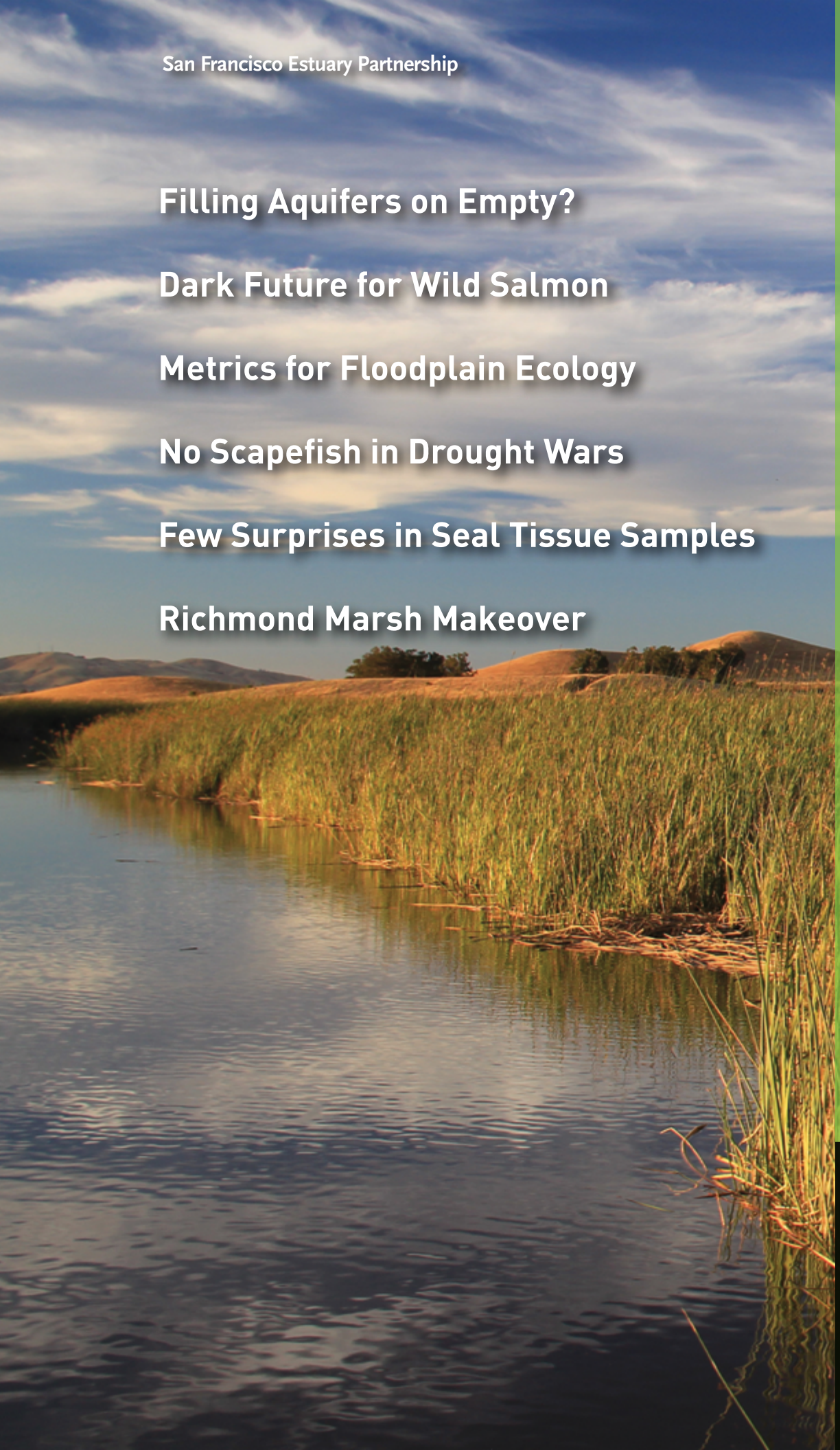
San Francisco Estuary Partnership



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ESTUARY NEWS

SCIENCE • RESTORATION • WATERSHED • POLITICS • SPECIES • BAY

JUNE 2015
VOL. 24, NO. 2

GREAT MINDS GATHER FOR STATE OF THE ESTUARY 2015

Every two years, the San Francisco Estuary Partnership organizes a conference focused on the management and ecological health of the San Francisco Bay-Delta Estuary. This year's September 17-18 conference at the Oakland Marriott will showcase the latest information about the estuary's changing watersheds, major stressors, recovery programs for species and habitats, and emerging challenges. It will also explore the foundations of many of the findings of the *2015 State of the Estuary* report, and the *2015 Pulse of the Bay*, both of which will be released at the conference.

If you would like to nominate projects for the Jean Auer Award and the Environmental Project Awards contact Darcie Luce, Friends of the Estuary, darcieluce@gmail.com before June 30.

The Partnership thanks our premier conference sponsors: State Coastal Conservancy and the Delta Stewardship Council. We also thank our current anchor co-sponsors: Bay Area Clean Water Agencies, City of San Jose, Friends of the San Francisco Estuary, Regional Monitoring Program, and the San Francisco Public Utilities Commission.

CONFERENCE WEB SITE:
www.sfestuary.org/soe/

PHOTO-CALL: GOT PIX?

Submit for 2015 Report!

The Partnership is hard at work producing an update to the *State of San Francisco Bay 2011*. The new *State of the Estuary 2015*, however, will review the status of more than 40 indicators of the Estuary's health in a greatly expanded review of how the latest science and monitoring results could better inform management of San Francisco Bay and the Sacramento-San Joaquin River Delta. Report editors are looking for fresh, engaging, high quality, high-resolution photos for print and online use in the forthcoming report.

SUBJECT MATTER SHORTLIST

All from our watershed only please, and recent photos too, or those not already in print please!

PEOPLE DOING THINGS IN WATER
Scientific research
Restoration
Recreation
Livelihoods
Stewardship

WATER USE & IMPACTS
Irrigation
Conservation
Stormwater
Green infrastructure
Pollution
Oil Spills

ECOSYSTEM PROCESSES & EVENTS
Flooding
Tidal changes & king tides
Drought and heat
Plankton & algal blooms & food web
Migrations
Erosion & subsidence
Climate change

LANDSCAPE SCENES
San Francisco Bay & Delta open water and shoreline scenes
Sloughs and rivers
Wetlands, mudflats and marshes
Urban, industrial, suburban, agricultural shores
Creeks, Rivers & Riparian Zones & Floodplains
Cropland and agriculture
Riparian woodlands
Restoration sites
North and South Bay salt ponds

LIVING THINGS
Shorebirds
Waterfowl
Chinook salmon
Sturgeon
Longfin & Delta smelt
Leopard sharks
Crab
Eelgrass
Oysters
Invertebrates
Seals, sea lions, dolphins, whales
Ridgeway's Rail
Tidal marsh birds
Herons & egrets
Sandhill cranes
Black rail
Tri-colored blackbird
Cormorants
Plankton & zooplankton
Wetland & riparian plants
Invasive species

Please make sure your photo has your name in the title "YourName-1.jpg" etc. Send photos to stateoftheestuary2015@gmail.com. If your photos are selected for publication, you will be contacted shortly by photo editor Kathleen Wong.

Photo: Rick Lewis

THANK YOUS

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G R O U N D W A T E R

Filling Up on Empty

"We are sucking our aquifers dry," the headline reads. Could this be a good thing?

The bad effects of declining groundwater levels are known: land subsidence, the cost of pumping from deeper wells, the drying up of surface springs and streams. But there is a potential gain as well. Using up one resource, the water stored under the ground, we are creating another: storage space far greater than any conceivable new dam could provide. "Historical overdraft," writes engineer Jay Lund, "may be an effective means of underground reservoir construction." If so, we have been building like mad.

Of course a reservoir, to be of any use, has to work both ways: it must fill when water is plentiful in order to be emptied when it is not. So far we have been much better at emptying than filling. Under last year's Sustainable Groundwater Management Act, we are finally getting organized to control chronic depletion. A few in the water world are asking a further question: If the rains come back, can we not only stabilize these banks but fill them up again, buying ourselves insurance against droughts, maybe much worse ones, to come?

At first glance the thought is compelling. We use, in cities and on farms, some 35 to 40 million acre-feet of water a year. The reservoirs behind dams can hold something less than 50 MAF, basically a year's supply. But the porous deposits of sand and gravel that underlie much of the state originally contained at least a billion acre-feet of water. Of this we have so far removed 150 MAF or more. The depleted zone alone could hold at least three times as much water as surface reservoirs; drilling still deeper could theoretically not only harvest more water but also open more storage space.

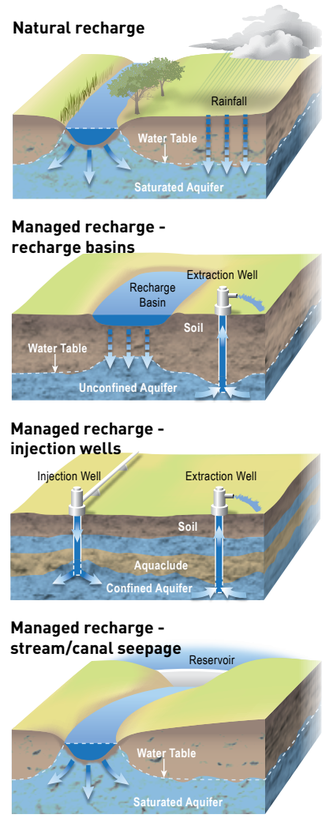
To judge the real potential we have to ask two additional questions: just where is this empty aquifer capacity, and where would we find the water to fill it?

Let's start where the groundwater balance is best understood and least troubling. The aquifers in several large urban water districts along the coast and in the Inland Empire of southern California have long been managed as storehouses for wet-year and imported water. These reserves have been drawn down now, but not to crisis levels. One Bay Area example is the Zone 7 Water Agency in the Livermore Valley, where the local aquifer is slightly fuller this year than last. "We're in pretty good shape so far," says Engineering Manager Jarnail Chahal.

Of course the water cached in these aquifers has come largely from long-distance imports—from the Sierra Nevada, from the Delta—and these may prove less and less reliable in a drought-prone future. To increase supply security, managers are looking to amp up groundwater recharge from strictly local sources.

Stormwater is a big one. Rather than whisking occasional torrents away from homes and businesses, the agencies are looking to capture them, spread them, and cache them underground. Above all this means opening more recharge areas. Zone 7 is acquiring old quarry pits. In Southern California, the concrete bottoms of flood control channels are being opened up to reconnect surface flows to aquifers below. "Flood management *is* drought management," says State Water Resources Control Board member Steven Moore.

Floods are now and then. A never-failing source of local recharge is the water we have already used.



Source: California Water Plan, DWR

Public resistance may still bar the way to simply reintroducing highly treated wastewater to the mains, but mixing it in with the vast stock in an aquifer serves even better for water

continued to page 10

Zone 7's new lake near Livermore, secured as mitigation for the removal of aquifer gravels by mining companies. The agency plans to move water through a chain of such lakes, reclaimed quarry pits, to recharge the region's groundwater basin and Zone 7's wells. Photo courtesy Carol Mahoney.

ENDANGERED

Crystal Ball for Salmon Dark

The future of wild salmon in California's Central Valley is dire. A new survey of senior salmon science and policy experts forecasts that river-spawned and -reared Chinook in the Sacramento and San Joaquin Rivers will be functionally extinct by the end of the century.

This bleak outlook contrasts starkly with the hopeful public message from most restoration professionals and wildlife agencies.

Working in fisheries for nearly a decade, lead author Sierra Franks, an Oregon State University student, had noticed discrepancies between the tone of official statements and the private comments of people in the field. Even so, Franks says, she was surprised by the overwhelming pessimism of the 26 surveyed experts, who were promised anonymity to encourage their candid responses.

Coming from academia, nonprofit organizations, and government agencies, the experts "had different stakes in the matter, yet were all on the same page," says Franks.

"We've done a lot for a long time to degrade salmon habitat," she says. "Now it seems it's too little, too late."

The causes expected to erase salmon from the landscape are familiar: a rising human population, dams, conversion of wetlands to agriculture, pollution, the presence of hatchery fish, commercial fishing, and of course climate change.

Photo courtesy The Bay Institute

In a future where water is expected to be far scarcer than today, Franks says, "who's going to knock down big reservoir dams during a drought? It doesn't look good."

Even so, some experts believe salmon could enjoy a happier ending if Californians alter current policies and attitudes. They cite closing the fishery even temporarily as one possible measure. "Here we have them listed under the Endangered Species Act, yet we're allowing for harvest — it's an odd combination," Franks says. Eliminating the hatchery fish estimated to make up 97 percent of salmon could also go a long way toward aiding the recovery of wild populations.

Getting Californians to identify with this historically abundant species could also catalyze change. "All the salmon fishing that used to take place in the early 1900s has mostly been forgotten," Franks says. "In one generation this happened. We as a society watched it take place, and most people, outside of fisheries professionals, didn't seem to care." If more people were aware salmon were swimming past their backyards, goes the logic, they might be more likely to save water for fish instead of keeping their lawns green.

In the Pacific Northwest, by contrast, salmon is an iconic species on par with the grizzly and gray wolf, partly thanks to public art in airports, city murals, and widespread public education. "People there are removing dams, and here we're proposing to build more," Franks says.

The specter of extinction may spark a more honest debate about what is really required to sustain wild salmon in the Central Valley. The paper was already a hot topic at a recent fisheries conference in Santa Cruz. "Hopefully this paper generates more discussion about salmon and knowledge about this fish becomes more mainstream," Franks says.

Coauthored by Oregon State University professor of fisheries Robert Lackey, "Forecasting the most likely status of wild salmon in the California Central Valley in 2100" was published in the April issue of *San Francisco Estuary and Watershed Science*. **KW**

California Aqueduct moving freshwater across the state. Fresh water diversion away from historic habitats is one driver of salmon extinction. Photo: BurRec

RIVERS

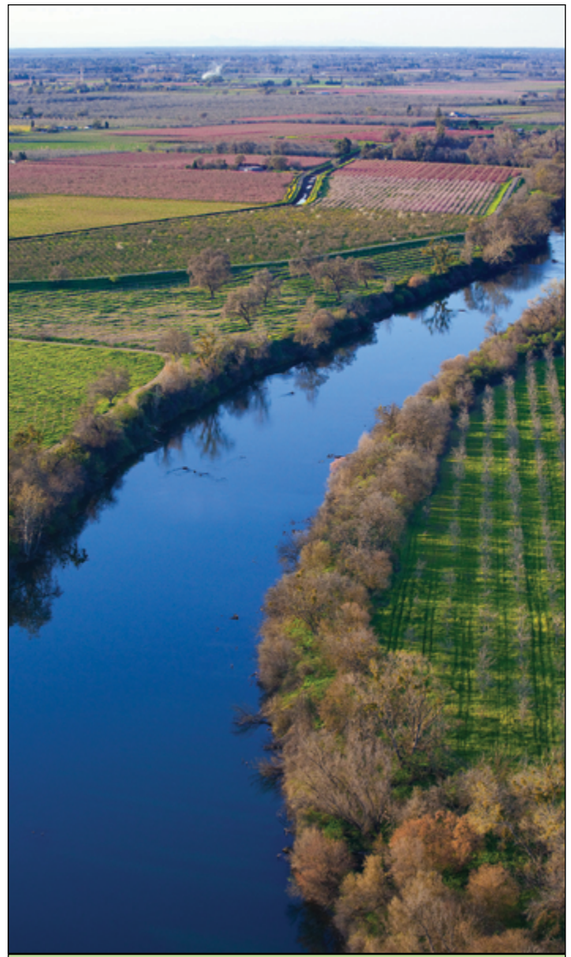
Three in One or None of the Above?

The days of scorched earth floodplains on Central Valley rivers could be over soon if the Department of Water Resources' new draft conservation strategy is finalized—and put into action. The strategy calls for restoring river functions and key habitats, conserving endangered species, and improving fish passage, all while reducing flood risks. "We've been talking about multi-benefit projects for 20 years," says American Rivers' Director of Conservation for Flood Management John Cain. "The science is super clear but the number of projects in the ground is very limited."

A draft of the new *Central Valley Flood System Conservation Strategy* was recently released, and a 60-day public comment period will be set soon, with a final version to be developed in the fall, says DWR's Stacy Cepello. He says the information, tools, and data associated with the strategy are being incorporated into state basin planning and regional flood management programs, and that the current challenge is to integrate the essential content into the 2017 update of the *Central Valley Flood Protection Plan*, which he expects to be wrapped up by the end of 2016.

While highly supportive of the conservation strategy, many environmental organizations are worried about how it will in fact be integrated into the flood protection plan. American Rivers and other groups have worked on the strategy for four years to make sure it includes specific measurable conservation objectives. Without specifics, says Cain, it's "hard to tell what we're planning and designing to achieve."

The strategy identifies which metrics are important, including how much habitat was there historically and how much is needed for species recovery. "We can't expect improvements in the flood system alone to achieve recovery," says Cain. "But if we can use habitat improvement metrics to show how flood management projects simultaneously recover species, then we're in a position to demonstrate that these are the kinds of projects that should be permitted quickly."



Feather River, crowded up against Central Valley crops. Photo: Anthony Dunn.

Multi-benefit river restoration projects are hardly a new idea, but California has been slow to truly embrace them. Cain says, for example, that the Three Rivers setback levee project on the Feather River is great, but that at the time the project was done, DWR "said they did not do floodplain restoration, only flood control or levee projects." The result is that there are 1,600 acres of floodplain with no habitat in terms of vegetation, says Cain. "If you want to improve conditions for endangered fish, most of the work you need to do is in the floodway."

Diana Jacobs, Board Chair of the Sacramento River Preservation Trust, is also thrilled with the approach taken in the strategy. But she sees a big disconnect between the state's plans and those of the US Army Corps of Engineers, which is proposing to rock another 80,000 linear feet of Sacramento River banks (not to mention their ongoing opposition to vegetated levees). "Their proposal hardly recognizes that the conservation strategy is out there—there's barely a linkage with the state flood protection plan," she says.

Jacobs worries that the new conservation strategy could just end up being this "thing over in left field" instead of being the "the tail that wags the dog." She also worries that something this big and comprehensive could fizzle out, as has happened in the past. "It's always easier to take the old pathways. So we still have this plumbing and hardscape that are preventing fish recovery. We're not going to have habitat unless we give the rivers a little more room with setback levees. And we're not going to have the ecosystem processes without more room. Until they get serious it's just another great report." **LOV**

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ENVIRONMENT

No Scapefish in Drought Wars

According to the Biblical book of *Leviticus*, the ancient Israelites designated a goat to bear the weight of their sins. Nowadays, the scapegoat is not required to be a goat. When it comes to assessing blame for the worsening California drought, a scapefish will suffice. Some media outlets, notably the *Wall Street Journal* in a recent op-ed piece, point to the hapless Delta smelt as a culprit in the state's water crisis, as well as a prime example of the iniquities of the federal Endangered Species Act.

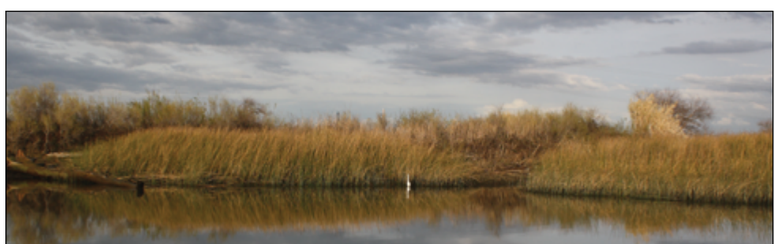
Here's a taste of the *Wall Street Journal* piece: "To protect smelt from water pumps, government regulators have flushed 1.4 million gallons of water into the San Francisco Bay since 2008....Parched Californians may soon wonder when it's their turn for such concern." Similar interpretations have surfaced on Fox News and elsewhere. But Rosenfield and other knowledgeable water-watchers say these viewpoints are misinformed at best, disingenuous at worst. Delta water is not being wasted by being

Photo: Dave Giordano, Ecositemedia.com

As is so often the case, though, it's not that simple. Day-by-day analysis of water exports from the Delta by Jon Rosenfield and Greg Reis of The Bay Institute shows that smelt protection has had very little to do with water export restrictions during the drought. The bottom line is that water allocations have been cut because of record-low snowpack and reduced runoff. When diversions by the State Water Project and the federal Central Valley Project have been further curtailed over the last three dry years, it's usually because water quality regulations that safeguard water for cities and farms against excessive salinity also limit exports in order to ensure that the projects can pump fresh water to urban and agricultural customers. Protection of endangered anadromous fish like salmon and steelhead has played a minor role, but delta smelt regulations have not governed exports since early in 2013. As for the ESA, supporters argue that it's far from the draconic and inflexible law caricatured by its critics. Its real shortcomings are insufficient commitment to the recovery of imperiled species and a chronic lack of funding for implementation.

flushed out to sea: it's working hard to serve multiple purposes for Californians, urban and rural alike.

"Clean Water Act protections have controlled Delta exports on most days by far over the last three years," says Rosenfield. That was true even after the State Water Resources Control Board weakened or eliminated water quality protections for fish and wildlife in separate actions in 2014 and 2015. The intent of the Water Board regulations is to manage salinity in the Delta by tweaking freshwater flow rates, in the interest of agricultural irrigators and urban customers. From 2013 through March of this year, water quality regulations have governed exports on 75 percent of all days, salmon protection on 11 percent, smelt protection on a mere 8 percent. (Army Corps of Engineers permits, voluntary reductions, and system capacity accounted for the remaining 6 percent.) On no day in 2014 or 2015 were ESA smelt protections triggered.



Cache Slough smelt habitat. Photo: Matthew Young

As Rosenfield explains it, the regulatory mechanism for constraining water exports that might impact sensitive species begins with an interagency consultation under Section 7 of the ESA. The water agencies—the federal Bureau of Reclamation and the California Department of Water Resources—are required to present their operational plans for review by the US Fish and Wildlife Service and National Marine Fisheries Service. The fish and wildlife agencies then issue species-specific Biological Opinions. "If the operation plans would cause or increase the jeopardy of extinction, the wildlife agencies need to provide Reasonable and Prudent Alternatives (RPAs) to the plan," he says. Separate but overlapping RPAs govern the delta smelt, under FWS jurisdiction, and salmon, steelhead, sturgeon, and orcas, under NMFS. On any given day, one of the RPAs may trigger a reduction in exports. They operate along with, and as a minor adjunct to, the Clean Water Act regulation. Because of the prolonged and severe drought conditions, the water quality protections are triggered more frequently. Rosenfield says The Bay Institute's analysis shows that the smelt RPA has had no effect for most of the current drought. "The salmon RPA limits exports on some days," he adds. "And even when the RPAs are limiting exports, they don't get shut off; they just get turned down."

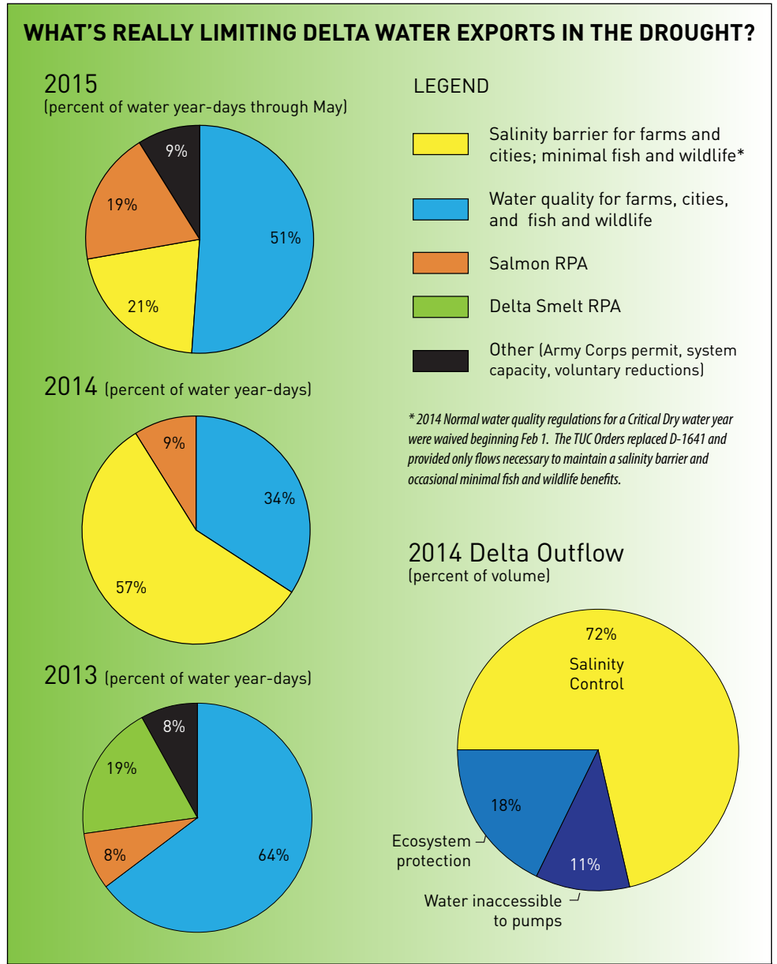
Rosenfield and Reis mined their data from public annual and daily reports by the multiagency Delta Operations for Salmonids and Sturgeon group of water and wildlife agencies documenting water project (SWP and CVP) exports; in-Delta diversions are not included. He notes that some interpolation was needed: "There are times of year, mainly summer and fall, when no one provides updates on what's controlling exports. This premilinary analysis requires an educated guess. But that wouldn't change the story in terms of the proportion of days when the RPAs are controlling."

Others have stressed the state's multiple goals in regulating Delta exports. "Delta outflow is also essential to maintain water quality for farmers and cities in the Delta, and ultimately for the CVP and SWP itself: freshwater flowing out of Delta pushes against the tides bringing saltwater upstream, creating a barrier that enables the CVP and SWP to pump fresh water instead of salt water," writes Doug Obegi of the National Resources Defense Council in his blog. In fact, the Water Board's analysis of 2014 Delta outflows shows that 72 percent of the water that was not exported last year was needed simply to control salinity intrusion into the Delta.

Beyond smelt and salmon, the Endangered Species Act is the real target of media critics and their political allies. "The ESA is doing what we asked it to do, preventing species from going extinct," Rosenfield notes. "Although it's one of the best-written pieces of legislation we have, it could be better in making sure listed species recover. There's no legal enforcement of recovery at all." He adds that if the Clean Water Act and other environmental legislation had been properly enforced, "the ESA would be far less relevant."

Rather than revising the federal act, Obegi advocates giving wildlife agencies adequate resources to implement it. "There's a huge backlog of species awaiting listing, including California's longfin smelt," for which protection was determined to be warranted but precluded by lack of funds. Recovery plans for a number of non-pelagic species needs to be updated. Obegi also says more grants for habitat restoration and even simple devices like fish screens could reduce the conflict between water supply and environmental protection.

Mark Rockwell's Endangered Species Coalition has its plate full defending the ESA from Congressional attempts to weaken it (at press time, eight such bills were pending in the US Senate). The problem with reauthorizing the act, he says, is that it can't be done selectively: "When you open up the law, you open it up for everything." If a changed political climate allowed constructive revision, Rockwell would like to see a stronger emphasis on species recovery in Section 10 of the Act, which governs Habitat Conservation Plans, and a way of insulating the critical habitat designation process from political arm-twisting.



The last time the Delta Smelt RPA was controlling exports was for 71 days during winter 2013. For most of the drought, exports have been limited in order to repel salt water. Data extracted from multi-agency daily and annual Delta operations reports, as well as State Water Board data (outflow), and summarized by The Bay Institute, 2015, with support from The Nature Conservancy.

Rockwell and Obegi agree that major changes in the way California uses water can defuse the fish-versus-farms controversy. That would include realistic pricing for irrigators, meaningful penalties for residential water wasters, tackling the antiquated and baroque water rights system, and conservation strategies like recycling, conjunctive use, and groundwater storage enhancement. Rockwell's group has identified 55 actions the state can take to ride out the drought. "We don't use water efficiently everywhere in this state," he sums up. "It's time we learned how to do that. The drought creates an opportunity for a come-to-Jesus meeting on this." Finally, we may be able to move beyond scapefishing. **JE**

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CLIMATE CHANGE

Pretty Penny for Extreme Event

Parts of the Bay Area received nearly 17 inches of rain over a 21-day period last winter, resulting in widespread flooding, power outages, and property damage. But imagine if such an atmospheric river delivered as much as 12 inches in the span of a single week — and that it coincided with a cluster of king tides. What would losses be like then?

That's the scenario considered by a new report called *Surviving the Storm*, from a coalition of Bay Area agencies and private partners. Its answer? Financial damages totaling $10.4 billion. To put that in context, the 1989 Loma Prieta earthquake is estimated to have cost $11.3 billion, adjusted for inflation.

Most of the damage modeled in the report from the hypothetical super storm — which would be California's most severe since 1862 — is tied to flooding at the bay shore and along the myriad rivers and creeks coursing through the region. When record runoff rushing to the bay meets unusually high tides, it simply has nowhere to go.

Approximately 355,000 people and $46.2 billion in structures are located within the region's 100-year floodplain. The $10.4 billion figure may actually underestimate such a storm's economic impacts, as it excludes physical damage to key infrastructure; doesn't account for Delta flooding, which could singlehandedly double the tab; and doesn't consider future increased risk from sea-level rise.

To reduce risk, the report's authors recommend investing in infrastructure including sea walls and levees. "There is a particular opportunity around wetlands," says Sean Randolph, a lead author and senior director at the Bay Area Council Economic Institute. "Wetlands are a very good defensive buffer, and the opportunity to restore tens of thousands of acres, especially in the South Bay, is one significant tool that is available to us." **NS**

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ADAPTATION

Richmond Marsh Makeover

Breuner Marsh tucks behind a spit of land along the Richmond shoreline. To the north, a wetland named after a dynamite company, to the south, Chevron's refinery. For the past century the site has been filled-in to make way for plans that included an airfield, industrial uses, and most recently, a string of condos designed for commuters in a hurry to be elsewhere.

None of those came to pass, in large part because of the efforts of community members from Parchester Village, which backs up to the marsh. For years residents of the housing development, built primarily for African-American shipbuilders after World War II, have organized to keep what remained of the marsh as open space. "This is an environmental justice story," says Chris Barton, the environmental programs manager for East Bay Regional Park District. "Local advocacy over the years has come from the residents of the area."

Now that vision of a restored marsh, free from the threat of development, is being realized. East Bay Regional District purchased the land in 2011 and, with the support of various partners, has undertaken a massive $12 million overhaul of the 164-acre site.

Photo: Sydney Temple, Questa Engineering

The restoration began in earnest last year, when bay fill, some of it contaminated with toxins, was removed. The site was sculpted by heavy equipment and graded to look — and act — like a functioning salt marsh and coastal prairie habitat, including mudflat, low marsh, high marsh, transition zone and upland areas. The plan also includes an interconnected network of seasonal wetland pockets. EBRPD will manage the restored marsh to provide habitat and forage for endangered species such as the Ridgeway's rail and the salt marsh harvest mouse and other critical wildlife.

Additional construction work to make Breuner Marsh accessible to the public is slated for the next two summers. Plans include a boardwalk closing a 1.5-mile gap in the Bay Trail.

But maybe the most innovative portion of the restoration project involves using some of the 110,000 yards (about 7,000 big truck loads) of old bay fill to prepare for the future sea level rise. "In line with the district's mission, the project has co-equal goals to provide public access while preserving and restoring habitat values," Barton says.

Once deemed clean, removed bay fill was strategically repositioned and graded to create transition zones and uplands with higher elevations than the lower tidally-influenced flats. The raised areas are part of what Barton calls an "adaptive retreat design".

"In our analysis San Pablo Bay has a low sediment budget," says Jeff Peters, a technical consultant for the project from Questa Engineering Corporation. "Over time the high marsh will convert to low marsh and the low marsh will convert to open water."

"We had our design team look at things like sediment accretion, sea level rise projections and identifying the most cost effective approach for maximizing restored wetland area while handling the least amount of bay fill," Barton says. "Then we set the elevations of the new marsh, uplands and trail, based on the new design. What we designed will be there in the future." **DM**

CONTAMINANTS

Beyond the Blubber

When John Kucklick talks about interrogation techniques, his subjects aren't tight-lipped terrorists, they're bits of blubber. Harbor seal fat is a well-known repository of legacy contaminants from the Bay like PCBs, flame retardants and DDT, but the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP) wanted to know what they might be missing. In 2010, they asked Kucklick, a scientist with access to a national database of 330,000 chemicals and some pretty cutting edge software, to check their blubber for unknowns.

Harbor seals. Photo: Rick Lewis

"We wanted to spot any troublesome chemicals before they harm our wildlife," says Rebecca Sutton, a senior scientist with the San Francisco Estuary Institute. The test compared San Francisco Bay seal blubber with blubber from Alaska (samples taken only from dead seals or tissue banks), and South Bay mussels with samples from more pristine Bodega Bay, looking for "CECs," contaminants of emerging concern that aren't currently monitored. "The good news is that no surprising new bad actors turned up. This means we don't have to pivot and run after a whole new set of chemicals we didn't expect," says Sutton.

Kucklick "interrogated" the samples, to use his term, looking among thousands of chemicals for those that both last a long time in the environment and build up in the food web and fatty tissues. "Most of the chemistry we do involves looking for X, Y, or Z on an EPA list of chemicals of concern, and most of the time we're using detection methods that have been specifically developed for those chemicals. In this exercise, however, we wanted to look at samples in a very open way," he says.

For this project, Kucklick, an investigator for the National Institute of Standards and Technology, conducted a non-targeted scan using two-dimensional gas chromatography and time of flight mass spectrometry to look for thousands of chemical fingerprints. "Gas chromatography is like when you put black ink on a napkin and add water, all the colors go to their corners," he explains. "Some compounds separate out into signals, like different shades of grey."

The second part of the interrogation, time of flight mass spectrometry, passes chemicals through something similar to a light bulb filament so they break up into pieces, creating molecular fragments of different weights with telltale fingerprints. "Your ability to detect stuff is only as good as your library and how cooperative chemicals are with the technique you are using," he says.

While the RMP may not need to go so far as water-boarding blubber to get cooperation, the next step will involve a certain susceptibility to water. Sutton wants to see similar open-ended analysis applied to water-soluble, rather than just fat-soluble, products. "Many of our personal care products, and cleaning and detergent products, produce water soluble compounds that may not be removed by wastewater treatment. A good next step would be to scan for those," she says.

South Bay mussel sampling. Photo: Tony Hale.

A few interesting things did turn up in the first scan, however. Bay mussel and harbor seal samples did contain five contaminants not previously identified in wildlife, and for which toxicity is largely unknown. Some of these derive from dyes, coatings, plastics and combustion processes. The scan also found a number of unusual DDT breakdown products, as well as some naturally forming brominated compounds that probably originate from small organisms in the ocean. "Relative to what we know is already in seal fat, the new stuff is at very low levels and in small quantities," says Kucklick. "The good news is we didn't find anything like a whole new class of PCB-like chemicals."

Sutton adds: "This exercise reminds us that the original or parent contaminants may not always be the most important chemicals to monitor in wildlife."

Beyond the blubber, the mussel tissue scans found derivatives of amphetamines (a sign, perhaps, of increasing illicit drug use) and antibacterials (such as a methylated form of triclosan used in hand soaps). Mussels filter directly from the water column, offering a different picture of contaminants in the food web, and of what's being pumped into the Bay with treated human wastewater.

"People are exposed to chemicals like crazy, but we don't accumulate most of them because they pass through our systems and we excrete them," says Kucklick. "That doesn't mean they aren't bad for us, or for seals, or for the environment. The next phase would be to look at what's not in the fat." **ARO**

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TWEAKING AQUIFER MANAGEMENT

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supply. "What aquifers offer urban areas is storage for recycled water," says Peter Vorster, hydrogeographer for the Bay Institute. Southern California is decades ahead of the north in making use of this resource.

Water recycling, stormwater capture, aquifer management, along with ordinary conservation, make a package so potent that at least one urban district in Southern California is planning to wean itself from long-distance water imports, taking in "project water," for recharge purposes, only in the wettest years. In certain cases, water autonomy seems almost within reach.

When we talk of aquifer depletion, though, we are really thinking of the vast sedimentary beds underlying the Central Valley, the agricultural heartland. Their condition varies. To the north of the Delta, Sacramento Valley aquifers are, even today, relatively full. To the south, in the San Joaquin Valley, the empty spaces proliferate. If these underground vacancies are to be turned into assets on a major scale, this is where it has to occur.

There are two big obstacles to refill. The lesser one, though quite big enough, is the chaotic state of most attempts to manage California's groundwater. The greater one is geography.

Much of the Valley floor is covered by irrigation districts that serve water from reservoirs, streams, or aqueducts to their customers, mostly farms. In wet years, farmers use more district water, allowing underground water tables to rise. In drier years, when surface flows are less plentiful, they rely more on wells. This more-or-less automatic alternation sounds like a formula for balance, but often it hasn't been. Decade by decade, in many districts, total pumping has outrun total recharge, with the usual nasty results.

Matters are worse in the "white spaces," large areas of the Valley that have no surface water input and are not organized in districts at all. Though water is legally a public resource,

Semitropic Junction pumping plant — west of Wasco, California — where both ground and surface water can be redirected according to water banking agreements between the agricultural district and urban water districts north and south. Photo courtesy Semitropic Water Storage District.

water in the ground has always been treated as the property of the overlying landowner. Without regulation, the incentive is to pump and pump, extracting water before the next farm gets it. These swathes of the Wild Water West account for much more than their share of the depletion that is ringing alarm bells today.

At the other extreme, some water districts have repurposed themselves as "water banks," tracking deposits and withdrawals rigorously. Some of these serve local agriculture only; others contract with distant urban customers, renting out storage space. The oldest of these operations is the Semitropic Water Storage District north of Bakersfield, which serves not only 140,000 acres of farmland but also a group of distant "banking partners," including Zone 7, the Santa Clara Valley Water Agency and the Metropolitan Water District of Southern California. In wet years, when the State Water Project deliveries are generous, Semitropic distributes these to its farmers and lets the underground lake swell through natural recharge and irrigation seepage. In dry years it switches its farmers to groundwater, letting its distant partners take some or all of the allotted Semitropic aqueduct share. Even in the current drought, water levels remain rather high.

Our dry spell also shows the limitations of this system. While Semitropic can feed banked water into the southward-flowing aqueduct, there is no physical mechanism for getting it north, "upstream." The exchange water the northern partners are supposed to get instead may simply be unavailable when aqueduct deliveries are near zero — as they were last year.

Groundwater isn't governed by the lines on maps that separate water banks from irrigation districts and both from anarchic "white spaces." It flows to where the pumping is. One manager's prudent practice can be sabotaged by unrestrained extraction next door. Under the new Sustainable Groundwater Management Act, the free-for-all is supposed to come to a gradual end.

In this future not-so-wild water west, can the total volume of water stored in Central Valley aquifers actually increase over time? Here's where geography takes over.

The bad news comes from the Tulare Basin, the 16,400 square mile pocket at the southern end of the San Joaquin Valley. Sitting just north of the Tehachapis and metropolitan Southern California, traversed by the California Aqueduct and the Friant-Kern canal, the basin might seem like a logical water depot for the whole state. And indeed the important Kern County water banks are here. But expansion of this function seems unlikely. The accumulated overdraft is huge, and the amounts of water that might be conserved in flood years or added from the north (via imports from the Delta or from a proposed new dam on the San Joaquin) are not large enough even to stop the bleeding. Only a shrinkage of agriculture can do that. Richard Matteis of the California Farm Bureau, which opposed the new groundwater law, laments that reaching balance will require the retirement of at least half a million acres of farmland. What is left will be devoted more and more to high-value crops, like the debated and delicious almond.

Photo: Anthony Dunn

The picture is more hopeful in the next region north, the central area watered by the San Joaquin and its tributaries. Here there are both empty spaces underground and wet-year runoff to fill them. To complicate matters, however, this region is rather short on another essential resource: suitable recharge zones. The ones that exist all need to be pressed into service. The best candidates are riverbeds, floodplains, and fallowed or dormant fields.

The slowly progressing attempt to restore the San Joaquin River can be seen as an aquifer recharge project. When the dry middle section of the river was rewatered on an interim basis in 2009, it took several months for surface flow to make it through; most of the water released was going underground. Though the drought has delayed the next steps in recovery, recharge of the riverside aquifer goes on. There is more water in the ground and otherwise available to farmers today, says Peter Vorster, than there would have been without the restoration program.

Given that a river is flowing, the next recharge step is to give it back its flood plain, undoing the old-fashioned channelization that hustles valuable peak flows seaward. A Nature Conservancy project on the Cosumnes River found that pulling back dikes one thousand feet allowed even modest runoff surges to spread — and sink into the ground.

Farmland itself can be used for recharge where the subsurface geology is right. On the Cosumnes, part of the newly opened flood plain supports row crops during the growing season. Nearby on the Mokelumne, the San Joaquin County Groundwater Basin Authority is working with the East Bay Municipal Utility District toward a much larger project that may use both fallow fields and dormant vineyards as winter spreading zones.

The project is starting on a tiny demonstration scale. "We want to show that we can put water in the ground, pull it out again for our customers, and leave the source area better off than before," says Richard Sykes of EBMUD. He sees great potential ahead. "There is 1 MAF of empty aquifer in the area. If the Groundwater Basin Authority and its partners could fill it up, it would be a huge benefit to everyone, both in normal water years and in extended drought."

The Authority's Brandon Nakagawa agrees: "This opens a lot of doors for us," he says.

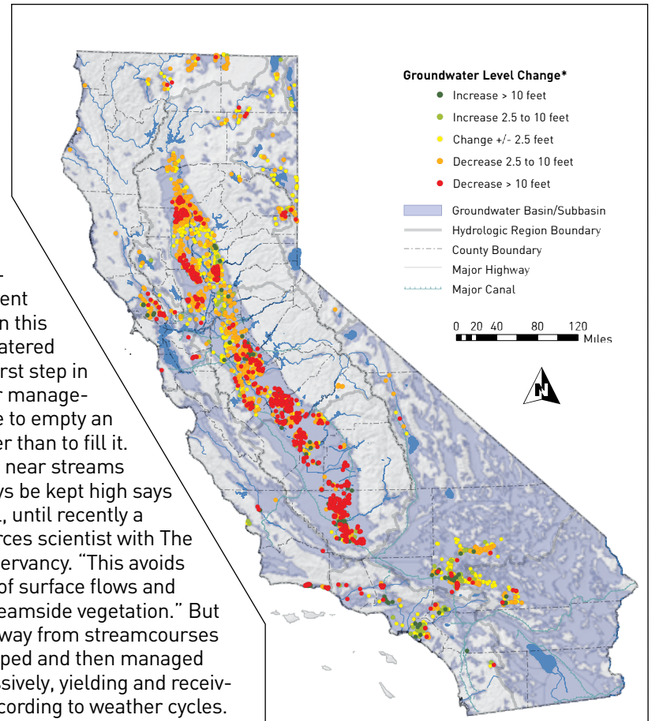
The Sacramento Valley is a different case again. In this fairly well-watered region, the first step in groundwater management may be to empty an aquifer rather than to fill it. Water tables near streams should always be kept high says Maurice Hall, until recently a water resources scientist with The Nature Conservancy. "This avoids further loss of surface flows and supports streamside vegetation." But zones well away from streamcourses might be tapped and then managed more aggressively, yielding and receiving water according to weather cycles.

Several rules and tools apply in all the regions. First, aquifers must be kept clean. Much attention has been paid of late to contamination by "produced water," the millions of contaminated gallons that come up with oil and are disposed of by being pumped underground again. Rather less fuss has been made about pollution by nitrates sinking in from the surface, especially under feedlots and dairy farms.

Second, water recycling matters here as well. Treated municipal wastewater is already used for irrigation and recharge; that troublesome oil field water might also be purified.

Third, releases from conventional reservoirs can be re-jiggered to support recharge, feeding water downstream according to the rate at which spreading areas can absorb it. The details are intricate, involving a new balance of flood control, water supply, and environmental concerns. Lester Snow of the California Water Foundation summarizes: "Reservoirs should be operated as forebays to the aquifers."

Let's say all these things, and a few others, were done. How much storage might we actually gain?



Change in Groundwater Levels 2010-2014

**Groundwater level change between spring 2010 and spring 2014 as determined from water level measurements in wells. Map and chart based on available data from the DWR Water Data Library as of 11/08/2014. Data subject to change without notice.*
Map Source: California Department of Water Resources, Public Update for Drought Response – November 2014.

In a paper published last November, a group at the U. C. Davis Center for Watershed Studies tackled this question head on. The results, under the title "Integrating Storage in California's Changing Water System," were promising but sobering. "At most," the authors concluded, "California's large-scale water system could utilize up to 5-6 MAF of additional . . . storage capacity," whether behind dams or underground. Runoff is simply not sufficient, based on historical fluctuations, to fill more.

Six or so MAF of storage capacity is not to be sneered at. It could be extremely valuable. If it were underground, as favored by most experts, it would amount to at least a doubling of *managed* aquifer space. If utilized correctly, it could definitely help us ride out multi-year droughts like the one

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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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COVER PHOTO *Cache Slough fish habitat*
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we are currently enduring. What it would not provide, the authors make clear, is long-term insurance against droughts worse than those we've seen.

Never mind global warming: We needn't go back too many centuries to find evidence of such droughts. There are drowned trees in the beds of Tenaya Lake and Mono Lake — trees that began as seeds at a time when the lakes were shrunken, and had time to sprout and reach full size before the waters rose again. The work of geomorphologist and paleoclimatologist Scott Stine and others suggests medieval dry periods that lasted a century or two.

In 2011, a group of researchers including Stine and Jay Lund tried to model the effects of a drought lasting 72 years in which precipitation never exceeded half the historical norm. In a drought of that length, without wet interludes, all reserves would be exhausted. The state would be forced to live on its year-to-year water income. The key to economic survival in such a situation, the modelers conclude, is a free-wheeling market system in which water flows to whatever user could pay most for it. Cities would have little trouble coping. Agriculture would make large adjustments, abandoning most of its lower-value crops and contracting overall. The real loser, in this trial run, would be the Bay Delta estuary, fish, and the environment in general. The river flows that are currently mandated would either be impossible to maintain or so costly that there would be great pressure to cut them back (see p. 6).

Removal of riverside levees along the Cosumnes is allowing floodwaters to spread onto floodplains and facilitating aquifer recharge (Andrew Nichols wading in December 2014). Photo by Alison Whipple.

This research used CALVIN, "an economic-engineering optimization model for the entire water system of California." CALVIN has its baked-in assumptions, its limits, and its critics. But no one seems to challenge the essence of this result. A really long drought would make California a different place from the one we think we know.

Does all this mean that the idea of storage against longer droughts is a pipedream? I put this question to another knowledgeable fellow, John Cain of American Rivers. "Not at all," says Cain. "But it is like a retirement account. To build it, you can't count on windfalls. You have to put money into it all the time, and you can't raid it prematurely."

To continue Cain's analogy, it is tough to pad a savings account when you're spending more than your income, most of the time. We have been doing that, in water terms, not for months or years, but for many decades.

Stopping groundwater overdraft means using less water, at least in many places, and with sometimes painful results.

Reversing it, even on a large scale, is possible. But it can only happen if we use less water still. **JH**

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