BayWAVE ASSET PROFILES

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Asset Profile: Land

Land is a significant asset along the Marin shoreline that provides space for homes, commercial goods and services, recreation and education, worship, and the ability to create financial equity and wealth. Within Eastern Marin's steep narrow valleys, dry, flat, and easily developable land a very limited resource. While a majority of the vulnerable properties feature buildings, several are agricultural, park, service oriented, or natural in use, and have unique vulnerabilities (see Utilities, Working Lands, Recreation, and Natural Resources Profiles). The following are general key issues related to land vulnerability:

- Almost all land hosting human activity identified in scenarios 1, 3, and 5 could be vulnerable to tidal flooding on a near daily basis, with some months worse than others.
- Shoreline property that becomes tidally flooded and transitions to the water side mean sea level boundary would become public trust land, and may be required to pay a leasing fee to the State Lands Commission.
- Many properties are built on fill and mud, which could become soggier and, consequently, vulnerable to increasing rates of subsidence.
- Shoreline armoring protecting land from flooding, except in Hamilton and the Redwood Landfill, is not regulated or certified, and could expect overtopping after three feet of sea level rise.
- Properties untouched by rising tides may become isolated and cut off from essential services, such as wastewater service and travel through low-lying areas.
- San Rafael's Canal neighborhood, one of the lowest income and most diverse areas of the shoreline, could expect a large number of rented or leased properties flooded at the average higher high tide in the near-term. By the end of the century, the entire area could flood daily, from the shoreline to Interstate 580.
- Marin County communities feature several house boat and boat communities' that exist within the existing tidal range. These properties are especially vulnerable themselves, as is their connection to dry land.
- Sea level rise will likely simultaneously impact multiple jurisdictions and properties with differing ownership and financial capacities, creating imbalances in adaptation abilities.

IMPACTS AT-A-GLANCE: SCENARIO 6

13,000 properties	100,000+ people
$9 billion in assessed land value flooded (2016 dollars)	Stormwater and tidal impacts already occur along the shoreline and up major creeks
Residential, commercial, industrial, open space, parks, ranch lands, utilities, and transportation parcels	Property Owners County of Marin Sausalito Mill Valley Belvedere Tiburon Corte Madera Larkspur San Rafael Novato

Flooding around houseboats in Sausalito. Nov. 24, 2015. Credit: Marin County DPW

Subsidence in Marinship, Sausalito. Credit: Marin County CDA

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Corte Madera Ecological Reserve. Credit: C. Kennard

Acres

Near-term: Scenarios 1 &2
As shown in Table 3**Error! Reference source not found.**, overall, less than 5,000 acres could be tidally flooded by 2030, and an additional 3,000 acres could flood with saltwater during storm surges. These acreage figures amount to six percent of the study area as being vulnerable to tidal and storm surge flooding, and another three percent of land in the study area as being vulnerable to a 100-year storms surge alone.

In the near-term, as shown in Table 4, the most impacted communities by acreage are:

1. Bel Marin Keys, 1,759 acres
2. Waldo Point Harbor, 598 acres, and
3. San Rafael, 449 acres.

Following these top three are Novato with 430 acres, and Strawberry, Corte Madera, and St. Vincent's with around 200 acres flooded each. All other communities could anticipate about or less than 100 acres being exposed to sea level rise. Note that many of these acres, especially in Bel Marin Keys, San Rafael, Novato, Corte Madera, and Larkspur, include several hundred acres in marshland that buffer development from the Bay. Southern Marin shoreline properties east of US Highway 101, especially those resting on fill in the low lying areas, are the most vulnerable to tidal flooding and subsidence. Adding a 100-year storm surge impacts several more properties in these communities, and several others in Corte Madera, Bel Marin Keys, Santa Venetia, and Tamalpais Valley.

Table 3. Exposed Acres by Scenario

Scenarios		Acres	
		#	% of study area
Near-term	1	4,829	6
	2	8,072	9
Medium-term	3	6,685	8
	4	13,544	16
Long-term	5	16,332	20
	6	17,854	21

Source: MarinMap, CoSMoS

Table 4. Acreage Exposed in the Near-term

Location		Scenario 1	Scenario 2
		10" MHHW	+100-year Storm Surge
Municipalities	San Rafael	449	1,360
	Novato	426	1,336
	Corte Madera	230	430
	Larkspur	132	202
	Tiburon	48	47
	Mill Valley	44	103
	Sausalito	26	52
	Belvedere	24	85
Unincorporated Jurisdictions	Bel Marin Keys	1,759	1,794
	Waldo Point	598	610
	St. Vincent's	256	346
	Strawberry	255	282
	North Novato	118	575
	San Quentin	116	115
	Tiburon	102	108
	Almonte	99	137
	Paradise Cay	67	69
	Santa Venetia	29	211
	Pt. San Pedro	14	62
	Greenbrae Boardwalk	13	21
	Kentfield	10	28
	Bayside Acres	9	9
	Country Club	4	4
	Black Point	1	58
	Tamalpais	0	28
Study Area		**4,829**	**8,072**

Source: MarinMap, CoSMoS

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Table 5. Acreage Exposed in the Medium-term

Location		Scenario 3	Scenario 4
		20" MHHW	+100-year Storm Surge
Municipalities	San Rafael	869	1,590
	Novato	1,327	3,535
	Corte Madera	313	640
	Larkspur	147	299
	Tiburon	48	49
	Mill Valley	62	183
	Sausalito	35	65
	Belvedere	24	130
Unincorporated Jurisdictions	Bel Marin Keys	1,802	2,155
	Waldo Point	604	611
	St. Vincent's	339	353
	Strawberry	270	301
	North Novato	226	2,457
	San Quentin	115	115
	Tiburon	103	108
	Almonte	115	146
	Paradise Cay	69	74
	Santa Venetia	56	221
	Pt. San Pedro	58	65
	Greenbrae Boardwalk	14	22
	Kentfield	12	33
	Bayside Acres	10	10
	Country Club	4	4
	Black Point	62	346
	Tamalpais	1	29
	Marin City	None	3
Study Area		**6,685**	**13,544**

Source: MarinMap, CoSMoS

SMART Bridge, Novato. Credit: Marin County DPW

Medium-term: Scenarios 3 &4

A majority of the vulnerable communities do not see significant gains in tidally flooded acreage in medium-term scenario 3. Overall, less than 2,000 additional acres could expect MHHW tidal flooding over scenario 1. And, in general, 10 to 100 more acres are impacted in each community, though communities with large low-lying areas could expect twice as many acres exposed. This is observed for San Rafael, Novato, North Novato, and Santa Venetia. In this time period, Novato surpasses San Rafael in exposed acreage, though much of this land is marsh or wetlands, whereas San Rafael's exposed land is intensely developed. Within the study area, with the compounding 100-year storm surge in scenario 4, 5,000 more acres could flood compared to scenario 2. The 100-year storm surge is the major contributor to flooding on additional land in the medium-term compared to the near-term. This jump in vulnerable area is due to the potential failure of shoreline levees south of Novato.

Long-term: Scenarios 5 &6

At five feet of sea level rise, scenario 5, a much larger number of acres are impacted by higher high tides at 16,300 aces, and an additional 1,500 acres that could expect only storm surge flooding. The communities with the most land area that could be exposed to tidal flooding are:

1. Novato, 3,998 acres,
2. North Novato, 2,827 acres, and
3. Bel Marin Keys, 2,332 acres.

The flooded areas are primarily natural, agricultural, flood control, and sanitary district lands. Corte Madera follows these top three with 900 acres flooded at average high tides, though similarly, much of this land is marsh. With an additional 100-year storm surge, the majority of exposed acreage in the study area is in:

1. Novato, 4,000 acres,
2. North Novato, 3,000 acres
3. Bel Main Keys

Following these communities is San Rafael, with more than 2,100 acres, and St. Vincent's, with more than 1,400 flooded acres. Corte Madera could anticipate nearly 1,000 acres flooded from a storm surge. All other communities could expect 550 acres or less that could suffer 100-year storm surge flooding at 60 inches of sea level rise, scenario 6.

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Table 6. Acreage Exposed in the Long-term

Location		Scenario 5 20" MHHW	Scenario 6 +100-year Storm Surge
Municipalities	Novato	3,998	4,249
	San Rafael	1,856	2,121
	Corte Madera	906	994
	Larkspur	379	544
	Tiburon	190	273
	Mill Valley	169	180
	Sausalito	106	135
	Belvedere	84	149
Unincorporated Jurisdictions	North Novato	2,827	2,930
	Bel Marin Keys	2,332	2,350
	St. Vincent's	1,240	1,413
	Waldo Point	611	613
	Black Point	388	408
	Strawberry	328	375
	Santa Venetia	232	269
	Almonte	146	157
	San Quentin	122	135
	Tiburon	107	113
	Paradise Cay	91	111
	Pt. San Pedro	78	83
	Kentfield	53	118
	Tamalpais	28	30
	Greenbrae Boardwalk	24	24
	Bayside Acres	12	24
	California Park	9	10
	Country Club	9	10
	Marin City	7	36
Study Area		**16,332**	**17,854**

Source: MarinMap, CoSMoS

House boats. Waldo Point Harbor. Dec. 2014 king tide. Credit: Marin County DPW

Vulnerable Parcels

Land is divided into parcels for ownership and development purposes. Examining parcels can provide a window into the land uses, and how much of each land use, that could be exposed, vulnerable, and by when.

Near-term: Scenarios 1&2

As shown in Table 7, by number of parcels, the top three vulnerable jurisdictions are:

1. San Rafael, 700parcels,
2. Larkspur , 90 parcels, and
3. Mill Valley, 80 parcels.

This highlights that while not the highest in acreage, San Rafael could have the highest number of properties, and therefore people, impacted, requiring a much greater level of preparation and coordination. By proportion a few smaller unincorporated communities emerge as being the most vulnerable. These are:

1. Greenbrae Boardwalk, 62 percent of parcels,
2. Almonte, 32 percent of parcels, and
3. Waldo Pt. Harbor, 12 percent of parcels.

Greenbrae's 62 percent of parcels is alarming, especially given that the parcels are primarily residential that extend into existing tidal areas accessible only by a long narrow boardwalk. The municipalities could expect five percent or less of their parcels tidally flooded within this time period.

With the additional storm surge, scenario 2, Greenbrae Boardwalk could experience increased tidal flooding on 78 percent of the parcels on both sides of US Highway 101. In fact, the homes within the Corte Madera Creek corridor, west of US Highway 101, could be subject to greater flooding than those extending into the marsh lands. Similarly, 68 percent of Almonte could be compromised, as could 36 percent of Santa Venetia, as the existing levees could be overtopped. San Rafael could expect up to 11 percent of its parcels impacted with the additional storm. All other municipalities could expect less than six percent of the parcels impacted by a bay 100-year storm surge.

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By type, the primary land use that could be flooded is tax exempt. These are primarily sanitary and flood control district owned lands, along with some park land. The next most impacted land use by parcel count is residential. San Rafael, Greenbrae Boardwalk, Almonte, Waldo Point, and Larkspur areas that could tidally flood in the near-term are residential.

Countywide, two percent of parcels could be vulnerable in scenario 1 and an additional 4 percent could also face the storm surge. Broken down by major land use type, as shown in Table 14, one percent of residential, five percent of commercial, and eight percent of industrial parcels could face tidal flooding. Add on the bay storm surge, and an additional four, nine, and 27 percent, respectively, of parcels could weather storm surge flooding.

Table 7. Number and Proportion of Vulnerable Parcels in the Near-term

Location		Scenario 1		Scenario 2	
		#	%	#	%
Municipalities	San Rafael	709	4	1,926	11
	Larkspur	90	2	246	5
	Mill Valley	80	1	195	3
	Belvedere	51	5	56	6
	Tiburon	46	1	46	1
	Sausalito	40	1	61	2
	Corte Madera	9	0	201	6
	Novato	3	0	7	0
Unincorporated Jurisdictions	Waldo Point	59	12	68	13
	Greenbrae Boardwalk	54	62	68	78
	Bel Marin Keys	45	6	121	16
	Paradise Cay	28	8	34	9
	Strawberry	26	2	29	2
	Almonte	22	32	46	68
	Bayside Acres	19	9	19	9
	Tiburon	13	4	22	7
	St. Vincent's	7	10	12	18
	Santa Venetia	4	0	604	36
	Kentfield	2	0	4	0
	San Quentin	1	1	1	1
	Black Point	1	0	9	1
	Country Club	1	0	2	0
	Tamalpais	0		97	4
Study Area		1,310	2	3,826	6

Source: MarinMap, CoSMoS

By community, Greenbrae Boardwalk could expect up to 85 percent of its residential parcels compromised. Both Paradise Cay and Tiburon could expect 20 percent of their commercial parcels compromised. And San Rafael could expect 11 percent of their commercial and 17 percent of industrial parcels compromised. While only a few industrial parcels exist, nearly all of them could suffer tidal impacts.

Table 8. Vulnerable Parcels Land Uses in the Near-term

Land Use	Scenario 1		Scenario 2	
	#	Acres*	#	Acres*
Multi-family Residential Improved	131	51	166	69
Multi-family Residential Unimproved	5	1	7	1
Mobile Homes	7	0	202	1
Single Family Attached	716	11	1,283	36
Single Family-Residential Improved	508	142	2,274	464
Single- Family Residential Unimproved	52	24	93	76
Floating Home	52	1	53	1
Commercial Improved	249	311	437	640
Commercial Unimproved	22	109	67	275
Industrial Improved	109	57	181	123
Industrial Unimproved	11	3	25	143
Common Area	13	50	39	178
Rural Unimproved	0	0	1	169
Exemption Improved	0	0	3	223
Exemption Vacant	0	0	0	0
Tax Exempt	1	28	6	201
No Data	20	13	46	38

**Whole parcels are summed, not just the exposed portion of the parcel. Source: MarinMap, CoSMoS*

With the additional storm surge, these communities and several other could expect sizeable impacts to residential, commercial, and industrial properties, both improved and unimproved. For example:

- Greenbrae Boardwalk could expect nearly 100 percent of its residential parcels to flood.
- Santa Venetia could expect nearly 40 percent of its residential parcels to flood with surge waters.
- Bel Main Keys and Waldo Point Harbor could expect 14 percent of residential parcels to flood.
- Waldo Point Harbor could anticipate 16 percent of its industrial parcels to be compromised.
- Tamalpais Valley could expect more than 75 percent of their commercial parcels long Shoreline Highway to be compromised.
- Almonte could also see a considerable 50 percent of commercial parcels flooded, and even more considerable, the less than 10 industrial parcels could flood.
- San Rafael could expect nearly 10 percent of residential, 25 percent of the commercial compromised, and 52 percent of industrial parcels to suffer from temporary flooding.
- Eighty-three percent of Larkspur's industrial parcels could face storm surge flooding.
- Finally, Corte Madera could expect nearly 20 percent of commercial parcels to flood.

Medium-term: Scenarios 3 and 4

Medium-term scenarios 3 and 4 comparisons for parcels and land use are relatively similar to, though marginally more severe than, scenarios 1 and 2. The top three locations with the greatest number of vulnerable parcels are:

1. San Rafael, 1,301parcels,
2. Larkspur, 121 parcels, and
3. Bel Marin Keys, 97 parcels.

Adding the storm surge alters this order with San Rafael still topping the list, with more than 2,000 flooded parcels, Santa Venetia following with more than 650 parcels, and Corte Madera with slightly less than 650 parcels. Flooded parcels account for nearly 40 percent of the residential parcels in Bel Marin Keys. Several hundred parcels are also vulnerable in Larkspur and Mill Valley. Also of note, Belvedere Lagoon area homes could be temporary flooded with saltwater during a storm surge event.

Canal neighborhood, San Rafael, is highly vulnerable to sea level rise. Credit: MarinMap

As shown in Table 9, he ranking of communities by percent of parcels that could experience tidal flooding in medium-term scenario3 are:

1. Greenbrae Boardwalk, 66 percent of parcels
2. Almonte, 47 percent of parcels, and
3. St. Vincent's, 18 percent of parcels.

The additional 100-year storm surge increases the portion of vulnerable parcels to alarming levels in Greenbrae and Almonte. The top three vulnerable communities by proportion of parcels flooded during a storm surge event are:

1. Greenbrae Boardwalk, 80 percent of parcels,
2. Almonte, 76 percent of parcels, and
3. Santa Venetia, 36 percent of parcels.

Looking closer at land use county wide shows that the majority is vulnerable parcels is made up of residential parcels. This includes multi-family, single-family, and floating homes. As shown in Table 14, by proportion, about 20 percent of industrial parcels could anticipate tidal flooding at MHHW. At the community level:

- *All* of the residential parcels in Greenbrae Boardwalk could face some storm related flooding on the marshland parcels and the associated landward parcels, where many residents park their vehicles.
- If Santa Venetia's existing levees are overtopped as predicted, nearly 40 percent of

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the residential parcels there could anticipate temporary bay flooding.

- Similarly, Belvedere could expect storm surge flooding on up to 22 percent of residential parcels.
- Corte Madera could experience storm surge flooding on 57 percent of its industrial parcels, and sixteen percent of its residential parcels eat of US Highway 101.
- Larkspur could expect storm flooding on 90 percent of its industrial parcels east of US Highway 101.
- San Rafael could experience flooding on 57 percent of industrial parcels and 28 percent of commercial parcels.
- Bel Marin Keys could anticipate storms urge flooding on 23 percent of residential parcels.

Table 9. Number & Proportion of Vulnerable Parcels by Community in the Medium-Term

Location		Scenario 3		Scenario 4	
		#	%	#	%
Municipalities	San Rafael	1,301	7	2,188	12
	Larkspur	121	3	445	10
	Mill Valley	80	1	338	6
	Belvedere	52	5	210	21
	Tiburon	47	1	49	1
	Sausalito	48	1	68	2
	Corte Madera	68	2	635	17
	Novato	6	0	55	0
Unincorporated Jurisdictions	Waldo Pt.	64	13	73	14
	Greenbrae Boardwalk	57	66	70	80
	Bel Marin Keys	97	13	172	23
	Paradise Cay	38	10	54	15
	Strawberry	25	2	76	5
	Almonte	32	47	52	76
	Bayside Acres	19	9	20	9
	Tiburon	16	5	22	7
	St. Vincent's	12	18	13	19
	Santa Venetia	4	0	652	39
	Kentfield	3	0	9	0
	San Quentin	1	1	1	1
	Black Point	15	2	46	5
	Country Club	2	0	2	0
	Tamalpais	3	0	98	4
	North Novato	None		24	3
Study Area		3,191	5	5,372	8

Source: MarinMap, CoSMoS

Long-term: Scenarios 5 &6

Throughout the study area, more than 8,000 parcels, or 10 percent of parcels in the study area, could be impacted by 60 inches of sea level rise. Add on the 100-year storm surge, and nearly 12,800 parcels, about 20 percent of all parcels in the study area.

Table 10. Vulnerable Land Uses in the Medium-term

Land Use	Scenario 3		Scenario 4	
	#	Acres*	#	Acres*
Multi-family Residential Improved	102	41	144	56
Multi-family Residential Unimproved	4	1	5	1
Mobile Homes	0	0	166	1
Single Family Attached	465	6	1,092	29
Single Family-Residential Improved	270	94	1,402	305
Single- Family Residential Unimproved	43	28	69	50
Floating Home	52	1	53	1
Commercial Improved	133	123	343	505
Commercial Unimproved	17	89	42	177
Industrial Improved	49	23	158	99
Industrial Unimproved	5	2	19	5
Common Area	12	48	30	122
Rural Unimproved	1	28	1	28
Exemption Improved	14	9	31	17
Exemption Vacant	5	69	5	69
Tax Exempt	135	2,738	314	4,636
No Data	4	9	4	9

Source: MarinMap, CoSMoS

** Whole parcels are counted, not just the exposed portion of the parcel.*

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Table 11. Vulnerable Parcels at MHHW by Community in the Long-term

Location		Scenario 3	Scenario 4
		60" MHHW	+100-year Storm Surge
Municipalities	San Rafael	1,856	2,121
	Novato	3,998	4,249
	Corte Madera	906	994
	Larkspur	379	544
	Tiburon	106	135
	Mill Valley	190	273
	Sausalito	84	149
	Belvedere	169	180
Unincorporated Jurisdictions	Bel Marin Keys	2,332	2,350
	Waldo Point	611	613
	St. Vincent's	1,240	1,413
	Strawberry	328	375
	North Novato	2,827	2,930
	San Quentin	122	135
	Tiburon	107	113
	Almonte	146	157
	Paradise Cay	91	111
	Santa Venetia	232	269
	Pt. San Pedro	78	83
	Greenbrae Boardwalk	24	24
	Kentfield	53	118
	Bayside Acres	12	11
	Country Club	9	10
	Black Point	388	408
	Tamalpais	28	30
	Marin City	7	36
	California Park	9	10
Study		**6,685**	**16,332**

Source: MarinMap, CoSMoS

Marin Yacht Club, San Rafael. Credit: Marin CDA

By number of parcels, the top three impacted communities in long-term scenario 5 are:

1. San Rafael, 2,650 parcels,
2. Corte Madera, 1,104 parcels, and
3. Novato, 800 parcels.

San Rafael, one of the largest communities in the study area, is the most impacted with more than twice as many impacted parcels as the next highest municipality. In San Rafael, the 2,650 vulnerable parcels account for 15 percent of all parcels, 12 percent of residential, and 40 percent of commercial parcels. With the additional 100-year storm surge, an additional 1,000 parcels in San Rafael could be vulnerable to temporary floodwaters. This could damage one fifth of the city overall, with 20 percent residential and 50 percent commercial parcels vulnerable.

According to San Rafael asset managers, vulnerable buildings include 30 grocery stores, 10 pharmacies, 16 medical clinics, 48 doctor offices, 35 childcare facilities, five residential care facilities, seven convalescent facilities, 16 gas stations, 29 building supply stores, and other critical facilities. These businesses contain critical goods, such as food, medical, and buildings supplies.

The second most impacted community by number of parcels, Corte Madera, is also the second most impacted by proportion of vulnerable parcels. One third of Corte Madera parcels could be vulnerable to sea level rise, and more than 40 percent of parcels could be impacted by additional storm surge at this sea level. Nearly 30 percent of residential and 70 percent of commercial parcels could be impacted as well. Adding the storm surge at this sea level, Corte

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Madera could anticipate impacts to nearly 40 percent of the residential parcels, and 80 percent of the commercial parcels. These properties include homes and major regional retailers.

Novato is the next highest by count; however, these parcels constitute a small percentage of residential and commercial parcels in the community, as many of these parcels are not developed. Larkspur follows, nearing 700 parcels, with a large portion of vulnerable commercial parcels. Similar is true for Tiburon. In Belvedere, 30 to 40 percent of parcels are vulnerable, including 30 to 40 percent of residential and commercial parcels. With the storm surge, these numbers rise to 50 to 60 percent. Mill Valley and Sausalito could anticipate significant impacts as well, especially with the 100-year storm surge associated with scenario 6.

The top three vulnerable communities by portion of parcels flooded tidally by long-term scenario 5 are:

1. Bel Marin Keys, 94 percent,
2. Greenbrae Boardwalk, 80 percent, and
3. Almonte, 78 percent of parcels.

This outcome mirrors earlier outcomes, where the smallest shoreline communities could expect flooding throughout the entire developed area.

With respect to land use, 10 percent of residential parcels county wide could become vulnerable by long-term scenario 5. While less significant in number, by proportion, a concerning 27 percent of commercial, and 37 percent of industrial parcels county wide could be vulnerable to tidal flooding at MHHW with 60 inches of sea level rise.

The 740 commercial parcels in the study area that could flood at MHHW host 1,720 buildings with 115 living units that would become useable. Vulnerable businesses are concentrated in San Rafael, with more than 550 impacted parcels with structures, with Corte Madera, Larkspur and Sausalito being the next most impacted, nearing 100 parcels with structures each. Vulnerable residential parcels host approximately 8, 450 living units that would flood directly, or at least be difficult to leave or return to.

In unincorporated Marin, Strawberry could expect about 15 percent of commercial parcels to be impacted by sea level rise, and 30 percent of the commercial parcels to be impacted with the additional storm surge, though primarily in the parking areas. Commercial parcels in Black Point tend to be located in the low-lying State Route 37 corridor, and could tidally flood on about 30 percent of parcels, and storms urge flood an additional five percent of parcels. Waldo Point Harbor house boats and commercial areas could also be significantly impacted, especially to the 100-year storm surge.

Table 12. Number & Portion of Vulnerable Parcels in the Long-term

Location		Scenario 5		Scenario 6	
		#	%	#	%
Municipalities	San Rafael	2,646	15	2,646	15
	Larkspur	687	15	687	15
	Mill Valley	361	6	361	6
	Belvedere	356	36	356	36
	Tiburon	145	4	145	4
	Sausalito	88	3	88	3
	Corte Madera	1,104	30	1,104	30
	Novato	800	4	800	4
Unincorporated Jurisdictions	Waldo Pt.	75	15	75	15
	Greenbrae Boardwalk	70	80	70	0
	Bel Marin Keys	711	94	711	94
	Paradise Cay	103	28	103	28
	Strawberry	155	9	155	9
	Almonte	53	78	53	78
	Bayside Acres	23	11	23	11
	Tiburon	18	5	18	5
	St. Vincent's	22	32	22	32
	Santa Venetia	653	39	653	39
	Kentfield	52	2	52	2
	San Quentin	1	1	1	1
	Black Point	66	8	66	8
	Country Club	6	1	6	1
	Tamalpais	94	4	94	4
	North Novato	30	4	30	4
	California Park	41	15	41	15
	Marin City	None		20	4
	Pt. San Pedro	None		5	50
	China Camp	None		5	45
Total		**8,360**	**13**	**12,763**	**19**

Source: MarinMap, CoSMoS

Table 13. Vulnerable Land Uses in the Long-term

Land Use	Scenario 5		Scenario 6	
	#	Acres*	#	Acres*
Multi-family	192	77	345	292

Residential Improved				
Multi-family Residential Unimproved	12	2	19	10
Mobile Homes	204	1	220	1
Single Family Attached	1,948	57	2,776	83
Single Family-Residential Improved	4,070	801	5,940	1,384
Single- Family Residential Unimproved	147	88	275	375
Floating Home	52	1	53	1
Commercial Improved	643	796	1,016	1,795
Commercial Unimproved	95	308	133	364
Industrial Improved	204	128	289	519
Industrial Unimproved	38	162	53	170
Common Area	55	188	143	392
Agricultural Improved	1	169	2	640
Agricultural Unimproved	4	317	5	721
Rural-(Improved)	0	0	3	275
Rural Unimproved	10	660	20	880
Exemption Improved	71	44	110	367
Exemption Vacant	19	491	23	494
Tax Exempt	582	8,903	983	16,277
No Data	18	88	28	132

Source: MarinMap, CoSMoS

**Whole parcels are counted, not just the exposed portion of the parcel.*

Condos along Saltworks Canal, Strawberry. Credit: Marin County DPW

In scenario 6, by nearly a factor of nine, the majority of the storm flooded parcels consists of residential parcels, and amounts to 15 percent of all residential parcels in Marin County. In addition, while significantly fewer in number, the vulnerable commercial parcels are more than 40 percent of all commercial parcels in the County. More alarming is that more than 50 percent of industrial parcels could be impacted by flooding during a 100-year storm surge. The 1,149 commercial parcels hosting 2,180 businesses and 258 living units could be vulnerable by scenario 6, 60 inches of sea level rise and 100-yearstorm surge.

As shown in Table 14, the community with the greatest portion of their residential parcels impacted is Greenbrae Boardwalk, with 100 percent of parcels potentially facing tidal flooding. If the tide gates are open or are unable to hold back water, 95 percent of Bel Marin Keys residential parcels could face tidally flooding. In addition, Santa Venetia could anticipate tidal flooding on up to 40 percent of residential parcels, followed by Belvedere and Paradise Cay.

With the 100-year storm surge variable, 100 percent of Greenbrae Boardwalk and Bel Marin Keys could flood making living on dry land a challenge for each entire community. Sixty percent of residential parcels in Paradise Cay and fifty percent in Santa Venetia could flood during a storm surge, only ten percent of which would only suffer storm surge flooding, while the other parcels would experience both tidal and storm surge flooding.

The community with the greatest portion of commercial parcels impacted by tidal flooding at 60 inches of sea level rise is Tamalpais Valley, where much of the commercial development is along

Shoreline Highway in Tamalpais Junction. Corte Madera's vulnerable highway corridor commercial development constitutes 66 percent of all commercial parcels in Corte Madera. Tiburon follows, with 64 percent of commercial parcels, concentrated in the downtown Tiburon area, under tidal influence by long-term scenario 5.

By long-term scenario 6, both North Novato, at Binford Road, and Black Point, along State Route 37, could expect 100 percent of commercial parcels to flood. Belvedere and Almonte could expect more than 80 percent of commercial parcels to flood. Tamalpais Valley and Corte Madera could anticipate about 80 percent of commercial parcels flooding.

By long-term scenario 5, all industrial land in Larkspur and Almonte could flood at MHHW. More than 70 percent of Corte Madera and North Novato industrial parcels could flood at the average higher high tide. By long-term scenario 6, these areas would experience additional storm surge flooding. In addition, 100 percent of North Novato and Pt. San Pedro industrial land could be compromised during a 100-year storm-surge event. San Rafael could suffer, followed by Sausalito, which could expect 62 percent of the industrial parcels to flood with surge waters.

Landfill Sites

Marin residential and business garbage is disposed of at Redwood Landfill. This site may be vulnerable to sea level rise; however, the CoSMoS model does not incorporate recent improvements to the levees surrounding the site intended reduce flooding potential. Thus, modeled sea level rise projections likely overestimate flooding potential on this site. Waste Management makes regular improvements to the levees to account for subsidence, sea level rise, and pest damage.

The formally operated and now inactive landfill sites in the exposure area are:

- San Quentin Disposal Site, San Rafael: Vulnerable at the existing Marin Honda dealership. Vulnerable by scenario 5.
- Ghilotti Brothers Disposal Site, San Rafael: Site is completely surrounded by tidal waters by scenario 5 water levels.
- Horst Hanf Landfill, now Bayview Business Park, San Rafael: Vulnerable at about 40 inches of sea level rise, between scenarios 3 and 5.
- Bellam Landfill, San Rafael: Vulnerable by scenario 5.
- Hamilton Army Airfield Landfill #26: Vulnerable by scenario 5.
- Dunphy Park, Sausalito: Completely covered by, scenario 5.
- Larkspur Disposal Site (Piper Park): Impacts as early as 40 inches of sea level rise, between scenarios 3 and 5, and could anticpate site wide impacts by scenario 5.
- Mill Valley Dump, now Mill Valley Middle School, vulnerable to overland flooding by scenario 5.

Landfills are often subjected to subsidence because they are typically located where marshes once existed, and because buried materials settle over time. If toxic substances are contained in these sites, the toxin could be carried off the site and into the bay.

The maps on the following pages show the northern and southern study area parcels that could be vulnerable to the rising average higher high tide and 100-year storm activity modeled across the 6 scenarios. The areas in the call out circles enable the reader the see areas that are difficult to see on the large scale map. The circles do not indicate that these areas are more vulnerable than others along the shoreline.

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Table 14. Portion of Land Use Vulnerable to Sea Level Rise by Community and Onset

	Location	Scenario 1			Scenario 2			Scenario 3			Scenario 4			Scenario 5			Scenario 6		
		% of industrial	% of residential	% of commercial	% of industrial	% of residential	% of commercial	% of industrial	% of residential	% of commercial	% of industrial	% of residential	% of commercial	% of industrial	% of residential	% of commercial	% of industrial	% of residential	% of commercial
Municipalities	San Rafael	17	3	11	52	9	24	37	6	19	57	10	28	61	12	40	76	16	50
	Larkspur	0	2	0	83	5	11	30	2	4	91	9	13	**100**	15	18	**100**	25	48
	Mill Valley	0	1	1	0	3	5	0	1	1	0	5	13	0	6	10	0	12	32
	Belvedere	0	5	0	0	5	0	0	5	0	0	22	25	0	37	33	0	47	58
	Tiburon	0	1	7	0	1	7	0	1	9	0	1	7	0	3	64	0	7	**84**
	Sausalito	3	0	2	21	0	4	8	0	3	30	0	5	41	0	10	62	2	51
	Corte Madera	0	0	0	0	5	17	0	2	3	9	16	41	**76**	29	66	76	39	77
	Novato	0	0	0	0	0	0	0	0	0	2	0	1	5	4	3	22	6	9
Unincorporated Jurisdictions	Almonte	75	0	1	**100**		48	**100**	0	2	**100**	0	70	**100**	0	74	**100**	1	87
	Bayside Acres	0	11	1	0	11	0	0	18	1	0	11	0	0	13	0	0	21	0
	Bel Marin Keys	0	4	0	0	14	0	0	47	0	0	19	0	0	95	0	0	100	0
	Black Point	0	0	0	0	0	0	0	0	0	0	4	18	0	6	27	0	19	36
	California Park	0	0	0	0	0	0	0	0	0	0	0	0	0	18	0	0	23	100
	China Camp SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Country Club	0	2	0	0	0	0	0	3	0	0	0	0	0	2	0	0	6	0
	Greenbrae Brdwlk	0	85	0	0	97	0	0	85	3	0	100	0	0	**100**	0	0	**100**	0
	Kentfield	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	8	0
	Marin City	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	50
	North Novato	0	0	0	0	0	0	0	0	0	57	0	20	71	0	40	100	0	100
	Paradise Cay	0	20	1	0	12	0	0	19	1	0	19	0	0	36	0	0	66	0
	Pt. San Pedro	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	**100**	0
	San Quentin	0	5	0	0	0	0	0	5	0	0	0	0	0	0	0	0	11	0
	Santa Venetia	0	3	0	0	38	5	0	3	0	0	39	5	0	40	10	0	50	10
	St. Vincent's	0	0	1	0	0	0	0	0	1	0	0	0	0	0	**100**	0	**0**	**100**
	Strawberry	0	7	0	0	1	2	0	7	0	0	4	9	0	9	15	0	17	32
	Tamalpais	0	0	0	0	3	76	0	0	0	0	0	76	0	3	76	0	3	76
	Tiburon	0	20	0	0	9	0	0	20	0	0	9	0	0	7	0	0	32	0
	Waldo Point	4	1	3	16	14	5	13	1	3	16	14	47	16	0	60	16	14	73
	Marin County	8	1	5	27	5	14	19	2	6	32	6	18	37	10	27	53	15	42

Source: MarinMap, CoSMoS

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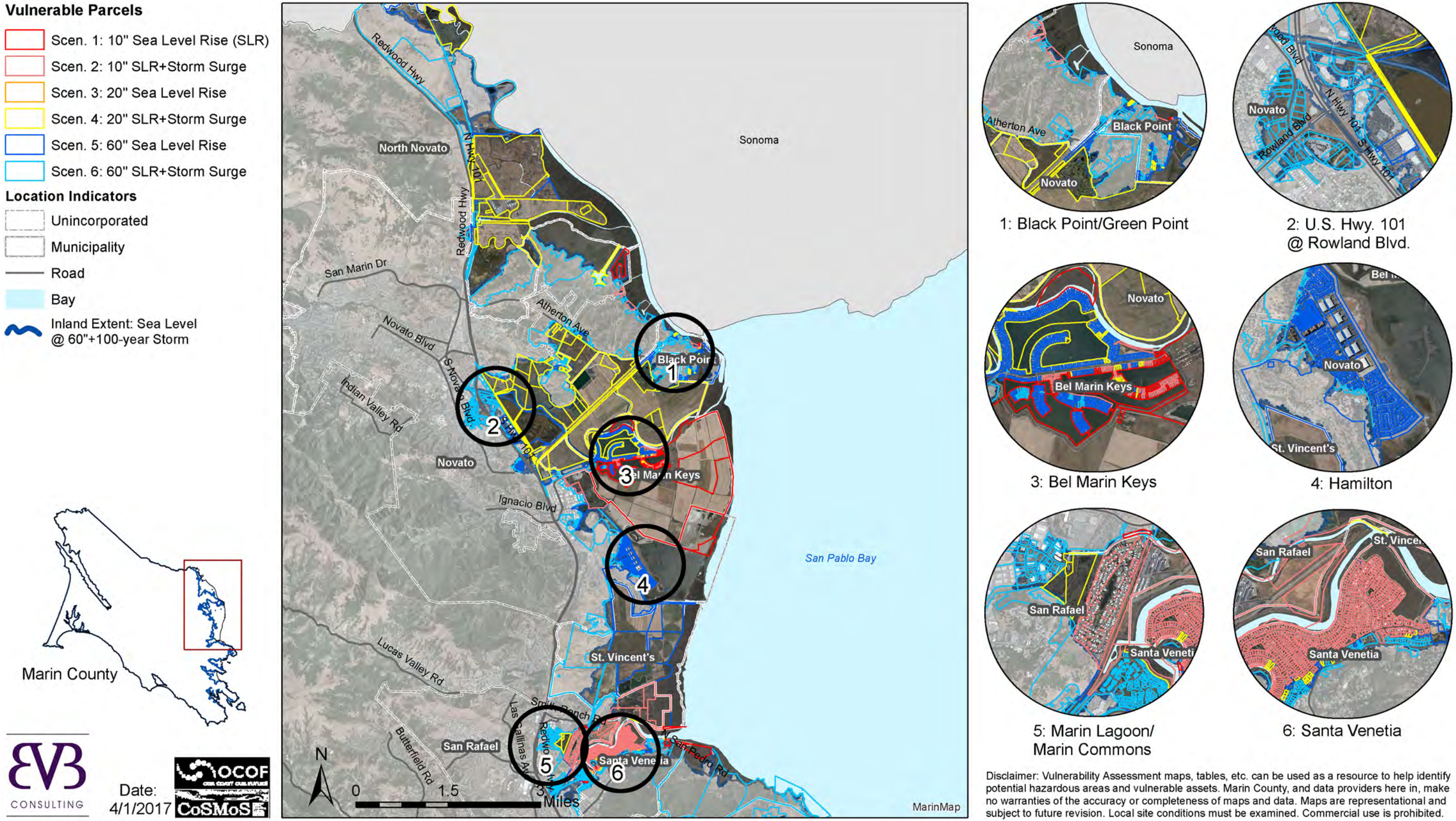
Map 10. Northern Study Area Parcels Vulnerable to Sea Level Rise



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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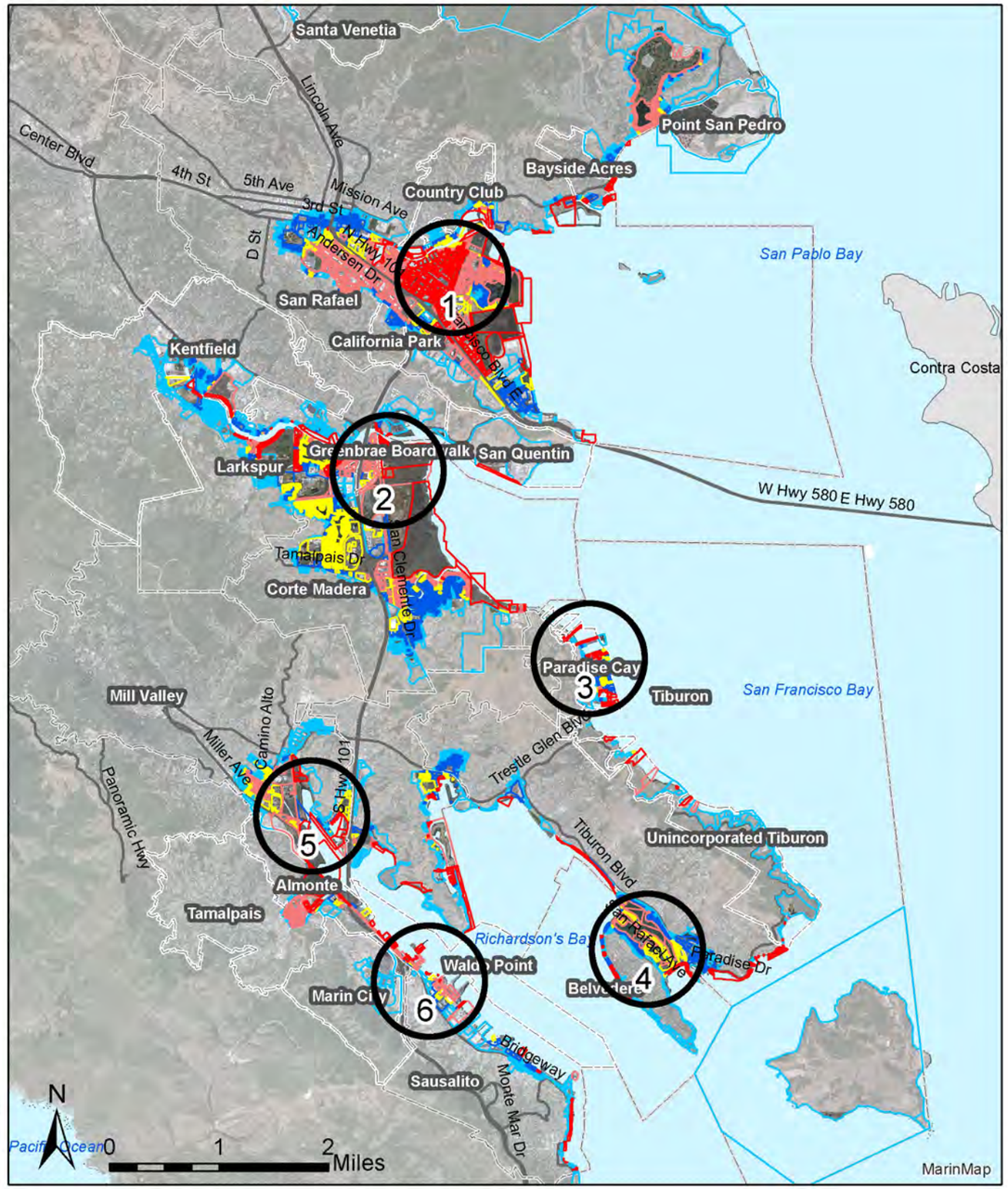
Map 11. Southern Study Area Parcels Vulnerable to Sea Level Rise and a 100-year Storm Surge

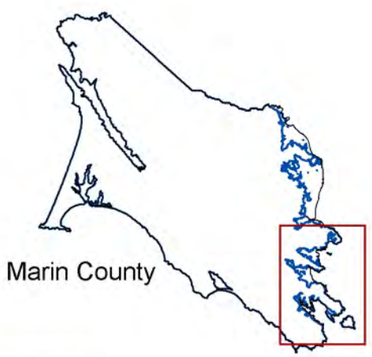
Vulnerable Parcels

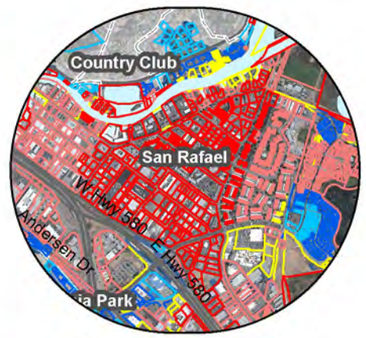
- Scen. 1: 10" Sea Level Rise (SLR)
- Scen. 2: 10" SLR+Storm Surge
- Scen. 3: 20" Sea Level Rise
- Scen. 4: 20" SLR+Storm Surge
- Scen. 5: 60" Sea Level Rise
- Scen. 6: 60" SLR+Storm Surge

Location Indicators

- Unincorporated
- Municipality
- Road
- Bay
- Inland Extent: Sea Level @ 60"+100-year Storm

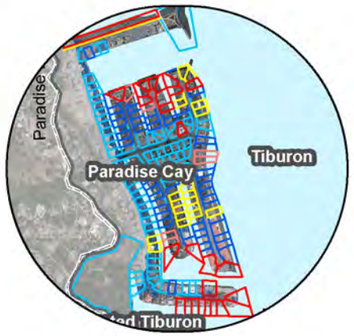




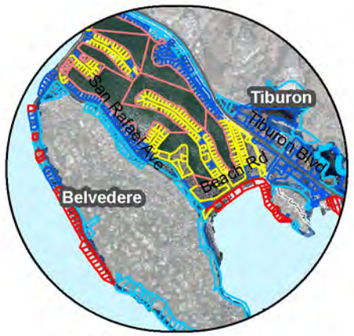


1: Canal Neighborhood

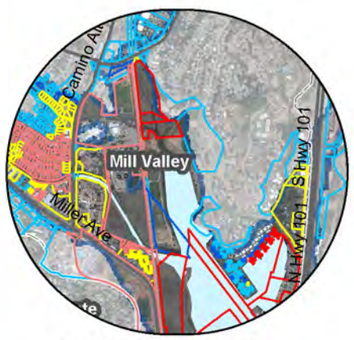
2: Greenbrae/Larkspur



3: Paradise Cay



4: Belvedere/Tiburon



5: Mill Valley Bayfront

6: Waldo Pt. Harbor

Date: 1/8/2017

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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Other Considerations

Economic

The Marin shoreline accounts for hundreds of millions of dollars in economic activity. The more than 12,000 vulnerable properties, account for $9 billion[1] in assessed land value as shown in Table 15. Buildings account for even more value, as presented in the Buildings Profile. Unincorporated Marin parcels that are expected to be vulnerable to sea level rise contribute $100 million[2] in annual property tax revenue to roughly 55 taxing agencies. Municipal tax revenues would add several hundred million in additional revenues to this figure. Table 16 breaks down the $100 million in property tax contributions from the vulnerable properties in unincorporated Marin. Improvements, such as buildings and utility services, also contribute to tax contribution figures.

Properties that become part of the tidal prism could face new or increasing lease costs for existing on what would become tidal public trust land. This would add an extra cost of living to shoreline in Waldo Point or Greenbrae Boardwalk, for example. To learn more about this see the Management sections. Consequently, in some cases, state regulatory requirements could be a hurdle for individual property owners in preparing for sea level rise and maintaining their properties in the most cost effective ways.

Finally, several areas are protected by and/or feature shoreline armoring, such as seawalls, revetments, levees, bulkheads, bluff walls, and other hard engineering structures, to impede flooding and erosion. These protective structures may be, or become, too low, requiring increased maintenance, replacement, or relocation as tides rise. Typically, any of these improvements can be costly to a land owner or to tax payers. Many structures are in need of repair to withstand existing conditions. Several structures in the northern study area are on public lands and maintained by a government agency. Individual private properties in Santa Venetia, and other shoreline locations also feature protective walls.

Table 15. Assed Value of Vulnerable Parcels in Long-term Scenario 6

Location	Assessed Land Value
Municipalities	
Belvedere	$514,534,915
Corte Madera	$587,230,682
Larkspur	$545,595,904
Mill Valley	$251,987,082
Novato	$367,196,698
San Rafael	$1,121,051,641
Sausalito	$208,295,600
Tiburon	$225,509,830
Unincorporated Jurisdictions	
Almonte	$257,783,545
Bayside Acres	$69,653,807
Bel Marin Keys	$189,484,482
Black Point	$160,685,655
California Park	$42,337,997
Country Club	$158,247,024
Greenbrae	$15,424,906
Kentfield	$1,680,999,994
Marin City	$114,975,806
North Novato	$186,992,022
Paradise Cay	$193,534,136
Pt. San Pedro	$26,235
San Quentin	$8,213,721
Santa Venetia	$347,647,404
St. Vincent's	$5,532,566
Strawberry	$954,668,631
Tamalpais Valley	$853,733,767
Tiburon	$170,837,044
Waldo Point Harbor	$6,174,871
Total	**$9,238,355,965**

Source: Marin County Department of Finance 2015/2016 tax year

[1] 2016 dollars
[2] 2016 dollars

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Table 16. Tax Generation for Parcels Vulnerable to Sea Level Rise Long-term Scenario 6

Tax District	Tax Revenue
County General	$22,835,222
Tamalpais High School District	$10,781,271
Marin Community College	$7,360,565
Education Revenue Augment	$7,303,352
Mill Valley School District	$6,991,178
Southern Marin Fire	$5,750,363
Kentfield School District	$5,225,279
Kentfield Fire	$4,109,315
Novato Unified School District	$3,765,050
County Library	$2,954,595
County School Service Fund	$2,528,240
San Rafael Elementary Schools	$2,253,634
Community Service Area (CSA) #19 Fire Protection	$1,950,984
Novato Fire	$1,906,311
San Rafael High School	$1,690,337
Ross Valley Sanitation No. 1	$1,564,305
Reed Union School	$1,446,789
Marin County Open Space	$1,020,102
Tiburon Fire	$795,261
Richardson Bay Sanitation	$745,599
Tamalpais Community Service District (CSD)	$649,472
Flood Control Zone (FCZ) 3 Richardson Bay	$635,130
Marin County Highway Lt	$615,373
Sausalito-Marin City School District	$595,858
Marin County Transit	$586,546
County Fire Department	$512,272
Ross School	$493,532
Strawberry Recreation	$473,938
Bel Marin Keys CSD	$443,596
CSA 17 Kentfield	$401,931
FCZ 7 Santa Venetia	$359,149
Mosquito Abatement	$317,948
Corte Madera Sanitation No. 2	$288,308
Marin City CSD	$270,722
FCZ 1 Novato	$215,209
Bay Area Air Quality	$205,089
#6 Novato Sanitation	$146,654
CSA 18 Gallinas	$128,756
FCZ 4 Bel Aire	$127,962
Almonte Sanitation	$108,938
Las Gallinas Valley Sanitary District	$104,146
FCZ 9 Ross Valley	$81,954
Larkspur-Corte Madera School District	$80,287
San Rafael Sanitation	$64,836
CSA 6 Santa Venetia	$57,811
Sausalito-Marin City Sanitation	$55,230
CSA 16 Greenbrae	$46,234
Tiburon Sanitation No. 5	$41,804
Murray Park Sanitation	$41,684
San Quentin Sanitation	$19,282
Alto Sanitation	$19,182
CSA 9 Northbridge	$12,074
North Marin Water	$10,822
Petaluma Joint High	$7,026
Dixie School District	$6,543
Santa Rosa Junior College-Laguna Joint School	$1,275
Lincoln School	$723
Total	**$101,205,044**

Source: S. Kucharos, County of Marin Department of Revenue, June 6. 2016

Environmental

Existing seawalls and other shoreline protective devices that could be enhanced or added to protect buildings could result in the loss of beaches, wetlands, and other habitats and recreational areas by preventing these areas from migrating inland. Industrial sites could contain toxic chemicals that could be ecologically damaging if it enters the bay waters. As tidewaters move into marshlands, high marsh, or areas with infrequent saturation could become saturated more often and shift to low marsh, and eventually mudflats, and lastly open water. This could have devastating impacts on natural and recreational resources. Developing new unimproved lands to replace the land that becomes undevelopable could destroy inland habitats. Additionally, upgrading infrastructure that already passes through sensitive marsh and tidal habitats could be temporarily impaired as room is made to undergo construction. To learn more about the outfall of these potential consequences, see the Natural Resources and Recreation Profiles.

Social Equity

The primary issue with respect to parcels is the difference in tenure. Property owners may be more able to prepare for and implement preparation measures to protect their wellbeing. Whereas, renters would not have the power or ability to change their residence in advance of sea level rise and would be dependent on the action of the property owner and larger public works. This is especially critical because a significant portion of the properties impacted in the near-term host large numbers of multi-family rental units, this disconnect could present challenges in reaching the residents and ensuring their safety.

Without programs to get the word out, renters may miss out on important information and resources to stay safe during storm events and prepare for sea level rise. With long-term sea level rise, displaced residents may not have access to equivalent or affordable housing near the jobs, schools, social networks, and facilities they rely on.

Public shoreline access may also be diminished as parks become inundated, impacting recreational opportunities for everyone, though these impacts could be disproportionately burdensome by lower-income households, especially those fish for food off of public piers and pathways. See the Recreation Profile to learn more about public land equity considerations.

Management

On County of Marin jurisdiction lands, the Baylands District provides for open space, outdoor recreation, and other open lands, including areas suited for park and recreational purposes, access to beaches, and areas that link major recreation areas. State and Federal areas are managed by policies of those governing agencies to provide public access as well.

The Bay Conservation Development Commission (BCDC) retains development permit authority over tidelands below mean high tide, submerged lands, and public trust lands. Potential state boundary changes could occur as waters rise and shift mean sea level rise inland. This would cause the public trust land boundary and regulations to move further inland. This could complicate existing property ownership and management.

In addition, political will and funding would be required to acquire land for necessary road alterations, or other public infrastructure relocations.

In most cases, facilities and structures on private property are the responsibility of the property owner. This can present complications when shoreline armoring is owned by individual property owners as is the case in Santa Venetia. Efforts to improve the levees on a comprehensive scale may prove challenging amongst so many decision makers

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BUILDINGS

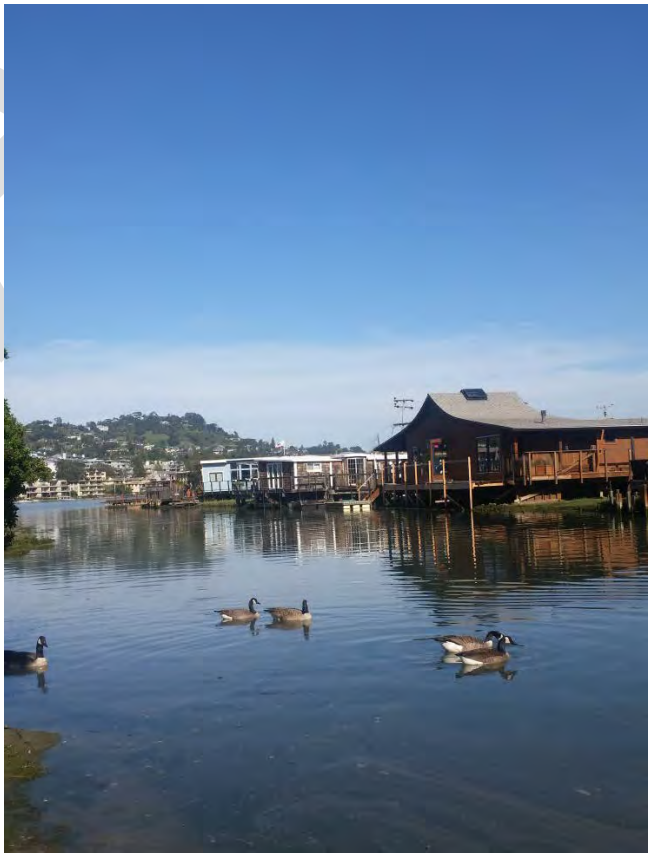
Asset Profile: Buildings

Buildings on the flooded parcels are significant assets along the Marin shoreline. Buildings house commercial activity, learning, worship, employment, home, and daily life. In addition, buildings provide a significant amount of wealth and equity for property owners. Moreover, everyone, despite age, income, or ethnicity uses and depends on the function of several buildings across the region. The following are key issues related to building vulnerability:

- Almost all buildings along Marin's shoreline could be vulnerable to tidal and/or storm surge flooding.
- Many homes and their surroundings are built on filled bay mud and could sink, or subside, as the ground below saturates with water.
- According to utility managers, the earliest threats of flooding and subsidence may be to non-structural building components, such as utility and mechanical systems at or below grade. Malfunctions could make a building unusable even if the building is dry.[3]
- Buildings untouched by rising tides may become isolated and cut off from essential services, such as wastewater service and roads.
- A large majority of existing armoring protecting buildings along the shoreline, except in Hamilton and the Redwood Landfill, could be overtopped daily after three feet of sea level rise.
- In San Rafael's Canal neighborhood, one of the lowest income and most diverse areas of the shoreline, a large number of residents and businesses could be impacted in the near-term. By the end of the century the entire area could flood daily from the shoreline to I-580 and US-101.
- Several public facilities, including three schools, the Tiburon Fire Station, San Rafael Fire Station 54, Larkspur Ferry and emergency fuel tanks, and the Sewerage Agency of Southern Marin (SASM) wastewater treatment plant could be vulnerable in the near to medium-term.
- The Belvedere/Tiburon Post Office, San Rafael Main Post Office, San Rafael Transit Center, and seven schools could be vulnerable to sea level rise in the long-term.
- Several retirement and/or lower income communities are impacted in the long-term.
- The majority of impacted buildings are on residential parcels.

IMPACTS AT-A-GLANCE: SCENARIO 6

12,000+ homes, businesses, & institutions	100,000+ people
Billions of dollars in built assets vulnerable	Regional
Houseboats, mobile homes, multi-family housing, single-family housing	Property Owners County CDA Sausalito Mill Valley Belvedere Tiburon Corte Madera Larkspur Corte Madera San Rafael Novato



Lagoon homes on Boardwalk I, Corte Madera Creek. Larkspur. Credit: BVB Consulting LLC

[3] See Appendix A for a list of interviewed utility managers.

BUILDINGS

Structural Factors

Most of the vulnerable buildings in the study area, especially residential and office, are wooden single-story or two-story buildings, and are susceptible to water damage from flooding and storm surges. Buildings built prior to 1970 typically have T-footing foundations that extend 18 inches deep. Such buildings are prone to scouring from water hitting above their foundations, and their wooden floors are more likely to slide off the foundation. This foundation type is very common amongst the vulnerable buildings in the study area.

Homes built after 1970 are secured to drilled piles 20-30 feet deep with reinforced steel cages and concrete to connect the homes to the foundation. These buildings are engineered to resist settling and earthquake impacts, and could withstand lateral forces from water and wind during storms. However, much of the older housing along the shoreline was built beginning in the 1950's. Areas such as Almonte, Waldo Point Harbor, and Marin City in Southern Marin were built as work force housing under low budget conditions. In the Canal neighborhood, vulnerable buildings are a mix of apartment complexes, light industrial sites, and neighborhood commercial sites. One section, near Spinnaker Point, is a single family home subdivision that is not directly at risk until later in the century; however, vehicular access during high tides and storm surges may prove challenging before then.

In addition, Almonte, Belvedere, Santa Venetia, Paradise Cay, Bel Marin Keys, the Corte Madera shoreline, the Marinship neighborhood of Sausalito, and shoreline and downtown portions of San Rafael were built on bay fill and mud, and already experience subsidence. These areas could anticipate increased rates of subsidence as bay waters saturate the soil from the below. Tamalpais, Corte Madera, Santa Venetia, Bel Marin Keys, Belvedere, and Almonte are bordered by earthen berms, or levees, that provide protection under current sea levels; however, these structures could expect overtopping after three feet of sea level rise. Bel Marin Keys, Corte Madera, and Belvedere also manage lagoons that are relatively protected from tidal influences if properly managed and overtopping does not occur.

A few mobile home parks are at risk including the Los Robles Park in Novato, Marin Valley Country Club in Novato, Contempo Marin in San Rafael, Golden Gate Trailer Park in Larkspur, and Marin RV Park in Greenbrae. All of these are relatively close to the shoreline marshes and are prone to flooding.

Floating homes are another major housing type in southern Marin and could be some of the most impacted. Many of these homes are tethered to pylons with u-locks that could float off the top of the pier if the tide is high enough. Others are tied with ropes that have their limits, and if the tides rise higher than the ropes, the boat could sink. The most vulnerable houseboat types, known as arks, are attached to the ground on a thick concrete foundation and do not fluctuate with the tides. About 20 arks are harbored in Richardson's Bay. A few others exist in Greenbrae Boardwalk and on Boardwalk One in Larkspur.

All 450 house boats in Richardson's Bay have the following vulnerabilities in common.

- They have utility lines tied to the docks and many of the docks are at a fixed elevation.
- Front entrances too many of the homes are on the lower level linked to the main dock with finger docks that go down or up to the tide. If the tide is too high, the finger docks may be dangerously slanted, or even flooded at one end or the other. These ramps are already relatively steep at king tides according to the Richardson Bay Floating Homes Association.
- In addition, the parking and access areas could be flooded and are already prone to continuous subsidence.

On the eastern half of Greenbrae Boardwalk, metal pipes are fixed to the boardwalk.

Finally, though not buildings, unauthorized residential boats anchored in the waters of Richardson Bay are highly vulnerable to storms and higher tides. According to the Richardson Bay Floating Homes Association, about 250 boats are in the Bay as residences, though some may be junk boats without residents.

Commercial structures, except for those on piers, and a few wooden structures, tend to be cinder block construction with stucco or paint sealing. Cinder block buildings built over twenty years ago are likely unreinforced and more vulnerable than newer reinforced buildings.

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BUILDINGS

Greenbrae Boardwalk. April 2016. Credit: BVB Consulting LLC

Table 17. Vulnerable Buildings by Scenario

Scenario		Buildings	
		#	%
Near-term	1	717	1
	2	4,498	6
Medium-term	3	2,013	3
	4	5,608	7
Long-term	5	9,167	12
	6	12,138	16

Source: MarinMap, CoSMoS

Overall, Marin County shoreline properties, especially those on fill in the low-lying areas east of US Highway 101, are the most exposed and vulnerable to flooding, storm surges, and subsidence. The following sections present the available data for buildings in the near-, medium, and long-terms.

Near-term: Scenarios 1 & 2

In the near-term scenario 1, 10 inches of sea level rise, more than 700 buildings could be vulnerable to tidal flooding. The buildings are concentrated in:

1. San Rafael, 410 buildings,
2. Greenbrae Boardwalk, 72 buildings, and
3. Waldo Point Harbor, 61 buildings.

Table 18. Physical Vulnerabilities of Buildings

Factors	Influence
Building Elevation	▪ At or below grade – If the lowest floor is as high as or below the flood level, it is susceptible to saltwater flooding. Mechanical or electrical equipment, pumps, utilities, heat, ventilation, power, openings (e.g. windows, entryways, or ventilation grates), etc. can be vulnerable if at or below grade.[4] ▪ Bluff top developments are highly vulnerable to erosion and scouring of the bluff toe.
Materials	▪ Wooden buildings tend to be lighter and low-rise, and can incur structural damage.[5, 6] ▪ Cinder block, brick, and reinforced concrete built buildings are heavier, taller, and less vulnerable to damage.[7] Brick foundations are able to withstand up to 3 feet of flooding (highly unlikely unless building is very old).[8] ▪ Mobile and manufactured homes tend to be susceptible to flooding and may suffer in storm and high tide events.
Building Codes	▪ Buildings built before modern building codes and FEMA requirements for flood prone areas will be more susceptible.[9]
Surrounding environment	▪ Buildings in areas without or failing shoreline armoring are more vulnerable.
Foundation	▪ Older foundation types are more vulnerable to sea level rise. ▪ Buildings built on fill and/or bay muds could be vulnerable to worsening subsidence.

[4] The City of New York, *A Stronger, More Resilient New York* (2013), 75.
[5] Ibid.
[6] Bay Conservation and Development Commission, *Housing Indicators Table*. Unpublished document.
[7] The City of New York, *A Stronger, More Resilient New York* (2013), 75.
[8] Bay Conservation and Development Commission, *Housing Indicators Table*. Unpublished document.
[9] The City of New York, *A Stronger, More Resilient New York* (2013), 76.

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Homes along San Pablo Bay, San Rafael. May, 2016. Credit: BVB Consulting LLC

Table 19. Vulnerable Buildings in the Near-term

Location		Scenario 1		Scenario 2	
		#	%	#	%
Municipalities	San Rafael	410	2	1,846	10
	Larkspur	40	1	382	9
	Belvedere	32	2	84	5
	Tiburon	26	1	42	1
	Sausalito	21	1	113	4
	Novato	6	0	17	0
	Corte Madera	5	0	255	7
	Mill Valley	5	0	207	3
Unincorporated Jurisdictions	Greenbrae Boardwalk	72	59	112	91
	Waldo Point	61	16	89	23
	Bel Marin Keys	20	3	118	17
	Almonte	7	1	63	7
	Strawberry	7	0	58	3
	Paradise Cay	4	1	48	16
	Tiburon	1	0	18	6
	Santa Venetia			911	41
	Tamalpais			100	3
	Black Point			15	1
	North Novato			7	0
	Country Club			5	1
	Bayside Acres			3	1
	Pt. San Pedro			2	2
	China Camp			1	9
	De Silva Island			1	6
Total		**717**	**1**	**4,498**	**6**

Source: MarinMap, CoSMoS

Vulnerable buildings in San Rafael are concentrated in the Canal neighborhood, the lowest income and most diverse neighborhood in the region with many limited English proficient residents. Structures on Greenbrae Boardwalk and Waldo Point Harbor are houseboats that are highly vulnerable to higher high tides.

An additional storm surge, could impact more than 4,000 additional buildings, totaling six percent of the building stock in the study area. The top three communities with the highest number of vulnerable buildings under scenario 2 conditions are:

1. San Rafael, 2,000 buildings
2. Santa Venetia, 900 buildings, and
3. Larkspur, 400 buildings.

Of note, 250 buildings in Corte Madera, and 207 in Mill Valley could also experience flooding under the conditions of scenario 2.

By percent of building stock impacted under scenario 1 conditions, the top three vulnerable communities would be:

1. Greenbrae Boardwalk, 59 percent,
2. Waldo Point Harbor, 16 percent, and

3. Bel Marin Keys, 3 percent of buildings in the community.

These figures are presented in Table 19. During, a storm, significantly more buildings could be at risk, amounting to seven percent of buildings in the County. The top three communities by portion of building stock flooded are:

1. Greenbrae Boardwalk, 91 percent,
2. Santa Venetia, 42 percent, and
3. Waldo Point Harbor, 23 percent of buildings in the community.

These numbers are cause for concern in some of Marin's most unique small communities. And while this flooding may only be temporary, nuisance storm flooding could be reoccurring and devastating.

Flood Depth

Each property could flood with a different amount of water depending on the property's proximity to the Bay and its tributaries. While some buildings may be able to avoid some flooding because they are elevated above ground level, determining which of the 12,000 exposed buildings are elevated and by how much is beyond the scope of this report. Thus, the analysis in Table 20 assumes all vulnerable buildings are situated at ground level. This table illustrates how many of the vulnerable buildings are flooded with one, two, or ten feet of water in scenarios scenario 1, 3, and 5. Storm surge flooding in scenarios 2, 4, and 6, would add an additional three feet of flooding to the figures. In scenario 1, a majority of the vulnerable buildings could expect up to 3 feet of tidal flooding at MHHW. Flooding could be deeper at the highest tides and shallower at low tides. A few buildings could expect up to 9 or 10 feet of tidal flooding in the near-term.

Medium-term: Scenarios 3 & 4

In the medium-term, several more buildings in the communities vulnerable in the near-term could be flooded, especially during a 100-year storm surge. At 20 inches of sea level rise, scenario 3, over 2,000 buildings across the study area could be vulnerable to tidal flooding, about twice as many as in the near-term. By community the communities with the most buildings vulnerable to tidal flooding are:

1. San Rafael, 1,088 buildings,
2. Larkspur, 165 buildings, and
3. Corte Madera, 138 buildings.

Table 20. Vulnerable Buildings by Flooding* at MHHW in Near-term Scenario 1

Average Flood Level (feet)	Number of Buildings
0.1-1	156
1.1-2	204
2.1-3	284
3.1-4	48
4.1-5	9
5.1-6	9
6.1-7	7
7.1- 8	8
8.1-9	3
9.1- 10	1

**Flood depth data is not available for every vulnerable building. Buildings that already exist beyond the mean sea level are not included.*

Source: MarinMap, CoSMoS

San Rafael's Canal neighborhood continues to experience the most severe flooding. In larkspur, the vulnerable buildings are on Boardwalk One and along the Corte Madera Creek. A stormy bay could surge waters into more properties in these communities and have some striking impacts in additional communities. The top three communities with the highest number of buildings vulnerable to storm surge flooding are:

1. San Rafael, 2,097 buildings,
2. Larkspur, 1,200 homes, and,
3. Santa Venetia, 945 buildings.

While San Rafael and Larkspur continue to see worsening conditions, communities that are otherwise protected by some type of armoring to tidal flooding could flood during a 100-year storm surge combined with 20 inches of sea level rise. This includes Santa Venetia and Corte Madera. Sausalito could expect flooding in the Marinship and Old Town neighborhoods. Of note, Mill Valley's Redwoods Community, and several hundred additional buildings near Richardson's Bay, could experience storm surge flooding in this time period.

By percentage of buildings stock impacted, unincorporated water based communities could expect the worst conditions, similar to the near-term.

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The top three communities that could expect the greatest portion of their building's flooded are:

1. Greenbrae Boardwalk, 66 percent,
2. Waldo Point Harbor, 23 percent, and
3. Paradise Cay, 17 percent of buildings in the community.

These small communities are surrounded by tidal water at high tides today. They incorporate boating and the water as a way of life, and are aware of the risks. Adding a storm surge at this level of sea level rise could even devastate some of these smaller bay oriented communities.

1. Greenbrae Boardwalk, 66 percent,
2. Santa Venetia, 42 percent, and
3. Paradise Cay, 26 percent of buildings in the community.

In addition, Bel Marin Keys and Corte Madera could expect about quarter to a fifth of their buildings stock compromised during a storm surge. Corte Madera could expect impacts in the San Clemente and Paradise Drive area. Note also that these communities were built on fill and thus, vulnerable to increased rates of subsidence.

East pier, Kappas Marina house boats, Waldo Point Harbor, March 10, 2016. Credit: BVB Consulting LLC

Table 21. Vulnerable Buildings in the Medium-term

Location		Scenario 3		Scenario 4	
		#	%	#	%
Municipalities	San Rafael	1,088	6	2,097	11
	Larkspur	165	4	670	13
	Belvedere	65	4	90	5
	Tiburon	42	1	44	1
	Sausalito	67	2	133	4
	Novato	17	0	56	0
	Corte Madera	138	4	804	21
	Mill Valley	7	0	325	5
Unincorporated Jurisdictions	Greenbrae Boardwalk	81	66	115	98
	Waldo Point	87	23	90	23
	Bel Marin Keys	92	13	176	25
	Almonte	30	3	84	9
	Strawberry	33	2	117	7
	Paradise Cay	52	17	80	26
	Tiburon	13	4	18	6
	Santa Venetia	2	0	945	42
	Tamalpais	2	0	103	4
	Black Point	18	2	30	3
	North Novato	2	0	183	11
	Country Club	6	1	6	1
	Bayside Acres	2	1	5	2
	Pt. San Pedro	2	2	4	5
	China Camp	1	9	1	9
	De Silva Island	1	6	1	6
	Kentfield			11	0
Total		2,013	3	5,608	7

Source: MarinMap, CoSMoS

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Table 22. Vulnerable Buildings by Average Flooding* at MHHW in the Medium-term

Average Flood Level (feet)	Number of Buildings
0.1-1	342
1.1-2	469
2.1-3	366
3.1-4	281
4.1-5	118
5.1-6	30
6.1-7	47
7.1- 8	54
8.1-9	20
9.1- 10	2
10.1+	4

**Depth data is not available for every vulnerable asset.*
Source: MarinMap, CoSMoS

Flood Depth
In the medium-term, the portion of buildings vulnerable to three feet or less greatly increases with several hundred more buildings subject to this level of flooding. Nearly 500 buildings are vulnerable to deeper flooding of four to eight feet deep. Additionally, over 20 buildings could experience up to nine feet of flood waters.

Long-term: Scenarios 5 & 6
In long-term scenario 5, more than 9,130 buildings, 12 percent of all buildings in the study area, could be directly affected by sea level rise. With the 100-year storm surge added, scenario 6, 12,138 buildings, making up 16 percent of buildings in the study area could flood.

By number, San Rafael, Corte Madera, Santa Venetia, and Bel Marin Keys have the highest number of vulnerable parcels across every scenario. Figures for the top three are:

1. San Rafael 2,495 buildings
2. Corte Madera, 1,283 buildings, and
3. Santa Venetia, 982 buildings.

Several hundred other buildings in Larkspur, Belvedere, Mill Valley, and Novato could be vulnerable as well. And more than 100 buildings could be vulnerable to tidal flooding at 60 inches of sea level rise.

Table 23. Vulnerable Buildings in the Long-Term

Location		Scenario 5		Scenario 6	
		#	%	#	%
Municipalities	San Rafael	2,495	13	3,247	18
	Larkspur	802	19	1,160	28
	Belvedere	423	24	470	27
	Tiburon	153	4	261	7
	Sausalito	154	5	299	10
	Novato	672	4	871	5
	Corte Madera	1,283	33	1,468	38
	Mill Valley	329	5	536	8
Unincorporated Jurisdictions	Greenbrae Boardwalk	119	97	120	98
	Waldo Point	90	23	386	100
	Bel Marin Keys	683	96	707	99
	Almonte	86	9	106	11
	Strawberry	185	11	264	15
	Paradise Cay	157	51	219	71
	Tiburon	17	6	23	7
	Santa Venetia	982	44	1,142	51
	Tamalpais	98	3	103	4
	Black Point	65	6	89	8
	North Novato	219	14	268	17
	Country Club	18	4	21	4
	Bayside Acres	5	2	6	3
	Pt. San Pedro	21	24	25	29
	China Camp	1	9	1	9
	De Silva Island	1	6	1	6
	Kentfield	79	3	247	8
	St. Vincent's	10	11	16	18
	San Quentin	10	3	32	9
	California Park	10	5	13	6
	Marin City	1	0	38	9
Study Area		**9,167**	**12**	**12,138**	**16**

Source: MarinMap, CoSMoS

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Homes in Black Point on San Pablo Bay. Credit: CDA

Table 24. Number of Vulnerable Buildings by Average Flood* Level at MHHW in the Long-term

Average Flood Level (feet)	Number of Buildings
0.1-1	564
1.1-2	1,235
2.1-3	1,344
3.1-4	1,762
4.1-5	1,486
5.1-6	1,011
6.1-7	489
7.1- 8	290
8.1-9	289
9.1- 10	167
10.1+	298

**Flood depth data is not available for every vulnerable asset. Source: MarinMap, CoSMoS*

Across the scenarios, San Rafael is one of the most vulnerable communities, especially in the Canal Area. According to San Rafael asset managers, vulnerable buildings, in addition to multi-family, and some single family housing, include thirty grocery stores, ten pharmacies, sixteen medical clinics, 48 doctor offices, 35 childcare facilities, five residential care facilities, seven convalescent facilities, 16 gas stations, 29 building supply stores, and other critical facilities. These businesses either contain critical goods like medications and access to medical and buildings supplies after a major storm or flooding event or house some of the most vulnerable populations in the region.

By percentage of buildings stock impacted, unincorporated water based communities could still see the greatest impacts, similar to previous observations. The top three communities with the largest portion of their building stock that could flood at men higher high tide are:

1. Greenbrae Boardwalk, 97 percent,
2. Bel Marin Keys, 96 percent, and
3. Santa Venetia, 44 percent of buildings in the community.

The top two of these communities are tidally flooded in their near-entirety on a near monthly basis. A 100-year storm surge at this level of sea level rise would devastate some of these smaller bay oriented communities.

1. Waldo Point Harbor, 100 percent,
2. Bel Marin Keys, 99 percent, and
3. Greenbrae Boardwalk, 98 percent of buildings in the community.

Flood Depth

In the long-term, over 3,000 buildings could be vulnerable to at least three feet of flooding, with more than 4,000 additional buildings experiencing more than three feet to six feet of flooding. An additional 1,000 buildings could be vulnerable to depths greater than 6 feet, with several hundred flooded by nine to ten feet of saltwater.

Table 25 lists some of the vulnerable buildings along Marin's eastern shoreline. This list shows onset and tidal mean higher high water (MHHW) for neighborhoods, and in some cases, specific buildings were assessed.

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Table 25. Example Vulnerable Buildings[a] Assets Ranked By Onset and Flooding at MHHW

Location	Asset	Scenario 1	Scenario 2	Scenario 3
		Near-term	Medium-term	Long-term
Sausalito	Sausalito Ferry facilities	No data[b]		
Tiburon	Tiburon Ferry facilities	9'3"	10'	12'9"
Tiburon	Tiburon Waterfront	9'2"	9'11"	12'9"
Belvedere	West Shore Road homes	0-5'10""	0-6'5"	3"-9'3"
San Rafael	Canal neighborhood/ Spinnaker Pt.	0-5'3"	6"-5'	1"-7'4"
Greenbrae	Boardwalk homes north of 101	0-5'	0-5'8"'	3'-8'6"
Larkspur	Golden Gate Ferry Terminal buildings	0-5'	2'9"-5'4"	2'9"-6'9"
Greenbrae	Boardwalk homes south of 101	0-4'9"	0-5'5"	5'-8'5"
Corte Madera	Marina Village	0-3'5'	0-4'	11'-6'5"
Larkspur	Boardwalk 1	2"-3'	5-"3'10"	3'2"-6'5"
Belvedere	Corinthian Hill homes	2'10'	3'2"	4'7"
Bel Marin Keys	Homes west of Bel Marin Keys Blvd.	0-2'7"	0-3'	3"-8'2"
Paradise Cay	Homes	0-2'4"	0-2'8"	5'3"
Larkspur	Industrial and commercial east of Hwy 101	0-1'9"	0-2'4"	2'2"-6'7"
San Rafael	GGBHTD headquarters & bus depot	0-1'6"	0-2'4"	4'2"-5'
Corte Madera	Mariner Cove neighborhood	0-1'3"	0-2'	1"-5'3"
Larkspur	Riviera Circle homes	0-10"	0-1'7"	1"-5'2"
San Rafael	Bahia Vista Elementary School	8"	2'3"	4'8"
Belvedere	Beach Road homes	6"	2'2"	4'
Waldo Point	Businesses		0"-7'7"	1'5"-10'10"
Strawberry	Greenwood Cove homes		0"-6'3"	6"-8'
Sausalito	Marinship neighborhood		0-6'	11"-9'
San Rafael	Peacock Gap Lagoon and golf course homes		0-6'	2"-8'9"
Santa Venetia	Santa Venetia homes		1"-3'6"	2"-6'7"
Corte Madera	Paradise Dr. auto dealerships and commercial		0-3'	2'-8'2"
Bel Marin Keys	Homes east of Bel Marin Keys Blvd.		1"-2'	3"-5'
Almonte	Shoreline development		0-2'	1'8"-5'
Tiburon	Tiburon Blvd. shopping		4"-2'	10"-4'2"
Greenbrae	Marin RV Park		0-1'10"	3'5"-6'8"
Tamalpais	Birdland Neighborhood		0-1'10"	2"-5'9"
Tamalpais	Tam Junction commercial		0-1'10"	2"-5'
Corte Madera	Aegis Senior Living		1'9"	4'7"
Tiburon	Cove Shopping Center		1'8"	3'11"
Mill Valley	Shelter Bay development		0-1'3"	5"-4'5"
Almonte	Caltrans Corporation Yard		1'	4'
San Rafael	Marin Community Clinic		10"	3'8"
Corte Madera	CA Highway Patrol Marin office		9"	6'
San Rafael	Marin County Health Innovation Campus		4"	3'4"
San Rafael	Montecito Plaza		1"	2'2"
Novato	Hamilton neighborhood			2"-12'4"
Novato	Vintage Oaks Shopping Center			5"-9'4"
Larkspur	Golden Gate Mobile Home Park			2'-8'4"
Belvedere	Belvedere Lagoon homes			5"-7'9"

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Location	Asset	Scenario 1	Scenario 2	Scenario 3
		Near-term	Medium-term	Long-term
Corte Madera	Neil Cummins Elementary School			7'6"
Corte Madera	Madera Gardens			2'-7'4"
Larkspur	Heatherwood neighborhood			7'
San Rafael	Marin Lagoon			6"-7'
Corte Madera	Corte Madera Town Center Commercial			5'
North Novato	Binford Road Business Park			5'
San Rafael	Davidson Middle School			4'10"
Strawberry	Strawberry Circle homes			1'4"-4'8"
Mill Valley	Sycamore neighborhood			3"-4'5"
Larkspur	Multi-family on Larkspur Plaza Dr.			4'5"
Strawberry	Commercial along Seminary Marsh			5"-4'
Novato	NSD Wastewater treatment plant			4"-4'
Larkspur	San Andreas High School			4'
Mill Valley	Redwood Retirement Residential			7"-3'5"
Tiburon	Post Office			3'11"
Kentfield	Apartments/offices off Sir Francis Drake Blvd.			3'10"
Larkspur	Redwood High School			3'4"
Strawberry	Homes along Seminary Dr.			7"-3'2"
San Rafael	Downtown			1"-3'2"
Larkspur	Tamiscal High School			3'
San Rafael	PG&E office and yard			3'
San Rafael	Ritter Clinic			2'10"
Mill Valley	Mill Valley Shopping Center			6"-2'6"
Tiburon	Tiburon Fire Station			2'6"
Kentfield	Homes along McCallister Slough			6"-2'5"
San Rafael	San Rafael Transit Center			2'5"
Tiburon	Town Hall			2'4"
Tiburon	Library			2'4"
Mill Valley	SASM wastewater treatment plant			2'3"
Corte Madera	Cove Elementary School			2'3"
San Rafael	San Rafael High School			2'2"
San Rafael	Marin County Emergency Services			2'2"
Corte Madera	The Village at Corte Madera			5"-2'
Corte Madera	Aegis Senior Living			1'10"
Kentfield	Homes along Beren's Slough			10"-1'8"
Corte Madera	Marin Montessori			1'7"
Belvedere	Belvedere Corp Yard			1'5"
Bel Marin Keys	Bel Marin Keys CSD office			1'3"
Strawberry	Westminster Presbyterian Church & Preschool			1'2"
Larkspur	Tamalpais Adult School			1'2"
Mill Valley	Mill Valley Middle School temporary buildings			1'2"

[a]For groups of buildings, a maximum flood depth is provided. [b]No data provided for facilities located in water beyond mean sea level. Source: CoSMoS, MarinMap. Credit: BVB Consulting LLC

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All of these assets are also vulnerable to an additional 3 feet of storm surge flooding during a 100-year storm surge, not accounting for precipitation on the site. In addition, the following structures could be vulnerable to an additional storm surge at 60 inches of sea level rise:

- Marin Country Day School, Corte Madera (emergency shelter),
- Martin Luther King Jr Academy Marin City,
- Tamalpais High School Mill Valley,
- Glenwood Elementary. School San Rafael,
- Anthony G Bacich Elementary School, Kentfield,
- Adaline E Kent Middle School, Kentfield,
- Strawberry Point Elementary School,
- Belvedere City Hall, Police Department, Community Center
- Sanitary District No. 5 Paradise Cove treatment plant, Unincorporated Tiburon,
- Strawberry Village Shopping Center,
- Alto Shopping Center,
- Marin County Expo Center and Amphitheater, Santa Venetia,
- Novato Corp Yard,
- Las Robles Mobile Home Park Novato,
- Novato Fire Association office,
- Holy Innocents Episcopal, Corte Madera (emergency shelter),
- Marin Lutheran Church, Corte Madera (emergency shelter),
- College of Marin, Kentfield

Tamalpais High School athletic fields along Richardson Bay. Nov. 25, 2015. 10:40 a.m. Credit: Light Hawk Aerial

Public Facilities

Vulnerable government, or public, facilities include: 24 schools, five fire stations, Larkspur Landing ferry facilities , SASM wastewater treatment plant, Golden Gate Bridge, Highway and Transportation District bus depot and maintenance facilities in San Rafael, and the CA Highway Patrol Marin Office could be vulnerable in the near to medium-term.

The post offices in Tiburon and San Rafael's Bellam Blvd. location, and the San Rafael Transit Center could be vulnerable nearing the end of the century. The Marin County Expo Center and Amphitheater is also vulnerable near the end of the century. To learn more about fire, police, and emergency shelter facilities see the Emergency Services Profile. For more information on transportation related facilities, see the Transportation Profile.

Several community centers including the Belvedere Community Center, Mill Valley Recreation Center, Corte Madera Community Center, and Belvedere CSD building could be vulnerable in the long-term. The Belvedere Community Center is housed in the same building as the police department and city hall. The Mill Valley Recreation Center also functions as an emergency shelter.

Also of concern are potentially vulnerable corporation yards in Belvedere and Novato. Corporation yards often contain heavy machinery and fuel tanks for refueling public fleets. These places often also contain tools that would be useful in emergencies and disaster recovery that could be threatened by flooding.

Though the buildings are not directly impacted, North Marin Water District headquarters and yard could experience access issues at high tide in the long-term, and could expect greater impacts in combination with stormwater flooding. The Central Marin Sanitation Agency treatment plant could also experience vehicular access issues nearing the end of the century. This could prevent employees from arriving at work to conduct the necessary operations and maintenance work that needs to be completed. For more details on buildings and facilities related to sanitary or water districts, see the Utilities profile. For parcels related to recreation, see the Recreation Profile.

Schools (Private and Public)

Schools vulnerable to sea level rise are listed in Table 26. Marin Montessori, Corte Madera, and

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Bahia Vista, San Rafael, could be vulnerable to storms at scenario 2 and to sea level rise by scenario 3. Neil Cummins Elementary, Corte Madera, is vulnerable to storms at 20 inches of sea level rise and is vulnerable to sea level rise at 60 inches, scenario 5, along with Cove Elementary School, Corte Madera, Tamiscal High School, Larkspur, Anthony G Bacich Elementary School, Kentfield, and Westminster Presbyterian Church Preschool, Tiburon. The remainder, and majority, of schools in the table are not vulnerable to sea level rise alone and can be found under scenario 6, with 60 inches of sea level rise and a 100-year storm surge.

Additionally, several of these schools, including Neil Cummins Elementary, Adeline E. Kent Middle School, Anthony G Bacich Elementary School already experience stormwater back up flooding during high tides, and as time continues this confluence of flooding could worsen.

Once high tide reaches the school grounds they could likely be lost to marshlands. In many cases the athletic fields are compromised first. At Tamalpais High School, the only portion impacted by sea level rise alone is the low lying athletic fields. Flooding can debilitate a school's ability to perform, especially if the buildings are compromised. In 2005, the Cove School experienced a 6.5 foot king tide and a 2.5 foot stormwater level that shut down half of the school for two weeks of reconstruction. During this time, students doubled in the useable space.

In addition to the school property being impacted directly, the schools are also impacted by the ability of students, teachers, and staff to access the location. This is the case at nearly every school on the list. And, aside from busing in the Novato School District, all other students arrive individually by vehicle or non-motorized means. If too few students are able to travel, schools that are funded with state equalization aid, and required to meet an average daily attendance threshold, could experience losses in funding and capacity, and more frequent closures.

These issues are also a concern for childcare facilities, where the child population is typically younger than school-aged. Children at thirty-five different childcare facilities could be vulnerable in San Rafael alone. The Westminster Presbyterian Church's preschool also falls in this category.

Table 26. Schools Vulnerable to Sea Level Rise and the 100-year Storm Surge

	Scenario			
	2	4	5	6
Corte Madera		Neil Cummins Elem.	Schools in scenario 4 Marin Montessori Cove Elem.	Schools in scenarios 4 & 5 Marin Country Day School
Larkspur			Tamiscal High	Schools in scenario 5 Redwood High Henry Hall Middle School San Andreas High
Marin City			Martin Luther King Jr Academy (Middle)	Schools in scenario 5
Mill Valley			Mill Valley Middle School	Schools in scenario 5 Tamalpais High
San Rafael	Bahia Vista Elem. Trinity Preschool	See scenario 2	Schools in scenarios 2 & 4 Davidson Middle San Rafael High	Schools in scenarios 2, 4 & 5 Glenwood Elem.
Kentfield			Anthony G Bacich Elem. Adaline E Kent Middle	Schools in scenario 5
Strawberry			Strawberry Point Elem. Westminster Pres. Church Preschool	Schools in scenario 5

Source: MarinMap, CoSMoS

Medical Facilities

Several medical facilities, large and small could be vulnerable, and access to nearly all other in the study could be impeded from the east. Medical facilities in the tidally flooded area are:

- Marin Community Clinic, on Kerner Boulevard in San Rafael, is vulnerable to near-term storm surges, and medium-term sea level rise.

- Marin County Health, on Kerner Boulevard in San Rafael, is vulnerable to near-term storm surges, and medium-term sea level rise.
- Passport Health, on Eliseo Drive in Larkspur, is vulnerable to long-term tidal flooding, with worse conditions during a 100-year storm surge.
- Ritter Health Center, on Ritter Street in San Rafael, is vulnerable to long-term sea level rise flooding, with worse conditions during a 100-year storm surge.
- Marin County Emergency Medical Services, on Mitchell Boulevard in San Rafael, is vulnerable to long-term sea level rise flooding, with worse conditions during a 100-year storm surge.

The parking lots are also compromised on most of these sites. And while all emergency medical facilities are outside of the vulnerable area, access to them through the flooded area could be limited, leading to further injury, or worse, loss of life.

Retirement and Assisted Living

Several sites house people who are older in age and may have limited mobility or sensory abilities. These people may be especially vulnerable in floods, power outages, and other events that could isolate them. The locations that could be impacted are:

- The Redwood's, Mill Valley,
- South Eliseo Convalescent Home, Larkspur,
- Aegis, Corte Madera,
- Contempo Marin, San Rafael,
- Los Robles Park, Novato,
- Aegis, San Rafael,
- Golden Home Extended Care, San Rafael,
- Miracle Hands Homecare, San Rafael,
- Saint Michael's Extended Care, San Rafael,
- Schon Hyme Rest Home, San Rafael,
- All Saints Extended Care, Inc., San Rafael,
- Country Villa San Rafael,
- Harmony House, San Rafael,
- Kindred Transitional Care & Rehabilitation, San Rafael,
- Pine Ridge Care Center, San Rafael,
- San Rafael Care Center, Inc., and
- San Rafael Healthcare & Wellness Center, LP.

Potential Damages

Using the FEMA Hazus scale applied in post-disaster assessments for debris[10] Table 27 estimates the cost of damages to buildings and their contents depending on the severity of damage. This analysis uses scenario 6, the worst case scenario with a storm surge strong enough to cause significant damage. A smaller surge may cause minor damage, where as a large surge would cause moderate damage or even destroy buildings. This analysis assumes all buildings in scenario 6 are impacted either at a minor, moderate, or major level, and not a mix of minor, moderate, and major, which would likely reflect reality more closely.

According to the *Structure Debris Estimates: Hazus Level 1 Flood and Wind Losses*,[11] building damage costs[12] are assigned as:

- Yellow Tag
  - Affected: Loss is $0 to $5,000, or 2.05 tons of debris per 1,000 square feet.
  - Minor: Loss is $5,001 to $17,000, or 4.1 tons of debris per 1,000 square feet.
- Orange Tag: Loss is greater than $17,000 or 8 tons of debris per 1,000 square feet.
- Red Tag: Destroyed as defined by the FEMA inspector.

Waldo Point Houseboats. Nov. 24, 2015

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

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

[12] 2016 dollars

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By long-term scenario 6, if all vulnerable buildings experience minor injury, $60 million (2016 dollars) in damages could occur. If all of the buildings are moderately damaged, more than 200 million in damages could be incurred. If all of the buildings were to be destroyed by a storm surge and/ or lost to tidal flooding the assessed value of that lost buildings could surpass $6 billion (2016). If the land cannot be reclaimed for development, another $9 billion in assessed land value would be lost, totaling, $15 billion (2016 dollars) in assessed value. Reality would likely reflect a mix of these outcomes, costs would be incurred gradually in the previous decades, and damaging storm surges could occur multiple times within the timeframe of this assessment.

Maps on the following pages show vulnerable buildings by onset and location. Buildings in the southern portion could be vulnerable sooner than those in the northern portion of the study area. The areas in the call out circles enable the reader the see areas that are difficult to see on the large scale map. The circles do not indicate that these areas are more vulnerable than others along the shoreline. For even closer imagery, see the Community Profiles.

Table 27. Damage Cost [a] Estimates Applied to Vulnerable Buildings in Long-term Scenario 6

Location		Yellow Tag-Minor	Orange Tag-Moderate	Red Tag-Destroyed
		$5,000/building minimum	$17,001/building minimum	Assessed structural value
Municipalities	San Rafael	$16,235,000	$55,202,247	$1,496,065,489
	Corte Madera	$7,340,000	$24,957,468	$726,321,314
	Larkspur	$5,800,000	$19,721,160	$1,496,649,606
	Novato	$4,355,000	$14,807,871	$629,369,009
	Mill Valley	$2,680,000	$9,112,536	$300,215,511
	Belvedere	$2,350,000	$7,990,470	$356,209,805
	Sausalito	$1,495,000	$5,083,299	$228,617,482
	Tiburon	$1,305,000	$4,437,261	$187,457,062
Unincorporated Jurisdictions	Santa Venetia	$5,710,000	$19,415,142	$124,787,181
	Bel Marin Keys	$3,535,000	$12,019,707	$188,722,172
	Waldo Point	$1,930,000	$6,562,386	$21,056,654
	North Novato	$1,340,000	$4,556,268	$7,911,796
	Strawberry	$1,320,000	$4,488,264	$214,941,911
	Kentfield	$1,235,000	$4,199,247	$99,778,853
	Paradise Cay	$1,095,000	$3,723,219	$123,268,429
	Greenbrae Brdwlk	$600,000	$2,040,120	$8,836,871
	Almonte	$530,000	$1,802,106	$37,738,121
	Tamalpais	$515,000	$1,751,103	$22,654,207
	Black Point	$445,000	$1,513,089	$15,807,484
	Marin City	$190,000	$646,038	$24,685,548
	San Quentin	$160,000	$544,032	$689,013
	Pt. San Pedro	$125,000	$425,025	$33,137
	Tiburon	$115,000	$391,023	$36,868,808
	Country Club	$105,000	$357,021	$6,311,404
	St. Vincent's	$80,000	$272,016	$4,477,392
	California Park	$65,000	$221,013	$1,508,352
	Bayside Acres	$30,000	$102,006	$5,340,362
Total		**$60,690,000**	**$206,358,138**	**$6,366,322,973**

[a]2016 dollars. Source: MarinMap, CoSMoS, FEMA

BUILDINGS

Map 12. Northern Study Area Vulnerable Buildings

Vulnerable Assets

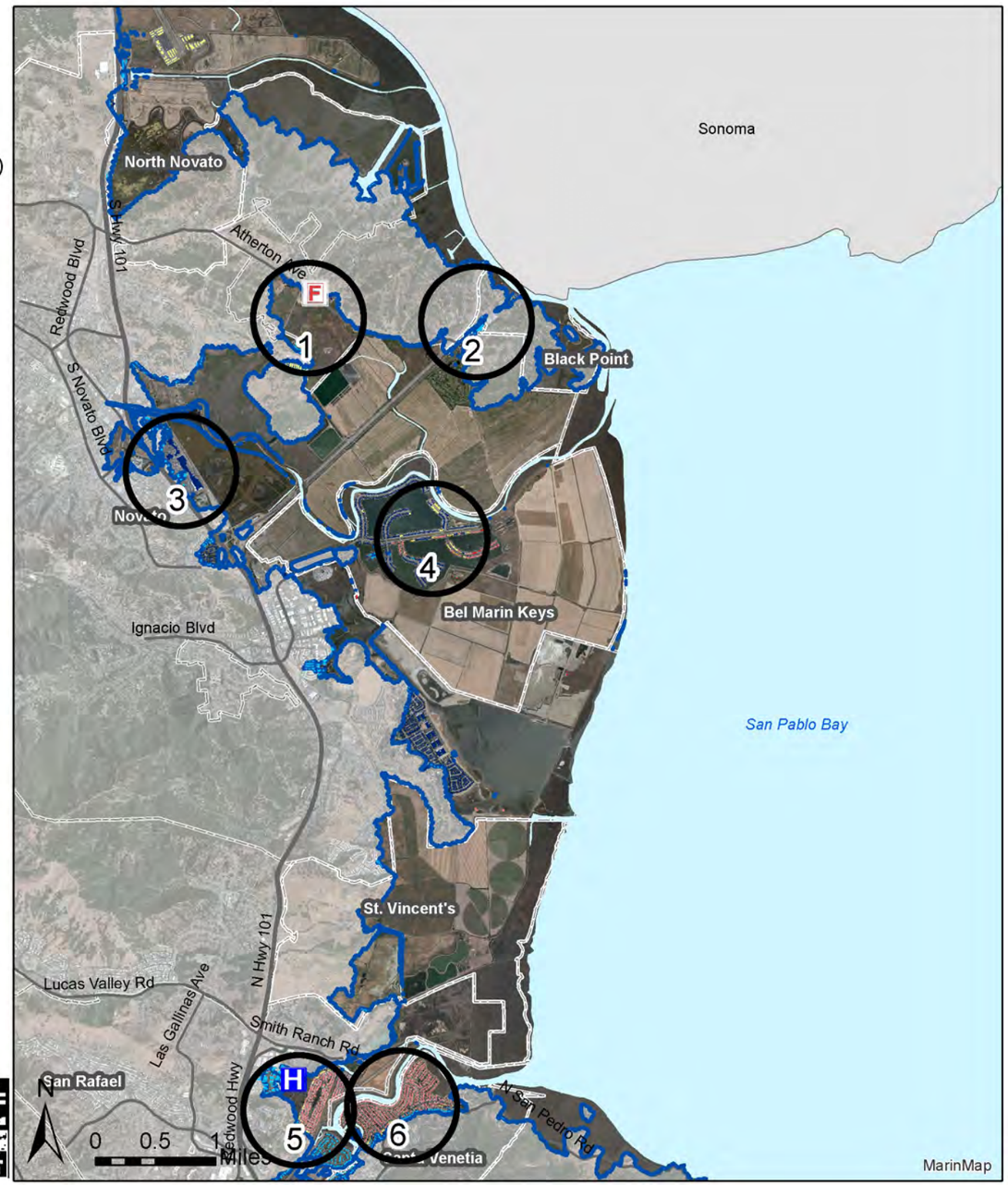
- F — Fire Station
- H — Medical Facility

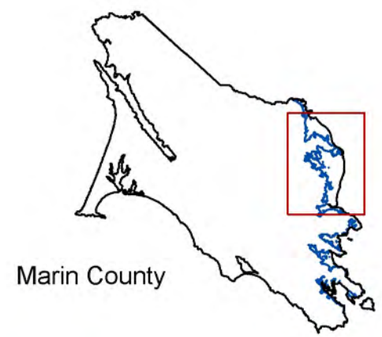
Vulnerable Buildings

- Scen. 1: 10" Sea Level Rise (SLR)
- Scen. 2: 10" SLR+Storm Surge
- Scen. 3: 20" Sea Level Rise
- Scen. 4: 20"SLR+Storm Surge
- Scen 5: 60" Sea Level Rise
- Scen. 6: 60"SLR+Storm Surge

Location Indicators

- Unincorporated
- Municipality
- Road
- Bay
- Inland Extent: Sea Level @ 60"+100-year Storm



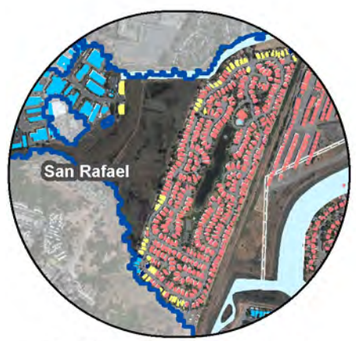


1: Green Point

2: Black Point

3: Vintage Oaks Shopping Center

4: Bel Marin Keys



5: Western Santa Ventia

6: Eastern Santa Venetia

EVB CONSULTING

Date: 3/30/2017

OCOF CoSMoS

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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Map 13. Southern Study Area Vulnerable Buildings

Vulnerable Assets

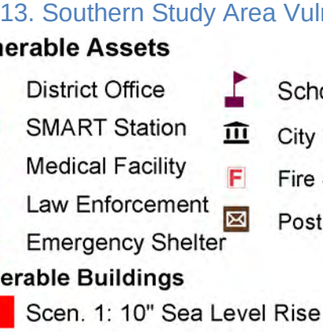
- District Office
- SMART Station
- Medical Facility
- Law Enforcement
- Emergency Shelter
- School
- City Hall
- Fire Station
- Post Office

Vulnerable Buildings

- Scen. 1: 10" Sea Level Rise (SLR)
- Scen. 2: 10" SLR+Storm Surge
- Scen. 3: 20" Sea Level Rise
- Scen. 4: 20"SLR+Storm Surge
- Scen. 5: 60" Sea Level Rise
- Scen. 6: 60"SLR+Storm Surge

Location Indicators

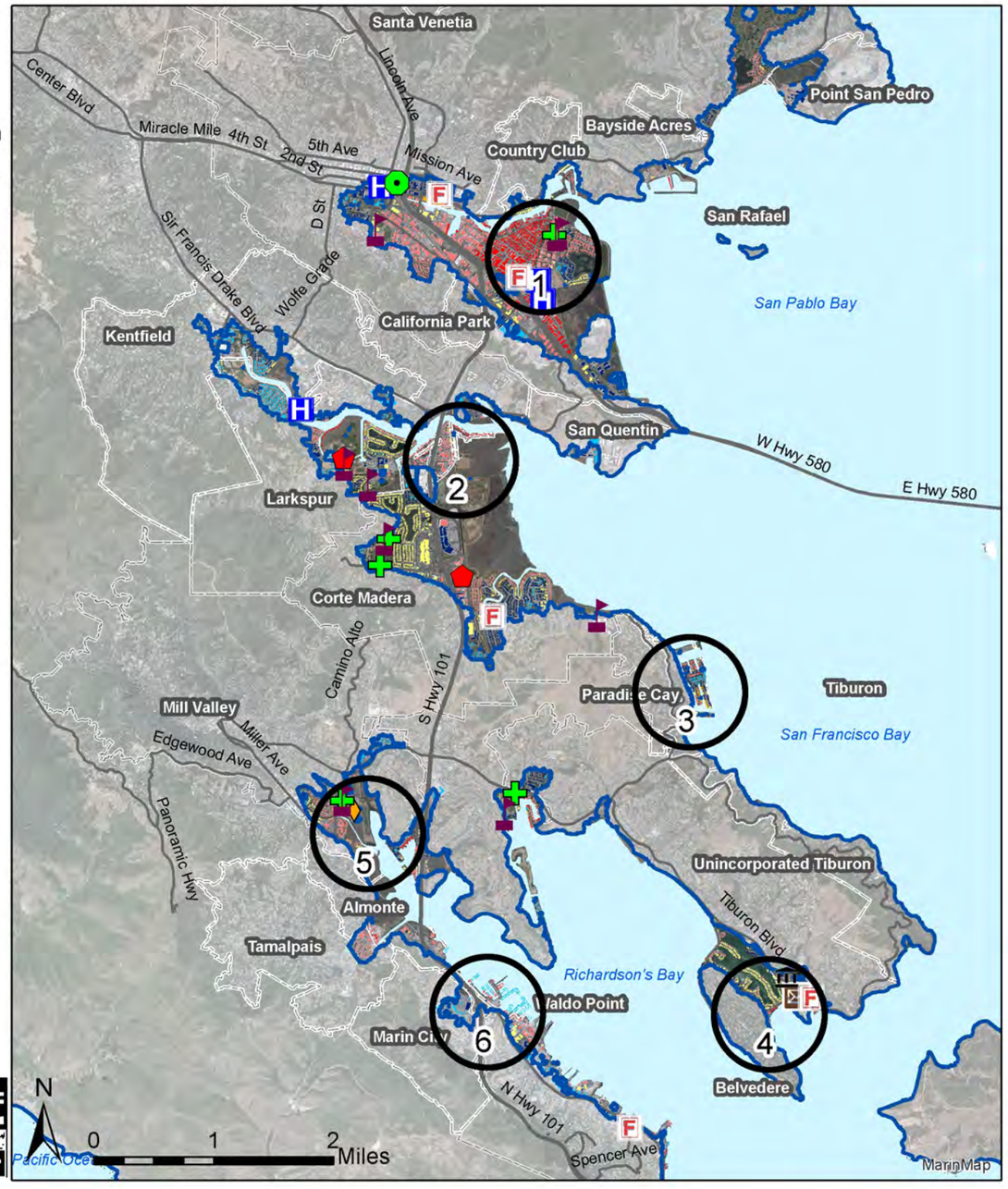
- Unincorporated
- Municipality
- Road
- Bay
- Inland Extent: Sea Level @ 60"+100-year Storm



EVB CONSULTING

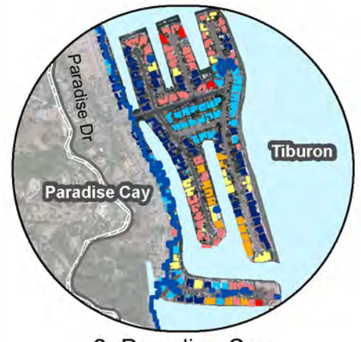
Date: 2/11/2017

OCOF CoSMoS

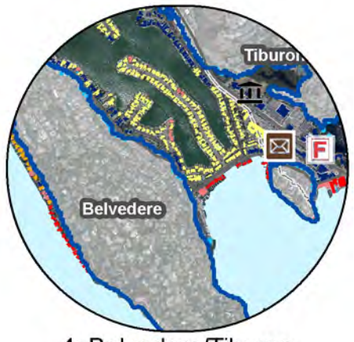


1: Canal Neighborhood

2: Greenbrae Boardwalk/ Larkspur



3: Paradise Cay



4: Belvedere/Tiburon

5: Mill Valley

6: Marin City/Waldo Pt. Harbor

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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Other Considerations

Economic

The Marin shoreline accounts for hundreds of millions of dollars in economic activity. The more than 12,000 vulnerable buildings, account for more than $6 billion in assessed improvement value as shown in Table 28. Unincorporated Marin properties that are expected to be vulnerable to sea level rise contributed $101,205,044[13] in 2015 property taxes to roughly 55 taxing agencies. Table 29 breaks down the multi-million-dollars in contributions from vulnerable properties in unincorporated Marin by taxing jurisdiction. Municipal tax revenues would add several hundred million in revenues.

Sales tax would also decline if the vulnerable commercial areas in Sausalito, Marin City, Corte Madera, Mill Valley, Larkspur, San Rafael, and Novato flood. Tourism tax could also decline because more than ten hotels could be impacted in Sausalito, Almonte, Mill Valley, Tiburon, and San Rafael. Access issues could impact other guest accommodations outside of the vulnerable portions of the study area.

Employment opportunities at shopping, industrial, and office sites could be lost. Moreover, businesses require transportation access for their deliveries, employees, and customers that is compromised under the BayWAVE scenarios, typically before the business itself is vulnerable. Employees within or who have to pass through the vulnerable areas may not be able to get to work. Access issues would also impact additional shopping centers, including the Marin Country Mart in Larkspur.

In addition to tax generation impacts, on-site expenses could be incurred by property owners. According to the National Flood Insurance Program, a 1,000 square foot home built on slab that experiences 1 foot of flooding can experience an estimate of $27,000[14] in damages to the structure and its contents.[15] A 2,000 square foot homes could anticipate an estimate of more than $52,000[16] in damages to structures and their contents.

Table 28. Economic Value of Vulnerable Buildings in Long-term Scenario 6

Location	Assessed Improvement Value[a]	Single Family Home Median Market Value[b]
Municipalities		
Larkspur	$1,496,649,606	$1,263,482,000
San Rafael	$1,496,065,489	$1,755,058,800
Corte Madera	$726,321,314	$1,475,834,400
Novato	$629,369,009	$684,226,000
Belvedere	$356,209,805	$1,397,145,700
Mill Valley	$300,215,511	$831,482,400
Sausalito	$228,617,482	$60,985,000
Tiburon	$187,457,062	$572,516,000
Unincorporated Jurisdictions		
Strawberry	$214,941,911	$1,665,727,200
Bel Marin Keys	$188,722,172	$569,754,900
Santa Venetia	$124,787,181	$1,243,810,000
Paradise Cay	$123,268,429	$581,863,200
Kentfield	$99,778,853	$3,080,781,000
Almonte	$37,738,121	$783,140,400
Tiburon	$36,868,808	$343,509,600
Marin City	$24,685,548	0
Tamalpais	$22,654,207	$2,762,400,000
Waldo Point	$21,056,654	0
Black Point	$15,807,484	$366,133,700
Greenbrae	$8,836,871	$76,532,500
North Novato	$7,911,796	$359,582,600
Country Club	$6,311,404	$252,193,200
Bayside Acres	$5,340,362	$109,798,400
California Park	$1,508,352	$103,793,800
San Quentin	$689,013	$27,449,600
Pt. San Pedro	$33,137	0
Total	**$6,366,322,973**	**$20,367,200,400**

Source: [a]Assessor Tax Data 2015/2016, [b]Zillow May 2015

[13] 2016 dollars
[14] 2016 dollars
[15] National Flood Insurance Program. The Cost of Flooding Estimator Tool https://www.floodsmart.gov/floodsmart/content/overlays/cost_of_flooding_nonajax.jsp. Accessed Dec. 13, 2016.
[16] 2016 dollars

BUILDINGS

Table 29. Sample Tax Generation for Parcels Vulnerable in Long-term Scenario 6

Tax District	Tax Revenue
County General	$22,835,222
Tamalpais High School District	$10,781,271
Marin Community College	$7,360,565
Education Revenue Augment	$7,303,352
Mill Valley School District	$6,991,178
Southern Marin Fire	$5,750,363
Kentfield School District	$5,225,279
Kentfield Fire	$4,109,315
Novato Unified School District	$3,765,050
County Library	$2,954,595
County School Service Fund	$2,528,240
San Rafael Elementary Schools	$2,253,634
Community Service Area (CSA) #19 Fire Protection	$1,950,984
Novato Fire	$1,906,311
San Rafael High School	$1,690,337
Ross Valley Sanitation No. 1	$1,564,305
Reed Union School	$1,446,789
Marin County Open Space	$1,020,102
Tiburon Fire	$795,261
Richardson Bay Sanitation	$745,599
Tamalpais Community Service District (CSD)	$649,472
Flood Control Zone (FCZ) 3 Richardson Bay	$635,130
Marin County Highway Lt	$615,373
Sausalito-Marin City School District	$595,858
Marin County Transit	$586,546
County Fire Department	$512,272
Ross School	$493,532
Strawberry Recreation	$473,938
Bel Marin Keys CSD	$443,596
CSA 17 Kentfield	$401,931
FCZ 7 Santa Venetia	$359,149
Mosquito Abatement	$317,948
Corte Madera Sanitation No. 2	$288,308
Marin City CSD	$270,722
FCZ 1 Novato	$215,209
Bay Area Air Quality	$205,089
#6 Novato Sanitation	$146,654
CSA 18 Gallinas	$128,756
FCZ 4 Bel Aire	$127,962
Almonte Sanitation	$108,938
Las Gallinas Valley Sanitary District	$104,146
FCZ 9 Ross Valley	$81,954
Larkspur-Corte Madera School District	$80,287
San Rafael Sanitation	$64,836
CSA 6 Santa Venetia	$57,811
Sausalito-Marin City Sanitation	$55,230
CSA 16 Greenbrae	$46,234
Tiburon Sanitation No. 5	$41,804
Murray Park Sanitation	$41,684
San Quentin Sanitation	$19,282
Alto Sanitation	$19,182
CSA 9 Northbridge	$12,074
North Marin Water	$10,822
Petaluma Joint High	$7,026
Dixie School District	$6,543
Santa Rosa Junior College-Laguna Joint School	$1,275
Lincoln School	$723
Total	**$101,205,044**

Source: S. Kucharos, County of Marin Department of Revenue, June 6. 2016

In addition, several existing buildings are protected with shoreline armoring, such as seawalls, revetments, levees, bulkheads, bluff walls, and other hard engineering structures, to impede flooding and erosion. With higher tides, these protective structures may become compromised and require increased maintenance or replacement, or relocation. Some may already be in need of repair to withstand existing conditions. These expenses can be significant and would require increasing upkeep and improvement as tides rise.

For properties that become part of the public trust lands, regulations could diminish an individuals' capacity to maintain and retain value in their properties in the most cost effective ways. The equity held in these properties could be lost; negatively impacting a major contributor to wealth. In addition, these homeowners may be required to pay leasing fees to the State of California, that they do not currently pay.

Several low-income and affordable housing locations, the Canal neighborhood, Marin City, and other locations along the shoreline, could be compromised by higher sea levels, having significant economic and displacement impacts on the most vulnerable citizens in the county. Moreover, as developable land area diminishes and housing supply is lost, the cost of housing in the County could escalate more rapidly, making it difficult for low income resident to relocate nearby.

Environmental

Storm damage could result in building debris that could pollute the bays and ocean. Many buildings also contain potential water contaminants that could be swept out to sea. When homes are repaired or rebuilt, resource consumption will occur. As homes are demolished and relocated, additional consumption could occur, and degradation of the relocation site is likely. Additionally, using seawalls and other shoreline protective devices to protect buildings could result in the loss of beaches, wetlands, and other habitats and recreational areas by preventing these areas from migrating inland.

Social Equity

Equity concerns may arise regarding who should pay for adaptation or recovery related to sea level rise impacts, or what places should be protected and when. Temporarily or permanently relocating residents can sever neighborhood relationships, reducing neighborhood cohesion and breaking down emergency networks. Neighborhoods without these social networks are especially vulnerable to sea level rise and storm threats, and may have a harder time recovering from disasters.

People living with scarce financial resources are especially vulnerable to sea level rise. According to the Healthy Marin Partnership, 2013 Community Health Needs Assessment, between 50 and 70 percent of Marin's shoreline residents in the BayWAVE study area pay more than 45 percent of their income on housing and transportation combined.[17] The affordability standard is 30 percent of income on housing and 15 percent on transportation. [18] This indicates that a large portion of residents are already burdened by these basic expenses. Consequently, these households have less income for other necessities such as emergency preparedness, medical care, healthy food, child care, and education.

In addition, those with health or mobility constraints, who do not own a home or car, or are not proficient in the English language, may be disproportionally burdened by sea level rise and storms. Notably, in the Canal neighborhood of San Rafael, hundreds of residents meet several of these criteria. If displaced, the loss would be significant to these residents, their neighborhood, and the regional economy. In addition, the cost of repairs may be passed on to the tenants and increase the cost of living, potentially pricing existing residents out of their neighborhood.

Table 30. Income Spent on Housing & Transportation, 2005-2009

Jurisdiction	% residents paying more than 45% on housing & mobility
SF-Oakland-Fremont Region	48
Marin County	56
Sausalito	52
San Rafael	50
Larkspur	54
Corte Madera	55
Mill Valley	61
Strawberry	61
Kentfield	67
Belvedere	58
Tiburon	70
Novato	54
Santa Venetia	53
Tamalpais-Homestead	67
Black Point-Green Point	64
Marin City*	No data

Source: Human Impact Partners, 2015, H+T Index, CNT

** No data is available for Marin City, though Marin City figures may be incorporated with a nearby community.*

17 Human Impact Partners. 2013. Healthy Marin Partnership. Community Health Needs Assessment Sub-county Health Indicators.

18 Human Impact Partners. Healthy Marin Partnership. Community Health Needs Assessment Sub-county Health Indicators. 2013.

In Marin City, also a low-income community, the commercial shopping center is already vulnerable to stormwater flooding in combination with existing storm and king tides. Sea level rise could push tides even closer to stormwater outlets preventing the release of stormwater, and causing it to back up into the community. By scenario 6, storm surge flooding could reach directly over US Highway 101 and into the commercial and multi-family affordable housing on the other side. The loss of the shopping center could reduce local employment opportunities, shopping options, and community character. The apartments across from the shopping center could also be impacted by storm surge flooding. Combined with existing stormwater issues, this could displace several vulnerable residents and trap many more.

At worst, with long-term sea level rise, displaced residents the Canal neighborhood of San Rafael may not have access to equivalent affordable housing near the jobs, schools, and facilities they rely on and may be forced to leave their neighborhood. Residents in Marin City may be temporarily displaced by the long-term, with the potential to return to restored housing. In both areas, the residents are not responsible for restoring the buildings, and dependent on the investment and action of property owners. This would also apply to the many businesses serving these communities that lease their facilities.

Management

The Bay Conservation Development Commission (BCDC) retains development permit authority over tidelands (below mean high tide), submerged lands, and public trust lands. Potential state boundary changes could occur as tide levels rise. This could significantly impact private property rights when flooded land becomes lands of the State and existing residents are forced to pay new leasing fees.

Individual property owners may take individual measures to protect their property that could be damaging to neighboring properties, creating private property conflicts. And in some communities getting property owners to work together towards a shared goal may prove challenging.

In addition, as housing units are lost to the Bay, political representation based on population could shift to other areas, both with in and out of the County. Planning and implementing adaptation measures for higher water levels could span several election cycles across several levels of government. Successful preparation would require continuous political support from mayor to mayor, council to council, state congress person to person, and so on for several decades. If government priorities shift away from supporting sea level rise preparation, communities could be less equipped to weather increased flooding.

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TRANSPORTATION

Asset Profile: Roads, Trails, & Waterways

Low lying roads and other ground transportation infrastructure in Marin's bayside communities are already susceptible to flooding at high tides, especially king tides combined with storms. At worst, some roadways will become completely inundated most hours of the day or degraded and eroded beyond repair.

If the road network becomes compromised, communities would be extremely vulnerable to reduced goods movement and limited access to supplies essential for daily living, such as food, gasoline, medications, or other household items. Emergency service, postal service and garbage disposal could be interrupted, highway on and off ramps closed down, and commuting and tourism capacity significantly reduced. This will impact the vulnerable communities on the shoreline and in the inland valleys that depend on vehicular access through the flooded areas. Water travel will likely be able to adapt, however during storms, boats and boat lauches, marinas, and piers could experience significant damage and acess to them could be cut off. The following are key issues related to transportation vulnerability:

- The road network acts as a lynch pin, such that, if disrupted or destroyed, several other assets will also be disrupted or destroyed. While temporary shut downs could be tolerated in the near-term, chronic flooding could render road segments permanently impassable.
- Several key corridors, including the Manzanita Park & Ride and Tamalpais Junction corridor, already experience seasonal flooding that will likely worsen in the near-term.
- Many roadways serve as emergency access and evacuation routes, and could be flooded when residents need them most.
- Providing lifeline services to communities with limited access is an existing challenge during storm events.
- Vulnerable roadways can also cover and protect critical utility lines.
- .Not all residents have cars. Thousands of residents and visitors travel by foot, bike, depend on others, or use transit, and may not be able to evacuate in emergencies.

IMPACTS AT-A-GLANCE: SCENARIO 6

Nearly 130 miles of wet road, 3 ferries, 15 marinas	300,000+ people
Everyday living, tourism	Regional
More than $1 billion needed	Caltrans Marin County & Local Departments of Public Works Private Road Owners and HOAs Marin Transit Golden Gate Bridge, Highway and Transportation District Sonoma Marin Area Rail Transit Transportation Authority of Marin

US Highway 101 on ramp at Manzanita is already flooded at high tides, especially combined with storms. Credit: Unknown

- Transit services would become increasingly interrupted during high tides and storms, disproportionately impacting households with incomes below the county median income.
- While roads and parking areas can tolerate infrequent storm flooding, erosion susceptible areas, and those vulnerable to frequent flooding,

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could experience recurring damage and capacity reductions. Lighting systems in parking lots and along roads could be impacted, and could cause electrical hazards.
- Subsidence is already a factor for many roads and will likely worsen as the ground becomes saturated with bay waters further inland.
- The weakest points for the highways systems are on and off ramps, which are typically at the lowest elevations. Without access on and off the highways, they are not useable by several hundred thousand residents, commuters, and visitors.
- Roadways are also compromised by flooding from freshwater creeks during storms.

The most vulnerable high capacity roads are:

- Shoreline Highway from the Manzanita Park and Ride to Tam Junction,
- Highways US-101, I-580, and 37,
- Miller Avenue and Camino Alto in Mill Valley,
- Tiburon Boulevard in Tiburon,
- San Rafael Drive in Belvedere,
- San Clemente, Paradise, and Lucky Drives in Corte Madera,
- Redwood Highway and Sir Francis Drake Boulevard in Larkspur,
- Several arterials and local streets downtown around the US Highway 101 corridor and in the Canal neighborhood in San Rafael,
- Rowland Way in Novato, and
- Bel Marin Keys Boulevard.

These highways and arterials are the access ways to neighborhoods, major employers and commercial areas, and the rest of the bay area region. Commuting within and in and out of the County could become an increasing challenge as tides reach new heights and floodwaters deepen. These routes are also the backbone of the transit system, which Marin's autoless households depend on. Table 31 shows the cumulative lengths of all the roads and trails vulnerable in each community.

The table also annotates who is responsible for the roadway. In several cases, responsibility for a road may be divided amongst several governments that will need to work together when making improvements and adjustments for higher flood waters. Some important examples are Point San Pedro Road, Paradise Drive, and Sir Francis Drake Boulevard. In addition, several streets are privately maintained and could necessitate action by homeowner's associations or individual property owners. The property owners would likely need to work in cooperation with the public street improvement the private street connects to. The annotations are as follows:

M = Marin County
C = State of California
L = Local Municipality
P = Private

One limitation of this assessment is the ability to analyze bridges. Bridges within Highways US-101 and I-580, in most cases, are elevated above future flood depths analyzed in this analysis. However, flooding at higher levels on the supportive pillars and the weight of water at the low ends of the bridges could cause increased wear and tear to the bridges structural integrity.

Traffic backed up on Gate 6 Rd. in Waldo Point Harbor. Dec. 12, 2015. Credit: Marin County DPW

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Table 31. Roads Vulnerable to Sea Level Rise and Storms by Community

	Near-term		Medium-term		Long-term	
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
	8 miles (0% of study area)	30 miles (2% of study area)	20 miles (1% of study area)	62 miles (4% of study area)	100 miles (6% of study area)	130 miles (8%) of study area
Bus Routes	GGT:8, 10, 18, 24, 27, 37, 38, 40, 44, 54, 56, 58, 70, 72, 74, 76, 80, 97, 101 MT: 17, 23.29, 35, 36, 71, 228	Routes in Scenario 1	GGT: 4 MT: 19, 22, 61, 66, 113, 115, 117, 119	Routes in scenarios 1-3	GGT: 2 MT: 45, 49, 68, 219, 233, 251, 251, 251, 257, 259, 125, 126, 127, 145, 151, 154	Routes in scenarios 1-5
Municipalities						
Belvedere		San Rafael Ave [L] Hilarita Cir [L] Edgewater Rd [L]		Roads in scenario 2 Barn Rd [P] Beach Rd [L] Community Rd Cove Rd [L] Cove Road Pl [L] Leeward Rd [L] Mallard Rd [P] Peninsula Rd [L] Teal Rd [P] Windward Rd [L]	Roads in scenarios 2 & 4 Embarcadero Dr [P] Lagoon Rd [L] Maybridge Rd [L] West Shore Rd [L]	Roads in scenarios 2, 4, & 5 Bellevue Ave [L] Golden Gate Ave [L]
Mill Valley		Redwood Hwy [L] Amicita Ave [L] Camino Alto [L] Gomez Way [P] Miller Ave [L] Nelson Ave [L] Oxford Ave [L] Park Ter [P] Plymouth Ave [L] Frontage Rd [L] Surrey Ave [L] Sycamore Ave [L] Tamalpais Commons Ln [P] Valley Cir [L]		Roads in scenario 2 Hamilton Dr [L] Ryan Ave [L]	Roads in scenarios 2 & 4 E Blithedale Ave [L] Plymouth Cir [L] Roque Moraes Dr [L]	Roads in scenarios 2, 4, & 5 Ashford Ave [L] La Goma St [L] Leyton Ct [L] Lomita Dr [L] Matilda Ave [L] Meadow Rd [L] Nelson Ave [L] Shelter Bay Ave [L] Somerset Ln [L]

TRANSPORTATION

	Near-term		Medium-term		Long-term	
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Corte Madera		Hwy 101[C] Redwood Hwy[L] Paradise Dr[L] Baja Ct[L] Casa Buena Dr[L] Channel Dr[L] Conow St[L] Ebbtide Passage[L] Echo Ave[L] Fifer Ave[L] Golden Hind Passage[L] Harbor Dr[L] Lucky Dr[L] Nellen Ave[L] San Clemente Dr[L] Tamal Vista Blvd[L] Tamalpais Dr[L] Yolo St[L]		Roads in scenario 2 Apache Rd[L] Arrowhead Ln[L] Birch Ave[L] Cheyenne Way[L] Chickasaw Ct[L] Council Crest Dr[L] Edgemar Way[L] Hickory Ave[L] Lakeside Dr[L] Madera Blvd[L] Madera del Presidio Dr[L] Meadowsweet Dr[L] Mohave Ct[L] Mohawk Ave[L] Monona Dr[L] Navajo Ln[L] Sanford St[L] Seamast Passage[L] Seminole Ave[L] Tradewind Passage[L]	Roads in scenarios 2 & 4 Diamond Head Passage[L] El Camino Dr[L] Estrada Ln[L] Flying Cloud Course[L] Foremast Cv[L] Granada Dr[L] Key Largo Course[L] Key Largo Cv[L] Lanyard Cv[L] Meadow Creek Dr[P] Morning Star Course[L] Pacific Queen Passage[L] Paloma Dr[L] Prince Royal Dr[L] Prince Royal Passage[L] Sandpiper Cir[P] Seawolf Passage[L] Simon Ranch Rd[P] Spindrift Passage[L] Staghound Passage[L] Wornum Dr[L]	Roads in scenarios 2, 4, & 5 Ash Ave[L] Cay Passage[L] Chapman Dr[L] Council Crest Dr[L] Creekside Ct[P] Eastman Ave[L] Hickory Ave[L] Laurel Dr Parkview Cir[P] Pixley Ave[L] Redwood Ave Westward Dr[L]
Sausalito		Anchor Street[P] Coloma St[L] Gate 5 Rd[L, P] Harbor Dr[L] Heath Wy[L] Liberty Ship Wy[P] Spinnaker Dr[P] Varda Landing Rd[P]		Roads in scenario 2 Humboldt Ave[L, P] Turney St[L]	Roads in scenarios 2-4 Bridgeway[L] Johnson St[L] Litho St[L] Locust St[L] N Bridge Blvd[L] Napa St[L] Road 3[P]	Roads in scenarios 2-5 Bay St[P] Bee St[L] Caledonia St[L] El Portal St[L] Ensign St[L] Marina Plaza[P] Marinship Wy[L, P] Napa St[L] Pine St[L] Princess St[L] Richardson St[L] San Carlos Ave[L] Tracy Wy[L] Wateree St[P]

TRANSPORTATION

	Near-term		Medium-term		Long-term	
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Tiburon		Brunini Wy [L]		Roads from scenario 2	Roads from scenarios 2 Beach Rd [L] Blackfield Dr [L] Blackies' Pasture Rd [L] Cecilia Wy [L] Claire Wy [L] Harriet Way [L] Juanita Ln [L] Lagoon Vista [P] Leland Wy [L] Main St [L] Mar West St [L] Marsh Rd [P] Pamela Ct [L] Paradise Dr [L, M]	Roads in scenarios 2 & 5 Tiburon Blvd [C] Jefferson Dr [L] Washington Ct [L]
Larkspur	Hwy 101 [C] Redwood Hwy [L] Bon Air Rd [L] Greenbrae Boardwalk [M, P]	Roads in scenario 1 Creekside Dr [L] Doherty Dr [L] Industrial Wy [L, P] Larkspur Plaza [L] Rich St [L, P] Riviera Cir Dr [L]	Roads in scenarios 1 & 2	Roads in scenarios 1-3 Corte del Coronado [L] Diane Ln [L] Liberty St [L] Midway Rd [L] Tulane Dr [L] Via la Brisa [L] William Ave [L]	Roads in scenarios 1-4 Sir Francis Drake Blvd [L, M] Camellia Cir [P] Heather Wy [L] Rose Ln [P] S Eliseo Dr [L] Stanford Ct [L]	Roads in scenarios 1-5 Barry Way [L, P] College Ave [L, M] Cornell Ave [L] Corte del Bayo Real [L] Creek View Cir [P] Cross Creek Pl [P] Dartmouth Dr [L] Elizabeth Cir [P] Estelle Ave [L] Frances Ave [L] Gregory Pl [P] Gretchen Pl [P] Harvard Dr [L] Laderman Ln [P] Larkspur Lndg Cr [L] Lupine Ct [P] Magnolia Ave [L] Murray Ave [L] Orchid Dr [P] Sandy Creek Wy [P] Scott Pl [P] Victoria Wy [L] Yale Ave [L]

TRANSPORTATION

	Near-term		Medium-term		Long-term	
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Novato	Hwy 101 [C] Hwy 37 [C] Redwood Blvd [L] Rowland Wy [L]	Roads in scenario 1 Burma Rd [L] Perimeter Rd [L] Terminal Rd [L]	Roads in scenario 1	Roads in scenarios 1 & 2 Hamilton Dr [L] Ryan Ave [L] Deer Island Ln [L] Hanna Ranch Rd [L] Marsh Rd [L] Olive Ave [L] Two Water Trail	Roads in scenarios 1-4 Rowland Blvd [L] Bel Marin Keys Blvd [L] Hamilton Pkwy [L] Alconbury Wy [L] Alhambra Ct [L] Amelia Dr [L] Arnold Dr [L] Audubon Wy [L] Avocet Ct [L] Caliente Real [L] Club Dr [L] Emerson Ave [L] Ferdinand Way [L] Gann Way [L] Gateway Ct [L] Greenham Ct [L] Hamilton Landing [L] Hangar Ave [L] Hayford Ct [L] Holliday Dr [L] Hospital Dr [L] Inyo Cir [L] Laconheath Ave [L] Lassen Ln [L] Lavenham Rd [L] Los Padres Cir [L] Manuel Dr [L] Maybeck St [L] Mildenhall St [L] Modoc Pl [L] Moore Rd [L] Palm Dr [L] Pizarro Ave [L] Plumas Cir [L] Presidio Dr [L] Renaissance Rd [L] Richardson Rd [L] Richardson Wy [L] Ripley Ln [L] S Palm Dr [L] San Pablo Ave [L] San Pablo Ct [L] Stern Dr [L] Stonetree Ln [L] Tahoe Cir [L] Trinity Dr [L] Vintage Wy [L] Woodbridge Wy [L]	Roads in scenarios 1-5 Balboa Ct [L] Binford Rd [L] Donna St [L] El Arroyo Pl [L] El Granada Cir [L] Emerson Ave [L] Fairhaven Wy [L] Frosty Ln [L] La Crescenta Cir [L] Lea Dr [L] Leafwood Dr [L] Loleta Ln [L] Louis Dr [L] Palm Dr [L] Pamaron Wy [L] Rush Landing Rd [L] San Pablo Wy [L] Terminal Rd [L] Topaz Dr [L] Toyon Wy [L] Vera Cruz Ave [L]

TRANSPORTATION

	Near-term		Medium-term		Long-term	
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
San Rafael	Hwy 101 [C] Hwy 580 [C] Bellam Blvd [L] Francisco Blvd E [L] Kerner Blvd [L] Grand Ave [L] Irwin St [L] Canal St [L] Alto St [L] Amalfi Pl [L] Bahia Pl [L] Bahia Wy [L] Bahia Cir [L] Bay Harbor Wy [P] Belvedere St [L] Capri Ct [L] Castro Ave [L] Charlotte Dr [L] Elaine Wy [L] Fairfax St [L] Front St [L] Golden Gate Dr [L] Irene St [L,P] Larkspur St [L] Lido Ln [L] Lisbon St [L] Louise St [L] Madera St [P] Marian Ct [L] Market St [L] Medway Rd [L] Mill St [L] Mooring Rd [L] Novato St [L] Portofino Rd [L] Sea Wy [L] Shoreline Path Smith Ranch Airport [L] Sonoma St [L] Sorrento Wy [L] Summit Ave [L] Tiburon St [L] Verdi St [L] Vivian St [L] Yosemite Rd [L]	Roads in scenario 1 Pt. San Pedro Rd [L, C] Acadia Ln [L] Bahia Ln [L] Baxters Ct [P] Bedford Cv [L] Billou St [L] Bret Ave [L] Bryce Canyon Rd [L] Carlsbad Ct [L] Catalina Blvd [L] Crater Lake Wy [L] De Luca Pl [L] Dolores St [L] Du Bois St [L] Duffy Pl [L] Duxbury Cv [L] Falmouth Cv [L] Gary Pl [L] Glacier Way [L] Gloucester Cv [L] Hingham Cv [L] Hoag St [L] Hyannis Cv [L] Isla Vista Ln [L] Isle Royale Ct [L] Jordan St [L] Lagoon Pl [L] Lagoon Rd [L] Lincoln Ave [L] Loma Vista Pl [L] Lovell Ave [L] Marina Way [L] McNear Dr [L] Mesa Verde Wy [L] Nantucket Cv [L] Narragansett Cv [L] Newport Wy [L] Olympic Wy [L] Peacock Dr [L] Playa Del Rey [L] Plymouth Cv [L] Porto Bello Dr [L] Rice Dr [L] Riviera Dr [L] Rockport Cv [L] Salem Cv [L] San Marcos Pl [L] Shenandoah Pl [L] Shoreline Pkwy [L] Spinnaker Point Dr [L] Tahoe Pl [L] Teton Ct [L] Vista Del Mar [L] Windward Wy [L] Woodland Ave [L] Yellowstone Ct [L] Zion Ct [L]	Roads in scenario 1 Francisco Blvd W [L]	Roads in scenarios 1-3 2nd St [L] 3rd St [L] Lindaro St [L] Aqua Vista Dr [L] Baypoint Dr [L] Baypoint Village Dr [L] Biscayne Dr [L] Dodie St [L] Egret View [L] Loch Lomond Dr [L] Novato St [L] Pelican Wy [L] Royal Ct [L] Simms St [L] Yacht Club Dr [P]	Roads in scenarios 1-4 4th St [L] A St [L] B St [L] Hetherton St [L] Albert Park Ln [L] Avocet Ct [P] Brooks St [L] Chapel Cove Dr [L] Cijos St [L] Dowitcher Wy [P] Embarcadero Wy [L] Glacier Pt [L] Grange Ave [L] Jacoby St [L] Knight Dr [L] Leith Ln [L] Lido Ln [L] Lochinvar Rd [L] Lootens Pl [L] Mariposa Rd [L] Mary St [L] Mission Ave [L] Morphew St [L] Park St [L] Peacock Ln [L] Piombo Pl [L] Portsmouth Cv [L] Ritter St [L] Riviera Pl [L] Silk Oak Cir [L] Summit Ave [L] Surfwood Cir [L] Tern Ct [P] Turnstone Dr [P] Union St [L] Warner Ct [L]	Roads in scenarios 1-5 C St [L] Bayview St [L] Bridgewater Dr [L] Commercial Pl [L] Loma Linda Rd [L] Main Dr [L] Mariners Cir [L] Mark Dr [L] McInnis Pkwy [L] Milano Pl [L] Mitchell Blvd [L] Newport Wy [L] Octavia St [L] Paul Dr [L] Pelican Wy [L] Riviera Manor [L] Rockport Cv [L] San Pedro Cv [P] Sandpiper Ct [L] Shores Ct [L] Smith Ranch Rd [L] Taylor St [L] Waterside Cir [L] Willow St [L] Woodland Pl [L]

TRANSPORTATION

	Near-term		Medium-term		Long-term	
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Unincorporated Jurisdictions						
Almonte		Hwy 101 [C] Bolinas St [M] Pohono St [M] Shoreline Hwy [C]		Roads in scenario 2	Roads in scenarios 2 Almonte Blvd [M]	Roads in scenarios 2 & 5 Helen Ave [M]
Bayside Acres				Beach Dr [M]	Road in scenarios 4	Road in scenarios 4 & 5
Bel Marin Keys	Bel Marin Keys Blvd [M]	Roads in scenario 1 Bahama Reef [M] Del Oro Lagoon [M]	Roads in scenario 1	Roads in scenarios 1-3	Roads in scenarios 1-4 Bermuda Harbour[M] Calypso Shores [M] Caribe Isle [M] Cavalla Cay [M] Dolphin Isle [M] Montego Key [M]	Roads in scenarios 1-5
Black Point				Atherton Ave [M] Bachelors Rd [P] Bayview St [P] Beattie Ave [P] Buck's Landing Rd [M] Cavallero Ct [P] Channel Dr [P] Days Island Rd [P] Holly Ave [P] Norton Ave [P] Olive Ave [M] School Rd [M]	Roads in scenario 4 Glen Rd [P] Harbor Dr [P] Hunters' Club Rd [P] Tamarin Ln [P]	Roads in scenarios 4 & 5
California Park					Auburn St [M] Woodland Ave [M]	Roads in scenario 5
China Camp		N San Pedro Rd [M]		Roads in scenario 2	Roads in scenario 2	Roads in scenario 2
Country Club		Harbor View Ct [M]		Roads in scenario 2	Roads in scenario 2	Roads in scenario 2 Pt. San Pedro Rd [M] Summit Ave [M]

TRANSPORTATION

	Near-term		Medium-term		Long-term	
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Greenbrae Boardwalk	Greenbrae Boardwalk[P]	Hwy 101[C] Lucky Dr [M]		Roads in scenarios 1& 2	Roads in scenarios 1& 2	Roads in scenarios 1& 2
Kentfield				Berens Dr [M] Lilac Ave [M] McAllister Ave [M]	Roads in scenario 4 Lancaster Ave [M] Sherwood Ct [M] Stadium Wy [P]	Roads in scenarios 4 & 5 Acacia Ave [M] Bon Air Rd [M] College Ave [M] Hillside Ave [M] Kent Ave [M] Laurel Grove Ave[M] Sir Francis Drake Blvd [M]
Marin City					Hwy 101[C] Donahue St [M] Drake Ave [M]	Rods in scenario 5 Terners Dr [M]
North Novato	Hwy 37 [C]	Roads in scenario 1	Roads in scenarios 1 &2	Roads in scenarios 1-3 Airport Rd [M] Binford Rd [M]	Roads in scenarios 1-4 Hwy 101 [C]	Roads in scenarios 1-5
Paradise Cay		St. Lucia Place [M]		Roads in scenario 2 Jamaica St [M] Paradise Cay Marina [P] St Thomas Wy [M]	Roads in scenarios 2 & 4 Martinique Ave [M]	Roads in scenarios 2, 4, & 5 Saba Ln [M] Trinidad Dr [M]
Pt. San Pedro		McNear Brickyard Rd [P] McNears Rd [P]		Roads in scenario 2 Pt. San Pedro Rd[M]		
San Quentin	Hwy 580 [C]	Roads in scenario 1	Roads in scenarios 1 &2	Roads in scenarios 1-3	Roads in scenarios 1-4 Levee Rd [P]	Roads in scenarios 1-5 Waterfront Rd [P]

TRANSPORTATION

	Near-term		Medium-term		Long-term	
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Santa Venetia		N San Pedro Rd [M] Adrian Wy [M] Ash Wy [M] Birch Wy [M] Descanso Wy [M] Estancia Wy [M] Galerita Wy [M] Geneva Wy [M] Hacienda Wy [M] Hawthorn Wy [M] La Pasada [M] La Playa Wy [M] LaBrea Wy [M] Mabry Wy [M] Meadow Dr [M] Palmera Wy [M] Rafael Wy [M] Rosal Wy [M] Vendola Dr [M]		Roads in scenario 2 Rincon Wy [M]	Roads in scenarios 2 & 4	Edward Ave [M] Lowell Ave [M] Mark Twain Ave [M] Steven Wy [M] Whittier Ave [M]
Strawberry	Hwy 101 N [C]	Roads in scenario 1 Barbaree Way [M] Channel Lndg [P] Greenwood Bay Dr [P] Greenwood Cove Dr [M] Redwood Hwy Frontage Rd [M] Salt Lndg [M] Seminary Dr [M]	Roads in scenarios 1 & 2	Roads in scenario 2 De Silva Island Dr [P] E Strawberry Dr [M] Strawberry Cir [M]	Roads in scenarios 2 & 4 Belvedere Dr [M] Captains Lndg [M] Harbor Cove ay [M] Ricardo Rd [M] Seadrift Lndg [M] Tiburon Blvd [C] Villa Laguna [P]	Roads in scenarios 1-5 Heron Dr [M] Strawberry Lndg [P] Strawberry Village [P] Weatherly Dr [M]
Tamalpais Valley		Shoreline Hwy [C] Tennessee Valley Rd [M] Almonte Blvd [M] Cardinal Ct [M] Cardinal Rd [M] Flamingo Rd [M]		Roads in scenario 2	Roads in scenarios 2 & 4	Roads in scenarios 2, 4, & 5 Gibson Ave [M]
Waldo Point Harbor	Gate 6 Dock [P] Gate 6 Rd [M]	Gate 6 1/2 Rd [P] Liberty Dock [P]	Roads in scenarios 1 & 2	Roads in scenarios 1-3 Shoreline Hwy [C] Bolinas St [M]	Roads in scenarios 1-4	Roads in scenarios 1-5 Main Dock [P]

Source: MarinMap, CoSMoS

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Rowland Blvd., bike lane, and SMART rail line behind the Vintage Oaks Shopping Center could be vulnerable. Credit: BVB Consulting LLC

Table 32. Roadway Vulnerabilities

Elevation	▪ Roads at grade could be vulnerable to inundation, scouring, and erosion. ▪ During storms, or increased wave exposure, roads above grade, on bluffs, or adjacent to hill sides, are also vulnerable to erosion. ▪ Roads on bay mud could be vulnerable to subsidence and erosion.
Soils	▪ Most soils in the study area are erodible soils and are susceptible to slides, scouring, and subsidence.
Materials	▪ Asphalt and concrete exposed to frequent flooding and high levels of salt could deteriorate faster than in drier times. ▪ Lighting in parking lots could be vulnerable to flooding.

With few exceptions, all of the vulnerable municipal and unincorporated areas have at least one vulnerable roadway. As seen in the maps at the end of this profile, the majority of the roads vulnerable in scenario 1 are in San Rafael, with seven miles of the eight miles exposed. This includes US-101 and I-580 on and off ramps, and the actual roadway in some locations. The areas in the call out circles enable the reader the see areas that are difficult to see on the large scale map. The circles do not indicate that these areas are more vulnerable than others along the shoreline.

If a 100-year storm surge were to occur at 10 inches of sea level rise, scenario 2, Santa Venetia and Mill Valley also join San Rafael in having the majority of impacted roadways by number, and in mileage. Scenario 3, or 20 inches of sea level rise, is very similar in impact as scenario 1 and in the lowest lying areas, some roads in scenario 2 are also impacted under scenario 3. For scenario 3, in several locations, the extent is greater than scenario 1, but less than scenario 2 with the storm surge. Adding a 100-year storm surge to scenario 3 has a significantly greater impact, though temporary for those impacted in this scenario for the first time. And at 60 inches, or 5 feet, of sea level rise, hundreds of miles of roads and hundreds of roads could become flooded several hours a day during the highest tides each month.

Communities that could face sea level rise direct impacts to roads network in the near-term are Larkspur, Novato, San Rafael, Sausalito, Bel Marin Keys, North Novato, San Quentin, Strawberry, and Waldo Point Harbor. Those that will be impacted only under the storm scenarios in the near- and medium-terms include: Belvedere, Tiburon, Corte Madera, Mill Valley, Almonte, Greenbrae Boardwalk, Country Club, China Camp State Park, Tamalpais Valley, Santa Venetia, Point San Pedro, and Paradise Cay. Of note, several communities may not see dramatic roads impacts from sea level rise until the long-term projection in scenario 5. These communities include: Marin City, Kentfield, California Park, Black Point, and Bayside Acres. These communities, especially Marin City and Kentfield, see severe stormwater backups that could get worse as higher tides prevent precipitation from draining to the bays. Some of these communities may experience storm surge impacts under scenario 4 conditions. By this scenario, saltwater becomes a contributing factor to the already significant stormwater backups. Nevertheless, these communities depend on the networks in other shoreline communities, and could expect significant ripple effects from compromises in the network in before mid-century. In addition, the roads host nearly 2,500 streetlights that could be vulnerable. This could increase corrosion of the metal posts, rotting of wooden posts, and any low lying electrical components.

The County of Marin's major vulnerable roads include Sir Francis Drake Blvd., portions of Point San Pedro and North San Pedro Blvd. Some less traveled roads include residential streets along the shoreline in Santa Venetia, Bayside Acres, and Almonte. Marin County Public Works stressed that roadway impacts from water will severely degrade

the base and surface materials from the weight of vehicle traffic breaking up the roadway. The goal to limit water intrusion and avoid damage to the roadway system, including the roadway drainage facilities, is not easily met. Identifying cost effective and environmentally feasible solutions will require engineering studies with partnerships from local stakeholders and permitting agencies.

Caltrans is the asset manager for Highways US-101, I-580, 37, and 1, also known as Shoreline Highway. Marin County is in Caltrans District 4 with Sonoma, Solano, Napa, Contra Costa, Alameda, Santa Clara, San Mateo, and San Francisco Counties (see Map 15). Adapting District 4 systems for near-term exposure levels could cost billions of dollars. According to the *Caltrans Guidance on Incorporating Sea Level Rise*, the State Highway System is limited in adaptive capacity because of the numerous services it facilitates, its permanent location, longitudinal nature, long lifespan, and uncertain funding resources.[19]

Caltrans asks three questions in assessing sea level rise planning:

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

Other factors include anticipated travel delays, goods movement, emergency evacuation, travel safety, burden on public funds, impacts on connecting streets, and environmental constraints. Preliminary conversations with Caltrans asset managers indicate that Caltrans is well aware of the existing and arising concerns in the County.[20] According to Caltrans and the CoSMoS model the following are areas of concern:

- Manzanita Park and Ride Lot and Shoreline Highway, Almonte: This area already floods at high tides at about 4.5 feet NGVD about 20 to 30 times every year.
- US Highway 101 from Seminary Drive to Route 131 (Tiburon Boulevard), Strawberry: This stretch is prone to flooding at high tide and storm events, especially at the off ramps. This stretch of the highway is unprotected.
- US Highway 101 at Rowland Boulevard, Novato: This stretch floods, is adjacent to Scottsdale Pond, and a series of ponds, levees, and pumps operated by others protect it.
- US Highway 101 at the 101/37 Interchange, Novato: This vulnerable 3,100-foot stretch is protected by levees and pumps operated by others.
- US Highway 101 in low spots between Corte Madera and San Rafael: These low spots typically benefit from levees and pumps others operate to protect the larger area from flooding. These locations are south of Tamalpais Drive to Nellen Avenue, from Corte Madera Creek to Lucky Drive, and south of the US Highway 101/ I-580 Interchange to the south of San Rafael Harbor.
- State Route 37 between Atherton Avenue and US Highway 101: This stretch of 37 is protected by non-engineered levees that have a history of overtopping with combined high tides and Novato Creek flows.

Making improvements to these locations could cost $825 million to $1.1 billion depending on the adaptation methods chosen.[21,22]

Overall, a significant amount of transportation assets could be vulnerable. This could impact individual mobility and the movement of goods and services. Some critical examples are food delivery, solid waste and recycling removal, emergency and repair vehicles, and transit vehicles.

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

20 Sea Level Rise Vulnerability Assessment Interview. Caltrans. April 30, 2015. J. Peterson. D. Fahey. Marin County Development Agency. BVB Consulting LLC.

21 Sea Level Rise Vulnerability Assessment Interview. Caltrans. April 30, 2015. J. Peterson. D. Fahey. Marin County Development Agency. BVB Consulting LLC.

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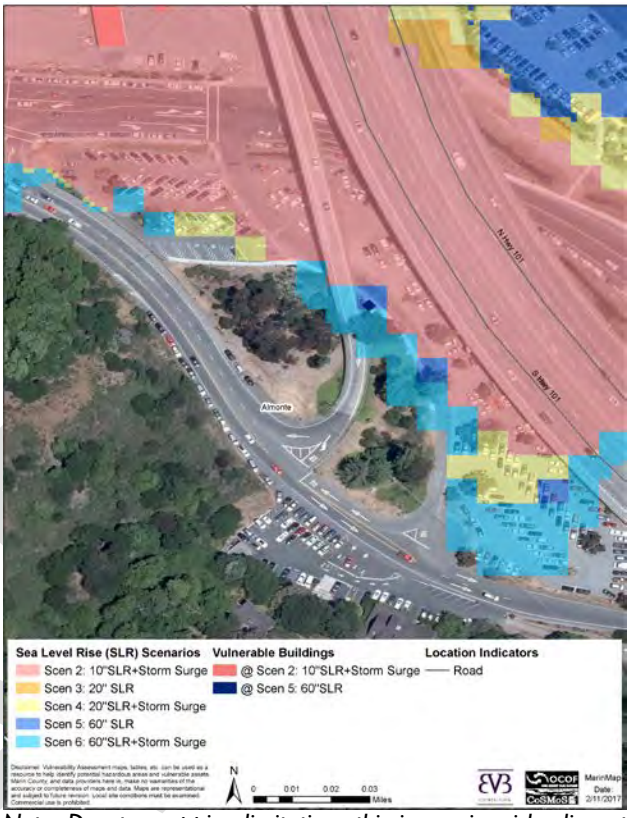
Richardson Bay Flooding, Jan. 1982. Credit: Marin DPW

Waldo Point Harbor King Tide. Nov. 24, 2015. Credit: Marin CDA

Map 14. Manzanita Park & Ride Sea Level Rise Exposure



Note: Due to mapping limitations this image is misleading at the freeway overpass. The water on top of the overpass in the image represents water under the overpass at ground level. The overpass is elevated above Richardson Bay. Source: MarinMap, CoSMoS. Credit: BVB Consulting LLC.

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Map 15. Caltrans District 4

Transit Service

Several entities provide transit services in Marin County both locally and regionally that could be impacted by sea level rise. Regional bus and ferry service is provided by the Golden Gate Bridge, Highway and Transportation District (GGBHTD) as Golden Gate Transit (GGT) and Golden Gate Ferry (GGF). Local bus transit is provided by the Marin Transit (MT). Several airporters and other charter buses transport travelers as well. Private ferry services are provided by Blue and Gold Ferries amongst other private services.

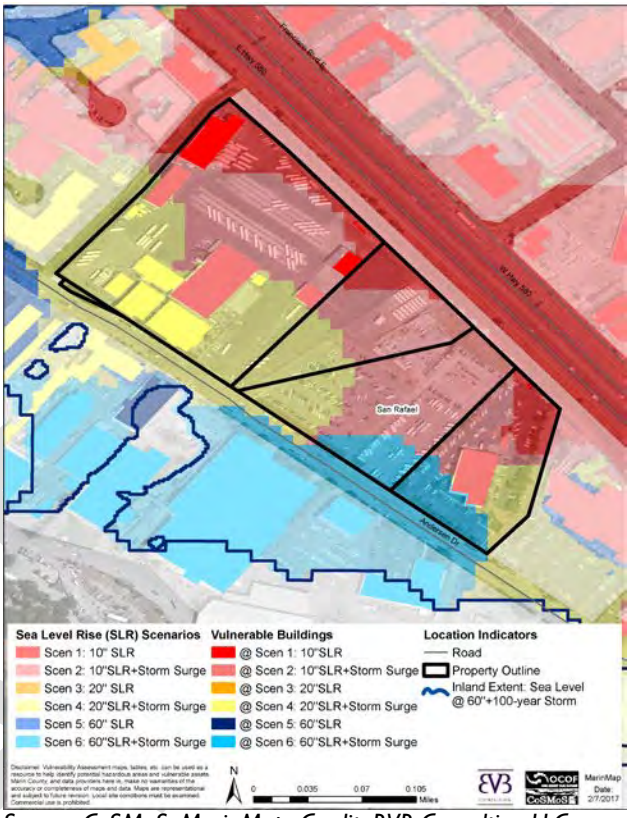
Bus routes that run on roads vulnerable to storm impacts and sea level rise are:

- GGT routes:
  - Scenario 1: 8, 10, 18, 24, 27, 37, 38, 40, 44, 54, 56, 58, 70, 72, 74, 76, 80, 97, and 101.
  - Scenario 3: 4
  - Scenario 5: 2
- MT routes
  - Scenario 1: 17, 23.29, 35, 36, 71, 228;
  - Scenario 3: 19, 22, 61, 66, 113, 115, 117, 119
  - Scenario 5: 45, 49, 68, 219, 233, 251, 251, 251, 257, 259, 125, 126, 127, 145, 151, 154.

These routes could be vulnerable to dangerous conditions and loss of access at stops and between them. MT has more than 170 stops and GGT has about 115 stops that could be vulnerable at MHHW in the long-term. Several of these stops are also used by the Marin Airporter and the Sonoma Airport Shuttle, including Manzanita Park and Ride in Almonte and the San Rafael Transit Center. Additional private company buses, such as Genentech, also pick-up commuters from the Manzanita site. Manzanita is already seasonally vulnerable and the San Rafael Transit Center is vulnerable in the medium- to long-terms.

In addition, the GGT Headquarters, Machine Shop, and Bus Depot could be vulnerable to sea level rise starting in the near-term. Exposure could be significant enough in the medium-term to warrant action on site. The facility is on Andersen Drive in San Rafael and also hosts the Marin Airporter depot, offices, and pick up location.

Map 16. GGBHTD Headquarters & Bus Depot Sea Level Rise Exposure



Source: CoSMoS, MarinMap. Credit: BVB Consulting LLC

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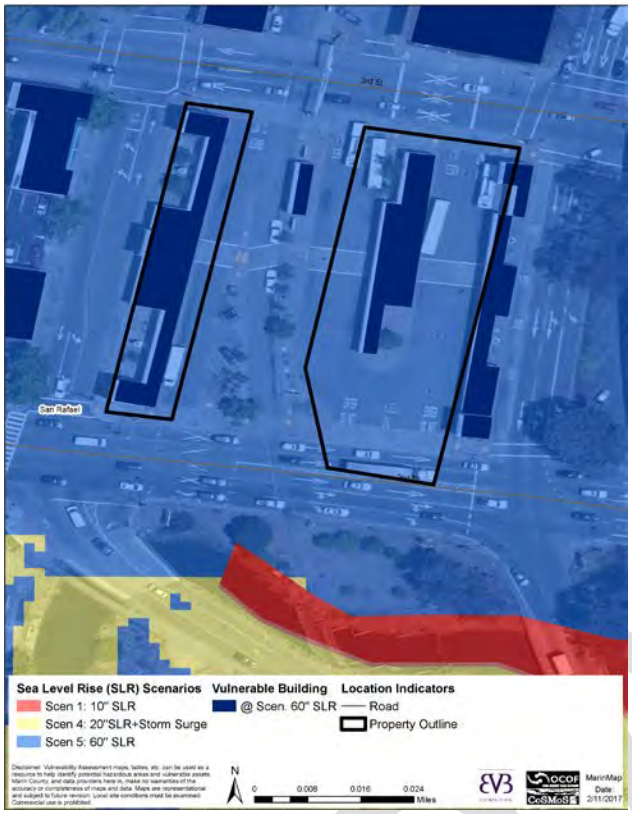
Map 17. San Rafael Transit Center Sea Level Rise Exposure



The SMART train is the only regional rail service soon to be available to Marin County residents. This new service could flood at several points along its rail line from Sonoma County, through Novato, San Rafael, and terminating in Larkspur.

The track itself is vulnerable to weakness in the base, or ballast, of pervious stones piled in a trapezoid. If flooded often enough these areas could subside and weaken overtime. Moreover, the rail right-of-way typically contains embedded utilities, and signal, switches, and electrical equipment.

The train cars themselves could be vulnerable to flooding because much of the mechanical equipment is on the bottom of the train car. Continued exposure to saltwater could cause increased rates of corrosion. If the water is deep enough, the train may not be able to pass at all. The mile posts where the track could flood include:

- 15.9 to 16.9, San Rafael/Santa Venetia
- 19.8 to 20.9, Central San Rafael
- 21.4 to 23.0, St. Vincent's
- 25.3 to 27.4, Novato behind Rowland Way
- 29.6 to 29.8, Novato
- 30.1 to 31.9, Novato
- 32.9 to 33.4, Novato, North Novato

The San Rafael Transit Center is the only SMART stop that could expect tidal flooding at 60 inches of sea level rise in long-term scenario 5.

Bicycling

Bike paths along existing roadways could be vulnerable as well, and much like cars, bicycles could be vulnerable to frequent saltwater exposure. In addition, several multi-use trails such as the Mill Valley-Sausalito and Corte Madera Creek Pathways could be vulnerable in the near-term because of the waterway crossing and bordering routes. Bikeways are also vulnerable to flooding in the northern part of the study area around Bel Marin Keys.

SMART railroad in Novato. Credit: BVB Consulting LLC

Mill Valley-Sausalito Multi-Use Path at high tide. Credit: J. Poskazner

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TRANSPORTATION

View of Larkspur Ferry parking lot and boats from Greenbrae Boardwalk. Credit: BVB Consulting LLC

Water Transportation

Boasting for commuting to work, leisure, sport, shipping, and other activities are important vulnerable uses of the Marin shoreline.

Ferry Service

Three ferries service the regional transportation network and one offers transport to Angel Island State Park. The three providing commuting services dock in Sausalito, Tiburon, and Larkspur. The Tiburon Ferry also serves a good portion of tourists, especially on sunny weekends. Of these, the most vulnerable is Larkspur Landing.

According to GGBHTD ferry asset managers, the Larkspur Ferry Terminal uses a hydraulic system that reaches its limits at king tides today. Major improvements to the site, parking capacity, and dock operating systems are discussed in the 10-year Master Plan for the facility. These plans include updating the facility to a float system capable of accommodating higher sea levels. Without this effort, the GGF Larkspur Ferry may have to eliminate service when tides are too high. At worst the majority of the property could flood tidally, eliminating access, parking, and offices.

The parking area is already susceptible to riverine flooding, and if the earthen berm is breached by the bay, the parking lot would have to weather saltwater exposure as well. This could lead to vehicle damage, especially over the extended periods of time commuters leave their vehicles on site. The ferry facility fuel containers could also experience tidal flooding. If this fuel source is compromised during a storm or through long-term exposure to corrosive saltwater, not only is this region wide resource threatened, the bay could be contaminated with fuel and other chemicals.

The Blue & Gold and Angel Island Ferry landings in Tiburon are vulnerable to sea level rise in the near-term. The GGT Sausalito Ferry operates on a float system that may be able to withstand sea level impacts in the near-term.

Harbors and Marinas

Privately owned boats are housed and/or leave from the following vulnerable water transportation facilities:

- Arques Shipyard and Marina, Sausalito,
- Buck's Landing (public),
- Cass Gidley Marina, Sausalito (public),
- Corinthian Yacht Club, Belvedere,
- Clipper Yacht Harbor, Sausalito,
- Five Star Yacht, Sausalito,
- Hi-Tide Boat Sales & Services, San Rafael,
- Loch Lomond Marina, San Rafael,
- Liberty Ship Marina, Sausalito,
- Lowrie Yacht Harbor, San Rafael,
- Marin Yacht Club,
- Marina Plaza Harbor, Sausalito,
- Paradise Cay Yacht Harbor,
- Pelican Yacht Harbor, Sausalito,
- Petaluma River Public Fishing Access (public),
- Richardson Bay Marina & Kappas Harbor, Waldo Point Harbor,
- San Rafael Port,
- San Rafael Yacht Club,
- San Rafael Yacht Harbor,
- San Francisco Yacht Club, Belvedere,
- Sausalito Marina,
- Sausalito Port,
- Sausalito Yacht Harbor,
- Schoonmaker Point Marina, Sausalito,
- Tiburon Yacht Club, Paradise Cay,
- Travis Marina, Fort Baker, and
- Waldo Point Harbor.

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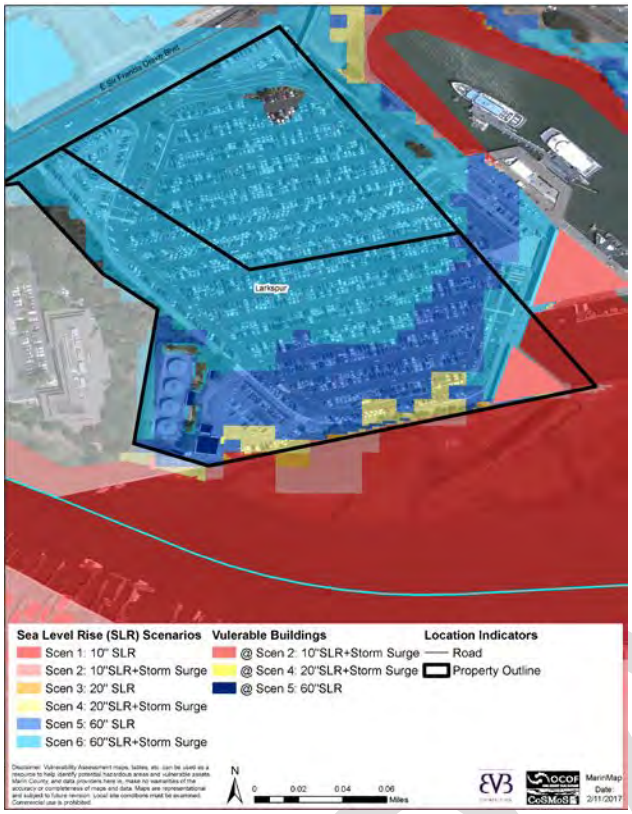
Map 18. Larkspur Ferry Terminal Sea Level Rise Exposure



Loch Lomond Marina, San Rafael. Credit: BVB Consulting LLC

Water transport facilities vary in vulnerability depending on the docks system, if the pylons the docks attach to are high enough for the highest high tides, and to subsidence of jetty walls. Just like Larkspur Landing, these harbors, if not set up high enough to handle the future's new high tides, could be vulnerable. Storms are known to cause damage to docks, piers, and boats as well, and damages to boats could lead to loss of life and/or significant economic losses.

Marina and harbor facilities serve several purposes and contribute significantly to economic strength and community character. The Sausalito shoreline has a concentration of boating industry activities. Several locations in Sausalito, Waldo Point Harbor, Belvedere, Tiburon, and Paradise Cay also serve as places to live. To learn more about residential vessels, see the Buildings profile. In addition to private residences, these harbors house tourist attractions, restaurants, and other forms of recreation that are a major draw for Marin County.

And while not located in Marin, Marin residents and businesses could be vulnerable to damages and shut downs at the region's ports. In 2007, the four major ports in Oakland, San Francisco, Redwood City, and Richmond processed nearly 2,388 thousand twenty-foot equivalents of marine cargo and 29.4 million tons of bulk cargo.[23] The port of Oakland hosts the largest volume of cargo as the nation's fourth busiest port, and carries more exports cargo than imports The Bay Area Region airports and sea ports are gateways to Marin and the world and generate a significant amount of productivity that Marin County benefits from and depend on.

Airports

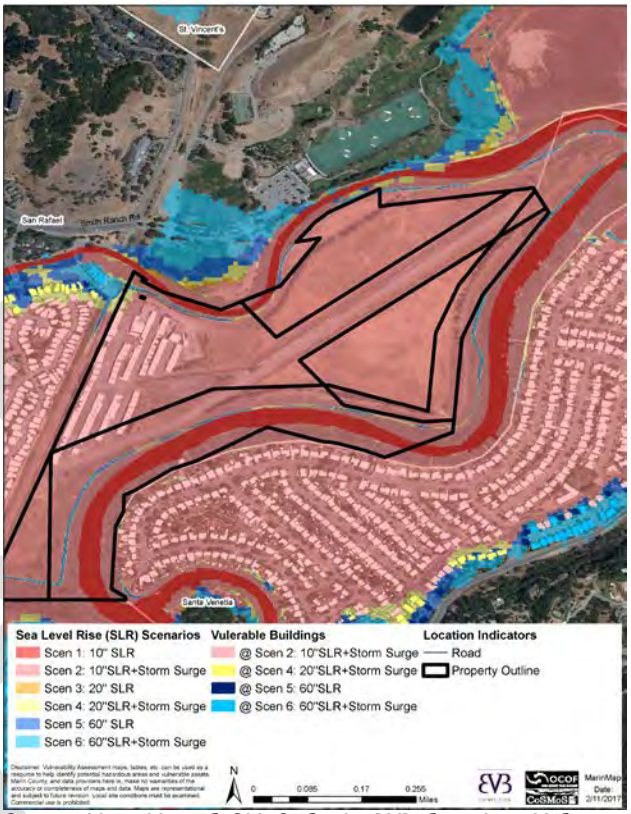
The Gnoss Field Airport in North Novato could be vulnerable in the long-term, and Smith Ranch airport in eastern San Rafael could be vulnerable in the medium-term. Both of these small plane facilities depend on levees for flood protection; however, Gnoss Field depends on levees managed by other land owners closer to shoreline. If the respective levees fail, both airfields would be vulnerable to high tides sooner than the timeline of this assessment

[23] Biging, Greg S., John D. Radke, and Jun Hak Lee (University of California, Berkeley). 2012. *Impacts of Predicted Sea-Level Rise and Extreme Storm Events on the Transportation Infrastructure in the San Francisco Bay Region.* California Energy Commission. Publication number: CEC-500-2012-040.

would anticipate. Flooding would reduce flight time windows, and would damage airplane storage areas and airplanes stored on site. Finally, increased subsidence could warp the buildings and runway.

Table 33 lists some of the potentially vulnerable transportation assets in the study area. This list shows onset as near-, medium-, and long-term time intervals, and the flood depth values calculated for tidal mean higher high water (MHHW). High and low values along each vulnerable roadway or pathway segment are provided. In scenarios 1, 3 and 5, a roadway may be impacted for short periods of daily high tides, be submerged, or somewhere in between.

Map 19. Smith Ranch Airport Sea Level Rise Exposure



Source: MarinMap, CoSMoS. Credit: BVB Consulting LLC

Table 33. Example Transportation Assets Ranked by Onset and Flooding at MHHW

Location	Asset	Near-term	Medium-term	Long-term
		Scenario 1	Scenario 3	Scenario 5
Sausalito	Sausalito Ferry facilities	No data	No data	No data
Sausalito	Marina Plaza Harbor	5'7"	8'6"	21'9"
Larkspur	Bay Trail	0-5'4"	0-6'	0-8'6"
Waldo Point	Richardson Bay Marina	4'5"	7'4"	18'7"
Tiburon	Ferry facilities	4'	5'	12'9"
San Rafael	Hwy 580 East bound	0-4'	0-4'10"	4"-7'8"
San Rafael	Kerner Blvd	0-4'	0-4'7"	8"-7'5"
Belvedere	Corinthian Yacht Club	4'	4'3"	11'
San Rafael	Francisco Blvd E	0-3'10"	0-4'7"	1'-7'5"
Bel Marin Keys	Bel Marin Keys Blvd	0-3'10"	0-4'6"	0-8'6"
San Rafael	Bellam Blvd	0-3'5"	0-4'	0-7'3"
San Rafael	Canal Street	0-3'4"	1'2"-4'2"	2'-7'11"

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Location	Asset	Near-term	Medium-term	Long-term
		Scenario 1	Scenario 3	Scenario 5
San Rafael	Bahia Way	2'-3'3"	2'4"-3'11"	5'2"-6'10"
Tiburon	Richardson Bay Lineal Park	0-3'	1"-3'7"	1"-15'
San Rafael	Hwy 580 West bound	1"-2'10"	1"-3'7"	1"-6'5"
San Rafael	Bay Trail	0-2'3"	0-3'	0-10'3"
Belvedere	San Francisco Yacht Club	2'2"	3'6"	8'10"
Greenbrae	Greenbrae Boardwalk	5"-1'7'	1'-2'4"	3'3"-5'
San Rafael	Hi-Tide Boat sales & services	6"	3'4"	8'5"
Almonte	Caltrans Corp Yard	0-6"	1'4"-1'9"	3'4"-4'5"
Sausalito	Sausalito Yacht Harbor	4"	1'	3'
Larkspur	Corte Madera Creek Path	0-3"	1"-2'	0-6'9"
Paradise Cay	Paradise Cay Yacht Harbor	2"	1'6"	3'10"
San Rafael	Lowrie Yacht Harbor	2"	9"	3'7""
San Rafael	San Rafael Yacht Harbor	1'2"	4'	10'4"
San Rafael	San Rafael Municipal Harbor	1'	2'	6'
San Rafael	Marin Yacht Club	1"	1'6"	3'9"
Mill Valley/ Sausalito	Mill Valley/ Sausalito Pathway		0-8'5"	1"-11'8"
Mill Valley	Bay Trail		0-8'	3"-12'5"
Tamalpais	Shoreline Highway		5"-7'5"	2"-12'5"
San Rafael	Grand Avenue		0-6'	7"-9'
San Rafael	Andersen Drive		0-5'	3"-8"
San Rafael	Francisco Blvd W		0-4'9"	1'8"-9'5"
North Novato	Gnoss Field Airport		4'	10'4"
San Rafael	Peacock Drive		0-4'	9"-6'8"
Almonte	Shoreline Highway		0-3'10"	1'6"-7'
San Rafael	SMART rail in central San Rafael		1'8"-3'9"	1'2"-6'8"
San Rafael	Loch Lomond Marina		3'7"	9'7"
San Rafael	San Rafael Airport		3'5"	8'10"
Corte Madera	Bay Trail		0-3'4"	0-8'6"
Sausalito	Schoonmaker Point Marina		3'3"	8'2"
San Rafael	Canal neighborhood		1"-3'	2"-7'8"
Larkspur	Larkspur Ferry facility		1'-2'6"	2'7"-7'9"
Corte Madera	Paradise Drive		0-2'5"	4"-9'
Sausalito	Clipper Yacht Harbor		2'5"	6'3"
San Rafael	Hwy 101 N		0-2'5"	6"-5'3"
Corte Madera	San Clemente Drive		1'2"-2'3"	1'9"-7'4'
San Rafael	Pt. San Pedro Road		0-2'2"	4"-5'10"
San Rafael	San Rafael Yacht Club		2'2"	5'7"
Sausalito	Gate 5 Road		0-2'2"	10"-4'10"
Sausalito	Cass Gidley Marina		2'	3'2"
San Rafael	GGBHTD headquarters & depot		1'8"-2'	4'2"-5'
Corte Madera	Tamalpais Drive		0-2'	2"-7'6"
San Rafael	Hwy 101S		0-2'	1'4"-5'

TRANSPORTATION

Location	Asset	Near-term	Medium-term	Long-term
		Scenario 1	Scenario 3	Scenario 5
Waldo Point	Gate 6 Road		0-1’9”	1’10”-4’9”
China Camp	N. San Pedro Road		0-1’8”	1’7”-3’8”
Mill Valley	Miller Avenue		0-1’7”	2’-4’8”
Larkspur	Larkspur Landing fuel storage		1’7”	4’2”
San Rafael	Downtown		1”-1’3”	3”-3’3”
Bayside Acres	Beach Drive		1”-1'	2’4”-3’10”
San Rafael	San Rafael Transit Center		11”	2’5”
Corte Madera	CA Highway Patrol Marin office		9”	7’2”
Santa Venetia	N. San Pedro Road		0-9”	1’8”-3’5”
Novato	Bay Trail		0-8”	0-12’7”
Belvedere	Belvedere Corp Yard		4”	1’5”
Larkspur	Doherty Drive		0-3”	05’5”
Belvedere	San Rafael Avenue		0-3”	2”-4’3”
San Rafael	3rd Street		5”	9’-3’10”
San Rafael	Smith Ranch Airport			1”-12’5”
Novato	Hamilton Parkway			4’8”-10’9”
St. Vincent’s	SMART rail			0-10’9”
San Rafael-East	SMART rail			1”-10’3”
Novato	SMART rail			0-9’8”
Novato	W Hwy 37			2”-8’4”
Corte Madera	N. Hwy 101			6”-7’8”
San Rafael	Lincoln Avenue			10”-7’4”
North Novato	SMART rail			0-7’
Novato	E Hwy 37			0-7’
Corte Madera	Redwood Highway			1’2”-6’8”
Santa Venetia	Neighborhood Streets			6”-6’8”
Black Point	Atherton Avenue			0-6’
Belvedere	West Shore Road			2’3”-5’5”
Corte Madera	S. Hwy 101			1’-5’5”
Larkspur	N. Hwy 101			3’6”-5’3”
Larkspur	Redwood Highway			4’2”-5’2”
Belvedere	Beach Road			11”-5’
Tiburon	Tiburon Blvd.			9”-5’
Larkspur	S. Hwy 101			2’3”-5’
Strawberry	Redwood Highway Frontage Rd			1’2”-4’10”
Larkspur	Riviera Circle			1’8”-4’9”
Mill Valley	Sycamore Avenue			0-4’7”
Larkspur	Hwy 101South at Lucky Dr.			2’7”-4’4”
Larkspur	Hwy 101North at Lucky Dr.			3’10”-4’3”
Larkspur	Redwood Highway Frontage Rd			3’-4’2”
Mill Valley	Redwood Highway Frontage Rd			9”-4’2”
Country Club	Pt. San Pedro Rd			5”-4’
Marin City	Hwy 101South bound			5”-4’

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Location	Asset	Near-term	Medium-term	Long-term
		Scenario 1	Scenario 3	Scenario 5
Strawberry	Seminary Drive			7”-3’7”
Mill Valley	Camino Alto between Miller and E. Blithedale Avenues			2”-3’6”
San Rafael	4th Street			1’-3’5”
San Rafael	2nd Street			1’-3’4”
Strawberry	Tiburon Blvd.			5”-3’4”
Tiburon	Bay Trail			6”-3’
Marin City	Redwood Blvd.			1”-3’
Larkspur	Sir Francis Drake Blvd			7”-2’9”
North Novato	Hwy 101South bound			1’9”-2’7”
Novato	Rowland Blvd.			0-2’7’
Almonte	Almonte Blvd.			1’10”-2’5”
Tamalpais	Tam Junction			1’6”-2’5”
Tiburon	Main Street			4”-2’5”
North Novato	Redwood Highway			1’9”-2’4”
San Rafael	Hetherton Street			1’4”-2’4”
North Novato	N. Hwy 101			4”-2’4”
Sausalito	Bay Trail			7”-2’3”
Sausalito	Bridgeway			7”-2’
Marin City	Hwy 101North bound			0-2’
Novato	Hwy 101North bound			0-2’
Strawberry	De Silva Island Drive			10”-1”10”
Kentfield	Stadium Way			1’5”-1’9”
Novato	Hwy 101South bound			0-1’9”
Paradise Cay	Paradise Cay Marina			1’-1’10”
Strawberry	Hwy 101North bound			1’7”-1’8”
Strawberry	Hwy 101South bound			2”-1’
Mill Valley	E. Blithedale Avenue			1”
Sausalito	Pelican Yacht Harbor		No data	

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

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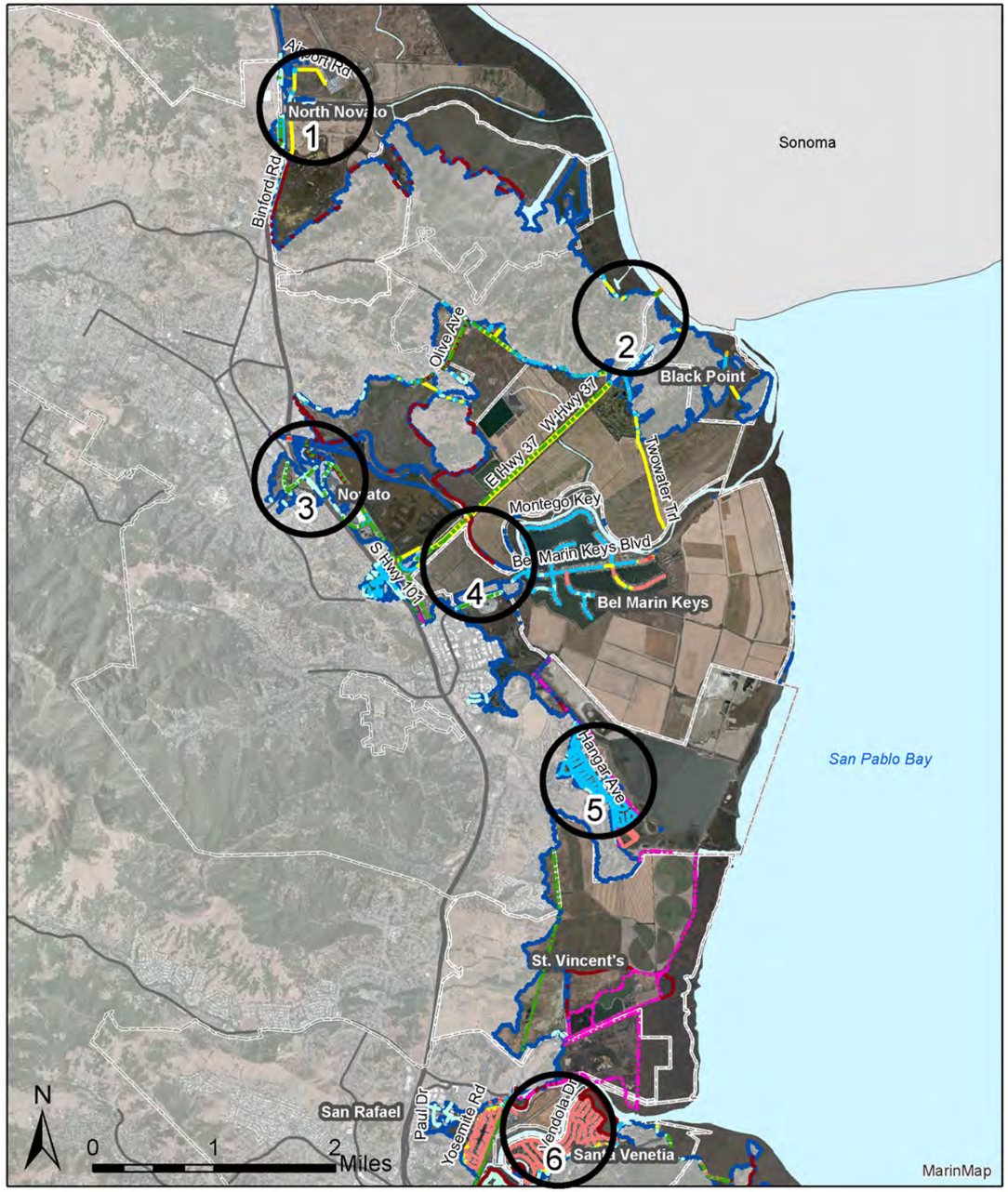
TRANSPORTATION

Map 20. Northern Study Area Study Area Roads, Trails, and Bike Paths Vulnerable to Sea Level Rise

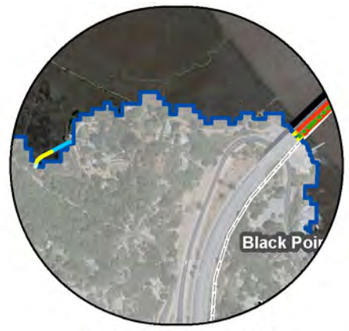
Vulnerable Assets
- Bike path
- Bay Trail
- Trail

Vulnerable Roads
- @10" Sea Level Rise (SLR)
- @10"SLR+ 100-year Storm Surge
- @20" Sea Level Rise
- @20"SLR+ 100-year Storm Surge
- @60" Sea Level Rise
- @60"SLR+ 100-year Storm Surge

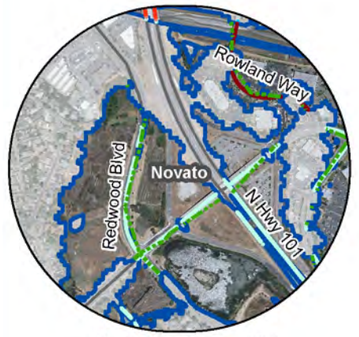
Location Indicators
- Unincorporated
- Municipality
- Road
- Bay
- Inland Extent: Sea Level @ 60"+100-year Storm



1: U.S. Hwy. 101



2: State Route 37

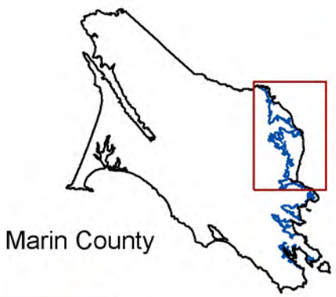


3: U.S. Hwy. 101 @ Rowland Blvd.

4: State Route 37 & Bel Marin Keys Blvd.

5: Hamilton

6: Santa Venetia



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Date: 4/1/2017

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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.

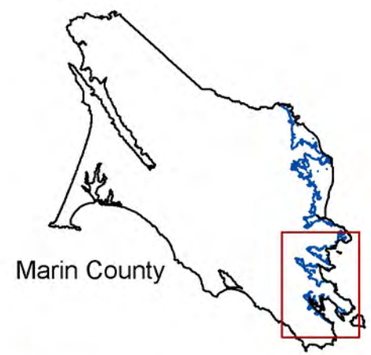
TRANSPORTATION

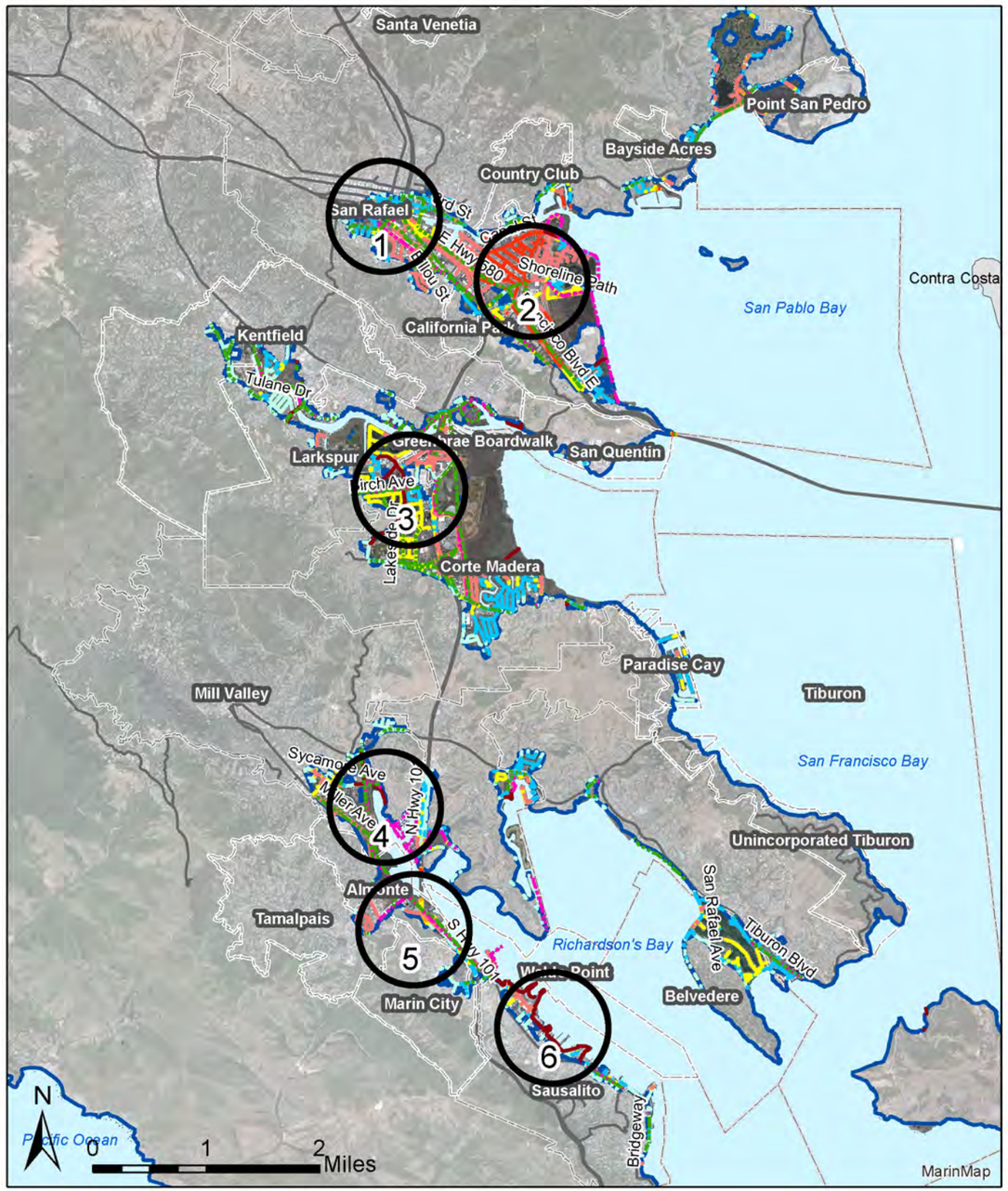
Map 21. Southern Study Area Roads, Trails, and Bike Paths Vulnerable to Sea Level Rise

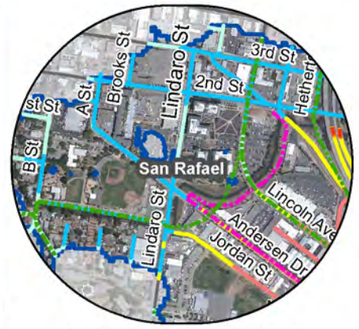
Vulnerable Assets
- Bike path
- Bay Trail
- Trail

Vulnerable Roads
- @10" Sea Level Rise (SLR)
- @10"SLR+ 100-year Storm Surge
- @20" Sea Level Rise
- @20"SLR+ 100-year Storm Surge
- @60" Sea Level Rise
- @60"SLR+ 100-year Storm Surge

Location Indicators
- Unincorporated
- Municipality
- Road
- Bay
- Inland Extent: Sea Level @ 60"+100-year Storm







1: Central San Rafael

2: Canal Neighborhood

3: Larkspur/ Corte Madera

4: Mill Valley

5: Almonte/Manzanita Park & Ride

6: Marin City/ Waldo Point Harbor

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Date: 2/11/2017

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TRANSPORTATION

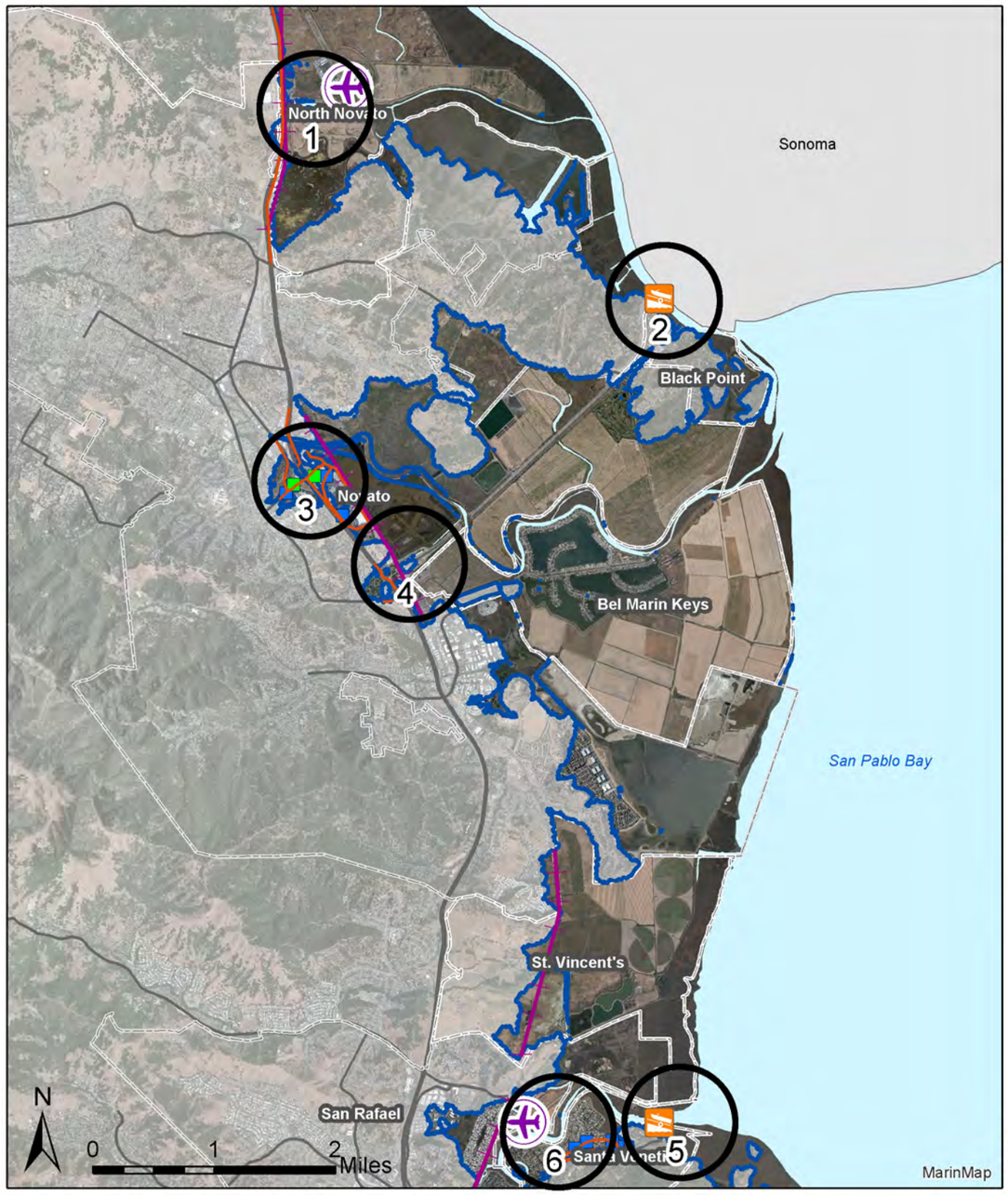
Map 22. Northern Study Area Vulnerable Transit, Air, and Marine Transportation Assets

Vulnerable Assets

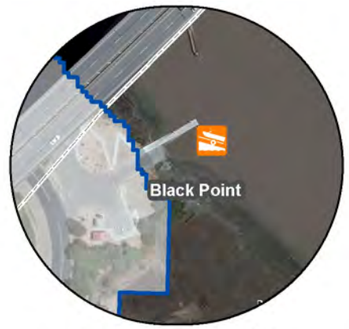
- Airport
- GGT Bus Stop
- MT Bus Stop
- Transit Route
- Public Boat Launch
- SMART Track

Location Indicators

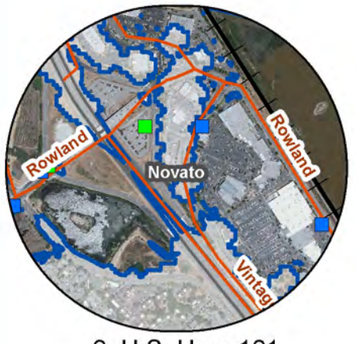
- Unincorporated
- Municipality
- Road
- Bay
- Inland Extent: Sea Level @ 60"+100-year Storm



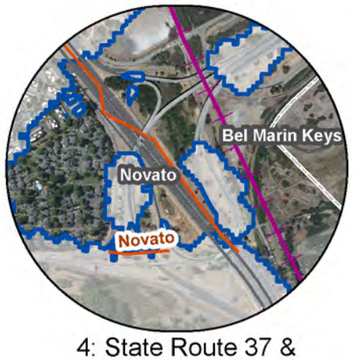
1: North Novato



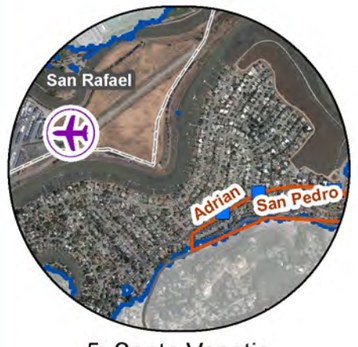
2: State Route 37



3: U.S. Hwy. 101 @ Rowland Blvd.

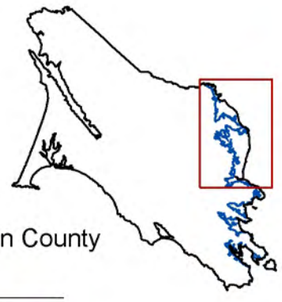


4: State Route 37 & Bel Marin Keys Blvd.



5: Santa Venetia

6: Buck's Landing



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TRANSPORTATION

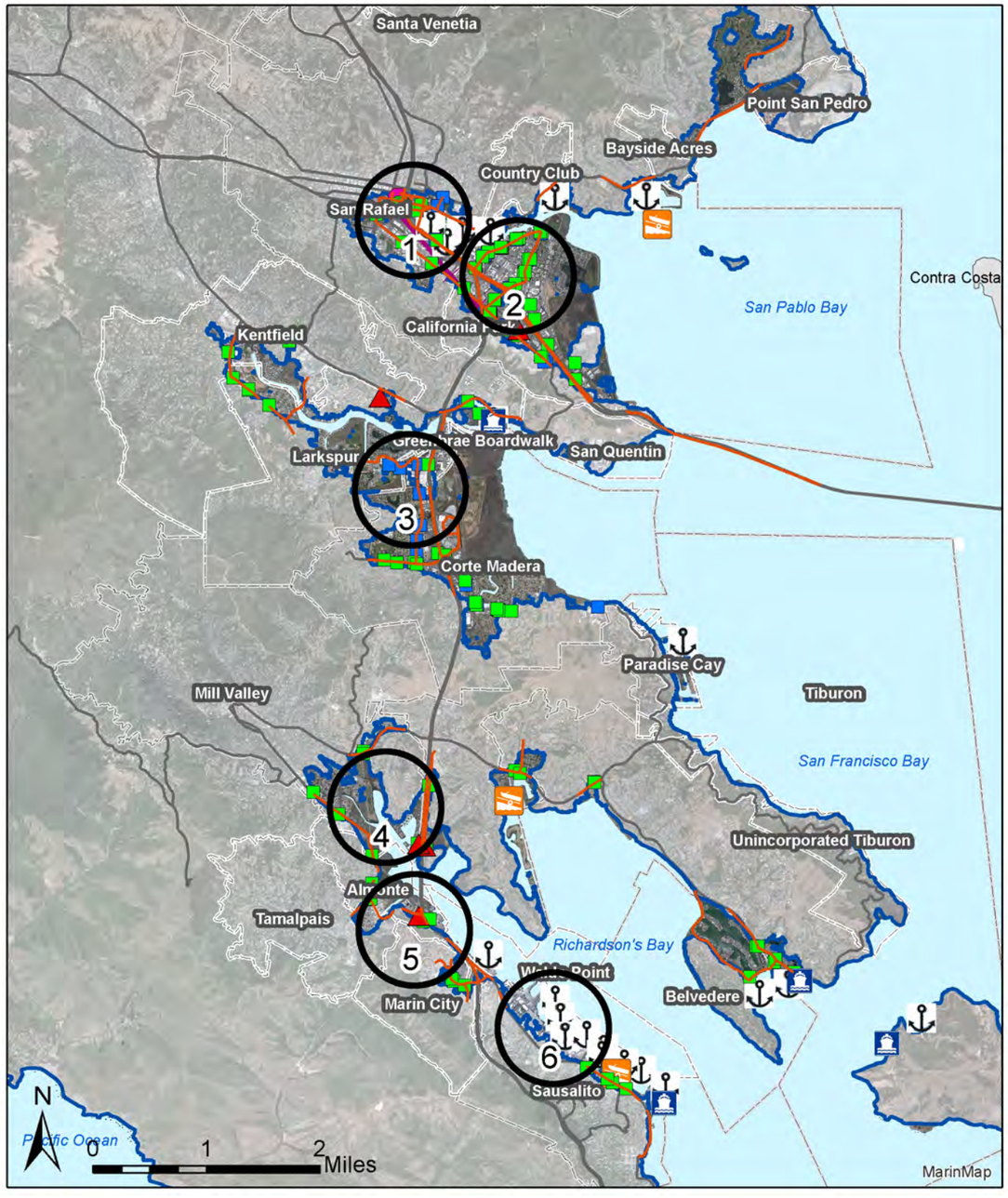
Map 23. Southern Study Area Vulnerable Transit and Marine Transportation Assets

Vulnerable Assets

- Park & Ride
- GGT Bus Stop
- MT Bus Stop
- Transit Route
- SMART Station
- SMART Track
- Ferry
- Public Boat Launch
- Marina

Location Indicators

- Unincorporated
- Municipality
- Road
- Bay
- Inland Extent: Sea Level @ 60"+100-year Storm



1: Central San Rafael

2: Canal Neighborhood

3: Larkspur/ Corte Madera

4: Mill Valley

5: Almonte/Manzanita Park & Ride

6: Marin City/ Waldo Point Harbor

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Date: 4/1/2017

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Other Considerations

Economic
Goods movement throughout the county is critical to all residential and employment uses. Road access, even water access, is essential for daily life activity, whether it facilitates supply transport, commuting to work, getting to school, or accommodating the several million tourists that visit Marin annually. Disruptions, large and small, can have significant economic ripple effects across many, if not most, sectors of the Marin community. Moreover, direct costs for damages to and upgraded transportation routes could run in the billions over the next several decades.

Allocating adequate funding for elevating roads will likely be difficult, straining limited local and county sources, and highly competitive allocations for state and federal funding sources.

Several road segments are protected by armoring, such as seawalls, revetments, bulkheads, bluff walls, and other hard engineering solutions to prevent flooding and erosion. These structures may become compromised and require increasingly costly maintenance or replacement. In some cases, where retreat is selected, the roads and protecting structures may be closed and abandoned in place, or relocated. If seawalls and bulkheads along the shoreline fail, repairs to the road and utilities underneath could be costly. Creating alternative routes may require acquiring private property and meet political resistance.

Environmental
Road repair and construction can have significant environmental impacts. When roads completely fail, sediment, asphalt, and automotive pollutants can enter into the surrounding properties and habitat. Constructing new roadways as alternative routes can also have significant environmental impacts, including significantly altering or developing existing habitats and/or becoming new barriers to habitat migration.

If not contained, fuel storage tanks in the study area could leak petrochemicals into the floodwaters or groundwater and into the San Pablo or Richardson Bays before entering San Francisco Bay and beyond. This is a concern for the automobile gas stations, fuel supplies at government work yards, and at Larkspur Ferry Facility.

Finally, abandoned boats anchored in Richardson Bay could sink or be damaged in a storm leaving debris and other contents in the water.

Social Equity
While Marin County has a relatively high household median income across the state and nation, neighborhoods of low-income residents and with low income residents are a significant portion of the vulnerable population and work force. Example locations include Marin City, San Rafael's Canal neighborhood, The Redwoods community, several mobile home parks, and houseboats in Richardson Bay. Roads serving these communities along the US Highway 101 corridor already experience stormwater flooding and tidal flooding that can disrupt traffic flow for hours. More severe flooding would only increase the frequency and length of traffic delays, and further prevent residents from traveling to work, school, or other appointments in a timely manner. The congestion could lead to loss of work hours and income, or lead to serious injury or loss of life in emergency situations.

This congestion would also disproportionally impact those who depend on public transportation. First, direct day of delays and safety concerns for passengers could prevent timely travel, and buses cannot simply take another route. And, expenses to protect or relocate the San Rafael Transit Center and the GGBHTD facilities and buses may be shared by public transit patrons, increasing transportation costs for those who tend to be from lower income groups.[24]

According to the Healthy Marin Partnership, 2013 Community Health Needs Assessment, roughly 20 percent of residents in the study area pay more than 15 percent of their income towards transportation costs alone, paying more than the national average. This cost burden is especially significant for Marin's retired residents, Marin City and San Rafael's Canal neighborhood residents, residents on boats in Richardson Bay, and other low-income communities that could experience the disruptions and damages of sea level rise and storms. This indicates that a some residents are already overburdened by this

[24] Marin Transit. July 2015. 2016-2025 Short Range Transit Plan. Pg. ES-3 <http://www.marintransit.org/pdf/SRTP/2016-2025/2016-2025SRTP_FINAL.pdf>, Accessed Jan. 6, 2017.

basic expenses; leaving less income available for other necessities such as emergency preparedness, medical care, healthy food, child care, or education. Vulnerable household with vehicles may require more frequent body work as saltwater exposure corrodes the body and mechanical components. And for residents of lesser means, recovery from temporary flooding damage may be a slower process than for residents with greater purchasing power and financial flexibility. Saltwater exposure to mechanical components could prevent a vehicle from working.

According to the Healthy Marin Partnership, 2013 Community Health Needs Assessment, between 50 and 70 percent of Marin's shoreline residents in the BayWAVE study area pay more than 45 percent of their income on housing and transportation combined.[25] The affordability standard is 30 percent of income on housing and 15 percent on transportation. [26] This indicates that a large portion of residents are already overburdened by these basic expenses, leaving less income available for other necessities such as emergency preparedness, medical care, healthy food, child care, or education. Households with vehicles could be burdened body maintenance expenses as saltwater exposure corrodes the body and mechanical components. And for residents of lesser means, recovery from temporary flooding damage may be a slower process than for residents with greater purchasing power and financial flexibility.

Management

Efforts to proactively reengineer existing routes will require collaboration amongst several land owners, private and public. Routes require connections to adjacent driveways and streets and must coordinate with access to underground utilities and drainage. Coordination is critical to ensure consistent access and wise use of financial resources. Environmental and land condemnation processes to acquire land for new routes can be extremely political, lengthy, and expensive. Planning and implementing adaptation measures for higher water levels could span several election cycles at all levels of government. Successful preparation would require continuous political support from mayor to mayor, council to council, state congress person to person, and so on for several decades. If government priorities shift away from supporting sea level rise preparation, communities could be less equipped to weather increased flooding.

25 Human Impact Partners. 2013. Healthy Marin Partnership. Community Health Needs Assessment Sub-county Health Indicators.

26 Human Impact Partners. Healthy Marin Partnership. Community Health Needs Assessment Sub-county Health Indicators. 2013.

Table 34. Income Spent on Transportation, 2005-2009

Jurisdiction	% residents paying more than 15% on mobility
SF-Oakland-Fremont Region	18
Marin County	21
Sausalito	20
San Rafael	20
Larkspur	20
Corte Madera	20
Mill Valley	21
Strawberry	21
Kentfield	21
Belvedere	21
Tiburon	21
Novato	21.
Santa Venetia	21
Tamalpais-Homestead	21
Black Point/Green Point	24
Marin City*	No data

Source: Human Impact Partners, 2015, H+T Index, CNT

** No data is available for Marin City, though Marin City figures may be incorporated with a nearby community.*

UTILITIES

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

Most habitable buildings depend on several utility systems including: water supply, onsite wells, septic systems (regulated as onsite wastewater treatment systems (OWTSs)), regional waste systems, electricity, propane, communications, and stormwater infrastructure. These systems are significant assets and can be disrupted or severely damaged before a building's structural components. Marin residents occasionally weather temporary disruptions once; however, at some point in the coming decades, these occurrences could become more frequent and costly. The following are key vulnerabilities for vulnerable utilities:

- Three wastewater treatment plants could expect flooding impacts if no actions are taken.
- All sanitary districts could be vulnerable to increasing saltwater infiltration into pipes and the treatment process.
- Subsidence can cause the roadway over a pipe to sink, placing bending pressure on the pipe.
- If the water table rises significantly buoyancy forces could stress and push pipelines closer to the surface.
- Homes in Black Point using OWTSs could expect reduced percolation area during high tides. Older systems without automatic shut-offs could contaminate the bay.
- PG&E electricity transmission lines may be prone to subsidence in bay mud and inundated areas along most of the shoreline.
- PG&E underground natural gas lines are also present in the study area in several communities and could be vulnerable.
- Stormwater drainage backups could increase with higher tides, and consequently flooding properties along creeks and creek tributaries.
- High winds and falling trees during storms threaten overland power and communication lines.
- Novato and Belvedere corporation yards could be vulnerable.
- Utility service employees may be prevented from travelling to office or worksite locations.

IMPACTS-AT-A-GLANCE: SCENARIO 6

12,100 buildings+		Property Owners Marin County Public Works Municipalities Sanitary Districts North Marin Water District PG&E AT&T
100,000+ people affected		
Increased operation costs and energy demands	Local & Regional	

Greenbrae Boardwalk utility lines and control systems. Credit: BVB Consulting LLC

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UTILITIES

Potable Water

According to engineers at North Marin Water District and the Marin Municipal Water District, potable water provision and district facilities are moderately sensitive to sea level rise and are unique to each district.

Pipelines are principally buried within existing roadways and would not be immediately affected by sea level rise. Improvements to the roadways to address sea level rise would facilitate improvements to buried infrastructure.

North Marin Water District (NMWD)

North Marin Water District supplies drinking water the City of Novato, northeastern Marin, and portions of west Marin. NMWD has several medium- and long-term vulnerabilities.

By the medium-term, the already vulnerable Bel Marin Keys distribution system could expect impacts from water table and saltwater intrusion that may get worse until the system is upgraded. In addition, a cathodic protection anode bed that serves this community is also vulnerable. Also in the medium-term, emergency reserves in vulnerable area could face infiltration and corrosion from saltwater exposure.

By the long-term, an intertie valve at State Route 37 that connects NMWD and Marin Municipal Water District could be vulnerable. In addition, there are potential threats to underground pipelines and above ground air valves that release air from the pipelines. And also in the long-term, the Deer Island Recycled Water Facility and Recycled Water Transmission Main from Las Gallinas Valley Sanitary District could be vulnerable. And also vulnerable in this time period are aqueduct control valves at Redwood and San Marin Drive.

Finally, the NMWD headquarters itself may be vulnerable to storm and tidal flooding due to existing hydraulic conditions along Rush Creek. This facility is where personnel, vehicles, equipment, and records are housed, and billing and other professional services are provided.

Marin Municipal Water District (MMWD)

Marin Municipal supplies drinking water to most of communities along the shore south of Novato. MMWD asset managers are confident that the water distribution system can sustain the impacts of regular high tides. For example, it would take more than 5 feet of sea level rise to compromise the pressurized water pipes. However, in scenario 6, five feet of sea level rise with a 100-year storm surge, the MMWD headquarters in Corte Madera is impacted. The impacted area contains the corporation yard, operations laboratory, workshop, emergency generators, and above ground fuel tanks. And in both scenarios 5 and 6, access to the facility could be challenging during high tides. Increased exposure to saltwater could also cause more rapid degradation of trucks and other equipment brought in and out of the facility.

Table 35. Potable Water Vulnerabilities

Underground Issues	• Saltwater intrusion could contaminate water in pipes through air valves, and wells for drinking and fire protection. • Water distribution: Pipes must maintain 24" of space from the groundwater table, and 32" below ground. As the water table rises, pipes will be exposed to saltwater and shift underground. • Pipes may be vulnerable to increased saltwater corrosion and subsidence.
Above Ground Issues	• Some houseboats use flexible hose connections that would wear more quickly if submerged in saltwater more often. • Saltwater could damage pipes that line boardwalks serving over water or marsh homes.

Source: NMWD

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UTILITIES

Map 24. Northern Study Area Vulnerable Water Service Assets

Vulnerable Assets

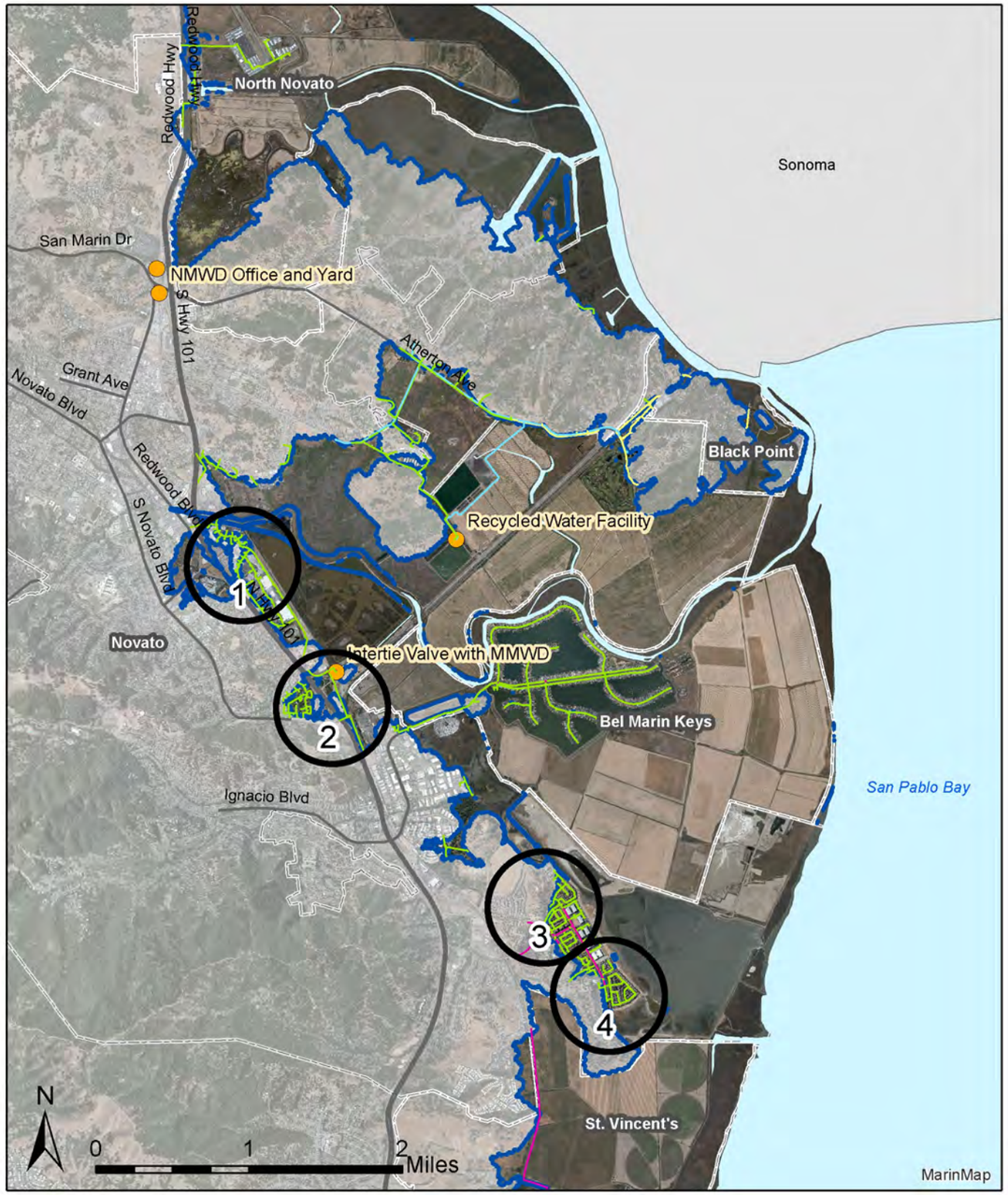
- NMWD Facility

Pipeline

- Other
- Intermediate
- Recycled Water
- Potable Water
- Water District Parcels

Location Indicators

- Unincorporated
- Municipality
- Road
- Bay
- Inland Extent: Sea Level @ 60"+100-year Storm

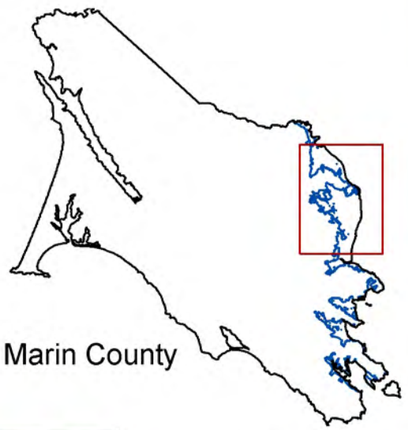


1: U.S. Hwy. 101 @ Rowalnd Blvd.

2: U.S. Hwy. 101 @ State Route 37

3: Upper Hamilton

4: Lower Hamilton



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Date: 4/1/2017

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UTILITIES

Map 25. Southern Study Area Vulnerable Water Service Assets

Vulnerable Assets

Water District Parcels

Location Indicators

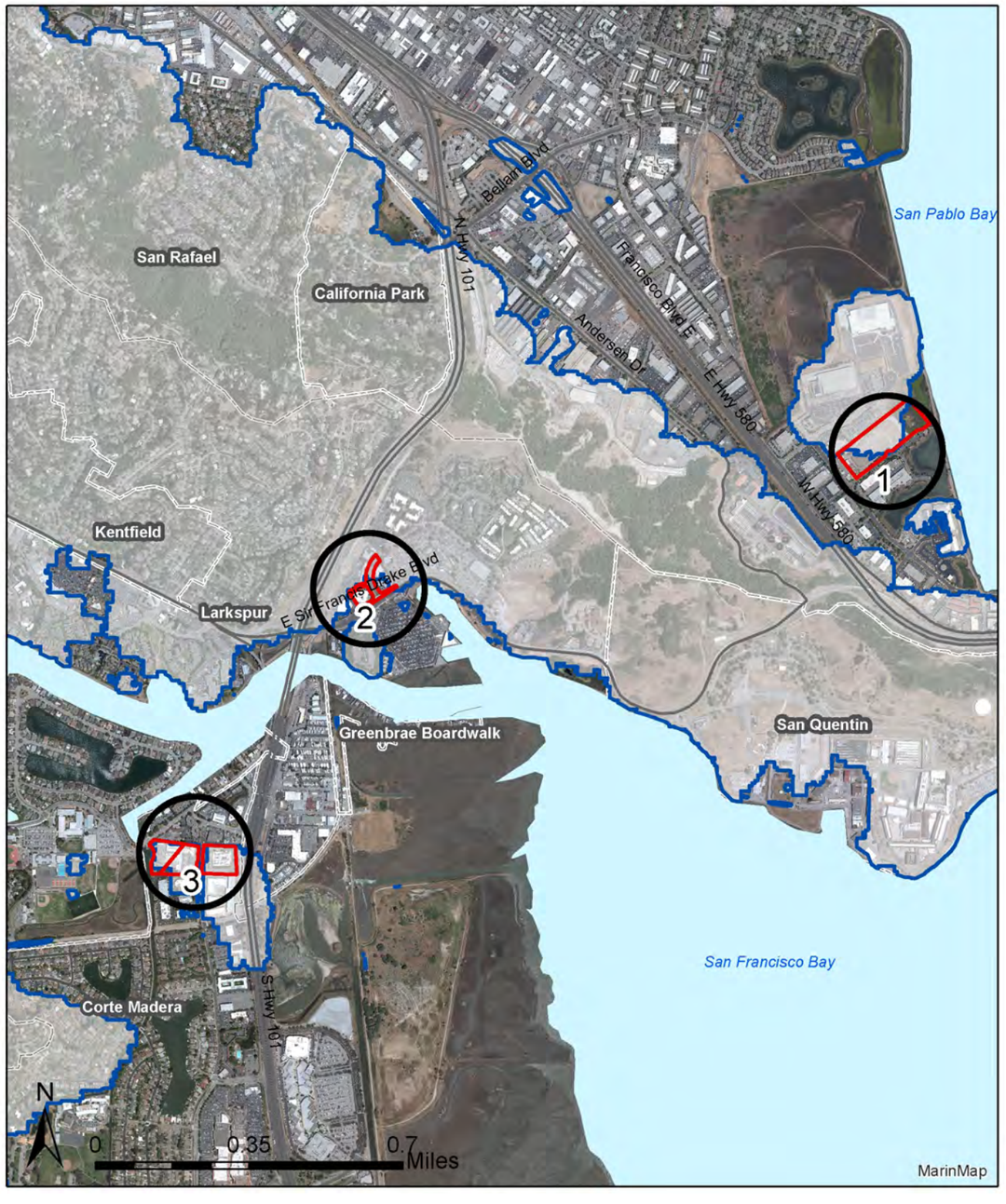
Unincorporated

Municipality

Road

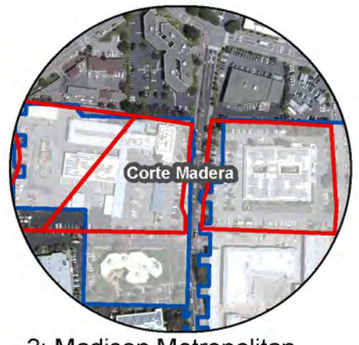
Bay

Inland Extent: Sea Level @ 60"+100-year Storm

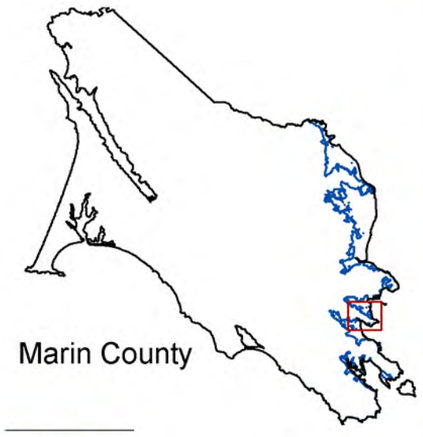


1: Kerner Business District

2: Sir Francis Drake Blvd.



3: Madison Metropolitan Water District Office & Yard



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UTILITIES

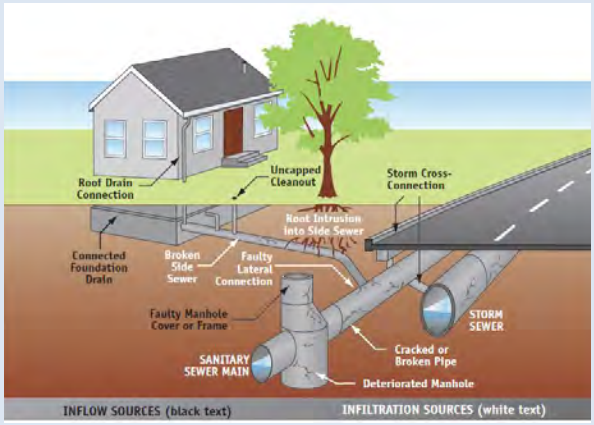
Sewer Service

The majority of businesses, facilities, and residences on the eastern shoreline of Marin County depend on community wastewater systems, and in several cases these systems connect to a treatment plant, or NMWD and MMWD water recycling systems. Sanitary districts with vulnerable assets include:

- Sausalito Marin City Sanitary District
- Sewerage Agency of Southern Marin
  - o Almonte Sanitary District
  - o Alto Sanitary District
  - o Tamalpais Valley Sanitary District
  - o Homestead Sanitary District
  - o Richardson Bay Sanitary District
  - o City of Mill Valley
- Central Marin Sanitation Agency
  - o Ross Valley Sanitary District
  - o San Rafael Sanitation District
  - o Corte Madera, Sanitary District No. 2
  - o City of Larkspur
- Novato Sanitary District

Because of its low lying nature, development on bay mud, and population density, southern Marin communities are most vulnerable to wastewater treatment issues. The most vulnerable are those dependent on the Sewerage Agency of Southern Marin (SASM) treatment plant. However, all sanitary districts could be impacted by inflow and infiltration into sanitary pipes and manholes. The excess water creates inefficiencies in treatment, and potentially flooding the system. Impacts to buildings near damaged pipeline or backed up systems is also possible in all of these districts. Cleaning up an individual single-family residence from sanitary sewer back-ups can cost more than $5,000.[27] If this combines with additional flooding, costs would soar even higher. In addition, subsiding pipes, mains, and pump stations are also a common concern. Finally, if the power is out for extended periods of time, diesel emergency sources for back-up generators at pump stations could at least be significantly more expensive to operate. If pump stations fail, sewage could back up and out of manholes and into the streets, parks, or yards where they exist. If the area is also flooded, harmful sewerage could spread widely throughout the flooded area creating significant public health risks.

Figure 4. Inflow and Infiltration Sources to the Sanitary System Pipeline



Source: King County Department of Natural Resources and Parks, Wastewater Treatment Division

Many systems were built decades ago and the original piping is ageing, punctured by tree roots, and/or bent from shifting soils. Because of this, storm and tidal waters can enter into the pipeline, diluting the effluent being sent for treatment. One of the largest sources of storm and tidal waters is the lateral pipes that connect each building to the shared district pipeline.

Storm and tide water infiltration can alter the chemistry needed for treatment and force more water than necessary to be treated; driving up costs, energy use, and processing times. According to asset managers, each treatment plant is designed for wet weather flows. If sea levels and storm waters infiltrate the system enough, wet weather protocols may be required more often, and could be severe enough to require nearly twice the quantity of chemicals, double the energy, and in the end, could be far less effective at disinfecting the wastewater. Disinfecting becomes challenging when water flows too quickly through the system, and when high salinity kills bacteria and organisms critical to the process.

Several districts offer cost share or loan programs to assist willing property owners in updating their lateral systems.

[27] 2016 dollars

Another concern asset managers have is that the top of the hatches, extending from treated effluent pipes already in the water, could be overtopped more frequently. This may warrant extending the apron and hatches upwards to accommodate higher tides and maintain safe access. Water over the hatches; however, does not impact pumping potential, as the system is pressurized and can withstand high water levels.

Table 36. Sanitary District System Vulnerabilities

Pump Stations	• Lift stations or pumps below water. • Pump stations can be overburdened by inflow and infiltration of saltwater in to the system.
Pipes	• Older underground metal pipes are corroding and more susceptible to increased saltwater exposure. • Older clay or metal pipes have cracks and wear that allow for inflow and infiltration. If not replaced, this will likely worsen, and could burden treatment plants. • Not all systems are pressurized and vulnerable to changes in the ebb and flow of the tides. • Subsidence can place bending forces on pipes. • Manholes extend below grade. If flooded, access will be lost and inflow and infiltration could occur.
Treatment Plants	• Levees protecting low-lying treatment plants could be overtopped, flooding the plants, offices, and exposing the facility to corrosive saltwater. • Treatment plants built on mud may see increased rates of subsidence. • Administrative and maintenance buildings are vulnerable to flooding.
Utility Users	• The lateral pipes connecting each building to the sewer mains could be vulnerable to infiltration of saltwater. This decreases efficiency and effectiveness of treatment. • Excess water can cause back-up into and damage buildings.

In addition to these general concerns, a few wastewater assets warrant further analysis because critical facilities could be directly impacted.

Sewerage Agency of Southern Marin (SASM)
The SASM treatment plant is located in Mill Valley and is bound by Bayfront Park featuring Arroyo Corte Madera Del Presidio Creek where it meets the marshes that lead to Richardson and San Francisco Bays. The facility serves the needs of nearly 30,000 people.[28] Because it is so close to shoreline in a low lying area, critical components of the waste water treatment plant could be vulnerable.

According to CoSMoS, the site could be impacted in combination with a 100-year storm surge in the storm scenarios 2, 4, and, 6. The tidal waters flow to and enter the property from the back of the site where the creek is closest and the elevation is the lowest. A few feet of sea level rise later and water travels from the opposite side of the plant, and the two sources meet in the middle. The plant could be vulnerable to sea level rise at around 4 feet, and certainly by scenario 5 at 5 feet. By 5 feet of sea level rise, the buildings could be tidally flooded with more than two feet of saltwater.

The maintenance and shop buildings are the first to be impacted, followed by the Secondary Clarifier opposite these buildings. Subsequently, the Primary Clarifiers and Recirculation and Effluent Pump Station could be vulnerable. By scenario 5, the remaining Secondary Clarifier, Gravity Thickener, Thickened Sludge Pump Buildings/Shop, Digesters No. 1 and 2, Digester Control Building, Administration Building, Reclaimed Water Facilities, and all parking areas could expect tidal exposure. The only remaining area is where the Equalization Basins, Emergency Overflow, and Trickling Filters are. With the storm surge on top of this all of these components are vulnerable to ocean waters.

SASM commissioned a flood study for the treatment plant property in 2014. The report examines FEMA stormwater flooding in combination with sea level rise amounts of 16 inches by 2050 and 55 inches by the end of the century from the NOAA Sea Level Rise Viewer.[29] While these scenarios are not directly comparable with the BayWAVE scenarios the resulting analysis provides additional timelines for

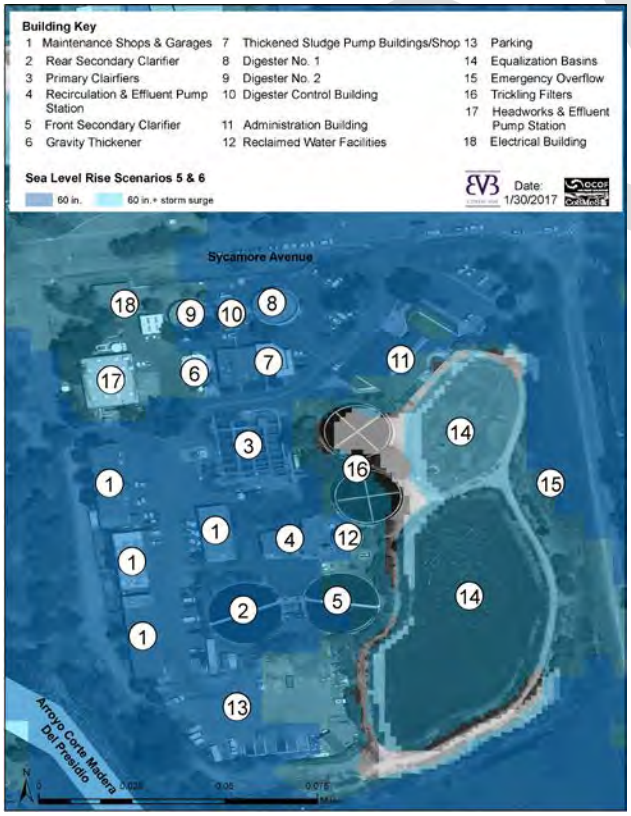
[28] SASM Master Plan. 2014.
[29] Carollo Engineers. June, 2014. *Sewerage Agency of Southern Marin Wastewater Treatment Plant Master Plan, Technical Memorandum No. 6 Flood Study*. Walnut Creek, CA.

factors not considered in this assessment. Table 6.1 in the report lists the following buildings as vulnerable to 100-year floods and sea level rise:

- By 2050
  - o Headworks and Solids Buildings, and
  - o Electrical Substation Buildings
- By 2100
  - o Control Buildings,
  - o Primary Clarifiers,
  - o Secondary Clarifiers,
  - o Recirculation and Effluent Pump Station,
  - o Recirculation Valve Vault,
  - o Effluent Metering Vault, and
  - o Equalization Basin.

Note that these features could be vulnerable during the coincidence of 100-year storm rain amounts from the land and sea level rise. The report does not include the 100-year storm surge from ocean in that time period. Both models likely under estimate the potential total flooding because neither incorporate both storm components of rainfall and ocean surge.

Map 26. SASM Exposure to Sea Level Rise



The SASM Technical Flood Study also provides proposals for protecting the site. According to the report, protecting the site for the long-term, not accounting for the ocean storm surge, with a berm, wall, and tide gates could cost more than $2.5 million. Marin County Public Works is also working with the agency and other partners to enhance the marshes protecting the channel to harness the effectiveness of nature based methods. These proposals and others are discussed in greater detail in the technical study and the Richardson Bay Shoreline Study.

Of the sanitary districts associated with SASM, the primary issues are related to inflow and infiltration on private properties, and old deteriorating pipelines slated for replacement in the coming decades.

Sausalito Marin City Sanitary District (SMCSD)
Sausalito Marin City Sanitary District could be burdened by several impacts within the district. The treatment plant is generally high enough to avoid significant impact to the facilities. SMCSD vulnerabilities are:

- Marinship area service could diminish as development is flooded out.
- The Main Street Pump Station in Sausalito collects and transports 95 percent of the effluent brought to the treatment plant and borders the shoreline.
- Locust Pump Station could become burdened with tidal water infiltration.
- Anchor Street Pump Station could become burdened.
- Princess Pump Station, 500 block of Bridgeway could become burdened, and controls across the street near the Trident Restaurant could be flooded.
- Marin City Pump Station could become burdened with tidal water infiltration.
- Drake Pump Station could become burdened with tidal water infiltration.
- Two pumps Stations on Gate 5 Road could become burdened with tidal water infiltration and could be vulnerable to subsidence.
- Two sewer pipes extending under US Highway 101 could be vulnerable to subsidence and road shifts.
- Access hatches along effluent pipes extending into Richardson Bay could be overtopped frequently.

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- Below grade electrical motors at the treatment plant could be flooded in the long-term at high tides with a storm surge.

Sanitary District No. 2
Sanitary District No. 2 serves Corte Madera and small areas of Tiburon and Larkspur. The district is vulnerable is similar ways to other sanitary districts such that:

- Underground pipes face compounding pressure forces from water and the road,
- Road erosion and collapse with underlain pipes,
- Saltwater inflow and infiltration causing inefficiencies in wastewater treatment,
- Continuously subsiding soils or fill, and
- Escalating activity, capacity demands, energy consumption, and wear and tear on pump stations in stormwater and wastewater systems,
- Aging individual site connections for water, sewer, and electrical, and
- Flood waters interrupting access for employees to reach work sites.

The district connects to the Central Marin Sanitation Agency treatment plant in San Rafael. The treatment plants is not physically vulnerable to sea level rise, however, employees may be prevented from traveling to the site to conduct their work activities.

Las Gallinas Valley Sanitary District (LGVSD)
The Las Gallinas Valley Sanitary District residents could be highly vulnerable. The treatment plant site could be vulnerable around the edges; however, the district is currently elevating the levee protecting the property. The district is planning for six feet of sea level rise and elevating the perimeter road 3-4 feet to an elevation nearly 12 feet above typical 100-year stormwater flood levels. In addition, they are participating with Marin County Public Works to complete a protective eco-tone slope and levee along the shoreline.

LGVSD vulnerabilities include:

- Santa Venetia relies on several pump stations located in the exposure area with tidal water infiltration.
- Main Lagoon relies on 9 pump stations in the exposure area with tidal water infiltration.
- Solar energy produced on site is located in the sea level rise exposure area.
- Santa Venetia and Marin Lagoon residents may flea the area in the face of sea level rise and reduce service needs.

Ross Valley Sanitary District
The Ross Valley Sanitation District office is in a flood prone area and could be vulnerable to sea level rise by scenario 1. In addition, according to asset managers, 3-feet or more of sea level rise combined with a storm surge could flood pump station-15 near the outlet of the Corte Madera Creek concrete flood channel section. Pump station 15 conveys more than 60 percent of all Ross Valley area wastewater.

San Rafael Sanitation District
In addition to the common issues, the San Rafael Sanitation District office is in a flood prone area and could be vulnerable to sea level rise and storms by scenario 6, and could experience access issues are early as scenario 1. The area surrounding the district office extending to the San Rafael Canal and downtown could also be flooded out of the service area if no action is taken to protect development.

Sanitary District No. 5
The smaller of two treatment plants in the District, the Paradise Cove Plant, is impacted at scenario 6, 5 feet of sea level rise, plus 100-year storm surge. The main issues are worsening erosion and flooding at this site, saltwater intrusion for sewer lines along Tiburon Blvd. that run along the beach, a manhole at Beach and Tiburon Blvd. that already floods, and pump station electrical panels.

The primary treatment facility off Tiburon Boulevard could anticipate some flooding during storm surges in the parking lot. This flooding may also create access issues for employees and cause wear and tear on facility vehicles and equipment.

A majority of the pipes are original, and are planned for replacement, including the force main for Belvedere. All sewage is pumped from smaller pump stations to one main pump station and the 50-year old connecting pipe needs repair.[30]

[30] Sea Level Rise Interview. Jan. 20, 2016. Sanitary District No. 5. Tony Rubio. Interviewed by C. Choo, Marin County Public Works.

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UTILITIES

Novato Sanitary District
The Novato Sanitary District Treatment plant is vulnerable just before 3 feet of sea level rise. By scenario 5, the lower half of the plant is covered by tidal waters. Storm conditions may impact the plant sooner. Much like SASM, the first buildings to be vulnerable are the shops and garages. However, the over flow basins are impacted early on. Next to be impacted are the UV Disinfection and Final Effluent Processing buildings. By 5 feet of sea level rise, tides reach the anaerobic digestion and clarification tanks. Adding a storm surge could also flood around the primary and secondary clarifiers altogether. The water will not likely be high enough to impact the process, however, electrical components may be lower and saltwater corrosion of the tanks and buildings could take a toll.

The district also has some facilities in Bel Marin Keys that are transitioning to submersible machines, and others at Gnoss Field Airport, Bahia, and the base of Deer Island that could be vulnerable to higher tides.

On-site Waste Water Treatment (OWTS)

The only community in the study area using OWTSs is Black Point. However, many of the built areas of these properties are at higher elevations and may be free from impacts from sea level rise. In the worst case, sea level rise could alter soil permeability and chemistry in the disposal field. If water levels are high and sustaining enough, effluent from the disposal field could contaminate the estuary waters. Even new shallow or above ground systems, with high water level kill switches, could be impacted by flood waters and affected by power outages. Erosion could also reduce land area available for percolation. Finally, if ground water rises under septic tanks it could have enough pressure to cause tanks to pop out of the ground.

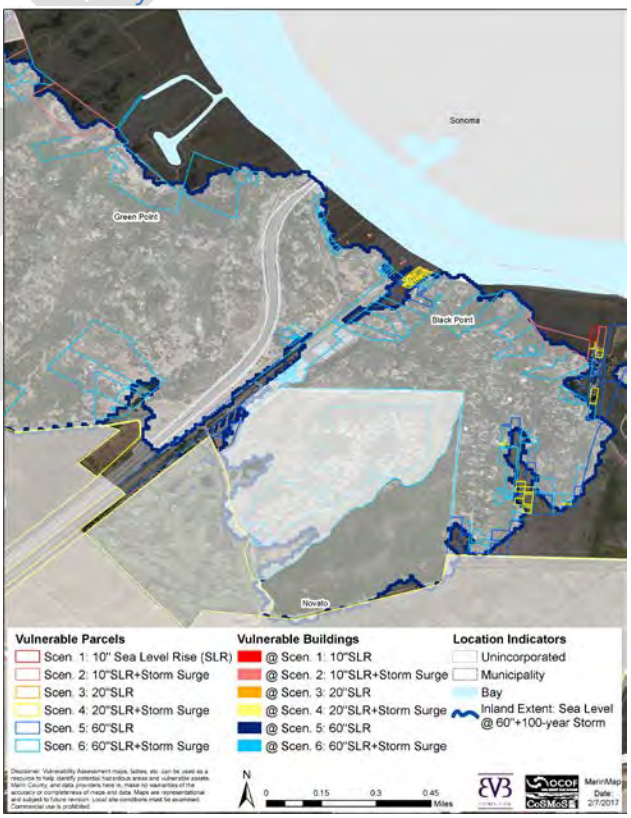
These systems are privately managed by the land owner and regulated by Marin County and the Regional Water Quality Control Board. Septic systems in are regulated by the Marin Countywide Plan (CWP), the Marin County Development Code, and the State Water Control Board's Onsite Wastewater Treatment Systems Policy. More information on regulations can be found at http://www.marincounty.org/depts/cd/divisions/environmental-health-services/septic-systems.

Table 37. OWTS System Vulnerabilities

Land Area	• Erosion can reduce the land area available to percolate waste. Saltwater intrusion into the leach field could impact percolation rates and reduce useable area.
Materials/ Models	• Older single field gravity systems are more susceptible to storm flooding than modern systems equipped with "flip" switches that turn off percolation when groundwater elevates too high. • Newer systems are vulnerable to power outages.

Source: Marin County Environmental Health and Safety

Map 27. Black Point Properties with Potentially Vulnerable OWTSs



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UTILITIES

Map 28. Unincorporated Tiburon Properties with Potentially Vulnerable OWTSs

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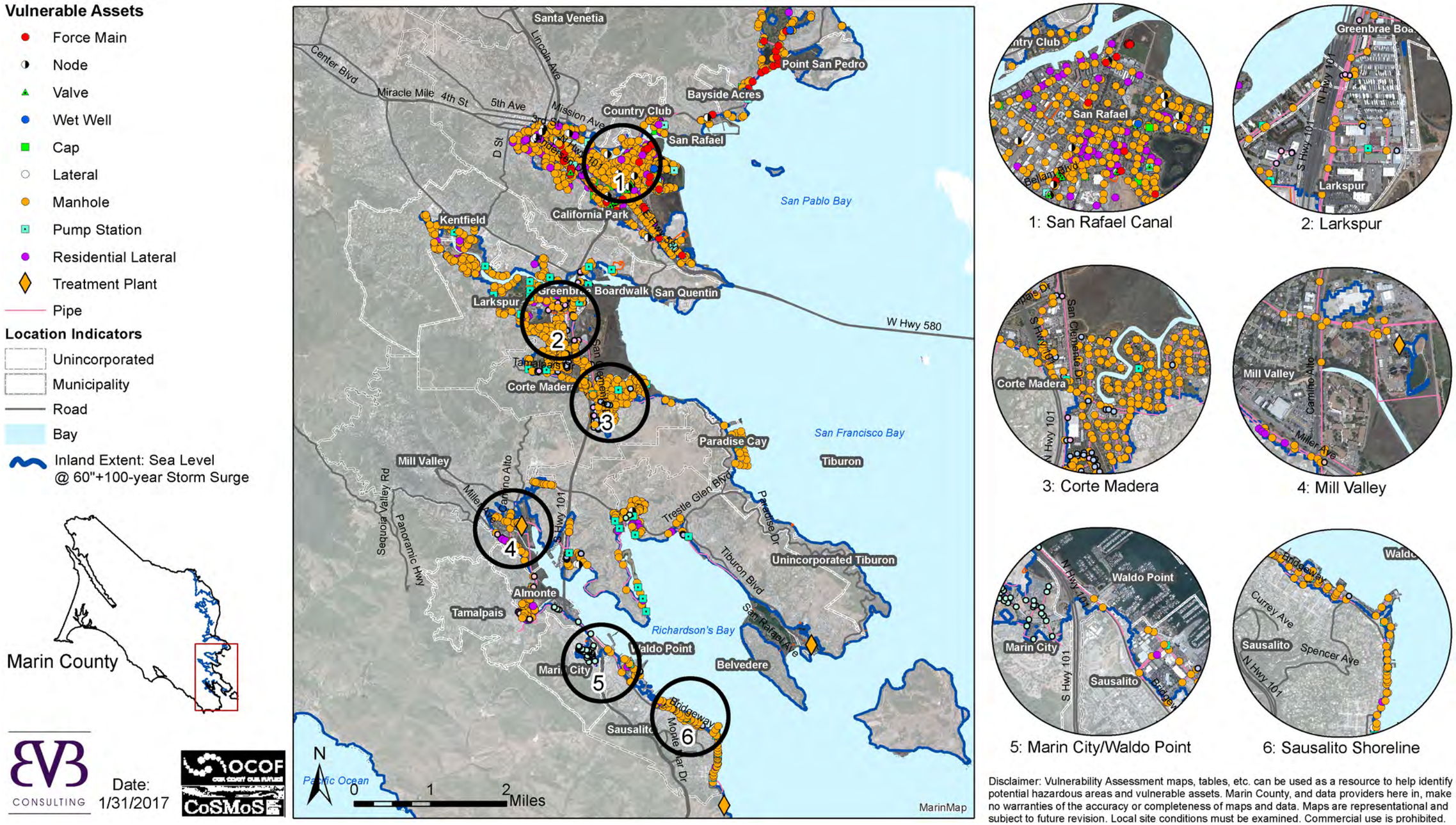
UTILITIES

Map 29. Southern Study Area Vulnerable Wastewater Assets



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

UTILITIES

Fuels (Home and Automotive)

Natural gas is the primary source of home fuel and Pacific Gas and Electric Company (PG&E), a California corporation, provides the gas through a network of stations and pipes to the majority of eastern Marin buildings. Within the natural gas service network distributions mains, distribution services, regulating stations, and transmission pipes and stations could be vulnerable to sea level rise.

As part of their own Natural Hazards Asset Performance initiative, PG&E found that nearly 30 percent of its gas transmission pipelines in Marin County are located in FEMA's 100-year flood zones, and about 9 percent are located within areas modeled for two feet of sea level rise, similar to scenario 3.[31] According to CoSMoS and Marin Map, PG&E has one above ground natural gas facility in San Rafael located in the exposed area. Distribution pipelines could be vulnerable in several locations from Tamalpais to Black Point. These include:

- Corte Madera: Pipelines are underneath Paradise Drive to Madera del Presidio to Paloma.
- Larkspur: Pipelines stretch aligned with US Highway 101.
- San Rafael: Pipelines are underneath Lindaro, 3rd, and Lincoln Streets.
- San Rafael: Pipelines extend along McInnis Blvd. to the North West Pacific Rail Road. The portion where the railroad line cuts through a tidal marsh could expect more frequent inundation.
- Novato: Pipelines are underneath Cutlass to Redwood Blvd.
- North Novato: Pipelines are along US Highway 101 North near the North West Pacific Rail Road and Gnoss Field Airport.

The current physical condition of PG&E's natural gas assets is estimated to be good based on inspections of selected pipe segments in 2010 and 2013 for corrosion potential. At this time, the condition is not expected to worsen.[32] However, flooding events could potentially induce landslides, which, in turn, could place bending stress along these pipelines, given the terrain conditions. As a longer-term risk, sea level rise may introduce buoyancy forces on pipeline segments.

Residents in northeastern Marin do not have natural gas service and may use propane for heat, hot water, and cooking. According to asset managers, propane tanks in the exposure area are highly vulnerable to sea level rise and storm impacts because propane tanks are stored outside at or slightly above grade. If a property floods, and waves and water dislodge the propane tank, increasing the risks of rupture or explosion. Additionally, propane is transported to the area through private contractors, such as McPhails, ProFlame, DiCarli's, Blue Rhino, etc. Route blockages could prevent residents from refilling tanks in a timely manner. With the most severe storms and high tides in the winter, these disruptions could occur when residents need the propane most.

Several automotive gas stations exist in the vulnerable area, including an emergency reserve set of tanks at Larkspur Landing holding more than 400,000 gallons of fuel. If the emergency reserve is compromised, the impact could be felt for nearly all emergency service providers in the North Bay. Moreover, gasoline from these sites could also contaminate the bay, potentially with severe economic and environmental outcomes. In addition, smaller underground tanks, common at gas stations, can be vulnerable to water exposure and the corrosive properties of saltwater.

Gas stations along the 101 corridor in Strawberry and sixteen additional gas stations, in San Rafael could be vulnerable to higher tides and/or a 100-year storm surge.

PG&E repair from storm damage in Tam Valley. Credit: Marin DPW

[31] Pacific Gas and Electric Company. 2016. *Climate Change Vulnerability Assessment.* http://www.pgecurrents.com/wp-content/uploads/2016/02/PGE_climate_resilience.pdf.

[32] Pacific Gas and Electric Company. 2016. *Climate Change Vulnerability Assessment.* http://www.pgecurrents.com/wp-content/uploads/2016/02/PGE_climate_resilience.pdf.

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Table 38. Potential Risks to Vulnerable PG&E Natural Gas Assets

Storm Flooding	• Reduced soil cover on pipeline or unsupported pipeline spans due to soil scour or erosion. • Damage from floating debris—such as tree limbs—coming into contact with gas pipelines (known as dynamic loading) and potentially collecting against the pipeline like a dam (known as static loading), resulting in bending stress. • Bending stress on the gas pipeline from unstable soil.
Sea Level Rise	• Damage from buoyancy forces on pipeline segments, and potential for erosion around segments

Source: PG&E, Asset Manager Interview Response, 2016

Electricity

According to PG&E, some electric distribution lines, distribution transformers, transmission lines, substations could be vulnerable to sea level rise. Vulnerable substations are located in Greenbrae, Larkspur, Ignacio (Novato), and Hamilton Wetlands (Novato).

Nearly 80 transmission towers are in the vulnerable portions of the study area east of Bel Marin Keys and South of Novato over to the Sonoma County boarder. While these towers can tolerate flooding, they are susceptible to increased rates of subsidence and erosion from near the mounting platform that supports it. Several other transmission towers are already in the bay off the shores of Corte Madera and Mill Valley that will be subject to even higher water lines and tidal pressure, and subsidence rates.

Other features that could expect increased rates of wear and tear from increased tidal influence are electrical poles. The tall large wooden poles could be vulnerable, currently and into the future, to falling tree branches; however, they can withstand some degree of flooding. Excessive or permanent flooding could weaken the poles over time, warranting replacement. Poles are also vulnerable to roadway collapse because the poles are often located in the right-of-way alongside roads.

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UTILITIES

Map 30. Northern Study Area Vulnerable Natural Gas and Electric Assets

Vulnerable Assets

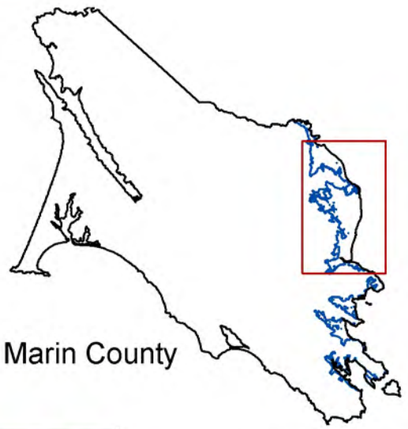
- Solar Array

PG&E Assets

- Electric Transmission Line
- Natural Gas Pipeline
- Substation
- Transmission Tower
- PG&E Property
- PG&E Buildings

Location Indicators

- Unincorporated
- Municipality
- Road
- Bay
- Inland Extent: Sea Level @ 60"+100-year Storm



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Date: 3/30/2017

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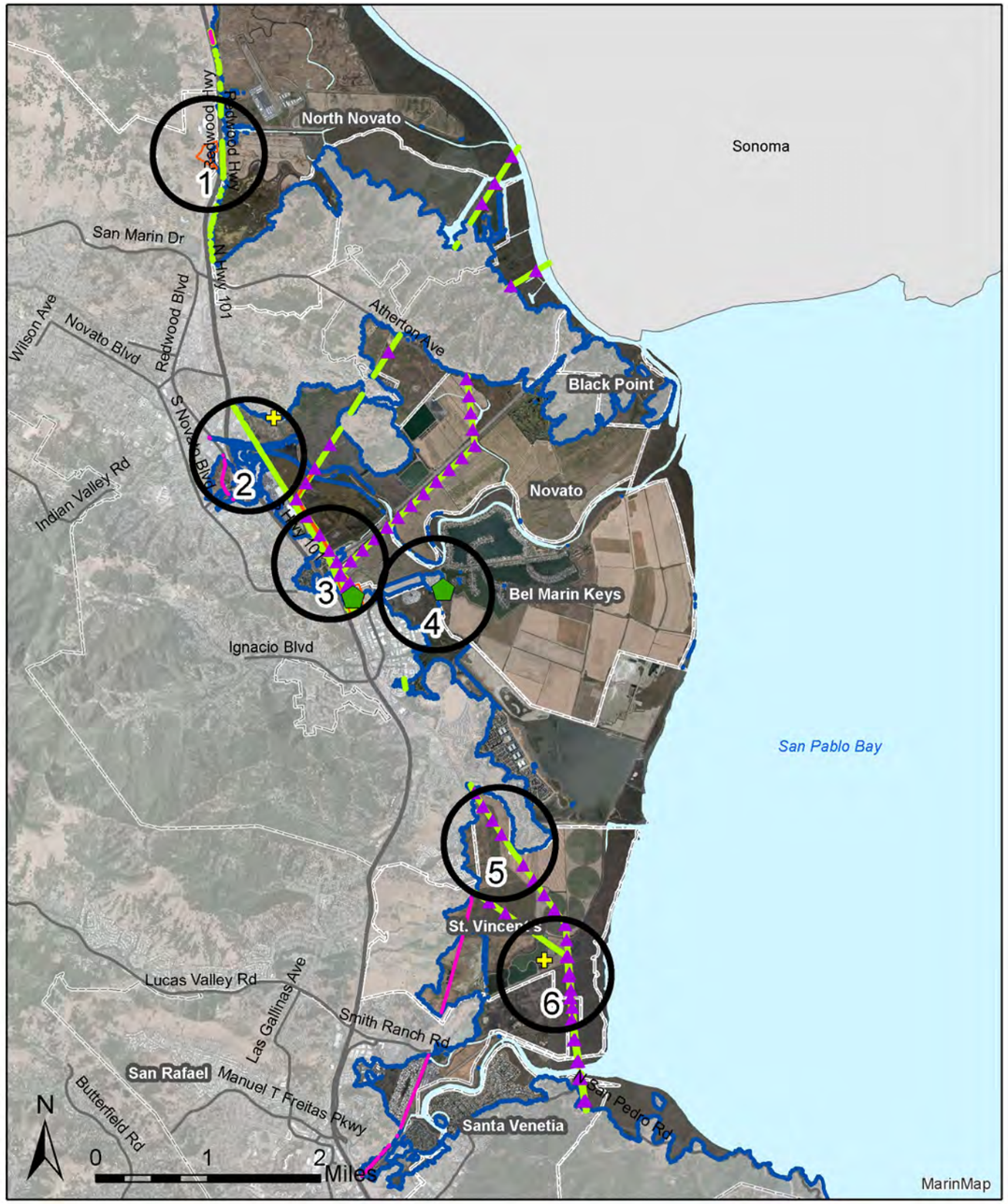
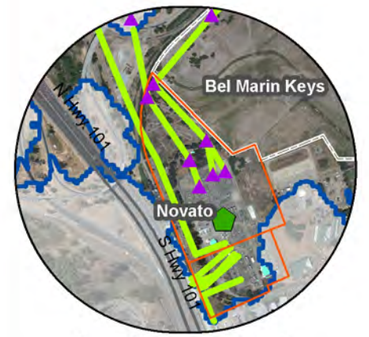


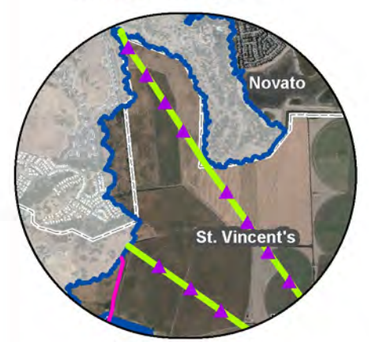
1: North Novato

2: U.S. Hwy. 101 @ Rowland Blvd.

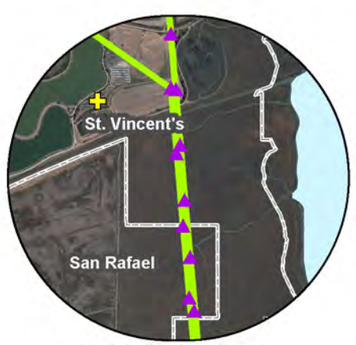


3: U.S. Hwy. 101 @ Bel Marin Keys Blvd.

4: San Clemente Dr.



5: St. Vincent's



6: McInnis Marsh

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UTILITIES

Map 31. Southern Study Area Vulnerable Natural Gas and Electric Assets

Vulnerable Assets

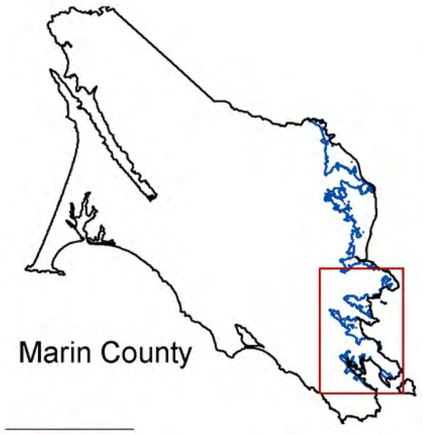
- Solar Installation

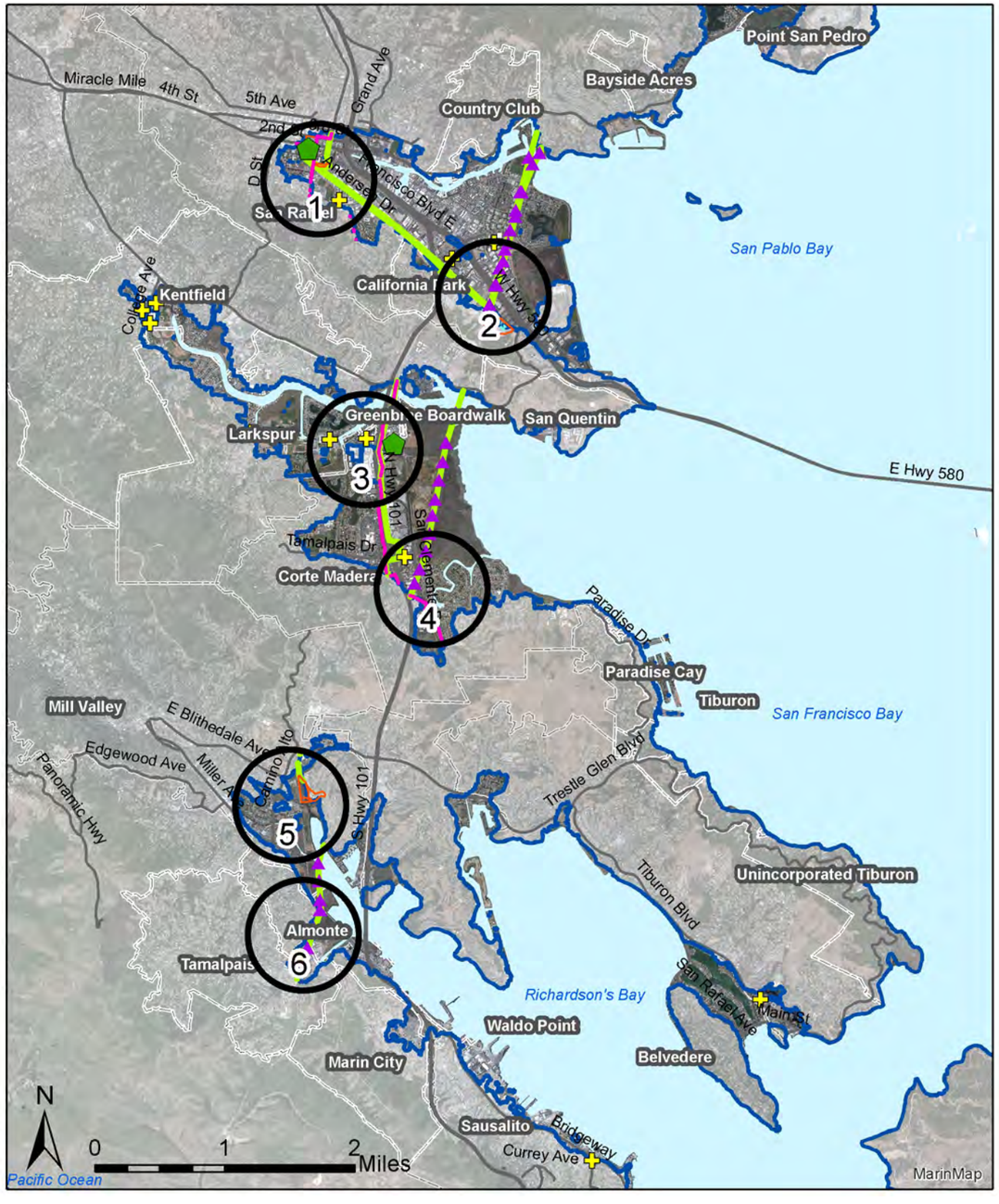
PG&E Assets

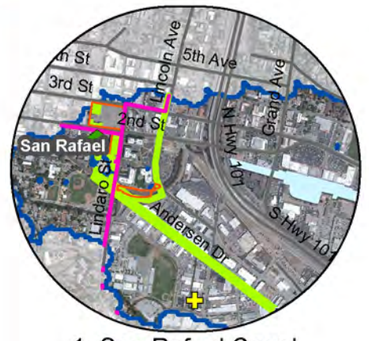
- Electric Transmission Lines
- Natural Gas Pipeline
- Substation
- Transmission Tower
- PG&E Property
- PG&E Buildings

Location Indicators

- Unincorporated
- Municipality
- Road
- Bay
- Inland Extent: Sea Level @ 60"+100-year Storm







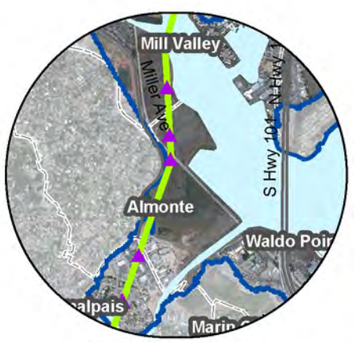
1: San Rafael Canal

2: Andersen Dr.

3: Larkspur Industrial Area

4: San Clemente Dr.

5: Sutton Marsh



6: Bothin Marsh

EVB CONSULTING

Date: 1/29/2017

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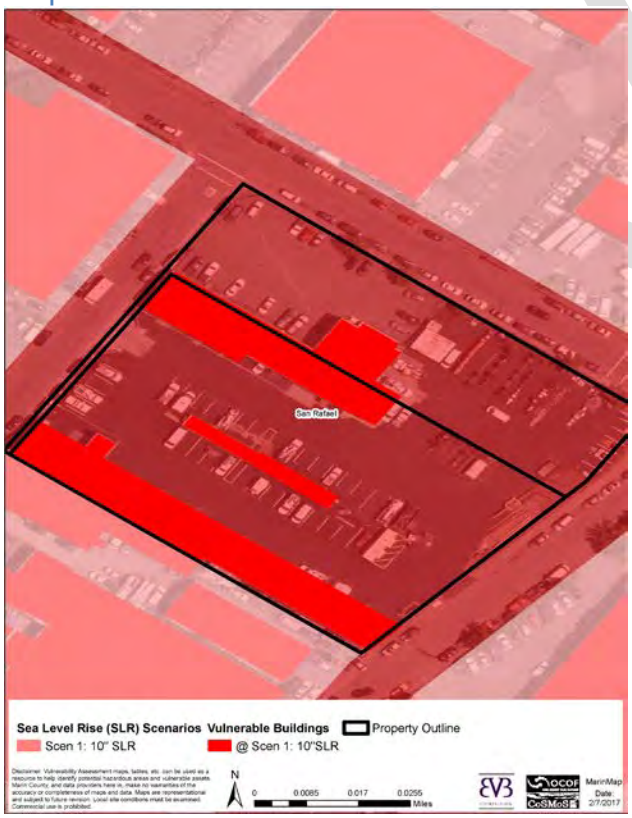
UTILITIES

Telecommunications

Several asset managers provide telecommunication services including: AT&T, Comcast, Charter, Dish, and others. According to AT&T asset managers, telecommunication assets are not vulnerable on their own, as they are designed to withstand wet weather and tidal impacts. In addition, consistent level of service is a primary goal of these companies; therefore, the company would anticipate and prepare for potential impacts. The most vulnerable assets are the communication cables under vulnerable roads. Poles are also vulnerable during storms to falling trees.

In addition, the AT&T Marin yard and office, located in the Canal neighborhood of San Rafael, is vulnerable to more than one foot of tidal flooding at MHHW in the near-term scenario 1. By medium-term scenario 3, tidal waters could be one foot deeper, nearly 5 feet deeper by long-term scenario 5. Storm surges would only increase flood depths. Tidal flooding of this nature would prompt relocating the facility to higher ground sooner than later.

Map 32. AT&T Yard & Office at MHHW



Utility lines crossing Coyote Creek where it enters Richardson Bay. Credit: Marin DPW

Stormwater Systems

Storm drains, culverts, pipes, storm sewers, outfalls, and pump stations are also a critical utility aligned with or under the road. Sediment build-up and sea level rise can block gravity flow through stormwater drainage paths that travel under the roads. This is especially common in areas with lagoons or other retention areas such as Marin City, Mill Valley, Corte Madera, San Rafael, and Santa Venetia. Several outlets to the bay are regulated by tidal flap gates that would not be operable as sea level rises past the design elevations. If the storm drains are unable to function, upstream flooding could occur and potentially flood buildings, weaken and erode the road, or worse, a hillside. These assets are managed by Marin County Flood Control.

Pump stations that are under tidal and storm surge influence could become ineffective and over worked. Tidal inundation of these facilities may impact their ability to convey upland stormwater downstream and may lead to flooding[33]. Exposed pump station in the study area are also vulnerable to extended power outages as other others outside the study area. If back-up generator, diesel fuel supplies, and stormwater professionals cannot perform under these conditions, these systems could malfunction. Stormwater pump stations at risk are they are Crest Marin, Cardinal Court, Shoreline pump stations in the Mill Valley and Tamalpais Valley corridor, and the Seminary and Reed Creek pump stations in Strawberry could face tidal flooding. In Tiburon,

[33] San Rafael Stormwater Asset Manager.

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UTILITIES

Pamela Court and Cove pump stations could face tidal flooding as well.

Stormwater infrastructure along private properties is typically managed by the property owner. However, there are extensive stormwater management systems in place in incorporated and unincorporated areas alike. According to several stormwater engineers, sea level rise could over burden and corrode pump stations, and lead to stormwater back-ups into the surrounding neighborhoods.

Caltrans manages storm drainage systems that are prone to backing up, such as Manzanita and Shoreline Highway in Mill Valley, and Lucky Drive in Larkspur. In addition, as discussed in the transportation section, US Highway 101 depends on the county, city, and town investments in stormwater management.

Stormwater Pump Station in Santa Venetia. Credit: BVB Consulting LLC

Overburdened stormwater systems could cause road flooding and traffic delays, or even flood buildings, such as school and recreation areas. Pump stations may also be vulnerable in a storm if electrical power is down for an extended period of time, though not likely from sea level rise alone. Instead, pumping may be required more often causing an increase in energy consumption, if the power fails, diesel consumption, and may cause more wear and tear on the machine. Pump stations vary in size, and even a smaller system can cost several hundred thousand to one million dollars. Larger systems can cost more.

The maps on the following pages highlight vulnerable Marin County Flood Control and Caltrans owned and operated stormwater facilities that could be vulnerable to sea level rise and storm burden. The areas in the call out circles enable the reader the see areas that are difficult to see on the large scale map. The circles do not indicate that these areas are more vulnerable than others along the shoreline.

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UTILITIES

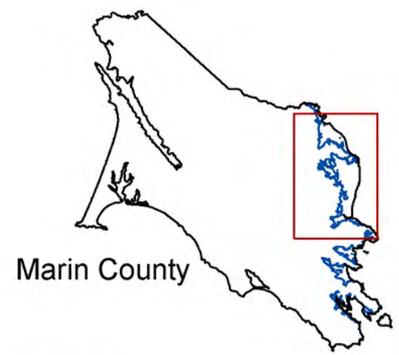
Map 33: Northern Study Area Vulnerable Stormwater Management Assets

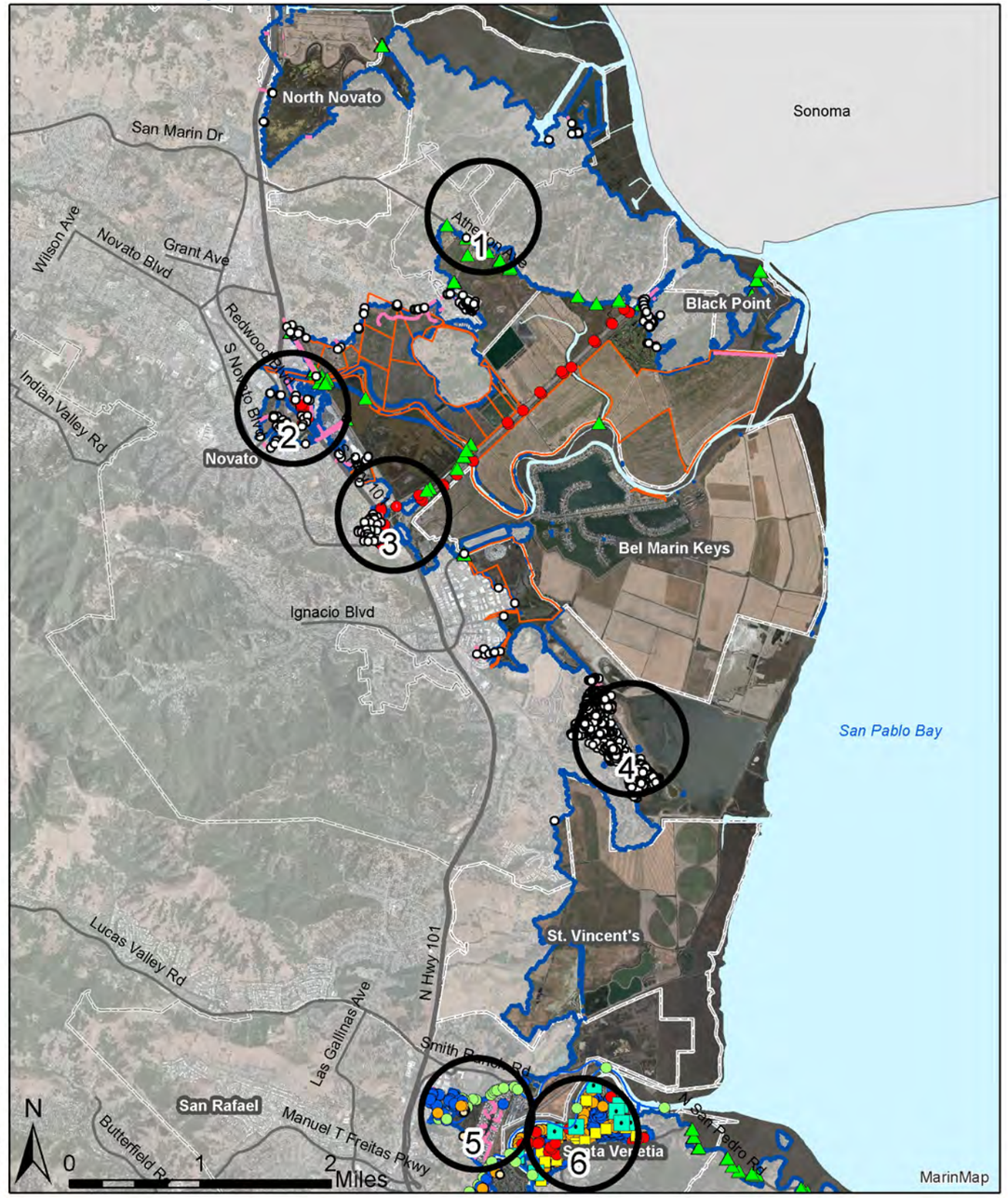
Vulnerable Assets

- Culvert
- Catch Basin
- Manhole
- Structures
- Pipe Inlet/Outlet
- Pump Station
- Channel
- Unspecified Node
- Pipe
- Flood Control Parcels

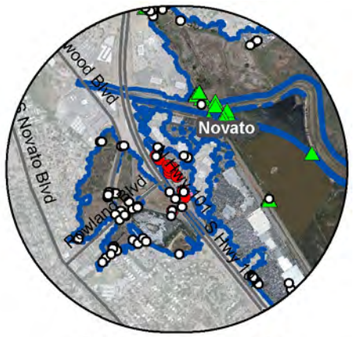
Location Indicators

- Unincorporated
- Municipality
- Road
- Bay
- Inland Extent: Sea Level @ 60"+100-year Storm





1: Green Point

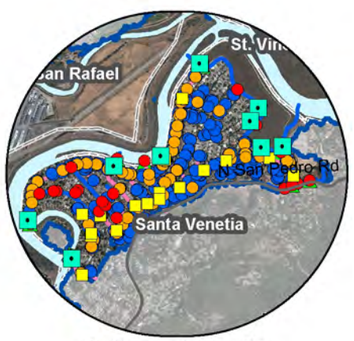


2: State Route 101 @ Rowland Blvd.

3: State Route 101 @ State Route 37

4: Hamilton

5: Las Gallinas



6: Santa Venetia

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Date: 4/1/2017

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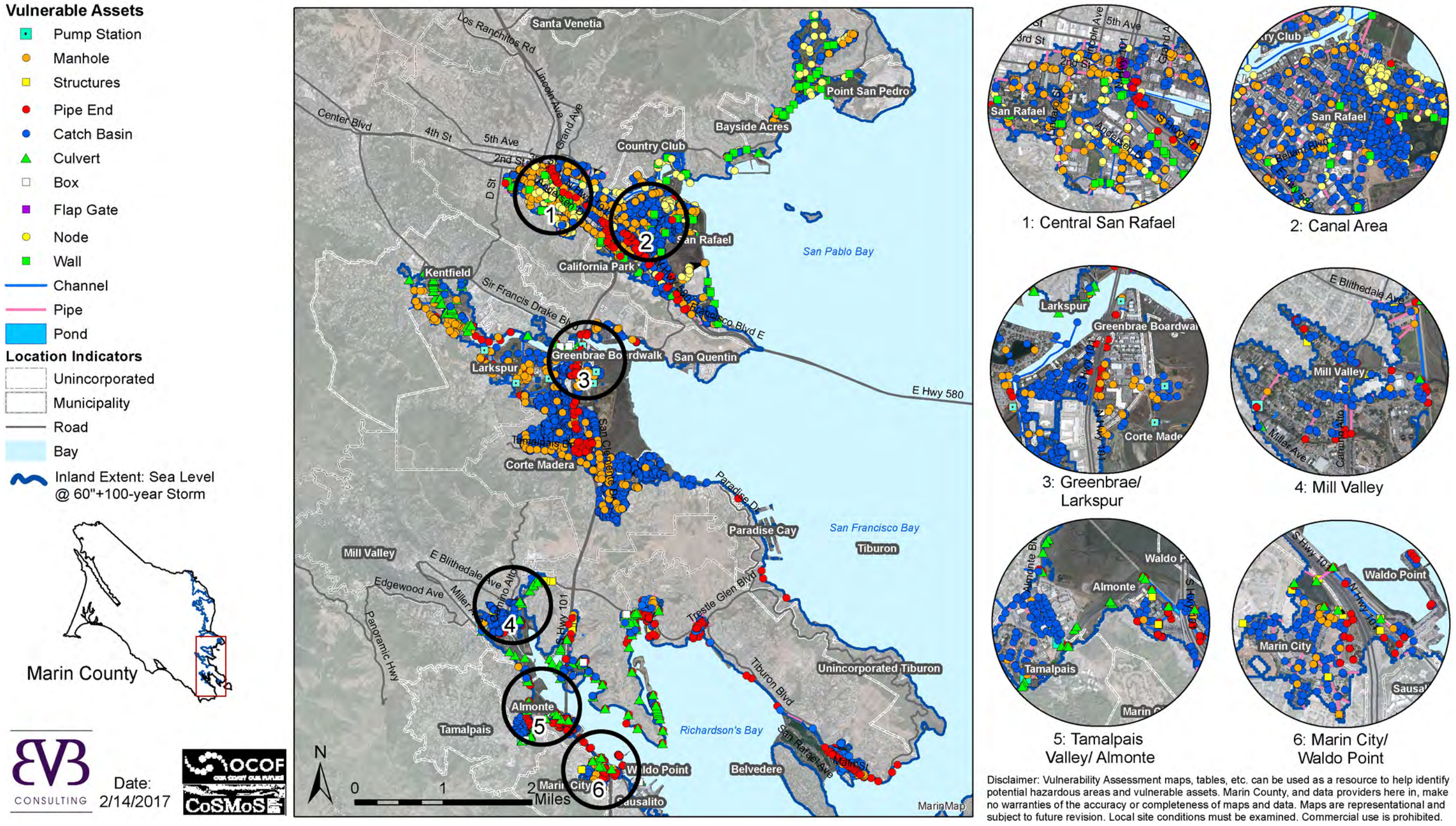
UTILITIES

Map 34. Southern Study Area Vulnerable Stormwater Management Assets



1: Central San Rafael

2: Canal Area

3: Greenbrae/ Larkspur

4: Mill Valley

5: Tamalpais Valley/ Almonte

6: Marin City/ Waldo Point

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UTILITIES

Table 39 lists some of the potentially vulnerable utility assets in the study area. This list measures onset and tidal mean higher high water (MHHW). Note that many utilities assets are underground and could be influenced before these scenarios are discernable on the surface.

Where buildings could be vulnerable to surface flooding, underground water, wastewater, and communications utilities could also be threatened. To learn more about threatened buildings read the Community, Land, and Building Profiles.

In addition to the sites listed in the table below the following sites, would only be vulnerable in scenario 6 to storm impacts:

- PG&E substation Novato,
- Sausalito-Marin City treatment plant,
- Tiburon Paradise Cove treatment plant, and
- Marin Municipal Water District (MMWD) headquarters, Corte Madera

Table 39. Example Vulnerable Utility Assets Ranked by Onset and Flooding at MHHW.

Location	Asset	Near-term	Medium-term	Long-term
		Scenario 1	Scenario 3	Scenario 5
Bel Marin Keys	NMWD cathodic protection well	Underground asset		
Bel Marin Keys	NMWD water distribution system	Underground asset		
Most shoreline communities	PG&E natural gas lines	Underground asset		
Greenbrae Bdwk	PG&E substation		No data	
San Rafael	AT&T headquarters and yard	1'4"	2'5"	6'
Novato	Novato Sanitary District treatment plant		2"-1'7"	5"-4'6"
Larkspur	PG&E Substation			4'
San Rafael	PG&E Headquarters			3'
Mill Valley	Sewerage Agency of Southern Marin (SASM) treatment plant			2'3"
Bel Marin Keys	PG&E electrical substation		No data	
Novato	NMWD air valves		No data	
Novato	Automated valve interconnecting NMWD and MMWD		No data	
Novato	NMWD fire water reserves	No data		
Marin City	Sewage pipes under 101	Subsidence, underground asset		
Most shoreline communities	PG&E transmission lines	Subsidence		

Source: MarinMap, CoSMoS, Asset Manager Interviews

UTILITIES

Other Considerations

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

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

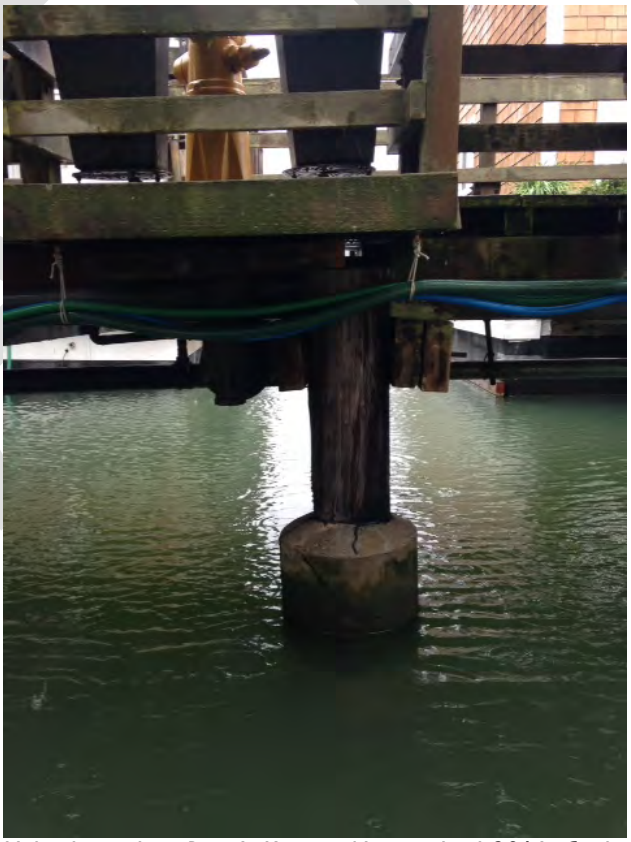
Burdened pump stations and treatment plants would also increase energy consumption, and therefore greenhouse gas emissions. According to asset managers, twice as many chemical inputs would be needed, otherwise less effective treatment could contaminate the bay.

Stormwater system backups can also send pollutants from roadways and industrial sites into natural resources and places where people live, work, and play, creating environmental health hazards.

Finally, multiple utility transmission lines and others are located in marsh areas or along waterways. If these systems were to become damaged, fire, or other electrical damage could occur.

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

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



Utility lines along Pier 6, Kappas Marina. April 2016. Credit: BVB Consulting LLC

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WORKING LANDS

Asset Profile: Agriculture

Working lands host cultivation and livestock activities. The majority of operations exposed to sea level rise on the Marin shoreline are ranches, dairies, and small produce farms. The parcels are concentrated in St. Vincent's, surrounding Bel Marin Keys, and in North Novato. The following are vulnerabilities these operations could face:

- Loss of vehicular access to and from sites and processing facilities during storms, and eventually, on a regular basis. Heavy vehicles may lose access as roadways become compromised by flooding.
- Flooding could reduce useable space more often and, in some locations, permanently.
- If operations maintain on site wells to care for their animals that are located in the exposed area, the water source could be vulnerable to saltwater intrusion and could become unusable without treatment.

As shown in Table 40, the majority of flooded agricultural uses are on public land that is leased to ranchers for grazing. Under scenario 5, with 60 inches of sea level rise, just over 4,100 acres across 27 parcels could be vulnerable. With storm conditions, an additional 200 acres across twelve parcels could be vulnerable. Two of the largest property owners are the Corda and Silviera properties; dedicated primarily to ranching. These are some of the last privately held operations on the Marin's eastern shore.

Table 40. Vulnerable Agricultural Parcels and Acreage (ac.) by Community

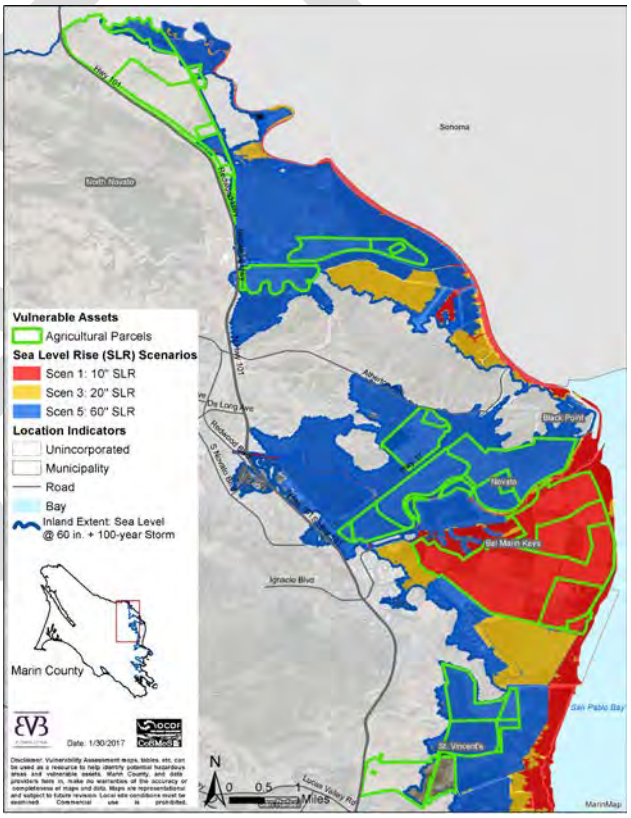
Term	Near		Medium		Long	
Scenario	1		3		5	
Location	#	Ac.	#	Ac.	#	Ac.
Bel Marin Keys	1	28	1	28	4	178
North Novato					7	510
St. Vincent's					5	460
Public Land	8	1,924	8	1,924	11	3,000
Total	**9**	**1,952**	**9**	**1,952**	**27**	**4,148**

Source: MarinMap, CoSMoS

IMPACTS AT-A-GLANCE: SCENARIO 6

4,150 agricultural acres (mostly ranch)	**13 land owners**
Site specific	**Vehicular access**
27 Parcels	**Property owners Lessees**

Map 35. Northern Study Area Vulnerable Working Lands



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Other Considerations

Economic
Vulnerable land based operations account for $17,745,567[34] in assessed land and improvement value that could decrease as lands newly under water become waters of the State. If exporting agricultural goods becomes an ever increasing challenge on flooded roads, economic impacts could be incurred, including job losses, and at worst complete operation relocation or closure.

Environment
Intrusion of brackish water could change the ecological conditions of the ranchlands and ranch management practices. Invasive species are already a growing concern in the agricultural community, and warming conditions, with a weakening in the native flora, could increase the extent of some heat loving invasive plant species. In addition, as grazing land becomes more tidally influenced, the opportunity water quality contamination from manure and wading increases. If agricultural wells are in the exposed are, they could be vulnerable to saltwater intrusion. This could necessitate additional engineering or new water sources all together.

Social Equity
Employees of these operations could be disproportionately impacted if operations need to reduce labor. Losing agricultural businesses and jobs could have significant impacts on social outcomes.

Management
Agriculture is a highly regulated industry at nearly all levels of government. For example, at the federal level is the Clean Water Act (Sections 401 and 404)[35] and total maximum daily sediment loads that farmers must comply with to reduce erosion and sediment loads to creeks. In several cases, to comply and improve water quality, farmers have fenced off creeks from livestock wading, installed new stream crossings and restored riparian areas that could be compromised under these sea level rise scenarios. Habitat changes prompted by sea level rise could require new conservation management plans and improvements in the coming decades to ensure water quality standards are upheld.

The Countywide Plan strongly supports continued diversified agricultural uses. The Agricultural Production Zone (APZ) and Agriculture, Residential Planned (ARP) districts are the zoning for most of the properties vulnerable in the study area.

[34] 2016 dollars
[35] US Environmental Protection Agency. Water: Clean Water Act. *Water Quality and 401 Certification.* http://water.epa.gov/lawsregs/guidance/cwa/waterquality_index.cfm

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NATURAL RESOURCES

Asset Profile: Habitats & Wildlife

Marin County is known and treasured for its beaches, estuaries, wetlands, marshes, creeks, national and state park lands, and wildlife preserves. Several natural resource assets on the Marin shoreline could be vulnerable to sea level rise and storms, however; it is important to note that a significant portion of the shoreline is developed or bordered by development in some way. This development and human activitvity has reduced the natural resilience of the baylands by constricting habitat, fragmenting habitat, altering sediment supply, and cutting off wildlife corridors.[36] Simultaneously, urbanization stresses wildlife with pollution, invasive species, food web disturbances, and close proximity to people and pets.[37] Natural habitats tend to be resilient to storms, however, some storms may be stonrg enough to cause large changes in landscape and worse, permanant inundation could shift habitats from one type to another in the same location, for example marsh to mudflats.[38]

Sea-level rise would cause fundamental changes in the bay and bayland habitats.[39] The following are natural resources and wildlife habitat vulnerabilities to sea level rise:

- Where space exists, sea level rise may push shoreline beaches and marshes inland, and shift existing tidal areas to standing water and/or flood inland areas with saltwater.
- Roads, rail, storm drains, and development greatly restrict habitats from migrating landward, and could completely eliminate them.
- Increases in salinity in freshwater and brackish water habitats can impact habitat suitability for existing species.
- Endangered species and special habitats are especially vulnerable.
- Ecosystem services, such as water filtration and existing levels of flood protection, may be compromised.

IMPACTS AT-A-GLANCE: SCENARIO 6

6,500 acres of wetlands

5,500 acres of marshland

5+ Narrow Beaches

568+ acres of Eelgrass

Ridgeway rail
Soft salty bird's-beak
White-rayed pentachaeta
Salt-marsh harvest mouse
Tidewater goby
And more…

CA DFW
USFWS
State Lands Commission
County of Marin
Local municipalities
Marin Audubon Society
National Audubon Society
Nature Conservancy

Corte Madera Ecological Reserve bordering Greenbrae Boardwalk, looking on to San Quentin. Credit: BVB Consulting LLC

[36] Goals Project. 2015. *The Baylands and Climate Change: What We Can Do*. Baylands Ecosystem Habitat Goals Science Update 2015 prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. California State Coastal Conservancy, Oakland, CA. Pg. 27
[37] Ibid.
[38] Ibid. Pg. 156, 158
[39] Ibid., Pg. 37

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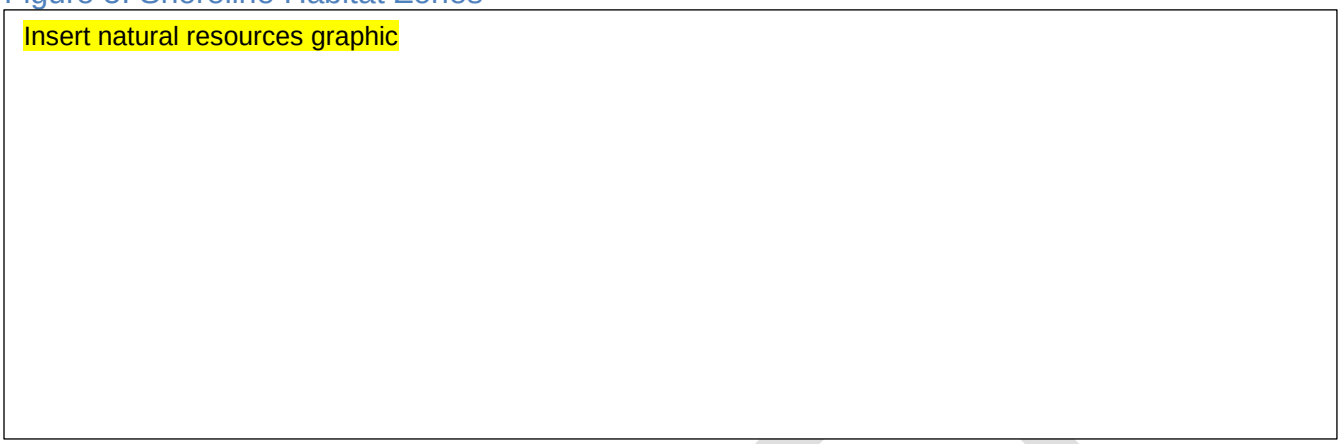
Figure 5. Shoreline Habitat Zones



A majority of the natural resource areas are managed by government agencies for public use. Major examples include: Golden Gate National Recreation Area, Bothin Marsh, China Camp State Park, and San Pablo Bay National Wildlife Refuge. In addition, natural resource lands are also held by non-profit organizations such as the Nature Conservancy or Audubon Society, and some habitats are privately owned.

Beaches

Sea level rise can inundate beaches and increase rates of shoreline erosion. This could potentially force beach inland.[40] However, in most cases along the urbanized shoreline, development, roads, or steep slopes, limit landward migration, causing beaches to shrink or disappear.[41] Several of the beaches along the shore are narrow and short and could be completely lost. This shift could affect many species, including pinnipeds (seals and sea lions), snails, and tidal and freshwater plants. In addition, shifts and losses in beach ecological zones could degrade the food web[42] and ecosystem.[43]

Bluff erosion can be exacerbated by sea level rise along the shoreline and can have varying impacts on beach habitats. Eroding bluffs can be a major source of sediment or rock, allowing beaches to evolve.[44] Alternatively, beach loss due to a major bluff collapse can negatively impact sand crabs, wrack consumers, and species that depend on beach habitats for breeding and nesting.[45] Beaches known to provide habitat include:

- Brick Kiln Park, Larkspur,
- Brick Yard Cove Beach, Strawberry,
- China Camp State Park Beaches,
- ESR Shoreline Park,
- Remillard Pond Beach,
- Marin Rod & Gun Club, San Rafael,
- McInnis Park,
- McNears Beach, Pt. San Pedro,
- Paradise Beach, Unincorporated Tiburon,
- Richardson Bay Center and Sanctuary beach, Tiburon,
- Private Beaches in Unincorporated Tiburon,
- San Pedro Cove Open Space, and
- Schoonmaker Beach, Sausalito.

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

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

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

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

[44] Baye, P. R., 2014. Memorandum: Bolinas Lagoon Restoration Project Design Review Group (DRG) Meeting San Francisco Bay Joint Venture Meeting Summary and Synthesis Draft.

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

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Mc Nears Beach. April 2016. Credit: BVB Consulting LLC

China Camp State Park, San Rafael. Credit: Marin CDA

Tidal Estuaries, Wetlands, & Marshes

An estuary is a partially enclosed shoreline body of brackish water, or a mixture of fresh and saltwater, with one or more rivers or streams flowing into it that mix with and transition to open ocean. Additionally, timing and extent of the rise and fall of the tide may be altered in estuaries and tidal rivers.[46]

Many estuaries feature marine wetlands and marshes. Wetlands and marshes also occur in other locations along the shoreline. Overlaying the BayWAVE scenarios on habitat data layers reveals that approximately, 6,500 acres of wetlands and 15,500 acres of marshlands along Richardson's Bay, San Francisco Bay, San Pablo Bay, and up the Petaluma River and several creeks could be impacted to varying degrees across all of the scenarios. Key sensitivities include drowning, erosion, and increased salinity.[47]

Data examined in the Bayland Habitat Goals Update (2015) indicate that tidal marshes in San Francisco Bay can withstand current 2–3 mm/year increase in sea level, as long as sediment availability is relatively high.[48] Without a comparable increase in land elevation from sediment delivery from erosion, and slowing subsidence, these intertidal habitats will be unable to adjust and thus, flood more frequently.[49,50] Much like beaches, these areas can be prevented from moving landward when backed by development, shoreline armoring, or cliffs.

Increased storm severity could have significant implications for erosion. Increased storm surge severity could also increase salinity of shoreline

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

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

[48] Goals Project. 2015. *The Baylands and Climate Change: What We Can Do*. Baylands Ecosystem Habitat Goals Science Update 2015 prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. California State Coastal Conservancy, Oakland, CA. Pg. 24

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

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

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wetlands and marshes further upland until freshwater inputs can balance out salinity. Studies on the effect of salinity extremes indicate that, when combined with temperature stress, salinity can negatively impact intertidal invertebrates through increased embryonic mortality[51,52] and decreased adult aerobic performance.[53] In addition, projected increases in storm activity can remove larger intertidal organisms.[54] If tides do not retreat as far as they currently do with sea level rise, these areas could shift from intertidal to underwater habitats.

In general, vegetation occurs from just above mean sea level (MSL) to just above mean higher high water. Cordgrass is found at lower elevations, and pickleweed is typically at the MHHW limit with a number of other species depending on local elevation, drainage, soils, site history and other factors. As sea level rises, these plants will need to migrate to higher lands land if sediment accretion does not maintain marsh elevation in relation to water level. The following are examples of vulnerable locations featuring estuarine, tidal wetland, and marsh habitats:

- Aramburu Wildlife Preserve, Strawberry
- Bahia/Rush Creek Marshes, Novato
- Bothin Marsh, Almonte
- Cal Park Hill wetlands
- Canalways Marsh, San Rafael
- China Camp State Park,
- Diked baylands, Novato
- Gallinas Creek, San Rafael
- Hamilton Wetlands, Novato
- Island Park,
- Madera Gardens Lagoons, Corte Madera
- Marin Audubon Society Lands,
- Marin Conservation League Lands,
- McInnis Marsh, San Rafael
- McNears Beach Park,
- Corte Madera Ecological Reserve,
- Triangle Marsh, Corte Madera
- National Audubon Society Lands,
- Nature Conservancy Lands,
- Paradise Beach Park, Unincorporated Tiburon
- Pt. Tiburon Marsh,
- San Pablo Bay National Wildlife Refuge, St. Vincent's
- Santa Margarita Island, Santa Venetia
- Santa Venetia Marsh,
- Scottsdale Marsh, Mill Valley
- Shorebird Marsh, Strawberry
- Spinnaker Point Marsh, San Rafael
- Strawberry Point Tidal Area, and
- Tiscornia Marsh, San Rafael.

Bay

Eelgrass is also a critical tidal habitat, typically in slightly deeper, saltier waters, associated with rocky ground. These habitats can be found in Richardson's Bay in Sausalito, Belvedere, and Tiburon. Eelgrass is a vascular, perennial marine plant that typically occurs in shallow waters from 0 to 6 feet below mean low tide.[55] Eelgrass beds trap suspended materials, take up nutrients and other dissolved substances, help to prevent erosion, increase water clarity and quality, produce organic matter, and export dying plant materials. Eelgrass beds also provide food and feeding grounds for several marine food chains.[56] As mean low tide rises closer to shore, these essential plants could be flooded out and denied adequate sunlight to survive and maintain this valued habitat.

Eelgrass beds are recognized by both federal and state agencies as sensitive and highly valuable habitat for a suite of species. They are regulated under the Magnuson-Stevens Fishery Conservation and Management Act. Eelgrass beds are listed as a Habitat Area of Particular Concern because they are susceptible to degradation, especially ecologically important, and/or located in an environmentally stressed area. National Oceanic and Atmospheric Association's fisheries policy recommends no net loss of eelgrass habitat function in California.[57] The

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

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

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

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

NOAA Fisheries West Coast Region. 2014. The Importance of Eelgrass. Updated fall 2014. http://www.westcoast.fisheries.noaa.gov/stories/2014/04_1107 2014_eelgrass_mitigation.html. Accessed 1/18/17

[56] Ibid

[57] Ibid

policy establishes protocols for mitigating adverse impacts on eelgrass, restoration, monitoring, and evaluation

Freshwater Resources

Freshwater habitats are also likely to see impacts from sea level rise and storm surges. Changes in salinity and water levels could cause habitat shifts, especially when these influences are regular and not seasonal. In scenario 6, with 60 inches of sea level rise and 100-year storm surge, saltwater can travel miles inland, totaling 211 miles of creeks that could be impacted by higher levels of saltwater. San Antonio Creek in North Novato could fill with saltwater up to ten miles upstream in the long-term. Similarly, the Corte Madera channel could fill with saltwater nearly eight miles inland. On average, up to one half of a mile upstream could be under tidal influence. This could shift existing freshwater habitat to brackish habitat. Creeks that could be affected by rising bay waters include:

- Armory Creek
- Arroyo Corte Madera del Presidio,
- Arroyo de San Jose,
- Baccaglio Basin Drainage,
- Basalt Creek,
- Beach Marsh Channel,
- Black John Slough,
- Castro Ditch,
- Cheda Creek,
- Corte Madera Channel,
- Corte Madera Creek,
- Corte Madera Outfall Channel,
- Coyote Creek,
- Deer Island Channel,
- East Creek,
- Estancia Ditch,
- Gallinas Creek,
- Glen Creek,
- Glenwood Creek,
- Greenbrae Creek,
- High Canal/Irwin Creek,
- King Mountain Creek (Brixon Creek),
- Larkspur Creek,
- Leveroni Ditch,
- Low Canal,
- Lynwood Slough,
- Mabry Ditch,
- Mahon Creek,
- McAllister Creek,
- Meadow Sweet Creek,
- Miller Creek,
- Murphy Creek,
- Novato Creek,
- Novato Ditch System,
- Nyhan Creek,
- Pacheco Creek,
- Peacock Gap Creek,
- Petaluma River,
- Reed Creek,
- Rush Creek,
- Ryan Creek,
- Salt Works Canal,
- San Antonio Creek,
- San Clemente Creek,
- San Rafael Airport Ditch,
- San Rafael Creek
- Simmons Slough,
- Strawberry Ditch,
- Strawberry Marsh,
- Sunny Oaks Drainage,
- Tamalpais Creek,
- West Creek,
- Willow Creek, and
- Wolfe Grade Creek.

In addition, freshwater ponds and vernal pools within the Petaluma Marsh System in North Novato, large freshwater emergent marshes along the western side of Novato Creek north of Highway 37, and Pacheco Pond could experience increased salinity and water level impacts, and therefore, habitat impacts, in the long-term.

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Bothin Marsh bordering Richardson Bay. Credit: MarinMap

Saltworks Canal, Strawberry. Credit: DPW

Wildlife & Endangered Species

The most vulnerable species are those that use the vulnerable habitats. Vulnerable habitats are beaches, tidal marshes, freshwater streams and ponds, eel grass beds in the intertidal zone. These habitats offer feeding and breeding ground for several mammal, birds, and insects, and host several rare and valued plants along Marin's eastern shoreline. Several species, and/or their habitats, are protected under federal, state, or regional regulations. Meeting existing habitat goals and needs may prove challenging as tides rise. Species potentially located within the geographic extent of scenario 5, when significant habitat changes could occur, are listed in Table 41.

Mammals

According to the Department of Fish and Wildlife, the following are recorded locations marine mammals inhabit (does not include federal park locations):

- Sausalito Basin 3,
- Strawberry Spit,
- Corte Madera Ecological Reserve,
- Angel Island, and
- Castro Rocks.

The Pacific Harbor Seal and Southern, or California, Sea Otter are known to use the San Francisco Bay. San Francisco Bay Pacific harbor seals have spotted coats, and many are fully or partially reddish in color. They reach six feet in length and weigh up to 300 pounds. Harbor seals are the third most common patient at The Marine Mammal Center. In general, Harbor seal colonies in the Bay Area are vulnerable to human disturbance, climate change and human-produced pollutants.[58]

The Southern Sea Otter is among the smallest of marine mammals and may live for 15-20 years in the wild. Sea otters occupy marine habitats from the littoral zone to depths of less than 330 feet, including protected bays. Sea otters in California are a threatened species due to past over hunting for their fur. Although they are protected from hunting, sea otters are still vulnerable, especially to habitat loss and oil spills.[59]

These species are already vulnerable, typically due to habitat destruction. Sea level rise would likely exacerbate the fragility of these habitats and the threatened and endangered specieis in them.

Another vulnerable mammal in the study area is the Salt marsh harvest mouse. Salt marsh harvest mice are endangered because of habitat loss,

[58] The Marin Mammal Center Website. Harbor Seal. Accessed Jan. 18, /2017. Last updated: Jan. 2017 http://www.marinemammalcenter.org/education/marine-mammal-information/pinnipeds/pacific-harbor-seal/ accessed.

[59] The Marin Mammal Center Website. Sea Otter. Accessed Jan. 18, 2017. Last updated: Jan. 2017 http://www.marinemammalcenter.org/education/marine-mammal-information/sea-otter.html.

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fragmentation, and alteration.[60] These mice are only found in the marshes of Corte Madera; the Marin Peninsula and San Pablo Bay, typically in the upper half of tidal salt marshes and the adjacent uplands during high tides.[61] Sea level rise would greatly impact this species, especially if the mouse's habitat is trapped by development. If high inundation rates occur in areas without upland habitat then reproduction could be reduced or eliminated. This is more likely an issue in the narrow valley outlets of southern portion of the study area, than the larger basins of the northern study area. Other potential impacts of sea level rise include changes and shifts in vegetation composition and the overtopping of all intertidal vegetation by higher storm surges. Such severe inundation could increase predation[62] and decrease reproductive success by flooding nests.[63]

Fish

The two listed fish off the shores of the study are the tide water goby and the longfin smelt. The tidewater goby is listed as Endangered at state and federal levels. Tidewater gobies are about two inches in length, translucent with gray, green, and brown. The tidewater goby's ideal habitat is a brackish estuary or marsh with shallow water, a sandy bottom, and cool temperatures. Tidewater gobies are vulnerable to the introduction of non-native species and sudden increases in salinity levels.[64] As brackish waters push further and further up narrow valleys during storms or the highest tides, and existing habitats increase in salinity, the amount of suitable habitat could decrease significantly. The longfin smelt is listed as threated on the California list and a candidate on the federal list. The largest longfin smelt population occurs in the San Francisco Estuary and Sacramento-San Joaquin Delta. This species occupies bay waters throughout summer and moves into lower reaches of rivers in fall to spawn.[65]

Harbor Seal. Credit: Bay Nature

Table 41. Example Vulnerable Species

Federal: Endangered	• Ridgeway rail • Soft salty bird's-beak • White-rayed pentachaeta • Salt-marsh harvest mouse • Tidewater goby • Chinook Salmon
Federal: Threatened	• Western snowy plover • California red-legged frog
Federal: Candidate	• Longfin smelt
Others	• Salt Marsh Yellowthroat • Southern sea otter • Delta smelt • Green Sturgeon Pacific Herring • Steelhead • Monarch Butterfly

Source: California Natural Diversity Database

[60] Shell hammer, H. 2000. Salt Marsh Harvest Mouse. Pp. 219 – 228 in Goals Project. 2000. Baylands Ecosystem Species and Community Profiles: Life history and environmental requirements of key plants, fish and wildlife. Prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. P. R. Olson, editor. San Francisco Bay Regional Water Quality Control Board, Oakland, California.

[61] Goals Project. 2015. *The Baylands and Climate Change: What We Can Do*. Appendix 5.1 Salt Marsh Harvest Mouse. Ecosystem Baylands Habitat Goals Science Update 2015 prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. California State Coastal Conservancy, Oakland, CA.

[62] Johnston, R. F. 1957. Adaptation of salt marsh mammals to high tides. Journal of Mammalogy, 38:529-531.

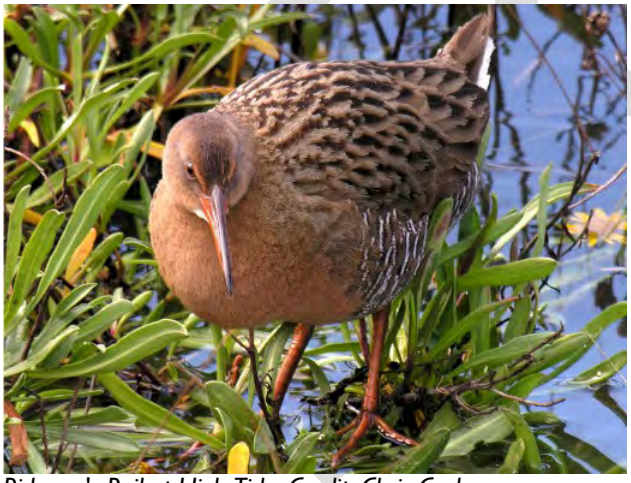
[63] Hardaway. H. C. and J. R. Newman. 1971. Differential responses of five species of salt marsh mammals to inundation. Journal of Mammalogy, 52:818-820.

[64] Farallones Marin Sanctuary Association Website. Endangered Spotlight: Tidewater Gobi Updated 2005. http://www.farallones.org/e_newsletter/2008-02/TidewaterGoby.htm Accessed Jan. 18, 2017.

[65] Goals Project. 2015. *The Baylands and Climate Change: What We Can Do*. Appendix 3.9 Longfin smelt. Ecosystem Habitat Goals Science Update 2015 Baylands prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. California State Coastal Conservancy, Oakland, CA.

Other important fish species that are sensitive changes in environmental conditions that could occur in the San Francisco, San Pablo, and/or Richardson's Bays are:

- Chinook salmon: These fish spend time in the ocean and migrate into freshwater rivers to spawn.
- Delta smelt: Delta smelt are endemic to the Sacramento-San Joaquin River Delta and occupies saltwater habitats and spawns in freshwater.
- Green sturgeon: These large and long living fish spend time in the ocean and migrate into freshwater rivers to spawn every three to five years and can be found traveling through the bay to breeding grounds in the Sacramento River.
- Pacific herring: The Pacific herring is typically found in large schools. Adults breed in estuaries in shallow areas along shorelines. Eggs are laid on kelp and eelgrass November through April. Richardson's Bay is considered a critical spot for spawning.
- Steelhead: Adults spend time in the ocean and migrate into freshwater rivers to spawn, after spending two to three years in the ocean. San Francisco Bay is within the range of two runs of steelhead.



Ridgway's Rail at High Tide. Credit: Chris Cochems

Birds

Shoreline wetlands, marshes, mudflats, and ponds provide valuable bird habitat. One of the largest protected habitats is the San Pablo Bay National Wildlife Refuge (SPBNWR) managed by United State Fish and Wildlife Service (USFWS), which connects to the Petaluma Marsh Wildlife Area managed by California Department of Fish and Wildlife (CDFW), another extensive area of habitat to the northeast. Both of these areas, and smaller marsh lands further south, are major winter-migration stopovers along the Pacific Flyway for waterfowl. Smaller shoreline habitats in southern Marin are also known to support vulnerable and valuable bird species.

Listed bird species that could be found in or moving through the eastern Marin shoreline are the Ridgway's rail, the Western snowy plover, San Pablo Bay National Wildlife Refuge. The Ridgway's rail is one of the largest rails in North America, very secretive, and primarily lives in salt and brackish marshes. The following locations are known to support Ridgway's rail populations:

- Richardson's Bay is known to support a small number of Ridgway's rails.
- Bothin Marsh Preserve, Mill Valley.[66] I
- The marsh at the mouth of Gallinas Creek, including China Camp, supports what appears to be the largest population of Ridgway's rails in the North Bay.[67]
- The Corte Madera Ecological Reserve supports one of the densest populations of Ridgway's rails in the northern San Francisco Bay.[68]

The Western snowy plover is a small shorebird that occurs along the Pacific Coast. They forage for small invertebrates in beach sand, kelp, and low--growing dune vegetation. A small population nests on and near the shores of the San Francisco Bay and may forage in Richardson's Bay. Other

[66] Distribution and population trends for the Endangered California Clapper Rail. State of the Estuary Conference, 26 October 2013, Oakland, CA.

[67] Goals Project. 2015. *The Baylands and Climate Change: What We Can Do*. Baylands Ecosystem Habitat Goals Science Update 2015 prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. California State Coastal Conservancy, Oakland, CA. Pg. 156

[68] Goals Project. 2015. *The Baylands and Climate Change: What We Can Do*. Baylands Ecosystem Habitat Goals Science Update 2015 prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. California State Coastal Conservancy, Oakland, CA. Pg. 168

unique and valuable bird species common in the study area are:

- California brown pelican: The California brown pelican, the smallest species of pelican, forages within Richardson's Bay and may be present in the study area.
- California least tern: The California least tern is the smallest of North American terns, has nesting colonies in the San Francisco Bay, and may forage within Richardson's Bay.
- Double-crested cormorant: Double-crested cormorant are large seabirds that live year-round in the San Francisco Bay. Cormorants forage within Richardson's Bay. The Richmond-San Rafael is a nesting site.
- San Francisco common yellowthroat: This subspecies of common yellowthroat is endemic to the San Francisco Bay region in wetland and riparian habitats. Yellowthroats may occur within the project during the breeding and nonbreeding season.
- San Pablo (Samuels) song sparrow: This subspecies lives in tidal marshes throughout the San Pablo Bay, San Francisco, and Richardson's Bays year-round. They are primarily associated with high marsh habitats dominated by pickleweed.

Additional migratory birds were reported in study area are Allen's hummingbird, marbled godwit, Nuttall's woodpecker, and the eastern grebe. Most migratory bird species, with a few specific exceptions, are protected under the federal Migratory Bird Treaty Act and California Fish and Game Code.

Insects

Insects could also see impacts to their habitats that directly impact their success at survival. The Monarch butterfly, an orange and black milkweed butterfly with a wingspan of 3.5 to 4 inches, could suffer from impacts to milkweed habitat along the coast. Populations of monarch butterfly are found in the San Francisco Bay region especially during the winter months. The Mission blue butterfly has a small a wingspan of 1 to 1.5 inches. They occur in coastal chaparral and grassland habits and depend on lupine plants for the egg, larvae, and pupae life phases. The butterfly was documented at Fort Baker, though it was not detected in the 1984 and 1985 during last survey.

Plants

Numerous special status plants with habitats that are expected to be vulnerable to sea level rise are:

- Franciscan thistle,
- Hairless popcornflower,
- Marin western flax,
- Oregon polemonium,
- Point Reyes salty bird's beak,
- Tiburon buckwheat,
- Tiburon paintbrush, and
- White-rayed pentachaeta.[69]

Salt marshes are host a variety of unique and valuable plants, such as pickleweed and cordgrass, in Novato, San Rafael, St. Vincent's, Tiburon, Strawberry, Tamalpais Valley, and Mill Valley. Patches in Novato, St. Vincent's, Mature wide salt marsh habitat has regenerated near the mouth of Coyote Creek, supporting regionally rare plant populations, including some of the largest colonies of northern salt marsh bird's beak in San Francisco Bay.[70]

In addition, eelgrass beds off the shores of Sausalito, Tiburon, and Belvedere previously discussed under Tidal Estuaries, Wetlands, and Marshes, are also vulnerable to sea level rise.

[69] Prunuske Chatham, Inc. March 2016. Draft Biological Resources Assessment: Dunphy Park Improvement Project Sausalito, Marin County.

[70] Goals Project. 2015. *The Baylands and Climate Change: What We Can Do*. Baylands Ecosystem Habitat Goals Science Update 2015 prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. California State Coastal Conservancy, Oakland, CA. Pg. 168

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Table 42. Example Vulnerable Natural Resource Assets Ranked by Onset and Flooding at MHHW

Location	Asset	Near-term	Medium-term	Long-term
		Scenario 1	Scenario 3	Scenario 5
Sausalito	Swedes Beach	Floods at existing high tides		
Novato	Scottsdale Marsh	Floods at existing high tides		
Unincorporated Tiburon	Paradise Beach Park	Floods at existing high tides		
Mill Valley	Bothin Marsh	Floods at existing high tides		
Corte Madera	Corte Madera Ecological Reserve	Floods at existing high tides		
Corte Madera	Triangle Marsh	Floods at existing high tides		
San Rafael	Tiscornia Marsh	Floods at existing high tides		
Novato	Bahia marshes	Floods at existing high tides		
State Park	Angel Island State Park	14’1”	14’10”	17’9”
San Rafael	Shoreline Open Space	10’3”	11’1”	25’4”
Tiburon	Pt. Tiburon Shoreline Park	8’	8’8”	11’6”
Pt. San Pedro	China Camp State Park	7’6”	8’1”	18’4”
San Rafael	John F. Mc Innis Park	7’6”	8’6”	10’6”
Larkspur	Piper Park	7’2”	7’11”	10’8”
Santa Venetia	Santa Venetia Marsh	7’	7’10”	9’11”
San Pablo Bay	Wildlife Refuge	6’9”	7’2”	19’
Santa Venetia	Santa Margarita Island	5’8”	6’8”	8’8”
Sausalito	Arques Shipyard & Marina	5’7”	8’6”	21’9”
Sausalito	Marina Plaza Harbor	5’7”	8’6”	21’9”
San Rafael	Jean & John Starkweather Shoreline Park	5’4”	6’	16’3”
Bel Marin Keys	Del Oro Park	5’2”	5’8”	8’9”
Sausalito	Dunphy Park	5’1”	5’8”	13’8”
Bel Marin Keys	Cavalia Cay Park	5’1”	5’8”	8’9”
San Rafael	Pickleweed Park	5’	5’8”	8’9”
Larkspur	Cal Park wetlands at Corte Madera Creek	4’10”	5’3”	8’2”
Waldo Point	Richardson Bay Marina	4’5”	7’4”	18’7”
Larkspur	Bon Air Landing Park	4’4”	5’	8’6”
Pt. San Pedro	McNears Beach Park	4’4”	5’9”	8’
Belvedere	Corinthian Yacht Club	4’	4’3”	11’
Tiburon	Mc Kegney Green	3’1”	5’7”	15’3”
Tiburon	Richardson Bay Lineal Park	0-3’	1”-3’7”	1”-15’
Larkspur	Remillard Park beach	2’11”	3’6”	6’2”
Belvedere	San Francisco Yacht Club	2’2”	3’6”	8’10”
Tiburon	Blackie's Pasture	0-9”	5’4”	12’9”
Tiburon	The Cypress Garden Park	7”	1’4”	4’4”
Sausalito	Sausalito Yacht Harbor	4”	1’	3’
Paradise Cay	Paradise Cay Yacht Harbor	2”	1’6”	3’10”
San Rafael	Lowrie Yacht Harbor	2”	9”	3’7””
San Rafael	Marin Yacht Club	1”	1’6”	3’9”

NATURAL RESOURCES

Location	Asset	Near-term	Medium-term	Long-term
		Scenario 1	Scenario 3	Scenario 5
Sausalito	Pelican Yacht Harbor	No data	No data	No data
Strawberry	Aramburu Wildlife Preserve	No data	No data	No data
San Rafael	San Rafael Yacht Harbor	No data	No data	No data
San Rafael	Beach Park		8'11"	11'10"
Mill Valley	Bayfront Park		8'3"	4'-11'6"
Sausalito	Schoonmaker Beach		7'2"	10'1"
Strawberry	Brickyard Cove		6'11"	9'11"
Corte Madera	Hal Brown Park		6'3"	9'2"
Strawberry	Strawberry Point Tidal Area		5'1"	8'1"
Strawberry	Seminary Marsh		4'4"	8'1"
Corte Madera	Shorebird Marsh		5'3"	10'9"
Strawberry	Strawberry Point Park		4'10"	9'2"
San Rafael	Loch Lomond Marina		3'7"	9'7"
Sausalito	Clipper Yacht Harbor		2'5"	6'3"
San Rafael	San Rafael Yacht Club		2'2"	5'7"
Bel Marin Keys	Montego Park		2'	5'4"
Sausalito	Cass Gidley Marina		2'	3'2"
Larkspur	Hamilton Park		10"	3'9"
Mill Valley	Shelter Bay		2"-9"	6"-1'10"
Novato	South Hamilton Park			11'6"
Novato	Deer Island Baylands			10'10"
Corte Madera	Madera Gardens Lagoons			10'4"
CA Fish & Wildlife	Gallinas Creek			10'2"
Corte Madera	Town Park			9'10"
Novato	Rush Creek			8'10"
Mill Valley	Sycamore Park			8'6"
Novato	Slade Park			8'
Bel Marin Keys	Caribe Isle Park			7'6"
Sausalito	Tiffany Beach			7'4"
Santa Venetia	Castro Park			7'
Santa Venetia	Adrian Rosal Park			6'3"
San Rafael	Shoreline Pathway			5'10"
Santa Venetia	Pueblo Park			5'1"
Tiburon	Zelinsky Park			4'11"
Tiburon	Pt. Tiburon Marsh			4'10"
San Rafael	Schoen Park			4'4"
Mill Valley	Freeman Park			4'2"
Strawberry	Greenwood Cove			4'1"
Corte Madera	Ring Mountain			3'6"
Mill Valley	Hauke Park			3'6"
Corte Madera	Skunk Hollow Park			3'4"
Tiburon	Bel Aire Park			3'
Larkspur	Bon Air Landing Park			2'4"
Corte Madera	San Clemente Park		No data	No data
Bayside Acres	Marin Islands Ecological Reserve		No data	No data

NATURAL RESOURCES

Location	Asset	Near-term	Medium-term	Long-term
		Scenario 1	Scenario 3	Scenario 5
North Novato	Petaluma Marsh Ponds			No data
Mill Valley	Arroyo Corte Madera del Presidio	Water resource		
Larkspur	High Canal	Water resource		
Larkspur	Larkspur Creek	Water resource		
Larkspur	Low Canal	Water resource		
Novato	Novato Creek	Water resource		
Novato	Petaluma River	Water resource		
Strawberry	Salt Works Canal	Water resource		
San Rafael	San Rafael Canal	Water resource		

Source: MarinMap, CoSMoS

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NATURAL RESOURCES

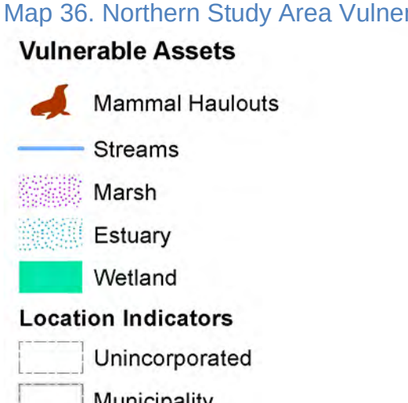
Map 36. Northern Study Area Vulnerable Natural Resources

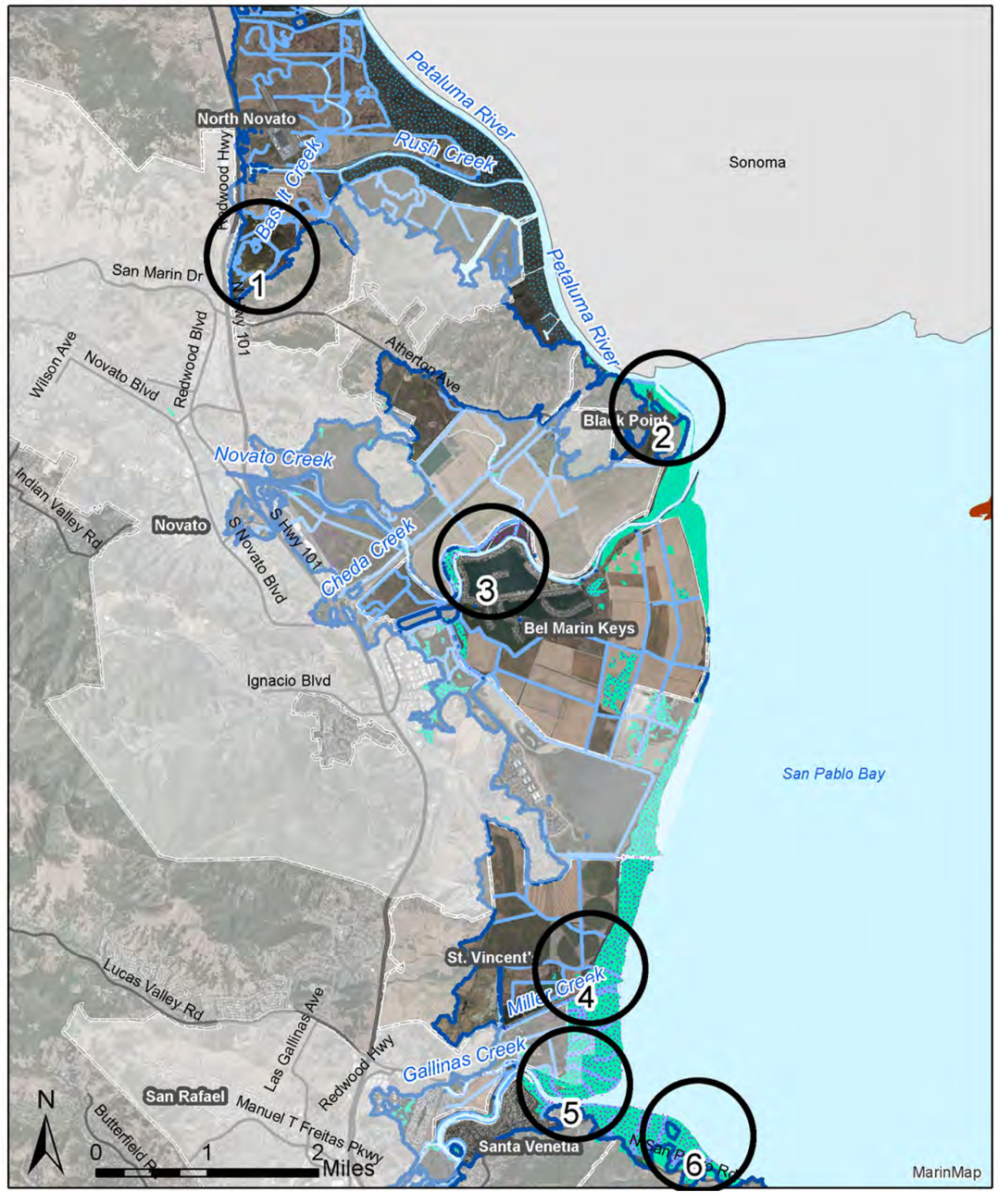
Vulnerable Assets

- Mammal Haulouts
- Streams
- Marsh
- Estuary
- Wetland

Location Indicators

- Unincorporated
- Municipality
- Road
- Bay
- Inland Extent: Sea Level @ 60"+100-year Storm

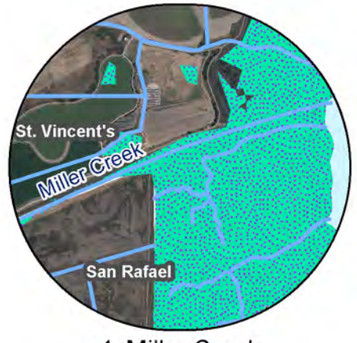




1: Rush Creek

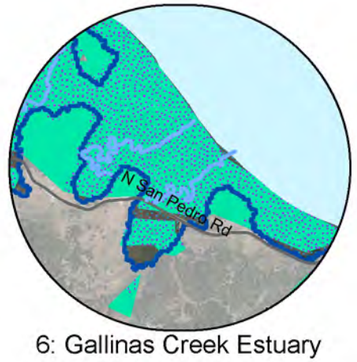
2: Black Point

3: Upper Bel Marin Keys



4: Miller Creek

5: Santa Venetia Marsh



6: Gallinas Creek Estuary

Date: 3/30/2017

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.

NATURAL RESOURCES

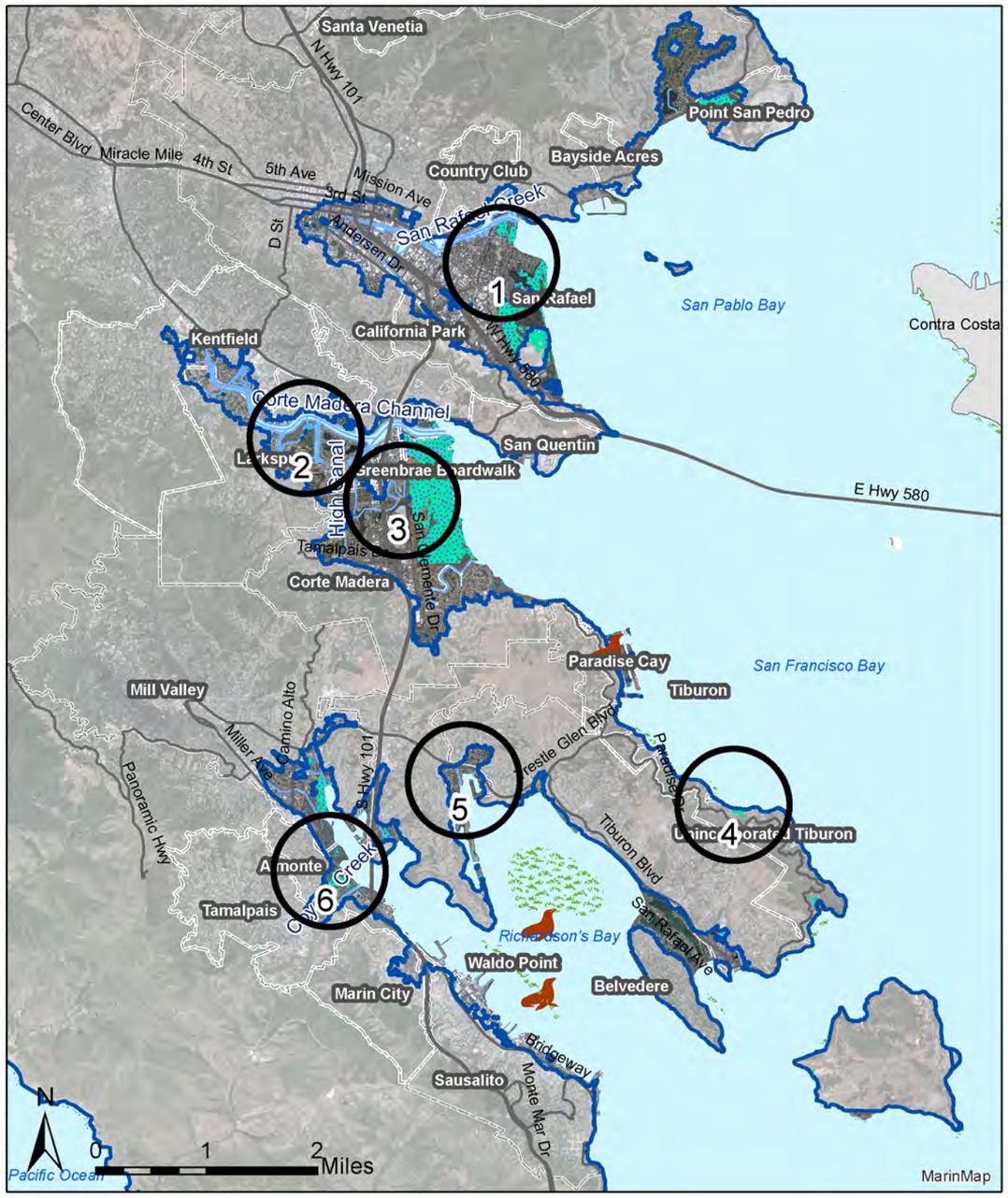
Map 37. Southern Study Area Vulnerable Natural Resources

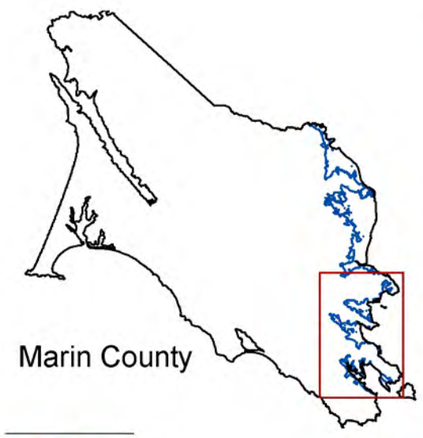
Vulnerable Assets

- Mammal Haulouts
- Streams
- Eelgrass
- Marsh
- Estuary
- Wetland

Location Indicators

- Unincorporated
- Municipality
- Road
- Bay
- Inland Extent: Sea Level @ 60"+100-year Storm





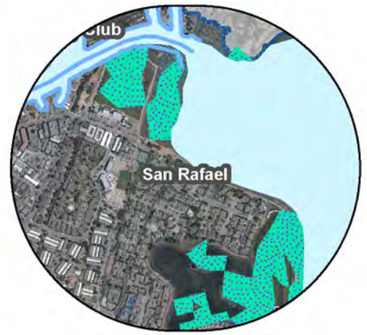
CONSULTING

CA Dept. of Fish & Wildlife

Date: 3/30/2017

OCOF

CoSMoS



1: Pickleweed & Tiscornia Marshes

2: Corte Madera Creek

3: Corte Madera Ecological Reserve

4: Paradise Beach

5: Strawberry Point

6: Bothin Marsh

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.

Other Considerations

Economic
Active and passive recreation on Marin's shoreline beaches, trails, and roads are major economic contributors to Marin (see the Recreation Profile for more information). Wildlife viewing is a major draw to the region and the inability to do so could significantly reduce tourism.

In addition, park maintenance costs could increase and substantial funding would be needed to relocate or improve infrastructure due to the high degree of scrutiny and environmental compliance required. These increased costs would be passed on to the tax payers and park users, creating potential disproportionate impacts across economic brackets.

Estuaries, beaches, bluffs, marine wetlands, and marshes also provide ecosystem services as buffers protecting development from waves and floods, filtration systems for pollutants, provide oxygen, and many others. Their loss could increase the cost of maintaining flood protection at the least.

Environmental
The complete or partial loss of tidal marshlands and other natural shoreline features could increase the reliance on structural shoreline protection to create a buffer from the rising waters, and would place shoreline residents at a greater risk of flooding. Multiple utility transmission lines and others are located in marsh areas or along waterways. If these systems were to become damaged, fire, or other electrical damage could occur. Finally, efforts to protect vulnerable built assets with new shoreline armoring could have detrimental impacts on shoreline habitats by reducing their ability to adapt. Several studies have also shown that walls can increase erosion on neighboring land areas.[71]

According to the Bayland Habitat Gals Update (2015), other challenges to improving or restoring habitat in the northern study area are:

- Commercial and residential developments at Bel Marin Keys,
- Hamilton Field, and at several sites to the south;
- Diked golf course in Black Point;
- Low-lying segments of State Route 37 and US Highway 101, other roads,
- Northwestern Pacific railroad track, and
- Development between the railroad and the highway.[72]

In the southern portion of the study area, primary constraints would be:

- US Highway 101,
- An urbanized edge with roadways and infrastructure that currently flood (e.g., Miller Avenue, Manzanita parking areas, the Mill Valley sewer plant),
- Northwestern Pacific railroad tracks,
- Erosion from the Golden Gate Ferry in Larkspur,
- Exotic predators (e.g., rats and red fox),
- Invasive *Spartina*, and
- On-site contaminants.[73]

Social Equity
As preparations are made to protect existing areas, or create new public areas, costs could increase, entrance fees, or in some cases, require new fees. These added could make visiting county, federal, and state parks cost prohibitive for those of lesser means. Loss of any protected, publicly accessible lands would reduce the opportunities for visitors to these open spaces. These losses could disproportionately impact those who enjoy nearby public space along our shoreline as access becomes increasingly difficult, and in some cases access could be impeded entirely.

Management
Protecting natural resources and wildlife can be highly controversial. For example, protecting breeding areas may limit public access or economic

[71] California Coastal Commission Sea Level Rise Policy Guidance: Interpretive Guidelines for Addressing Sea Level Rise in Local Coastal Programs and Coastal Development. August 12, 2015. http://documents.coastal.ca.gov/assets/slr/guidance/August2015/0_Full_Adopted_Sea_Level_Rise_Policy_Guidance.pdf

[72] Goals Project. 2015. *The Baylands and Climate Change: What We Can Do*. Baylands Ecosystem Habitat Goals Science Update 2015 prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. California State Coastal Conservancy, Oakland, CA. Pg. 159

[73] Goals Project. 2015. *The Baylands and Climate Change: What We Can Do*. Baylands Ecosystem Habitat Goals Science Update 2015 prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. California State Coastal Conservancy, Oakland, CA. Pg. 172

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activity. As tides rise, the available land area will be reduced and increase the competition for resources. Limited financial resources could reduce priorities for wildlife protection, park maintenance, and investment. Park management would be affected because infrastructure within parks may become inaccessible or degraded due to flooding and saltwater exposure. Large amounts of funds would be needed to relocate or improve infrastructure due to the high degree of scrutiny and environmental compliance that would be necessary. Making improvements for public access or restoring habitats would also need to be sensitive to the multiple cultural sites relating to Coast Miwok habitation and early European and Asian settlements in the vulnerable portions of the study area.[74]

Developing and implementing large projects will require multiple agencies and private partners to coordinate and contribute financially. Moreover, natural resources often cross political borders and require intergovernmental collaboration. Any in many cases, especially in the northern study area, changes to or failures in flood protection in the baylands or managed land areas could impact development further inland, such as State Routes 101 and 37, SMART rail lines, and Gnoss Field. Planning would necessitate coordination amongst local municipalities, Marin County, California Department of Fish and Wildlife, and Caltrans.

The Marin Countywide Plan and local jurisdiction general plans guide protecting natural resources and sensitive habitats when land is developed, preserving public access to the coast, and maintaining and enhancing shoreline resources. Other regional, state, and federal regulators may also be involved, and commonly local plans reflect these goals and take advantage of any programs and funds at the higher levels of government.

[74] Goals Project. 2015. *The Baylands and Climate Change: What We Can Do*. Baylands Ecosystem Habitat Goals Science Update 2015 prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. California State Coastal Conservancy, Oakland, CA. Pg. 159

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RECREATION

Asset Profile: Recreation & Public Access

Marin County is treasured for its immense recreation opportunities. Vulnerable recreation assets are small beaches, parks, marsh lands, trails, boating and fishing along the shoreline. Several of these recreational activities, and other such as wildlife viewing and kayaking, may simply shift as sea level rises, or require minimal management actions. However, ensuring continued safe public access to existing recreation areas could be a challenge.

Most recreation areas vulnerable to sea level rise are managed by local, county, state, and federal agencies for public use. Major examples include: Golden Gate National Recreation Area, China Camp State Park, the Bay Trail, Paradise Beach, Mc Near's Beach, and others. Others, such as the biplane rides, are privately managed.

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

- Sea level rise may push shoreline and bay recreation opportunities inland where possible. Where not possible, the asset could be lost.
- Access to recreational areas may become limited as roads and trails flood and erode.
- Tour buses could be impeded from visiting the area.
- Visitor serving business, such as restaurants, hotels and inns, boat rentals, and others, could be vulnerable to sea level rise and storm damage, and also to a host of other potential vulnerabilities in utility networks.

About 100 parks could be impacted to some degree, whether just kissed by the sea or completely claimed by it. Roughly 1,100 acres of the 12,000 acres in these parks may see sea level rise impacts. With a 100-year storm surge coincidence, an additional five parks and 120 acres could be impacted. Counted separately, school playgrounds amount to roughly 200 acres across 15 schools. For details on impacts to schools, see the Parcels & Buildings Profile.

IMPACTS AT-A-GLANCE: SCENARIO 6

Thousands of residents, millions of visitors

Boating Facilities **Pathways & trails** **Athletic fields** **Playgrounds** **Parks** **Fishing Piers**	**Property Owners** **CSP** **County Parks & Roads** **Caltrans**
8 Beaches	**20 Parks**

Boats docked at a Lowrie Yacht Harbor, San Rafael. Credit: BVB Consulting LLC

Mill Valley-Sausalito Multi-use path is well used by residents and visitors. Credit: S. Crooks.

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RECREATION

Table 43. Recreation Assets Vulnerable to Sea Level Rise at MHHW

M= Marin County Jurisdiction

	Near-term		Medium-term		Long-term	
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
All	**47 Parks 287 Acres**	**47 Parks 718 Acres**	**47 Parks 510 Acres**	**47 Parks 810 Acres**	**94 Parks 1,084 Acres**	**105 Parks 1,222 Acres**
Incorporated Jurisdictions						
Belvedere					Belvedere Community Center Mini Park	
Corte Madera	Triangle Marsh	See scenario 1	See scenario 1	See scenario 1 Susan Marker Trail [L]	See scenario 1 Bike Trail[M] Hal Brown Park[M] Madera Gardens Lagoons Ring Mountain[M] Shorebird Marsh Town Park Skunk Hollow Park	See scenarios 1 & 5
Larkspur	Bon Air Landing Park Cal Park Wetland[M] Bon Air Landing Park Piper Park Remillard Park	See scenario 1	See scenario 1	See scenario 1	See scenario 1 Heatherwood Park Niven Park San Clemente Park	See scenarios 1 & 5 Hamilton Park
Mill Valley	Bayfront Park Mill Valley/ Sausalito Path[M]	See scenario 1	See scenario 1	See scenario 1	See scenario 1 Freeman Park Hauke Park Mill Valley Rec Center Sycamore Park	See scenarios 1 & 5 Enchanted Knolls Park
Novato					Bahia Mini Parks Future Hamilton Rec Area Hamilton Airport Park Hamilton Amphitheater Park Slade Park Hamilton Community Center South Hamilton Park	See scenario 5 Scottsdale Marsh

RECREATION

	Near-term		Medium-term		Long-term	
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
San Rafael	Beach Park Gallinas Creek Pickleweed Park Starkweather Shoreline Park Open space off Bay Way	See scenario 1	See scenario 1	See scenario 1	See scenario 1 Albert Park Peacock Gap Park Schoen Park Canal/Shoreline Open Space	See scenarios 1 & 5
Sausalito	Dunphy Park Mill Valley/ Sausalito Path [M] Schoonmaker Beach Swedes Beach Tiffany Beach Turney Street Boat Ramp Yee Tock Chee Park	See scenario 1	See scenario 1	See scenario 1	See scenario 1	See scenario 1 City Government Facilities Gabrielson Park Island Park Marinship Park
Tiburon	Blackie's Pasture McKegney Green Pt. Tiburon Richardson Bay Lineal Park Shoreline Park The Cypress Garden Park	See scenario 1	See scenario 1	See scenario 1	Bel Aire Park Pt. Tiburon Marsh Zelinsky Park	See scenarios 1 & 5 Pt. Tiburon Tennis Courts South-Of-The-Knoll Park
Unincorporated Jurisdictions						
Almonte	Charles F. McGlashan Pathway[M]	See scenario 1	See scenario 1	See scenario 1	See scenario 1	See scenario 1
Bel Main Keys	Cavalia Cay Park Bahama Reef Boat Launch Dolphin Isle Boat Launch	See scenario 1	See scenario 1	See scenario 1	See scenario 1 Bel Marin Keys Public Dock Bel Marin Keys Yacht Club Caribe Isle Park Montego Park Calypso Bay Public Dock Bahama Reef Boat Launch Del Oro Park	See scenarios 1 & 5
Black Point	Black Point Boat Launch[M]	See scenario 1	See scenario 1	See scenario 1	See scenario 1	See scenario 1

RECREATION

	Near-term		Medium-term		Long-term	
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
No. Novato					Rush Creek [M] Deer Island [M]	See scenario 5
Sta. Venetia	Santa Margarita Island [M] Santa Venetia Marsh [M]	See scenario 1	See scenario 1	See scenario 1	Pueblo Park[M] Adrian Rosal Park[M] Castro Park[M] Candy's Park[M]	See scenarios 1 & 5
Strawberry	Brickyard Cove Community Park Community Park Boat Launch Strawberry Point Tidal Area [M] Strawberry Point Park Aramburu Island [M]	See scenario 1	See scenario 1	See scenario 1	See scenario 1	See scenario 1
St. Vincent's	John F. McInnis Park [M]	See scenario 1	See scenario 1	See scenario 1	See scenario 1	See scenario 1
Tiburon	Paradise Beach Park [M]	See scenario 1	See scenario 1	See scenario 1	See scenario 1	See scenario 1

Source: MarinMap, CoSMoS

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RECREATION

Beaches

Beaches are used for wildlife viewing, sunbathing, and accessing bay waters for swimming, kayaking, paddle boarding, and fishing. Sea level rise could inundate existing beaches and increase rates of shoreline erosion. This could potentially force beach recreation opportunities inland where beaches are not impeded by development, roads, or bluffs.[75] Beaches commonly used for recreation that could be vulnerable to sea level rise and storms include:

- Schoonmaker Beach, Sausalito,
- Swedes Beach, Sausalito,
- Tiffany Beach, Sausalito,
- Private beaches in Tiburon,
- Paradise Beach, Unincorporated Tiburon,
- Larkspur Landing Beach,
- Pt. San Quentin Beach (private),
- Marin Rod & Gun Club, San Rafael,
- McNear's Beach, Pt. San Pedro,
- Brick Yard Beach, San Rafael,
- China Camp State Park Beaches, and
- McInnis Beach, San Rafael.

Narrow Tiffany and Swede beaches in Sausalito. Credit: Sausalito

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

Estuaries, Wetlands, & Marshes

Primary recreational activities in estuarine areas such as the shoreline areas of Richardson Bay, San Pablo Bay, and the San Francisco Bay, are hiking, kayaking, paddle boarding, boating, bird watching, fishing, swimming, and other passive forms of recreation. Without a comparable increase in land elevation from sediment delivery, these recreational areas could flood.[76,77] Like beaches, estuaries can be prevented from moving landward when bordering development or cliffs. Vulnerable estuaries, wetlands, and marshes include:

- Bothin Marsh, Mill Valley,
- Santa Venetia Marsh,
- Shorebird Marsh, Corte Madera,
- Pt. Tiburon Marsh, and
- San Pablo Bay Wildlife Area, in the Bay off St. Vincent's.

Freshwater Resources

In scenario 5, with 60 inches of sea level rise, saltwater can travel miles inland up to, especially in Corte Madera Creek and the Petaluma River. This could significantly alter existing habitat and wildlife viewing opportunities, and may require adapting to create new opportunities. Creeks passing through parks that could be impacted by sea level rise include:

- Arroyo Corte Madera del Presidio,
- Baccaglio Basin Drainage,
- Castro Ditch,
- Corte Madera Channel,
- Corte Madera Creek,
- Corte Madera Outfall Channel,
- Coyote Creek,
- Estancia Ditch,
- Gallinas Creek,
- Glen Creek,
- Glenwood Creek,
- Greenbrae Creek,
- High Canal,

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

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

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- Larkspur Creek,
- Low Canal,
- Lynwood Slough,
- Mahon Creek
- Marin City Stormwater Pond Channel,
- Meadow Way Creek,
- Miller Creek,
- Nyhan Creek,
- Petaluma River,
- Reed Creek,
- Rush Creek,
- Ryan Creek,
- Salt Works Canal,
- San Rafael Canal,
- Sunny Oaks Drainage,
- Alto Shopping Center, and
- Wolfe Grade Creek.

Federal Parks

The National Park Service released *Adapting to Climate Change in Coastal Parks: Estimating the Exposure of Park Assets to 1 m of Sea-Level Rise*.[78] Note that the National Parks report uses a different methodology than this Assessment to determine vulnerability. While outside of the study area for this report, these federal park lands draw tourists and residents to and through Marin's bay area. Their report finds that high exposure to sea level rise could impact 43 assets valued at $57,870,724 and several recreational and habitat areas in the Marin County portion of the Golden Gate National Recreation Area.

Bay

Several open water recreation activities begin and end on the shoreline. While activities themselves will likely continue despite sea level rise, the facilities to serve these water based activities may need to adjust. These facilities include piers, harbors, marinas, boat launches, and fishing piers. Boating facilities using float systems for the docks and piers versus hydraulic lifts will fare better. Piers that are too short can be replaced, and ideally any project in the near future would incorporate a few extra feet above the current standard to be prepared for uncertainties in the future. A few of these facilities depend on jetties or break walls to protect the boats within them. These structures may also need to have elevation added to withstand higher tides. Jetties are also prone to subsidence and erosion.

- Arques Shipyard and Marina,
- Buck's Landing,
- Cass Gidley Marina,
- Clipper Yacht Harbor,
- Hi-Tide Boat Sales & Services,
- Loch Lomond Marina,
- Lowrie Yacht Harbor,
- Marin Yacht Club,
- McNear Public Fishing Pier
- Marina Plaza Harbor,
- Paradise Cay Yacht Harbor,
- Pelican Yacht Harbor,
- Petaluma River Public Fishing Access,
- Richardson Bay Marina,
- San Rafael Yacht Club,
- San Rafael Yacht Harbor,
- Sausalito Marine,
- Sausalito Yacht Harbor,
- Schoonmaker Point Marina, and
- Travis Marina.

According to Buck's Landing asset managers, monthly high tides that extend above the boat launch could cause up to a 75 percent reduction in capacity.

Mill Valley/Sausalito Multi-modal Pathway. Dec. 2014 King Tides. Credit: DPW

[78] 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.

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Richardson Bay Shoreline seating area. Dec. 2014 King Tide. Credit: DPW

Mill Valley/Sausalito Multi-modal Path through Bothin Marsh. Dec. 2015. Credit: J Poskazner

Sporting Facilities

In addition to the passive recreation, several sites offer sporting facilities such as soccer fields, baseball diamonds, tennis courts, and other features. These facilities typically have electronic centers to control lighting that could be vulnerable. In most cases, only portions of a park are impacted. At McInnis Park the miniature golf, batting cages, driving range, and restaurant are not vulnerable. However, the entrance to the facility is compromised in the long-term and the creek side soccer fields are impacted earlier. Other parks in this category include:

- Swede's Beach, Sausalito,
- Dunphy Park, Sausalito,
- Gabrielson Park, Sausalito,
- Marinship Park, Sausalito,
- Piper Park baseball, soccer, and cricket fields, Larkspur,
- Mc Near's pool, tennis courts, and volley ball courts, Pt. San Pedro,
- Tiburon tennis courts,
- Mill Valley Recreation Center ball fields,
- Corte Madera's Town Park facilities,
- Albert Park, San Rafael, where the minor league baseball team plays,
- Pickleweed Park and Children's Center,
- Belvedere Community Center basketball courts and park, and
- A small piece of the Strawberry Recreation District baseball field could be vulnerable

Bikeways and Trails

Several residents and visitors use the extensive bike and trail systems on a year around basis. The most well-known is the Bay Trail, a regionally managed asset that travels along the majority of the shoreline. The trail is vulnerable in low-lying locations; however, several elevated locations are overtopped by 3 feet of sea level rise and higher. Another well-traveled trail is the Mill Valley-Sausalito Pathway. This pathway is already in a tidal zone and experiences seasonal flooding. The areas just inland from the trail floods at high tides at about 4.5 feet NGVD about 20 to 30 times every year. In the near future, flooding could reduce travel capacity significantly during high tides and increase maintenance needs. The Corte Madera Creek and Charles F. McGlashan Pathways are also vulnerable to sea level rise. In addition, bike travel along roads is vulnerable when the roads could be vulnerable.

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To see list of potentially vulnerable roads, refer to the Transportation Profile.

Map 38. Marin County Area Bay Trail

Private Recreation

Several of the previous shoreline recreation activities are available and enhanced by private service providers. These include hotels, boat suppliers, surfing schools, restaurants, markets, tours, and several could be vulnerable to sea level rise. Of the 35 or so hotels in eastern Marin, fifteen could be vulnerable to regular high tides and storms. Seaplane Adventures is also a unique asset that will likely need to adjust to higher waters. Other major examples of areas featuring private recreational assets include:

- Marin Country Mart shops and dining (access issues only),
- Shelter Bay shops and dining, Mill Valley,
- Downtown Tiburon shops and dining,
- Tam Junction shops and dining,
- Sausalito shops and dining,
- Downtown San Rafael shops and dining, and
- Mt. Tam Racquet Club, Larkspur.

Vulnerable hotels include:

- Embassy Suites by Hilton, Santa Venetia,
- Acqua Hotel, Mill Valley,
- Water's Edge Hotel, Tiburon,
- The Lodge, Tiburon,
- Best Western Corte Madera,
- Marin Suites Hotel, Corte Madera,
- Extended Stay America, San Rafael,
- Travel Lodge, San Rafael,
- North Bay Inn, San Rafael,
- Motel 6, San Rafael,
- Holiday Inn Express, Mill Valley,
- America's Best Value Inn & Suites (access issues only), Mill Valley,
- Travelodge Mill Valley/Sausalito,
- Hotel Sausalito, and
- The Inn Above Tide, Sausalito

Table 44 lists some potentially vulnerable recreational assets at mean higher high water (MHHW) for each sea level rise scenario. Many recreational assets are shoreline based or water features. Some assets would only see impacts long-term scenario 6, with five feet of sea level rise and a 100-year storm surge only. These include Larkspur's Niven Park, Tiburon's tennis courts.

RECREATION

Table 44. Example Vulnerable Recreation Assets Ranked by Onset and Flooding at MHHW

Location	Asset	Near-term	Medium-term	Long-term
		Scenario 1	Scenario 3	Scenario 5
Sausalito	Swedes Beach	Floods at existing high tides		
Sausalito	Tiffany Beach	Floods at existing high tides		
Novato	Scottsdale Marsh	Floods at existing high tides		
Tamalpais Valley	Bothin Marsh	Floods at existing high tides		
Unincorporated Tiburon	Paradise Beach Park	Floods at existing high tides		
Sausalito	GG Sausalito Ferry	No data	No data	No data
State Park	Angel Island State Park	14'1"	14'10"	17'9"
San Rafael	Spinnaker Pt. open space	10'3"	11'1"	25'4"
Tiburon	Pt. Tiburon Shoreline Park	8'	8'8"	11'6"
Pt. San Pedro	China Camp State Park	7'6"	8'1"	18'4"
San Rafael	John F. McInnis Park	7'6"	8'6"	10'6"
Larkspur	Piper Park	7'2"	7'11"	10'8"
Santa Venetia	Santa Venetia Marsh	7'	7'10"	9'11"
San Pablo Bay	San Pablo Bay Wildlife Area	6'9"	7'2"	19'
Santa Venetia	Santa Margarita Island	5'8"	6'8"	8'8"
Sausalito	Arques Shipyard and Marina	5'7"	8'6"	21'9"
Sausalito	Marina Plaza Harbor	5'7"	8'6"	21'9"
San Rafael	Starkweather Shoreline Park	5'4"	6'	16'3"
Larkspur	Bay Trail	0-5'4"	0-6'	0-8'6"
Bel Marin Keys	Del Oro Park	5'2"	5'8"	8'9"
Sausalito	Dunphy Park	5'1"	5'8"	13'8"
Bel Marin Keys	Cavalia Cay Park	5'1"	5'8"	8'9"
Bel Marin Keys	Dolphin Isle Boat Launch	5'1"	5'8"	8'9"
San Rafael	Pickleweed Park	5'	5'8"	8'9"
Tiburon	Downtown shops & restaurants	0-5'	6"-3'11"	1'4"-12'9"
Larkspur	Cal Park Wetlands	4'10"	5'3"	8'2"
Bel Marin Keys	Bahama Reef Boat Launch	4'6"	5'2"	8'1"
Waldo Point	Richardson Bay Marina	4'5"	7'4"	18'7"
Larkspur	Bon Air Landing Park	4'4"	5'	8'6"
Pt. San Pedro	Mc Nears Beach Park	4'4"	5'9"	8'
Belvedere	Corinthian Yacht Club	4'	4'3"	11'
Sausalito	Shops & restaurants	3'6"	4'6"	11'6"
San Rafael	Open space off Bay Way	3'2"	3'11"	6'10"
Tiburon	Mc Kegney Green	3'1"	5'7"	15'3"
Tiburon	Richardson Bay Lineal Park	0-3'	1"-3'7"	1"-15'
Larkspur	Remillard Park	2'11"	3'6"	6'2"
Black Point	Black Point Boat Launch	2'8"	3'10"	7'
San Rafael	Bay Trail	0-2'3"	0-3'	0-10'3"
Belvedere	San Francisco Yacht Club	2'2"	3'6"	8'10"
San Rafael	San Rafael Yacht Harbor	1'2"	4'	10'4"
Almonte	Seaplane Adventures	9"	2'	5'
San Rafael	Lowrie Yacht Harbor	2"	9"	3'7""
Tiburon	The Cypress Garden Park	7"	1'4"	4'4"
San Rafael	Hi-Tide Boat Sales	6"	3'4"	8'5"

RECREATION

Location	Asset	Near-term	Medium-term	Long-term
		Scenario 1	Scenario 3	Scenario 5
Corte Madera	Corte Madera Creek Path	4”	1’11”	6’10”
Sausalito	Sausalito Yacht Harbor	4”	1’	3’
Paradise Cay	Paradise Cay Yacht Harbor	2”	1’6”	3’10”
San Rafael	Marin Yacht Club	1”	1’6”	3’9”
Tiburon	Blackie's Pasture	0-9”	5’4”	12’9”
Tamalpais Valley	Tam Junction shops & restaurants	0-8”	7”-2’	1’5”-5’3”
Corte Madera	San Clemente Park	No data		
San Rafael	Open Space 025		9’2”	12’2”
San Rafael	Beach Park		8’11”	11’10”
Mill Valley	Bayfront Park		8’3”	4’-11’6”
Mill Valley	Bay Trail		0-8’	3”-12’5”
Almonte	Charles F. McGlashan Path		7’6”	10’8”
Sausalito	Schoonmaker Beach		7’2”	10’1”
Strawberry	Brickyard Cove		6’11”	9’11”
Corte Madera	Hal Brown Park		6’3”	9’2”
San Rafael	Peacock Gap Neighborhood Park		6’3”	9’
Strawberry	Strawberry Recreation District Boat Launch		5’11”	8’11”
Strawberry	Greenwood Cove area community park		5’4”	10’
Corte Madera	Shorebird Marsh		5’3”	10’9”
Strawberry	Strawberry Point Tidal Area		5’1”	8’1”
Strawberry	Strawberry Point Park		4’10”	9’2”
Strawberry	Seminary Marsh area community park		4’4”	8’1”
San Rafael	Loch Lomond Marina		3’7”	9’7”
Corte Madera	Bay Trail		0-3’4”	0-8’6”
Sausalito	Schoonmaker Point Marina		3'3"	8'2"
Sausalito	Clipper Yacht Harbor		2’5”	6’3”
San Rafael	San Rafael Yacht Club		2’2”	5’7”
Bel Marin Keys	Montego Park		2’	5’4”
Sausalito	Cass Gidely Marina		2’	3’2”
San Rafael	Downtown shops & restaurants		1”-1’3”	3”-3’3”
San Rafael	Pickleweed Park facilities		1’2”	3’
Larkspur	Hamilton Park		10”	3’9”
Mill Valley	Shelter Bay		2”-9”	6”-1’10”
Novato	Bay Trail		0-8”	0-12’7”
Corte Madera	Bay Trail County Rte 17			13’4”
Corte Madera	Higgins Dock			11’10”
Novato	South Hamilton Park			11’6”
Novato	Deer Island			10’10”
Novato	Hamilton Amphitheater Park			10’6”
Corte Madera	Madera Gardens Lagoons			10’4”
San Rafael	Gallinas Creek			10’2”
Novato	Hamilton Airport Park			10’
Corte Madera	Town Park			9’10”

RECREATION

Location	Asset	Near-term	Medium-term	Long-term
		Scenario 1	Scenario 3	Scenario 5
San Rafael	Albert Park			9'3"
Novato	Rush Creek			8'10"
Sausalito	Turney Street Boat Ramp			8'8"
Mill Valley	Sycamore Park			8'6"
Larkspur	Heatherwood Park			8'2"
Novato	Slade Park			8'
Novato	Hamilton Community Center			8'
Novato	Future Hamilton Rec. Area			7'6"
Corte Madera	Susan Marker Trail			1'2"-7'6"
Bel Marin Keys	Caribe Isle Park			7'4"
Bel Marin Keys	Calypso Bay Public Dock			7'4"
Bel Marin Keys	Bel Marin Keys Dock			7'4"
Bel Marin Keys	Bel Marin Keys Yacht Club			7'4"
Santa Venetia	Castro Park			6'11"
Novato	Bahia Mini Parks			6'9"
Santa Venetia	Candy's Park			6'3"
Santa Venetia	Adrian Rosal Park			5'10"
Belvedere	Mini Park			5'3"
San Rafael	Canal/ Shoreline Park			5'1"
Santa Venetia	Pueblo Park			4'11"
Tiburon	Zelinsky Park			4'10"
Tiburon	Pt. Tiburon Marsh			4'4"
Belvedere	Community Center			4'4"
San Rafael	Schoen Park			4'2"
Mill Valley	Freeman Park			4'1"
Strawberry	Baseball diamonds			3'10"
Mill Valley	Mill Valley Rec Center			3'6"
Corte Madera	Ring Mountain			3'6"
Mill Valley	Hauke Park			3'4"
Tiburon	Bay Trail			6"-3'
Corte Madera	Skunk Hollow Park			3'
Sausalito	Yee Tock Chee Park			2'11"
Sausalito	Bay Trail			7"-2'3"
Tiburon	Bel Aire Park			2'4"
Larkspur	Bon Air Landing Park			2'4"
Fort Baker	Travis Marina			4'10
Black Point	Golf Course			No data
Santa Venetia	Buck's Landing	No data		
Sausalito	Pelican Yacht Harbor	No data		
Larkspur	Marin Country Mart	Access issues only		

Source: MarinMap, CoSMoS

RECREATION

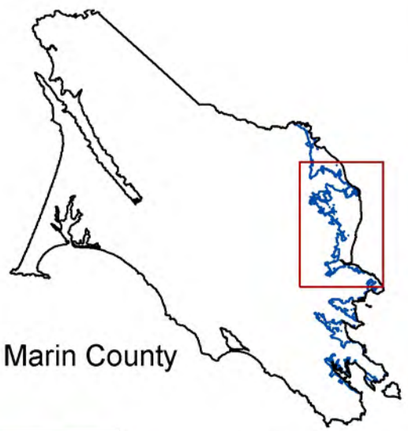
Map 39. Northern Study Area Vulnerable Recreation Assets

Vulnerable Assets

- Public Boat Launch
- Public Fishing Pier
- Bay Trail
- Trail
- Bikeway
- Park

Location Indicators

- Unincorporated
- Municipality
- Road
- Bay
- Inland Extent: Sea Level @ 60"+100-year Storm



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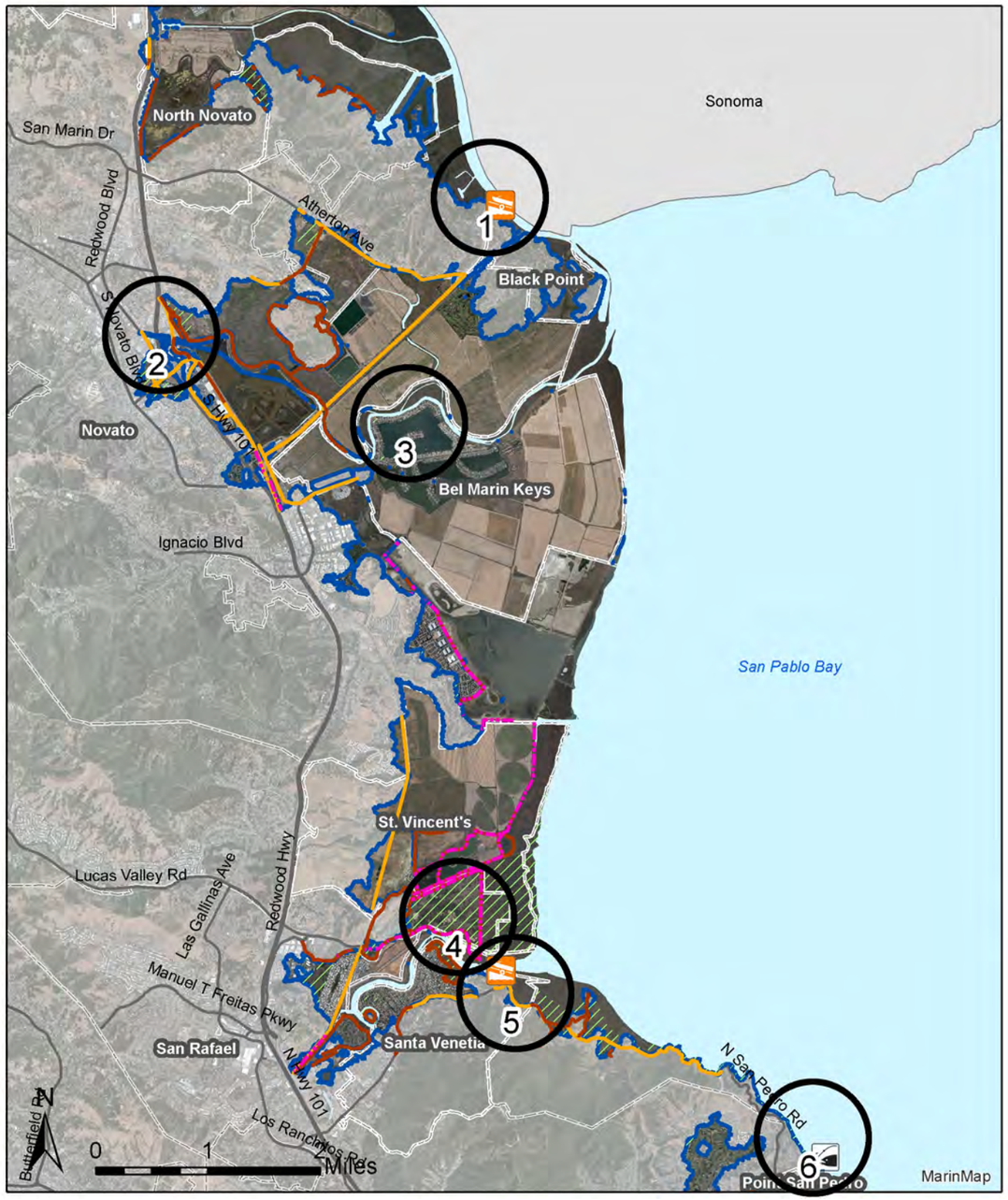


1: Black Point

2: Scottsdale Marsh

3: Bel Marin Keys

4: McInnis Park

5: Buck's Landing

6: McNears Beach Park

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.

RECREATION

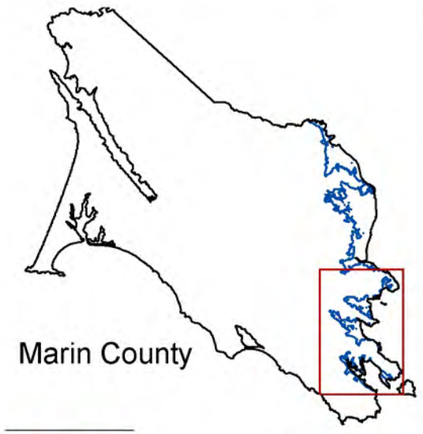
Map 40. Southern Study Area Vulnerable Recreation Assets

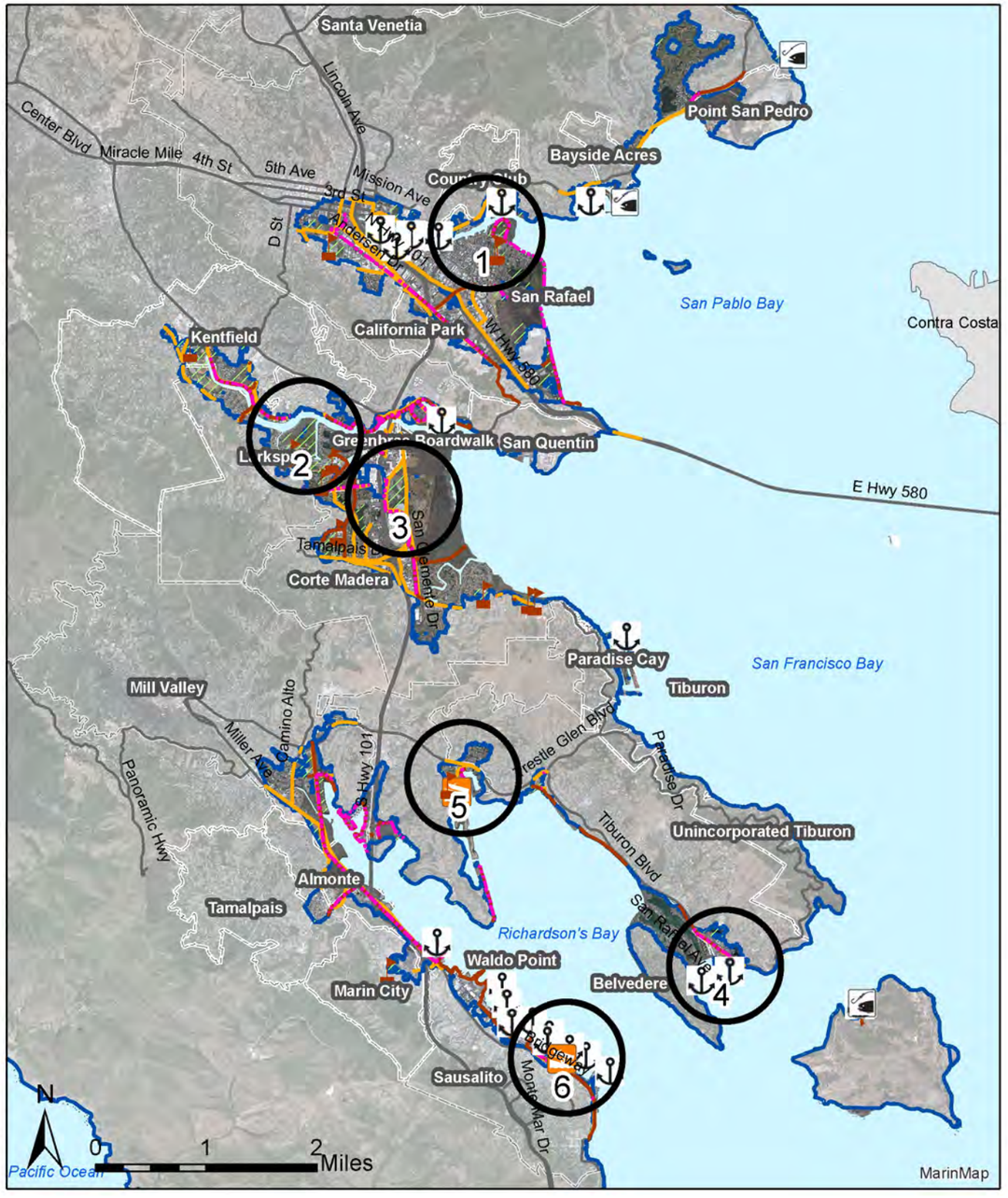
Vulnerable Assets

- School
- Public Boat Launch
- Public Fishing Pier
- Marina
- Bay Trail
- Trail
- Bikeway
- Park

Location Indicators

- Unincorporated
- Municipality
- Road
- Bay
- Inland Extent: Sea Level @ 60"+100-year Storm





1: San Rafael Canal

2: Corte Madera Creek

3: Corte Madera Marsh

4: Belveder/Tiburon

5: Strawberry

6: Sausalito Shoreline

Date: 4/1/2017

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RECREATION

Other Considerations

Economic
Active and passive recreation on and along Marin's shoreline are critical economic contributors to the regional economy that could be negatively impacted with rising seas. Several assets are national and regional draws. If roads, regional airports and transit service is disrupted these visitors may not be able to travel. This would greatly impact the tourist economy. Moreover, creating new spaces would incur significant additional costs to tax payers and users.

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

Social Equity
Beaches, estuaries, wetlands, and marshes provide unique low cost opportunities for wildlife viewing, shoreline access, and scenic enjoyment that could be lost to sea level rise.[79] The losses could be felt unequally across income levels because as free or low cost public access points are lost to the rising sea there could be less capacity to accommodate lower income households. This impact could also be experienced differently across geographies where reaching recreation opportunities is already hindered or could become hindered in the future. Those who fish for sustenance at bayside fishing piers, such as McNears Beach Park pubic fishing pier, could be disproportionately impacted and experience food insecurity.

Management
Protecting public access to natural resources and wildlife is a state and local priority. However, as Marin residents' daily lives become more and more vulnerable, preserving recreation opportunities could become a lower priority. National priorities could also affect Marin public lands and sanctuaries under federal jurisdiction.

[79] BCDC Vulnerability Assessment.

The Countywide Plan and local general plans seek to preserve recreational opportunities for residents and visitors, and to maintain and expand opportunities for public access. The County of Marin's Baylands district provides for open space, outdoor recreation, and other open lands, including areas suited for park and recreational purposes, access to beaches, and areas that link major recreation areas.

In addition, public trust lands include submerged land and tidelands below the mean high tide line in areas that do not contain tidal marsh and up to five feet above mean sea level in areas of tidal marsh. The Bay Conservation Development District (BCDC) retains development permit authority over:

- The Bay itself (all areas that are subject to tidal action, including sloughs, from the south end of the Bay to the Golden Gate to the Sacramento River,
- A shoreline band of land extending inland for 100 feet from the shoreline of the Bay,
- Select salt ponds,
- Select managed wetlands, and
- Certain waterways consisting of all areas that are subject to tidal action on named tributaries that flow into the Bay.

As sea level rise advances, the boundary of public trust lands will also move inland.

Paddle boarder on Miller Avenue in Bothin Marsh. Credit: Unknown

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EMERGENCY SERVICES

Asset Profile: Emergency Services

Marin's Bay communities are susceptible to earthquakes, tsunamis, fires, and more. Sea level rise could create additional hazardous conditions and impede emergency response. In fact, the primary vulnerability in the emergency services sector is continued safe and timely access to people in need. In addition to this, several service providers could face additional threats from sea level rise.

Sheriff

The primary issue with the Sherriff would likely be access to places in need of services during storms. In addition, the Marine Patrol keeps Rescue Boat 1 moored at Richardson Bay Marina, at 100 Gate 6 Road, Sausalito. Rescue Boat 2 on a trailer at Loch Lomond Marina in San Rafael. These facilities are on the water and are thus vulnerable to storm damage at any given time. Loch Lomond Marina main jetty wall could be overtopped by tidal flooding by near-term scenario 1. Interior portions of the marina may be less vulnerable than the model estimates due to recent construction elevating the site. Richardson Bay Marin is vulnerable to tidal flooding on the jetties, or pathways to the boat slips, by near-term scenario 1 and is nearly entire compromised by long-term scenario 5.

Fire Protection & Emergency Medical

Fire protection districts can provide a variety of services including ambulance, rescue and first aid, land clearing, fire prevention ordinances, and public education. Losing vehicular access is the main vulnerability for all of the fire districts in the area. Several fire stations could experience direct impacts: Station 54 in San Rafael, Tiburon, Station 13 in Corte Madera, and Station 2 in Novato could be vulnerable to sea level rise and storms. Fire Station 54 in San Rafael is on Castro Street in the Canal Neighborhood, the most diverse, disadvantaged, and severely impacted neighborhood in the study area. Southern Marin Fire Protection maintains a boat at the Pelican Yacht Harbor in Sausalito. This facility could expect tidal flooding reach the parking lot by long-term scenario 5.

IMPACTS AT-A-GLANCE: SCENARIO 6

Tens of thousands of residents, millions of visitors

Corte Madera Fire Station 13 San Rafael Fire Station 54 Novato Fire Station 2 Tiburon Fire Station CHP headquarters Two rescue boats Emergency Access Routes Hydrants Emergency water Supplies	Property Owners Office of Emergency Services Fire Departments County Sheriff CHP Municipal Police EMT providers

San Rafael Fire Station No. 54 is vulnerable. Credit: SRFD

Rescue Boat Liberty. Southern Marin Fire District. Credit: SMFD

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EMERGENCY SERVICES

Storm surges in scenario 6 almost reach Southern Marin Fire District Headquarters and station 14 in Corte Madera. Stations 52 and 55 in San Rafael could also face access issues. Finally, disruptions in water supply and corroding of reserve tanks could compromise fire service. This is primarily a concern in the northern half of the study area where NMWD has reserve emergency water tanks.

Local Police

Very few facilities are impacted directly. However, the Central Marin Police Authority building, serving San Anselmo, Corte Madera and Larkspur could become an island as the lands around it flood in the long-term. Flooding south of the station on Doherty Drive, in Larkspur, is already an issue during high tides and storms. The increased saltwater on roads around the station could lead to faster corrosion of the patrol SUVs. The Sausalito Police Department's two boats, Marine 1, berthed at Schoonmaker Marina, and Marine 2, berthed at the US Army Corps of Engineer's dock in Sausalito could also be vulnerable to storms damage and access to the boats could be difficult if tides are too high. If the marina facilities float systems are not adequately elevated to handle higher tides, the boats could be held under water.

California High Patrol (CHP)

Other than access issues, the Marin CHP Headquarters on San Clemente Drive in Corte Madera could face flooding impacts as early as scenario 3 in the medium-term. The building itself already experiences subsidence of the fill below. When the site starts to see regular flooding, patrol cars may see increased corrosion from exposure to saltwater. The property also has fuel tanks at-grade and two stormwater pumps that could become burdened. The auto shop with lift equipment, computer electronic systems, evidence room, and reports and sensitive paper data would be impacted if flood waters reach into the facility.

Emergency Shelters

Several schools and churches double as emergency shelters because they have capacity to house many people, offer refrigeration for medications, and have backup generators. The facilities that could be vulnerable under these scenarios include:

- Bahia Vista Elementary School, San Rafael,
- Army Corps of Engineers Bay Model Visitor's Center, Sausalito,
- Belvedere City Community Center,
- Corte Madera Community Center,
- Henry Hall Middle School, Larkspur,
- Kent Middle School, Kentfield (storm surge only),
- Mill Valley Middle School,
- MLK Gym Sausalito Parks and Recreation, Marin City (storm surge only),
- Neil Cummins Elementary School, Corte Madera,
- Pickleweed Park Facilities, San Rafael,
- St. Andrews Presbyterian Church, Marin City (storm surge only),
- Strawberry Point Elem School,
- Strawberry Recreation Center (storm surge only),
- Tamalpais High School, Mill Valley (access only),
- Westminster Presbyterian Church, Strawberry,
- Belvedere City Hall, and
- Tiburon Town Hall.

Other

Lastly, the emergency fuels reserves at Larkspur Landing are also vulnerable to sea level rise. Some of this fuel is used for day to day operations; however, the majority of the fuel is the North Bay emergency reserve. If high enough tides overtop the berm and get trapped in the fuel farm containment area, where two tanks store nearly 400,000 gallons of diesel fuel the saltwater could accelerate corrosion. Not only is this region wide resource threatened, the bay could be contaminated with fuel and other chemicals. Finally, for all of these services, if these public servants are unable to access their job sites, they would not be able to perform their duties in times of need and could leave communities at a loss.

Table 45 lists some of the potentially vulnerable emergency service assets related assets in the study area. This list measures onset and tidal MHHW. And the maps on the following pages highlight where vulnerable emergency facilities exist. The areas in the call out circles enable the reader the see areas that are difficult to see on the large scale map. The circles do not indicate that these areas are more vulnerable than others along the shoreline.

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EMERGENCY SERVICES

Several facilities may only be impacted during scenario 6, indicating that they could experience storm surge flooding. These assets include:

- Belvedere Community Center
- Southern Marin Fire Station, Sausalito
- St. Andrews Presbyterian Church, Marin City
- Strawberry Point Elementary School
- Strawberry Recreation Center
- Corte Madera Fire Station 13
- Novato Fire Protection Administrative Services, and
- Kent Middle School, Kentfield.

Table 45. Example Emergency Service Assets Ranked by Onset and Flooding at MHHW

Location	Asset	Near-term	Medium-term	Long-term
		Scenario 1	Scenario 3	Scenario 5
San Rafael	Fire Station No. 54	1'6"	2'7"	6'7"
San Rafael	Bahia Vista Elementary School	8"	2'3"	4'8"
Corte Madera	Neil Cummins Elementary School		2'5"	6'6"
San Rafael	Pickleweed Community Center		1'2"	3'
Tiburon	Fire Station		1'	2'6"
Larkspur	Henry Hall Middle School,		6"	1'2"
Novato	Fire Station 62		5"	1'
Mill Valley	Mill Valley Rec Center			3'10"
Waldo Point	Sheriff Water Rescue	Moored in Richardson Bay		
Sausalito	Rescue Boat	Moored in Richardson Bay		
Corte Madera	Recreation Center			Access Issues
San Rafael	Fire Station No. 52			Access Issue
San Rafael	Fire Station No. 55			Access Issue

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

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EMERGENCY SERVICES

Map 41: Northern Study Area Vulnerable Emergency Service Assets

Vulnerable Assets

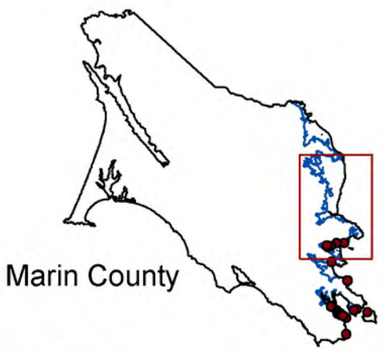
F Fire Station

Vulnerable Arterials & Highways

- @ Scen. 1: 10" Sea Level Rise (SLR)
- @ Scen. 2: 10"SLR+Storm Surge
- @ Scen. 3: 20"SLR
- @ Scen. 4: 20"SLR+Storm Surge
- @ Scen. 5: 60"SLR
- @ Scen. 6: 60"SLR+Storm Surge

Location Indicators

- Unincorporated
- Municipality
- Road
- Bay
- Inland Extent: Sea Level @ 60"+100-year Storm



EVB CONSULTING

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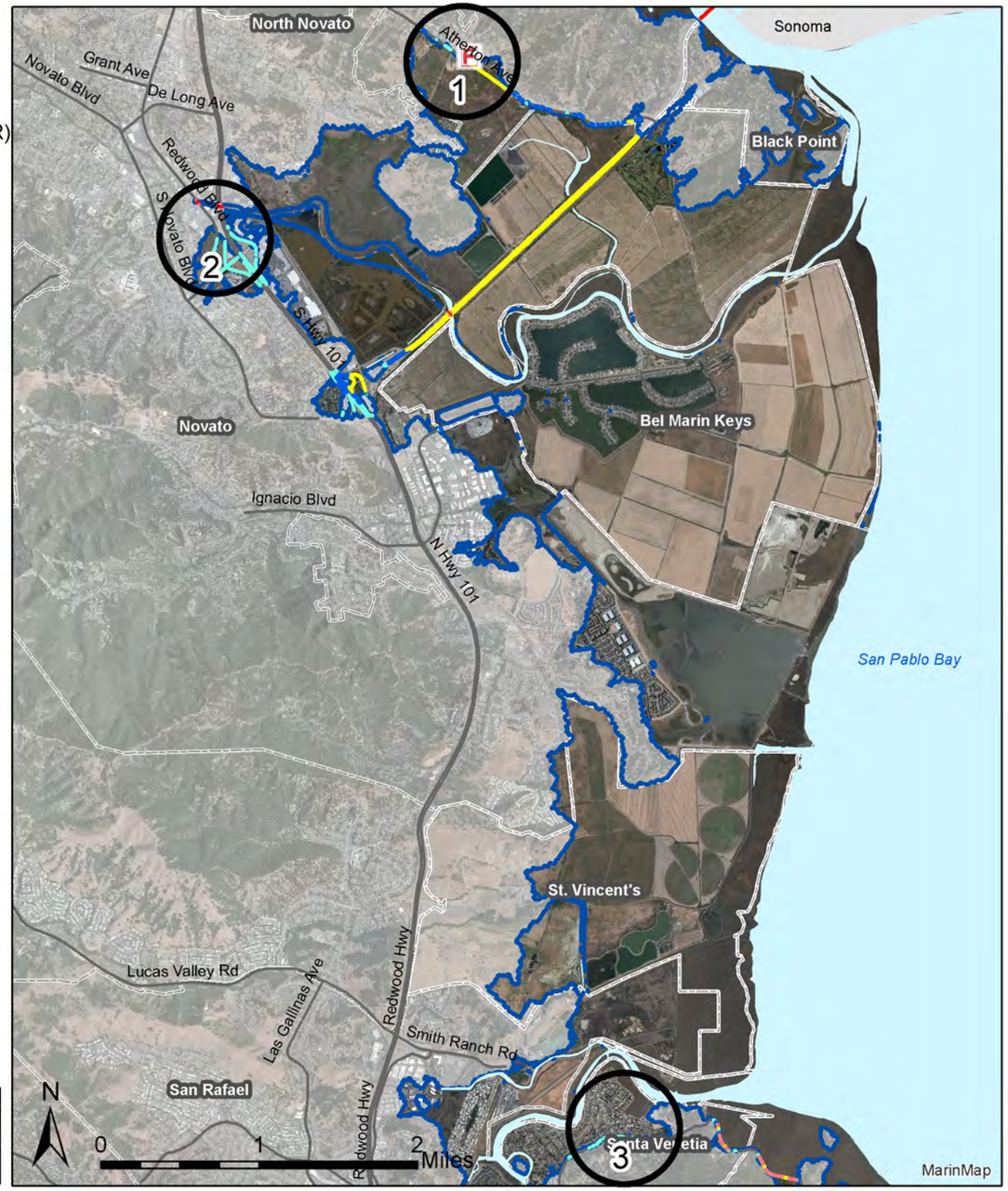


1: Atherton Avenue @ Olive St.

2: U.S. Hwy. 101 @ Rowland Blvd.

3: N. San Pedro Rd.

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.

EMERGENCY SERVICES

Map 42: Southern Study Area Vulnerable Emergency Service Assets

Vulnerable Assets

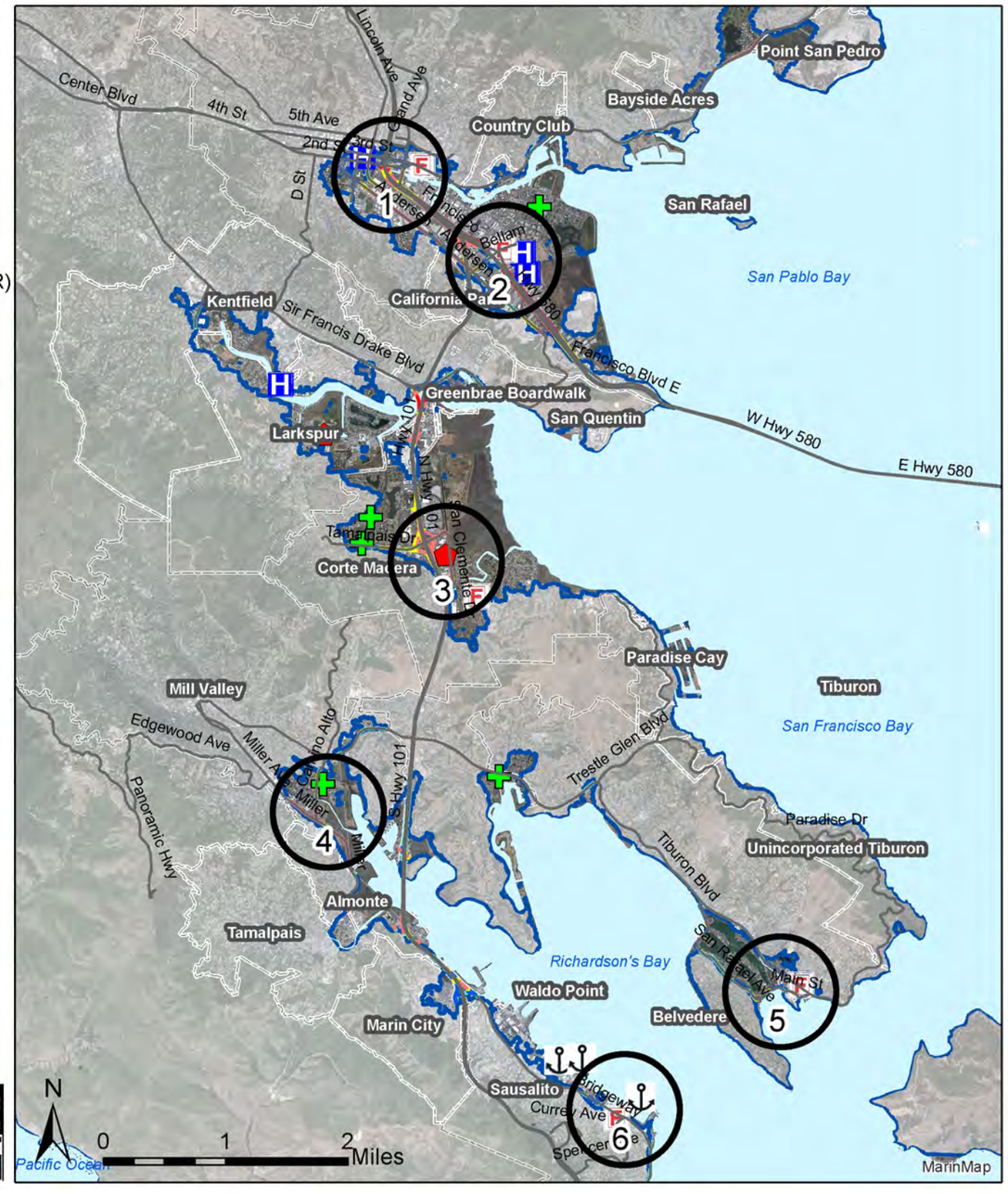
- Fire Station
- Emergency Shelter
- Law Enforcement
- Medical Facility
- Marina

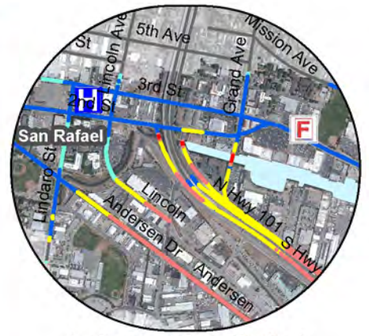
Vulnerable Arterials & Highways

- @ Scen. 1: 10" Sea Level Rise (SLR)
- @ Scen. 2: 10"SLR+Storm Surge
- @ Scen. 3: 20"SLR
- @ Scen. 4: 20"SLR+Storm Surge
- @ Scen. 5: 60"SLR
- @ Scen. 6: 60"SLR+Storm Surge

Location Indicators

- Unincorporated
- Municipality
- Road
- Bay
- Inland Extent: Sea Level @ 60"+100-year Storm





1: Central San Rafael

2: Canal Area

3: San Clemente Dr.

4: Miller Ave. @ Camino Alto

5: Belvedere/ Downtown Tiburon

6: Pelican Yacht Harbor

Date: 2/15/2017

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EMERGENCY SERVICES

Other Considerations

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

Environmental
Lack of fire services or access could prevent adequate protection of homes or entire communities. Wildfire may be able to consume greater acreages if local and fire roads are compromised. If the emergency fuel tanks are compromised due to sea level rise or storms, the bay could become contaminated as well.

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

- Low educational attainment
- Transit dependence (persons without vehicles)
- Non-English speakers
- Young children and aging adults
- Significant housing cost burden
- Household income
- Home ownership.[80]

Loss or compromised emergency services could be more devastating to communities with higher populations that fall into these demographic categories, such as Marin City or the Canal neighborhoods in San Rafael. In fact, the Castro Street Fire Station that serves the neighborhood could flood tidally itself in the near-term, and access from the next closest fire stations could be blocked entirely at high tide in the medium-term, compounding this area vulnerability.

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

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

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

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

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

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CULTURAL RESOURCES

Asset Profile: Cultural Resources

Marin County is rich with history. Miwok Native Americans inhabited the area for thousands of years and around 600 identified village sites remain throughout the county.[81] In the early 1800's, Mexican governors of Alta California issued 21 land grants and founded the Mission San Rafael Arcángel as a hospital to treat Native Americans dying of introduced diseases.[82] The Gold Rush increased demand for beef and dairy, leading migrants to settle in Marin, establishing ranches and businesses.[83] New ferries, trains, and bridges enabled more access allowing bayside communities to become commercial fishing, water based recreation and vacation hubs, as well as homes for commuters working in San Francisco[84].

Many of Marin's Bayside towns have maintained their historic characters and downtowns with architectural styles including Shingle Style, Arts and Crafts, Mission Revival, Italianate, and Modern. Julia Morgan, Bernard Maybeck, Willis Polk, Frank Lloyd Wright and Joseph Eichler are amongst the renowned architects who built in Marin County.[85] Sea level rise could impact valued cultural sites in the study area. The following are key vulnerabilities related to cultural resources:

- Tidal and storm surge flooding can destroy bayside archaeological sites and/or compromise data acquisition.
- Historic buildings along Marin's shoreline could be vulnerable to tidal and storm surge flooding, including homes and businesses in Larkspur, Sausalito, Belvedere, Tiburon, San Rafael, and Novato.
- Several publicly accessible sites within state or federal parkland could be vulnerable. Failure to protect these sites could lead to economic and intrinsic losses.
- Additional vulnerabilities lie in lack of comprehensive data on Marin's archaeological resources. Because the shoreline is only partially surveyed, potential losses in unmapped areas cannot be fully assessed.

IMPACTS AT-A-GLANCE: SCENARIO 6

More than 90 historic buildings in private ownership	**Archaeological Resources**
6 National Register of Historic Places Sites	**Public Sites in State and Federal Parkland**
Lack of comprehensive surveys	**State Parks National Park Service Local jurisdictions Marin County Property Owners Graton Rancheria Federated Indians**

Downtown Sausalito's Historic District is a social and economic hub. Credit: Marin CDA

[81] Wikipedia, Marin County California. Last updated July 3, 2016. en.wikipedia.org/wiki/Marin_County,_California#History
[82] Futcher, Jane. 1981. Marin, The Place, The People.
[83] Futcher, Jane. 1981. Marin, The Place, The People.
[84] Marin County Community Development Agency. 2007. Marin Countywide Plan.
[85] Ibid.

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CULTURAL RESOURCES

Vulnerable Assets

Cultural resources can be defined as "physical evidence or place of past human activity: site, object, landscape, structure; or a site, structure, landscape, object or natural feature of significance to a group of people traditionally associated with it."[86] Cultural resources analyzed in this assessment are archaeological sites and locally, state, and federally recognized historical structures.

Key resources include historic districts in Sausalito, Belvedere, Tiburon, San Rafael, Hamilton in Novato, and China Camp State Park. Often hubs for local businesses and heritage tourism, historic districts can play an important role in community economic development and sustainability. Historic sites may contribute to local sense of place, community character, and cultural identity. Historical sites can serve as museums or interpretive centers for educational purposes. Environmentally, the continued use of older buildings is generally much more energy efficient than new construction, thus helping to reduce greenhouse gas emissions.[87] Archaeological sites can provide scientific data such as plant and animal species that thrived under past climactic conditions which could useful in informing future natural resource management plans.

When assessing historical building vulnerabilities, many of the same physical factors can be considered which apply to all buildings, historic or none (see Table 23, physical vulnerabilities of buildings). However, unique considerations for historic buildings include:

- Direct/Tangible:
  - o Increased sensitivity due to age/condition leading to more severe physical damage to building fabric.[88]
  - o Damage or destruction to character defining features
  - o Damage or destruction of historic artifacts within the building
- Direct/Intangible: Irreplaceable loss of cultural heritage from deterioration/destruction of building or artifacts contained within building [89]
- Indirect/Tangible: Loss of tourism revenue[90]
- Indirect/Intangible: Loss of sense of place. [91]

Due to available information, this Profile focuses on direct/tangible losses, primarily structural damage to historic buildings. Tourism revenue is not available for all of the sites therefore; indirect/tangible losses cannot be fully assessed. Additionally, while loss of any of the sites will likely have negative cultural identity and sense of place impacts, quantifying these intangible losses is a challenge with no known U.S. precedents, and is beyond the scope of this report.

A handful of the vulnerable historic sites including China Camp State Park's Shrimp Shed, Marinship's Bay Model Visitor Center and Hamilton Army Air Field Fire House house museum collections open to the public with artifacts of historical interest. National Park Service's 2016 *Cultural Resources Climate Change Strategy* compiles possible types of impacts to museum collections from increased flooding, inundation, increased storm surge, shoreline erosion and more.[92] Amongst these impacts collections could face increased rusting, corrosion, rot, mold, mildew, insect attacks, swelling, direct damage/destruction, and damage/destruction from humidity and moisture. [93]

A historic resource inventory for unincorporated Marin does not exist. To date, Marin County's Architectural Commission has identified only one historic structure,[94] though it is outside the study area for this assessment.

Archaeological Sites

The State of California recognizes 630 archaeological sites in Marin County including permanent settlements, seasonal camps, hunting camps/special use sites, and petroglyphs covering thousands of years of Miwok Indian history. The

[86] National Park Service website. Last updated July 22, 2016. www.nps.gov/acad/learn/management/rm_culturalresources.htm

[87] National Trust for Historic Preservation. 2011. The Greenest Building: Quantifying the Environmental Value of Building Reuse.

[88] Stephenson, V. and D'Ayala, D. A New Approach to Flood Vulnerability Assessment for Historic Buildings in England (2014), 1036.

[89] ibid

[90] ibid

[91] ibid

[92] Rockman, Marcy, Marissa Morgan, Sonya Ziaja, George Hambrecht, Alison Meadow. 2016. Cultural Resources Climate Change Strategy. Cultural Resources, Partnerships, and Science and Climate Change Response Program, National Park Service.

[93] ibid, 22-23

[94] Bill Kelley and Marty Zwick (Marin County Architectural Commission), personal communications July 2016.

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Anthropological Studies Center at Sonoma State University is currently inventorying additional sites in anticipation of sea level rise and erosion. The blue lines depicted in Map 43 represent sixty-nine miles of surveyed public lands, and eight miles are partially surveyed. The complete surveys are limited to the public lands generally in West Marin. Much of the southern Marin shoreline is not applicable for the survey, as depicted in red. The marshlands in Corte Madera and Larkspur, China Camp State Parks, and St. Vincent's to Bel Marin Keys could feature archeological sites.

Specific locations of archaeological sites must remain confidential and Marin County CDA does not have a staff archaeologist to maintain and protect this sensitive information. Furthermore without allocated staff or financial resources, CDA's capability to conduct a comprehensive vulnerability assessment of archaeological sites is limited. However, Marin County has limited geographic and descriptive data that can be used to develop generalities on potential impacts. Based on the County's limited available spatial data, 19 sites could be vulnerable spanning all of the scenarios. Most of the sites are at or near the edge of the Bay.

Sites are considered vulnerable if they lie within the exposure zone, as tidal and storm surge flooding could impact the resources. Sites include permanent settlements represented by shell mounds or middens associated with marshes and other locations at or near the edge of the bay where shellfish/marine resources were available. Most of the sites are subject to tidal flooding at MHHW, with an additional handful subject to temporary flooding from seasonal storm surges.

Research on inundated archaeological sites, referred to as "wet site archaeology," can be used for clues on impacts from permanent sea level rise. [95] Sites located along sheltered bays where sea level rise is gradual may be less subject to destructive high-energy wave action during storms and therefore may fare better. [96] However, once sites are submerged data recovery becomes quite difficult and dangerous. [97] Underwater archaeology can be quite costly with numerous physical and safety challenges, and few organizations have sufficiently trained staff. [98]. Therefore, it is important to conduct cultural resource surveys prior to inundation to document what will be lost. [99]

National Park Service's 2016 *Cultural Resources Climate Change Strategy* also compiles possible types of impacts to archaeological sites from increased flooding, inundation, increased storm surge, shoreline erosion and more. In addition to total submersion, sites could be vulnerable from direct physical flood damage, destruction/loss of artifacts, post-flood subsidence, changes in pH, disturbance during flood clean-up, and more. [100]

A full assessment was conducted for Point Reyes National Seashore in 2013, factoring in topography and elevation, proximity to the ocean, underlying substrate, potential climate change impacts (e.g. inundation, wave erosion, sedimentation, etc.) and other factors. This assessment gave every site a rating of either high (should be mitigated within next 10 years) or low (should be mitigated within next 50 years). A more comprehensive survey such as this would need to be conducted for East Marin to fully assess the vulnerability of archaeological resources.

Table 46. Number of Known Vulnerable Archeological Sites

Near-term	3
Medium-term	5
Long-term	19

Source: Marin County CDA (confidential dataset)

[95] Newland, M. 2015. The Potential Effects of Climate Change on Cultural Resources Within Point Reyes National Seashore (Public Final Release, 2015). Prepared for the National Park Service. p. 30.
[96] ibid, 68.
[97] ibid, p. 69.
[98] ibid, 69-70
[99] ibid, 70
[100] Rockman, Marcy, Marissa Morgan, Sonya Ziaja, George Hambrecht, Alison Meadow. 2016. *Cultural Resources Climate Change Strategy.* Cultural Resources, Partnerships, and Science and Climate Change Response Program, National Park Service, 22-23

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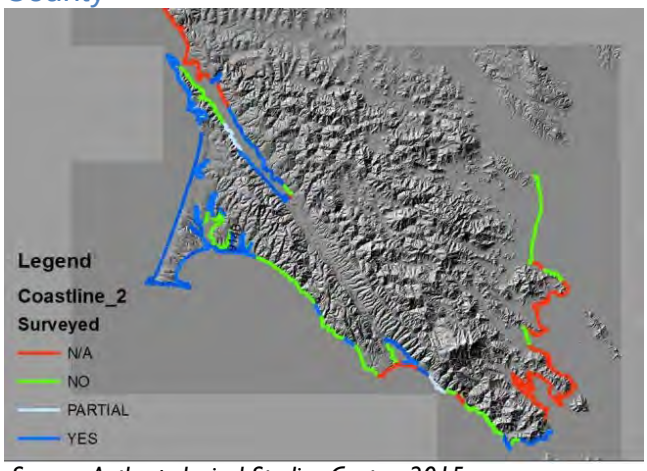
Map 43. Archaeological surveying in Marin County



Source: Anthropological Studies Center, 2015

Horseshoe Cove and Fort Baker (circa 1950s) Credit: Golden Gate National Recreation Area Park and Archives Record Center

Fort Baker

National Register of Historic Places
Vulnerable Resources: Seawall, Marine Hoist and Dock, Refueling Dock and Marine Railway
Scenarios: All
Flood Depths: 0-7'10''+100-year storm surge
Primary Building Materials: Concrete, Wood, Steel

At the southeastern foot of Marin County, Fort Baker was acquired by the Federal Government in 1866 and served as an Army Post until the mid-1990s. Now part of the Golden Gate National Recreation Area; its historic structures have remained intact including the numerous military buildings.

Three structures in the low lying area looking out to Horseshoe Bay could be vulnerable to flood depths of more than 4 feet in the near-term and nearly 8 feet plus storm surges in the long-term:

1. Seawall
2. Marine Hoist
3. Refueling Dock and Marine Railway (Replacement Value= $2,142,003 Asset Priority Index= 69, Facilities Condition Index= 0)

In the long-term flooding could impact Bridgeway and Downtown Historic District buildings lining its west side. Credit: Marin CDA

Sausalito

National Register of Historic Places (Downtown Historic District)
National Park Service Certified Historic District
City of Sausalito Historic Resources Inventory Listing
Vulnerable Resources: 26 National register district contributing sites, 17 noteworthy structures, 2 landmark buildings
Scenarios: All
Flood Depths: 09'04''+100-year storm surge
Primary Building Materials: Wood, concrete, brick, stucco, concrete

Prior to development of the Golden Gate Bridge, Sausalito was an important hub for rail, car and ferry traffic. During World War II, the city developed

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rapidly as a shipbuilding center. The Downtown Historic District centers on a ferry terminal with service to/from San Francisco, and remains an important area for commerce, and as a popular visitor destination. The district is a National Park Service Certified Historic District.[101]

Sea level rise is projected to inundate parts of Sausalito's Downtown Historic District in the near-term, with storms expanding the vulnerable area and exacerbating impacts. At the long-term scenario with a 100-year storm surge, 26 contributing sites could be vulnerable. Further analysis could determine specific vulnerability of each building based on location, flood depth, height above grade, materials, etc.

Sausalito's Historic Preservation Regulations include preservation and treatment guidelines and standards for historic buildings and properties. Current regulations do not address flooding, through future updates could consider the need for adaptation strategies necessary for flood protection and identify design approaches to minimize integrity impacts.

Both water and land access routes to Sausalito's Downtown Historic District could be vulnerable in the near term. GGF's Sausalito Ferry could face inundation in the near-term; however, because the facility is bayside of mean sea level delineation, flood depth values are not provided. In the long-term, parts of Bridgeway could be tidally flooded, and impacts will worsen with storms.

In other parts of Sausalito, a handful of private properties on the city's Historic Resources Inventory could also be vulnerable at varying scenarios. Sausalito's Ark Row District includes seven noteworthy properties, vulnerable to more than 6 feet MHHW in the near-term and more than 9 feet in the long-term. An additional ten other properties could be vulnerable in the long-term, including the original firehouse (8 of the 10 only subject to storms). Lastly, two of Sausalito's landmark buildings, Castle by the Sea and Ice House, could be vulnerable to storms by the long-term scenarios.

Marinship, Sausalito
Potential National/State Register Sites
Vulnerable Resources: 10 potential historic resources
Scenarios: All
Flood Depths: 2'1'' - 2'8''+100-year storm surge; flood depth data limited
Primary Building Materials: Concrete, wood, stucco, steel

The former Marinship yard, an approximately 210-acre site, was one of six Emergency Shipyards in the San Francisco Bay Area established during World War II. Marinship was built on bay fill, and some areas, such as Heath Way, have experienced approximately five feet of subsidence since 1943 based on photographic records.[102] In 2010, the Marinship Historic Context Statement inventoried and recorded every major World War II era building and structure. The effort concluded:

- Marinship retains a higher degree of architectural integrity then any of the other Bay Area World War II emergency shipyards,
- Eight surviving buildings could form a California Register eligible district in the southernmost portion of the district,
- Two sites are individually eligible for the National Register of Historic Place, and
- Four sites are individually eligible for the California Register of Historic Places.

These sites were never nominated for national or state historic registers, and therefore have no formal historic status. However, these resources can be considered potential historic resources.

In the near term, shipways that are part of Building 23, the Marinship Shipways and Offices, could be vulnerable to the increased 10 inches of sea level rise. More detailed analysis would be necessary to fully evaluate integrity impacts that may occur.

In the long-term, two buildings, the Marinship Maintenance Garage and the Marinship Mold Loft and Yard Office, could be vulnerable to tidal flooding at depths deeper than two feet. Both buildings were erected in 1942 with cinderblock construction and could be vulnerable to standing water. The Mold Loft could be eligible for the California Register, and the Maintenance garage could support a California register-eligible district.

[101] Office of Historic Places, accessed July 14, 2016. http://ohp.parks.ca.gov/?page_id=27283

[102] Robin Petravic (Heath Ceramics), personal communications. July 2016.

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Seven other properties could be vulnerable to the 100-year storm surge by the long-term scenario including Building 29, the Marinship Warehouse. This building now serves as the Bay Model Visitors Center which houses the U.S. Army Corps of Engineers Bay Model, a working hydraulic scale model of the SF Bay-Delta, completed in 1957.[103] The model is no longer used for research, but open to the public for educational purposes.

Gate 5 Road in Marinship. Jan. 2004. Credit: R. Petrav

Belvedere

Historic Resource Inventory database and local register
Vulnerable resources: *1 California Register of Historic Places site, 4 additional locally registered historic sites*
Scenarios: All
Flood Depths: 6''- 3'2'' + 100-year storm surge
Primary Building Materials: Wood

Originally a fishing community adjacent to the Tiburon railroad, Belvedere was settled in the late 19th century and incorporated in 1896.[104] Vulnerable historic resources in Belvedere include:

- Properties on Beach Road, along the northwest edge of Belvedere Cove are exposed, including several in the near term. A handful of these properties were designed by well-known architect Albert Farr including the Farr cottages/Farr apartments and the Belvedere Land Company. Additionally, the China Cabin is along this vulnerable waterfront. This saloon was once housed by the S.S. China, built in 1866 to carry passengers from San Francisco to Asia.[105]
- The Belvedere Presbyterian Church/City Hall/Community Center.

The 1905 Belvedere Land Company building, designed by Albert Far.[106]

Tiburon

Local Historic Inventory for Downtown Tiburon/List of Buildings Included and Eligible for California State Historic Building Code
National Register of Historic Places (Peter Donahue Building)
Vulnerable Resources: 21 buildings
Scenarios: All
Flood Depths: 1'4'' - 8'6''+100-year storm surge
Primary Building Materials: Wood

[103] U.S. Army Corps of Engineers Bay Model. Last updated August 18, 2016. en.wikipedia.org/wiki/U.S._Army_Corps_of_Engineers_Bay_Model
[104] Belvedere, CA. Last updated January 9, 2017. en.wikipedia.org/wiki/Belvedere,_California
[105] Belvedere-Tiburon Landmarks Society, China Cabin. Accessed January 18, 2017. landmarkssociety.com/landmarks/china-cabin/
[106] Albert L. Farr. Last updated October 10, 2016. en.wikipedia.org/wiki/Albert_L._Farr

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Vulnerable historic sites include more than 20 buildings along upper and lower Main Street. Built in the 1920s, original uses included saloons, apartments, a bank, hotel, grocery store, and butcher. Then and now, commercial uses provide commuters and visitors using the Tiburon Ferry Terminal with shops and restaurants. Several lower Main Street sites could be subject to tidal inundation in the near-term. Upper Main Street sites are subject to storm surge flooding in the long-term. Existing flood proofing and site improvements may help reduce building sensitivities and increase flood resiliency.

Just beyond the downtown area, the wood framed San Francisco and North Pacific Railroad Station House-Depot, or the Peter Donahue Building could be vulnerable to the 100-year storm surge. The building is listed on the National Register of Historic Places as the old station house at the ferry railroad terminus of the railroad[107] and is the only surviving dual use terminal west of the Hudson River. The building now houses the Tiburon Railroad and Ferry Depot Museums. On the bottom floor is scale model of Tiburon circa 1900-1910.

Road access would be drastically compromised including permanent flooding of Main Street and Tiburon Blvd., the main thoroughfare connecting Tiburon with Highway 101. Water access would also be compromised, as the Tiburon Ferry buildings, land, and docks could be flooded in the near-term.

Tiburon once served as the southern terminus of the Northwestern Pacific Railroad. Credit: Photographer on San Francisco and North Pacific Railroad Station House-Depot National Register of Historic Places Nomination Form

Tiburon's Main Street commercial buildings date back to the early 1900s, and are adjacent to the ferry terminal. Credit: Marin CDA

Angel Island
California State Landmark
National Register of Historic Places (Immigration Station)
Vulnerable Resources: Ferry terminal (access, non-historic)
Scenarios: All
Flood Depths: 0- 6'9''+100-year storm surge

Historically, Angel Island is best known for its immigration station, sometimes referred to as the "Ellis Island of the West." From 1910-1940, hundreds of thousands of immigrants often from China and Japan were detained on the island, sometimes for months as part of immigration control. The island is a popular destination for visitors with a variety of outdoor recreational activities and interpretation throughout its historical buildings.

Angel Island's historic structures are generally at higher elevations and not adjacent to water and therefore not vulnerable to sea level rise and increased storms. However, the Angel Island ferry is vulnerable in the near-term with flood depths increasing in the medium- and long-term scenarios. If the ferry terminal floods it could cause a reduction or loss in important tourism revenue needed to sustain the historic buildings.

[107] Arnett, Victoria Mason. 1994. National Register of Historic Places Form - San Francisco and North Pacific Railroad Station House/Depot.

Larkspur
Larkspur Historic Resources Inventory
Vulnerable Resources: 6 homes
Scenarios: All
Flood Depths: 1'1'' - 6'8''+100-year storm surge
Primary Building Materials: Wood

Six vulnerable historic homes lie along Boardwalk one, the only remaining of the four original communities of arks, or small canal homes accessed with boardwalks above the marshland. Many of the homes have had alterations and additions compromising the original defining features, though still retain historical character through features including size, materials, scale, color, etc.[108]

Larkspur's Boardwalk #1 has generally retained its cultural style of canal homes accessed via boardwalks. Credit: Marin CDA

San Rafael
San Rafael Historical/Architectural Survey & Historic Properties List
Vulnerable Resources: 1 Landmark, 1 District, at minimum 2 additional potentially historic areas, at minimum 4 additional potentially historic buildings
Scenarios: 2, 3, 4, 5, 6
Flood Depths: *0 to 6'+100-year storm surge*
Primary Building Materials: Wood, Brick

Much like other communities in Marin, San Rafael was once home to Miwok Indians prior to European settlement. The Mission San Rafael Arcángel, the last Spanish mission Spanish established in California was erected in 1817. In 1879, the San Francisco and North Pacific Railroad reached San Rafael. The national rail network linked with San Rafael in 1888 leading to increased settlement and economic growth.[109]

San Rafael's exposed historic resources could be vulnerable to both tidal flooding and 100 year storm flooding from San Rafael Creek, generally in close proximity to US Highway 101. Resources include the Litchfield Sign (local landmark), the French Quarter, two potentially historic areas (Ritter Street and Gerstle Park (partial), and four potentially historic structures.

San Rafael's French Quarter Historic District includes Victorian Homes now used for local businesses. Credit: Marin CDA

China Camp State Park
National Register of Historic Places
Vulnerable Resources: Shrimp Shed and 305' Pier
Scenarios: All
Flood Depths: 0-10'0''+100-year storm surge
Primary Building Materials: Wood
Historic American Landscape Survey: *Underway*

China Camp was once home to Miwok Indians who settled there due to its pristine salt marshes and Point San Pedro's ideally positioned vantage point. This site is also the only remaining historic

[108] City of Larkspur. 2005. Historic Resources Survey Re-evaluation

[109] Wikipedia, San Rafael, California. Last updated December 15, 2016. en.wikipedia.org/wiki/San_Rafael,_California

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Chinese-American shrimp village in the Bay Area. In the late 1800's China Camp housed around 500 residents, many from Canton, who made a living in shrimp harvesting. The shrimp were typically dried on the banks and shipped back to China for medicinal purposes. Both racially motivated legislation and environmental changes led to the decline of shrimping practices. However, several of the historic structures have remained structurally intact and a seventy-five acre district encompassing them was added to the National Register of Historic Places in 1979. Also included in the district is a Native American shellmound. Finally, a Historic American Landscape Survey (HALS) is currently underway to document the site's historic resources.[110]

Vulnerable structures at China Camp include the wood-framed shrimp shed and 305 foot pier along its waterfront. Flood depths could reach up to 10 feet of tidal water potentially drowning the pier and damaging both resources. The Shrimp Shed currently serves a visitor center with interpretive panels and artifacts educating the public on the early immigrant history, traditional fishing practices and more. These historic artifacts could also be damaged as the building is flooded. Erosion could further exacerbate impacts to the site, damaging cultural landscape features such as the beach itself. Furthermore, North San Pedro Road through China Camp currently gets flooded at king tides, compromising public and maintenance access. This may worsen with higher sea levels.

China Camp drying grounds. 1889. Credit: Wikipedia.

King Tide floods N. San Pedro Road in China Camp. Nov. 2015. Credit: Marin CDA

Hamilton Army Air Field
National Register of Historic Places
Vulnerable Resources: 8 buildings, 1 structure, 1 object
Scenarios: 5, 6
Flood Depths: 2'5''-10'4''+100-year storm surge
Primary Building Materials: *Concrete, Stucco*
Historic American Building Survey: *CA-2398*

In the 1930's, the 1,779 acre Hamilton Army Air Field was constructed as headquarters for the 1st Wing of the Air Force, one of only three such bases

[110] Patillo, C. *China Camp HALS*. Last updated July 1, 2012. http://halsca.blogspot.com/2012/07/china-camp-hals.html

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in the nation.[111] The site was transferred to the US Navy, Army and Coast Guard in 1974, and is now part of Novato. Currently buildings house a variety of residential and commercial uses.

The National Register of Historic Places Registration Form identifies 3 discontinuous areas of the historic district. [112] Of the three areas, Area C could be subject to average high tide flood depths of 2'5'' to 10'4'' by the long term scenario. All ten of its contributing resources could flood, including:

- Double hangars- 3 identical H-shaped buildings with a central shop and hangars on either end,
- Air Corps shops and hangar #9: Identical exterior to other hangar buildings, with half of its interior designed as a shop,
- Flagpole- 75 foot metal flagpole with historic plaque,
- Headquarters building- T-shaped with central two-story section and one-story wings,
- Non-Commissioned Officers' Barracks- 3 H-shaped 3-story buildings, and
- Electrical transformer vault.

Additionally, the Hamilton Field History Museum is housed in the historic 1934 firehouse directly adjacent to Area C and also exposed in the long term scenario. The museum opened in 2010 to collect, preserve, exhibit, and interpret Hamilton field and Hamilton air force base history.

Table 47 highlights the vulnerable cultural resource assets and ranks them by onset and flooding at MHHW. In addition to these sites, a few others could be vulnerable under long-term scenario 6 sea level rise conditions with a 100-year storm surge. These are:

- Sausalito, two landmark buildings,
- Belvedere Presbyterian Church/Belvedere City Hall/Community Center, and
- Tiburon Railroad Station House-Depot.

Hamilton Field's Headquarters now serves as the Novato Arts Center. Credit: Marin CDA

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[111] Maniery, M.L., and C.L. Baker. 1998. National Register of Historic Places Registration Form – Hamilton army Air Field Discontiguous Historic District.
[112] Ibid.

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Table 47. Vulnerable Cultural Resource Assets Ranked by Onset and Flooding at MHHW

Location	Asset	Near-term	Medium-term	Long-term
		Scenario 1	Scenario 3	Scenario 5
Confidential locations	Archaeological sites	3 sites	5 sites	14 sites @ 1'11''-10'8''
Belvedere	Four Waterfront Properties along Beach Road	6''	1'3''	3'0''–3'2''
Sausalito	Ark Row District	3'6''-6'2''	3'1''-6'10''	6'1''-9'5''
Tiburon	Main Street	2 buildings @ 7'3''-7'4'	6 buildings @ 6'8''-7'11''	11 buildings @ 1'4''-8'6''
Pt. San Pedro	China Camp Historic District*	0-7'3''	0-7'8''	0-10'0''
Larkspur	Boardwalk # 1	1'1''-3'1''	1'10''-3'10''	4'7''-6'8''
Fort Baker*	National Recreation Area	0-4'5''	0'-5'2''	0-7'10''
Angel Island	Angel Island* Ferry Terminal	0-'3''	0-11''	0-6'9''
Sausalito	Downtown Historic District*	4 sites	4 sites	4 sites @ 0-9'4'' (22 sites w/ storm surge)
San Rafael	The Litchfield Sign	w/ storm surge	3'3''	6'0''
San Rafael	The French Quarter District			2'2''-2'4''
San Rafael	2 potentially historic areas and at minimum 4 additional potentially historic structures			0-2'11''
Sausalito	Noteworthy structures outside the Downtown Historic District			2 sites @ 1'4''-6'1'' (8 sites w/ storm surge)
Sausalito	Marinship potential resources	1 resource		2 resources @ 2'1''-2'8'' (7 resources w/ storm surge)
Novato	Hamilton Army Air Field* Area C			2'5''-0'4''

**indicates listing on National Register of Historic Places*

Source: MarinMap; CoSMoS, Marin CDA; City of Sausalito, Historic Resource Inventory Listing, Marinship Historic Context Statement; Local Historic Inventory for Downtown Tiburon; China Camp National Register of Historic Places Inventory – Nomination Form; Update of the Historic Resources Inventory (Larkspur); Fort baker, Barry and Cronkhite National Register of Historic Places Inventory – Nomination Form; Sausalito Historic District National Register of Historic Places Inventory – Nomination Form; City of Sausalito, Historic Resource Inventory Listing; Historic Properties List (San Rafael); San Rafael Historical/Architectural Survey; Marinship Historic Context Statement; National Register of Historic Places Registration Form – Hamilton Army Air Field Discontiguous Historic District; City of Belvedere General Plan Update – Cultural Resources.

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Other Considerations

Economic

Historic preservation has proven to be an effective tool for small business sustainability, community development, renewal, and revitalization, heritage tourism development, and more.[113] Several of Marin's vulnerable historical areas house local businesses important to economic wellbeing. Loss or deterioration of these resources could have negative economic impacts. Additionally, Marin's historic sites contribute to the county's unique charm and character, adding to the appeal for tourism, thus assisting with economic development through increased visitor spending, sales tax, and transient occupancy tax. In some cases historic sites adjacent to the Bay may serve as shoreline armoring or buffer storm impacts helping to protect lands and properties inland thus helping to ensure their continued economic use.

Environmental

In addition to providing valuable information on cultural history, archaeological resources can be important information sources on natural history, which may be of increased importance as global temperatures rise. Through analysis of elements such as pollen, seeds, shells, and bones, archaeological data can reveal which plants and animals thrived during past climactic periods (e.g., the mid Holocene) with land and water temperatures comparable to potential future conditions with climate changes, including secondary impacts such as increased ocean acidification.[114] Such data could be applied for future ecosystem restoration and management plans.

In addition to allowing communities to remain intact, continued use of older buildings has environmental benefits. Retrofitting existing homes through elevation and flood proofing can extend their lives in the face of SLR and increased storms, thus avoiding the immediate need for new construction. Building reuse is almost always less environmentally taxing then new construction, and it can take 10 to 80 years for a new building that is 30% more energy efficient than an average performing existing building to overcome negative climate impacts from construction.[115] Materials production and transport, building construction, and demolition waste disposal all yield environmental impacts, which could be avoided through preserving/protecting existing buildings.

Social Equity

In addition to losing valuable historic information about the region, the loss of archaeological sites can have significant sense of place impacts, particularly for Native American's who consider the sites sacred, While documenting the sites can help preserve some of the valuable historical information, the loss of these irreplaceable resources could represent an unprecedented loss to history and culture with no established processes to mitigate their disappearance.

Social equity is important in the field of historic preservation. Both China Camp and Angel Island hold stories of historically marginalized Asian immigrants. Preservation of these irreplaceable sites is important to ensure they remain in the collective memory and contribute to a more inclusive understanding of local and national history.

Several of the public historic sites offer educational experiences that can be enjoyed by many people regardless of socioeconomic circumstances and age. China Camp, the San Francisco Bay Model, and Fort Baker can all be accessed for relatively low costs adding to their appeal for families with children.

Management

The loss of archaeological sites can present management challenges including the need for increased documentation and protection of sites, particularly those of high intrinsic value. Close coordination with Native American groups will be critical to ensure that adaptation strategies protect vulnerable archaeological sites.

Little guidance exists to inform the challenge of adapting historic sites in the face of sea level rise. Elevation may be structurally feasible, but could have negative integrity impacts. Levees and seawalls could have negative impacts to the cultural landscape. Relocation could remove sites from the historic districts or contexts. Such strategies may

[113] Rypkema, Donovan D., 2005. The Economics of Preservation: A Community Leader's Guide.

[114] Newland, Michael (Sonoma State Anthropological Studies Center). 2015. Personal Communications

[115] National Trust for Historic Preservation. 2011. The Greenest Building: Quantifying the Environmental Value of Building Reuse.

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therefore not be allowed under current local design review guidelines.

Section 106 of the National Historic Preservation Act of 1966 requires federal agencies to take into account project impacts on historic properties. This includes projects located on federal properties or using federal funding. Under Section 106, any alterations would need to be consistent with the Secretary of the Interior's Standards for the Treatment of Historic Properties. Adaptation strategies that have negative impacts on historic integrity, introduce incompatible elements, change the use or setting, or relocate landward are amongst the types of projects that would likely be deemed adverse effects.[116] Neglect and deterioration can also be adverse effects[117] that merit consideration as sea level rise and increased storms could exacerbate the deterioration of historic properties if not properly managed for.

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[116] Advisory Council on Historic Preservation. 2015. Protecting Historic Properties: A Citizen's Guide to Section 106 Review.
[117] Ibid.

CULTURAL RESOURCES

Map 44: Northern Study Area Vulnerable Cultural Resource Assets

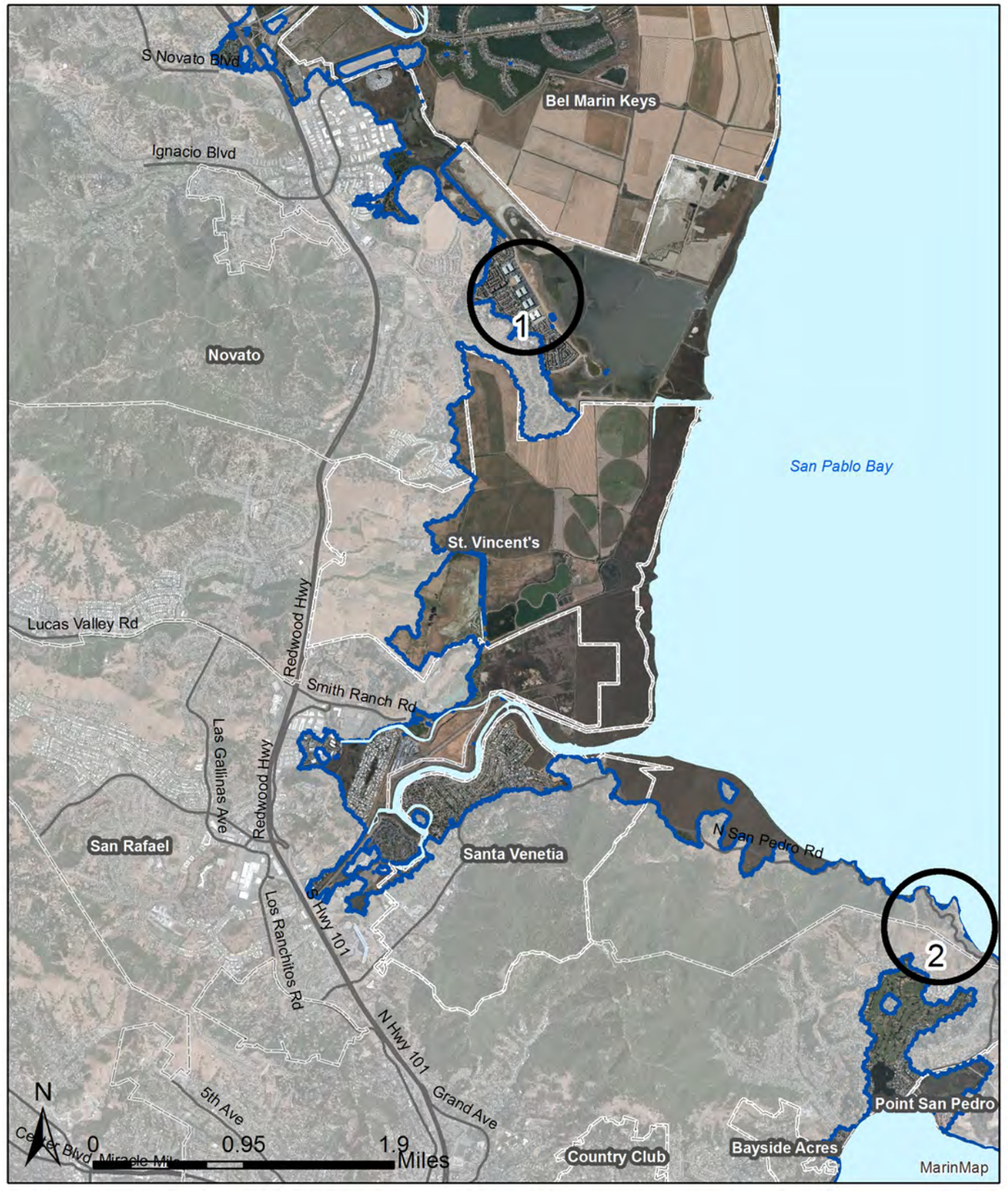
Vulnerable Historic Buildings

- Scen. 1: 10" Sea Level Rise (SLR)
- Scen. 2: 10" SLR+Storm Surge
- Scen. 3: 20" Sea Level Rise
- Scen. 4: 20" SLR+Storm Surge
- Scen. 5: 60" Sea Level Rise
- Scen. 6: 60" SLR+Storm Surge

Location Indicators

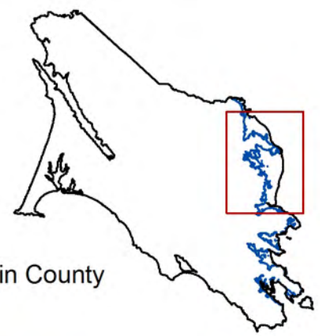
- Municipality
- Major Road
- Inland Extent: Sea Level

Archaeological resources may be present. Source: MarinMap; CoSMoS, Marin CDA; China Camp National Register of Historic Places Inventory – Nomination Form; National Register of Historic Places Registration Form – Hamilton Army Air Field Discontiguous Historic District;



1: Hamilton Army Air Field

2: China Camp State Park



Date: 2/17/2017

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.

CULTURAL RESOURCES

Map 45: Southern Study Area Vulnerable Cultural Resource Asset

Vulnerable Historic Buildings

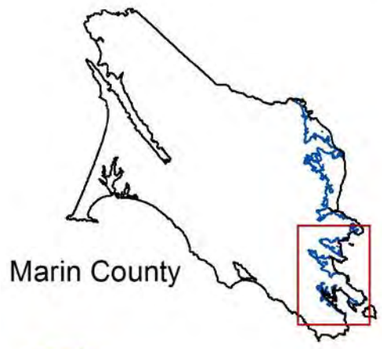
- Scen. 1: 10" Sea Level Rise (SLR)
- Scen. 2: 10" SLR+Storm Surge
- Scen. 3: 20" Sea Level Rise
- Scen. 4: 20" SLR+Storm Surge
- Scen. 5: 60" Sea Level Rise
- Scen. 6: 60" SLR+Storm Surge

Location Indicators

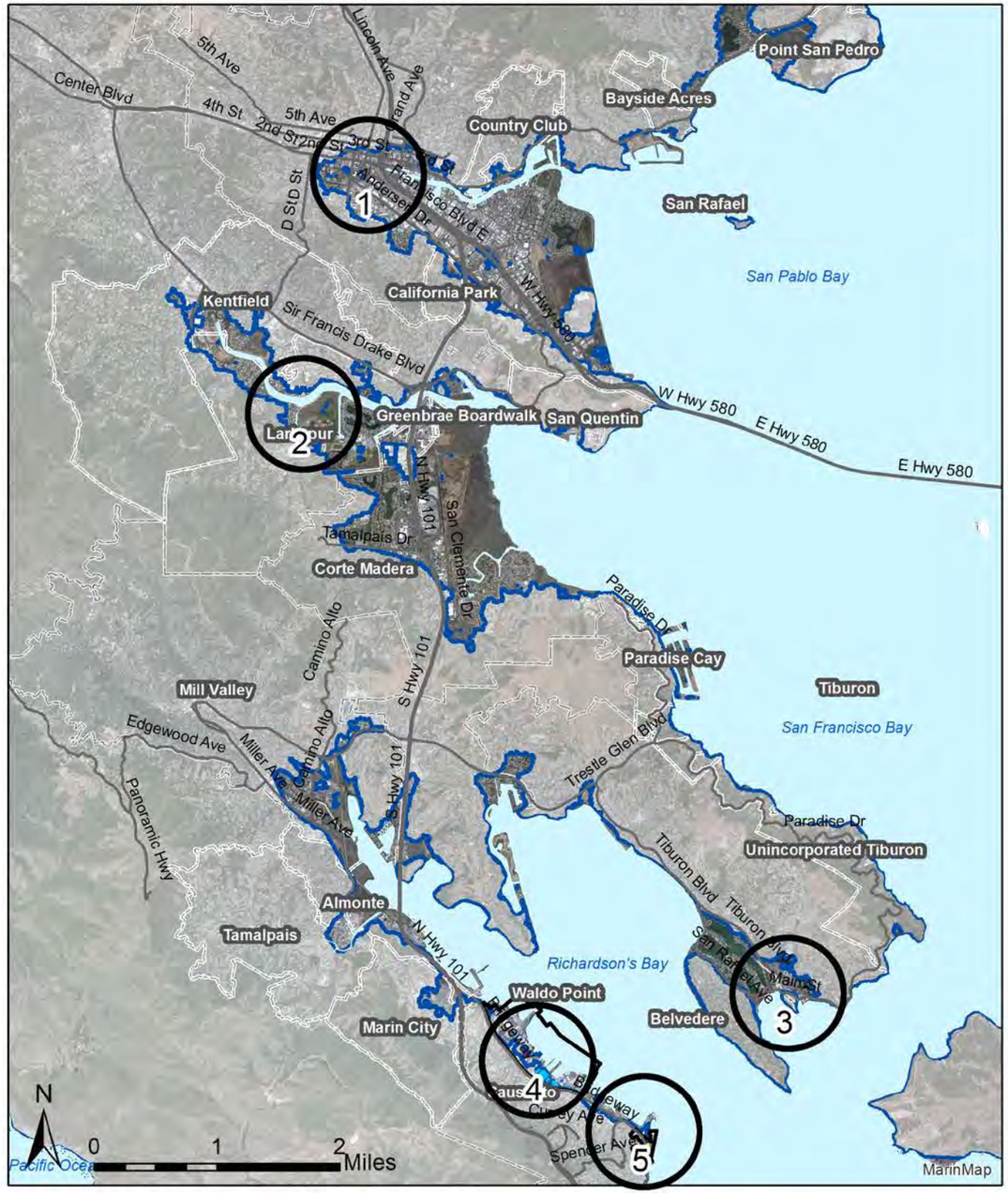
- Municipality
- Major Road
- Inland Extent: Sea Level @ 60"+100-year Storm

Archaeological resources may be present.

Source: MarinMap; CoSMoS, Marin CDA; City of Sausalito, Historic Resource Inventory Listing, Marinship Historic Context Statement; Local Historic Inventory for Downtown Tiburon; Update of the Historic Resources Inventory (Larkspur); Sausalito Historic District National Register of Historic Places Inventory – Nomination Form; City of Sausalito, Historic Resource Inventory Listing; Historic Properties List (San Rafael); San Rafael Historical/Architectural Survey; Marinship Historic Context Statement; City of Belvedere General Plan Update – Cultural Resources



Date: 2/17/2017



1: San Rafael

2: Larkspur

3: Tiburon-Belvedere

4: Marinship

5: Sausalito Downtown Historic District

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