Southern Marin Watershed Guide

Planning for Floods

Southern Marin
Flood Protection
and Watershed Program

July 2016

PHOTO: ANDREA DUNLAP

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Acknowledgements

This publication is a product of the Southern Marin Flood Protection and Watershed Program, a collaborative effort of the County of Marin, Marin County Flood Control and Water Conservation District Zones 3 and 4, and the City of Mill Valley.

This watershed guide and the Southern Marin Watershed Program are elements of the Marin County Department of Public Works' countywide Watershed Program.

The website **www.marinwatersheds.org** provides a wealth of information to support the community's understanding of watershed issues and to introduce ideas and possible next steps for watershed improvement and flood control, including existing condition reports for each watershed, descriptions of existing facilities, and other products.

The following people provided valuable feedback on draft versions of this report:

Chris Choo, County of Marin
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Roger Leventhal, County of Marin
Liz Lewis, County of Marin
Liz Lotz, County of Marin

Document production managed by
Rich Walkling, Restoration Design Group

Graphics by Bob Birkeland and
Erik Stromberg, Restoration Design Group

Layout by Leslie Stone Associates

This guidebook tells the story of our watershed and the flood risks we face together. Flooding affects our quality of life and livelihood: it threatens our homes and our businesses, and can impact everything we do in our normal day-to-day life, from getting our children to school to our access to emergency services.

The entire watershed landscape drains steeply, falling from Mt. Tam, flowing under buildings in downtown, widens and spreads through neighborhoods along the valley floor, past businesses on Miller Avenue, until reaching the wetlands at the bay. Sea level rise is also a concern and must be factored into any options we consider as we move forward. Solutions need to be integrative and work with our natural environment to ensure they protect the habitat and special species living in our backyards, such as the steelhead trout and Ridgway's rail. And since water disregards boundaries of any sort, we must carefully craft solutions that don't cause harm to one neighborhood while protecting another.

How we approach planning for watershed management and flooding defines our community, and the complexity of the issues highlights our need to work together. There are no easy solutions, but this guide will help us start from a common point of understanding as we work together to define solutions for the short-term as well as long-range planning. Learning to live with water will be a part of our future together.

We hope that you find this guide to be a useful resource, and that after reading it you will head outside to experience our beautiful watershed. We'll come back to ask for your help identifying the issues, developing projects, and improving the watershed for our future.

Stephanie Moulton-Peters
Mill Valley councilmember

Kathrin Sears
Marin County Supervisor, District 3

Introduction: Why we made this guide

Prevailing wisdom about California water asserts that two things are inevitable: there will be another drought and there will be another flood. Though it is hard to prepare for one while experiencing the other, this is exactly what our communities must do. The next flood will come and its consequences will be determined by our actions today.

The impacts of flooding are far-reaching. While flood waters may not reach your home or business, floods do close the roads you use, the businesses you rely on, and your local schools. They can restrict access for emergency vehicles. They can cause landslides and leave standing water in low-lying areas. They can impact our wastewater treatment and leave wildlife stranded and vulnerable. Should the current trends in climate change continue, these conditions will almost certainly become worse. These challenges require community input and support.

Use this guide as a springboard to understand and engage in planning for flood and habitat protection in Southern Marin. The guide will help articulate the balance we all seek between living among the natural beauty and addressing the flood risks of this unique location. It will assist you in understanding the existing conditions as well as the process for considering options to reduce flood risk and protect habitat.

The guide describes:

- The characteristics of a watershed and influences on flooding
- Habitat and inhabitants of the watershed
- What happens when it floods
- What causes flooding
- How land use affects flooding
- How flooding affects water quality and habitat
- How climate change and sea level rise impact flooding
- Who is responsible for flood protection in Southern Marin
- Potential tools to address flooding and sea level rise
- Flood issues and options for reducing flood risk in Southern Marin
- A process for project implementation

We hope you will enjoy this guide and engage in the planning process with us.

FLOOD PHOTO WITH CAR: COURTESY OF THE LUCRETIA LITTLE HISTORY ROOM, MILL VALLEY PUBLIC LIBRARY

As long as people have lived in Southern Marin, we have been dealing with floods and their impacts.

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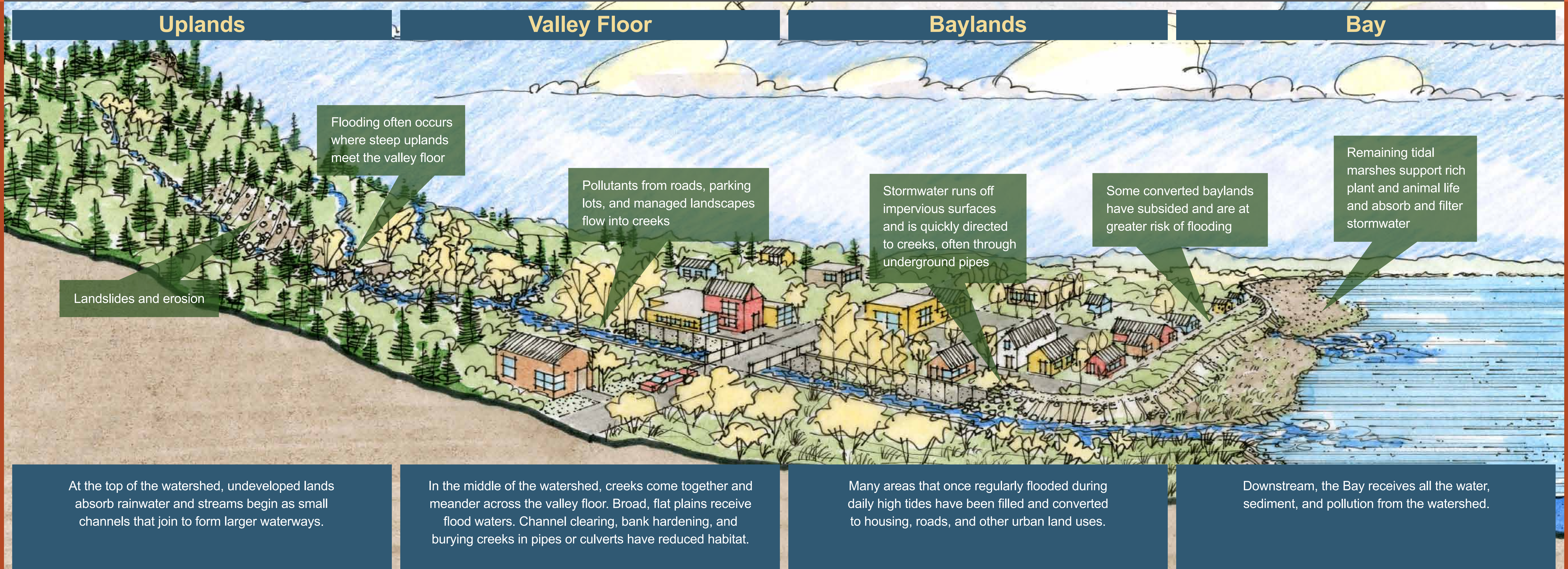
Understanding Watersheds

PHOTO: CRAIG SOLIN

Look to the hills above the community—from the Golden Gate National Recreation Area lands to Mount Tamalpais to Ring Mountain—and you will see the top of the Southern Marin Watershed. Rain that falls in this area drains to Richardson Bay.

What is a watershed?

The cities and communities of Southern Marin tend to be nestled in valleys or on adjacent, rolling hillsides. Steep ridgelines upstream and the waters of Richardson Bay downstream cradle these communities.



At the top of the watershed, undeveloped lands absorb rainwater and streams begin as small channels that join to form larger waterways.

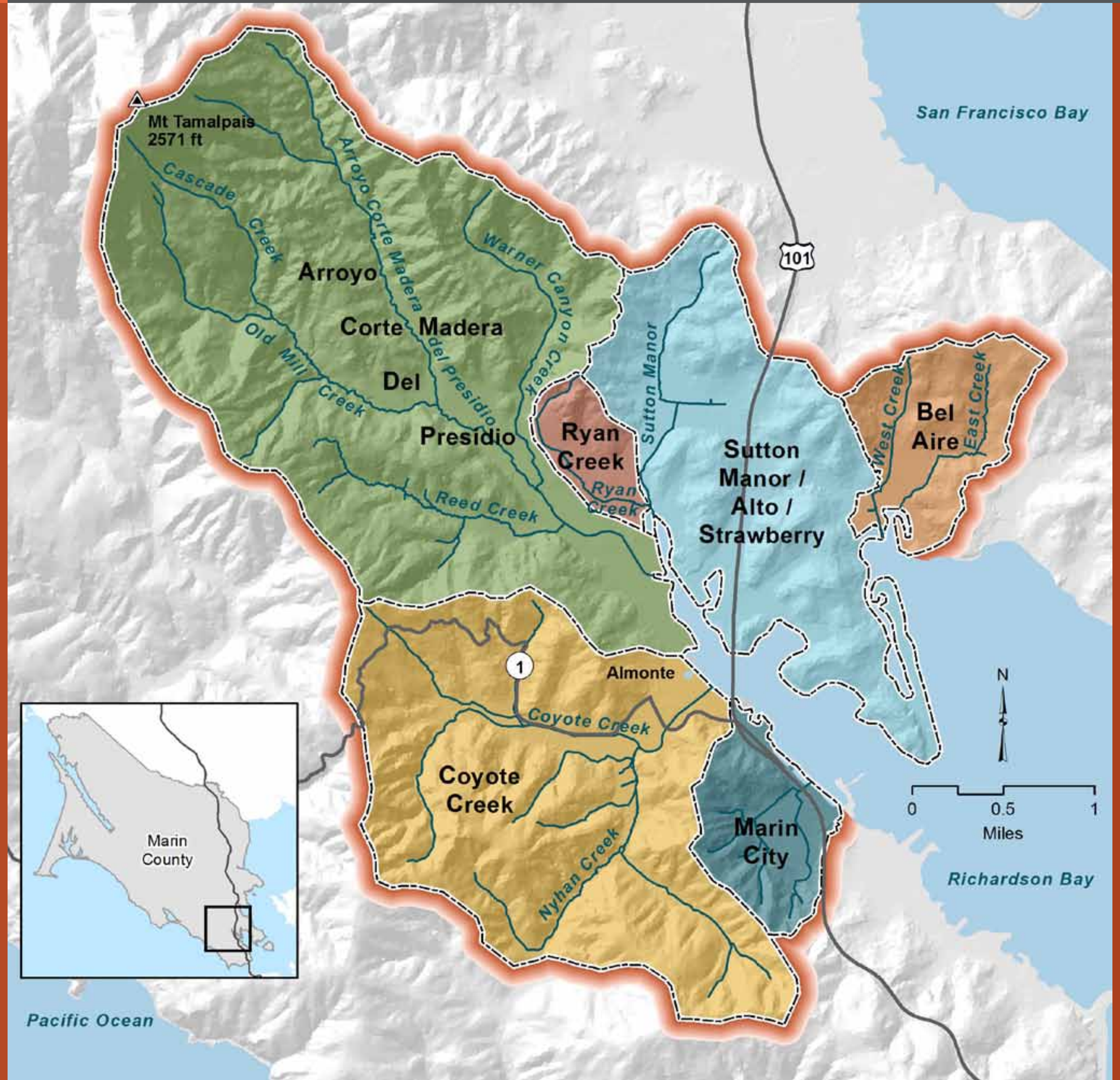
In the middle of the watershed, creeks come together and meander across the valley floor. Broad, flat plains receive flood waters. Channel clearing, bank hardening, and burying creeks in pipes or culverts have reduced habitat.

Many areas that once regularly flooded during daily high tides have been filled and converted to housing, roads, and other urban land uses.

Downstream, the Bay receives all the water, sediment, and pollution from the watershed.

What watershed do you live in?

The Southern Marin Watershed includes all the land that drains into northwestern Richardson Bay – 14 square miles in total. It is the body of land that roughly corresponds to the County of Marin's Flood Control Zones 3 and 4 – entities that were established to help address flooding in Southern Marin.



Within the Southern Marin Watershed are multiple smaller watersheds (subwatersheds) with their own outlets into the Bay. Planning at the watershed scale makes sense when dealing with water because it encompasses all the drainage area, upstream and down, with all its inhabitants and habitat.

Marin City Watershed

- 0.64 square miles
- For a century, the watershed was home to a dairy farm
- During World War II, the area was developed to house workers for the nearby shipyards

Coyote Creek Watershed

- 3.66 square miles
- Coyote and Nyhan Creeks drain steep slopes and join in former tidal marsh
- In the 1960s, lower Coyote Creek was converted to a flood control channel to protect nearby neighborhoods
- Includes Bothin Marsh, the largest remaining tidal marsh in the Southern Marin Watershed

Arroyo Corte Madera del Presidio Watershed

- 6.0 square miles
- In Spanish, the name means *the creek where wood is cut for the Presidio*
- In the late 1800s, the area developed first as a summer retreat and later as a full-fledged town

Ryan Creek Watershed

- 0.31 square miles
- Ryan Creek only flows after storms

Sutton Manor/Alto/Strawberry Watershed

- 2.5 square miles
- Includes Sutton Manor Creek and the Strawberry Peninsula
- In the late 1800s, the Eagle Dairy and the North Pacific Coast Railroad operated here

Bel Aire Watershed

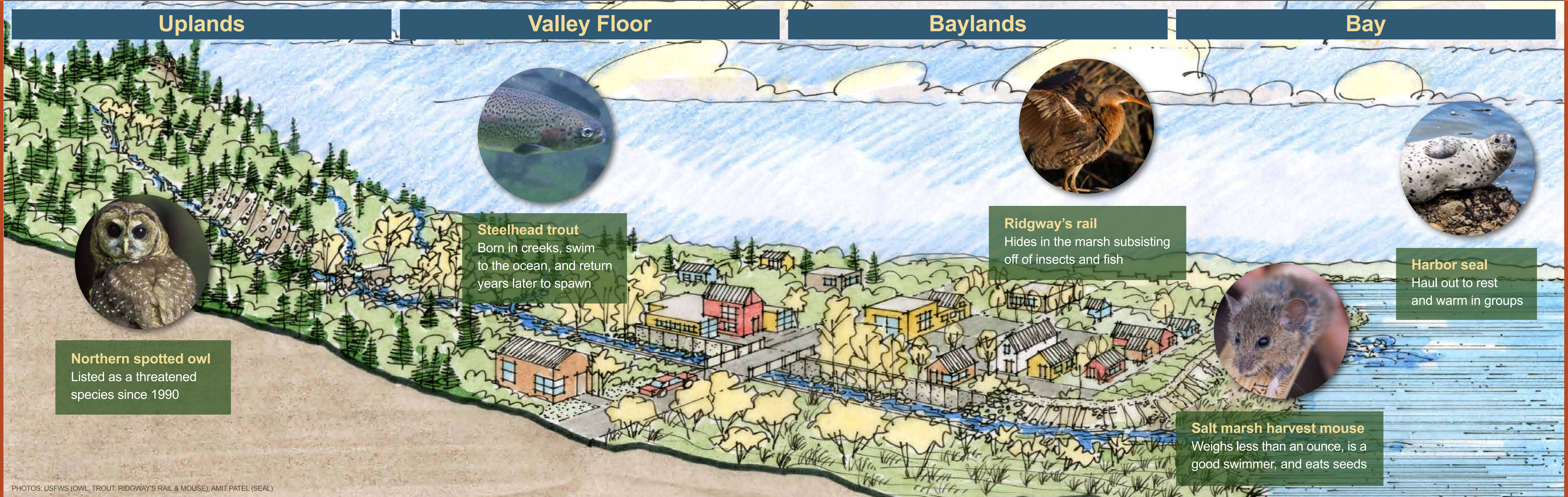
- 0.78 square miles
- Includes the Ring Mountain Open Space Preserve and neighborhoods in Tiburon

Fifty minutes from San Francisco; delightful climate; perfect drainage; trout streams; purest and best of water in great abundance; beautiful drives and perfect views of mountain, bay, forest, and city.

– Promotional material for Southern Marin from the 1890s

Creek and marsh habitat

Southern Marin's creeks and marshes are home to many threatened populations of plants and animals or species of concern. Species of concern have undergone a severe population decline and are now protected by law. Flood management decisions must give these species and their habitats – much of which are lost or fragmented – special consideration. Many would benefit from natural flooding.



Uplands	Valley Floor	Baylands	Bay
Open spaces provide habitat for wildlife	Nine species of fish live in Southern Marin's creeks	Remaining tidal marshes provide valuable habitat for wildlife	Richardson Bay is home to 55 species of fish, thousands of water birds, seals, and other animals

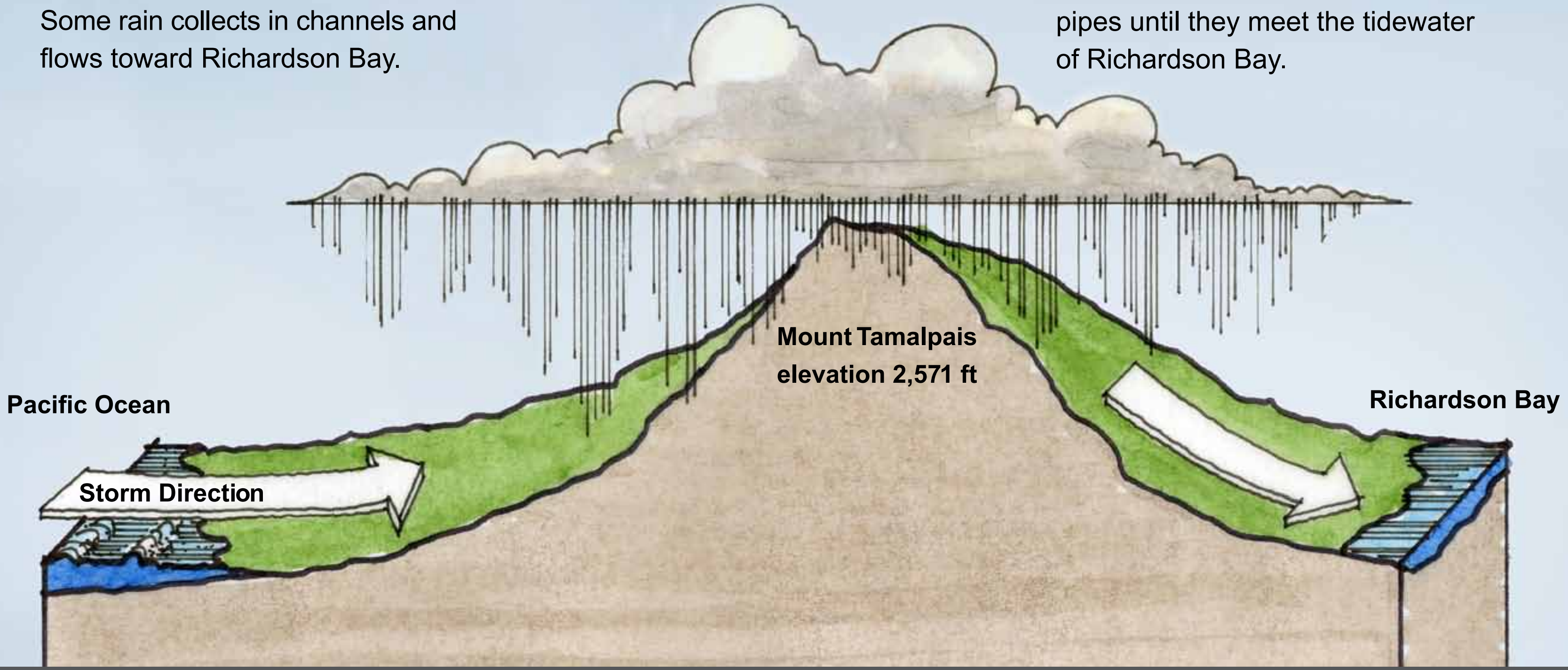
Understanding Flooding

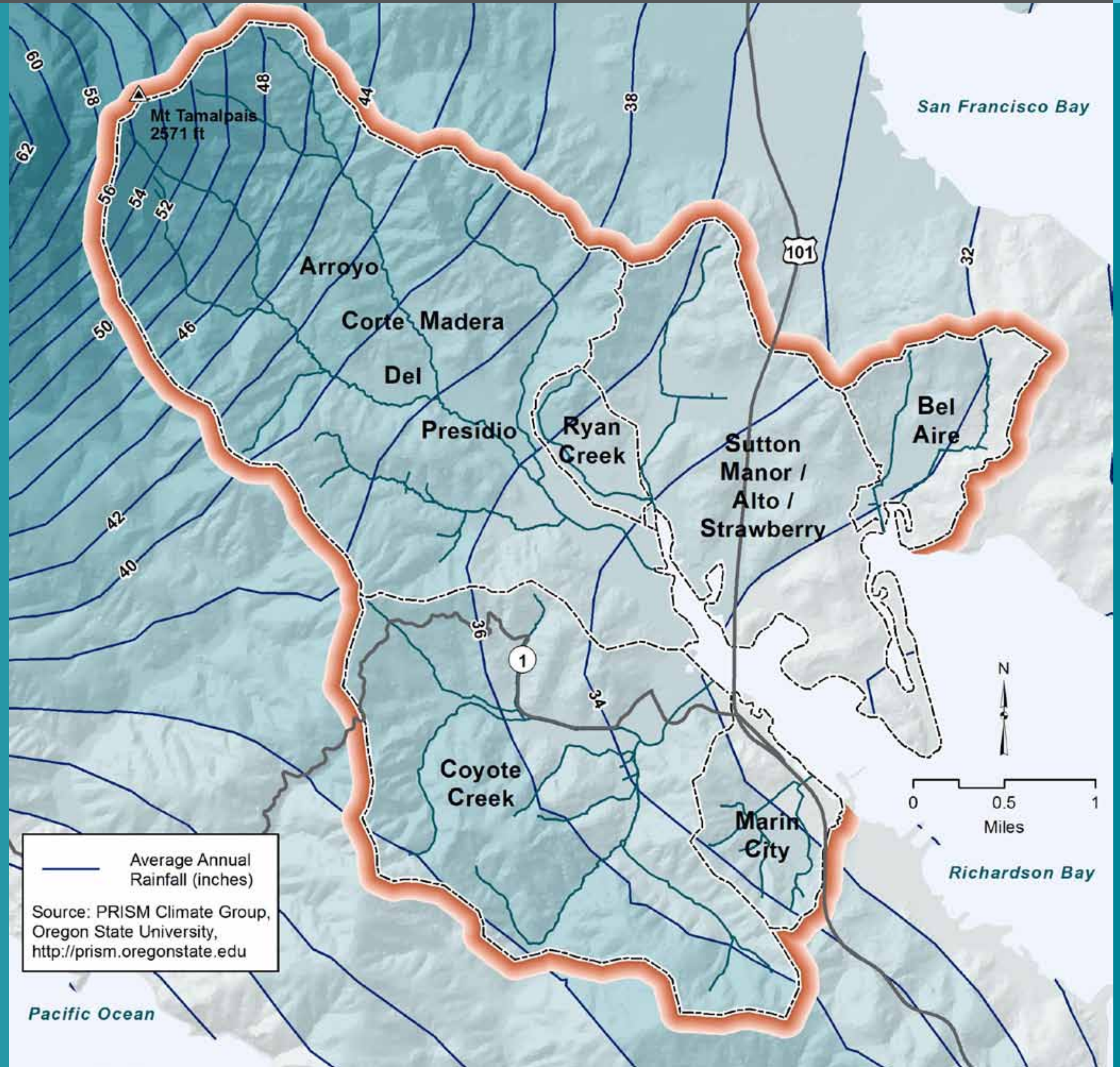
With this introduction to the Southern Marin Watershed, we can begin to understand how and why flooding occurs. Every drop of rain follows a different path downhill. Where it goes depends on how much rain falls, what people have done to modify its route through the watershed, and many other factors. If we understand the causes of flooding, we can begin to address its impacts.

What happens when it rains?

From roughly October to April, Mount Tamalpais and its ridges capture storms off the Pacific. An average of 56 inches of rain falls each year at the summit of Mount Tamalpais. Some of the rain seeps into the ground and emerges hours, days, and even months later. Some rain collects in channels and flows toward Richardson Bay.

Downstream, steep slopes give way to broad, flat valleys. On average, only 32 inches of rain fall each year at the mouth of the watershed but rain from the uplands contributes to the flows on the valley floor. During most rainfall events, waterways remain within their channels or underground pipes until they meet the tidewater of Richardson Bay.





The summit of Mount Tamalpais receives the most rainfall. The watershed is drier at lower elevations near the bay.

What happens when it floods?

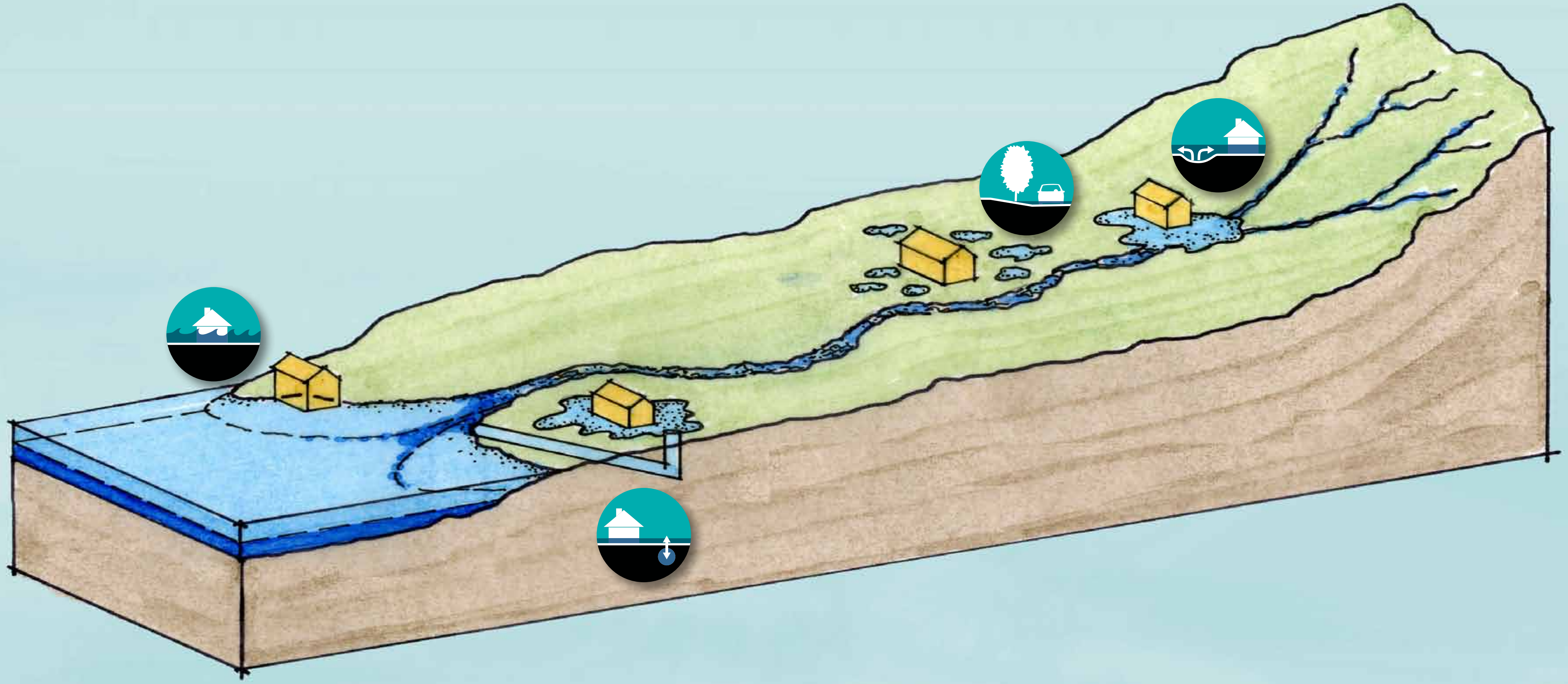
Flood types

TIDAL INUNDATION
Rising tides fill creeks and flood lowlands

Extreme high tide events exacerbate creek or stormwater overflow during storms. High tides can back up stormwater pipes and prevent non-tidal areas from draining. Sea level rise will increase the extent and frequency of tidal inundation.

STORMWATER OVERFLOW
Stormdrains back up

Stormwater drainage systems quickly convey rainwater through underground pipes to creeks and the Bay. When the stormdrains are obstructed or broken or when the creeks that they lead to are already full, water backs up onto the streets.



ISOLATED PONDING
Pools form on the ground

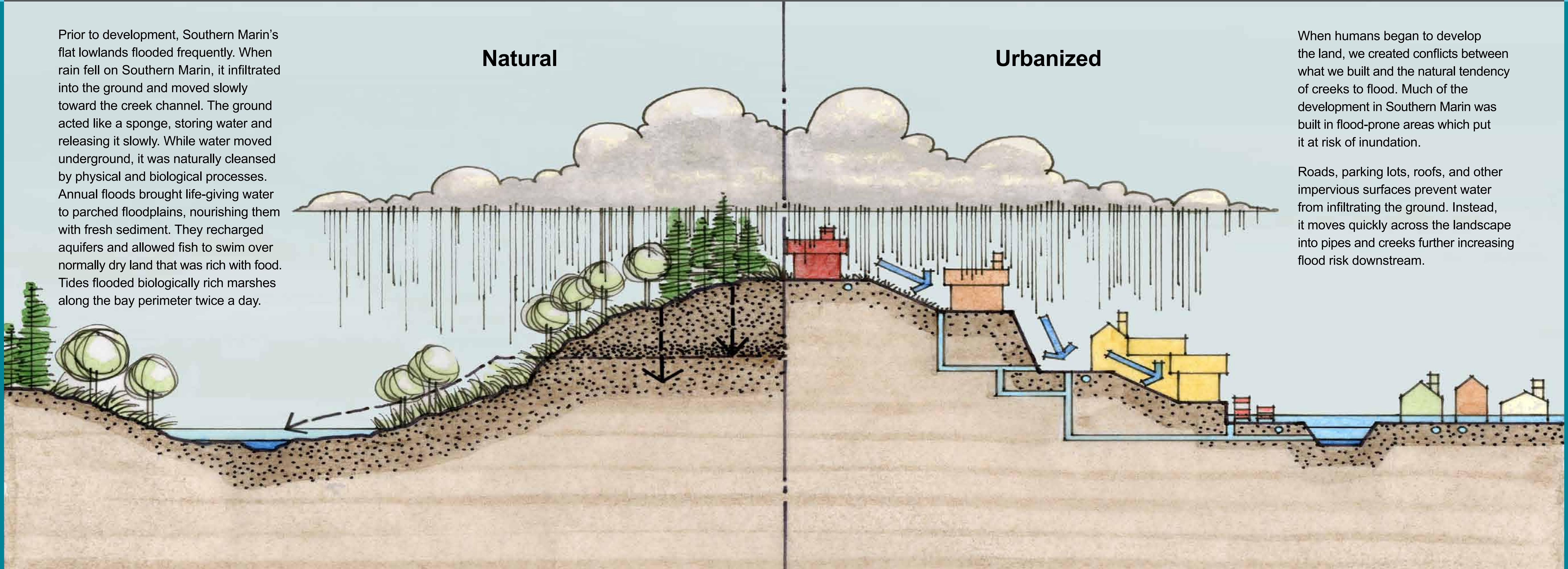
Isolated ponding can occur in any area that doesn't drain effectively – for example, in a natural depression in the landscape.

CREEK OVERFLOW
Creeks spill over their banks

Naturally, waterways regularly overflowed onto an adjacent flood plain. Buildings are now often located on these flood plains. The size and slope of a channel, blockages, proximity to the bay, and constrictions obstructing flow such as bridges, utility pipes, or adjacent buildings all influence the frequency and volume of creek overflow.

How have land use changes impacted flooding?

Prior to development, Southern Marin's flat lowlands flooded frequently. When rain fell on Southern Marin, it infiltrated into the ground and moved slowly toward the creek channel. The ground acted like a sponge, storing water and releasing it slowly. While water moved underground, it was naturally cleansed by physical and biological processes. Annual floods brought life-giving water to parched floodplains, nourishing them with fresh sediment. They recharged aquifers and allowed fish to swim over normally dry land that was rich with food. Tides flooded biologically rich marshes along the bay perimeter twice a day.



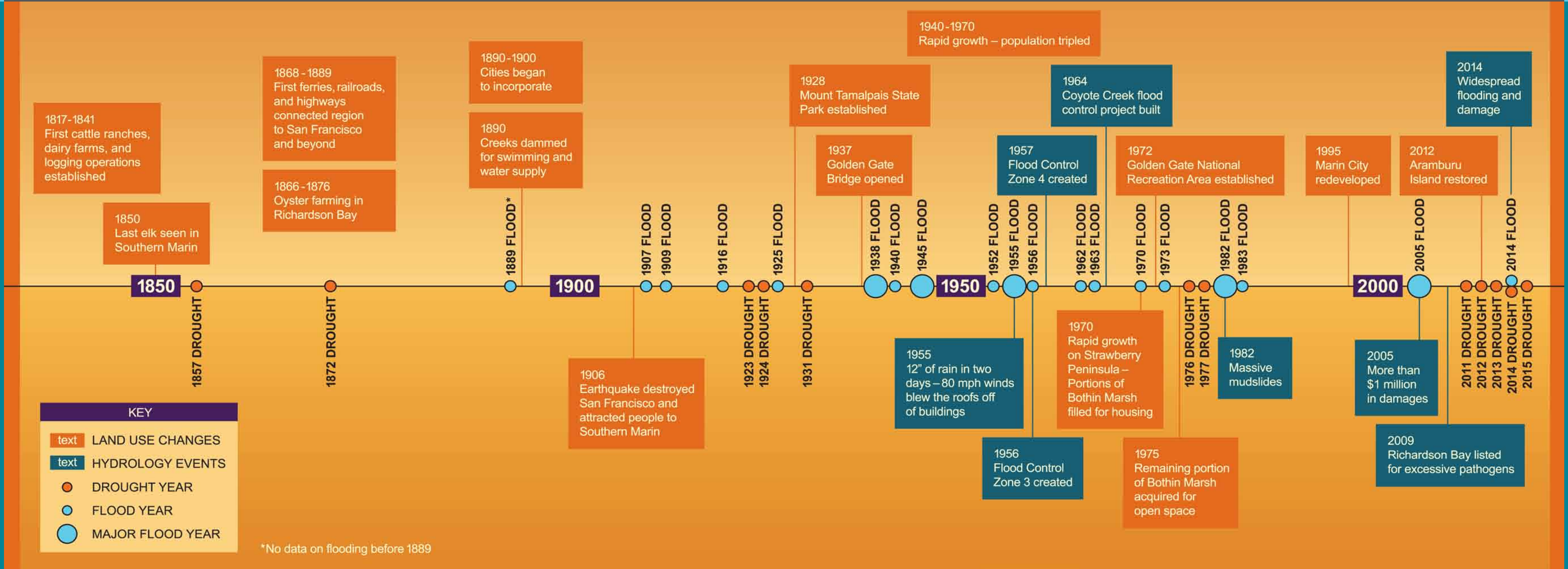
When humans began to develop the land, we created conflicts between what we built and the natural tendency of creeks to flood. Much of the development in Southern Marin was built in flood-prone areas which put it at risk of inundation.

Roads, parking lots, roofs, and other impervious surfaces prevent water from infiltrating the ground. Instead, it moves quickly across the landscape into pipes and creeks further increasing flood risk downstream.

The Southern Marin Watershed is home to 32,000 people, over 200 miles of roads and highways, 150 miles of sanitary sewers/ waterlines, seven sewage treatment districts, one sewage treatment plant, eight pump stations, and 40 miles of stormwater pipes. It is also home to our dwellings, the commercial areas where we gather, the schools we attend, and the creeks, hills, and wildlife we enjoy.

How have land use changes impacted flooding?

Prior to the arrival of the Spanish in 1775, 1,500 to 2,000 Coast Miwok made their home in Southern Marin. The land, creeks, and bay provided fresh water and food sources to sustain the local human population as well as elk and grizzly bears.



How does flooding impact water quality?

Water quality in Southern Marin is impaired by excessive nutrients, pesticides, elevated bacterial levels (such as fecal coliform), sediment from erosion, and sewage spills.

Moving water out to Richardson Bay as quickly as possible can have negative impacts on water quality. Waters that move slowly and have an opportunity to infiltrate can be cleansed by physical and biological processes that naturally occur underground.

The cities and county have stormwater programs to protect water quality. Flood protection must work to improve water quality in ways that are consistent with the mandates of the government agencies and the many water quality requirements in place.

By better managing our floods, we can improve water quality in Southern Marin and Richardson Bay.

Floods can also overwhelm sewage treatment facilities and wash untreated sewage into creeks, stormdrains, and Richardson Bay.

Stormdrains take untreated runoff from the exteriors of our homes and businesses directly to creeks and Bay.

How do climate change and sea level rise affect flooding?

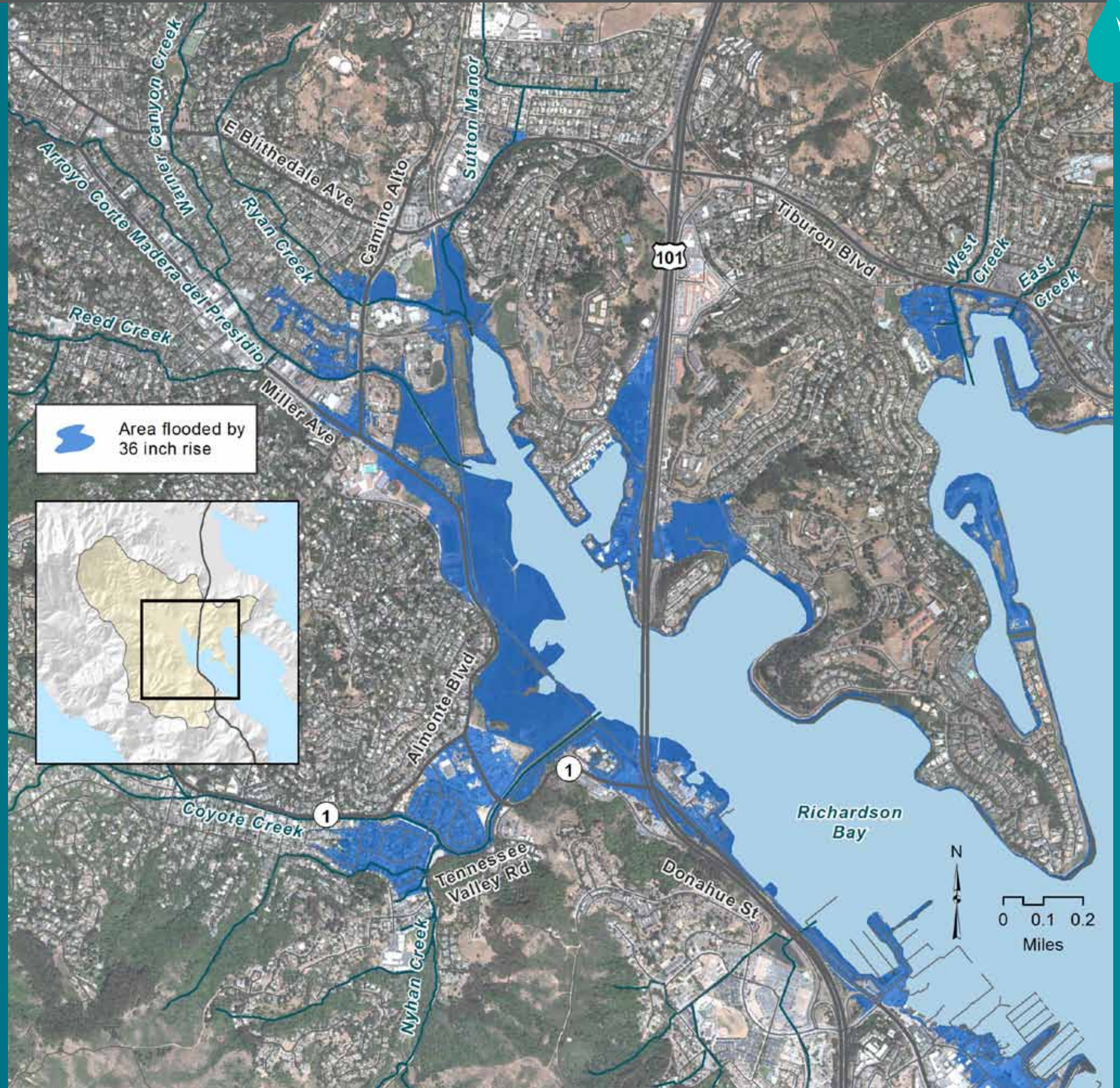
Dealing with flooding from rain and upstream runoff is already complicated. Sea level rise will make it even more complicated by increasing the frequency and duration of flooding.

When water temperature increases, water expands and takes up more space than cold water. As the planet warms, the water in the ocean warms, expands, and elevates sea levels. The changing climate has also melted parts of the ice caps at the North and South Poles. As this ice melts and flows into the ocean, it increases the amount of water in the ocean and raises sea levels even more. Sea levels in San Francisco Bay have risen seven inches over the past century.

Predictions of future sea level rise vary from 12 inches by 2030 to 60 inches by 2100. The Bay Conservation and Development Commission (BCDC) recommends using 36 inches of sea level rise for planning purposes.

Rising sea levels increase the upstream extent of tidal flooding, worsen creek overflow due to backwater effects of elevated high tides, and create larger, stronger waves which erode the shoreline and destroy sensitive marshes. Coastal flooding will have a large impact on cities and habitat.

A 36-inch increase in sea levels will greatly impact people’s lives throughout Southern Marin. Daily high tides will inundate major thoroughfares, schools, retirement communities, private homes, shopping areas, bike paths, and stormwater detention ponds. Valuable marsh and mudflat habitat will be permanently flooded. Infrastructure will need to be armored, abandoned, or relocated. Shorelines will be eroded by increased wave erosion, threatening even more infrastructure.



Reducing Flood Risk

With an understanding of how and why flooding occurs, we can take a closer look at how to reduce flood risk.

How can we protect ourselves from flooding?

There are many ways to reduce flood risk. Generally, multiple strategies are employed simultaneously. Possible approaches depend on the type of flooding, the physical setting, cost-benefit considerations, available funding, legal and permitting implications, and the support of the local community.

Away from the Channels

Hold Back Stormwater

Stormwater detention in basins or vaults captures stormwater before it enters the creek and releases it slowly to reduce downstream flooding. Finding the space for stormwater detention facilities can be difficult and expensive in urban areas.

PHOTO: A. VOLKENING

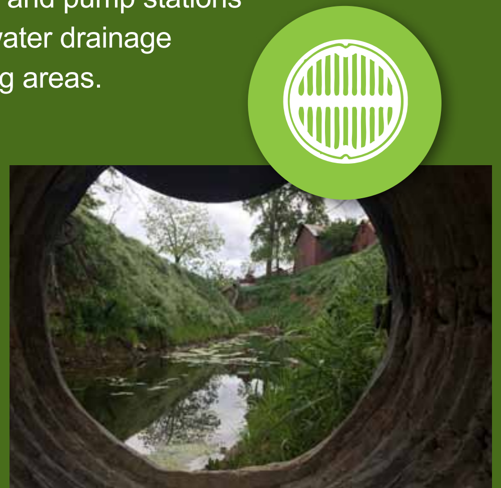
Stormwater Bypass

Stormwater pipes or channels bypass water from flood prone areas to a location downstream. New pumps and/or tide gates may be required depending on where the bypass flood waters are discharged.

Pipe Stormwater Underground

Conveying stormwater in underground pipes creates space for streets, homes, and other urban features. Well-maintained pipes may quickly move water downstream but underground infrastructure can be difficult to inspect and troubleshoot. Over time, land settles and pipes age, clog, and break. Downstream tides or flooding limit how fast water is able to exit the drainage pipe, so larger pipes do not necessarily improve drainage. Many stormwater pipes are located on private property.

Regular inspections, pipe flushing, repair, and eventual replacement of old or failed pipes are all necessary to reduce the risk of stormwater overflow. Tide gates and pump stations can improve stormwater drainage efficiency in low-lying areas.



Raise or Flood-Proof Buildings out of the Floodplain

Structure elevation is a reliable flood risk reduction strategy. It can be expensive and must be weighed against the expected damage and frequency of flooding to get a true picture of the costs and benefits. While it may raise a building above floods, it does not necessarily improve access from that building to nearby roads and resources that may be underwater or cut off by flooding.

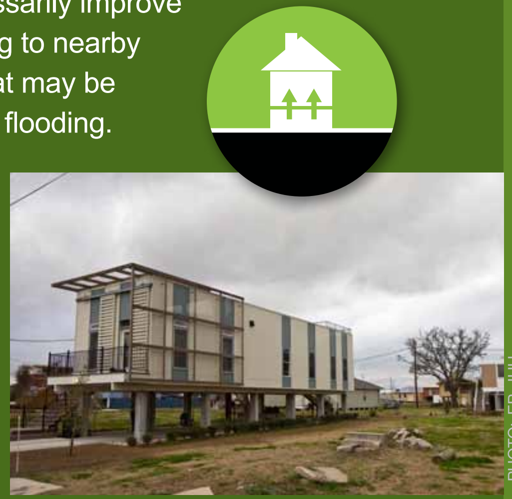


PHOTO: EP_JHU

How can we protect ourselves from flooding?

In and Along the Channels

Creek Maintenance

Vegetation trimming and targeted sediment removal within creeks and channels can help reduce flood risk, although the benefits can be short-lived. Creek maintenance is typically performed annually. Excessive vegetation or sediment removal can harm wildlife, water quality, and bank stability.

Increase Creek Flow Capacity

By replacing bridges or utility crossings, increasing the size of culverts, or widening the creek channel, we can increase the amount of water that can flow in a channel during floods. It can also provide space for habitat and promote bank stability. It is expensive because creek widening is constrained by buildings, roads, and property lines.

Stabilize Channels

Stabilizing creek banks and channel bottoms reduces erosion, stabilizes habitat, and protects infrastructure. This activity includes vegetating eroding slopes with native plants and sometimes re-grading bank slopes. Depending upon the location of infrastructure, the strategic placement of rocks, wood and/or installation of an engineered structure may be required to stabilize the creek banks.

Levees and Floodwalls

Levees and floodwalls constructed alongside the creek or bay confine floodwaters. While effective, levees and floodwalls must be contiguous throughout the area of flooding, require space and material, and may require pump stations and drainage pipes to move water over or through them and into creeks.

Habitat Enhancement and Restoration

Habitat enhancement and restoration to improve habitat for flora and fauna while reducing flood risk. Projects that remove obstructions to flow or allow flood waters to be absorbed by wetlands can reduce flood risk and improve critical habitat. Closer to the bay, strategic wetland restoration can absorb floodwaters and reduce the impact from storm-related waves.

How can we protect ourselves from flooding?

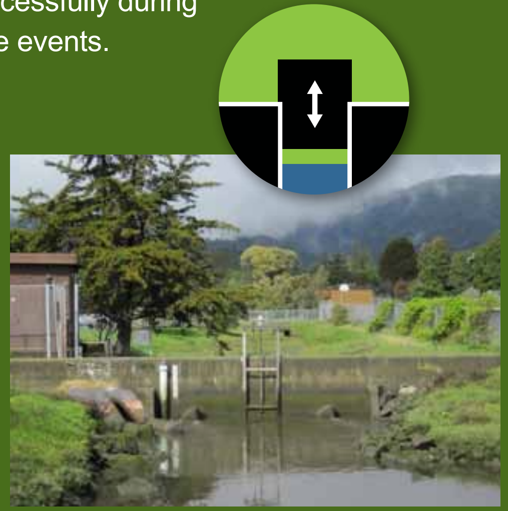
Near the Mouth of the Channels

Pump Stormwater from Low-lying Areas to Creeks

In the baylands, the District operates eight pump stations to move water out of low-elevation neighborhoods constructed on former marshlands. Rainfall from these areas drains to a point lower than the adjacent levees or creeks. Large pumps move ponded water into adjacent creeks where it can drain to the bay. Opportunities may exist to increase pumping capacity at currently-operated pump stations. Pumps are effective at protecting low-lying areas but they are expensive, require regular maintenance, and consume a lot of energy.

Block tides

Adjustable tide gates can extend across channels or attach to outfalls of stormdrain pipes that drain to creeks and channels. They are designed to keep tidal waters out of the stormdrain system during high tides and protect low-lying areas. They are prone to being stuck open by debris and require regular maintenance. Larger gates are manually operated increasing the burden to deploy them successfully during forecasted high tide events.



	Away from the Channels				In and Along the Channels					Near the Mouth of the Channels	
	Hold Back Stormwater	Stormwater Bypass	Pipe Stormwater Underground	Raise Buildings	Creek Maintenance	Increase Creek Flow Capacity	Stabilize Channels	Levees and Floodwalls	Habitat Restoration	Pump Stormwater	Block Tides
Costs											
Requires Right-of-Way	✓	✓	✓					✓	✓		
Requires Ongoing Maintenance		✓	✓		✓			✓		✓	✓
Benefits											
Environmentally Sustainable	✓			✓	✓	✓	✓	✓	✓		
Responsive to Sea Level Rise				✓					✓		
Improves Habitat						✓	✓		✓		
Improves Water Quality						✓	✓		✓		
Can be Implemented by Home Owners	✓[1]			✓					✓		

1. Small-scale retention on individual parcels

Who is responsible for flood risk reduction?

Everyone has a role to play. The "Whole Community" approach to flood risk reduction requires communities and government agencies to work together to understand, assess, and identify flood risk reduction needs and solutions. The collaboration and shared understanding creates communities more resilient to flooding and better able to adapt and respond when floods occur.

The Marin County Flood Control and Water Conservation District (District) maintains 3.6 miles of channels (17% of the total channel length) and related flood control infrastructure in the Southern Marin Watershed. Maintenance activities include regular servicing of eight pump stations, multiple tide gates, miles of levees and drainage ditches, and an annual vegetation maintenance program. Work is limited to areas where the District has permission to perform maintenance – on its own lands or where it has acquired easements.

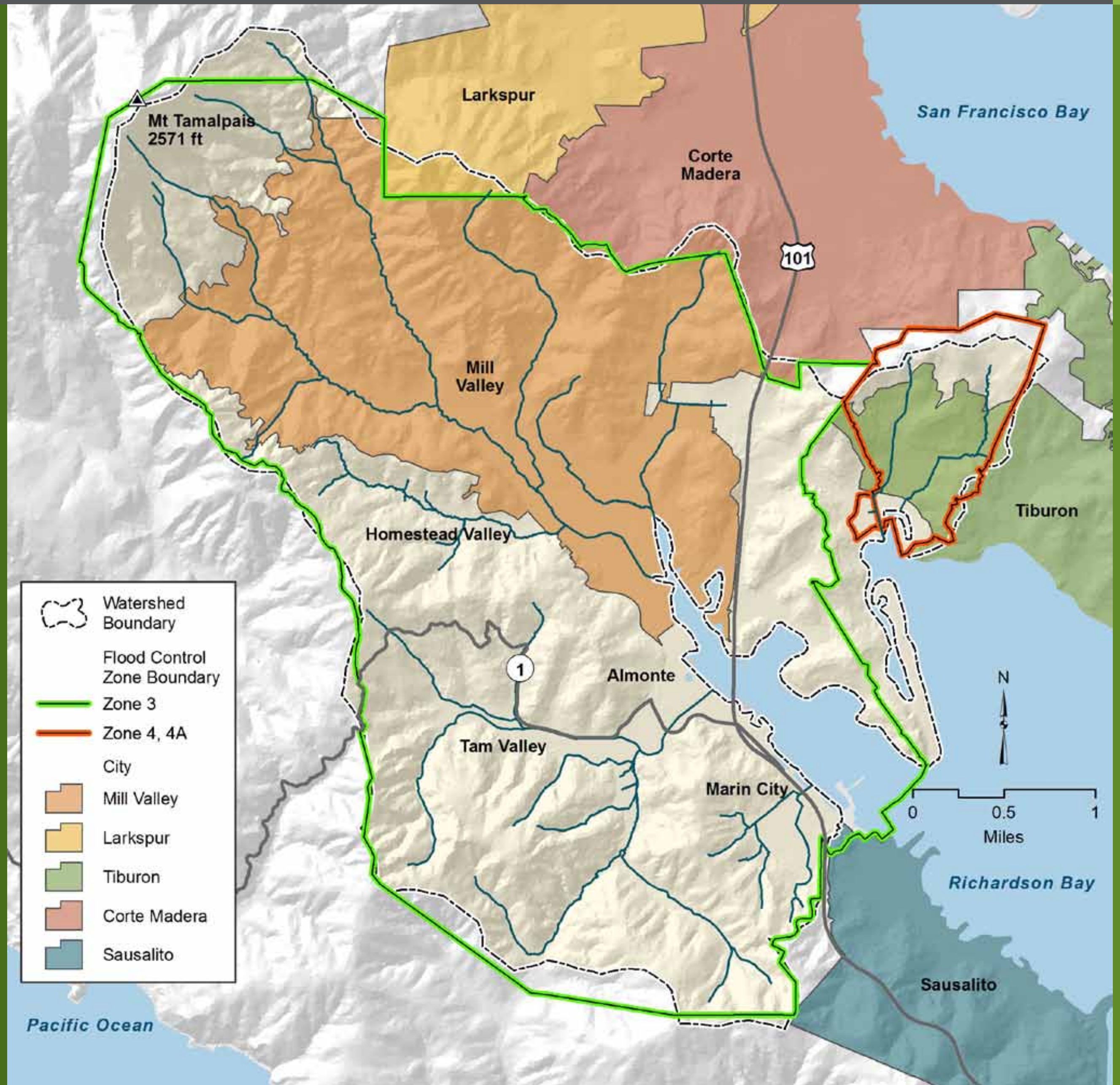
Two "Flood Control Zones" partner with municipalities and other agencies to provide flood risk reduction in Southern Marin. The District Board of Supervisors established Flood Control Zone 3 in 1956 and Flood Control Zone 4 in 1957.

Each zone has an advisory board of residents who are appointed by the District Board of Supervisors. The zones have authority to construct, operate, and maintain stormwater basins, levees, pumping stations, culverts, drainage ways, and creeks.

Property and special taxes (if approved by a majority of voters) support work in Zones 3 and 4. All revenues in the District are collected through the zones and must be spent in the zone providing the funding. The annual work program is coordinated by the zone engineer and the budget for the work program is reviewed annually by the advisory board prior to being adopted by the District Board of Supervisors.

Within the Mill Valley city limits, the City and Zone 3 share some responsibilities for reducing flood risk. The City of Mill Valley operates one pump station, numerous tide gates, and partners with Zone 3 to maintain some of the creeks. Roadways and underlying drains are regularly inspected and maintained by the City.

Within Tiburon town limits, the Town and Zone 4 share some responsibilities for flood protection. Roadways and underlying stormdrains within the public right of way are regularly inspected and, in incorporated areas, are maintained by the Town. Many of these stormdrains convey flow into stormwater pump stations which are operated and maintained by Zone 4.



Flood control zone map with subwatersheds and city/town boundaries

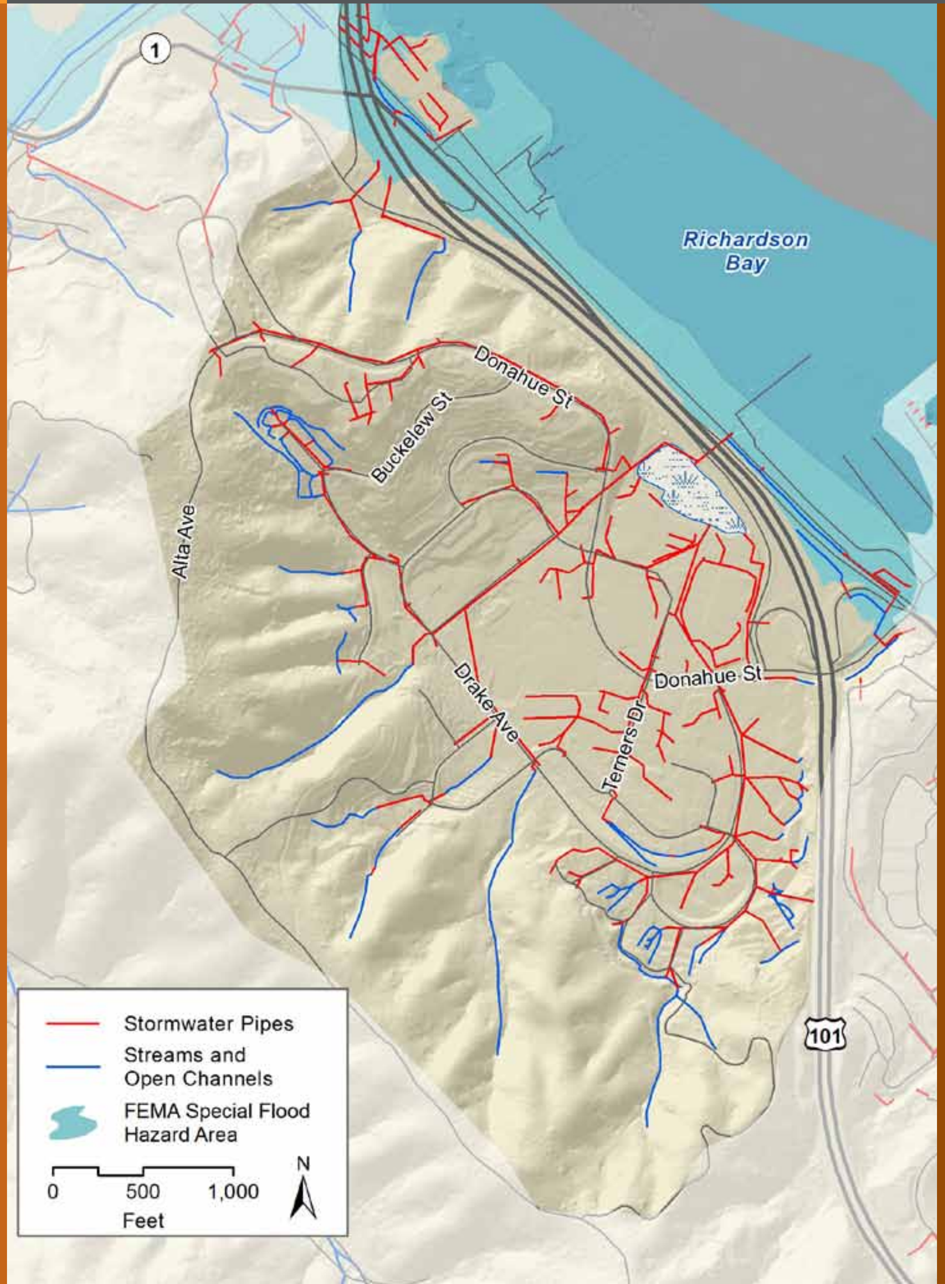
What Can Be Done in Your Watershed?

What causes flooding and what can reduce flood risk varies between subwatersheds in Southern Marin.

Marin City Watershed

Watershed Facts

Size: 0.6 square miles
Population: 2,754
Creek Length:
2.4 miles
% of Creek Maintained by District: 0%



The Marin City watershed is the southernmost sub-watershed and consists mostly of the unincorporated community of Marin City.

Before the Second World War, the small, bowl-shaped watershed was home to a dairy farm. During World War II, Marin City was developed to house workers for the nearby shipyards.

The National Park Service owns most of the upper watershed. The lower watershed is a mix of housing and commercial development.

Small channels drain the steep hillsides into a densely populated valley floor. As the channels meet the developed areas, they enter underground stormdrain pipes which converge in a small marsh (Marin City Pond) between the Gateway Center and Highway 101. Water levels in the pond can be manipulated by a manually controlled tide gate that drains into Richardson Bay. A second tide gate on the southeast side of the marsh controls drainage between the marsh and the Highway 101 off-ramp.

Challenges

Valley Floor

Creek overflow: Trash racks in small channels collect debris and help reduce blockage of downstream pipes. However, debris caught by the trash racks can block flow and flood the surrounding area. The channel, trash rack, and stormwater drain lie outside of the public right-of-way. The lack of regular debris clearing, inspection, and maintenance, and the dumping of debris in the channels all exacerbate flooding.

Baylands

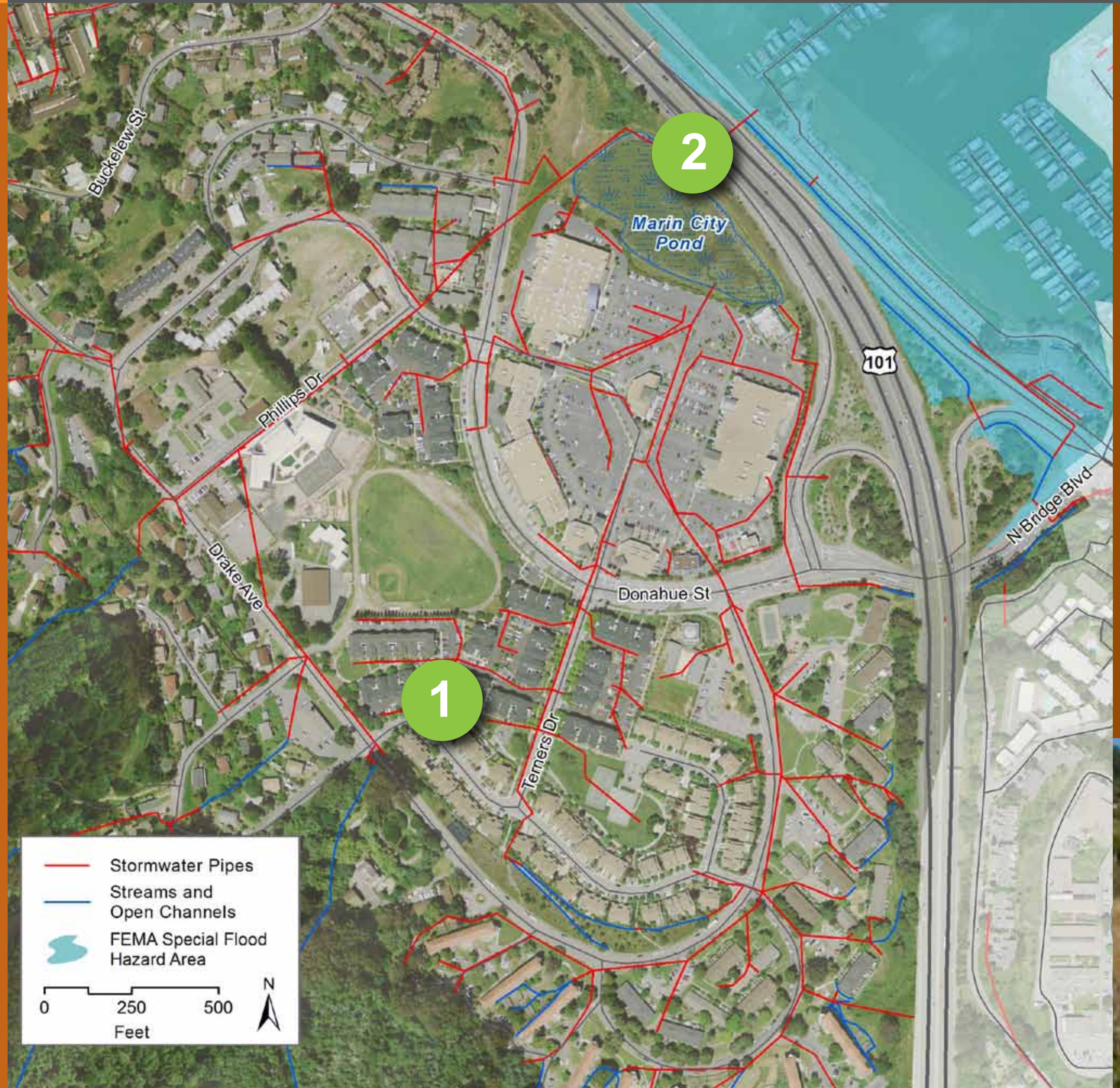
Isolated ponding: The lands in the lower watershed are former tidal marshes and have subsided. This impairs drainage, creates depressions, and causes localized ponding. The old bay shoreline which extended to Drake Avenue has been filled repeatedly, but the former bay mud beneath homes and the shopping center continues to subside.

Tidal inundation: The Marin City Pond collects water from stormwater pipes and the drainage to the bay can be limited by high tides.

Marin City Watershed

Goals

- Reduce stormwater ponding on roadways
- Improve water quality at Marin City Pond
- Reduce frequency of stormwater flooding
- Increase public safety and emergency access



Possible improvements

1 Valley Floor

Creek maintenance

- Regularly inspect and clean the channels upstream and the stormdrains downstream of the trash rack

Pipe stormwater underground

- Assess stormdrains to determine existing capacity
- Replace storm drain pipes based on the findings of the assessment

2 Baylands

Pipe stormwater underground

- Inspect and clean the stormdrains and water quality control device to determine condition
- Identify possible pipe replacement needs
- Replace pipes based on the findings of the inspection

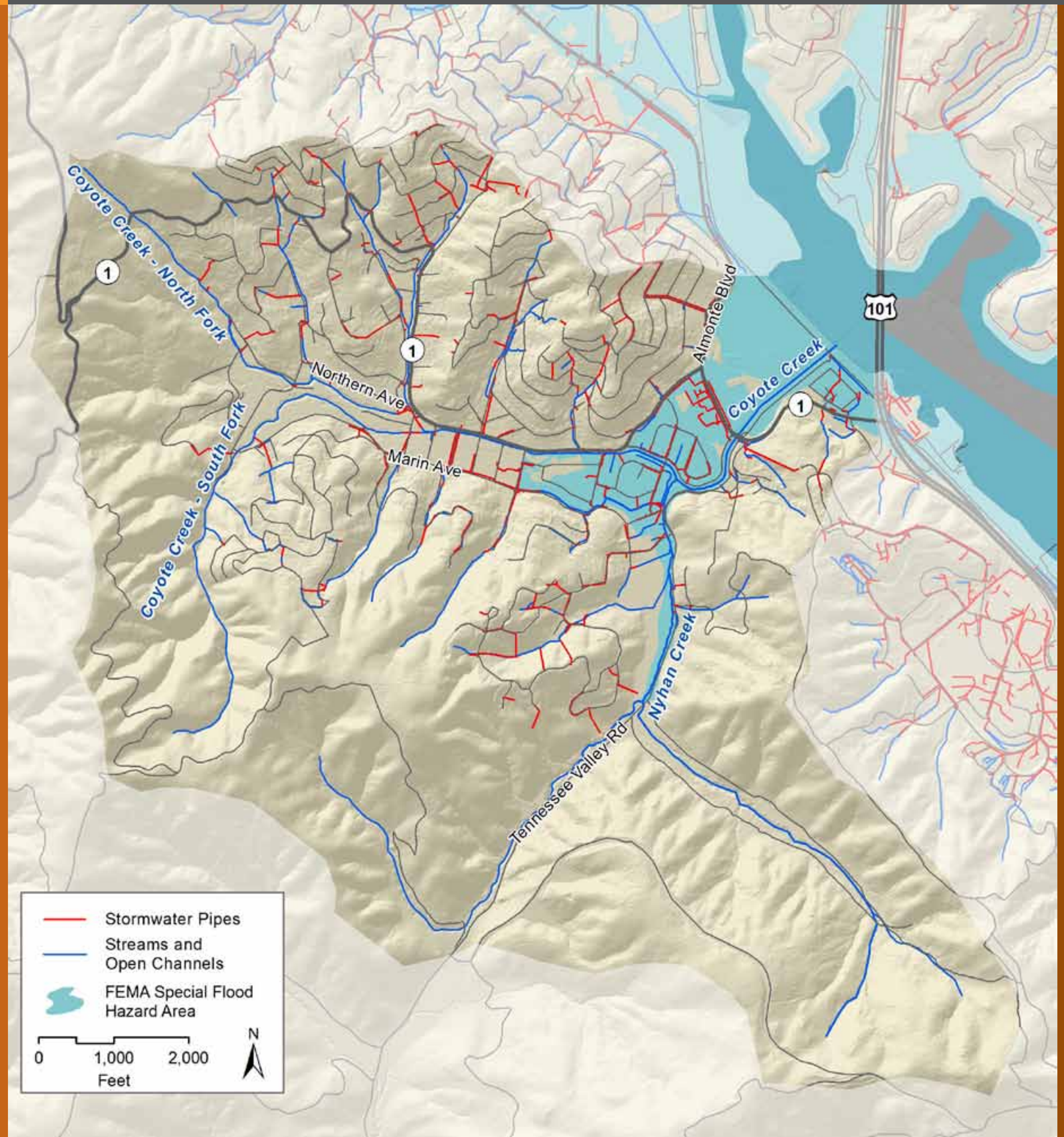
Pump stormwater

- Design and construct a new stormwater pump station

Habitat restoration

Watershed Facts

Size: 3.6 square miles
Population: 6,787
Creek Length: 14 miles
% of Creek Maintained by District: 11%
Creeks:
Coyote Creek,
Nyhan Creek,
Oakwood Valley Creek
Flood Control Facilities:
Coyote Creek Flood Control Channel
Coyote Creek Levees
Cardinal Road Pump Station
Crest Marin Pump Station
Shoreline Pump Station



Coyote and Nyhan Creeks capture and convey stormwater runoff from the steep upper watershed and valley floor, and join a half mile from the bay in a flat lowland that was formerly tidal marsh.

The National Park Service owns much of the uplands. On the valley floor, the 2-acre Tennessee Valley Marsh next to the Tamalpais Valley Elementary School is the largest freshwater marsh in the Southern Marin Watershed. In the baylands is the 106-acre Bothin Marsh Open Space Preserve - home to several sensitive species including Ridgway's rail and the hirsute Point Reyes bird's beak plant.

In an effort to reduce frequent flooding, the U.S. Army Corps of Engineers completed the Coyote Creek Flood Control Project in the 1960s. The project involved the construction of a concrete channel and earthen levee and was handed over to the District for ongoing operation and maintenance.

Challenges

Valley Floor

Much of the low-lying area of Tam Valley was developed by filling tidal marshes and creeks. Stormwater runoff was collected in a series of stormdrains and discharged directly to the creek. Flap gates on the end of the stormdrain pipes helped prevent high creek flows and tides from flowing back up the stormdrain system and into the nearby neighborhoods. In the 1960s, the Coyote Creek Flood Control Project helped reduce the occurrence of creek overflow and tidal inundation in Tam Valley. In the 1970s and 1980s, the addition of stormwater pump stations and floodwalls also helped reduce flood risk.

Isolated ponding: As Tam Valley's low-lying areas continued to subside, the effectiveness of the drainage system decreased. Depressions filled with stormwater and caused localized ponding. To address this, three pump stations were constructed between 1977 and 1985 and subsequently upgraded. Continued maintenance is needed to ensure that the pump stations continue to function as subsidence continues in the valley.

Creek overflow: The flood control facilities require frequent maintenance to address continued settlement of the levees, aging culverts and floodwalls, impeding vegetation, unauthorized encroachments, and sediment accumulation.

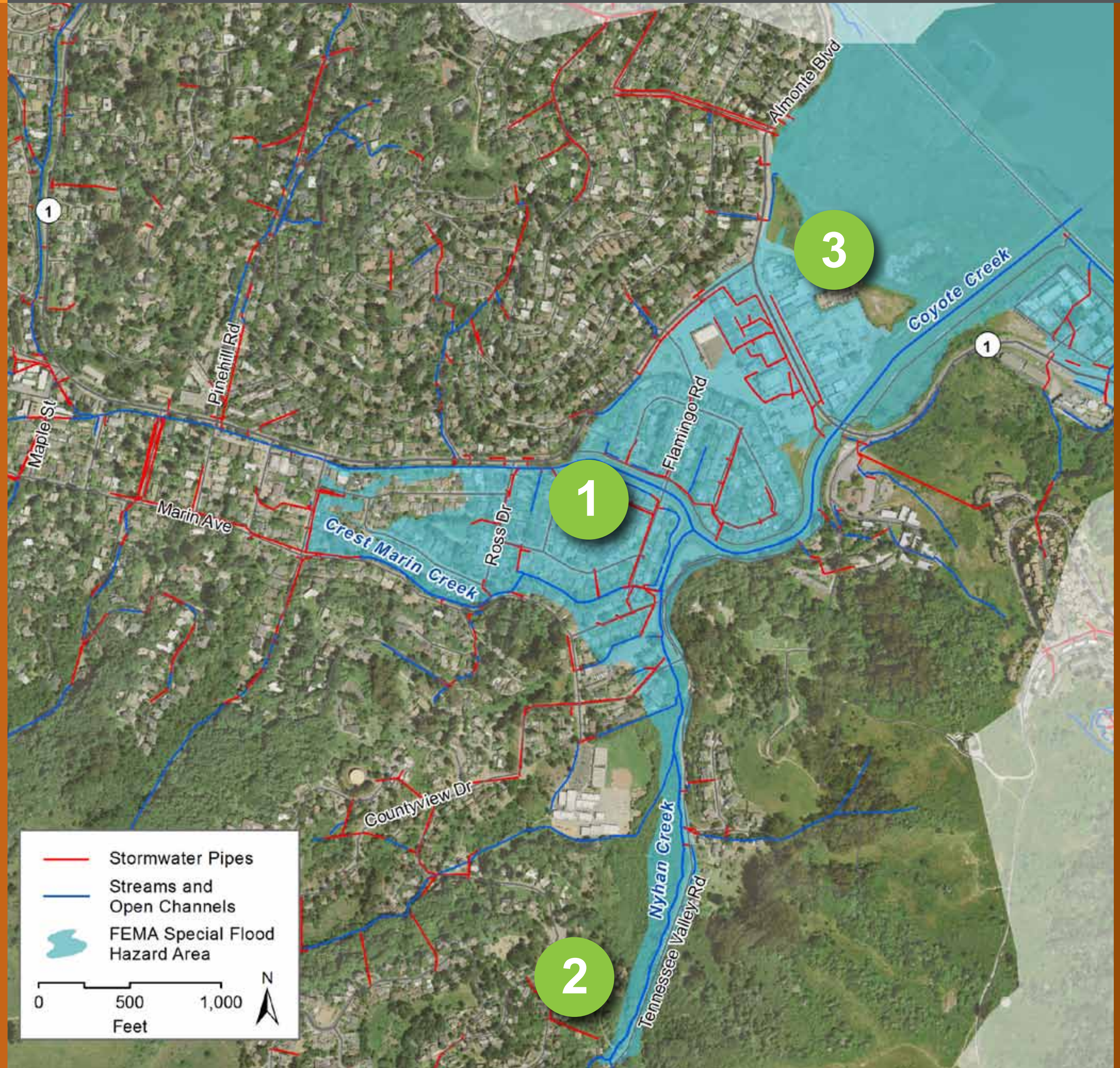
Baylands

Tidal inundation: High tides regularly flood the area east of Shoreline Highway. Originally, a portion of the Coyote Creek Flood Control Project extended downstream past Shoreline Highway, but the development of the lands behind the levees was never realized and the majority of the levee was not maintained to its original design elevation. Tidal flooding impacts several businesses and leads to closure of the Shoreline Highway, CalTrans' Manzanita Park-and-Ride lot, and the Mill Valley-Sausalito Pathway.

Coyote Creek Watershed

Goals

- Reduce the risk of stormdrain overflow and stormwater ponding in Tamalpais Valley
- Reduce the risk of creek overflow
- Reduce risk of tidal flooding
- Enhance and restore tidal and freshwater marsh and creek habitat



Possible improvements

1 Valley Floor

- Pump stormwater (create new and/or increase capacity of existing)
- Levees and floodwalls (create new and/or increase height of existing)
- Creek maintenance

2

- Habitat restoration at Tennessee Valley marsh

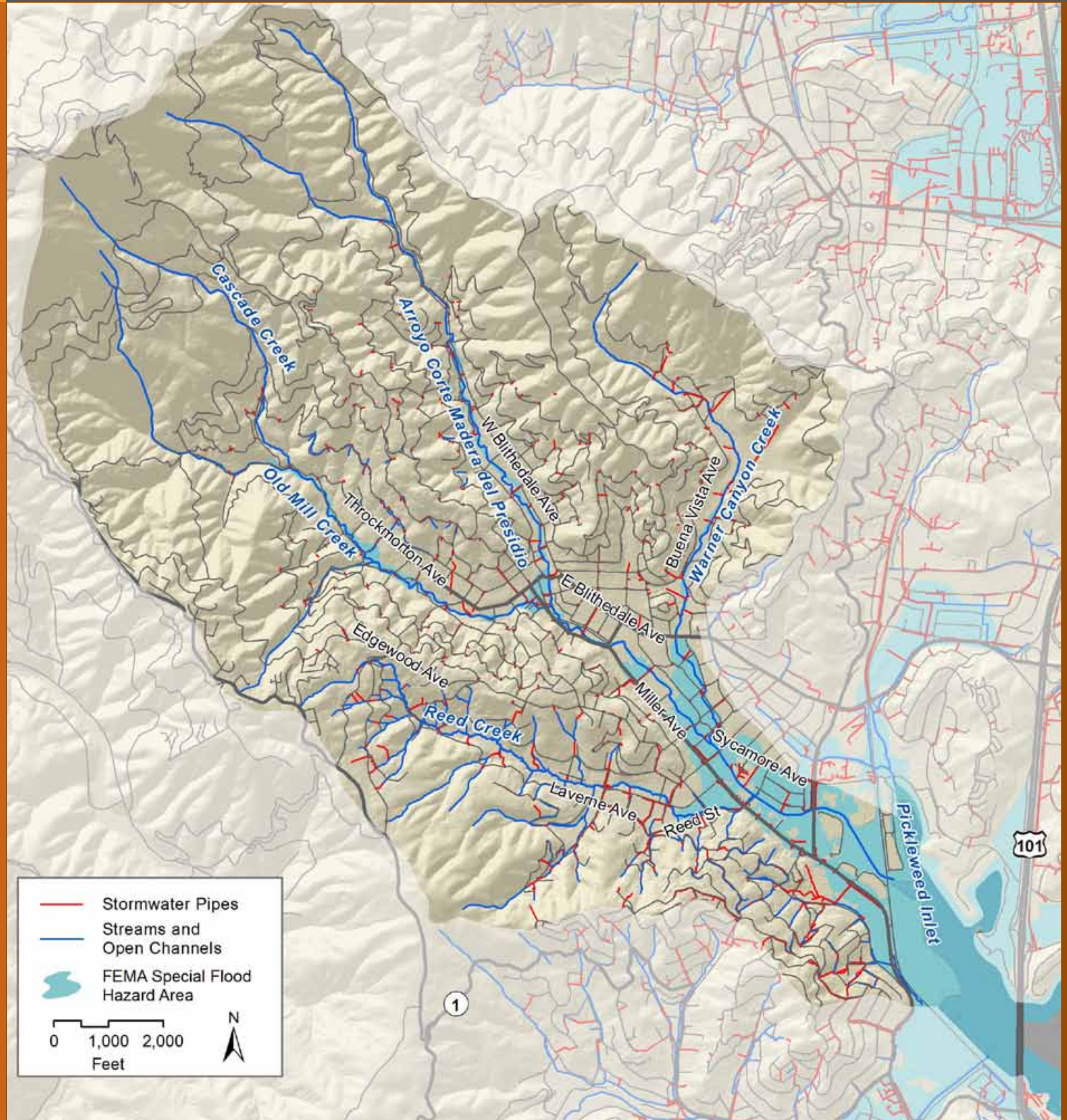
3 Baylands

- Habitat restoration
- Levees and floodwalls

Arroyo Corte Madera del Presidio Watershed

Watershed Facts

Size: 6.0 square miles
Population: 13,305
Creek Length: 29 miles
% of Creek Maintained by District: 4%
Creeks:
Arroyo Corte Madera del Presidio
Cascade Creek
Old Mill Creek
Warner Canyon Creek
Reed Creek
Flood Control Facilities:
Sycamore Pump Station



The Arroyo Corte Madera del Presidio subwatershed drains from the summit of Mount Tamalpais to Pickleweed Inlet on the Richardson Bay. In Spanish, the name means *the creek where wood is cut for the Presidio.* In 1836, the first saw mill began operating. By the late 1800s, the area had developed first as a summer retreat and later as a town with bridges, dams, local water supply, and houses along the creeks.

Today, Arroyo Corte Madera del Presidio, Cascade, Old Mill, Reed, and Warner Canyon Creeks drain the mostly forested uplands. Along the urbanized valley floor, buildings, roads, and infrastructure confine the creek to a narrow channel. Tidal marshes, which once extended well past Camino Alto are now limited to the perimeter of Pickleweed Inlet.

Challenges

Uplands

Creek overflow: Drainages in the upper watershed generally consist of steep, open channels with culverts placed at roadway crossings. Culverts on private property or protected public lands may not receive regular maintenance to ensure that water can pass freely through them.

In addition to the flood problems, Arroyo Corte Madera del Presidio has a number of fish barriers preventing upsteam passage for steelhead trout to their spawning grounds.

Valley Floor

Creek overflow: Arroyo Corte Madera del Presidio has flooded homes and businesses several times over the past century. The creek can spill over its banks at relatively low flows.

Stormwater overflow: Results from undersized stormdrains, differential settlement of inlets and pipes, high tides, and debris-choked pipes.

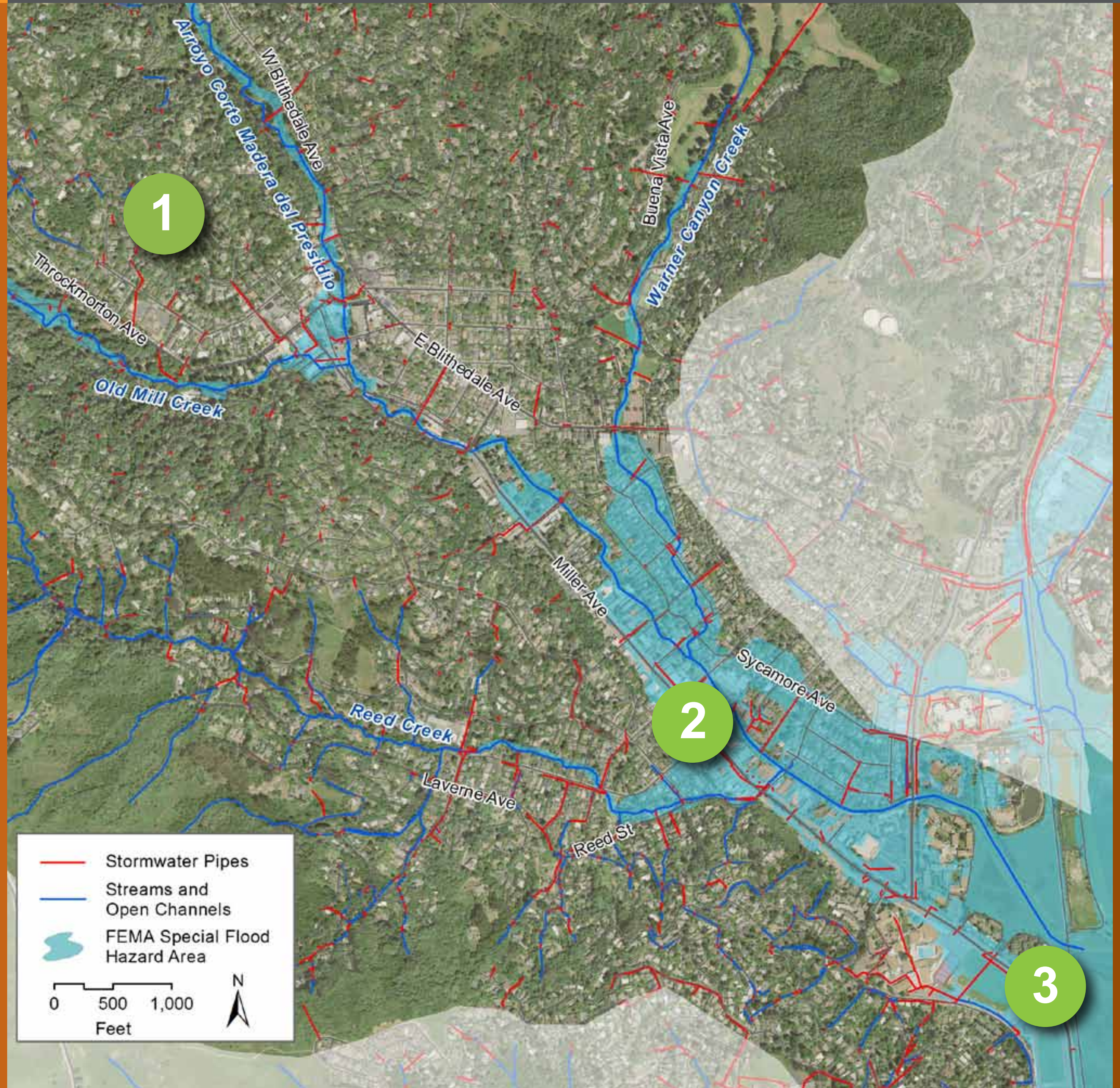
Tidal inundation: Extreme high tides can inundate low-lying areas near the shoreline. These parks, wastewater treatment facilities, commercial developments, roads, sewer, water and electrical utilities that serve all residents of the watershed may require protection, adaptation, and/or relocation.

Isolated ponding: Occurs in areas lacking stormdrains.

Arroyo Corte Madera del Presidio Watershed

Goals

- Reduce the frequency and severity of storm-drain overflow and stormwater ponding
- Reduce the frequency and severity of creek overflow within the upper Arroyo Corte Madera del Presidio Watershed, Cascade Creek, Old Mill Creek, Reed Creek, and Warner Canyon Creek sub-watersheds
- Reduce frequency and severity of creek overflow within the valley floor
- Reduce frequency and severity of direct tidal inundation



Possible improvements

1 Uplands

- Increase creek flow capacity
- Raise/flood-proof buildings out of floodplain
- Stabilize channel
- Habitat restoration

2 Valley Floor

- Pipe stormwater underground
- Levees and floodwalls
- Increase creek flow capacity
- Hold back stormwater
- Stormwater bypass
- Stabilize channel
- Raise/flood-proof buildings out of floodplain
- Habitat restoration – fish passage

3 Baylands

- Levees and floodwalls
- Pipe stormwater underground
- Habitat restoration

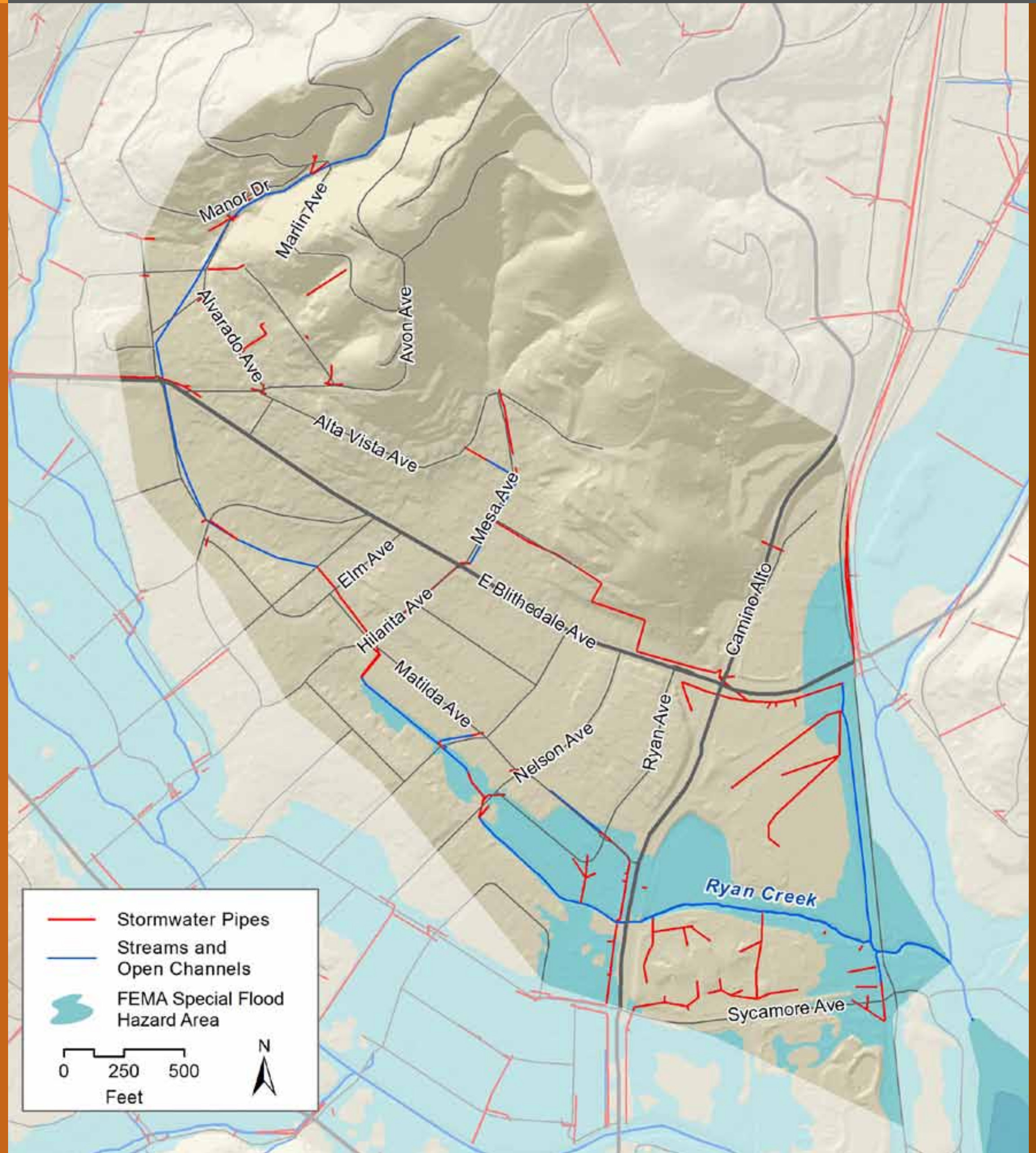
Watershed-wide

- Creek maintenance
- Pump stormwater

Ryan Creek Watershed

Watershed Facts

Size: 0.31 square miles
Population: 1,391
Creek Length:
1.3 miles
% of Creek Maintained by District: 1%
Creeks:
Ryan Creek
Flood Control Facilities:
Ryan Creek Pump Station



Ryan Creek only flows after storms and is practically unrecognizable as it moves through a series of ditches, culverts, and pipes in the neighborhood south of Blithedale Avenue and east of Camino Alto. Downstream of Nelson Avenue, Ryan Creek conveys flows in an open channel which is interrupted by short culverted sections at Camino Alto and two pathways at the Mill Valley Middle School. At the edge of the school, stormwater enters the intake of the Ryan Creek Pump Station where it is pumped into Richardson Bay. A concrete tidal barrier wall at the pump station equipped with a manually operated tide gate regulates tides within the creek.

Challenges

Valley Floor

Isolated ponding: The lack of extensive stormdrains to move stormwater results in ponding and, during intense rainfall, uncontrolled runoff flowing down gutters and streets.

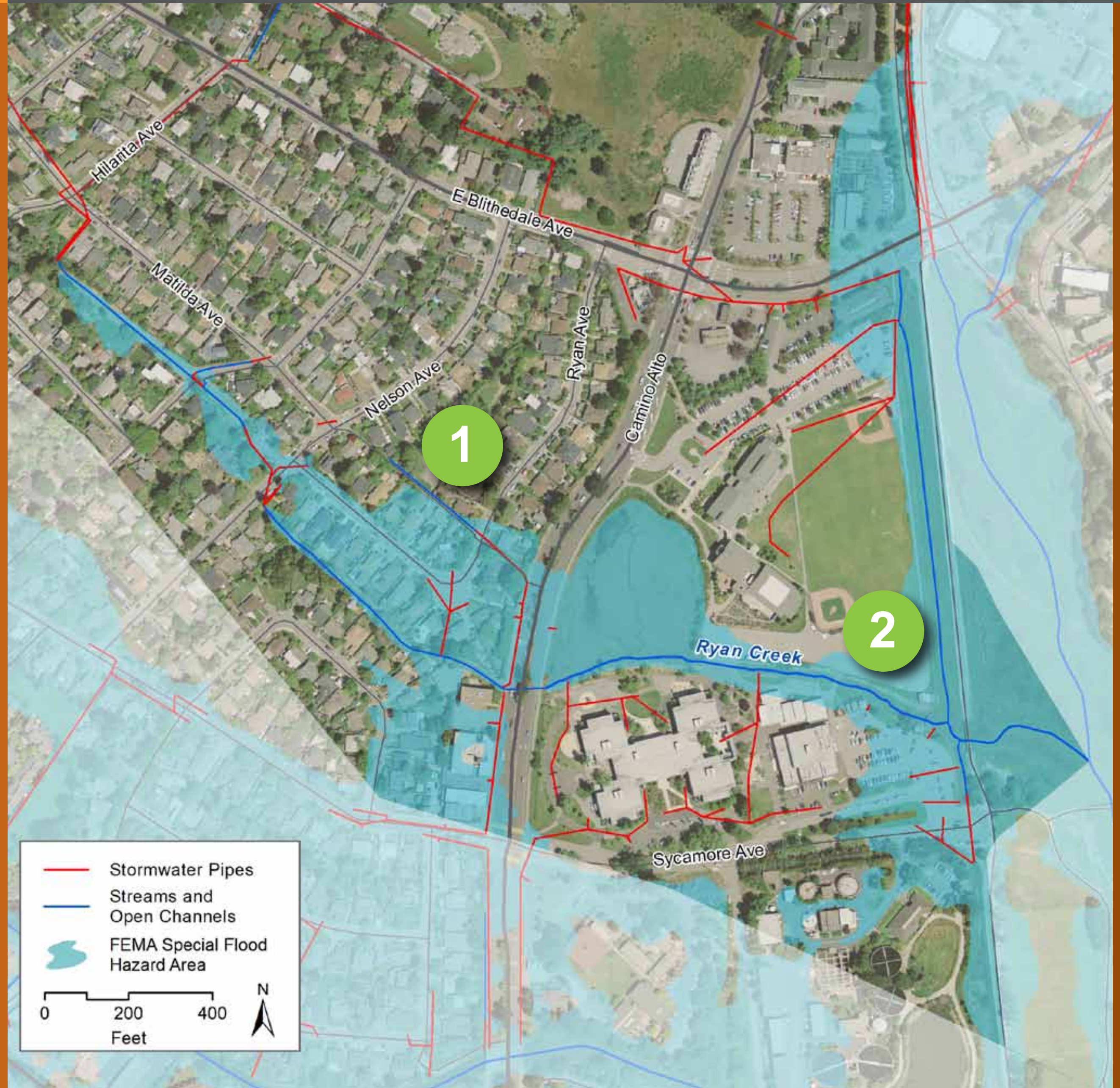
Baylands

Tidal inundation: Some stormdrain outfalls in tidally influenced portions of the creek are not equipped with tide gates. Low-lying areas upstream of these outfalls may be susceptible to tidal flooding.

Ryan Creek Watershed

Goals

- Reduce the frequency and severity of storm-drain overflow and stormwater ponding
- Reduce the frequency and severity of direct tidal inundation



Possible improvements

1 Valley Floor

- Pipe stormwater underground
- Levees and floodwalls
- Habitat restoration

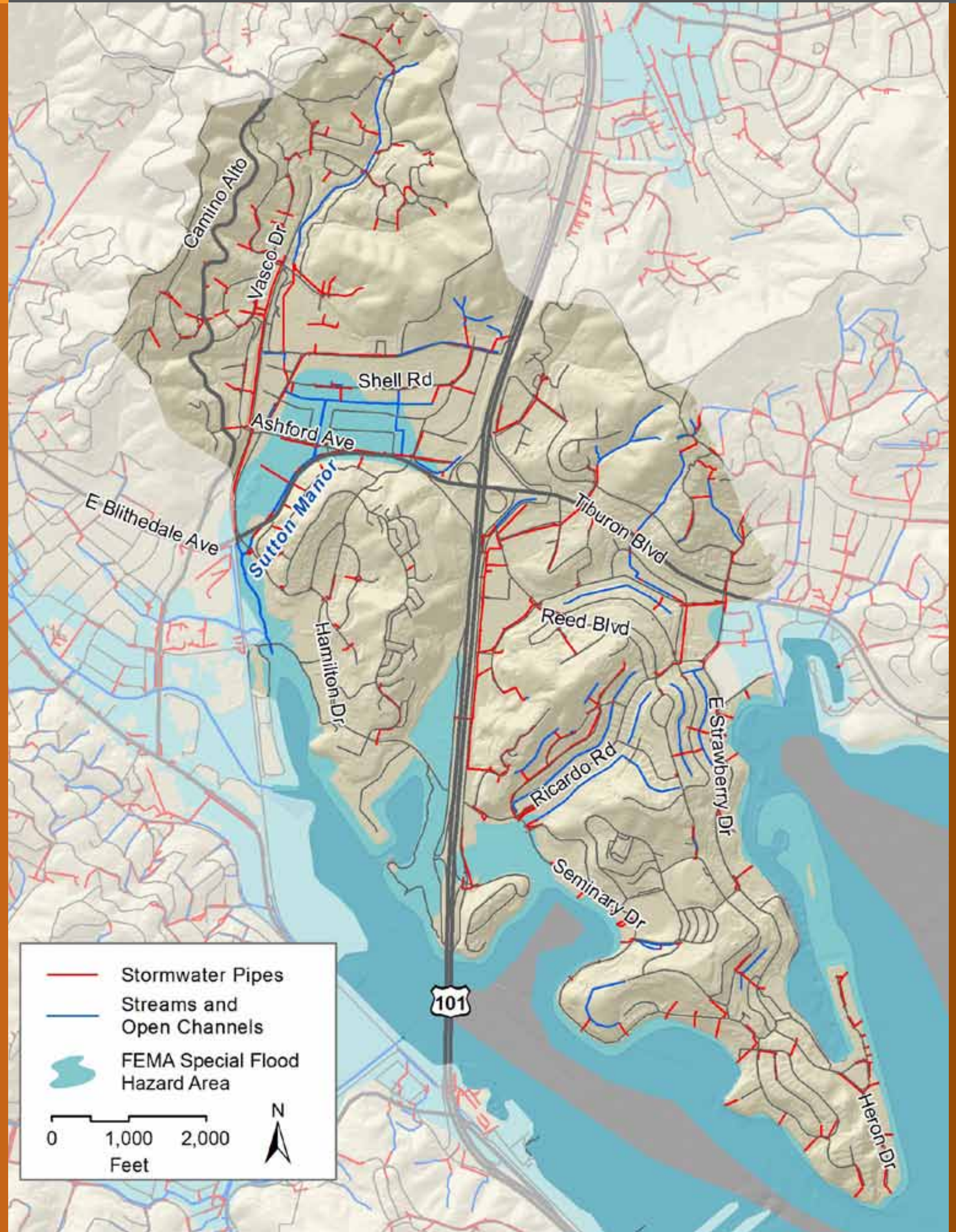
2 Baylands

- Pipe stormwater underground
- Block tides
- Habitat restoration

Sutton Manor/Alto/Strawberry Watershed

Watershed Facts

Size: 2.5 square miles
Population: 8,452
Creek Length: 3.7 miles
% of Creek Maintained by District: 3%
Creeks:
Sutton Manor
Flood Control Facilities:
Seminary Marsh Channel
Seminary Drive Pump Station



The Sutton Manor/Alto/Strawberry Watershed includes the Sutton Manor Creek Watershed and lands on the Strawberry Peninsula that drain directly through very small drainages into Richardson Bay.

The small Sutton Creek Watershed includes Horse Hill Open Space Preserve, the Edna Maguire School, houses, and commercial properties.

In addition to the street drainage system, major drainage facilities include a series of earthen- and concrete-lined open channels, pipes, culverts, and a wetland retention facility. Flows upstream of Ashford Avenue concentrate in a T-shaped ditch (known as the T-ditch), then flow into a concrete-lined channel that discharges into a marsh adjacent to Hauke Park.

Challenges

Valley Floor

Stormwater overflow: The majority of the residential development in the watershed had been completed when significant flooding occurred in January 1970. The existing stormdrain system was undersized and overwhelmed by the amount of storm runoff. Storm flows not captured by the system overflowed into yards and homes. Improvements were made in the following years to retain and redistribute runoff but flooding persists.

Isolated ponding: Occurs in areas lacking stormdrains.

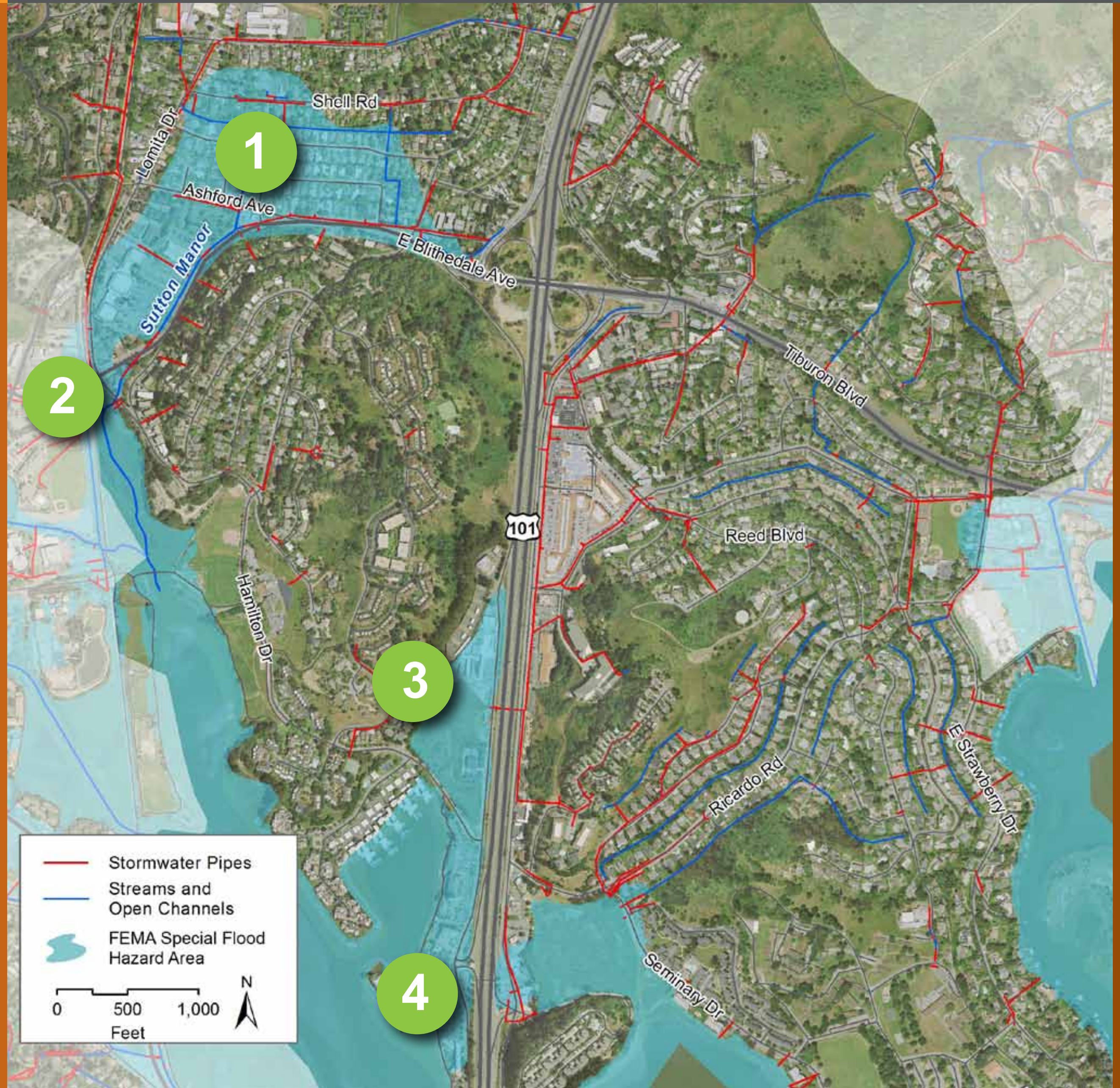
Baylands

Tidal inundation: Extreme high tides can inundate roadways, trails, and parking lots along the Richardson Bay shoreline. These parks, wastewater treatment facilities, commercial developments, roads, sewer, water and electrical utilities that serve all residents of the watershed may require flood protection, and/or relocation.

Sutton Manor/Alto/Strawberry Watershed

Goals

- Reduce frequency and severity of stormdrain overflow, channel overtopping, and stormwater ponding
- Reduce frequency and severity of direct tidal inundation



Possible improvements

1 Valley Floor

- Pipe stormwater underground (stormwater bypasses)
- Levees and floodwalls

2

- Pipe stormwater underground
- Levees and floodwalls
- Habitat restoration

3 Baylands

- Pump stormwater
- Habitat restoration

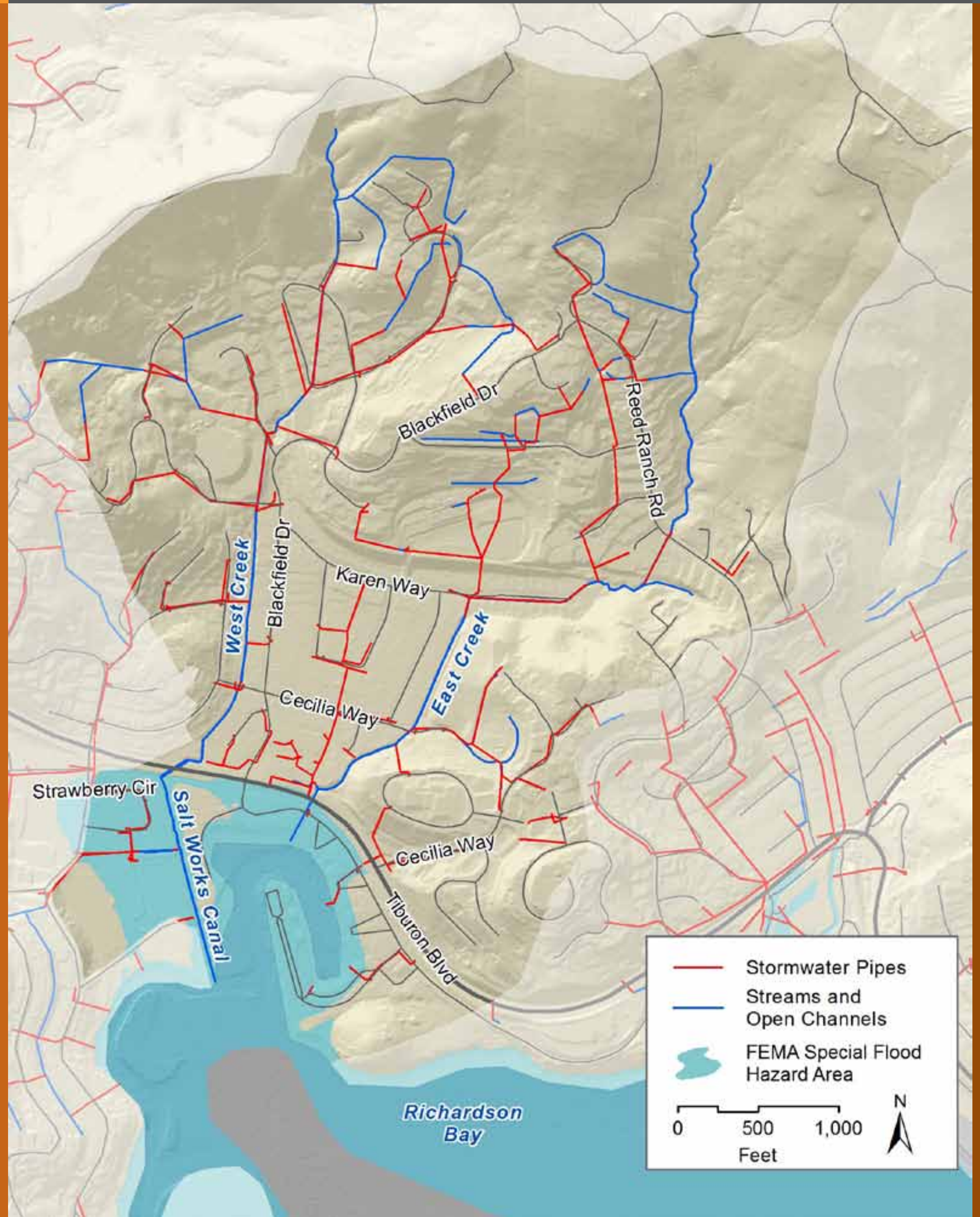
4

- Pipe stormwater underground

Bel Aire Watershed

Watershed Facts

Size: 0.78 square miles
Population: 2,095
Creek Length: 2.7 miles
% of Creek Maintained by District: 30%
Creeks:
West Creek
East Creek
Flood Control Facilities:
Strawberry Marsh Channel
Salt Works Canal
Strawberry Circle Pump Station
Pamela Court Pump Station
Cove Pump Station



The uplands of the Bel Aire watershed lie within the Ring Mountain Open Space Preserve. East and West Creeks drain the southern flank of the ridge through a residential neighborhood in the City of Tiburon. In the baylands, three stormwater pump stations (Cove, Pamela Court, and Strawberry) handle stormwater. Each pump station receives water for a separate stormwater collection system and helps keep stormdrains from backing up and overflowing.

Challenges

Valley Floor

Creek overflow: During large storm events, West Creek has historically overflowed into streets, backyards, and homes, and flooding has been reported on parcels fronting on Blackfield Drive. In 2006, water-inflated flood barrier bags served as temporary flood protection in advance of a large storm. On East Creek and along Karen Way, homes and landscaping encroach upon the creek reducing the creek's capacity where the District holds contiguous easements. Many private encroachments, such as landscaping improvements and small structures have been constructed in the easement and may impede channel flow.

Stormwater overflow: Underground stormdrain pipes that collect water from Blackfield Drive have backed up during high water conditions and may benefit from a tide gate.

Isolated ponding: Water also ponds along East Strawberry Drive between Tiburon Boulevard and Ricardo Lane.

Baylands

Tidal inundation: The tide gate east of the Strawberry Pump Station requires frequent maintenance to keep tidal flows from the channel. Existing berms and floodwalls have been constructed downstream of Tiburon Boulevard, but could overtop during extreme high tide events.

Stormwater overflow: Significant flooding due to stormwater overflow has occurred at the Cove Pump Station as recent as December 2014.

Bel Aire Watershed

Goals

- Reduce frequency and severity of creek overflow
- Reduce frequency and severity of stormdrain overflow and stormwater ponding across the Bel Aire watershed
- Reduce frequency and severity of tidal flooding, both in the near-term and in the future given projected sea level rise
- Increase public awareness of flooding issues

Possible improvements

1 Valley Floor

- Levees and floodwalls
- Increase creek flow capacity
- Raise/flood-proof buildings out of floodplain
- Habitat restoration

2

- Levees and floodwalls
- Increase creek flow capacity
- Raise/flood-proof buildings out of floodplain

3 Baylands

- Pipe stormwater underground
- Pump stormwater
- Levees and floodwalls
- Habitat restoration

What can we do about sea level rise in Southern Marin?

A 36-inch increase in sea levels will greatly impact people's lives throughout Southern Marin. Daily high tides will inundate major thoroughfares, schools, retirement communities, private homes, shopping areas, bike paths, and stormwater detention ponds. Valuable marsh and mudflat habitat will be permanently flooded. Infrastructure will need to be armored, abandoned, or relocated. Shorelines will be eroded by increased wave erosion, threatening even more infrastructure.

Unlike many of the strategies to address flooding described earlier in this document, adaptations to sea level rise are still in the early phases of evaluation. *The Richardson Bay Shoreline Study: Evaluation of Sea Level Rise Impacts and Adaptation Alternatives* investigates strategies that may help address the many risks associated with sea level rise. The extent of the problem requires collective action at the local, state, and federal levels of government.

Hard Engineering Adaptation Tools

Hard engineering alternatives refer to barriers that work to prevent high tides from flooding inland. These include floodwalls and levees, large tidal gates, rip-rap (to armor shorelines against increased wave erosion), and pump stations. These alternatives can be effective against sea level rise; however, they are expensive, barriers must be continuous, and can have a negative impact on aesthetics and habitat.

Soft Engineering Adaptation Tools

Soft engineering tools attempt to work more with natural processes to achieve engineering goals while also providing other benefits such as habitat. Wetland enhancement involves placing fill in marshes to keep pace with sea level rise and attenuate wave erosion. Horizontal levees are broad levees with gradual slopes that allow for extensive habitat on either side. Beach construction restores coarse-grained beaches along the shoreline to inhibit wave erosion.

Existing

Horizontal Levee

Implementing a flood risk reduction project

There are many steps between identifying a problem and implementing a flood risk reduction project. Given the interconnectedness of watersheds, a careful and deliberate process ensures that projects are designed and implemented correctly.

Funding is needed to construct new projects and maintain flood infrastructure. Working near or in water (creeks and wetlands) can add time to the design and permit process. Projects need dedicated funding for the life of the project; from design and permitting to construction and then maintenance. Funding for projects that provide multiple benefits, reduce flood risk, and improve habitat are attractive to grant funding agencies.

Funding can also come from the Flood Control Zone, but the amount of money held in reserve by each zone varies. Most of the reserves are used to maintain existing infrastructure and respond to emergencies. New funding within the zone can be raised with a ballot measure as the zones do not have ratepayers like other utilities. All zones are funded by annual revenues from *ad valorem* property taxes which vary considerably from one zone to another. The amount of revenue received from *ad valorem* property taxes in a particular zone is based on the total assessed value of property within the zone and the zone's share of property taxes which was in effect at the time Proposition 13 became effective.

Annual Work Program Process

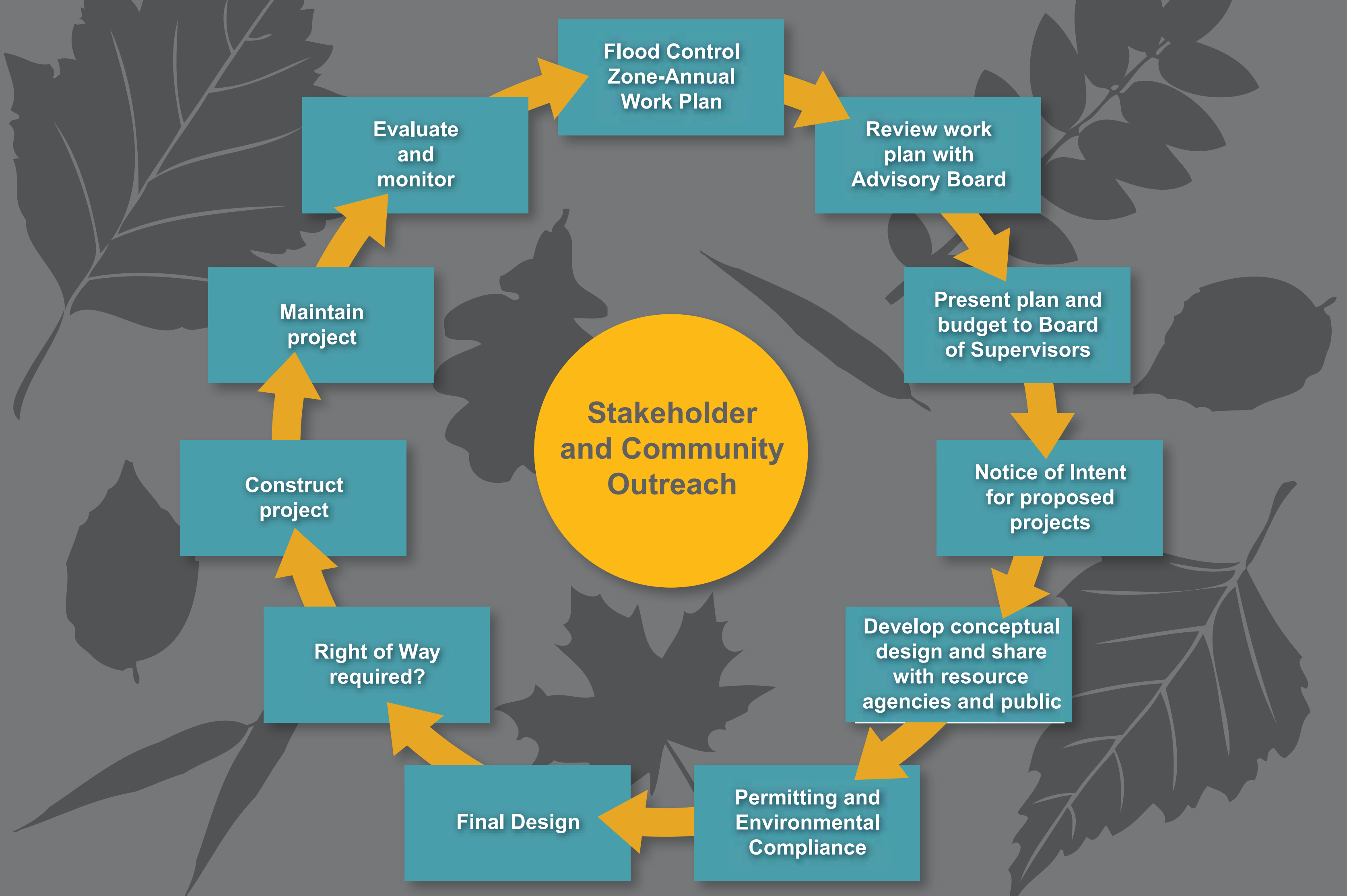


PHOTO: CHRISTIAN ARBALLO

Contacts

Project manager: Chris Choo
Senior Watershed Planner, County of Marin
Cchoo@marincounty.org
www.marinwatersheds.org
415.473.7586