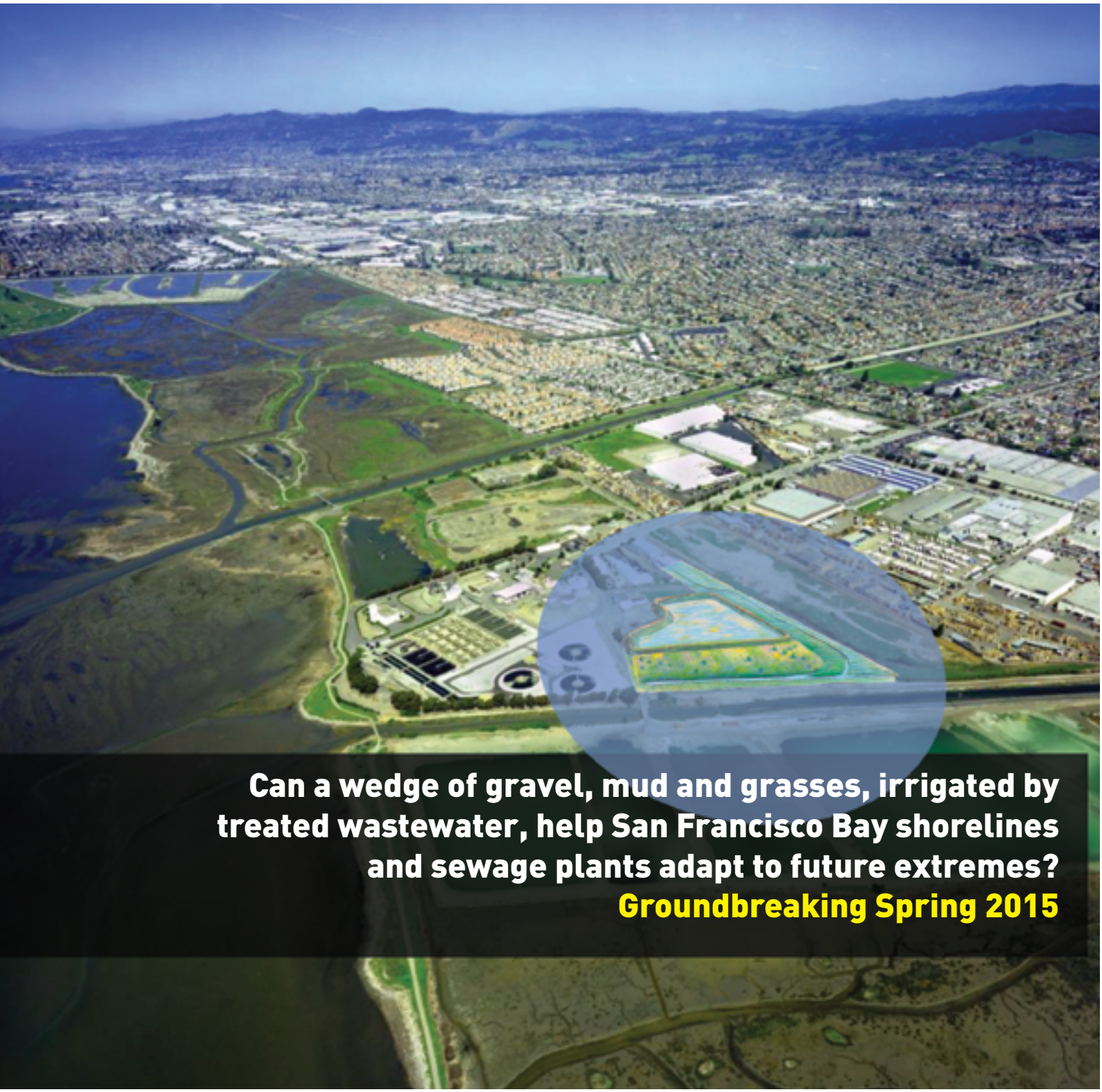
Oro Loma and Castro Valley Sanitary Districts to Test Experimental Levee



Can a wedge of gravel, mud and grasses, irrigated by treated wastewater, help San Francisco Bay shorelines and sewage plants adapt to future extremes?

Groundbreaking Spring 2015

Triple Win?

Water Quality, Flood Protection, Wildlife Habitat

When we built our roads, pipelines, airports and other critical infrastructure on the shores of San Francisco Bay, no one imagined the sea level would rise so fast in the 21st century. The National Research Council projects a regional rise for San Francisco Bay of 5-24 inches by 2050 and 17-66 inches by 2100. The National Oceanic and Atmospheric Administration lists the Bay Area as one of the top ten most vulnerable metropolitan regions in the country. As the ice caps melt and the Pacific Ocean expands, experts predict that water levels in the Bay will climb more rapidly than ever before. Meanwhile changes in the atmosphere may make storms more extreme.

The region has always been forward-thinking, however. Those in charge of the infrastructure now in harms way are making plans, and not all of them involve taller sea walls. This spring, a 10-acre field adjacent to the Oro Loma wastewater treatment and purification plant in San Lorenzo will be the site of an experiment testing ways in which the plant can use a basin to accommodate peak flows while taking a more natural approach to shoreline protection. If it works, experts hope the project can be a new model for adapting critical infrastructure at the Bay's edge to climate change.

> "Even if we cut our greenhouse gas emissions drastically, sea level will continue to rise. Today's flooding during king tides or storms will become less infrequent and more the norm. Everyone recognizes this is something much bigger than we can solve on our own. Even if we're just talking about building up our own levees, it's such an expensive proposition."
>
> **ERIK PEARSON**
> **ENVIRONMENTAL SERVICES DIRECTOR, CITY OF HAYWARD**

HISTORY

When a New Year storm sent Bay waves crashing over local levees in 2005, regional park manager Mark Taylor showed slides of the event to the Hayward Area Shoreline Planning Association (HASPA). This group, formed in the 1970s, realized sea level rise could worsen such events in the future. In 2008, aided by then City Councilmember Bill Quirk of Hayward, HASPA hired consultants Philip Williams and Associates (now ESA) to evaluate the potential impacts of sea level rise on the shore between San Lorenzo Creek and the San Mateo Bridge. This was one of the Bay Area's first serious planning efforts around sea level rise. By 2010, all this legwork had made the Hayward shore a perfect pilot project for the San Francisco Bay Conservation and Development Commission's fledgling Adapting to Rising Tides program (ART). Under the program, local agencies and surrounding jurisdictions worked with ART to pinpoint Hayward area facilities and shores at risk and explore adaptation proposals.

One proposal by Peter Baye and ESA was to create a new type of levee to mimic the natural slope from historic wetlands into upland areas. If planted with sedges and grasses, and irrigated with treated wastewater, this wedge of habitat, built alongside the new levee, could slow down waves, resist floods, and protect infrastructure and homes in the Bay Area flats. They called it an "ecotone slope." (Ecotone refers to those areas between different natural systems, such as land and water, or field and forest).

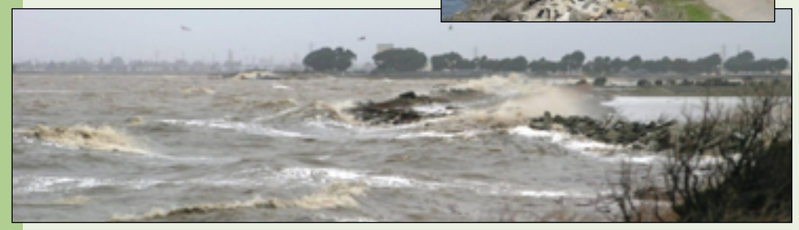
BAY AREA INFRASTRUCTURE AT RISK

- 8–10 wastewater treatment plants
- 9–15 power plants
- 208–235 hazardous waste sites
- 1,450–1,780 miles roads & highways
- 140–170 miles railroad track
- 4 airports
- Up to 270,000 residents in the flood zone
- $49–$62 billion property
- Shoreline parks & trails

Source: Pacific Institute 2012

Elsewhere around the Bay Area, people began describing similar kinds of ideas as "horizontal" or "laid back" or "habitat" levees. In any case, such proposals embraced concepts that have been floated by local biologists and restoration managers ever since they recognized the severity of sea level rise threats to their painstakingly-rebuilt bayland habitats.

When the Oro Loma Sanitary District offered a site for testing some of these adaptation ideas in 2012, support for the project grew. The district felt it would be a good investment in its future ability to provide services to its 46,000 customers, and to protect its facilities, in any kind of weather or flood condition.



2005 storm overtops Hayward Shoreline levees. Inset: Same levee after storm. Lower photo: Mark Taylor

PROJECT & PARTNERS

Oro Loma's project will turn a degraded diked bayland behind a wastewater treatment plant into an outdoor laboratory. On this flat, weedy field, construction crews will create two things: first, a two-acre wetland basin that can both remove nutrients from wastewater and provide extra wet weather storage capacity; and second, on one side of the basin, the experimental levee. Wastewater that has already undergone secondary treatment (required by Clean Water Act protections to prepare it for discharge into San Francisco Bay) will pass first across the surface of the basin and treatment wetland, and second through the levee and down into the sub-layers of 1.4 acres of experimental habitat slope. The idea is that the combination of treatment wetlands and newly designed habitats, and surface and sub-surface filtering processes, will support native plants and purify the water enough so that one day this kind of system can be directly connected to the Bay edge.

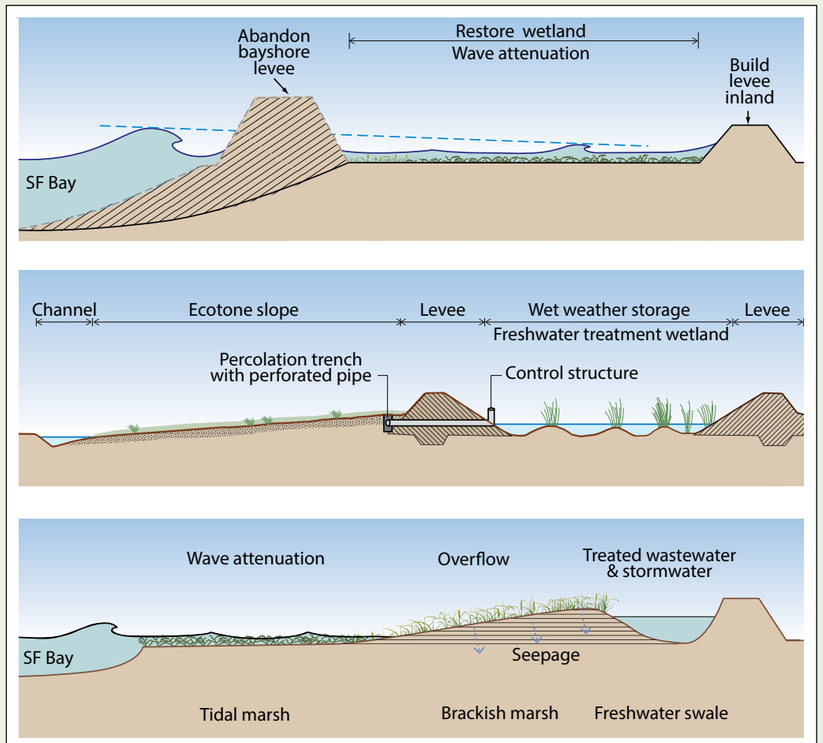
Oro Loma expects to start construction in spring 2015 and begin operating the experimental levee in early 2016. Construction is expected to end by late 2016, but researchers expect to monitor the results for up to a decade. Project partners include the Oro Loma and Castro Valley Sanitary Districts, which co-own the treatment plant, and the East Bay Dischargers Authority (for brevity's sake, however, subsequent references throughout this overview refer only to Oro Loma). Oro Loma also collaborated with the San Francisco Estuary Partnership to get funding through the Integrated Regional Water Management Program. Project consultants include Jeremy Lowe, ESA Associates; Peter Baye; Whitley Burchett and Associates; David Sedlak and Alex Horne, ReNUWIt, UC Berkeley; The Bay Institute and Save The Bay. The approximately $7 million project budget is being covered largely by the two sanitary districts and an IRWMP grant of $2.1 million from California's Department of Water Resources.

Natural slope wetlands still exist along East Bay shores that escaped development. Photo: Peter Baye

MORE THAN A TREATMENT WETLAND

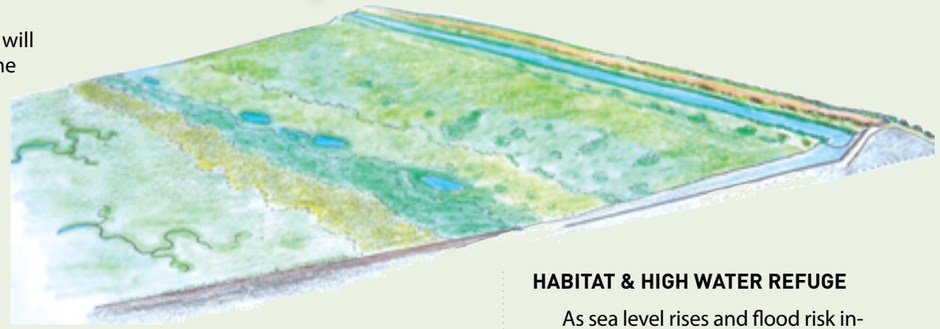
Wastewater treatment plants have long used wetlands for additional treatment of municipal wastewater effluent; it is well known that the natural bacterial and biological processes in wetlands can break down contaminants and remove nutrients that cause excessive algal growth in the Bay. In the Oro Loma experiment, the new treatment wetland and basin will not only enhance the quality of the treated wastewater before it reaches the ecotone slope, it will also do critical double duty as a storage facility during wet weather. During a storm or peak flow event, the basin is designed to store up to 8 million gallons of enhanced primary treated wastewater. Once rainfall subsides, this wastewater can be returned to the plant for more treatment.

> "If you can create a really wide levee, roughened up by a covering of plants, it will slow down waves, and maybe you can actually build a smaller levee. Also, what we're building in these cases is not technically a levee, but a sloping terrace, or ramp, against a levee."
>
> **PETER BAYE**
> **COASTAL ECOLOGIST**



Options for more resilient levees, habitats and shoreline protection. Top: moving the levee inland and buffering it with a wetland; middle, elements of Oro Loma experiment; bottom; profile of possible future shoreline gradient from fresh to salt water habitats. Source: ESA

The Ecotone Slope:
A Wide, Vegetated Terrace on the Bay Side of a Levee



The Oro Loma experiment will research how to engineer some important missing elements in the natural landscape back into the shoreline. The region has done a good job of learning how to recreate salt marshes, but most have little connection left to the creek mouths, moist meadows, cattail thickets, willow groves and barrier beaches that once served as transition zones, or "ecotones," between tidal habitats and terrestrial ones. Instead, our marshes and beaches more often back up directly on levees separating them from homes, industries and cities. The region may not be able to salvage historic creek connections in many areas, but it does have a reliable source of freshwater in the same zone: pipelines used for the distribution and discharge of treated wastewater along the East Bay shore. This water source, currently discharged in the deep Bay south of the Oakland airport, could provide millions of gallons of scarce fresh water to any shoreline adaptation zone in need of irrigation.

Transition zones naturally do all the things necessary to help our shorelines keep from drowning under advancing seas. Transition zones can change elevation by trapping or redistributing sediment, by bulking up with plant matter, and by naturally migrating landward. They can also encompass important salinity gradients from fresh to saltier waters. Harnessing these natural processes for the protection of both humans and the Bay ecosystem is what Oro Loma's ecotone slope experiment is all about. In this scenario, however, the transition zone will have to work its magic in a fraction of the space it might have under natural conditions.

The Oro Loma experiment creates a vegetated slope, or terrace on the Bay side of the levee, which emulates a natural alluvial fan or a creek mouth delta. These fans and deltas accumulated sediment eroded from upper watersheds. Such slopes might one day provide areas for marshes to migrate inland and upstream, in the face of sea level rise.

HABITAT & HIGH WATER REFUGE

As sea level rises and flood risk increases, the endangered species, birds, mice and other wildlife of the tidal marsh need places to escape high water. The addition of new ecotone slopes and transition zones in any future applications of this experiment's results could greatly enhance escape options and survival rates during flood events. In addition if such slopes were vegetated they would provide more places to hide from predators. With 570 miles of levees in the Bay Area, many in the vicinity of wastewater plants and pipelines, if only 25 percent were suitable for moist grassland or seepage slope levees the region could gain 5,000 acres of new habitat.

> "This ecotone slope experiment will be the first out the gate in the Bay Area to really ground-test some of the bold new ideas in our updated regional recommendations."
>
> **LETITIA GRENIER, LEAD SCIENTIST BAYLANDS ECOSYSTEM HABITAT GOALS 2015 UPDATE**

> "Responding to sea level rise in an environmentally friendly way is a decent win; but it can be a grand slam if it succeeds in addressing the water quality, flooding and habitat loss problems we face on our shorelines all at once."
>
> **JASON WARNER, GENERAL MANAGER, ORO LOMA SANITARY DISTRICT**

REGIONAL PRIORITY

Oro Loma's experiment addresses some new regional priorities set by leading restoration scientists. The 1999 *Bayland Ecosystem Habitat Goals* established regional scientific consensus around the need to restore 100,000 acres of tidal wetlands and transition zone habitats to save the ecosystem and provide habitat for endangered species. The 2015 goals update calls for even more emphasis on upland transition zones all around tidal marshes, and for restoring estuary-watershed connections that nourish the baylands with sediment and freshwater. Making North Bay and Suisun Bay landscapes more adaptive will be easier, as there are many remnants of original transition zones and very little development. In the South Bay , thousands of acres of former salt ponds offer a vast landscape for experimentation. In the East Bay however, space between urban buildings and the shore is constricted, suggesting the need for more engineered and complex adaptations.

MORE DECENTRALIZED DISCHARGE?

The Oro Loma experiment is located at a mid point on a 22-mile-long pipeline that collects treated wastewater from six plants (serving nine cities and unincorporated areas) and then moves it to a centralized discharge outfall to the Bay near the San Leandro Marina. Exploring ways to redirect and decentralize discharge of this increasingly valuable freshwater resource – and put it to good use irrigating ecotone slopes, transitional habitats and buffer zones along our shorelines – is another goal of the Oro Loma experiment.

The Experiment:
Soils, Plants, Wastewater and Nutrients

THE SANDWICH DESIGN

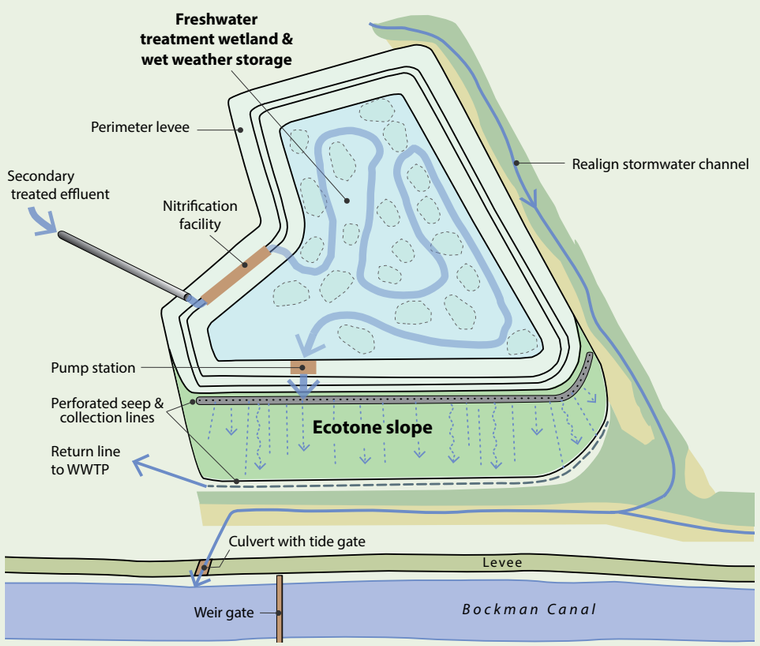
Each of the 12 experimental beds in the Oro Loma ecotone slope is set up like a sandwich. The bottom layer is impermeable clay, the middle layer is porous gravel, and the top layer is a mixture of bay mud and sandy soil where plants can grow roots. In most seasons, most of the water is expected to seep through the gravelly middle layer. The experiment seeks to create a terrestrial, not tidal, habitat with a subsurface watering system. As each bed is watered, scientists expect to see chemical and biological changes in both the treated effluent and the soils and plant roots it encounters.

NUTRIENTS A-Z

Some of the nutrients in sewage remain in the water after conventional treatment. Though adding nutrients to soil can help plants grow, when too many nutrients enter the Bay via wastewater discharges they can cause problems like algae blooms. When too much algae blooms and dies, it removes oxygen from the water and suffocates fish. Although San Francisco Bay has been historically resistant to such impacts from high nutrient loads, there is growing concern that changing conditions are pushing us toward a tipping point. As a result, the wastewater treatment community is partnering with regulators, environmental agencies and NGOs to evaluate alternatives for a long term response to increasing nutrient impacts on the Bay, which the Oro Loma experiment will explore.

REMOVING NUTRIENTS

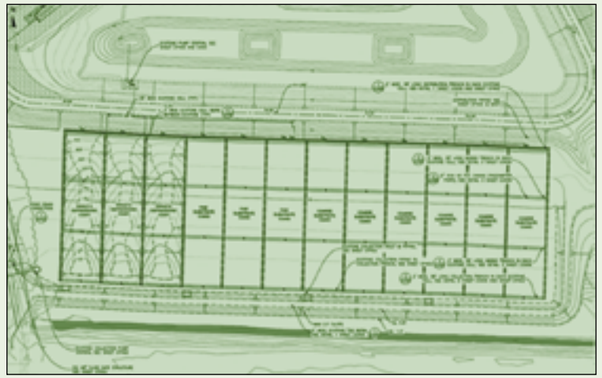
This experiment will use plants and soil microbes to remove nutrients from treated wastewater coming out of the Oro Loma Sanitary District facility. After passing through a conventional treatment wetland full of cattails and bulrushes, scientists estimate 10-30 percent of nutrients will be removed. The water will then be seeped into the buried gravel layer of the sandwich beds, which will include some wood chips. Two things should happen as it flows through this layer. First, microbes living in the wood chips will absorb nitrates and release inert nitrogen gas through a process referred to as denitrification. Second, plants growing in the soil above will sink roots down as far as the gravel layer and take up some of the water and nutrients. Scientists will test water going in, passing through, and coming out of the system to measure how effective the ecotone is at removing nutrients and other impurities. To guarantee no threats to Bay water quality from this experiment, the final product will be returned to the treatment plant. Project managers hope the effluent from the ecotone slope will turn out to be so highly purified that any future replicate slopes could be connected with, and seep into, outlying marshes and the Bay. Scientists also hope to see removal of the trace amounts of pharmaceuticals and synthetic hormones that are often present in the effluent – contaminants of emerging concern to the Bay ecosystem.



Source: ESA

SPECS

- Ecotone Area: 1.4 acres
- Ecotone Width: 480 feet
- Experimental Cells: 12 cells, each 40 feet wide & 150 feet long
- Ecotone Elevation: 5-foot drop basin side to canal, 30:1 slope
- Ecotone Vegetation Palettes: 4
- Ecotone Wet Zone: 2 feet
- Treatment Wetland Area: 2 acres
- System flow range: 100-300,000 gallons per day



The experiment is divided into 12 beds and will test four different combinations of soil types, plant species and watering regimes, as well as provide three replicates. Source: ESA

TREATMENT TOOLBOX

Removing problematic nutrients from wastewater with advanced technology requires significant energy and chemical inputs compared to a natural treatment system. The main reason wastewater treatment engineers select such systems is that they can control the entire process and reliably meet water quality objectives. A natural treatment system like the ecotone slope or wetland, on the other hand, is harder to control directly. Processes at work in them also vary with the seasons: microbes and plants are less active in the wintertime, for example. Scientists hope to better understand this seasonable variability through the Oro Loma experiment. In the case of San Francisco Bay, the fact that treatment performance may diminish in winter may not be an intractable problem, as that's when storms flush water quickly out the Golden Gate. Indeed in this region nutrient removal may be more important in spring, summer and fall — a period when the ecotone is expected to provide the greatest benefits.

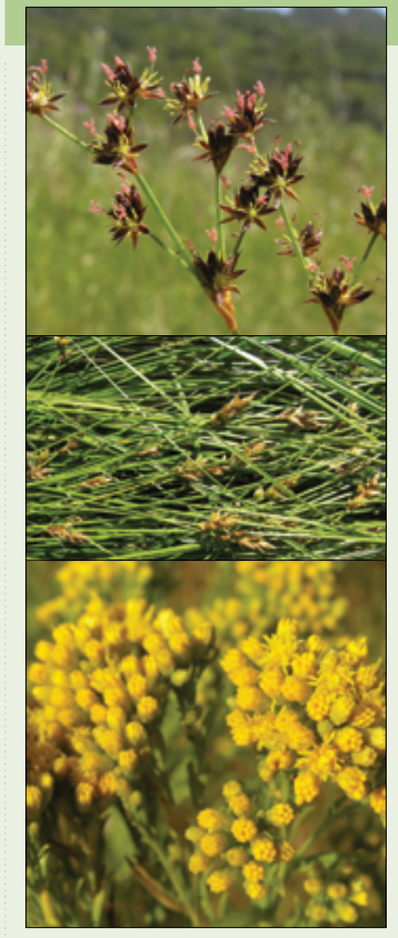
NATIVE PLANTS & NURSERY

The planting palette for the Oro Loma was carefully chosen to include a diverse range of species native to wet meadows, stream banks, and low spots where seasonal pools might occur. Species were also chosen for their efficiency in removing nitrates and phosphorus from wastewater. The growing and planting will be done by Save The Bay's community-based restoration program. First they will locate existing East Bay plant stocks growing in lowlands or grasslands, and then harvest or transplant material to a new nursery established on the Oro Loma property. There, they plan to grow more than 70,000 seedlings in 50 raised beds for use in the experiment. More than 20 species — including creeping wild rye, Baltic rush, spikerush, basket sedge and field sedge, western ragweed, California blackberry, and alkali bulrush – will be tested for growth and resilience in the experimental ecotone slope.

THREE-YEAR MONITORING PLAN

The Oro Loma project is an experiment. What happens on the project site will be meticulously monitored over the next three years by researchers from the University of California, Berkeley as part of the NSF ReNUWIt Engineering Research Center. These scientists and other team members will monitor both ecological and effluent treatment parameters. Every three months, they will assess general site conditions (stress, erosion, damage from grazing waterfowl), plant health and vigor, composition of the plant community, and any encroachment by weeds and invaders. They will also take samples of water coming in and going out of the ecotone slope for lab analysis at UC Berkeley. At the lab, they will also measure everything from concentrations of various kinds of nitrogen and phosphorous to the amount of total organic carbon, temperature, pH, dissolved oxygen, salinity and more.

> "The Bay is becoming more nutrient-enriched, and the Oro Loma project will demonstrate if natural means can be used to treat this problem in a low cost and ecologically beneficial way. We need more innovative, multi-benefit approaches that address habitat loss, sea level rise defense, and water quality challenges."
>
> **IAN WREN, SCIENTIST**
> **SAN FRANCISCO BAYKEEPER**



Brown-headed rush, field sedge, and western golden rod, three species to be tested in the experiment. Photos: Peter Baye

The Challenge:
Funding, Collaboration and Regulation

The Oro Loma experiment is timely. Findings from its water quality, flood control and habitat restoration tests will inform much-needed improvements and adaptations to the shoreline's infrastructure in the decades ahead. Many levees and flood control facilities and sewage treatment plants are more than 50 years old, and were built in the Clean Water Act era when federal and state grants covered most costs. The time to plan is now; everything from railroad tracks to gas pipelines to freeways and airports will be in the same boat as flood risk increases. Much of what makes the Bay Area hum is built right on its shores. Though concerns about such challenges to our infrastructure have been growing for decades, funds to address them have not.

Oro Loma plant. Source: Sara Burke, OLSD

Beyond the price tag, the regulatory and institutional challenges of doing multi-benefit projects remain substantial. When clean water regulations, flood control specs, and bans on Bay fill were written 20-50 years ago, local conditions were quite different than they are today. In the same time span, scientific results from regional water quality monitoring programs and ecosystem restoration activities are suggesting the need for change in our priorities for the management of wastewater, sediment and flooding whilst continuing to protect the Bay's ecological riches. Those involved in the Oro Loma project are not alone in tackling these challenges. Groups all around the Bay Area are now trying to collaborate on shoreline protection projects with multiple objectives like the one described in these pages.

"The challenges of modernizing our institutions to handle these multi-benefit projects are more complex than the science or engineering of designing and building them. If this small experimental project succeeds, it will help convince people that the extra effort required to make it compliant with the patchwork of regulations out there, or to use pots of money that normally are reserved for other purposes, may be worth it. Oro Loma has been a wonderful partner on the project."

DAVID SEDLAK
PROFESSOR
UNIVERSITY OF CALIFORNIA BERKELEY

"If we're going to ask ratepayers to ante up, it's time to look at all options. Maybe treatment is good enough now that instead of piping wastewater into outfalls in 30 feet of Bay water, we can run it through wetlands. Rather than spending $50 million to rehabilitate our outfall, I'd rather spring for something where we can see the benefits right on our shore."

MICHAEL CONNOR
GENERAL MANAGER
EAST BAY DISCHARGERS AUTHORITY

"Some partners have got land, some have sediment, some have water, some have other resources. Individually we're not going to fix the problem, but working together I think we can."

JEREMY LOWE
COASTAL GEOMORPHOLOGIST
ESA ASSOCIATES

PROJECT PARTNERS & FUNDERS

Oro Loma Sanitary District
Castro Valley Sanitary District
East Bay Dischargers Authority
California Dept. of Water Resources
San Francisco Estuary Partnership
The Bay Institute
Save The Bay

PRIMARY CONSULTANTS

ESA
Peter Baye
ReNUWit, University of California, Berkeley

FOR MORE INFORMATION

Contact Jason Warner, General Manager, Oro Loma Sanitary District 510-276-4700
jwarner@oroloma.org

Editor: Ariel Rubissow Okamoto

Design: Darren Campeau

Art: Brad Evans, ESA (diagrams & cover sketch); Peter Baye (centerfold drawing).

2nd Version, Printed 2/26/15