in East Shore. Credit: CDA

Natural Resources

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 narrow and vulnerable to loss from coastal storm events. Since most are backed by armor they are vulnerable to higher tides and inundation associated with sea level rise.

EAST SHORE

Table 75. East Shore Average Beach Widths and Vulnerability Levels

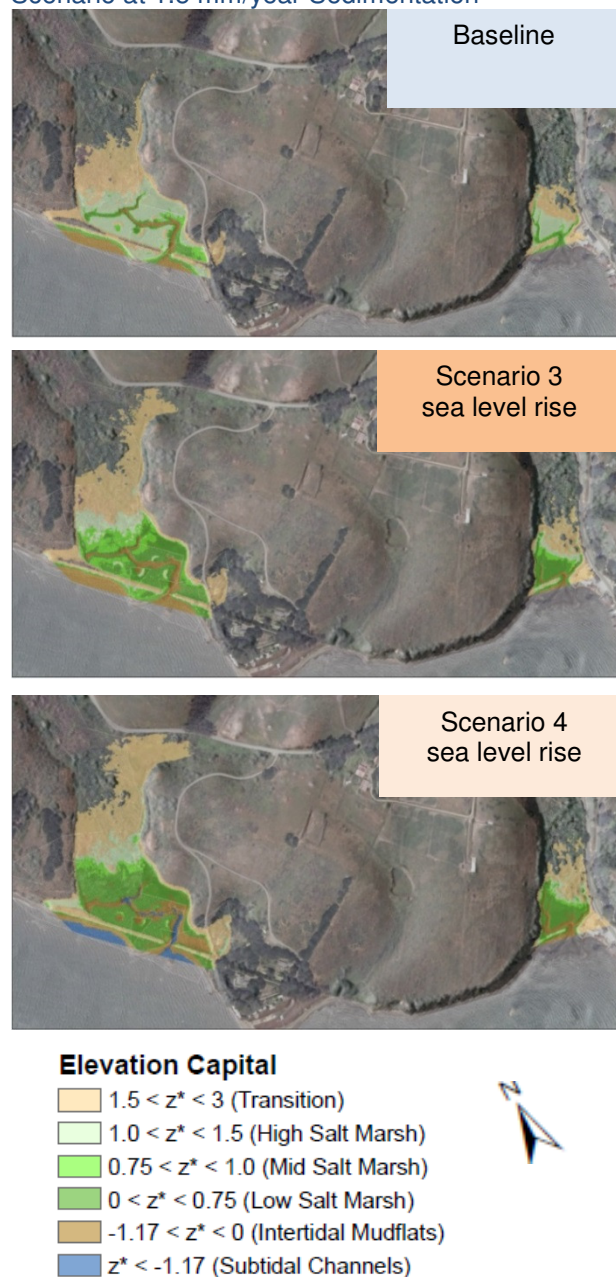
	Base line	Scen 1 & 2	Scen 3	Scen 4	Scen 5
Width	Beaches along Tomales Bay are less than 10 meters wide				
Vulnerability	High	High	High	High	High

Source: OCOF, Marin Map, OPC, ESA

Just like the beaches, Tomales Bay marsh habitats along this stretch of shoreline are also vulnerable to drowning. One example is the Audubon Canyon Ranch's Cypress Grove Preserve just north of Marshall. In addition to habitat, its historic Victorian cabins serve as an important center for ornithological research, and their destruction could be a significant loss to the field of conservation science. Map 80 shows how habitat types change from the baseline to the medium-term and long-term scenarios using an average historic sedimentation rate of 1.6mm/year⁴² at the Cypress Grove Preserve on the right and near Hog Island Oyster on the left of the images.

Table 76 shows the increasing vulnerability of marsh functions at Cypress Grove as sea level rises and marshes are squeezed against steep slopes. The high marsh in long-term scenario 4 is about the same acreage as in the medium-term scenario 3. The acreage of mudflat does increase as the former low lying marsh areas are drowned. For Walker Creek, as shown in Table 77, the area of high and mid marsh diminishes considerably from current conditions to long-term conditions as the wetland migrates up the funnel shaped valley. Upstream in the Walker and Keys Creek valleys, river floodplains can be expected to expand onto adjacent flat terrain as sea levels rise.

Map 79. East Shore Marsh Habitat Shifts by Scenario at 1.5 mm/year Sedimentation



Source: ESA, 2015

⁴² Smith, S. V. and J. T. Hollibaugh (1998). The Tomales Environment, University of Hawaii, School of Ocean and Earth Science and Technology and San Francisco State University, Tiburon Center. <http://lmer.marsci.uga.edu/tomales/tomenv.html>

EAST SHORE

Table 76. Cypress Grove Preserve Marsh Habitat Distribution at 1.6 mm/year of Sedimentation (acres)

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	0	0	0	1	4	< -1.17

Source: ESA, 2015, OCOF

Table 77. Walker Creek Area Marsh Habitat Distribution at 1.6 mm/year of Sedimentation (acres)

Habitat Type	Area (acres)			z* Range
	Baseline	Scenario 3	Scenario 4	
Transition zone	52	69	77	1.5 - 3
High salt marsh (salt grass)	48	13	17	1 - 1.5
Mid salt marsh (pickleweed)	26	13	7	0.75 - 1
Low salt marsh (cordgrass)	43	70	47	0 - 0.75

Source: ESA, 2015, OCOF

Recreation

A number of Tomales Bay recreational assets, such as Miller Boast Launch and the only all-tide Marconi Boat Launch may need to adjust to rising seas and have moderate adaptive capacity in the near- and medium-terms. In the long-term these assets are vulnerable to inundation. Several other visitor serving uses are in the vulnerable shoreline buildings. The loss of these assets could have economic and quality of life impacts for residents.

could cause structural damage and weaken the historic integrity and character. Archaeological Sites could be present in the exposure zones.⁴³

Emergency Services

Temporary or permanent flooding of Shoreline Highway could compromise emergency access between Marshall and Point Reyes Station.

Historic & Archaeological Resources

Exposed historic buildings on the shoreline include the Marshall Tavern, Marshall Store, and J. Shields and Sons Coal and Feed. Because these buildings are adjacent to the water, near-term sea level rise

⁴³ Newland, M. April 1, 2015. Sonoma State University, personal communication.

EAST SHORE

Map 80. East Shore Vulnerable Developed Assets



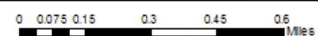
Exposed Roads

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

* Roads may also have utility pipes underneath, are used for recreation, and serve as emergency access in some locations.

- Agricultural Parcels
- Aquaculture
- Buildings
- Parcels
- Parkland
- Historic District
- Commercial
- Education
- Emergency
- Food
- Government Service
- Historic
- Institutional
- Recreation
- Residential
- Transportation
- Utilities

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

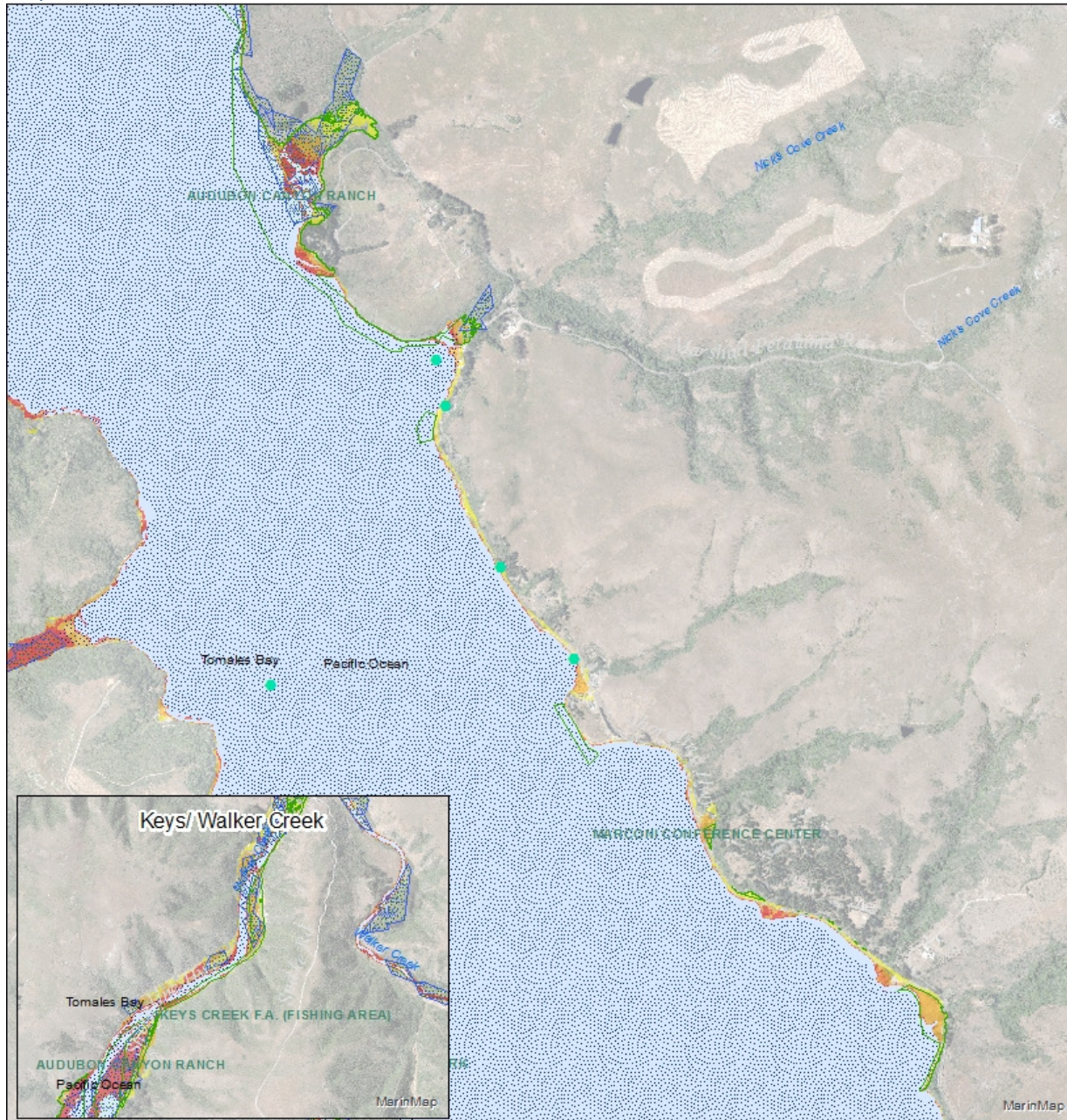


Source: Marin Map, Our Coast Our Future, CA Coastal Commission
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EAST SHORE

Map 81. East Shore Vulnerable Natural Resource Assets



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 0.075 0.15 0.3 0.45 0.6 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: 10/19/2015



DILLON BEACH

Community Profile: Dillon Beach

West Marin's northernmost community, Dillon Beach, features a small bluff top residential community, and low-lying recreational beaches, dunes, camping, fishing, and boating facilities. North of Dillon Beach to the County line is the most rural section of the study area and could see impacts to ranching and wildlife habitats. Key issues include:

- Flooding on Bay Drive leading to Lawson's Landing.
- The centralized Oceana Marin Sewer System could be degraded by erosion and waves.
- Bluff top homes could experience heightened erosion risks as sea levels rise.
- Camping capacity at Lawson's Landing could be reduced due to inundation and erosion.
- North of Dillon Beach, agriculture could face vehicular access constraints and decreases in land area due to erosion and higher water lines.

Dillon Beach is a 200-acre community with four subareas: Oceana Marin, the Village, Dillon Beach Resort, and Lawson's Landing. The 283 people living there in 2010 were primarily Caucasians, with a few residents of Latino, American Indian and Alaska Native; or Asian descent. They tend to be upper-middle class with a median age of 57.5 years⁴⁴ and household income of roughly \$200,000.⁴⁵ The average household size is slightly fewer than two persons. Of the 440 homes, 33 percent are occupied, and of those occupied, 85 percent are owner-occupied.⁴⁶

⁴⁴ U.S. Census Bureau Profile of General Population and Housing Characteristics: 2010

⁴⁵ U.S. Census Bureau, 2006-2010 American Community Survey, DP03

⁴⁶ U.S. Census Bureau Profile of General Population and Housing Characteristics: 2010

IMPACTS AT-A-GLANCE

Storm and tidal impacts already occur		2 businesses
Private tourism assets exposed	Residential Tourism Agriculture	Oceana Marin HOA Lawson's Landing Dillon Beach Resort Property Owners



Dillon Beach. Credit: Wanderbat

Vulnerable Assets

Dillon Beach's vulnerable assets include the centralized Oceana Marin sewer system, Bay Drive (connects Lawson's Landing to the rest of the community), plus recreational, natural resource, and agricultural assets including Dillon Beach Resort and Lawson's Landing facilities, grazing lands, and the Estero Americano and Stemple Creek Recreation Areas. Archaeological sites may also be vulnerable.

In addition to sea level rise, accelerated erosion under these sea levels is a significant threat in Dillon Beach. Maps 83, 84, and 85 at the end of this profile illustrate developed assets vulnerable to sea level rise, natural assets vulnerable to sea level rise, and accelerated erosion areas, respectively. The following sections provide greater detail for vulnerable assets in Dillon Beach.

DILLON BEACH

Table 78. Dillon Beach Vulnerable Assets

Asset (not exhaustive)	Tidal & Extreme Event Flooding Depth Estimates					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	
Lawson's Landing Facilities	2"	1'1"	<u>2'11"</u>	<u>3'10"</u>	<u>7'3"</u>	I, E, WS, HW, HS
Bluff Top Homes	X	X	X	X	X	E
Dillon Beach Resort Parking Lot					<u>1'6"</u>	I
Stemple Creek Recreation Area	X	X	X	X	X	HS
Estero Americano	water resource					HS
Sewage Pump Station	bluff top asset					E

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

Parcels & Buildings

The boat house at Lawson's Landing is a fully equipped boathouse and outboard shop with boat and motor rentals and supplies (e.g., bait, tackle, food, beverages, etc.), and is exposed and vulnerable sea level rise. Without the boathouse, visitors and residents could face new barriers to fishing, boating, and other recreational activities. Staff residences at Lawson's Landing are also vulnerable to flooding and erosion. These houses are critical to sustain the camp and recreation grounds and the services it provides.

shows cost estimates of up to \$300,000 in damages for these buildings and their contents exposed in Scenario 5, with the assumption that every building would face the same level of damage as designated by FEMA Hazus post-disaster tagging thresholds.

Nearly all of the damage could occur at the high end of the long-term scenarios.

Table 79. Dillon Beach Exposed Parcels & Buildings by Scenario

	Parcels	Buildings
Scenario 1	3	0
Scenario 2	3	0
Scenario 3	6	1
Scenario 4	7	1
Scenario 5	7	5

Source: Marin Map, OCOF

Table 80. Dillon Beach FEMA Damage Levels Applied to Buildings Exposed in Scenario 5

Buildings	Yellow Tag-Minor (\$5,000-17,000)	Orange Tag \$17,001+	Red Tag (County assessed improvement value)
5	\$50,000-85,000	\$85,001+	\$282,597

Source: Marin Map, OCOF

DILLON BEACH

Table 81. Dillon Beach Blufftop Buildings Vulnerable to Accelerated Erosion

	Buildings
Scenario 1&2*	8
Scenario 3*	22
Scenario 4*	43
Scenario 5*	101

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

Buildings here are not vulnerable to hazardous conditions as described in the other community profiles. However, 8-101 bluff-top residences could be vulnerable under accelerated erosion across scenarios 1-5. See [Map 84](#).

Transportation

Bay Drive connects Lawson’s Landing with the rest of Dillon Beach and could be exposed with near-term scenarios, complicating local residents’ and employees’ daily routines, preventing recreational access, and cutting off emergency access. North of Dillon Beach, exposed roads are primarily impacted at creek crossings and adjacent to the ranching properties, such as bridges along Middle Road and Valley Ford Franklin School Road.

Table 82. Dillon Beach Exposed Road Segments (Scenarios 2-5 include roads in previous scenarios)

Scenarios 1 & 2	Scenario 3	Scenario 4	Scenario 5
Bay Dr. (Private) Valley Ford Frank Sch Rd. (County) Middle Rd. (County)			

Source: Marin Map, OCOF

Utilities

The community’s water is supplied by Coast Springs Water Company and a community owned Estero Mutual Water Systems. Both are public water systems regulated by the State. Coast Spring Water Supply has seven groundwater wells in Dillon Beach, with a large portion of the water pumped

from a single large well adjacent to the channel of Dillon Creek. The remaining wells are not exposed. Estero serves approximately 132 single-family residential connections in Oceana Marin, and around 40 undeveloped lots in Ocean Beach. The two wells are not exposed to sea level rise; however, the system includes a catchment basin that could be impacted.

The centralized sewage treatment system for most of Oceana Marin’s 233 dwelling units is vulnerable to high waves and erosion. Loss or dysfunction of this sewer system would cause the homes to be unlivable, and potentially cause negative ecological and public health impacts from untreated sewage being released into the environment.

Working Lands

Coastal erosion and sea level rise may reduce the area of grazing land (ranging from 100 acres (Scenario 1) to 405 acres (Scenario 5), thus weakening the local agricultural economy. Rural ranchlands will see an increase in salinity in major creeks and creek tributaries that lead into the Pacific Ocean. Moreover, and of even greater concern, is access to and from the ranches along flooded roads throughout the region and county because getting supplies in an out of these operations is critical to their function and profitability.

Natural Resources

Due to the amount of dune sand present at Dillon Beach, the beach width has a higher capacity to transgress with sea level rise compared to other beaches in the study area. Because it is a dune system, a marsh elevation capital analysis was not appropriate here. However, marsh habitat at Lawson’s Landing is currently undergoing restoration efforts. North of Dillon Beach towards the County line, Stemple Creek, Americano Creek, and Estero Americano and San Antonio are unique natural resources that will likely see habitat shifts from tidal habitats to wet habitats in the Estero and from freshwater habitat to brackish habitat in the creeks.

Recreation

The private Dillon Beach Resort is a destination for vacationing, surfing, picnicking, bird watching, and more. The parking lot is subject inundation at the long-term (high end scenario) which, if not

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addressed could have negative economic impacts from reduced visitor spending. North of Dillon Beach, Estero Trail could flood where it accesses the beach and Stemple Creek Open Space Area could see increases in tidal habitat.

As a fishing, boating, and camping destination, the loss or deterioration of Lawson's Landing could also have negative impacts on the community. Without Lawson's Landing, visitor traffic to Dillon Beach could be significantly reduced, potentially leading to the closure of local businesses.

Coastal armoring at Lawson's Landing includes two seawalls and a berm to stabilize the area's dunes. If the seawalls fail, the campsites could become too wet or muddy to use. The berm is not recognized on the OCOF model as it was installed after the LIDAR was flown, and therefore its vulnerability should be further assessed in future studies.

Emergency Services

As discussed above, Bay Drive connects Lawson's Landing with the rest of Dillon Beach and flooding would cut off access for emergency vehicles, thus leading to health and safety impacts for Lawson's Landing residents and visitors.

Historic & Archaeological Resources

Archaeological sites could be present in the exposure zones.⁴⁷

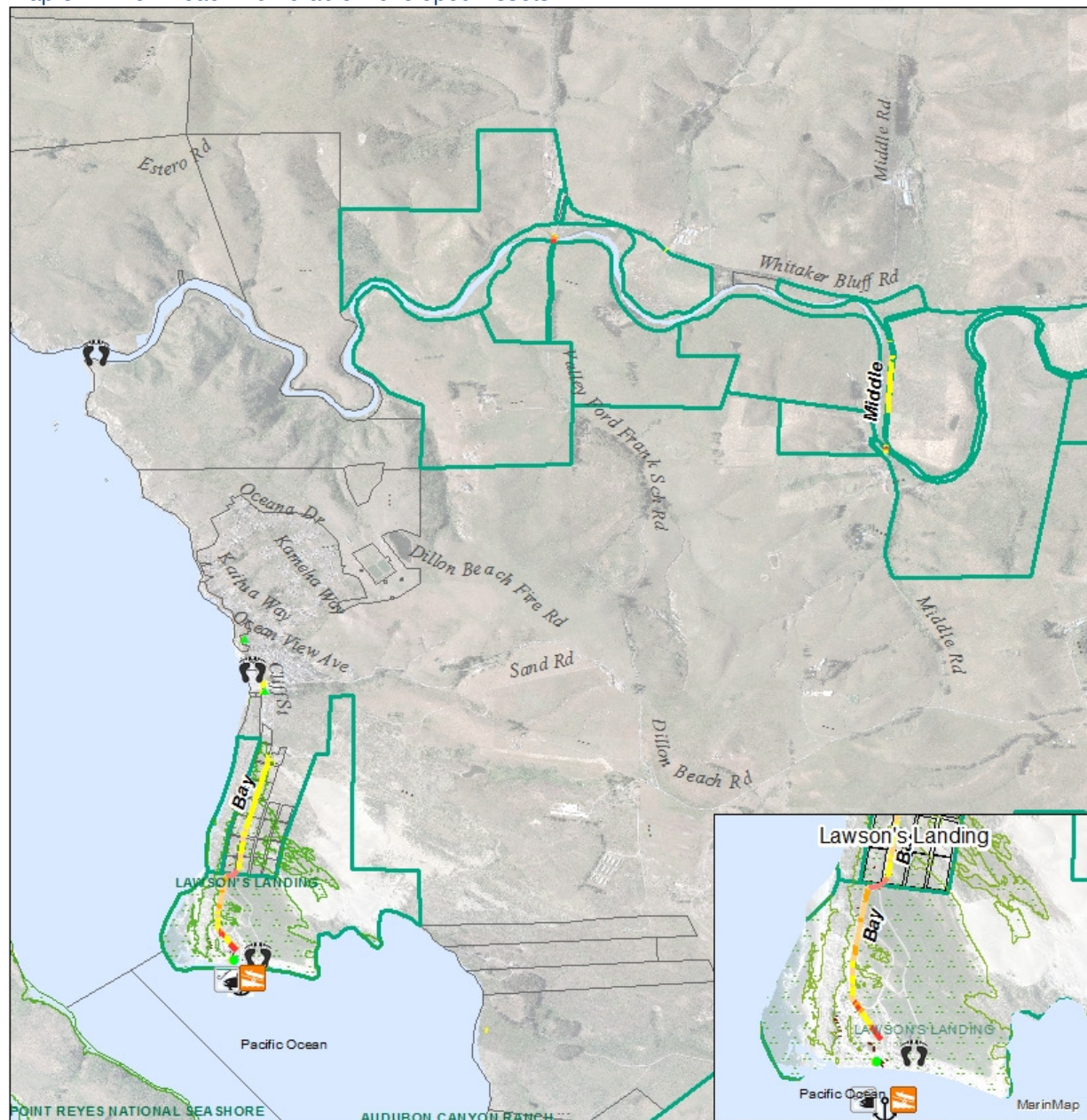


Mouth of the Estero Americano. Credit: California Coastal Records Project

⁴⁷ Newland, M. April 1, 2015. Sonoma State University, personal communication.

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Map 82. Dillon Beach Vulnerable Developed Assets



Exposed Roads

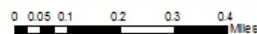
- 10" + Annual storm
- 10" + 20-year storm
- 20" + 20-year storm
- 40" + 100-year storm
- 80" + 100-year storm

- Agricultural Parcels
- Aquaculture
- Buildings
- Parcels
- Parkland
- Historic District

- Commercial
- Education
- Emergency
- Food
- Government Service
- Historic
- Institutional
- Recreation
- Residential
- Transportation
- Utilities

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

* Roads may also have utility pipes underneath, are used for recreation, and serve as emergency access in some locations.

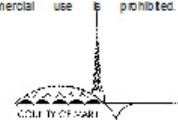


Source: Marin Map, Our Coast Our Future, CA Coastal Commission

Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets.

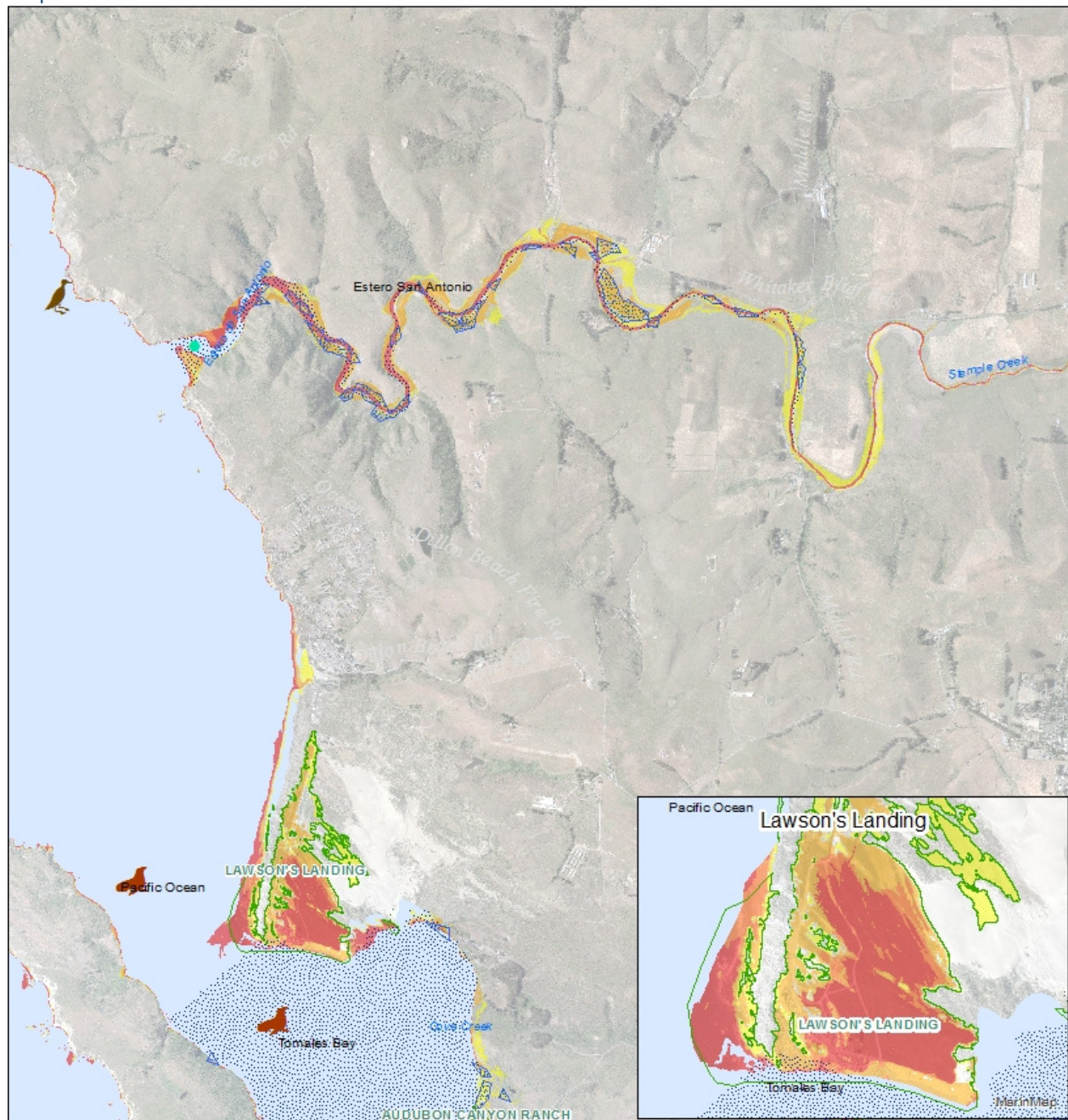
Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

Date: 10/19/2015



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Map 83. Dillon Beach Vulnerable Natural Resource Assets



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 0.15 0.3 0.6 0.9 1.2 Miles



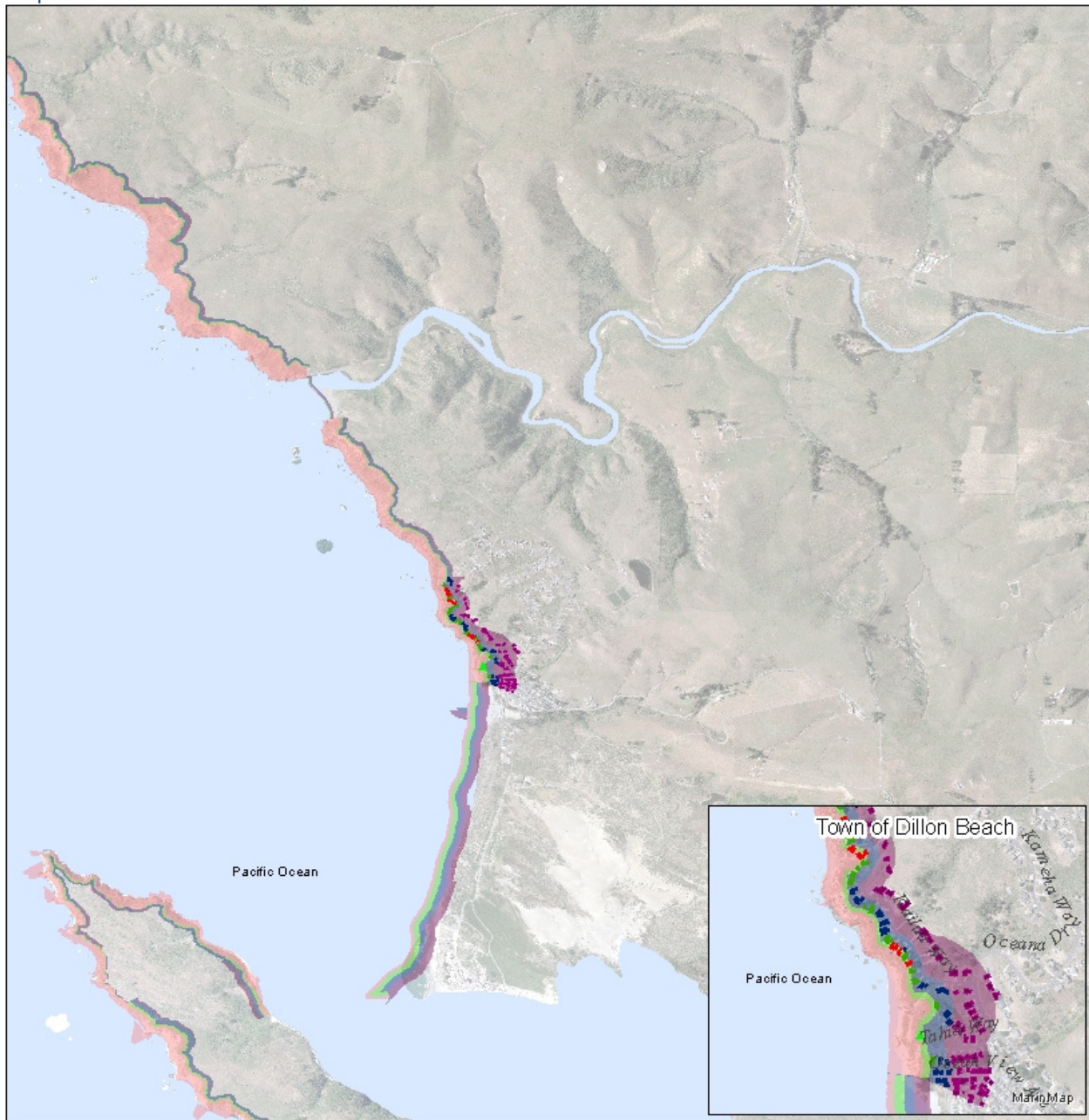
Source: Marin Map, Our Coast Our Future, Department of Fish & Wildlife
 Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness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

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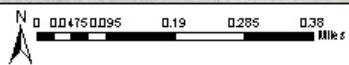


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Map 84. Dillon Beach Accelerated Erosion Based on C-SMART Sea Level Rise Scenarios



Accelerated Erosion	Buildings Exposed	Exposed Roads
■ Scenarios 1 & 2	■ Scenarios 1 & 2	— Exposed Roads
■ 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 hazards, 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 prohibited.

Date: 10/2/2015