

Fight or Flight at the Coast?
North Bay's Highway to the Future
Developers Hedge Around Higher Water
Urban Farms Feed Change



WATER
ENVIRONMENT
CLIMATE
EQUITY

SPECIAL ADAPTATION ISSUE

Moving from talk to action
on resilience in 12 Bay and
Delta counties.

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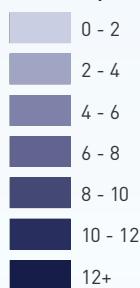
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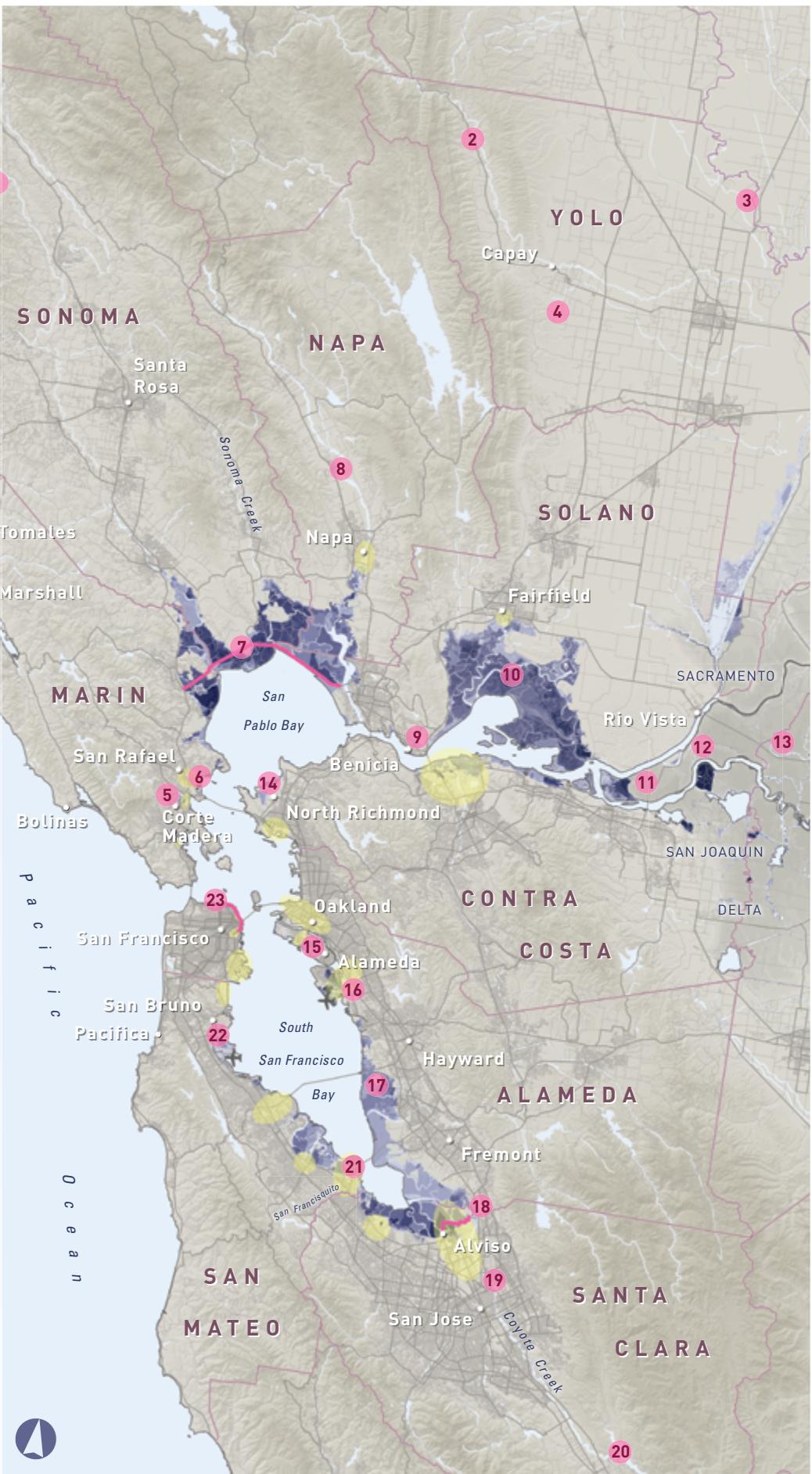
- Roads
- ART Bay Area Hotspots*
- Open water at present

36" Sea Level Rise

Flood Depth (ft)



0 10 20 mi



Map: Amber Manfree. *Source: Base map updated from BCDC ART Bay Area 2020 report including "hot spots" where vulnerabilities in transportation, priority development areas, and community risk from sea-level rise overlap.



Region Moves to Adapt

CARIAD HAYES THRONSON,
GUEST EDITOR

In 2017, I wrote for this publication about nascent efforts to address sea-level rise in various communities around the Bay. At the time, many of the efforts were taking their cues from the detailed inundation maps developed by BCDC's Adapting to Rising Tides (ART) project. A year later, the Resilient by Design Bay Area Challenge (RBD) elicited innovative visions for building resilient communities in vulnerable areas. Since then, it has become clearer than ever that climate change is upon us now, and that it means much more than melting icebergs and swelling

oceans: Northern California has seen an almost relentless chain of extreme weather events, including flooding from wetter-than-usual winter storms (even as total rainfall remains well below normal), giant wildfires, and blisteringly hot days.

With this special issue, we at ESTUARY wanted to look at the steps communities in each county around the Bay and Delta are taking to adapt to our new climate reality. The projects explored in these pages range from daunting infrastructure improvements to climate-friendly farming practices; they are driven by county and municipal governments, state and local agencies, community organizations, and even private landowners. Strong planning and powerful science inform them, including ART's new region-wide analyses. Some projects seek to pick up where

RBD left off, while new communication forums such as BayCAN are fueling regional progress.

Two themes link stories from the past and the present: first, the critical, overarching need for enormous, stable financial resources for adaptation—the Restoration Authority can't pay for everything; and second, the importance of looking at every investment and land use decision from all angles. Projects that achieve multiple benefits, prepare us for multiple hazards, and consider multiple jurisdictions offer the best path to resilience. Some of the most exciting projects explored in this issue will potentially build communities that are not only resilient in the face of climate change, but altogether healthier and more livable. We can get there, but it will take courage, collaboration, and conviction on everyone's part.



PERSPECTIVE

For Resilience, Think Equity

ALLISON BROOKS, BAY AREA REGIONAL COLLABORATIVE

Never before has it been more important to imagine and invest in a future that is decidedly different than the world we are facing today. The COVID-19 pandemic and the protests sparked by police brutality have laid out in stark terms the underlying systemic inequalities and racism in our society that make poor, elderly, black, and brown people socioeconomically vulnerable and expose them to trauma and risk.

These vulnerabilities will only be exacerbated by climate change, unless we work together now to achieve multiple objectives: address inequality and systemic racism; create equity in terms of health and access to opportunity for low-income communities of color; and invest in strategies to reduce the impacts of extreme storms, flooding, sea-level rise, wildfires, and other hazards. COVID-19 also makes an indisputable case for a decidedly unsexy focus on preparedness—making investments today to prepare our communities for an uncertain tomorrow.

As Congress and California's state government consider stimulus packages intended to help our economy recover, we have a responsibility to

ensure that every precious dime spent is responsive to the current crisis and serves as an investment in a more resilient and equitable future for all. As this special issue of ESTUARY illuminates, the San Francisco Bay Area has a diverse range of projects underway that—if fully funded rather than requiring years of slogging to piece together resources—could greatly accelerate efforts to adapt. These projects include improvements to vulnerable infrastructure as well as community-based strategies to manage local threats to health and safety.

While stimulus packages often put the focus on “shovel-ready” projects, it’s useful to recognize that the best way to build a fair, just, and resilient economy is to support projects that can achieve multiple objectives, ensuring that future generations benefit from these one-time investments. This could mean embracing complicated projects that require multiple phases of engineering and environmental analysis, and that ensure local priorities and needs are met through inclusive community engagement.

Some projects highlighted in this issue have been funded in part by valuable grant programs that no longer exist—such as Caltrans’ Senate

Bill 1 Advanced Adaptation Planning Program—but have been essential to help build buy-in from local stakeholders, foster informed decision-making, and move creatively from planning to implementation. Local leaders urgently need these resources to prepare for what’s ahead.

Early in the epidemic, the coordination demonstrated by Bay Area county health departments was effective in saving lives. Soon individual health departments began tracking local data on a more granular level to identify hot spots and stabilize conditions. This led to the current situation, where health departments tailor their policy responses to local circumstances, while at the same time embracing common policies like requiring masks and social distancing.

Climate change will demand similar responses, including regional-scale coordination, analysis, and resource generation to support local ingenuity. Through this unprecedented experience, individuals, communities, and local leaders have all felt both hopeless and hopeful. As we prepare for bigger changes ahead, remembering both our shared vulnerabilities and those of our most at-risk communities will be key to building lasting resilience.

Allison Brooks is Executive Director of Bay Area Regional Collaborative.

C O N T R A C O S T A C O U N T Y

Greener, Fatter Levees Boon to Richmond Resilience?

DANIEL MCGLYNN, REPORTER

In early May, despite the now normal issues of groups gathering for video calls and virtual PowerPoints, the San Francisco Bay Restoration Authority voted unanimously to fund the early stages of a massive new infrastructure project along the North Richmond shoreline with a grant of \$644,709. The shoreline is now one step closer to becoming home to a horizontal, or living, levee that provides both flood protection and habitat. The proposed project, in the planning stages since 2017, will be anchored near a wastewater treatment plant managed by the West County Wastewater District. The facility, just north of the Richmond Bridge and situated among the marshes fed by Wildcat and San Pablo creeks, is vulnerable to flooding.

A bulk of the grant will go toward geotechnical, topographical, and other studies of the site to figure out just how big the levee will become. "The proposed project will look at two different scales," says the San Francisco Estuary Partnership's Josh Bradt, who is managing the Richmond project for the Restoration Authority. "One will study what it would take to build it just on wastewater district property, while the other will study what it would take to expand the project from Castro Cove in the south all the way to Giant Marsh to the north." The first option would mean 0.6 linear miles of levee and 2.6 acres of transitional habitat (the zone between tidally influenced marsh and uplands), while the second option would expand the levee to 4.5 linear miles and create 15 acres of transitional habitat.

North Richmond's future living levee will create a physical barrier between rising seas and critical infrastructure and make the treatment plant more climate resilient. Depending on the final scope, flood protection could extend to other infrastructure such as the Richmond Parkway and nearby communities. The levee also provides an area of retreat in the form of upland habitat for

ecologically important plant and animal species. Existing wetlands in the vicinity are among the best examples of intact marsh environments left in the Bay Area.

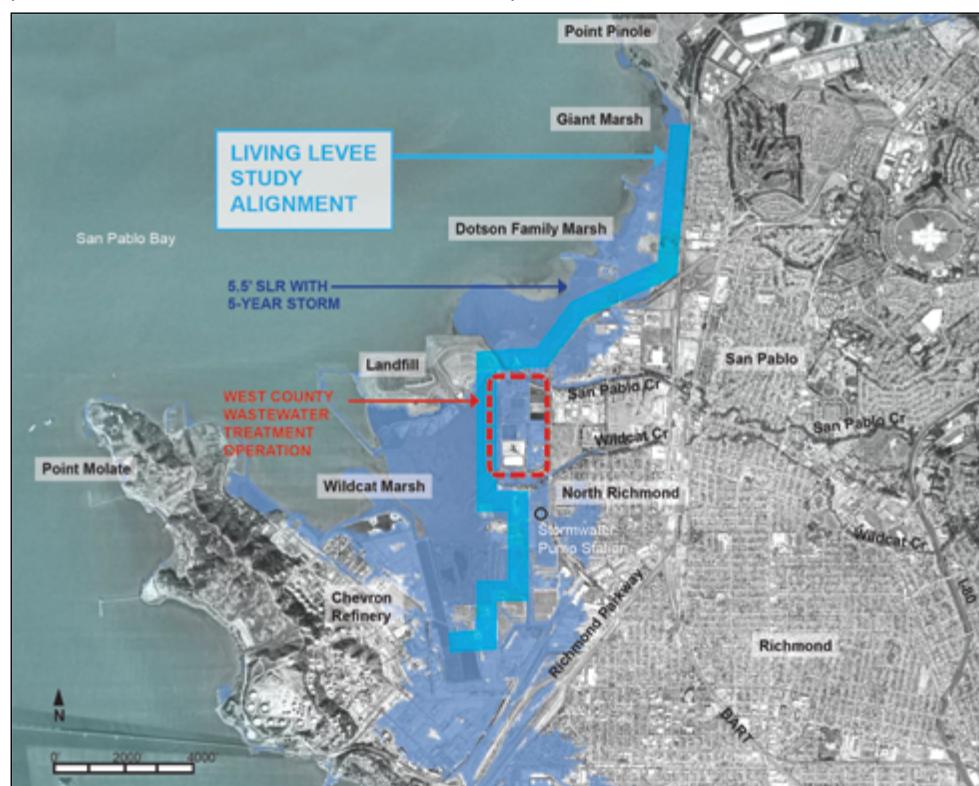
As the name implies, the North Richmond Living Levee won't just be a static flood control barrier. The plans call for using the levee to address local community demand for more access to the shoreline, as most recently outlined in both the 2018 Resilient by Design challenge and the earlier North Richmond Shoreline Vision plan. Key among the planned features is to use the levee project to connect two segments of the Bay Trail. "The proposed project will go beyond just protecting the water treatment plant ratepayers," Bradt says. "It will provide a greater public benefit."

The construction of a living levee on the North Richmond shoreline demonstrates the challenges and opportunities of adapting to climate change — and reimagining what the future could hold throughout Contra Costa County. Many of the 19

cities within the county, along with the county itself (large swaths, like North Richmond, are unincorporated and under county control) are planning projects to prepare for future weather volatility.

So far the adaptation efforts in the county have been decentralized. There is no clear-cut guidance or overarching governance structure with the teeth or budget to hasten the pace of resiliency projects. The county does have a five-year-old climate action plan focused on increasing the use of renewable energy. Updates to the plan, now underway, include better ways to measure and track progress toward goals.

Meanwhile, sea-level rise along the county's sprawling shoreline continues at a rapid pace. According to a study prepared for the county last year by graduate students at UC Berkeley's Goldman School of Public Policy, average projected countywide sea-level rise may hit up to a foot in the next decade, two feet by 2050, and more than five feet by the end of the century.



The North Richmond Living Levee study area. Source: Mithun



Channelized Rheem Creek has flooded neighborhoods in North Richmond and nearby Rollingwood.
Photo: Margarito P Gomez

Much of the potential for climate change adaptation in Contra Costa County is outlined in a Bay Conservation and Development Commission (BCDC) Adapting to Rising Tides (ART) report. The ART research cut the county into two halves. Findings on the western part of the county (Richmond to Bay Point) were published in 2017, while the research for the eastern part of the county (the Delta) was released in April of this year. The report identified three big near-term climate-related county-wide issues.

The first is the loss of jobs and the impact that rising seas and other weather-related disruptions will have on the local economy. Contra Costa County is still very much defined by its working shoreline, which hosts four of the five major Bay Area refineries, as well as warehousing and manufacturing facilities, and major railways. According to the 2017 ART report, there are 4,853 industry-zoned acres at risk of flooding in the county. All four major refineries fall into that category.

The second ART finding is that climate change impacts will not be evenly dispersed among communities and residents. Unless there is a major change, the same communities that bear the brunt of the emissions and poor air quality from the oil and gas sector — the county's largest industry — are the same ones likely to end up under water. "The county contains seven out of the ten largest industrial pollution sources in the Bay Area," says Jody

London, Contra Costa County sustainability coordinator and lead on its climate action plan. "There is a lot of concern about the impacts that has on health; disadvantaged communities are disproportionately impacted by these activities."

These concerns are leading some in the county to push for major structural change in the local economy. "The Sustainability Commission, which is a county advisory body, is recommending that the board of supervisors adopt a climate emergency resolution," says London. One of the recommendations is to create a carbon transition advisory group. "[We want to know] what it looks like for health, jobs, and revenues if there is less fossil fuel activity in the county — how do you plan for that?"

Also on the environmental equity front, existing flood control initiatives are not evenly distributed across the county. Efforts are underway to change that. On the banks of Rheem Creek — which flows through Richmond, the city of San Pablo, and the unincorporated county neighborhoods of Rollingwood and North Richmond — residents are currently working with the Watershed Project (a Richmond-based nonprofit), the national conservation organization American Rivers, staff from the City of Richmond, and other local stakeholders to study nature-based ways to make the creek function again.

For years the channelized Rheem Creek has flooded two blocks of the neighborhood that lies on the border

HIGHTIDE

Anatomy of a Horizontal Levee

Horizontal levees are to flood control what electric cars are to personal transportation. In both cases, the two innovations leverage existing infrastructure and ways of thinking while also making an attempt to be less environmentally damaging than their predecessors.

As with some other nature-based adaptation strategies, the idea of a horizontal levee is relatively new. So new, in fact, that there still isn't agreement about what to call them (ecotone levee and living levee are still in the running). Regardless of the name, the concept was first pioneered as part of shoreline protection efforts along the Chesapeake Bay. Imported to the San Francisco Bay Area, the first major horizontal levee was constructed in 2015 for the Oro Loma Sanitary District in San Lorenzo (see "Nudging Natural Magic," Estuary News, December 2017).

A horizontal levee is a different shape than a conventional riprap-over-dirt levee and can support vegetation. When built in combination with water treatment infrastructure, this new kind of levee can provide flood control as well as habitat and water quality benefits. In the case of Oro Loma, treated freshwater from the plant is filtered through the sloping, terraced levee, irrigating plantings. In the process, plants and microbial processes remove more nitrogen, phosphate, and pharmaceutical traces from the irrigation water than standard wastewater treatment, according to Oro Loma studies. The design of the levee also creates an opportunity to restore, or at least mimic, historic marsh habitat. A well functioning marsh isn't just a wide plain subject to the feast and famine of tidal influence. Rather, a healthy marsh is full of nuance and gradients in the form of slopes and uplands that provide shelter — and in the case of sea-level rise — a place for marsh species to retreat. **DM**

continued on next page

between the city of Richmond and Rollingwood. With funding from the Coastal Conservancy, a solutions-oriented group was able to interview community members about the creek's history and behavior. The group found that most of the creek is choked with vegetation behind fences on private property, and that the creek issues have been jurisdictionally ambiguous, resulting in decades of inaction.

By piecing together the community interviews and some mapping work, the Rheem Creek group found that the creek bed has risen higher than the surrounding neighborhood in some places due to years of sediment build-up. The group is now studying how best to fix the situation with nature-based solutions. Ideas include planting shade trees to stifle creekside thickets and incorporating floodplain into a local park design. "There's not much we can do with the actual channelized structure of the creek," says Aysha Massell, director of California Integrated Water Systems for American Rivers. "But we intend to develop a robust monitoring and maintenance plan."

What marries all of the climate change adaptation plans and projects together in Contra Costa County is the opportunity to create a new sector of the economy and local jobs that foster equity, access, and a strong sense of place. "North Richmond is one of the most disadvan-

taged communities in the Bay Area. So we are engaged in placemaking efforts, including better access to Wildcat Creek, which will hopefully make people more aware that they are living near the mouths of two major creeks in the East Bay," says John Steere, a planner for Contra Costa County helping local groups build watershed connections. "Tying local jobs with green infrastructure planning and maintenance is really a public benefit."

There is plenty of recognition of the need for climate change adaptation projects, and no shortage of ideas about what kinds of projects to build or organize. Between federal, state, and local funding bodies, there isn't even a lack of money to get these projects off the ground. The biggest bottleneck in the resiliency pipeline is reluctance among local governments, land managers, and grantees to back projects that have no clear strategy for covering the long-term expenses of nature-based infrastructure like rain gardens, urban forests, and complete streets.

"There has to be funding for green infrastructure operations and maintenance, otherwise that's where those projects go to die," says Juliana Gonzalez, the executive director of the Watershed Project. Gonzalez and Steere are working to create a Green Benefit District, which is a potential new funding model for long-term restoration and

greening projects. The Dogpatch and Northwest Potrero Hill neighborhood Green Benefit District in San Francisco is an example of how this model could work. While that district raises money through parcel taxes, Gonzalez is advocating for alternative funding such as new traffic or redevelopment fees, mitigation funding from polluting industries, and climate adaptation funding for disadvantaged communities. "The idea is that the more we get people involved and can pay them to be block ambassadors or work on local conservation crews, then when the horizontal levee comes online we can create local jobs and local stewardship."

In a larger context, the North Richmond living levee project is a demonstration of what can happen when several major stakeholders work together — along with a strong community voice. The working group for the North Richmond living levee includes officials from the county, the city of Richmond, the wastewater district, Chevron, and the East Bay Regional Park District, all collaborating to figure out how to make the most of the project. "I really hope this approach of developing alignment among multiple stakeholders is something that will take off," Bradt says. "Especially if it can show that there is a way to leverage resources and dollars to have a greater impact."

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Students from a San Francisco State Wetlands Ecology class plant *Suaeda californica* over an arbor of tree branches in the transition zone of a multi-habitat living shorelines experiment at Contra Costa's Giant Marsh. The arbors will provide areas of high water refuge for wetland birds and mammals. Read more and see videos of this landscape scale experiment in shoreline adaptation, in which oyster reefs and eelgrass beds will help buffer the county from the advancing Bay, in Estuary News June 2019, Supershore at Giant Marsh. Photo: Katharyn Boyer.

S A N F R A N C I S C O C O U N T Y

San Francisco Prepares for Water From All Directions

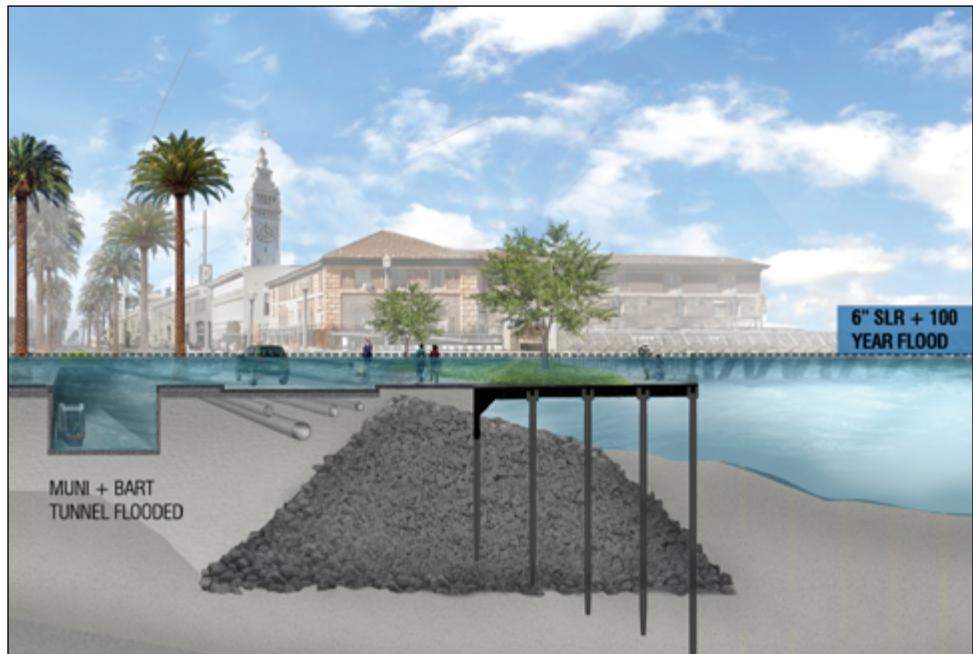
ISAAC PEARLMAN, REPORTER

"Even a city with as many resources as San Francisco has can't do this [alone]," says Lindy Lowe, speaking of the climate change threats looming over the City by the Bay. "It's too big."

The perils San Francisco faces include three-to-ten feet of sea-level rise this century, a sharp increase in extreme heat days, and more severe floods and drought. As city officials grapple with today's severe housing and inequality crises, they are also confronting the need to preserve aging infrastructure, such as the city's hundred-year-old stormwater system and a busy international airport that sits below sea-level. But perhaps no one confronts a bigger challenge than Lowe, director of the Port of San Francisco's Waterfront Resilience Program: reinforce the city's 7.5-mile bayside shoreline, where a sagging century-old seawall built atop unstable, muddy fill is all that stands between the rising San Francisco Bay and \$22 billion worth of real estate.

"A strong earthquake could move the Embarcadero seawall bayward," Lowe explains. A big seismic event would churn the muddy soil underneath the seawall and most of the waterfront into a soupy liquid, rupturing streets and utilities and causing the seawall to collapse. Like loosening a belt cinched tight around a swollen stomach, this release would allow the fill stacked behind the seawall to slide into the Bay, and could fracture the waterfront as much as 200 to 300 feet inland, due to what's known as "lateral spread." San Francisco Bay would rush in over miles of waterfront that have been filled and developed over the past 150 years. "I don't think of it as a seawall, I think of it as a retaining wall," Lowe says. "It was put in place to hold all the fill put into the bay from the late 1800s to early 1900s."

Galvanized by an alarming 2016 report calculating a 72% chance of a large earthquake in the Bay Area by 2043, the Port is now racing to identify



San Francisco is expected to see 12" to 24" of sea-level rise by 2050 and up to 66" by 2100.

critical seismic weaknesses and flood risks as part of its 20-year, \$5 billion waterfront resilience initiative. Armed with \$425 million in bond funding that San Francisco voters passed in 2018, the Port has bored below ground to test the soil strength underneath the seawall, collected high-resolution bathymetry, and modeled future wave and flood impacts along the waterfront. Equally important, the Port began intensive community outreach and engagement in the downtown, Mission Bay, and Islais Creek neighborhoods to enlist residents' help in identifying critical facilities and community assets.

These efforts culminated in the Port's multi-hazard risk assessment, one of the first of its kind in an era when many agencies and plans tend to focus narrowly on one impact, not how risks can interact. Community meetings and neighborhood outreach events have elicited valuable knowledge from local citizens: for example, how the consequences of losing waterfront ferry landings, power substations, or bus and train lines would ripple throughout the city and region, and what local assets

residents value most for protection and adaptation.

All this will inform what solutions are available. In 2018, the Port partnered with the United States Army Corps of Engineers to begin the process of soliciting federal funds for fixing the seawall. This year will reveal which path the waterfront will take moving forward. "Right now we are at this really critical pivot," says Lowe. "Over the next six months we'll be advancing recommendations in all the buckets: near-term, mid-term, and long-term."

The San Francisco airport, on the other hand, currently has a clear and simple path forward: build higher. "We're like a small city," points out Joe Birrer, director of engineering and construction services at SFO. Besides runways and terminals, the airport operates its own substantial electrical distribution and wastewater systems. In 2015, updated flood maps from the Federal Emergency Management Agency showed a 100-year storm could overwhelm airport levees and inundate most of

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the runways, which lie below sea-level. "We realized we are at a much greater risk of flooding than previously thought," Birrer says.

Built in 1927 atop filled-in marsh and cow pasture, the airport is now one of the busiest in the United States, serving more than 50 million people per year. Most of the earthen berms and seawalls holding back the Bay from runways were built 40 years ago, and today tides seep into gaps and occasionally overtop them during storms — though the airport hasn't yet had to interrupt service due to flooding. "We take this seriously," Birrer says. "It doesn't have to happen today, but we need a long-term process that will protect the airport well into the future."

In 2015 the San Francisco Board of Supervisors set out to improve the airport's shoreline protection, approving a \$58 million project to protect it from 11 inches of sea-level rise. This project was scrapped in 2018, after the State of California released much higher sea-level projections. The current proposal, approved last September, will raise the airport's entire 10-mile perimeter by five feet, reinforcing the perimeter with miles of sheet pile walls and concrete. The new bill is \$587 million, though with 30 years of bond interest payments the total cost will end up around \$1.7 billion. The pricetag seems worth it: according to SFO's own research, the airport helps generate \$72 billion of economic activity annually in the Bay Area.

By adding three feet to protect against sea-level rise, and an additional two feet to counteract waves, airport officials say their new shoreline protection will serve until at least 2085 in all but the most extreme sea-level-rise scenarios. "The system we are putting in place is supposed to address 36 inches of sea-level rise and a 100-year storm," says Birrer. "If we curb our emissions, we will be protected beyond 2085. I imagine the people who come after us, it will be on their minds as they watch what happens."

But the shoreline isn't San Francisco's only battle zone against climate change. Storms will be stronger and more frequent. By 2100, atmospheric rivers are expected to be more common, and could deliver as much as half of California's annual rain in torrential downfalls. Two-hundred-year storms like the



With a shift in project scope from the Embarcadero Seawall to waterfront-wide resilience, the Port has made an extra effort in recent years to engage residents across its entire 7.5 mile jurisdiction. Here, Bayview Hunters Point residents vet draft program goals and prioritize flood impacts at a January 2020 Islais Creek community meeting with the Port, SF Planning, USACE, and other partners.

Photo: Port of San Francisco

one that caused the Great Flood of 1862 could occur every 40 to 50 years in the Bay Area. And as stronger storms pummel San Francisco and increase inland flooding, hotter weather will decimate the Sierra snowpack that currently provides 85% of the city's water.

In order to prepare San Francisco's creaky stormwater infrastructure for these stronger storms and more frequent droughts, the San Francisco Public Utilities Commission (PUC) has been installing rain gardens, permeable pavement, and bioretention planters in neighborhoods across the city. These projects help prepare for larger storms by diverting runoff that could overwhelm the city's antiquated stormwater system. Additionally, they naturally filter runoff and allow more rain to percolate into the soil, replenishing San Francisco's groundwater. The PUC is also looking at using building code changes to modernize the city's stormwater system over time. San Francisco is one of the last cities in California to use combined stormwater and sewage pipes; most cities now separate the two.

Grandiose infrastructure projects aside, one smaller step is to ensure the city's numerous agencies and departments work better together to confront the climate impacts hover-

ing on the horizon. "It's critical to coordinate among different agencies so we are not creating any unintended negative consequences by protecting one asset without taking into consideration other assets," says Sandra Hamlat, principal resilience analyst for the City of San Francisco.

Hamlat has been leading the Climate Resiliency Integration team, an additional group that is, in true bureaucratic fashion, tasked with helping various departments collaborate on climate change responses. But lately, the unexpected COVID-19 emergency has demanded San Francisco's full attention. "Right now I've been deployed as a disaster service worker, but we're still trying to do as much climate resilience as we possibly can," says Hamlat, who optimistically hopes the lessons the city is learning from today's crisis will inform future ones.

And so as we social distance into the summer, and stagger back to our feet after COVID-19's gut-punch, San Francisco officials and planners begin returning to the work of preparing for the much larger blows that await from climate change.

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Big Projects, Wet Feet?

ISAAC PEARLMAN, REPORTER

On September 3, 2019, Golden State Warriors CEO Rick Welts stood proudly in front of the newly inaugurated \$1.4 billion Chase Center basketball arena. "A brand new journey starts today," he promised the assembled luminaries and fans. Having built on Mission Bay's watery footprint, the Warriors defended their new arena against sea-level rise, saying in an official statement it will stay dry in 2100 "even with the anticipated 36 inches of sea-level rise."

Just three weeks later, a massive \$1 billion dollar housing and commercial development less than a mile up-shore from the Chase Center received permission to break ground. Dubbed "Mission Rock," the project is also designed for sea-level rise: 66 inches by 2100. In other words, almost twice as much as its waterfront neighbor.

Over the past decade a wave of these shoreline "mega-developments" have hit the Bay Area. Since 2010, developers have sunk \$22 billion into more than a dozen waterfront projects less than eight feet above today's high-tide line.

"In San Francisco, almost half of all new housing development in the city is concentrated along the waterfront," says Emily Loper, policy director for the economic development advocacy group Bay Planning Coalition.

These projects promise thousands of much-needed housing units, millions of square feet of commercial space, and acres of waterfront public space. However, the State of Califor-

nia estimates sea-level rise of up to ten feet by 2100 — a figure seemingly incongruous with the lower numbers used by developers, and one that would push many of these new mega-developments into risky flood zones.

For example, the Central Bay's \$6 billion Treasure Island development is designed to withstand three feet of sea-level rise. The \$1 billion Alameda Point in the East Bay is built for 18 inches, with contingencies for higher levels. The overhaul of the Potrero Power Station in San Francisco's Dogpatch neighborhood, which on April 21 became the first development virtually approved by the city due to coronavirus, is designed for 6.9 feet of sea-level rise. The Pier 70 project directly adjacent to Potrero will be about 1.5 feet lower than its neighbor, and its waterfront park will be even lower. These four projects alone total over \$10 billion, and will provide 13,000 housing units (though only about 25% of them affordable) and hundreds of acres of parks, trails, and other public waterfront amenities. But how is it possible they use such different sea-level-rise numbers?

"These developments have been in the works for many years, and the projections have changed over time," explains Loper. In 2012, for example, the upper range of projected sea-level rise for California was 55 inches, or 4.6 feet by 2100. In 2018, the State of California issued revised estimates that now top out at 6.9 to 10 feet by the end of this century.

Dr. Kristina Hill, professor at UC Berkeley's Department of Landscape Architecture and Environmental Planning, isn't buying it. "There are documents from the 1990s pointing out the sea-level-rise problem," she says. "Developers and the engineers they hired often chose a middle number, because it sounded reasonable. But they knew [it could be worse]."

Currently each project has the flexibility to choose from the State of California's high, medium, or low sea-level-rise projections to determine its own risk based on unique site characteristics, lifespan, and consequence. "Not every project constructed today is completely resilient to the flood risk it might encounter in 2100," points out Ethan Lavine, chief of permits at the San Francisco Bay Conservation and Development Commission (BCDC). "But each is being built in such a way they should be able to adapt to that flood risk when the time comes to do so." BCDC has rigorously applied sea-level-rise policies requiring that projects be designed to withstand expected 2050 levels and have plans for adapting to 2100 levels.

A few forward-thinking developers have planned for adaptation, acknowledging the need to be ready if the San Francisco Bay rises higher and faster than what they have designed for. Treasure Island, Pier 70, and Mission Rock are committed to monitoring local sea-level rise and developing future plans to improve drainage and shoreline protection as needed. Mission Rock even makes this a component of its shoreline park, with plans for terraced shelves to mark different

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Shoreline terraces at Mission Rock's waterfront park are designed to show daily tidal heights and the rise of San Francisco Bay over time.
Rendering: Tishman Speyer, Scape



New housing for seniors at Alameda Point. Rendering courtesy Eden Housing

tidal heights and the upwards creep of the Bay over time. All three projects will use fees generated via special community facilities districts to help pay for future adaptation measures.

However even these adaptation attempts are fraught with uncertainties, such as how exactly to monitor and enforce a permit requirement 30 years into the future, or if the adaptation accounts will have sufficient funds when they are needed. And few appear to plan for the fact that due to stronger storms, extreme water levels will become more frequent. For example, a study this year found historical 50-year water heights could be an annual occurrence by 2050.

"No doubt an adaptive approach requires additional coordination over time," admits Lavine. "But I think it only makes sense that a project built today that will be around for 75 to 100 years or more will need to commit to planning and implementing measures to adapt its shoreline."

Other projects, however, have a more laissez-faire attitude towards sea-level rise. The Chase Center, with its sunken arena floor and basement practice courts below Bay level, relies on one of the lowest figures for future sea-level rise at three feet by 2100. Its "adaptation plan" to install floodgates and curbs appears to simply shunt floodwater away from the arena, where it could collect in adjacent streets and parcels. The \$218 million luxury condo project at 75 Howard Street (also known as One Steuart Lane) and the \$42.6 million Tidelands Condominiums in San Mateo appear to somehow have left out sea-level rise altogether in their design. Notably, all three of these projects were built outside of BCDC's jurisdiction.

Why are these developments using lower sea-level-rise estimates, and therefore increasing their risk? One simple factor is the cost of importing dirt to raise grades, building floodwater retention projects, and lifting building

pad heights. Additionally, factoring in higher sea-level rise could increase costs of toxic waste cleanup for legacy contaminants in projects like Bayview Hunters Point, Candlestick, and Treasure Island. Still, it's not as if money is lacking: a real estate development industry standard is 20% return on investment, though individual projects can vary widely.

Even so, many developments tend to fall back on unimaginative (and cheaper) adaptation strategies based on simply fortifying the shoreline. "We're supposed to be a futuristic region, a tech region, and we're doing seawalls?" asks Hill incredulously. "How lame, when we could be talking about floating cities and extensive beaches and wetlands."

Another reason could be reliance on public infrastructure for protection. Hundreds of millions of taxpayer dollars are currently dedicated to raising miles of levees in Foster City and the South Bay, as well as buttressing and eventually replacing the San Francisco seawall (see page 7). In addition to shielding essential public facilities like ferry landings, fire and police stations, utilities, and waterfront streets, these massive public works will also end up protecting billions of dollars of private property. It is likely no coincidence that the Golden State Warriors were major funders of Proposition A, the San Francisco seawall bond, which passed in 2018. Or that Facebook, Inc. donated money toward the SAFER Bay project that will end up shielding its Menlo Park waterfront campus from rising waters.

"I'm sure private projects that haven't adequately prepared for sea-level rise are counting on public funds to provide protection in the future," Hill says.

"We absolutely need to plan for how these major shoreline protection projects can be accomplished with equity as a primary, co-equal goal [to protection]," adds Lavine diplomatically.

Another issue is that these developers will be long gone in 20 or 30 years, when the one-to-two feet of sea-level rise that they have designed for is lapping at our doorsteps. Which raises the question, who will be left to pick up the bill if and when these developments flood? As the San Francisco Bay gradually creeps higher, it is not clear who will be liable for developments that suddenly find themselves in the flood hazard zone, nor what the requirements are for flood insurance and disclosures pertaining to future flood hazards. Not to mention the legal mess that would result if flooding goes through an underbuilt property to its neighbor, or adjacent public streets.

"A lot of this is going to come out in the courts," says Hill. "And we're still waiting to see how the public trust doctrine will be interpreted as the tide gets higher. That's why it's so important that the region starts planning ahead and blocking developments that will be fragile and expensive."

As if there weren't enough barriers to sea-level-rise adaptation, the economic downturn caused by the coronavirus pandemic will inevitably tighten adaptation and resilience budgets. Loper points out optimistically that this makes the private developer adaptation commitments even more essential, but concedes a regional shoreline protection plan is critical.

"There has to be a larger strategy in place so that these projects are not simply islands of resilience," agrees Lavine.

Hill, however, is more blunt. "We have a choice between leaving future generations vulnerable properties and rigid seawalls, or resilient properties and dynamic wetlands," she says. "Do we want to leave behind a legacy, or liability?"

Note: Isaac Pearlman formerly worked at BCDC as an environmental scientist.

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S A N T A C L A R A C O U N T Y

Forty Miles of Creek, Six Adaptation Projects

ROBIN MEADOWS, REPORTER

In 2017, a perfect storm hit the City of San Jose in Santa Clara County. The stage was set by a series of late winter rains that left the ground soggy and creeks brimming. Then, on February 21, a whopper of an atmospheric river struck. “It dropped three inches of rain in the upper Coyote watershed,” recalls Mike O’Connell, a deputy director in San Jose Public Works. Coyote Creek, which winds through the heart of the city, overtopped its banks, flooding businesses and hundreds of homes up to depths of six feet. Thousands of people were evacuated and property damages exceeded \$70 million.

As winter rains intensify with climate change, flooding will worsen in Santa Clara County, the Bay Area’s largest by population, with about 1.8 million people, and second largest by area at about 1,300 square miles. In the hills edging the Santa Clara Valley, which extends the length of the county, wildfire is also a threat. On the valley floor, where most of the people live, major threats in addition to riverine flooding are blistering hot summer days and shoreline flooding as San Francisco Bay rises. The Coyote Creek system — 1,500 miles of waterways that drain a 350-square-mile watershed — connects half a dozen elements that are key to climate adaptation, from reservoirs to creek confluences to the Bay shore.

The creek runs 40 miles from Anderson Reservoir in the Diablo Range foothills to the Bay shore near Alviso, passing through San Jose, the largest city in the county with nearly one million people. The 2017 flood began at the

reservoir, which was already almost full when the atmospheric river rolled in. “That was the trigger,” says O’Connell, the City of San Jose’s liaison with Valley Water, the agency that supplies water and manages flooding in the county. About 32,000 acre feet — 10 billion gallons — surged over the dam’s spillway, overwhelming Coyote Creek downstream. “You can’t stop that amount of water,” he adds.

Most of the time, Anderson Reservoir is nowhere near full: it’s restricted to 58% capacity due to seismic concerns. In October 2020 that will go down to zero because the latest study shows the entire dam needs to be replaced. “It’s a public safety risk,” says Rechelle Blank, a Valley Water civil engineer. Anderson Dam was built in 1950 over a major fault, and would not withstand a magnitude 6.6 earthquake. A dam breach at full capacity could flood a 70-mile-long area from San Francisco Bay to Monterey Bay.

The new dam will have a larger outlet for releasing water gradually during storms, in contrast to 2017’s overflow. “In the end we’ll get a dam with more flexibility,” O’Connell says. “It’ll be safer for all of the South Bay.” Another benefit is that returning the reservoir to full capacity will boost local water storage during the dry years to come, reducing the county’s reliance on imported water. The project is currently projected to cost \$575 million and wrap up in 2029. In May a bill to expedite the dam replacement unanimously passed the state assembly’s Water, Parks & Wildlife Committee.

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PLANNING

Silicon Valley 2.0 Reboot

When it comes to climate adaptation, it seems like everyone from municipalities to resource agencies has a plan. Now Santa Clara County is rebooting its 2015 climate resiliency initiative, Silicon Valley 2.0, with an eye towards coordinating them all. Call it Silicon Valley 3.0.

Strengths of the current version include a powerful online interface for assessing climate impacts. “Plans often sit on the shelf,” says Jasneet Sharma, who heads Santa Clara County’s Office of Sustainability. “But Silicon Valley 2.0 is really a decision support tool for cities.” Users can drill down to specifics, such as the vulnerability of roads to flooding, with a graphic display that’s easy to take in at a glance.

The reboot will update this online tool to be even more user friendly. For example, vulnerability and risk maps will be interactive by default. In addition, new options will include an index for social vulnerability as well as downloadable fact sheets on the impacts of each climate hazard.

Another priority for the reboot is strengthening coordination with other planning efforts countywide. “Many climate impacts don’t stop at jurisdictional boundaries,” Sharma says. “We hope to provide a platform that will bring us all together in a coordinated regional strategy.” She envisions identifying best practices, sharing solutions, co-creating toolkits, and offering training for cities with less capacity. “There’s a lot to be done,” she says. “We’re just getting started.” RM

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Looking north over the Coyote Valley to San Jose and San Francisco Bay. Photo: Santa Clara Valley Open Space Authority

Below the reservoir, Coyote Creek is getting some much-needed work along nine miles that are prone to flood. The City of San Jose put up \$100,000 for clearing debris from the channel to speed flood water conveyance; Valley Water's efforts include installing short flood walls to protect homes on the edges of open space during really high floods. "We built a lot of parks next to the creek to buffer the land," O'Connell says. As rainstorms become more severe, the parks will double as flood basins. Valley Water will also relocate or raise about 10 homes built in the creek channel beginning in the 1800s.

"If I've learned anything in my 25 years here, it's that you have to give creeks room to move," says Valley Water planning engineer Afshin Rouhani, explaining that this slows the water, decreasing flooding and bank erosion. "The more you stay away from the active part of the creek, the more resilience it has to climate change." Efforts

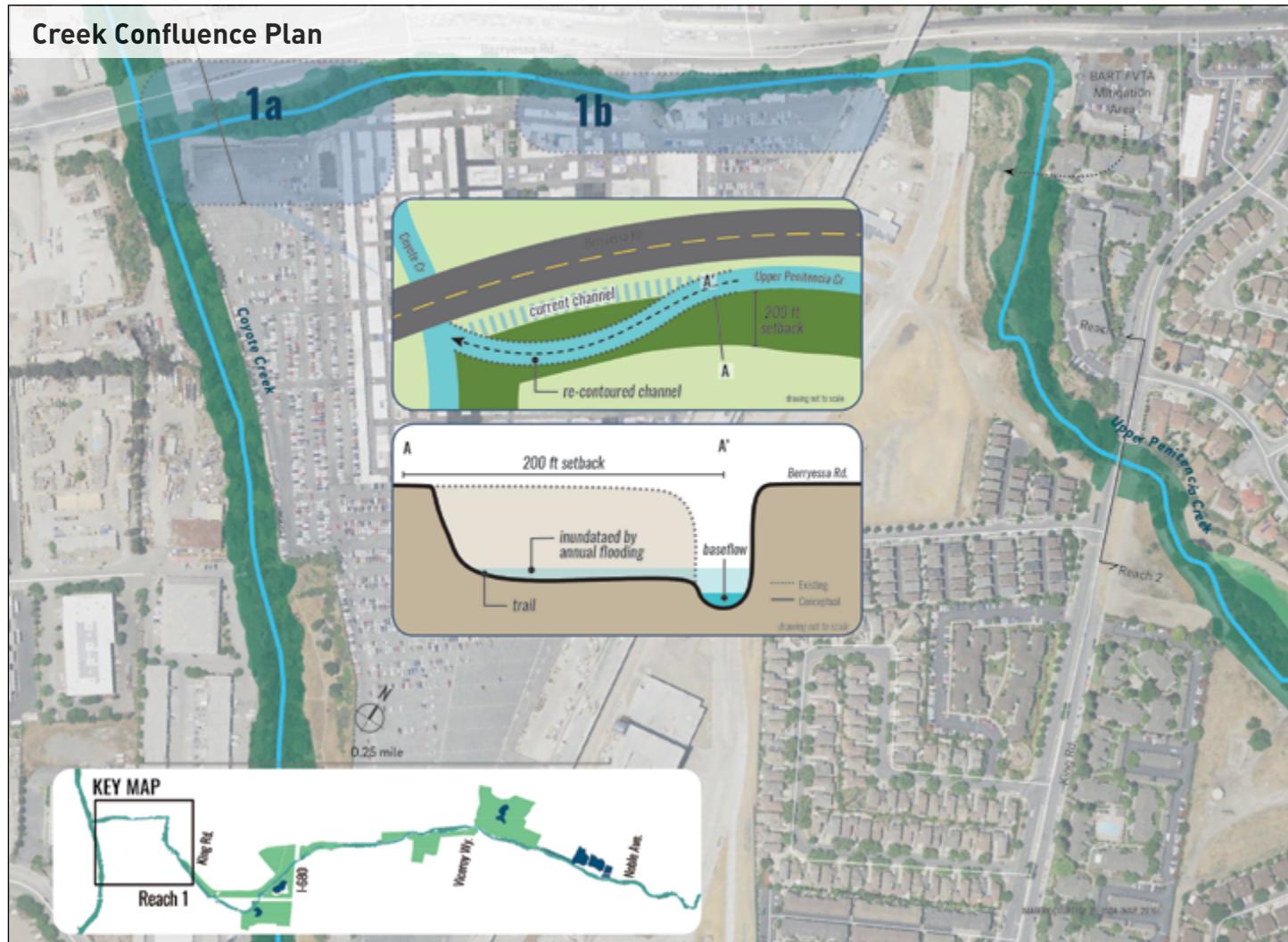
to lower the risk of flooding along the creek through San Jose will cost about \$80 million and are scheduled to finish in 2025.

Valley Water is also putting the finishing touches on a plan for four miles of Upper Penitencia Creek, which flows into Coyote Creek and has the potential to flood about 8,000 homes and businesses, as well as the just-built Berryessa BART Station. "This creek has flooded many times and comes close every time there's a significant rain event," Rouhani says. Damages could run into the hundreds of millions of dollars.

Upper Penitencia Creek is the largest free-flowing stream in the watershed, providing important habitat for steelhead trout. As with Coyote Creek, Valley Water also plans to return this one to as natural a state as possible within the confines of local development. "It was connected to Coyote Creek through a very small ditch by farmers in the 1800s," Rouhani says.

"We want a vegetated floodbench with a meandering creek." Restoring this floodplain will entail setting the levees back a couple of hundred feet; luckily there's plenty of room to do this. "We can widen the creek because most of the lands have been preserved," he adds. This project, estimated at \$24 million, is scheduled for completion in 2026.

Besides working with nature on the ground, Valley Water is embracing the latest flood prevention technology in the atmosphere. In 2019, the agency installed an X-band radar system on top of its Penitencia Water Treatment Plant in the hills bordering San Jose. X-band radar picks up rain at lower elevations than the existing S-band radar system, and is the first part of a new \$27 million system that is currently scheduled to cover the entire Bay Area by the end of 2021. "A lot of our rainfall comes from atmospheric rivers and many of these storms are so low lying that they're not picked up



Vision for the confluence of Coyote Creek and Upper Penitencia Creek (1a modifies the creek channel and improves habitat; 1b extends improvements and mitigation).

by the current system," says Emily Zedler, a Valley Water civil engineer.

X-band radar also offers far sharper resolution than S-band — 100 meters versus one kilometer — that allows tracking rain in near-real time. This now-casting will streamline emergency operations. "We'll be able to say where we think the heaviest rain is going to be in 30 minutes to an hour, and deploy people who are out on the job," Zedler says, noting that this capability will be increasingly important as storms become more extreme with climate change.

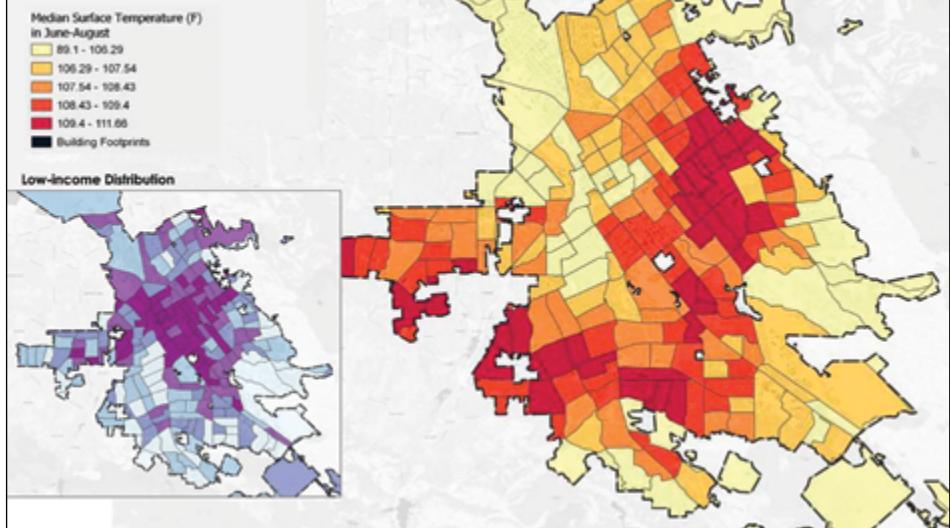
In the county's urban areas away from waterways, heat islands are a concern. "Places with a lot of hard-scape, especially asphalt, absorb heat and then radiate it out," explains Ken Davies, deputy director of the City of San Jose's Climate Smart San Jose. Air temperatures in cities can spike 22 degrees above those in nearby rural areas, putting children, the elderly, and those in poor health at risk.

On days when temperatures soar above 97 degrees, the City of San Jose opens 10 community centers to provide respite for people without air conditioning. Davies expects the need for these centers to grow: high heat days in San Jose are projected to increase from the current five or 10 to about 24 per year by 2050. To pinpoint the areas of greatest need, the city will map heat islands. "Trees and parks can mitigate heat so you tend to find more severe effects in disadvantaged communities," he says. "There are more rentals so people have less control over adding trees."



*Stockpiling dirt in advance of shoreline project at Alviso site. May 2019.
Photo courtesy USCOE*

San Jose Hot Spots Overlap with Lower Income Areas



Heat risk by census tract (climate change is already making hot days hotter). Recent median summer surface temperature (from 89-111 degrees F, yellow to red) overlap with low income distribution (dark purple 14-45% of population living below two times federal poverty level).
Sources: Census Bureau, USGS, NASA, NPR study

Where Coyote Creek meets the Bay, sea-level rise is the greatest climate threat. The South Bay shoreline from Palo Alto to Milpitas is packed with offices and homes built on low-lying land, making it one of the state's riskiest areas for flood damages. In 2005, a team that includes Valley Water and the U.S. Army Corps of Engineers launched the South San Francisco Bay Shoreline Project to assess flood risks along the county's entire 18-mile shore.

The assessment revealed that the risk is greatest in San Jose's Alviso neighborhood, which has subsided as much as six feet due to historic groundwater overdrafts. All that stands between Alviso and the Bay is berms built to separate the area's former commercial salt ponds. "They are just rings of mud," says Valley Water's Blank. "We need to build an engineered levee." The Alviso section of the Shoreline Levee project will entail a four-mile, 15-foot levee from Alviso Marina County Park to the Coyote Creek Bypass Channel, as well as a nearly 3,000-acre tidal marsh restoration that includes an ecotone slope; completion dates could be as early as 2024 for the levee and 2032 for the restoration. The project received \$61 million from Measure AA towards a total cost of about \$200 million.

But in February the project hit a snag. "Bids came in at twice the Corps' estimate of \$17.6 million," Blank says. "We were shocked." Now the team is regrouping. "We believe we can find the cost savings to make this project

affordable," says Neil Hedgecock, chief of the U.S. Army Corps of Engineers San Francisco District's Interagency and Civil Works Branch.

Cost-cutting possibilities include relaxing criteria for the vast quantity of soil — one million cubic yards — needed to build the levee. Current environmental and engineering requirements are so stringent that suppliers have to custom-mix a lot of the soil, which drives up expenses. In addition, both truck frequency and delivery hours are limited at the construction site's access routes, which are in Alviso Marina County Park and Don Edwards San Francisco Bay National Wildlife Refuge. Restrictions on delivery frequency make construction less efficient; restrictions on delivery hours are not cost-effective for contractors, who must still pay full-day fees for trucking. "We've got to find a way to work together," Blank says. "We all want the same thing."

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S A N M A T E O C O U N T Y

Adaption Complexities Spur Planning Innovation

CARIAD HAYES THRONSON, REPORTER

Driving over the Bay flats toward the Dumbarton Bridge's western approach, it's easy to imagine how a few feet of sea-level rise could submerge the roadway. The bridge touches down only 750 feet from the shoreline, and the approach skims just above the fill it's built on. With at least three to six feet of sea-level rise a virtual certainty by the end of the century, the approach and adjacent communities are the focus of a new multi-agency resilience study scheduled for release in June. The study, with participants including the Metropolitan Transportation Commission, San Francisquito Creek Joint Powers Authority (SFCJPA), CalTrans, cities of East Palo Alto and Menlo Park, and the Bay Area Regional Collaborative among others, is the most recent example of the integrative approach to climate adaptation that characterizes many of the county's efforts.

Different Worlds

The section of Interstate 280 that runs down the middle of San Mateo County has often been called the "World's Most Beautiful Freeway," offering panoramic views of the Santa Cruz Mountains and Crystal Springs Reservoir, as well as the occasional glimpse of San Francisco

Bay. From the highway, the traveler might not guess at the vastly different worlds on either side. To the east lie almost all of the county's 20 cities, encompassing the spectrum of socio-economic conditions, including leafy Silicon Valley suburbs, tech mogul estates, and low-income communities perched at the edge of the Bay, as well as transportation infrastructure that includes Highway 101, two transbay bridge approaches, and San Francisco International Airport. West of 280, beyond the wooded mountains, hundreds of square miles of farmland and open space, as well as the beachside towns of Half Moon Bay and Pacifica, spill to the edge of the Pacific Ocean.

Over the past decade, the county has made responding to climate change a priority, establishing several new programs within the Office of Sustainability. The Climate Ready Collaborative brings together leaders from different sectors and jurisdictions to explore adaptation solutions, while SeaChange SMC focuses specifically on sea-level rise.

Wildfire and excessive heat are emerging as local climate concerns, but it is water — too much of it — that worries local officials most. With shore on both sides, San Mateo County is considered the California

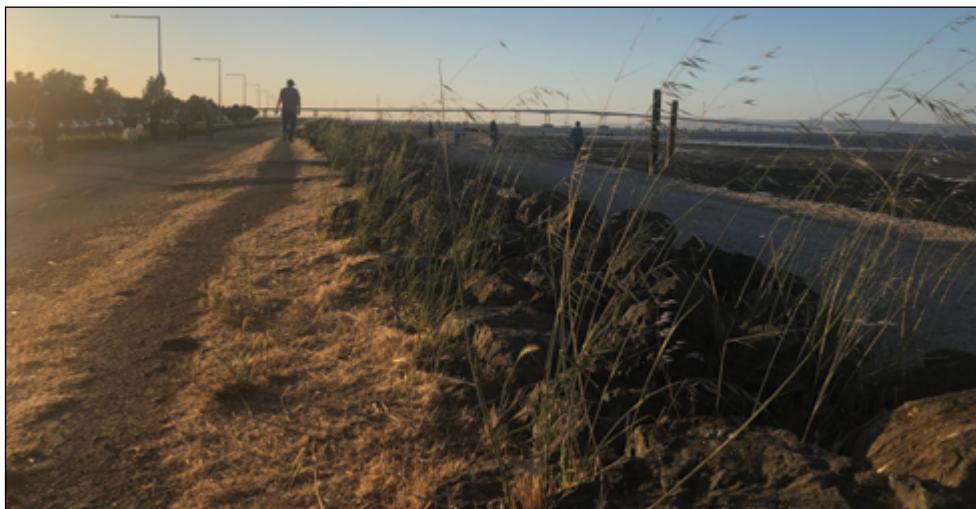
county most at risk from sea-level rise, at least in dollar terms. A vulnerability assessment completed in 2018 found that in a mid-range sea-level rise scenario, property worth \$34 billion would be flooded on the bayshore and the coast north of Half Moon Bay. Facing that reality, the county's leadership has undertaken some of the Bay Area's boldest steps toward protecting its shores.

Flood Control for a Changing Climate

Traditional flood control agencies don't have the flexibility and resources to help multiple cities collaborate to confront the climate change hydra of rising seas, coastal erosion, flooding from major storms, and higher groundwater levels. Recognizing this, in January 2020 the county transformed its long-standing but limited flood control district into a new countywide Flood and Sea-level Rise Resiliency District. "It's not realistic to think that each city could address these challenges singlehandedly," says County Supervisor Dave Pine, chair of the new District's Board of Directors. "We wanted to create an organization that could work across jurisdictions and create expertise for the long run."

One of the new agency's initial priorities is addressing flooding at Bayfront Canal, a sliver of Redwood City and unincorporated San Mateo County that has flooded "in almost any size storm" for decades. Atherton, Redwood City, Menlo Park, and the County all have an interest in the project, which would reroute canal flows to the nearby Don Edwards San Francisco Bay National Wildlife Refuge.

"Historically, these entities haven't been able to collaborate in the way that's needed to make progress," says Pine. "The new district can act as a quarterback to push the project forward." Pine says the district has a design and is currently seeking permits and developing a new agreement among the partners to fund construction.



In 2018 Foster City voters approved a \$90 million general obligation bond to fund raising the city's levee by five feet. Construction is expected to begin in fall 2020. Photo: Adele Thronson

Potential new initiatives for the District include a shoreline protection project along the Burlingame-Millbrae Bayfront, where the two cities have conducted vulnerability assessments. Such a project would be aligned with San Francisco Airport to the north and might include Oculus, Facebook's virtual reality venture, which will soon occupy a new office complex on the Burlingame shore. Additionally, says Pine, the District is committed to identifying projects along the county's coastline to champion. The District will focus its initial efforts in or north of Half Moon Bay, but SeaChange SMC's South Coast Sea-level Rise Study, a vulnerability assessment for the coast south of Half Moon Bay now underway, may suggest new possibilities.

Setting a Precedent

The new resilience district is not the county's first collaborative effort to tackle large-scale flood protection. Near the border with Santa Clara County, the SFCJPA — which includes the new District, the cities of Palo Alto, Menlo Park, and East Palo Alto, as well as Valley Water — is continuing a multi-project effort to prevent flooding from storms and sea-level rise along the creek and at its mouth. In 2018, it completed the largest multi-jurisdictional sea-level rise project in California along the Bay shoreline, and last September, the SFCJPA board certified the final EIR for its Upstream of Highway 101 project, which will address persistent flooding in its three cities. Phase One of the project will protect against a 70-year flood event by widening the creek channel and replacing two bridges. A second phase is now be-

ing studied to provide 100-year flood protection through a combination of raised banks downstream and retention basins built upstream on Stanford University land.

The joint powers authority's other project, called SAFER Bay, covers 11 miles of shoreline, from Palo Alto's southern border to Redwood City. In 2019 the SFCJPA completed a feasibility study of alternatives for protecting the Palo Alto portion, which is now in the hands of the city. For the San Mateo County portion of the shoreline, the authority is in the process of designing and performing environmental analysis for a combination of horizontal levees and other features in East Palo Alto and Menlo Park, near the Dumbarton Bridge and the South Bay Salt Pond Restoration project.

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WATERWAYS

Simple and Powerful for Colma Creek?

At South San Francisco's Colma Creek, one of the sites of the 2018 Resilient by Design Bay Area Challenge, the Hassell+ team received a grant from the Bay Area Regional Collaborative — and later a Priority Conservation Area grant — to develop "the simplest and most powerful idea in our proposal," according to Hassell's Richard Mullane. That idea is to adapt and restore the

creek's native ecology to improve flood risk and create public access along the creek corridor to the waterfront. Mullane expects to release a report in July that will outline various scenarios and rank their costs vs. benefits. "We're hoping to get a continuous pedestrian and bike connection all the way along the creek over, under or around 101," he says. "We'll also highlight funding opportunities at a regional and state level because we really think that's part of our commitment to the city [of South San Francisco], rather than just making big, beautiful images and putting pressure on a small city to deliver."

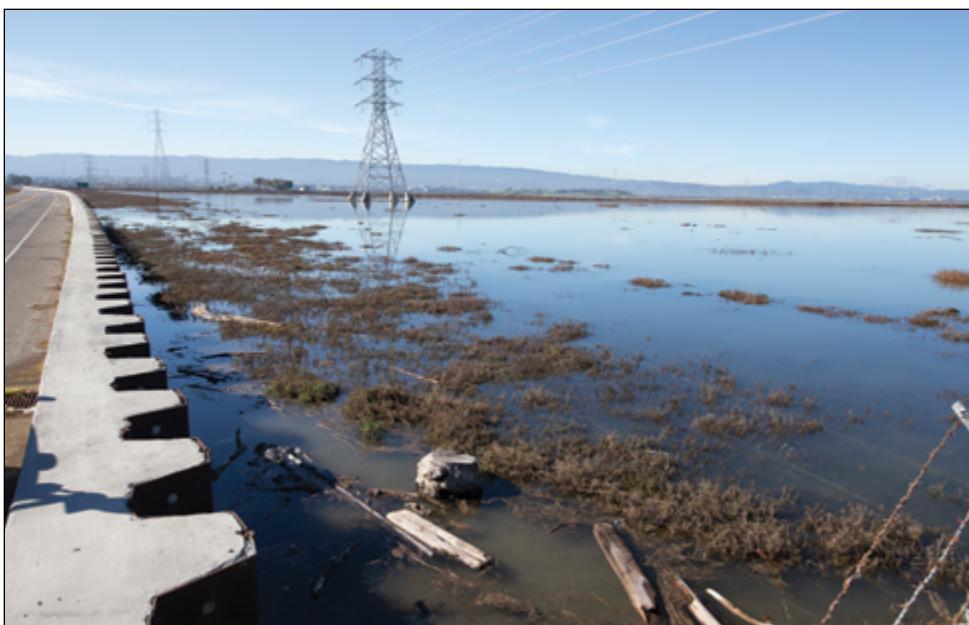
The report will also include a toolkit for other communities. "We think Colma Creek is fairly typical of conditions in many cities around the Bay," says Mullane. "We found 40 creeks that previously connected communities to the Bay but are now cut off by a freeway and flood. Everybody's seeing this opportunity to restore them, and turn back towards them, for amenities and recreation." Mullane says the report will describe the trade-offs between restoration, flood management, and public access and show how those objectives can be balanced. **CHT**

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The Colma Creek corridor project would connect the community with the shoreline. Source: Hassell



Dumbarton Bridge Resilience Study project area. Source: MTC. Top: Bridge causeway close to sea-level. Photo: Caltrans/John Huseby

"The first phase of work is to protect about 90% of East Palo Alto properties, and, in Menlo Park, restore two former salt ponds," says Len Materman, who headed the SFCJPA for more than 11 years before taking the helm at the new county-wide District on May 1. "If we restore both ponds, it's over 600 acres that would be mitigation for the impacts of protecting both cities."

The SFCJPA is also one of the participants in the Dumbarton Bridge study. In addition to homes, businesses, habitat, and transportation infrastructure, the study area contains a PG&E substation, a fire department training facility, and Facebook's headquarters, all of which are vulnerable to flooding from sea-level rise. The goal of the study is to develop adaptation alternatives for the area, including either building a levee along both sides of the bridge approach, or raising it and placing it on a causeway. How the choice among alternatives will be made — and who will make it — remain unclear.

Funding Questions Remain

Also unclear is who will foot the bill to tackle Dumbarton's update and many other critical projects. "As of now we don't have funding for concrete next steps," says MTC's Stephanie Hom. "Some of the partner agencies will continue to look for opportunities to move the work forward in whatever capacity that may be." She expects the partners will work closely with the new resiliency district.

Indeed, one of the priorities of the new district is to develop a long-term funding strategy. "We need to [consider whether the] county should have one or more mechanisms to fund these projects rather than hunting for grants or cobbling together money from city general funds or special taxes," says Materman. "As the county is thinking holistically about planning, it will also think holistically and creatively about funding." Of course, the ultimate costs are unknowable, as sea-level rise has no fixed end date. "You can't simply come up with a plan, implement it, and call it a day," says Pine. "It'll be a challenge we have to confront for many, many decades or longer."

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Retreat or Fight for Coastal Communities?

ALASTAIR BLAND, REPORTER

In the coastal getaway town of Stinson Beach, king tides and storm surges regularly put roads and parking lots underwater — wintertime events that give locals an unnerving idea of what rising sea-level will look like for the small community. “We know sea-level rise is coming, but here, we say we’ve already got it,” says Stinson Beach homeowner Jeff Loomans, also the president of the Greater Farallones Association, which has been active in sea-level rise planning.

Rising sea-level is no longer a distant matter of if or when. Firm science and unyielding line graphs into the future make it clear: the swelling ocean is a reality that is shaping state development policy and challenging coastal communities. Pushed forward by the unstoppable momentum of global warming, repeating waves gnaw at the shore, causing beaches to vanish and sea cliffs to crumble. And homes that once offered residents a piece of the California dream now serve as seaward windows into the uncertain future of coastal living.

The ocean rose about six inches during the 20th century and it could rise six to 10 feet more by 2100 — a

slow-motion tsunami. For some shoreline landowners, the implications seem simple. “We can either fight it or retreat,” says Willy Vogler, whose family owns a share of Lawson’s Landing, a 1,000-acre coastal property at the north end of Tomales Bay. Several feet of sea-level rise will flood this campground and boat-launching destination, and while the site’s owners are now studying their options for what to do as the water rises, Vogler and his family — owners here since 1928 — are fortunate enough to have an escape route: The parcel includes the hillside just east of the water’s edge. “We could just back up the hill,” Vogler says.

A few miles south, in Marshall, the options are fewer. “There’s a bluff right behind us — retreat isn’t an option for these homes,” says George Clyde, whose house stands on pilings over the water of Tomales Bay. Nor is relocation a viable option for most of the homes at Stinson Beach. The town is backed by both the waters of Bolinas Lagoon and the protected slopes of Mount Tamalpais.

“People talk about ‘managed retreat,’ but retreat to where?” says Jack Liebster, advance planning manager for Marin County. The prospect of

managed retreat is especially unpalatable in Pacifica, where the community has debated whether to protect the shoreline with cement and rock or move back and allow the Pacific Ocean to migrate inland. Sea walls and piles of riprap can, at least temporarily, protect vulnerable structures from rising waters, but they have a very negative side effect: by preventing natural sand replenishment from inland deposits, such wave barriers can cause a beach to disappear at the foot of a sea wall. This makes rigid shoreline protections very controversial and generally unfavorable to state planners and many environmentalists.

Sam Schuchat, executive officer of the California State Coastal Conservancy, believes fighting the swelling ocean is a battle people will only lose and that many, if not most, vulnerable communities will eventually have to retreat. “Nothing that we build is going to protect us for very long,” he says.

The diverse geography of the California coast, and each community’s integration into its particular landscape, makes sea-level planning very complicated. So do stiff regulations on new coastal developments, which can impede homeowner efforts to upgrade their properties as the waters rise.

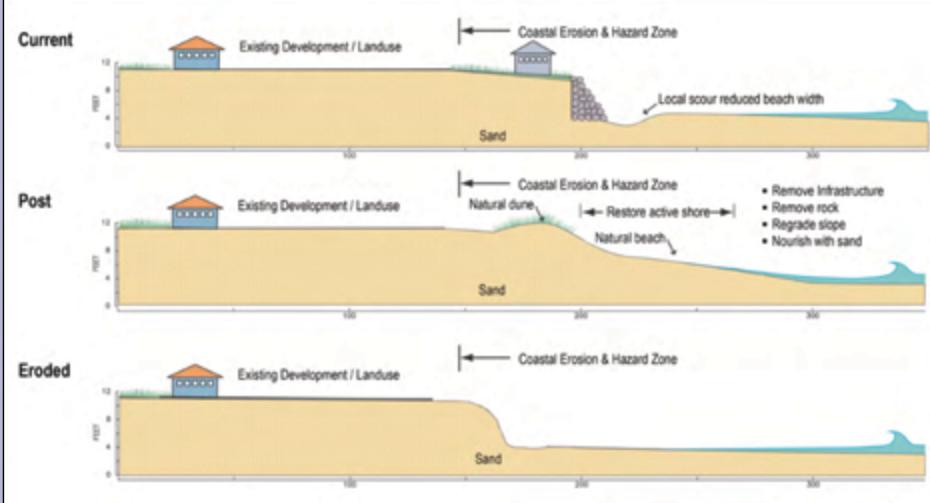
Demographic variation among coastal dwellers also shapes the way different communities grapple with

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Erosion threatens cliff-top buildings in Sonoma County. Photo: Jacoba Charles

Managed Retreat in Stages



Managed retreat involves removing waterfront structures and restoring dunes or marshes to provide a natural barrier. Source: ESA PWA

rising sea-level. Poorer communities seem likelier to be lost — like Imperial Beach, at the border with Mexico. Here, the ocean routinely surges onto the waterfront. Projections show inundation of whole neighborhoods in 80 years, and while many residents have called on leaders to fight the ocean, retreat looks inevitable.

Wealthy communities are likelier to be pampered with shoreline protection and mitigation efforts. Del Mar, in San Diego County, has rejected managed retreat as the community looks ahead, and is instead leaning toward enhanced seawall protections. Similarly, Malibu built a rock wall at the high-tide line in 2010 to shield expensive homes on the bluffs above. This has had severe consequences for Broad Beach, which is now nearly gone and becomes entirely submerged at the highest tides. The saga is a classic California example of social beach injustice — sacrificing the public sand to save mansions.

At the Surfrider Foundation, California campaign director Jennifer Savage feels the long-term public cost of coastal armoring must be weighed against the private property benefits they provide. Her group has taken a general stance against seawalls as a go-to measure to protect shoreline structures. “With building any kind of hard armoring, we’re making the choice between protecting what belongs to everyone and protecting what belongs to private property owners,” Savage says.

USGS research geologist Patrick Barnard has studied waves and storms to help forecast climate impacts over the next 80 years. He says California’s sea cliffs already retreat at a rate of a foot per year on average (usually in the form of decadal landslides). “That rate could double in the next century,” he says.

Seawalls will only delay the process for a geologic moment. Barnard explains that beach incision caused by seawalls eventually undercuts the barrier itself. This can cause the barrier to topple. In the end, money is spent on ill-fated projects and the sea still consumes everything: wall, property, and cash.

Mitigating beach loss is possible but laborious. Some communities run programs of dumping dredged sand on impacted beaches, but maintaining such life-support efforts in perpetuity is a tall order. Beach nourishment programs in San Diego County, for example, have been both expensive and, in the end, ineffective. “Sand replenishment is not a long-term solution,” Savage says.

Along the heavily developed Southern California coast, seawalls and other revetments line 38% of the shoreline south of Santa Barbara, according to a 2018 report on shoreline armoring from California State University Channel Islands. Among counties, Ventura has taken the firmest stance against the ocean, armoring 58 percent of its coastline.

In Northern California, nearly half the coastline is preserved, and very little is developed. With little infrastructure to protect from rising seas, there has been scant investment in seawalls, rockpiles, and other protections. Sonoma and Marin counties, with 340 miles of coast between them, have armored, respectively, just 1.2% and 4.7% of the coast. San Mateo County, with almost 60 miles of coast, has armored 9%. San Francisco County’s short ocean coastline features a seawall for most of the length of Ocean Beach, but the total coastal mileage is only about 10. (Inside the Bay, the stats are skewed toward heavy armoring.)

Still, there are a few oceanfront towns and scattered structures at risk as sea-level rises. Already, several seaside homes perched on crumbling bluffs north of Bodega Bay, at Gleason Beach, have been vacated by their owners, and state roadway officials are planning to reroute a 3,000-foot section of Highway 1 inland approximately 400 feet.

In Pacifica, discussion of managed retreat has met fierce pushback from homeowners like Mark Stechbart. He says a managed retreat program would be far more expensive than the potential alternative of seawalls and beach replenishment. “We would lose a half or a third of the town,” he says. “It would be a billion dollars. Who’s going to pay for that?”

Stechbart says a thousand homes, a shopping center, a sewage pumping plant, an RV park, a golf course, and Highway 1 would have to be sacrificed under a managed retreat regime, which has been discussed in public forums. Facing intense opposition from community members, however, officials released a planning report in February that makes scant mention of managed retreat.

Stechbart lives in a home at the foot of Montara Mountain, roughly a mile inland and 800 feet above sea-level. Still, he worries, homes like his will lose virtually all value “if the Coastal Commission gets their way.”

“They very callously want to kiss off everything built in the past 43 years,” he says, referring to a clause in the Coastal Act that allows “existing” structures to be protected with seawalls. But there has been much disagreement over what “exist-

ing" means. Lesley Ewing, a senior engineer with the California Coastal Commission, says it describes homes that existed prior to 1977, the year the California Coastal Act became law.

However, some stakeholders see a broader definition of the word. "We think 'existing' means what's there right now," Liebster says. This is the literal interpretation of the language, he believes, arguing that legislative action is required "if you want to change the meaning of the law."

But in the era of sound climate science, it's clear that many coastal projects should arguably never have been built in the first place, and protecting them could mean sacrificing public beaches. At Linda Mar Beach in Pacifica, the waterfront shopping center was little more than a surf shop, a café, and a dirt lot 20 years ago. But in the past 15 years, it has seen major investments and upgrades, including a supermarket and craft beer taproom — all just a few feet above the current high-tide line. Whether such development deserves seawall protection lies at the heart of the local controversy and reflects the significance of the Coastal Act's debatable language.

Regardless of what is legally obligated, Schuchat thinks protecting Pacifica's waterfront neighborhoods will be a lost cause. "Even if our resources were unlimited, we couldn't protect Pacifica," he says. "There just aren't engineering solutions that can handle that."

At the southwest corner of San Francisco, officials are planning to use a touch of both managed retreat and concrete defense to deal with a confluence of challenges. Here, the beach is feeling the squeeze as the rising ocean pushes against the riprap that protects a southerly section of the coastal Great Highway. The city's plan is to reroute the highway eastward, giving room for the water to move inland without washing out the beach. Simultaneously, a seawall will be built around the city's sewage treatment plant, which would cost far too much to relocate.

In Stinson Beach, projections show that the sandy strand could be totally underwater by 2100. But there is no firm plan yet to do anything — just a list of ideas. These include protective measures, like seawalls, and adaptive ones, like elevating threatened homes and roadways and relocating a fire station.

There is another idea, too: restoring wetland habitat along Bolinas Lagoon. Such a "living shoreline" would employ native vegetation to hold the soil in place while natural sedimentation adds to the habitat, effectively building the mudflats higher, keeping the shoreline abreast of the rising waterline, and shielding both homes and Highway 1.

"It's a wonderful solution — a natural, native-plant-based habitat solution that reduces erosion and wave impacts, even as the sea rises," says Loomans, who owns a home on the sandy spit reaching northward from the town center. "No one wants a concrete wall out here." Natural solutions are also being discussed at Lawson's Landing: encouraging beach grasses to anchor sand dunes and building native oyster reefs and eelgrass beds, which would create wave breaks while encouraging the deposition, rather than the erosion, of sand.

munities, until sea-level rise makes that impossible."

Jack Ainsworth, executive director of the California Coastal Commission, says the agency has been working with the County of Marin on approaches to safe and sustainable development in coastal hazard areas. "This ongoing process is very challenging," he says. "It requires input and buy-in from many stakeholders with diverse opinions on how best to plan for rising sea levels."

It's undeniable that those rising seas, once discussed as a figment of a foggy future, are happening. Clyde, who is 78 and has closely watched the waterline since moving to his Marshall home in the late 1990s, says he has not seen any obvious change yet in the highest of the high tides. "But," he adds, "it seems that the lowest tides aren't quite as low anymore."



A rock berm guards waterfront homes from high tides and waves at Pacifica State Beach, better known as Linda Mar. The small community, and the nearby shopping center, are a nexus point of community politics and climate engineering as sea-level rises. Photos: Alastair Bland

For Clyde and others in the town of Marshall, basic foundation improvements could lengthen the lifespans of their homes. However, the Coastal Commission's regulations make such storefront upgrades very difficult and costly. In effect, warns Clyde, the Coastal Commission's policies will fast-track the eventual loss of shoreline homes. "This place will be inundated eventually, but we could get a few more decades of life out of them if they'll let us," Clyde says. "We'd like to be able to protect and maintain our homes, and enjoy our resilient com-

Jennifer Savage of Surfrider Lives on the Samoa Peninsula, the sandy spit that shields Humboldt Bay from the ocean. In January, she watched as a storm pushed the water higher than she can recall ever seeing in her 18 years of living there. "The entire beach was underwater," she says. "I'd never seen that before. It was creepy."

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M A R I N C O U N T Y

Squeezed by Geography

NATE SELTENRICH, REPORTER

In most respects, Marin County is a privileged place. It ranks first in the Bay Area for income per capita, and includes many of the region's priciest zip codes. But its miles of Bay and ocean shoreline and many low-lying towns, positioned to afford easy coastal access and world-class scenery, represent a major liability in the era of sea-level rise.

Marin is considered one of the Bay Area's most vulnerable counties. That's largely because the vast majority of its critical infrastructure, including roadways and utilities, exists within a slim strip of land along the Bay shore at low elevation. Much of the county's housing stock and commercial and industrial activity is also concentrated along the country's eastern edge, from the Golden Gate Bridge to Highway 37.

"Marin is the canary in the coal mine in some ways, because almost everything is in that narrow strip along the Bay," says Roger Leventhal, a senior engineer with Marin County Public Works.

Smack in the middle of this span is San Rafael, population 59,000. The county's economic and transportation hub — and home to many of its lowest-income, most vulnerable residents — faces the greatest risk of all. Its downtown and adjacent Canal District — a waterfront neighborhood where immigrant Latino and Vietnamese residents live in aging, high-density apartments — were considered among the region's most threatened sites during the 2018 Resilient by Design (RBD) challenge.

The canal, also known as San Rafael Creek, is about 1.5 miles long and drains a significant portion of the city. Projections indicate that much of the area along its south bank could see major flooding with just ten inches of sea-level rise.

Solutions developed during the RBD process range from the relatively straightforward — like restoring 20-acre Tiscornia Marsh at the creek's mouth, which is already in progress, or raising a nearby levee — to the life-changing and intractable, like retreating from parts of the shoreline that cannot be saved.

San Rafael is now in the midst of updating its general plan to help it respond to rising seas more systematically over the next two decades through a mix of zoning, building codes, and other policies, says Paul Jensen, community development director for the city. The plan is likely to recommend new city government requirements for considering future sea-level when reviewing capital projects; code amendments that establish minimum elevations for building floors; and a formal framework for evaluating physical adaptation projects, from upgraded pump stations and restored wetlands to brand-new levees.

The updated general plan will also suggest a sea-level-rise overlay, a zoning tool that imposes additional requirements and restrictions on properties located within a defined waterfront strip, Jensen says. Its

precise boundaries have yet to be defined, but are likely to follow 2050 projections included in the 2019 Marin BayWAVE report, which outlines waterfront vulnerability and sea-level-rise impacts across the county.

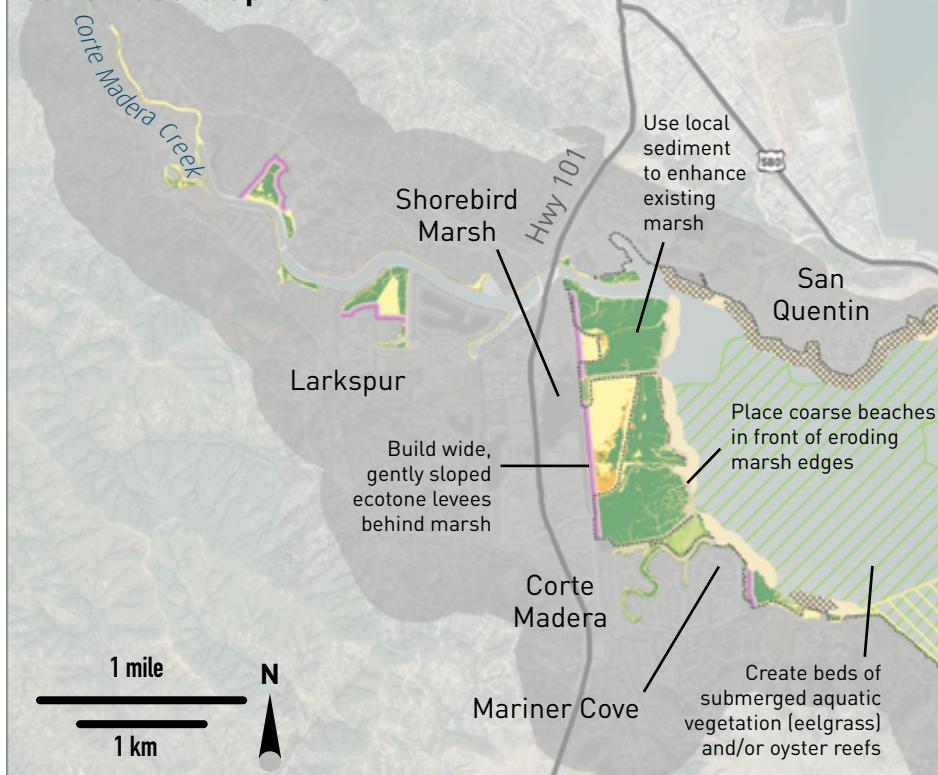
"What's fortunate for San Rafael is that there's been a lot of attention [to] this topic here," says Jensen.

"The timing is right for us to do what we can, and put what we can in our general plan."

Marco Berger, community resilience coordinator for the Canal District nonprofit Multicultural Center of Marin, says it's also important for at-risk residents to have a say in how their neighborhood responds to the crisis. To that end, he leads the Canal Community Resilience Committee, a group of about 40 local residents that began meeting in November 2019 to discuss issues including sea-level rise. He also coordinates community outreach for a broader climate change response program called Drawdown Marin.

"The idea is to bring in people who usually would not have contact with

Corte Madera Options



In 2019, SFEI, Point Blue, and Marin County planners used Corte Madera as a case study to draw up hypothetical adaptation options over time, with an emphasis on nature-based solutions. This forward-thinking planning process is based on prior work identifying "operational landscape units" around the Bay, natural habitats and open spaces that, if taken into consideration while planning for infrastructure and urban adaptation, would add up to better multi-jurisdiction, multi-benefit solutions all around. Corte Madera is currently moving these ideas forward, incorporating community input, and also considering adaptation to wildfire, and other climate hazards.

or access to resources or may not normally be at the table, to create real equity, where those people are getting heard and having opinions and sharing input that officials might hear and take back into their plans," Berger says.

A few miles south along the shore is Corte Madera, home to 10,000 people. As in San Rafael, development is concentrated in low-lying areas along the waterfront, including on Bay fill. Roughly a quarter of its properties fall within the FEMA floodplain, according to director of public works and town engineer R.J. Suokko. "A big chunk of our community is at risk for sea-level rise," he says.

More urgently, one crucial roadway already floods and another may not be far behind. Sections of Lucky Drive, which crosses Corte Madera Creek just west of Highway 101, and Paradise Drive, which hugs the Bayshore, have both been targeted for raising within the next five years.

"[Lucky Drive] is one of three key arteries into Central Marin," Suokko says. "It already floods annually, and in December it was a couple feet [under water], to where I wouldn't advise sedans passing." The city has not secured funding for either project, but is currently looking for grant opportunities, he says.

One potential source is a countywide half-cent sales tax benefiting transportation projects and roads, approved by voters in 2018 for 30 years, with 1% of revenues earmarked specifically for addressing sea-level-rise impacts. This may be the only dedicated source of new local funding for transportation adaptation in the Bay Area to date.

In 2019 total revenues were \$27 million, providing about \$270,000 to the sea-level-rise program, none of which has yet been spent, says Derek McGill, planning manager for the county transportation authority. "It's not a substantial sum in terms of infrastructure redevelopment budgets, but we hope it can at least be a seed that attracts federal and state funding."

Another coordinated, countywide effort revolves around the 2019 publication of a land-use planning guide that recommends baseline policies and an approach to adaptation planning for sea-level rise. County leaders are using it to build consensus among planning directors in nine shoreline cities, including San Rafael and Corte Madera.

FIREWATCH

Backdoor Threat

San Rafael rises toward heavily forested China Camp State Park, while Corte Madera reaches into the county's mountainous interior: wildfire territory. Leaders in both towns recognize that climate change will come roaring at their back door just as surely as it will lap at their front steps.

Voters countywide seem aware of the risk, too. In February, they approved Measure C, a new parcel tax to fund efforts to protect residents from wildfire through early warning systems, defensible space inspections, shaded fuel breaks, and cleared evacuation routes.

Vast swaths of undeveloped and forested lands fill central Marin, from Mount Tamalpais to lesser known ridgelines and peaks in the north. These county, state, national, and water district properties are bordered by, and in some cases interspersed with, remote residences and small communities. As weather patterns shift and the next drought looms, the wildfire threat to interior Marin appears to be growing by the year.

The Measure C ballot language doesn't explicitly refer to climate change, but the official argument in favor led with a clear message: "So far, Marin has escaped a major fire. However with longer, hotter, drier

fire seasons combined with abundant natural vegetation, the need for coordinated fire prevention is crucial."

The Central Marin Fire Department, which serves Corte Madera and neighboring Larkspur, is on heightened alert after recent fire seasons, says fire marshal Ruben Martin. This year it has worked "aggressively" to improve evacuation routes and remove hazardous vegetation along roadways. "Due to climate change, we have been experiencing longer fire seasons," Martin says. "Historically, Marin's fire season began in May and ended in October. We are now experiencing vegetation fires as late as December."

Sarah Minnick, a vegetation and fire ecologist with Marin County Parks, says a landscape and vegetation mapping effort now underway will help the county prepare for and fight future wildfires. "This can provide us insight into some opportunities to address tree mortality or fuel buildup," she says. The new maps can also be compared against older, less-detailed "landform" maps to see how vegetation types have shifted over time — from grassland to shrubland, for instance. "This is impacted by climate change and has implications for fire and how it moves on the landscape," Minnick says. **NS**

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Also in 2019, Point Blue and the San Francisco Estuary Institute, in partnership with the county, developed a separate framework designed to help planners Bay Area-wide include nature-based strategies alongside or in place of hard infrastructure like seawalls and bulkheads as they prepare their shorelines for rising tides. Using four Marin cities located at creek mouths as case studies, the report evaluates the landscapes and shorelines for nature-based adaptation opportunities and constraints, and includes colorful maps detailing outcomes (see diagram).

Beaches, tidal marshes, oyster reefs, ecotone levees, and other sorts of living shorelines that provide wildlife habitat as well as flood protection already figure prominently in adaptation

efforts in every corner of the county, from Tomales Bay to Richardson Bay to diked Baylands in Novato.

Leventhal, who's helping lead a number of these projects, says natural shorelines can buy planners a couple decades by providing wind and wave protection and reducing erosion, but ultimately won't be enough.

"If sea-level is really going up on the order of feet, [these projects won't] necessarily stop that," he said. "The scale of the problem is so big that I don't know of anything [currently] being implemented that's going to make a significant difference."

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SONOMA COUNTY

New Eyes on Floods and Fire

JACOBA CHARLES, REPORTER

As the Kincade fire prompted the evacuations of nearly 200,000 Sonoma County residents last fall, many — including this writer — found themselves glued to their computer screens, watching grainy images from a network of strategically placed cameras.

"During the fire they were the hottest things on the internet," says Dale Roberts, an engineer with the Sonoma County Water Agency (Sonoma Water), which installed the first of the cameras in Sonoma County. These fire cameras are one of the myriad strategies being adopted by agencies, research institutions, nonprofits, and other stakeholders to combat the impacts of climate change that threaten upheaval in virtually all areas of our lives.

Flames have become the unofficial face of climate change for Sonoma County, in the wake of the catastrophic Tubbs and Kincade fires that tore through the northern parts of the county in 2017 and 2019. Together the two fires burned more than 114,000 acres, roughly a tenth of the county. They claimed 22 lives, destroyed almost 5,000 homes, and caused nearly 300,000 evacuations, including many who had to evacuate twice.

However, increased frequency and severity of wildfire is only one of the many ways that climate change is poised to affect life in Sonoma County. "The fires got us all out of our silos," says Lisa Micheli, president of the Pepperwood Foundation and Dwight Center for Conservation Science. "The inextricable linkages between the natural world and our built environment mean that we all need to talk to one another."

Drought and warmer temperatures promise to disrupt agriculture and the natural environment, such as the fog-dependent coast redwoods. Drought also threatens water supplies and increases the chances of catastrophic wildfire, while intense and frequent winter storms mean increased probability of flooding. The Russian River already has the highest repetitive flood loss damages of any location west of the Rockies, according to Caitlin Cornwall, project manager with the Sonoma Ecology Center.

"In the big picture, I tend to think of climate hazards as the horsemen of the apocalypse: there is fire, flood, drought, heat wave, and sea-level rise," says Cornwall. "We had all of these before, really on a regular basis — just not at this frequency or severity."

County Overview

Sonoma County has long been known for its scenic nature and its agriculture, and both of those characteristics remain. Historic exports included hops, prunes, and apples, as well as redwood lumber and tanoak bark for tanning hides; today, it is the largest wine producer of the North Bay's famous Wine Country region. The majority of the county is undeveloped privately owned pasture or forestland.

Large numbers of tourists bringing vital revenue — as well as climate impacts in the form of car and airplane emissions — are drawn to the vineyards and the scenic beauty that ranges from the broad valley and rolling hills of the southern and eastern county to the steep bluffs and ridges of the Coast Range. The meandering Russian River has attracted summertime bathers and boaters in droves since the 1800s.

Despite this, Sonoma County has the second-lowest population density of the nine counties surrounding



Aftermath of the Tubbs Fire, Santa Rosa, October 2017. Photo: Jacoba Charles

the San Francisco Bay, behind Napa county. It also has comparatively little development along its southern border adjacent to the San Pablo Bay; this offers the county some protection from the impacts of sea-level rise, apart from the threat to Highway 37 (see p.25). The wetland complex along the Petaluma River is the largest intact historical wetland in the Bay Area, and perhaps in California, according to Kendall Webster of the Sonoma Land Trust.

As with the rest of the Bay Area, Sonoma County's politics skew to the left — a fact that has likely given it a leg up in its approach to climate change. In addition to a progressive local government, it is home to numerous agencies, organizations, and stakeholders that are tackling the problem, including the world-renowned conservation science organization Point Blue.

Spotlight on Sonoma Water

Among the many groups that are working to tackle climate change in the county, Sonoma Water has been notably undertaking a variety of forward-thinking projects. Beginning in 2015, the agency achieved its goal of producing "zero-carbon water," by storing, treating, and supplying water to its 600,000 customers using electricity generated from non-fossil-fuel sources.

"We'd rather have a stable climate, but it varies, so we'd be hypocritical if we were contributing to the cause of that variation," Roberts says. While the agency contracts to obtain 80% of the needed power, the remaining 20% is generated locally, from solar, geothermal and hydropower. "I wish



Fire cameras northeast of Santa Rosa. Photo courtesy Pepperwood Preserve

this approach was more prevalent in the water industry, but it's a fairly conservative industry in general," Roberts says.

But that is only the beginning of the adaptations the agency has made. It had already begun exploring the idea of the fire cameras when the Tubbs fire sparked more interest in 2017, according to Roberts. "We funded eight fire cameras in the area and got them up and running in a year or so," Roberts says. "That sort of nudged PG&E into putting in almost 20 more."

The cameras use "pan-tilt-zoom" technology, and are part of a larger network of cameras throughout western states called ALERTWildfire, which is managed jointly by the University of Nevada Reno, University of California San Diego, and the University of Oregon.

Another climate change impact facing Sonoma Water is increased extreme-weather events such as flood and drought. The water agency has to balance both, working to ensure that reservoirs don't overflow during storms while also retaining enough water to carry customers through the dry season.

A new tool they are using to achieve these often conflicting goals is Forecast Informed Reservoir Operation, which uses regionally specific modeling for the Russian River Watershed to anticipate when and exactly where a rain-laden atmospheric river will arrive, and just how much rain it is anticipated to drop (see also Santa Clara p.13).

This year, despite the third-lowest rainfall in 127 years, the new system allowed the agency to save an extra 18% of water in storage, according to Roberts. "We had a really wet November and December, but even so we kept the water level in our reservoirs higher than we normally would because we could see that there were no more atmospheric rivers predicted," he says. "Now we have a lot more water stored this year than we ever would have historically. If you don't try anything new nothing bad will happen but nothing awesome will happen either." He added that the final decision about when and how much to release during winter rests with the Army Corps of Engineers, describing their willingness to try the new approach as "a pretty bold move on their part."

The agency has engaged with numerous other projects that will

help mitigate or adapt to climate change, including launching the Fire Smart Lake Sonoma program; collaborating with first responders, private landowners and stakeholders to reduce wildfire fuel loads to protect critical drinking water supplies; elevating electrical equipment above the 500-year flood level; increasing "situational awareness" of mudslide risk by making data from stream and rain gauges above and below burned watersheds public; and continuing collaboration with research institutions to apply modeling to their water management.

Sonoma Water is set to complete its Climate Adaptation Plan later this year.

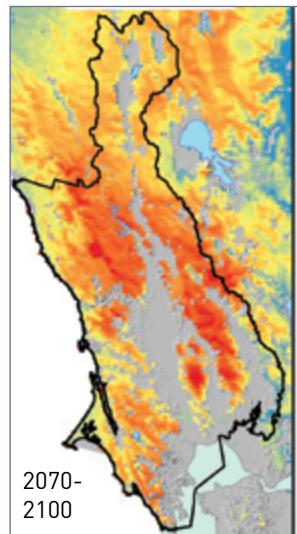
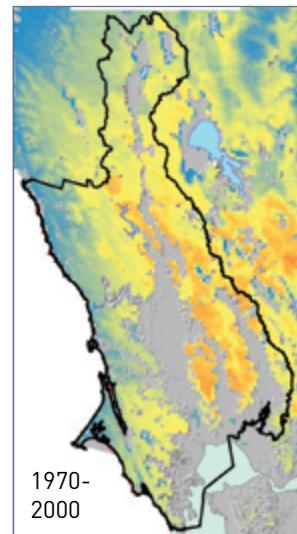
An Active County

Sonoma Water is only one example of the proactive approach the county has taken to address climate change. In 2014, Sonoma County was one of 16 communities recognized as "climate action champions" by the Obama Administration. Sonoma was the first in the nation to create a local government agency specifically to address climate change. The Regional Climate Protection Authority, formed in 2009, has committed to pursue a 25% reduction in greenhouse gas emissions from 1990 levels through formal partnerships and pooled resources (financial and human), and by working across silos. (In 2020, San Mateo County also formed a new agency to cross silos, this one aimed at flood resilience.)

In the last decade, the county has taken many other steps to address climate change. Last fall, the Board of Supervisors approved a declaration of a climate emergency, which will enable it to prioritize projects that reduce greenhouse gas emissions, mitigate climate change impacts, and promote climate resiliency. Sonoma Clean Power, a community choice aggregation program launched in 2014, brings renewable electricity to a majority of county residents.

In 2013, the Sonoma County Agricultural Preservation and Open Space District and Sonoma Water were

Probability of Burning Two or More Times



Source: North Bay Climate Ready Natural Resource Managers

awarded a \$1.2 million NASA grant to work with the University of Maryland on a prototype remote sensing project to inventory the county's forest carbon stocks, monitor sea-level rise, and map groundwater. Meanwhile the Sonoma Resource Conservation District, independent of county government, offers a LandSmart planning program to assist landowners in implementing practices such as soil and water conservation, habitat enhancement, and carbon sequestration to manage their lands for climate change adaptation. Carbon-farm plans and forest management plans and practices are being implemented to achieve both local and watershed-based objectives.

However, following the 2016 presidential election federal funding for climate change-related projects and research slowed to a trickle. Now, in the midst of the coronavirus outbreak and economic downturn, the flow of funding has slowed even more. "Our county is working so hard — every agency has climate as a priority on their agenda but they are really maxed out, they could use more resources," said Micheli. "We're at the point where the limit is not scientific knowledge, or knowing what we need to do — we now need to make the social progress required to act on our knowledge and shift the status quo."

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N A P A C O U N T Y

Planting for Resilience

CARIAD HAYES THRONSON, REPORTER

Travel brochures for Napa County almost universally feature the same images: a valley floor carpeted with vineyards, nestled between hillsides dotted with spreading valley oaks. As climate change brings hotter days — and more of them — to the county, these twin pillars of the landscape, grapevines and oak trees, are both challenged by it and central to local resilience strategies.

Napa County shares many of the characteristics of Sonoma, its neighbor to the west, including an economy largely dependent on agriculture and the tourism fueled by its wine industry and bucolic landscape. Ironically, many of the measures that are now cushioning some of the effects of climate change were enacted to protect that landscape long before the climate became a worry. Various statutes enacted since the 1960s have limited development on Napa Valley's floor and hillsides, while several flood control and aquatic habitat restoration projects along the Napa River buffer flooding from sea-level rise.

But in recent years, the county has been slow to respond to the crisis. A climate action plan has been in the works since 2011, but has yet to be adopted — a delay some local activists attribute to pushback from the powerful agriculture industry (though several cities, including Napa and American Canyon, have their own plans). The current draft of the plan, which was completed in 2019, includes a vul-

nerability assessment that identifies increasing temperatures and reduced rainfall as the biggest threats to the county, threatening agriculture and drinking water supplies, and fueling wildfires.

Even in the absence of an official plan, the county is pursuing several climate projects, according to county planner Jason Hade. These are primarily focused on reducing greenhouse gas emissions and expanding water recycling.

Meanwhile, other entities, including agencies and individual businesses, are spearheading efforts to adapt to the new climate reality, centering on the county's iconic flora.

"Napa is historically one of the better environments for the valley oak, the massive trees you see on postcards," says Napa Resource Conservation District's (RCD) Lucas Patzek. Historically Napa's alluvial plains were covered with oak forests, mostly composed of valley oaks. Roughly 90% of them have been lost to development, according to a 2012 report by the San Francisco Estuary Institute that inspired the RCD to establish a community-based re-oaking program. A county ballot measure that would have tightened restrictions on oak removal failed by a thin margin in 2018.

Hotter, drier weather will likely make Napa's environment less hospitable to oaks, particularly valley oaks, which require a lot of water and prefer cooler temperatures. "Native oak

trees are experiencing climate change, and they are also our friends as we humans think about how we are going to [adapt]," says the RCD's Frances Knapczyk. Oaks sequester a tremendous amount of carbon, improving the soil's ability to hold moisture, aiding groundwater recharge, while their huge canopies provide shade, "which is going to be super important as the temperature goes up. Our streams are going to need more shade, and so are our buildings," says Knapczyk.

In 2019, the RCD partnered with North Bay Watershed Association and SFEI to develop a regional re-oaking strategy that identifies the best places to plant the trees and works with landowners to integrate them onto their property. "We started with Napa and Sonoma counties but the same methodology can be applied to Marin and Solano," says Patzek. The RCD is also working with the cities of Napa and American Canyon to develop a cohesive urban forestry plan in part to reduce heat island effects. Beyond the RCD's efforts, the county has budgeted funds to help replant oak woodlands and promote oak education throughout the county.

Of course, oak trees can only do so much to mitigate the local effects of climate change, and those effects — drought, heat, and wildfire — are creating an unnerving threat to the wine industry, which dominates the local economy. "Right now Napa is in a sweet spot for growing premium wine grapes," says local climate activist Jim Wilson. "But it's well known that in a couple of generations it won't be."

That vision of the future is leading some Napa winters to experiment with varietals and viticultural techniques — and even new growing regions. Beckstoffer Vineyards is conducting a trial north of Napa in Lake County, where seasonal variation is greater, "to forecast the impacts of climate extremes and how they relate to Cabernet production," says director of operations Cliff Nelson. "We hope to stay ahead of the impacts of climate on Cabernet in traditional growing areas."

Nelson points out that the climate has already changed significantly, and that growers have adapted. He says he has no plans to shift operations to another locale. "Napa is a very special area and I do not think it will ever be replicated or reproduced."

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Iconic Napa Valley flora. Photo: Ariel Okamoto

Highway 37: The Road to Restoration

JOHN HART, REPORTER

San Francisco Bay has seven highway bridges with tolls, eight if you count the span linking Antioch to the Delta. In the future it just might have nine. The latest candidate is not the long-debated Southern Crossing, but rather a series of causeways carrying California's single most vulnerable road in the era of sea-level rise: State Route 37 between Vallejo and Novato.

A bridge on dry land? But the dryness of this region is a fading illusion. Over a century ago, dikes, pumps, and fill transformed a 50,000-acre wetland wilderness into a fabric of fields and managed ponds — for a geological blink of an eye. Now the tides are returning, in a process partly planned and partly inevitable. In the name of habitat, something like half of the old wetlands along this arc have been reopened to the Bay, with much more to come.

Elsewhere, pumps labor to keep the water out of fields that have sunk as much as seven feet below sea-level. At some points the asphalt of Highway 37 lies no more than two feet above typical daily tide levels. In the wet winters of 2017 and 2019, the low points flooded for weeks at a time. While the nine miles from Vallejo to Sears Point feel most exposed, the western reach in Marin has proved especially inundation-prone.

Throw into this hydrophilic situation the factor of sea-level rise: over a foot by 2050 and three feet by 2100, to pluck mid-range numbers from the State's latest complex table of probabilities. With each revision, the estimates nudge upwards. Ten feet of rise by century's end is quite possible. Storm surges and peak runoff will add to the pressure at times. And the encroachment won't stop at a convenient cut-off date. Based on the record of past warm periods, a 2015 paper in *Science* suggested, the total accumulated rise could be twenty feet or more.

From head-on collisions in the 1980s to crippling congestion now, Highway 37 is a familiar headache for highway engineers. The focus on its very survival dates back to 2010. In that year the Federal Highway Administration and the California Department of Transportation chose this road for one of the first studies ever on roads and sea-level rise. Study lead Fraser Shilling of the Road Ecology Center at UC Davis credits two Caltrans workers, Katie Benouar and Kome Ajise, for wrangling this unusual support of long-distance planning by agencies sometimes accused of limited vision. "This whole field has moved forward in leaps because of champions [like these]," says Shilling.

As the Davis team wrapped up its SR 37 Integrated Traffic, Infrastructure and Sea-level Rise Analysis, the initiative passed to the local level. In 2015, the counties along or near the route — Solano, Napa, Sonoma, and Marin — joined the Metropolitan Transportation Commission and Caltrans in a Highway 37 Policy Committee. Fearing that engineers might not take full account of the vast marsh restorations underway in the area, the Sonoma Land Trust, the Coastal Conservancy, and others joined in a State Route 37-Baylands Group. In 2017, the group laid down markers: Whatever is done with the east-west highway must also improve the passage of tides and stormwaters north and south, not further impede those flows.

This statement was more than just advice. The Baylands Group spoke for powerful landowners along the route, notably the state and federal wildlife agencies. It had the backing of the Environmental Protection Agency and the regional water board. And it had arithmetic on its side. It was only by factoring in a lot of environmental improvement that any major retrofit could pencil out economically; without the "green" factor, its cost-benefit ratio would fall below one, a Caltrans make-or-break metric.

In fact the highway planners readily accepted that they must do two things at once: preserve and improve an overburdened transportation link, and support the great North Bay wetlands project. While they were at it, they also undertook to find a place for the Bay Trail and to make life easier for the many workers who commute from Vallejo to Marin. "It's much more joined-up thinking than we've had in the past," says Jeremy Lowe of the San Francisco Estuary Institute.

What is now called the Resilient 37 program has weighed the options for the short term, and the long. The uncontroversial early steps are aimed at relieving congestion. The two-lane stretch between Vallejo and Sears Point will likely be reconfigured to offer one or two additional lanes; a traffic circle will smooth the difficult intersection of 37 and northbound Highway 121 near the Infineon Raceway. But all such works are for a generation only.



Levee repair after recent flooding on Highway 37. Photo: Caltrans/John Huseby

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The long-term options are much more varied, debatable, and costly. Three bights of the Baylands must be traversed or circumvented: a small one around Novato Creek, a larger one east of the Petaluma River, and a vast one between Sears Point and the Napa River.

The cheapest fix in each case would be to raise the road on much wider embankments, putting maximum barriers in the way of natural flows. The most dramatic would be to build a straight-line over-water bridge between Novato and Vallejo. The most circuitous would be to shift the highway northward, at least in the eastern reach, skirting the largest lobe of the marshy realm.

But the option that has floated to the top in analysis and stakeholder conversations is to leave the road roughly where it is but elevate it on pilings for many long stretches, making it

The work could be “self-mitigating.” “The wetlands could do what they need to do,” says Jessica Davenport of the Coastal Conservancy, “and the road would be out of harm’s way.”

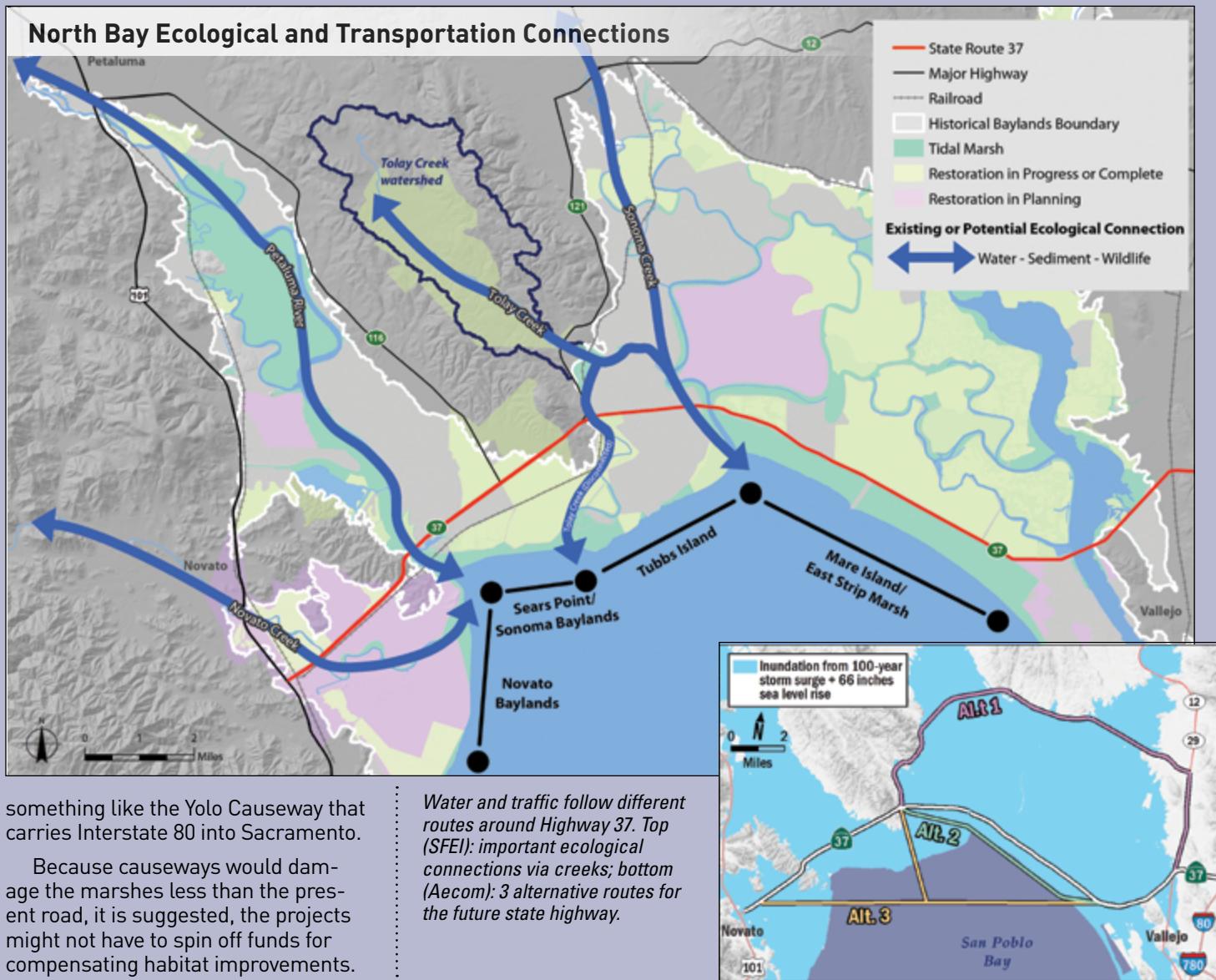
The apparent drift toward the maximal causeway option arouses one dissent worth noting: from Fraser Shilling, lead author of the UC Davis study that started this ball rolling. In 2017, he and Steven Moore, then a member of the State Water Resources Control Board, wrote an op-ed suggesting more attention to the northern route. “Acknowledging that today we would never build a costly highway through sensitive tidal marshes, [we could] move the transportation function inland and off the marshes altogether.”

Shilling feels the same today. He questions Resilient 37’s initial conclusion that the northern path would do more harm than the southern. “I think

an honest appraisal of environmental impacts would bring [the northern route] to the front. The marshes will suffer under the causeway option.” As for cost, Shilling finds incredible the conclusion that skirting the marsh would be pricier than crossing it. Among other things, he points out, these estimates assume that the “new” 37 must start and end exactly where the “old” one does.

The arguments on costs and impacts will continue for a while. “There really is no perfect solution,” says SFEI’s Lowe.

The immediate next step is to firm up plans for the western reach of the road, from US 101 to State Route 121, called Segment A. The Metropolitan Transportation begins a “design alternative assessment” this month; Caltrans will gear up its CEQA process soon after. Attention will then turn to



something like the Yolo Causeway that carries Interstate 80 into Sacramento.

Because causeways would damage the marshes less than the present road, it is suggested, the projects might not have to spin off funds for compensating habitat improvements.

the near-term improvements for Segment B, from 121 to Mare Island. The ultimate vision for this problematic stretch will take longer to confirm. "Timing will be dependent on funding," says Stefanie Hom of the Metropolitan Transportation Commission (MTC).

Besides the highway, two other transportation lines have claims on planners' attention in the San Pablo Baylands: the Bay Trail and the railroad. Along these northern shores the Bay Trail is largely an aspirational dotted line, but Sonoma County has a genuine hiking and cycling path almost from border to border. One segment makes a loop around Tubbs Island; the second follows a new levee in the Sears Point Wetlands Restoration Project. A gap of less than a mile separates the two. In the near term, advocates want to forge this missing link. The voids in Solano County and Marin County will be more challenging to fill. In the long-term, the trail might evade rising waters to the north, or wind up bundled in alongside causeways. If offset from or sunk lower than the traffic lanes, the path could still be a pleasant walk or ride.

A rail line, now used only for freight, runs from Novato to Suisun City, where it joins the Capitol Corridor Amtrak route. The tracks parallel Highway 37 in Segment A from Novato to Sears Point and then swing north near the marsh edge, passing south of Sonoma and Napa on their way east. The California State Rail Plan of 2018 foresees passenger service on this route, and Sonoma-Marin Rapid Transit, which owns much of the line, is interested in providing it someday.

Though not so vulnerable as the road, the tracks, too, will eventually have to be elevated or shifted in the face of sea-level rise. In their present location, they also complicate restoration projects; the need to protect them limited marsh expansion at Sears Point. Again, the long-term solution is to combine the highway and the railroad in one corridor. (And what about the far-out possibility of retaining the railroad only?) These fundamental issues seem to be beyond the scope of the current planning.

Which brings us to the massive question all acknowledge and no one yet can answer: where does the money come from? The maximum causeway option, by the latest estimate, would

cost about \$3.5 billion. Vital though it is, Highway 37 seems to be no one's burning priority. And there are so many other claims. The MTC noted in January: "For this east-west connection, the proposed resilience project [has] higher costs and lower benefits than other transportation facilities requiring protection from rising sea-levels."

To stand a chance in the race for funds, the highway must pay part of its own way. This spring, before the coronavirus scrambled priorities, Senator Bill Dodd of Napa introduced legislation to make it a toll road. (This would turn back the clock: the route first opened, in 1928, as a private turnpike.) A \$5 or \$6 toll, Dodd estimates, could yield \$650 million over twenty years. That is a far cry from \$3.5 billion, but it would certainly cover interim work and serve as a lever to pry loose larger blocks of funding from the state and, above all, the feds. "If people really want to do this," says the Coastal Conservancy's Davenport, "there's always a way."

In the current health and financial crisis, it has to be said, the way seems longer than ever before. It is a special case of a general problem. As the Bay Area girds for sea-level rise, the initial question is: What would it take to save everything? What can we do, we ask, to protect this neighborhood, this road, that bridge, this stadium, this waterfront? The Resilient by Design competition brought out many attractive partial solutions, including the bold "Grand Bayway" vision for the San Pablo Baylands. The prevailing mood is: yes, we can do it, if we are smart, if we are quick, and if we can raise colossal sums. It is surely good, as a thought experiment, to test out a policy of minimal retreat.

But — especially if the more pessimistic estimates of sea-level rise prove correct — brutal facts are going to force a triage. Is letting go of an asset like Route 37 out of the question? "We cannot abandon it," says Sonoma Supervisor Susan Gorin firmly. Consultant Doug Wallace, formerly of EBMUD, offers another view. "When circumstances force our hand," he says, "we will think previously unthinkable thoughts."

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RESTORATION

Separating Two Creeks to Reduce Flood Peaks

The diking and draining of the San Pablo Baylands began 150 years ago and peaked in the 1980s. The long journey back began in 1994, with a tiny restoration on the Petaluma River, called "Carl's Marsh" for its champion, Carl Wilcox of the California Department of Fish and Wildlife. The success of that small project led to big and then bigger ones — and to a vision for a vast new wetland system.

The latest piece of that vision is the Sonoma Creek Baylands Strategy, due for release in June. Developed by the Sonoma Land Trust, it is funded in large part by the San Francisco Bay Restoration Authority through 2016's Measure AA. The U.S. Fish and Wildlife Service, the Resources Legacy Fund, and the Dolby Family Fund have pitched in as well.

The strategy addresses lands along the lower course of Sonoma Creek that are still behind dikes and largely in private ownership. This terrain is the next frontier for restoration, as funds become available and property owners find themselves ready to sell. "Willing landowners, the SR 37 redesign, and the pressure of climate change set the stage for this study," says Kendall Webster of the Trust.

The emerging preferred alternative calls for restoring some 5,000 additional acres of marsh and rerouting Tolay Creek so that it flows directly into the Bay instead of joining Sonoma Creek. By separating the two creeks, the plan will reduce the flood peaks on Sonoma Creek and postpone the day when a key bridge on Highway 37 has to be lengthened and raised.

That highway — together with the Bay Trail and a railroad line owned by Sonoma-Marin Rail Transit — looms large in the thinking of restoration planners. Agnostic about the details of routing, the Sonoma Creek Baylands Strategy underlines the need to get infrastructure out of the way of water movement, and favors "co-location" of the three transportation lines.

Could transportation budgets ultimately help fund the restorations? "That's the unicorn we're pursuing," Webster says. **JH**

SOLANO COUNTY

Small Town and Big Marsh Brace for Spreading Bay

ROBIN MEADOWS, REPORTER

When heavy rains coincided with an extreme high tide in 2005, water from the Carquinez Strait overtopped flood protections in the City of Benicia. Making matters worse, the high seas also submerged stormwater outfalls. Water backed up stormdrains, inundating historic homes and small businesses.

As tides keep rising, scenarios like this will play out more often—and with greater severity—along the Solano County shoreline, which extends 40 miles as the crow flies from San Pablo Bay to the Delta. The county, which covers 900 square miles and is home to half a million people, assessed climate vulnerabilities in its 2011 Sea-level Rise Strategic Program, noting that the document is “a first step and call to action to identify opportunities inherent in the challenge.” High risk areas in addition to Benicia include Highway 37, which runs along the San Pablo Bay (see p. 25), and the Suisun Marsh, the Bay Area’s largest remaining wetland.

In 2016, the City of Benicia — population about 28,000 — developed a climate adaptation plan. “This was the first stand-alone climate adaptation plan for a city of its size,” says climate expert Alex Porteshawver, who worked on the project with a team of consultants. “In general, smaller jurisdictions don’t have stand-alone plans.”

Strategies for protecting Benicia from floods include retrofitting downtown streets with rain gardens to absorb stormwater, equipping stormwater outfalls with tide gates to reduce water backup, and expanding the remaining salt marsh to form a natural barrier to sea-level rise along the shore.

Most of Solano County’s shoreline is along the Suisun Marsh, which encompasses one-fifth of the jurisdiction and is by far the most extensive area vulnerable to climate-driven flooding. A mix of diked and tidal wetlands, it falls under the Suisun Marsh Protection Plan, which dates to 1977. The SF Bay Conservation and Development Commission (BCDC) recently launched



Bay Trail on the Benicia waterfront. This popular near-shore trail, which circles much of the Bay, is vulnerable to sea-level rise but also represents a critical buffer zone. Photo: Paul Okamoto.

a review of the protection plan. “There were environmental concerns — like climate change — they may not have been thinking about in the ‘70s,” says agency coastal scientist Rachel Wigginton, who leads the review.

At the protection plan review’s kickoff meeting in February, stakeholders identified likely areas of concern. “Climate was one of the big topics,” Wigginton says. The next step is for the stakeholders to set priorities. Possibilities for sea-level rise adaptation include giving tidal marsh room to migrate upland, bolstering levees to withstand increased pressure from rising waters, and using salinity control gates to keep salty ocean water from penetrating further inland.

Nearly half of the Suisun Marsh is diked. “Bigger rains and flood events will overwhelm the levee system,” says Steve Chappell, who directs the Suisun Resource Conservation District. “We need to keep pace with sea-level rise.” This will entail raising levees and pumping water out more often.

Most of the marsh is public land, but it also has about 140 privately owned duck clubs that maintain habitat for waterfowl. The marsh is a major stop along the Pacific Flyway, attracting more than one-quarter of the state’s wintering waterbirds. While most climate adaptation is publicly funded, duck club owners are in the unusual position of paying out of

pocket for — and deciding whether to implement — any such measures themselves.

That said, duck club owners must still deal with California’s increasingly variable environment. “Flooding from bigger rainstorms and severe droughts are more immediate threats,” explains Chappell, who advises the marsh’s private landowners on stewardship. “They need to be prepared.” Drought can worsen saltwater intrusion in these managed wetlands, requiring increased freshwater infusions to flush out the salinity.

Caring for his piece of the marsh is a labor of love for Kent Hansen, co-owner of the Goodyear duck club, 400 acres on Morrow Island near the Benicia-Martinez Bridge. “We spend a lot of time maintaining levees and controlling invasive plants,” says Hansen, who grew up in a farming community and has worked his land in the marsh for two decades. “Sea-level rise is a worry to us but we can only address it year by year.” The 10 members of his club will foot the bill for about \$25,000 in routine maintenance this year, which does not include major levee work.

To Hansen, it’s all worth it. “We look at ourselves as conservationists—the marsh is full of really cool wildlife,” he says. “It’s an amazing place.”

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A L A M E D A C O U N T Y

Parks and Cities Seek Shore Resilience

JOE EATON, REPORTER

For Alameda County, climate vulnerability is no abstraction. King tides push the waters of San Leandro Bay into parking lots at Martin Luther King Regional Shoreline. When Diablo winds rattle the eucalyptus, Berkeley and Oakland hill-dwellers recall the conflagrations of 1923 and 1991 and dread the next one. The county feels the bite of both edges of the climate sword: fire and flood.

Alameda is a big (739 square miles), populous (an estimated 1.7 million), diverse county: hills and flatlands, students and retirees, new money and underground artists, banh mi, birria, boulani, barbecue. It encompasses the academic powerhouse of UC Berkeley, the South County tech scene, mushrooming urban infill construction, grotesque real estate values, proliferating homeless encampments, brownfields, and former military bases in varying stages of cleanup. While some cities are skewing whiter and richer, communities of color remain substantial. There's overlap with pockets of socioeconomic disadvantage, many in low-lying bayside areas.

With highways, BART, a major airport and seaport, business parks, and sports complexes, Alameda is dense with critical infrastructure. Yet it's also rich in open space, much of it in a regional park system shared with bordering Contra Costa County, its coastal units stitched together by the San Francisco Bay Trail. Some coastal wetlands harbor endangered species. There's a lot at risk here, and cities, the East Bay Regional Park District (EBRPD), and other entities are engaging with climate adaptation on multiple fronts.

Parks at the Forefront

With 58,713 acres and 426 miles of trail in Alameda County alone, the EBRPD is the largest landowner on the shoreline and plays a large role in adaptation planning. District policy gives precedence to science-informed and nature-based climate solutions, and management is also attuned to social equity issues. "What is being protected by our levees, trails, and wetlands is largely the flatlands, with more

disadvantaged communities than the East Bay Hills," observes government affairs manager Erich Pfuehler. He adds that EBRPD has encouraged the San Francisco Bay Restoration Authority to focus on equity issues in the East Bay in allocating funds from 2016's Measure AA regional parcel tax.

The park district's Alameda County portfolio includes two Restoration Authority funded projects: Encinal Dunes in the city of Alameda, and Coyote Hills in the south county, where ambitious plans are afoot. "Coyote Hills will be a climate-smart park," says district deputy general manager Ana Alvarez. "It's located in the city of Fremont, but visitors come from other areas, like Newark, with large economically disadvantaged populations." In the works are riparian forest restoration to sequester carbon, expanded seasonal wetlands to increase floodwater storage capacity, and an interpretive program that speaks to climate change.

For its 47 miles of Bay Trail, EBRPD has begun assessing risks and prioritizing projects, with funding from Caltrans through 2017's transportation-infrastructure-focused Senate Bill 1 (see p.3). Engineer Jack Hogan of Arup, one of several consulting firms involved in the planning project, points out that there's more to the trail than recreation: "It wasn't designed to provide shoreline flood protection, but it is the de facto protection in some areas."

His team has used a number-crunching approach to help EBRPD choose which trail segments to tackle first, weighting each section on hazard, vulnerability, and consequences. EBRPD has yet to decide on priorities, but from what chief of planning Brian Holt says, segments along the Oakland Estuary could well make the cut: "It's an area of concern — endangered species at Arrowhead Marsh, I-880, the port and airport, buildings that come right up against the shoreline."

Looking for Lines of Defense

Worries about a rising Bay flooding the cluster of roads, utilities, and endangered species habitats on a long stretch of Hayward shoreline put the area on planners' radar more than a decade ago. Since then it has served as a micro-regional planning pilot for how to assess risk and adapt.

The Hayward Area Shoreline Planning Agency (HASPA), a new joint powers authority composed of local park districts and municipalities, is developing a Shoreline Master Plan with SB 1 funding. Regional park units include the Hayward Regional Shoreline, with its popular interpretive center, and a preserve for the endangered salt marsh harvest mouse.

Earlier this year a team of consultants led by New York-based SCAPE presented three potential strategies for

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Alameda's resilience plan explores options for spots vulnerable to sea-level rise such as this lagoon inlet on Bay Farm Island.

review by the project's stakeholders. Alternative options for placement of the "line of protection" against rising tides were dubbed "Closer to the Bay," "Down the Middle," and "Further Inland." A preferred alternative, likely incorporating elements from multiple plans, will be chosen later this year after stakeholder feedback.

HASPA's Taylor Richard says two options aren't currently on the table in planning for a projected four-foot sea-level rise: armoring the shoreline and managed retreat. "At seven feet or higher, maintaining structures may become unfeasible. But in the

timeframe we're looking at managed retreat isn't likely — it's too far out there," she says. "One of our goals is to build resilient communities. The plan, in the timeframe we're exploring, is to protect housing."

All three proposals involve some realignment of the Bay Trail, with two moving it significantly farther inland. When that was suggested by the Adapting to Rising Tides program of the SF Bay Conservation and Development Commission (BCDC), the idea generated pushback as incompatible with the "blue water experience" valued by trail users. Agency planners

and stakeholders will be discussing tradeoffs. "We'll get together with our Ouija boards and crystal balls and figure it all out," jokes city of Hayward planner Damon Golubics.

Sometimes a line of defense can be crafted with nature-based materials. Near the HASPA project area, the Coastal Conservancy is moving forward with a gravel beach and berm at the Eden Landing Ecological Reserve. The project, supported by a National Coastal Resilience Grant, was an element originally developed by SCAPE and others working to unlock Alameda Creek in the 2018 Resilient by Design challenge.

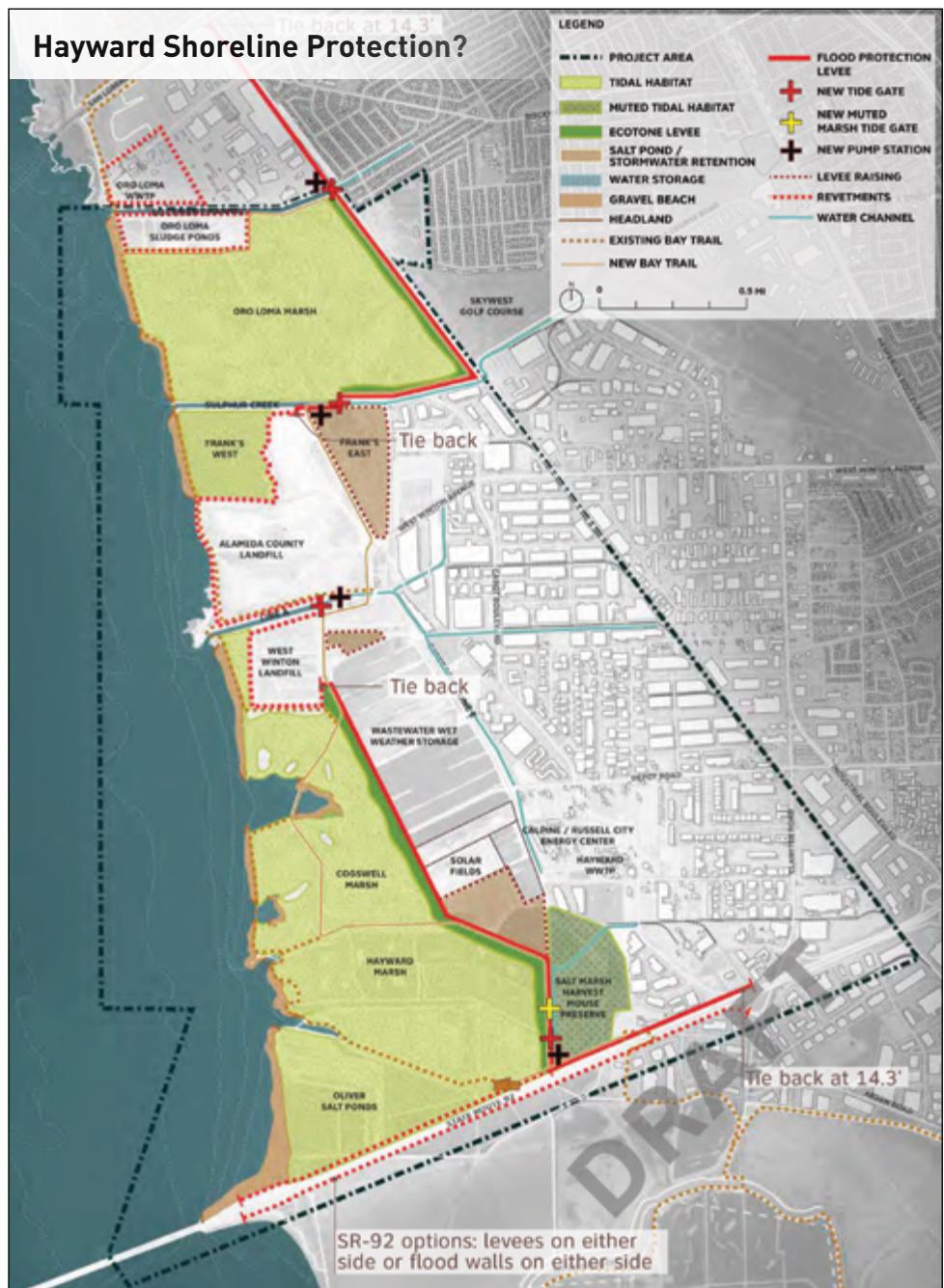
Using coarse-grained material like gravel, the beach and berm will help stabilize the outboard levee at Eden Landing. Project manager Laura Cholodenko says information from similar projects at Aramburu Island in the North Bay and Pier 94 in San Francisco was reviewed to help inform the design. "The 300-foot beach is a pilot project," she explains. "If it performs well and provides erosion protection, we can scale it up and install it along other areas of the levees." The project, now early in the permitting process, would provide roosting and foraging habitat for sensitive bird species like the California least tern and western snowy plover (see *Estuary News* June 2018).

Considering Equity

Meanwhile, in revising an older climate action plan, the City of Alameda is investigating how groundwater may compound future flooding. Groundwater is also an emerging concern in East Oakland, where research reveals the potential for dangerous interactions with soil contaminants.

The City of Alameda's Climate Action and Resiliency Plan is unusual in its attention to the increased risk and social equity implications of flooding. Climate resiliency consultant Lauren Eisele, an Alameda resident, says that the island city's original climate plan emphasized greenhouse gas emissions and was not completely implemented. She and other members of Community Action for a Sustainable Alameda (CASA) pushed for a revision.

A new plan was developed by Boston consulting firm ERG. Mapping social vulnerability with an index from BCDC, the plan reported that some of



"Down the Middle" line of flood protection. One of three options in the Hayward shoreline adaptation plan. Map: SCAPE

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Tending the Urban Earth and Its People

AUDREY MEI YI BROWN, REPORTER
ROBIN BEAN CRANE, RESEARCH & ART

While most activities ground to a halt in the COVID-19 crisis, nature didn't skip a beat at urban farms across the Bay Area. Urban farms meet an array of local needs, whether it's for organic food, living wage jobs, a community center, or a place to connect with nature. With the CO-VID crisis, and with many American communities touched by loss and fighting racism, these needs have become even more acute. Farms, gardens, and nurseries across the Bay Area are rising to the challenge.

Times of extraordinary change reveal how future climate injustices may well play out: the "haves" marshal the means to protect themselves and the "have-nots" bear the burden of impacts. In particular, the nation is gaining painful insight into how pre-existing vulnerabilities and prejudices get lethally compounded in a crisis.

The voices of Bay Area farmers, shared in this story, highlight personal experiences of climate justice and community resilience. Urban farms and gardens strengthen their communities, in the face of both climate change and persistent inequality.

Gardening for Health and Justice

Yenni Copto grafts fruit trees for East Oakland's Planting Justice, a combination farm, nursery, and education program that serves people impacted by mass incarceration and social inequity. The community the nursery serves has been her home for twelve years, and it is already experiencing tangible climate impacts.

"I remember, when I was a little girl, the heat waves didn't used to be this hot," says Copto. She has felt firsthand the escalation of heat and unbreathable air from wildfires, which in recent years have razed communities across the state. Many of Copto's neighbors have asthma, a condition linked to prolonged exposure to air high in particulate matter. In East Oakland, the air is already polluted by the 880 freeway, and wildfires only exacerbate the pollution. But Copto's neighbors have noted improved air quality around the nursery.

Planting Justice uses no chemical pesticides or fertilizers, in order to protect the plants they grow and the people who eat them. From the organization's standpoint, the resilience

of the land is intimately tied to the health of the people. Fresh produce in itself presents a health boost, given that the area is a food desert. "Aside from the nursery you have to drive to get organic food that's not processed," says Julio Madrigal, a Planting Justice farmer.

As Copto's community proves, a food desert is not just a place of lack. They can be dynamic communities, animated by people who have found innovative and resourceful ways to meet their needs despite their circumstances.

Cultivating Community

Urban farms strengthen a community's social safety net. Even before the COVID crisis, they offered resources and mutual aid through informal community networks. "The chayote, collard greens, herbs for respiratory distress, garlic — it was all already growing before COVID," says Wanda Stewart, a garden educator at Hoover Elementary School Garden in West Oakland.

In a time when bulk food supply chains have broken down across the country, the local scale of community farms has emerged as a strength rather than a vulnerability. Marianne Olney-Hamel is a farmer with Berkeley Basket CSA, which grows produce in three Berkeley backyards. The farm participates in an intricate web of cooperation. "Because we are so small and hyper-local, there is opportunity for community building and mutual aid, like some CSA members delivering boxes to those who are disabled or can't leave the house," says Olney-Hamel.

The farms foster relationships between neighbors, and between the community and the land. Zolina Zizi is a farmer with Urban Tilth, and she maintains the community garden along the Richmond Greenway's three-mile community bicycle and pedestrian trail, along with a nearby edible forest that boasts more than sixty varieties of fruit trees. She has observed the mutual benefits that the Greenway and the community gain from each other. "Homeless



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folks have a really good relationship with the garden and help take care of it, and make sure nobody bothers it," Zizi says. In turn, the garden's bounty is available to all for free, as a community resource.

"It's the ultimate in stacking functions," says Stewart, describing the diverse benefits, including support for mental wellness, that coalesce in community gardens and farms. At Hoover Elementary, she has observed firsthand how her students' test scores, behavioral issues, and general ability to focus improved after the school's garden education program was implemented. At Planting Justice, the staff includes people re-entering society from jail and the prison system. The farm provides structure and a tight-knit community. "People who have worked with us have stayed out of trouble for years, because we give them the support and resources they need," says Copto.

Farming for the Future

In anticipation of a changing climate, Shao Shan Farm in Bolinas has intentionally stressed its crops with minimal watering and selected seeds for drought tolerance. Owner Scott Chang-Fleeman is entering his second growing season, selling heritage Asian produce to CSA members across the Bay Area as part of the urban greenbelt. As someone who

learned how to farm during the worst drought in California history, Chang-Fleeman knows what he will be up against in the future and is preparing today. In an effort to conserve water and minimize impact, at Shao Shan all irrigation water is gathered as rainwater catchment. The farm does not divert water from streams or draw water from wells.

Not all farmers are on equal footing when it comes to preparing for climate impacts. Much of a farmer's power and ability to plan ahead hinges on land ownership, which has been denied to many farmers of color. That inequity galvanizes Chang-Fleeman. "California's agricultural landscape was built by people of color, and it was stolen from them. There needs to be a redistribution and re-allocation of wealth when it comes to land ownership and agriculture," he says.

This history affects how farmers today like Minkah Taharkah can prepare for disasters. "People who come from historically marginalized communities have certain generational setbacks that impede our ability to get prepared," says Taharkah, a farmer with the Black Earth Farms Collective in Berkeley, which practices African indigenous agroecology on UC Berkeley-owned land at the UC Gill Tract Community Farm. Because they cultivate land that they

don't own, they can't count on being able to farm it in the future, making it difficult to plan ahead. Nevertheless, the Collective is undeterred. "Working within a communal structure of different parcels of land will allow us to build a network that [provides for] different types of disaster preparedness," she says.

In addition to supplying the community with food and jobs, the farms seek to shift how people care for the land and each other. Before he joined Planting Justice over ten years ago, Madrigal wasn't aware of the pesticides and chemicals in the food he ate. "Learning about farming opened my eyes to having that connection to growing my own food, for myself and my family," he says. As one of Planting Justice's teachers, he hopes to pass on that awareness to his students.

When it comes to raising awareness of climate change in the community, he thinks the lessons lie in the garden. "When people grow gardens, they start to realize that we emit a lot of pollution and that we have to allow nature to recover," he says.

Taharkah also sees implicit lessons in cultivating the land that have long-term impacts. "We learn from plants that things take time. We have to move at their speed alongside them. Continuing to return to the earth together is an integral part of addressing all these crises," she says.

"I don't think the climate change piece is in any way separate from the people piece," says Stewart. "The people systems have served me as well: sharing resources, seeds, relationships. Those relationships are what get us through. We're tending the earth and tending its people."



Y O L O C O U N T Y

Carbon Goes Deep

ALETA GEORGE, REPORTER

Spring is a busy time of year for Full Belly Farm, a 400-acre certified organic farm in Yolo County's Capay Valley about 90 minutes northeast of San Francisco. The farm sells produce to restaurants and farmers' markets in normal times, and continues to sell produce and other goods through a popular CSA in these not-so-normal times.

"Springtime is when we plant summer crops and are in full-on harvest of spring crops," says Paul Muller, one of the founding owners. Added to their springtime mix of tasks is a project devoted to testing a new soil practice in collaboration with UC Davis. Full Belly Farm is participating with several other California farmers in a study of an organic, no-till vegetable production system to capture and retain the most possible carbon in the soil, reduce greenhouse gas emissions, and produce healthier soils and more nutritious crops.

In this second year of the three-year experiment, Full Belly Farm has planted 15 acres with a mixture of legumes and grasses — such as oats and wheat — to keep the soil continuously covered. Before the cover crop goes to seed, they roll it down with a tractor so that the plants die in place and form a thick mulch mat. They plant the crop seeds directly in the mulch bed without turning it over.

"By not disturbing the soil, the whole soil system behaves very differently," says Muller. It captures more carbon and keeps the soil open and porous. "A love of the plow might be a misguided relationship. Turns out it may not be the best for the soil ecosystem," he adds.

Full Belly Farm has grown crops in the Capay Valley for 35 years, just a blip in an agricultural tradition that includes the Yocha Dehe Wintun Nation, whose people have tended the land for over two millennia. Agriculture covers 87% of Yolo County, and is the county's largest industry. According to a Climate Action Plan adopted by the county in 2011, agriculture contributes just 14% of the

county's greenhouse gases (GHGs). Most of the rest is generated in the cities of Woodland, Davis, and West Sacramento. Although the 2011 plan lists measures with targeted goals for reducing and sequestering carbon by 2020, a county spokesperson said the measures were not tracked, and are therefore not reportable.

Scott Stone has always done "cowboy composting," which he explains is spreading old hay around the property. Now he is in his second year of a California Healthy Soils demonstration project, part of the Healthy Soils Initiative, a collaboration of state agencies that promotes healthy soils to increase carbon sequestration and reduce GHG emissions. Stone has also applied for a second grant to plant cover crops and apply compost on more range-land. The two projects cover about 200 acres.



Cover crops span a walnut orchard. Source: River Garden Farms

No more normal

Whether or not the actions of Yolo County farmers and ranchers are being tracked, many are keenly aware of climate shifts and actively involved in GHG reduction strategies.

Scott and Karen Stone run Yolo Land & Cattle, a 7,500-acre ranch that lies partly in the Blue Ridge Berryessa Natural Area. The ranch, which has been in the family for 46 years and has a conservation easement on 7,000 of its acres, runs a cow and calf operation that produces grass-fed and grass-finished Angus beef.

The Stones have planted riparian areas and hedgerows for carbon sequestration, use solar water pumps to reduce GHGs, and manage a 400-acre conservation easement for Swainson's hawk on their irrigated pastureland. In 2007, their efforts earned the ranch the Environmental Stewardship Award.

In 2019 they had a real problem on their hands after the 2018 County Fire burned 7,000 acres of the ranch in July. The following winter, 36 inches of late rain pummeled the scorched ground. "In January, we had about six inches over a two-day event and it just tore apart the ranch," he says. A high-intensity fire burns vegetation and organic material in soil, which renders it less able to absorb water and more susceptible to erosion.

"There's no such thing as a normal weather year anymore, and drought keeps raising its head on a pretty consistent basis," says Stone. In the past, the ranch generally received about 18 inches of annual rainfall starting in October, when the weather is still warm enough to get the grasses growing. Later rains are colder, and the grasses are slower to germinate, says Stone.

continued on next page

The ranch has had only 11 inches of rain this year, leaving the stock ponds in the hills empty. "It's going to be a long summer and fall," says Stone.

Scaling up to scale down carbon

On the northeastern edge of Yolo County sits River Garden Farm, a family-owned 15,000-acre operation near the Sacramento River. Its primary crops are rice, walnuts, sunflowers, and corn, which are shipped around the world.

With grants from the Healthy Soils program, River Garden Farms is cover-cropping a 113-acre rice field and a 300-acre walnut orchard for three years, and planting a riparian grassland and hedgerow a mile long and 12 feet wide. With another recently approved grant, they will cover crop another 300-acre walnut orchard. "I hope we are moving towards building healthier soils that can store more carbon," says assistant general manager Dominic Bruno.

The farm has been taking soil samples and sending them to a lab, but they do not yet have results to

share. "It's cool to go out and see flowers blooming and bugs flying around. It feels like you're doing the right thing, but we don't have any hard evidence yet," says Bruno. "It kind-of comes back to being good stewards of the land, being part of the community, and preserving a healthy environment for ourselves and for those around us," he adds.

Yolo County farmers and ranchers are not going it alone. They have support from the Yolo County Resource Conservation District (RCD), UC Cooperative Extension, and others. "A well-managed farm can provide more than just food," says RCD director Heather Nichols. "Simply by being an open space they provide services. We want to help them produce even more functions than they already do."



Yolo Land & Cattle applying compost with support from the state's Department of Food and Agriculture's Healthy Soils Program. Photo: YLC

"I do not know if I am setting an example for other farmers and ranchers with my projects," says Stone. "I am trying to do the right thing for the resources that I am stewarding, and if we can share the science that shows we are doing the right thing for the land, then that is a win for all."

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CUTTING EDGE

Hedgerows Make Good Neighbors

In the early 1970s, secretary of agriculture Earl Butz urged farmers to plant "fence row to fence row" in order to squeeze all they could from the land. The cost of his admonition

resulted in "clean" farms across the nation with sterile fields devoid of riparian habitat, beneficial insects, and healthy soils.

John Anderson, a retired UC Davis veterinarian and founder of Hedgerow Farms in Winters, bucked the notion that a producing farm had to be devoid of wildlife, and began to repair the farmland he bought in the late 1970s. "One impact of successful farming is the unfortunate, lifeless state of

vast acres once so important to the myriad of species that inhabited the Sacramento Valley," wrote Anderson in 1998. He planted his drainage ditches with native trees and grew hedgerows, field borders of varying plants that provide habitat for beneficial insects and predators. As farmer Paul Muller says, they "set the table" for wildlife to return.

When Anderson discovered that there were few places to buy native seeds, he started Hedgerow Farms. It became a demonstration site, from which Anderson proselytized the advantages of bringing "farm edges back to life."

"Thanks to the vision of John Anderson, Yolo County has led the way in implementing these living systems," says Heather Nichols, director of Yolo County Resource Conservation District. "RCD and others have planted 50 miles of hedgerows in Yolo County in the last 20 years." **AG**



Hedgerows invite wildlife to return to field edges, providing habitat for beneficial insects, birds and predators. Source: Hedgerow Farms

SACRAMENTO & SAN JOAQUIN COUNTIES

Sinking Islands Capture Carbon Credits

EMILY UNDERWOOD, REPORTER

As sea-levels rise and land in the Delta sinks, agencies and land-owners are recognizing that levees alone will not protect critical fresh-water supplies and infrastructure. Encouraged by a recently vetted new method for creating carbon offsets from wetlands, a flurry of new climate adaptation projects on publicly owned islands strewn along the central Delta corridor aim to defend against sea-level rise, restore habitat, and reduce greenhouse gas emissions.

On May 11, the California Department of Water Resources (DWR) set in motion a plan to flood a 1,000-acre tract of Sacramento County's Sherman Island called "Whale's Belly" with several inches of water, in hopes of creating marshland that will restore fragmented wetland habitat, slow the loss of peat, and prevent thousands of tons of carbon dioxide from escaping into the atmosphere.

Meanwhile back in March, the Metropolitan Water District of Southern California received a \$1 million planning grant from the Department of Fish and Wildlife to conduct an assessment on four islands it purchased in 2016 — Bacon Island, Bouldin Island, Webb Tract, and a majority of Holland Tract. Over the next year or so, the district will consider various opportunities for restoration on the islands, ranging from carbon sequestration in wetland marshes to rice farming to promote sustainable agricultural practices, then rank each island according to its suitability for different approaches, according to MWD senior engineer Russell Ryan.

Until recently, the prospect of selling carbon credits in the Delta remained fairly abstract. This spring, however, researchers from DWR, UC Davis, UC Berkeley, and the consulting company HydroFocus cleared an important hurdle when an independent team of scientists approved their protocol for determining how many tons of carbon Delta wetland



A HydroFocus employee making accretion measurements in wetlands. Photo: Max Schenk

restoration can keep out of the atmosphere. (The team calculated that 1,700 permanently flooded acres would soak away 56,000 tons of carbon dioxide over a five-year period.)

Now that the protocol has been vetted, the American Carbon Registry will be able to start selling credits to companies that want to offset their carbon footprint. The added benefits of helping wetlands and protecting water supplies are likely to increase the credits' per-ton value from the average of \$3 to \$4 per ton to "maybe up to \$7 or so" per ton, says hydrologist Steven Deverel of HydroFocus, who helped develop the protocol.

California's Air Resources Board is now evaluating the protocol for use in the state's strict "compliance market," created for entities

like gas and oil companies that are required by California law to limit their carbon emissions. If it passes muster, that could raise the value of wetland-produced credits to around \$16 per ton, a rate that approaches what farmers can make raising corn or another traditional field crop, Deverel says.

Many important questions remain to be answered, such as how long farming families would have to commit to converting their land to wetlands. One goal of the new restoration projects is to test whether selling carbon credits could be a viable economic alternative for farmers whose land is increasingly too wet to allow the operation of heavy farm equipment. "There are many places [in the Delta] that farmers don't farm because it's a little soggy, and it's just not worth it to them," says Randall Mager, a senior environmental scientist with DWR. "Can we take that marginal land and turn it into full-on carbon sequestration that farmers can actually make some money on?"

Environmental organizations are also watching the new carbon credit market closely, in hopes that it could provide a mechanism to both fund their own projects and help farmers. On Staten Island in San Joaquin County, for example, The Nature Conservancy is converting several thousand acres into wetlands and rice fields to provide bird habitat, an undertaking that could hypothetically support itself through the sale of carbon credits. Over the long run, farmers who use at least some of their land to sequester carbon and slow the loss of peat may have a better chance of holding on to their farms, says Dawit Zekle, associate director of the conservancy's land program. Their farms "might look different...but at least they'd still preserve their investment."

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San Francisco Bay and the Sacramento-San Joaquin River Delta comprise one of 28 "estuaries of national significance" recognized in the federal Clean Water Act. The San Francisco Estuary Partnership, a National

Estuary Program, is partially funded by annual appropriations from Congress. The Partnership's mandate is to protect, restore, and enhance water quality and habitat in the Estuary. To accomplish this, the Partnership brings together resource agencies, non-profits, citizens, and scientists committed to the long-term health and preservation of this invaluable public resource. Our staff manages or oversees more than 50 projects ranging from supporting research into key water quality concerns to managing initiatives that prevent pollution, restore wetlands, or protect against the changes anticipated from climate change in our region. We have published *Estuary News* since 1993.

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ALAMEDA COUNTY, cont'd from page 30

Alameda's neighborhoods at near-term risk of flooding from sea-level rise are among the most vulnerable in terms of income, housing, health, and English-language skills. Alameda's bridge-and-tunnel links to Oakland and existing hardened shoreline infrastructure pose challenges to adaptation, but the plan proposes nature-based solutions (living shorelines, wetland restoration) for other areas. "Several of the major adaptation projects will require increases in local funding, as well as federal and regional grants," says longtime CASA leader Ruth Abbe.

The influence of sea-level rise on groundwater levels was not included in the plan's flooding vulnerability assessment; the city of Alameda has hired Christine May of Silvestrum Climate Associates to fill this gap. Rising seas could push groundwater up, encroaching on pipes and basements and emerging to flood the surface, according to another expert, UC Berkeley's Kristina Hill. Using data on wells along the Bayshore, Hill, May, and UC researcher Ellen Plane mapped potential groundwater flooding hotspots. In a 2019 article, they reported significant potential for groundwater flooding in parts of Oakland, Hayward, and Fremont, including Interstates 580 and 880 and the Oakland airport.

Flooding is only part of the risk. Hill and her students just completed a

survey of historic contamination in East Oakland, identifying a dozen or more sites where rising groundwater could mobilize contaminants, some of which are no longer being monitored by the SF Bay Regional Water Quality Control Board. Groundwater can also contribute to seismic risk through soil liquefaction, particularly in areas of Bay fill like West Oakland and Alameda.

Hill says regulators and climate adaptation planners have overlooked groundwater. That's changing, though: groundwater is being incorporated in the Adapting to Rising Tides database, and a current collaborative proposal could fund more comprehensive mapping through a Bay Planning Coalition adaptation grant.

While rising seas threaten coastal assets, EBRPD and the cities are bracing for ever-lengthening fire seasons. The East Bay Hills are a type specimen of the wildland-urban interface areas common throughout the drying West. "Our fire chief is very concerned about Tilden Regional Park" on the Alameda/Contra Costa line, says Holt. "In Oakland, the area of the 1991 Tunnel Fire has historically burned every 20 to 30 years," he says. EBRPD's Wildfire Hazard Reduction and Resource Management Plan, adopted in 2010, had a long and tortuous path to implementation, complicated by changes in regional partnerships and litigation over eucalyptus removal. "We have a thinning plan for eucalyptus," Holt explains. "It's not practical to remove them all."

Funding all these projects will be more challenging than anyone could have imagined a few months ago, with state and local budgets stressed by pandemic response. The City of Alameda has delayed the hiring of a resiliency manager and postponed an infrastructure bond and other revenue measures, according to CASA's Abbe. "In the face of COVID it tends to look a little grim," Hayward's Richard notes. "But it's really long-range. We have a lot of time to pursue grant options, look at different funding sources." Richard and Golubics are looking at Restoration Authority funding for Hayward.

Another resource may be the EBRPD's Green Bonds, which can be used for adaptation, as well as other purposes. The district's vegetation clearance for wildfire risk reduction was funded in a special-district measure 16 years ago; the district is now advocating for more funding and personnel.

Pfeuhler has heard talk of a possible state climate stimulus bond initiative for a future ballot. For now, he says he'd like to see better regional coordination to support adaptation to the heightened risks of fire and flood: "We need to figure out a way to address funding that's more holistic, less piecemeal."

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