

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 launches, marinas, and piers could experience significant damage and access 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

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- 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, 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 support pillars, and the weight of water at the low ends of a bridge could cause increased wear and tear and compromise 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 & Routes 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

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	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

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	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 ^{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

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	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

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

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	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

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	Near-term		Medium-term		Long-term	
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Greenbrae	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

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	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 North bound ^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	<ul style="list-style-type: none"> ▪ 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	<ul style="list-style-type: none"> ▪ Most soils in the study area are erodible soils and are susceptible to slides, scouring, and subsidence.
Materials	<ul style="list-style-type: none"> ▪ 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.

Source: Asset Manager Interviews

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 to 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, Country Club, China Camp State Park, Tamalpais Valley, Santa Venetia, Point San Pedro, and Paradise Cay. Of note, several communities may not experience 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, experience 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. Repeated saltwater exposure could increase corrosion of the metal posts, rotting of wooden posts, and damage 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

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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.⁶⁴

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.⁶⁵ 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.^{66,67}

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.

⁶⁴ 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.

⁶⁵ Sea Level Rise Vulnerability Assessment Interview. Caltrans. April 30, 2015. J. Peterson. D. Fahey. Marin County Development Agency. BVB Consulting LLC.

⁶⁶ Sea Level Rise Vulnerability Assessment Interview. Caltrans. April 30, 2015. J. Peterson. D. Fahey. Marin County Development Agency. BVB Consulting LLC.

⁶⁷ 2014 dollars

TRANSPORTATION

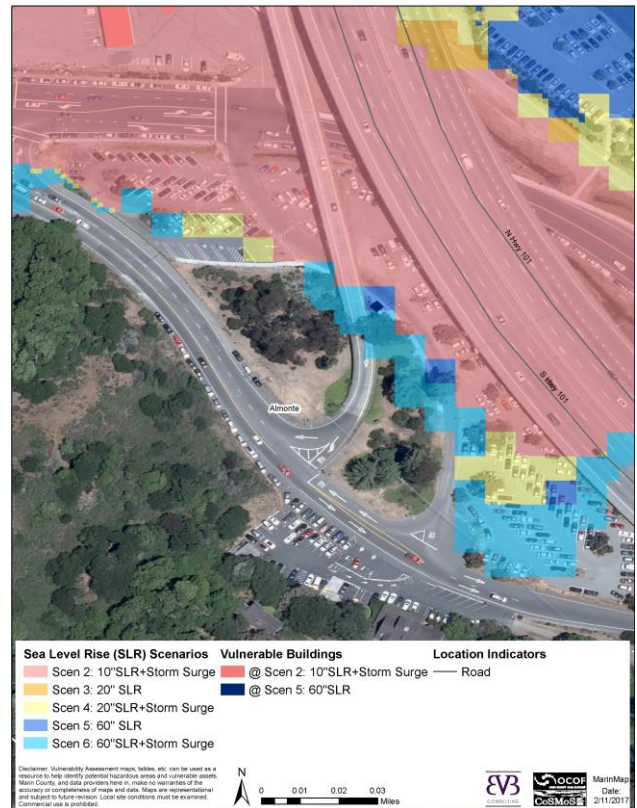


Richardson Bay Flooding, Jan. 1982. Credit: Marin DPW



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

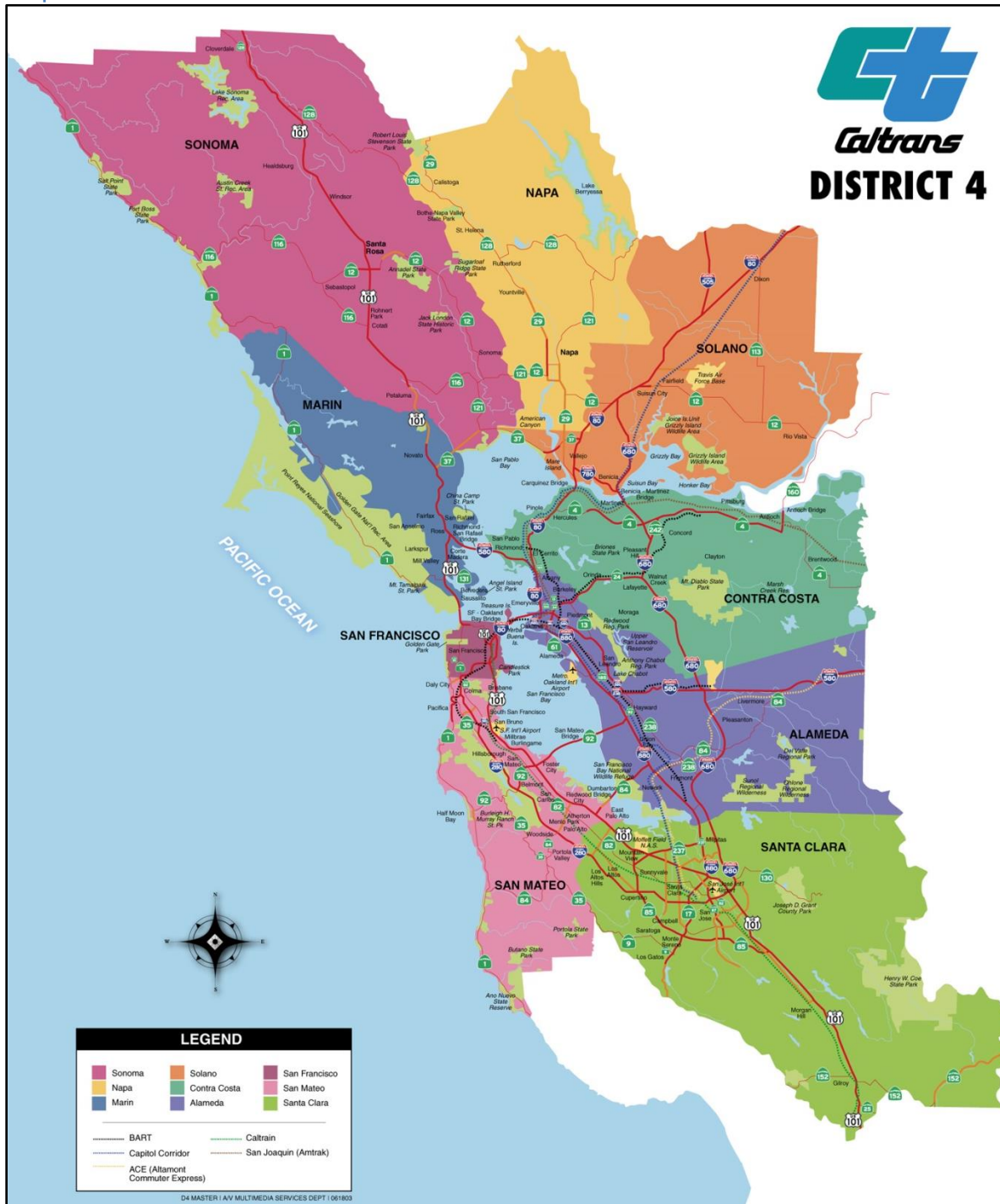
Map 14. Manzanita Park & Ride Sea Level Rise Exposure



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's Bay. Source: MarinMap, CoSMoS. Credit: BVB Consulting LLC.

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Map 15. Caltrans District 4



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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.

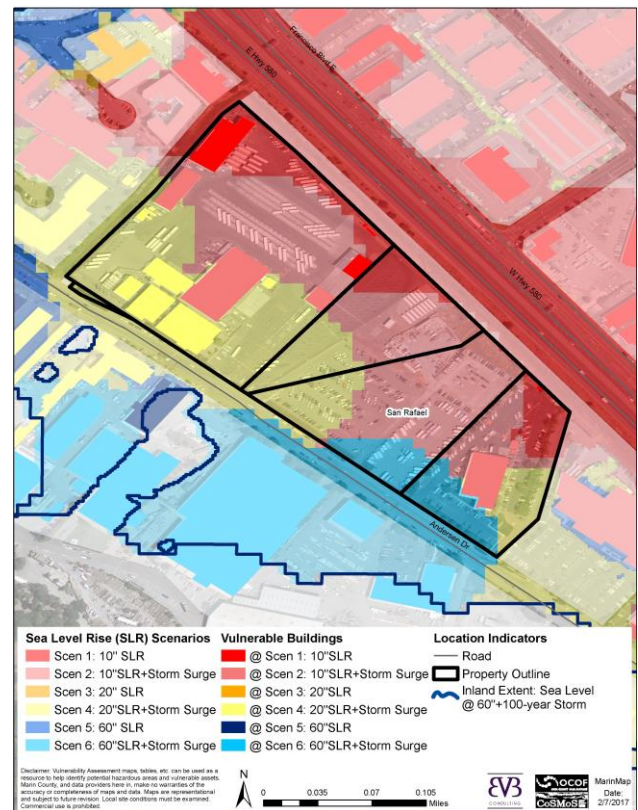
Bus routes that run on roads vulnerable to storm impacts and sea level rise are:

- 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, 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.

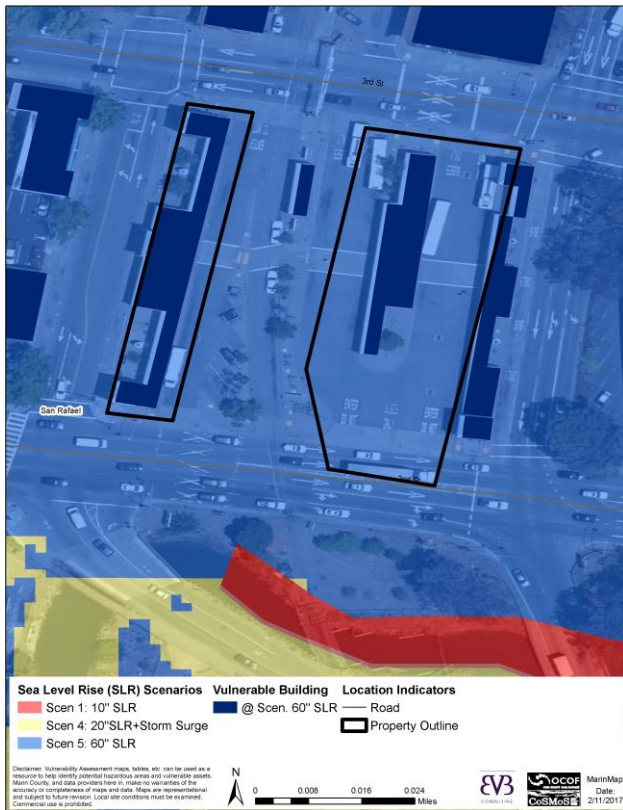
Map 16. GGBHTD Headquarters & Bus Depot Sea Level Rise Exposure



Source: CoSMoS, MarinMap. Credit: BVB Consulting LLC

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Map 17. San Rafael Transit Center Sea Level Rise Exposure



- 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

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



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

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 GGF Sausalito Ferry operates on a float system that may be able to withstand sea level impacts in the near-term.

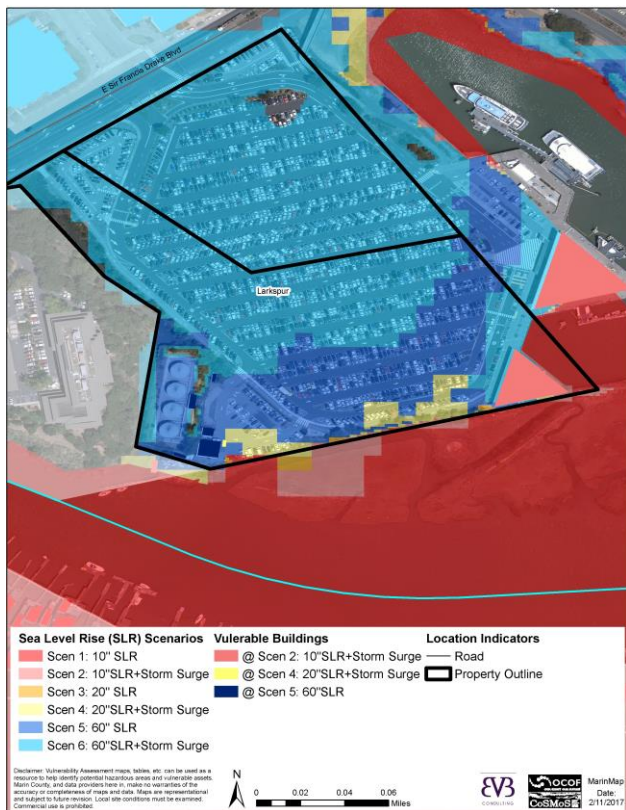
Harbors and Marinas

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.⁶⁸ 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 depends on.

Airports

The Marin County Gness Field Airport in North Novato could be vulnerable in the long-term, and San Rafael Airport could be vulnerable in the medium-term. Both of these small plane facilities depend on levees for flood protection; however, Gness 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

⁶⁸ 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.

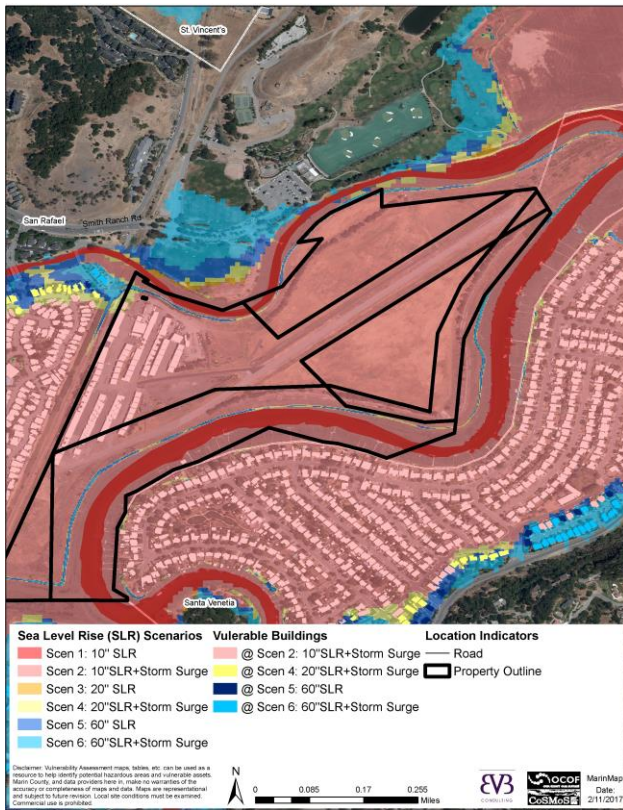
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would anticipate. Flooding would reduce flight time windows, and would damage airplane storage areas

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.

and airplanes stored on site. Finally, increased subsidence could warp the buildings and runway.

Map 19. San Rafael Airport Sea Level Rise Exposure



Source: MarinMap, CoSMoS. Credit: BVB Consulting LLC

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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	GGF Sausalito Ferry facilities	No data ^a		
Tiburon	Ferry facilities	No data ^a		
Sausalito	Marina Plaza Harbor	5'7"	8'6"	21'9"
Larkspur	Bay Trail	0-5'4"	0-6'	0-8'6"
Larkspur	GGF Larkspur Ferry facility	5'	5'4"	6'9"
Waldo Point	Richardson Bay Marina	4'5"	7'4"	18'7"
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"
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	GGBHTD headquarters & depot	0-1'6"	0-2'4"	4'2"-5'
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	Gross 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"

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Location	Asset	Near-term	Medium-term	Long-term
		Scenario 1	Scenario 3	Scenario 5
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"
Corte Madera	Paradise Drive		0-2'5"	4"-9'
Sausalito	Clipper Yacht Harbor		2'5"	6'3"
San Rafael	Hwy 101North bound		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"
Corte Madera	Tamalpais Drive		0-2'	2"-7'6"
San Rafael	Hwy 101South bound		0-2'	1'4"-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"
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	San Rafael 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	Hwy 37 West bound			2"-8'4"
Corte Madera	Hwy 101North bound			6"-7'8"
San Rafael	Lincoln Avenue			10"-7'4"
North Novato	SMART rail			0-7'
Novato	Hwy 37 East bound			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	Hwy 101South bound			1'-5'5"
Larkspur	Hwy 101North bound			3'6"-5'3"
Larkspur	Redwood Highway			4'2"-5'2"

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Location	Asset	Near-term	Medium-term	Long-term
		Scenario 1	Scenario 3	Scenario 5
Belvedere	Beach Road			11"-5'
Tiburon	Tiburon Blvd.			9"-5'
Larkspur	Hwy 101South bound			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'
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"
San Rafael	San Rafael Transit Center			2'5"
North Novato	Redwood Highway			1'9"-2'4"
San Rafael	Hetherton Street			1'4"-2'4"
North Novato	Hwy 101 North bound			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		

^a Data not available for assets are located bayside of mean sea level. Source: MarinMap, OCOF Exposure and Flood Depth data, Asset Manager Interviews

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

Vulnerable Assets

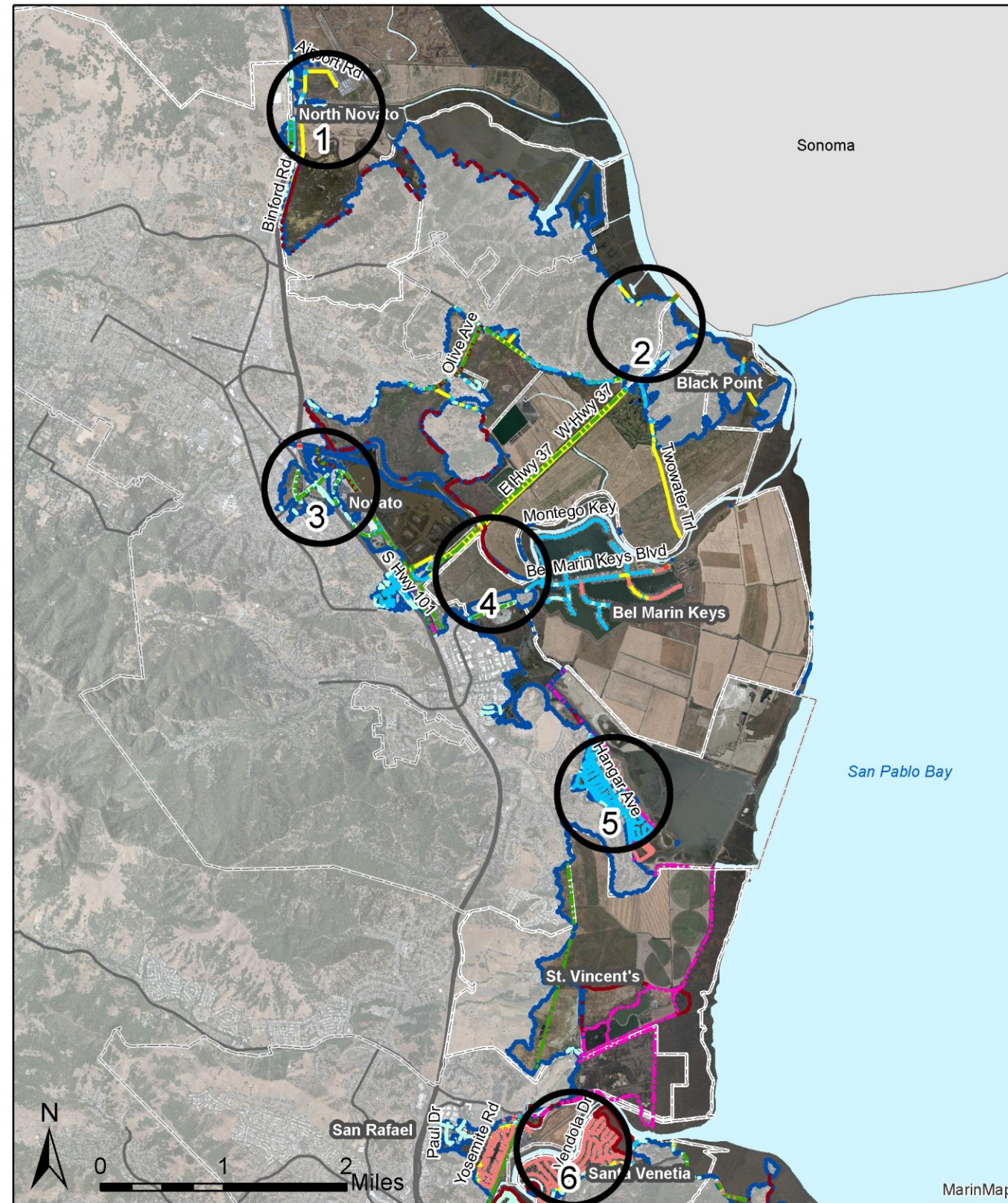
- Bike path
- Bay Trail
- Trail

Vulnerable Roads

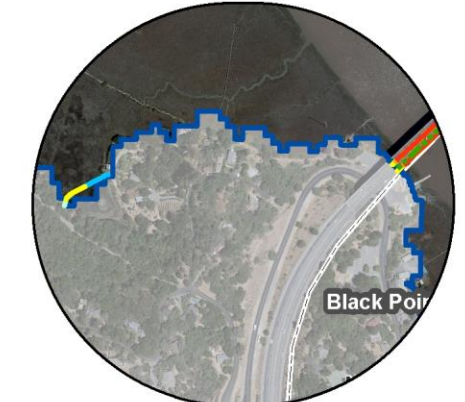
- @10" Sea Level Rise (SLR)
- @10"SLR+ 100-year Storm Surge
- @20" Sea Level Rise
- @20"SLR+ 100-year Storm Surge
- @60" Sea Level Rise
- @60"SLR+ 100-year Storm Surge

Location Indicators

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



1: U.S. Hwy. 101



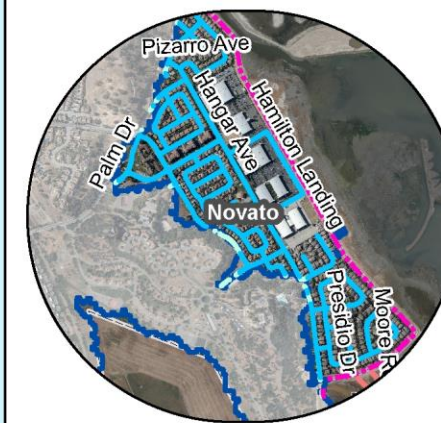
2: State Route 37



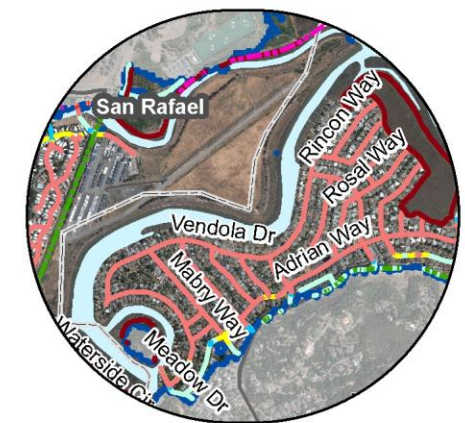
3: U.S. Hwy. 101 @ Rowland Blvd.



4: State Route 37 & Bel Marin Keys Blvd.

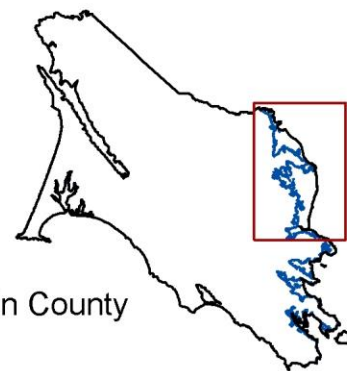


5: Hamilton



6: Santa Venetia

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.



Marin County



Date: 4/1/2017



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

Vulnerable Assets

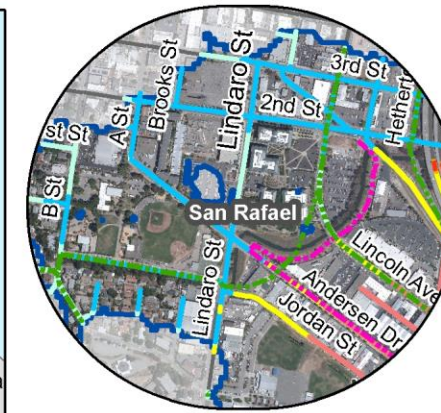
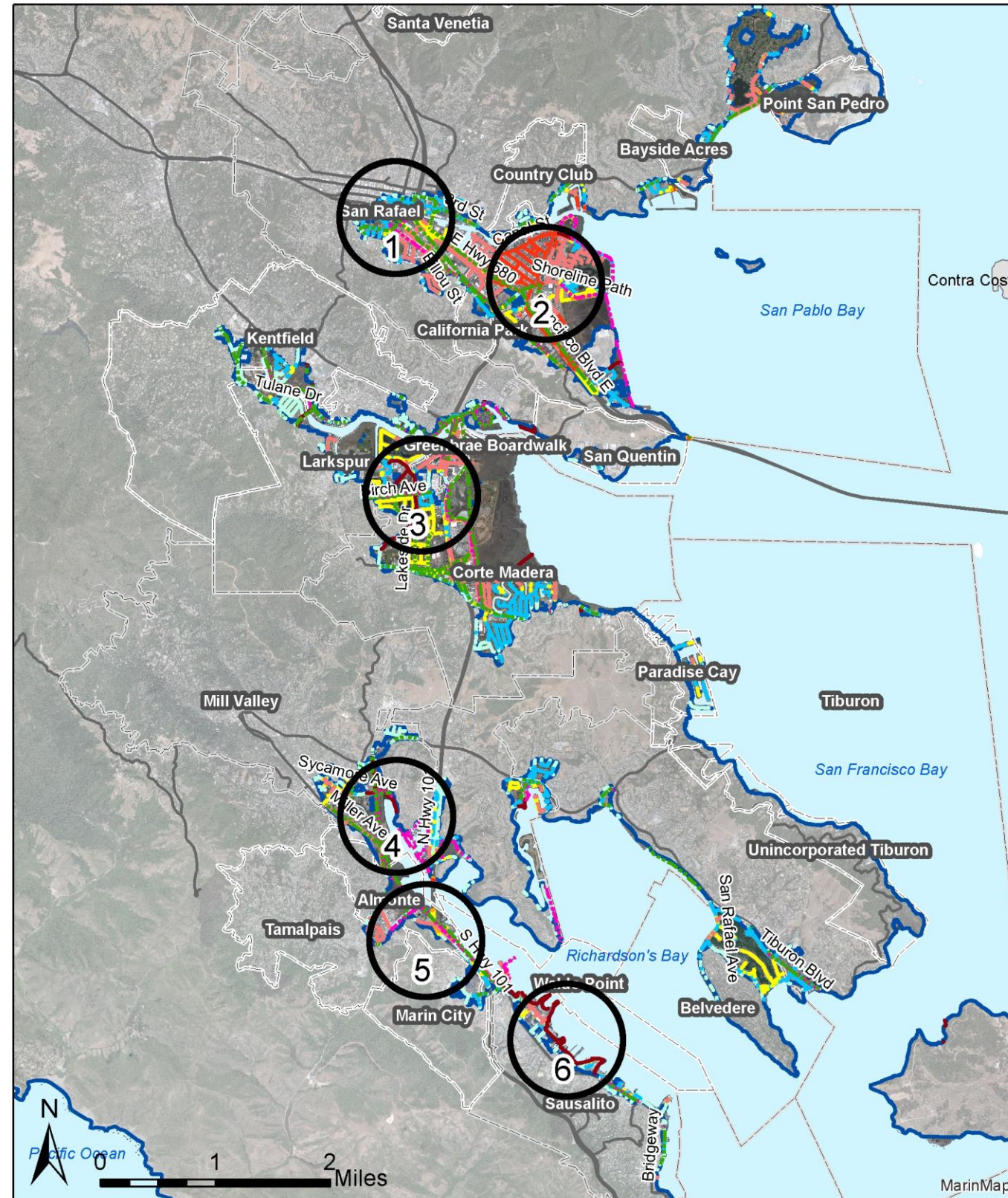
- Bike path
- Bay Trail
- Trail

Vulnerable Roads

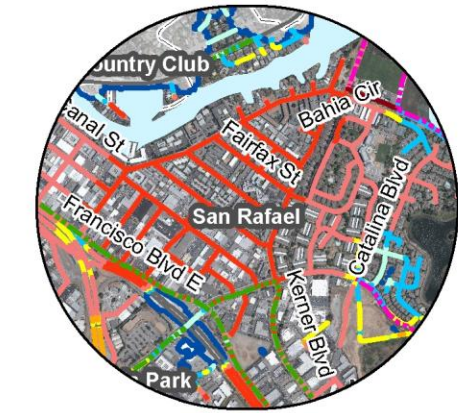
- @10" Sea Level Rise (SLR)
- @10"SLR+ 100-year Storm Surge
- @20" Sea Level Rise
- @20"SLR+ 100-year Storm Surge
- @60" Sea Level Rise
- @60"SLR+ 100-year Storm Surge

Location Indicators

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



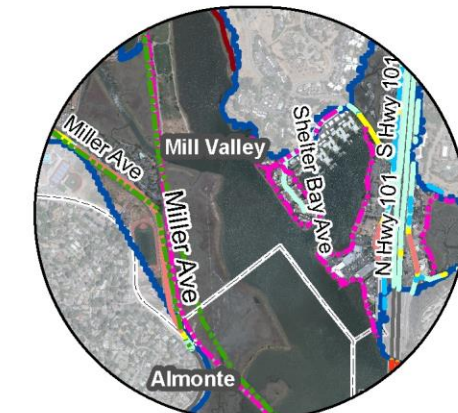
1: Central San Rafael



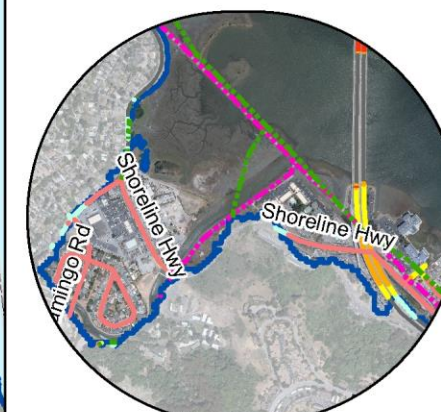
2: Canal Neighborhood



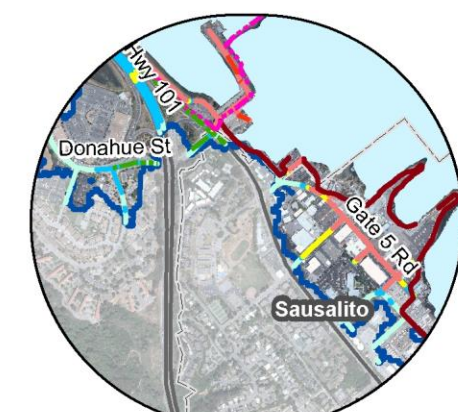
3: Larkspur/
Corte Madera



4: Mill Valley

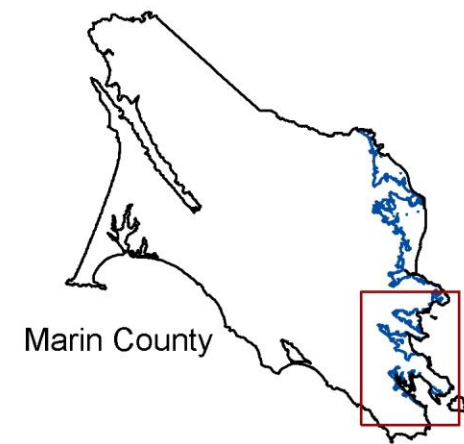


5: Almonte/Manzanita
Park & Ride



6: Marin City/
Waldo Point Harbor

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



Date: 2/11/2017

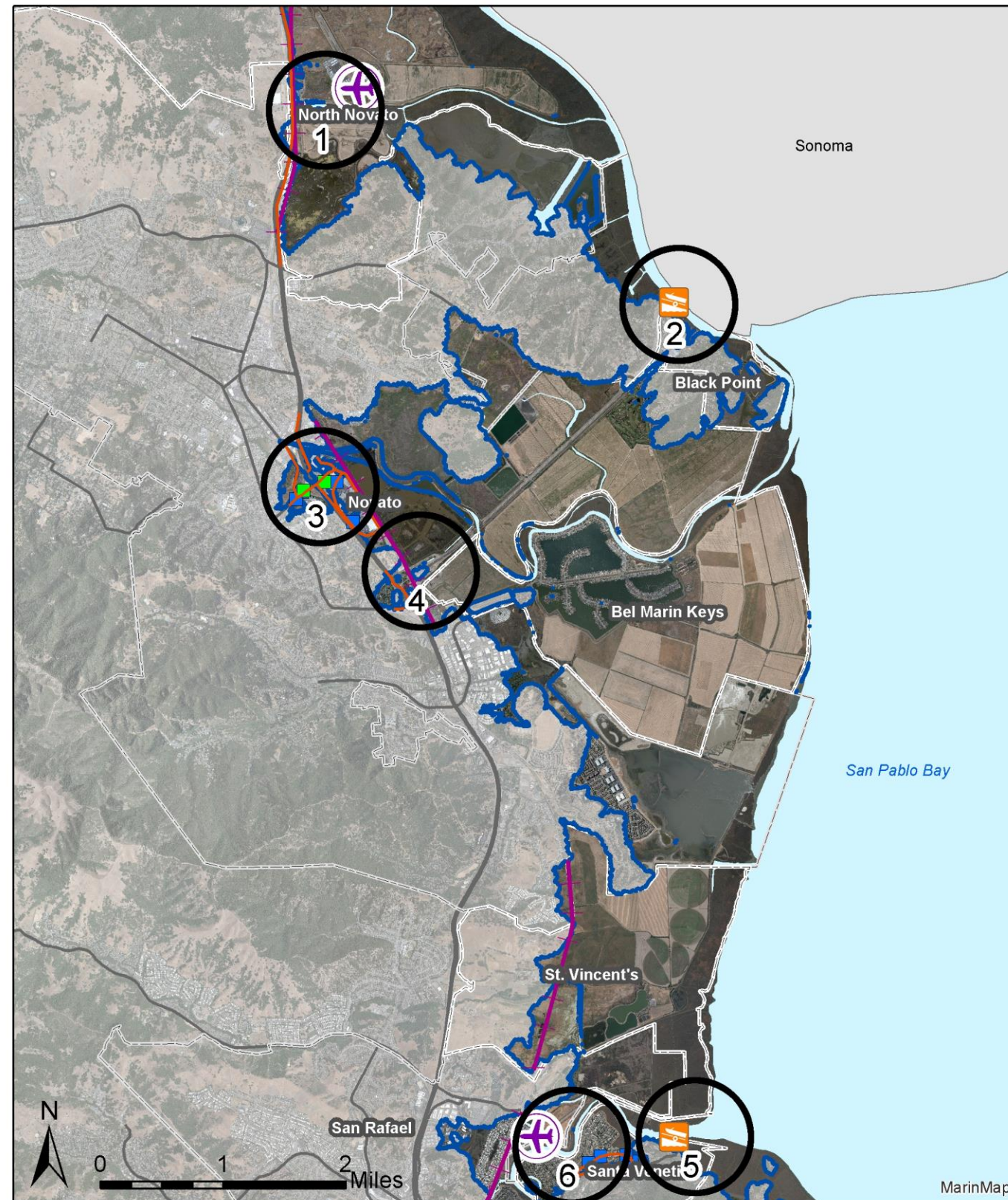


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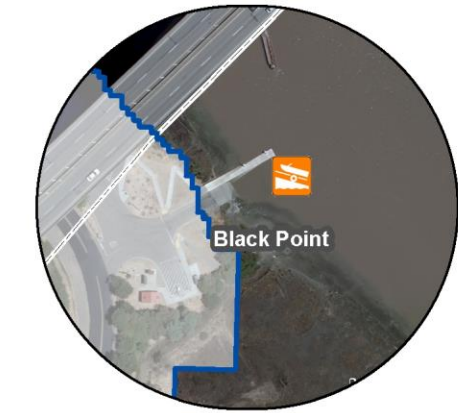
Map 22. Northern Study Area Vulnerable Transit, Air, and Marine Transportation Assets

Vulnerable Assets

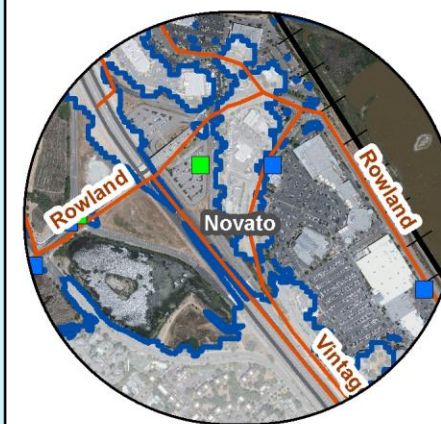
-  Airport
 -  GGT Bus Stop
 -  MT Bus Stop
 -  Transit Route
 -  Public Boat Launch
 -  SMART Track
- Location Indicators**
-  Unincorporated
 -  Municipality
 -  Road
 -  Bay
 -  Inland Extent: Sea Level @ 60"+100-year Storm



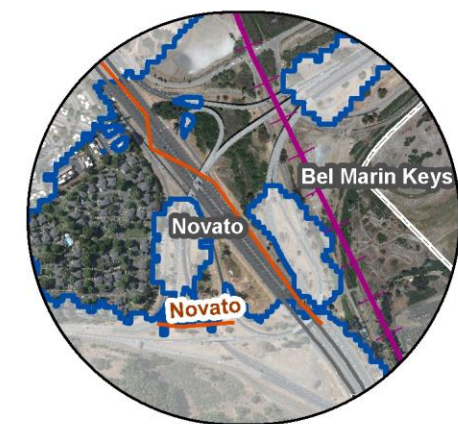
1: North Novato



2: State Route 37



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



4: State Route 37 & Bel Marin Keys Blvd.

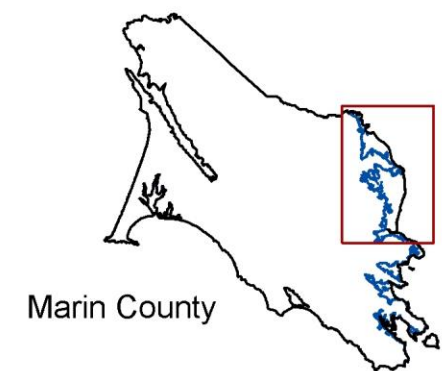


5: Santa Venetia



6: Buck's Landing

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



Date: 3/30/2017



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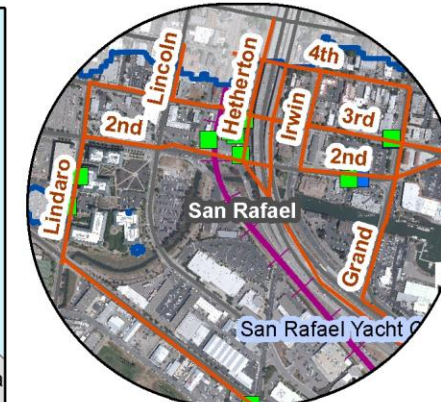
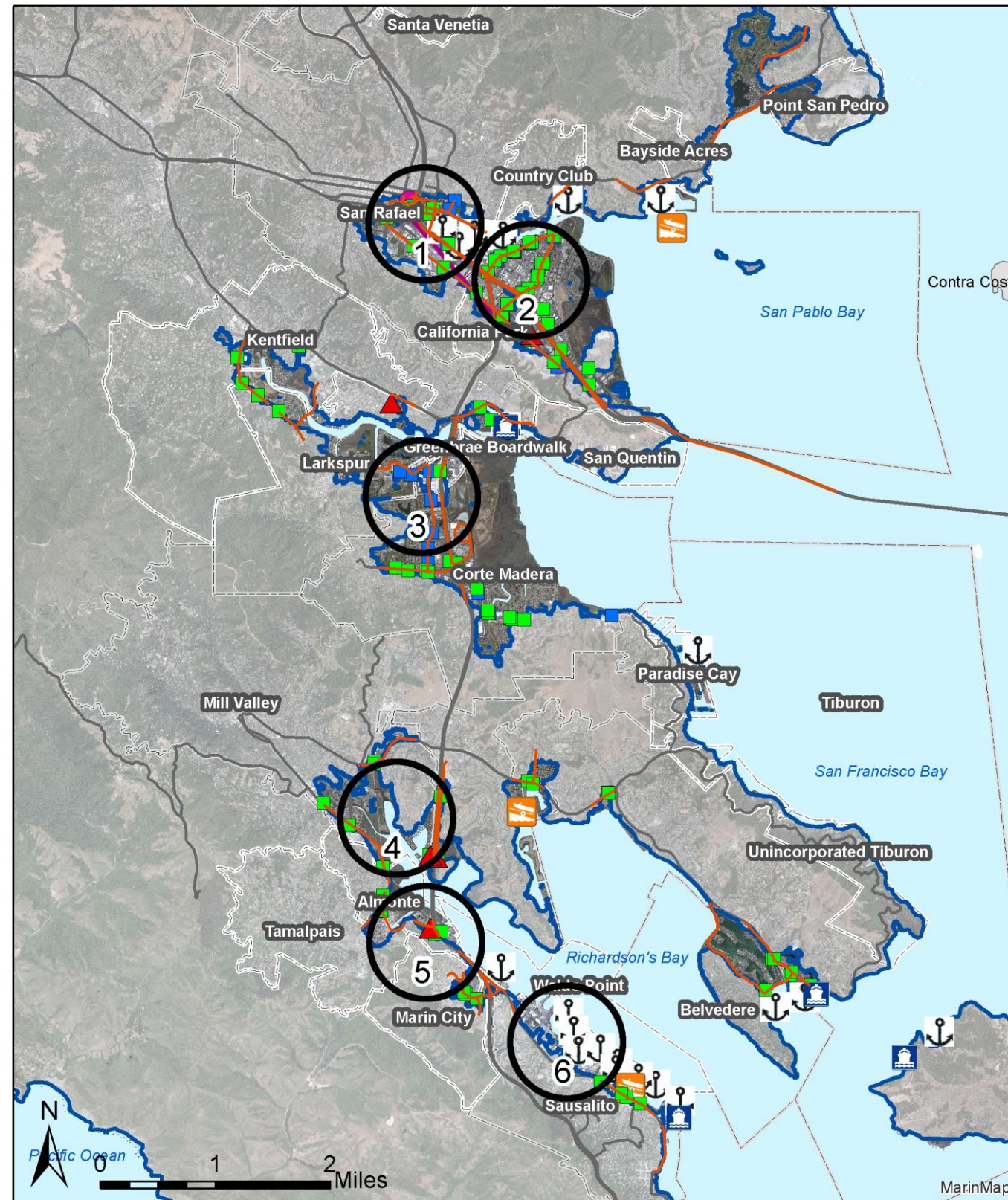
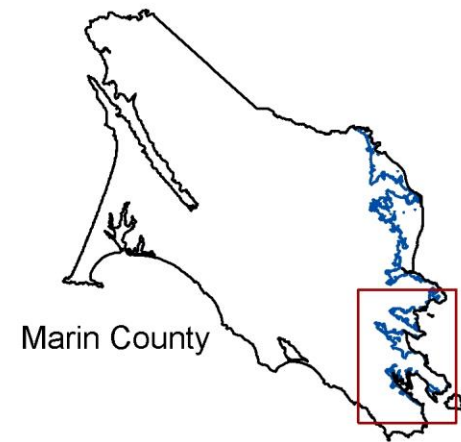
Map 23. Southern Study Area Vulnerable Transit and Marine Transportation Assets

Vulnerable Assets

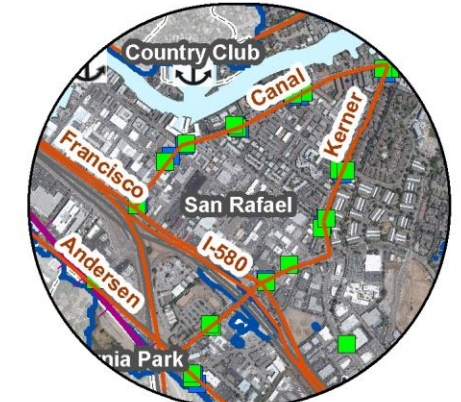
- Park & Ride
- GGT Bus Stop
- MT Bus Stop
- Transit Route
- SMART Station
- SMART Track
- Ferry
- Public Boat Launch
- Marina

Location Indicators

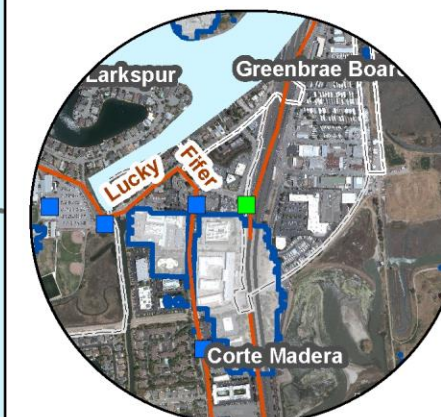
- Unincorporated
- Municipality
- Road
- Bay
- Inland Extent: Sea Level @ 60"+100-year Storm



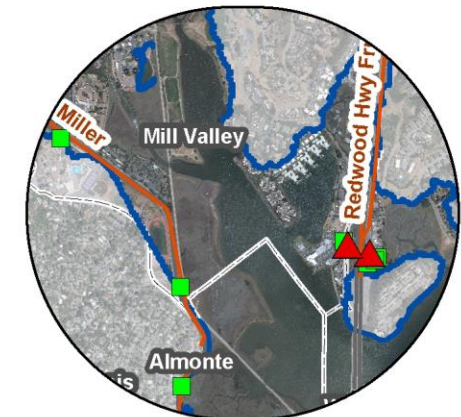
1: Central San Rafael



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's 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's 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's 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 disproportionately impact those who depend on public transportation. First, flooding could prevent timely travel, second, flooding could prevent safe travel, and third, 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 relative to the County median income.⁶⁹

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's 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 basic expenses; leaving less income available for other necessities such as emergency preparedness, medical care, healthy

⁶⁹ 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.

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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.⁷⁰ The affordability standard is 30 percent of income on housing and 15 percent on transportation.⁷¹ 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.

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.

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

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