SAN FRANCISCO ESTUARY PROJECT

Agricultural Drainage

California's Central Valley is one of the most productive agricultural regions on earth, made possible by a year-round growing season and extensive water diversion projects. This multi-billion dollar agricultural industry uses almost 80 percent of the state's managed water. After irrigating crops, some of the water returns to the Estuary as drainage, often bringing harmful amounts of salts, trace elements, and chemical residues with it. For the San Francisco Estuary Project, examining this issue has become a priority in promoting environmentally sound management of the Bay and Delta.

The Estuary

The San Francisco Bay and Delta combine to form the West Coast's largest estuary, where the waters of the Sacramento and San Joaquin Rivers converge and flow into the Pacific Ocean. The San Francisco Bay Estuary encompasses roughly 1,600 square miles, drains over 40 percent of the state (63,000 square miles), contains about 5 million acre-feet of water at mean tide, and redistributes about 80-280 million cubic yards of sediment every year. Its Delta and watershed provide drinking water to 22 million Californians (two-thirds of the state's population), and irrigation water to 4.5 million acres of farmland. The Estuary also hosts a rich diversity of aquatic life and other wildlife. Each year, two-thirds of the state's salmon pass through the Bay and Delta, as do nearly half of the waterfowl and shorebirds migrating along the Pacific Flyway. Estuary waters enable the nation's fifth largest metropolitan region to pursue shipping, farming, fishing, recreation, birdwatching, commerce, and other activities.

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Agricultural Drainage

Only a portion of the water now diverted from the Estuary to irrigate Central Valley farm fields and orchards is actually taken up and transpired by crop plants. The rest evaporates from wet ground or percolates into groundwater, runs off the surface, or flows out through underground drains into evaporation ponds, streams, or ditches. At certain times of the year, agricultural drainage flows into the Estuary can be voluminous. These flows are of environmental concern because they may have picked up, dissolved, and mobilized salts, trace elements, pesticide residues, and other contaminants (see inside) enroute to the Estuary. During the summer, the lower San Joaquin River is mostly drainage, as is up to one third of the Sacramento River between Knights Landing and the city of Sacramento during rice growing season. Before California's water supply systems were built, the low rainfall received by most farming regions mobilized salts and trace elements very slowly. But with irrigation water acting as artificial rainfall, these substances, along with fertilizer and pesticide residues, mobilize more rapidly and can concentrate in harmful amounts in the water that drains from farm fields into the Estuary.

History

The increase in volume of agricultural drainage entering the Estuary is closely tied to the expansion of irrigation in the Central Valley. After the Gold Rush, Valley agriculture consisted mostly of non-irrigated grain farming. Not until the 1890s did breakthroughs in transportation began to create a national market for fruits, nuts, vegetables, and other crops requiring irrigation. When deep-well pumps became available in the 1920s, many farmers in the Valley began irrigating their fields with groundwater. As groundwater levels dropped, farmers sought the construction of large reservoirs that could supply them with surface water. The first large-scale, surface-supply irrigation projects were installed on the east side of the Valley. East side soils derive from the weathering of Sierra rock (usually granite), which results in coarse permeable soil low in salts and trace elements. As a result, drainage from the east side was relatively unpolluted and flowed easily through the soil and downstream to the Delta.

The Central Valley Project and State Water Project also brought canal water to the west side of the San Joaquin Valley. West side soils derive from the Coast Ranges, which have a different geologic history and chemical composition from those on the east side. They're formed from a complex mix of marine sediments including salts and trace elements, such as selenium, arsenic, boron, and molybdenum, which can be toxic to people and animals at certain concentrations; boron can be

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Substances of Concern in Drainage

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toxic to plants. Irrigation water mobilizes these salts and trace elements. As near-surface aquifers filled with drainage water from the irrigated fields (prevented from percolating downward by clay layers in the soil), growers were forced to install subsurface drainage systems to keep their fields from becoming water-logged. Those systems in turn drain into our rivers and streams and ultimately, San Francisco Bay.

The Central Valley Project and the State Water Project drastically altered the natural drainage patterns of the Central Valley. The San Joaquin River was diverted into the Madera and Friant-Kern Canals along the east side of the Valley. To replace the water diverted into these east side canals, the CVP Delta-Mendota Canal pumps water from the Delta to the vicinity of Mendota, where it is diverted into older canals along the lower San Joaquin. As a result, there is almost no fresh water flowing through the San Joaquin from the Sierra to the Delta: the lower course of the river is mostly agricultural drainage.

Farther north, the CVP's Tehama-Colusa, Corning, and Glenn-Colusa Canals divert water from the Sacramento River to irrigate the Sacramento Valley. The Bureau of Reclamation built the Orland and Solano Projects to intercept water from streams tributary to the Sacramento River. The soils in the Sacramento Valley do not contain the same levels of trace elements found on the west side of the San Joaquin, so concentrations of these chemicals in drainage water from this region are not as great a concern. However, fertilizer and pesticide residues are a problem here as they are throughout the state.

To date, Congress has exempted agricultural drainage from regulation under the Clean Water Act. However, under the Porter-Cologne Act, the Regional Board can issue Waste Discharge Requirements for drainage discharges to surface water bodies.

Salts

Salt management is an inevitable chore of irrigated agriculture. Salts occur naturally as rocks weather and form soil. While California's scanty rainfall is enough to dissolve bits of rock into salts, it's sometimes not enough to remove the salts, so they build up in the soil. Irrigation causes still more salt accumulation, because surface water diverted to irrigate fields already contains salts in solution. The CVP and SWP import about 1,600,000 tons of dissolved salts into the San Joaquin Valley every year.

Salts accumulating in the root zone make it harder for a plant to absorb the water it needs. At a certain level of accumulation, which varies for different species, the plant wilts and dies. To prevent this, farmers install subsurface drainage systems.

Trace Elements

Trace elements occur naturally in the rocks and soils of the Coast Range. Though most soils contain minute traces of these elements, some contain them in high concentrations. When mobilized by lots of irrigation water, elements such as selenium, arsenic, boron, and molybdenum can reach concentrations in the resulting drainage water that are harmful to wildlife.

The Kesterson National Wildlife Refuge in western Merced County revealed just how harmful high concentrations of these elements can be. When the CVP brought large amounts of canal water to the western San Joaquin Valley, clay layers in the soil blocked drainage, causing growers to install subsurface tile drains. As the drainage water was high in nitrates that could cause algae blooms in the San Joaquin River, the Bureau of Reclamation decided to dispose of it via a concrete-lined channel (San Luis Drain) to be built north to a Delta outfall.

Lack of funding and political resistance from Delta and Bay Area residents cut short the San Luis Drain. The Department of the Interior decided to allow the drainage water to evaporate from a series of 12 shallow ponds just east of Gustine, as part of the Kesterson National Wildlife Refuge. It was assumed that aquatic vegetation would absorb nitrates in the water and that pond sediments would immobilize the trace elements. In reality, however, pond algae began concentrating selenium to levels 100 to 2,600 times the level in [illegible] rich water, and provided a feast for fish and birds, moving the selenium farther up the food chain. While the selenium only affected some adult birds, it caused gross birth deformities—and mortality—in chicks. Amid great controversy, the U.S. Department of Interior closed Kesterson and filled in the ponds.

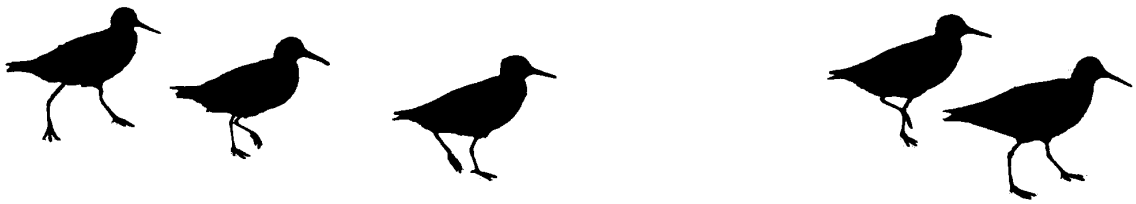
Growers, regulators, and water agencies are working to address and prevent similar problems from occurring in the Valley's remaining 5,000-some acres of evaporation ponds. Twenty-seven additional "substances of concern" have been identified, and the Central Valley Regional Water Quality Control Board has established water quality objectives and wastewater discharge requirements for the ponds.

Fertilizers

Agricultural drainage water contains nitrogen compounds from man-made fertilizers. Crops rarely absorb more than half of the nutrients in synthetic fertilizers, and the rest find their way into rivers and the Estuary. Probably the most damaging of these compounds to the Estuary's rivers—and toxic to fish—is ammonia, which enters rivers in runoff from excess field application of anhydrous ammonia, a common fertilizer. Ammonia also appears in runoff from dairies and cattle feedlots. Another residue that can cause problems is nitrate. Nitrate-rich water can cause excessive growth of algae and other aquatic plants in streams and ponds. When these plants decompose, they deplete the water of oxygen, killing fish and other aquatic animals.

Pesticides

While some pesticides are persistent in the environment, others break down quickly. But even shorter-lived pesticides can cause problems for aquatic life when they enter rivers and streams in drainage water. In past years, pesticide residues from rice fields in the Sacramento Valley caused fish kills, as well as taste and odor problems in Sacramento drinking water. Recent studies found organophosphorus and carbamate pesticide residues at concentrations toxic to invertebrates present in the San Joaquin River for extended periods of time, and the EPA has designated over [illegible] ater-quality impaired."



Reducing Discharges

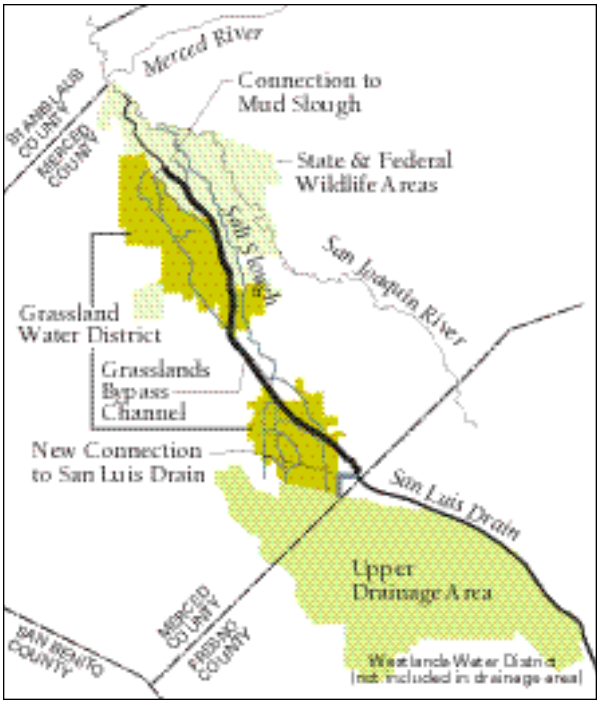
Salts and Selenium

California's varied geology and the chemical-intensive nature of agribusiness in the Estuary's watershed means that there will continue to be many substances that can concentrate to potentially toxic levels in agricultural drainage water. Where soils are high in salts or trace elements of concern, more efficient application of irrigation water can help reduce drainage. Water-saving technologies such as drip systems, gated pipes, and microsprinklers have improved greatly in recent years. Improvements in irrigation scheduling and water management can also reduce excess drainage, as can growing crops that use less water, or rotating or temporarily fallowing fields.

At present, farmers, scientists, and regulatory agencies are working to monitor drainage, develop treatment and prevention measures, and improve regulatory strategies for addressing drainage problems. A pilot reverse osmosis project recently installed in the Panoche Drainage District effectively reduced total dissolved solids (salts) from 5,000 to 70 ppm; however, the costs of large-scale application are still prohibitive. A pilot treatment project for selenium using algae and bacteria significantly reduced selenium concentrations, but it must be tested on a larger scale to determine its feasibility for widespread use. Wetlands flow-through systems have also shown to be effective at reducing selenium; however, these systems could attract and harm birds and other wildlife.

In the Grasslands region, farmers—with the support of environmentalists and government officials—developed an innovative program that has substantially improved water quality in the San Joaquin River. In the mid 1990s, a group of farmers agreed to new and increasingly stringent discharge limits in exchange for access to the Grasslands Bypass, which diverts their drainage from wetlands used by millions of waterfowl, shorebirds, and other wildlife. The agreement that established their access to the Bypass specifies a regional selenium load limit, which sets a cap on the total amount of selenium the farming districts can collectively discharge. The farmers have responded by allocating pollution permits to their various districts and allowing those districts to trade the permits amongst themselves. Each district has individually developed and implemented compliance mechanisms to meet its pollution limit. One commonly employed mechanism is tiered water pricing, but farmers have also used such techniques as recycling drainwater, recycling tailwater, using drainwater to grow selenium-enriched feed for dairy cows, using drainage to water farm roads, and planting eucalyptus trees that utilize drainage. Farmers are still experimenting with innovative drainage-control techniques to meet increasingly stringent discharge limits.

Farmers have benefited from this decentralized decision-making process that has allowed them to develop their own pollution allocation and compliance systems. This process has given them flexibility in responding to changes in economic, environmental, and technological conditions. Having recently completed the fourth year of this program, farmers are now discharging approximately 23 percent less than their total pollution limit. However, selenium loads are still in a problem in Mud Slough, a tributary to the San Joaquin, and in the river itself above the Merced. The Central Valley Regional Water Quality Control Board, environmentalists, and farmers are continuing to try to arrive at a solution for those areas. In the meantime, the California Department of Fish and Game and Grasslands farmers operate a hazing program to keep birds from using the slough.



Grassland Water District

Drainage water can be used on a series of increasingly salt-tolerant crops, thus producing economic benefits and reducing drainage volume before it is sent to on-site evaporation ponds. An

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Glossary

Bioconcentration or bioaccumulation—*Heavy metals and pesticides can be ingested and absorbed at the bottom of a food chain—for example, by algae or zooplankton. These compounds are then stored in the fatty tissues of the animals that eat the algae and zooplankton and are in turn passed along to the next level of predators, eventually reaching harmful levels at the top of the food chain. High concentrations can cause reproductive failure and birth defects (as seen at Kesterson).*

Carbamates—*A group of compounds used in herbicides, fungicides, and insecticides that were developed as a replacement for long-lasting chlorinated hydrocarbons such as DDT. While they do not accumulate in the food chain, some are toxic to bees and birds.*

Clay layer—*Layer of clay below ground surface that can impede downward percolation of water.*

Organophosphate or organophosphorous pesticide—*Any of a class of synthetic insecticides that are very toxic but less harmful to the environmental if applied properly) than chlorinated hydrocarbon insecticides like DDT.*

Salts—*A class of compounds that includes common table salt, sodium chloride, as well as salts of concern in irrigated agriculture; e.g. the various carbonates, bicarbonates, sulfates, phosphates, and chlorides of sodium, calcium, potassium, and magnesium.*

Subsurface drains—*Clay layers beneath the surface can cause irrigation water to accumulate in the root zone of plants. To drain this water, a network of pipes, formerly made of ceramic tile but now usually plastic, is buried in the fields below the root zone. The drains carry the excess water by gravity to a point where it can be pumped out to a canal, stream, or evaporation pond.*

Tailwater—*Excess irrigation water that runs off the surface of a field.*

Trace elements—*Members of the set of 92 naturally occurring elements found in low concentrations, usually less than one part per million, in rocks, soil, and water.*

Reducing Discharges

Resources

A Management Plan for Agricultural Subsurface Drainage and Related Problems on the Westside San Joaquin Valley. *Final Report of the San Joaquin Valley Drainage Program, U.S. Dept. of the Interior and the Cal. Resources Agency. 1990. Sacramento*

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Integrated On-Farm Drainage Management for the Harvesting of Salt in the San Joaquin Valley. *J. Diener, V. Cervinka, J. Tischer. March 2000.*

Land Retirement Demonstration Project. 1999 Annual Report. *May 2000. M. Selmon, P. Kelly, and C. Uptain, Endagered Species Recovery Program, Fresno, and S. Lee, USBR/Interagency Land Retirement Team. Fresno. May 2000.*

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The Water Quality Control Plan (Basin Plan), Second Edition. *Central Valley RWQCB. Sacramento.*

Water Quality Control Plan for Salinity, SF Bay/Sacramento-San Joaquin Delta Estuary. *Water Resources Control Board, State of California, 1991. Sacramento.*

Contacts

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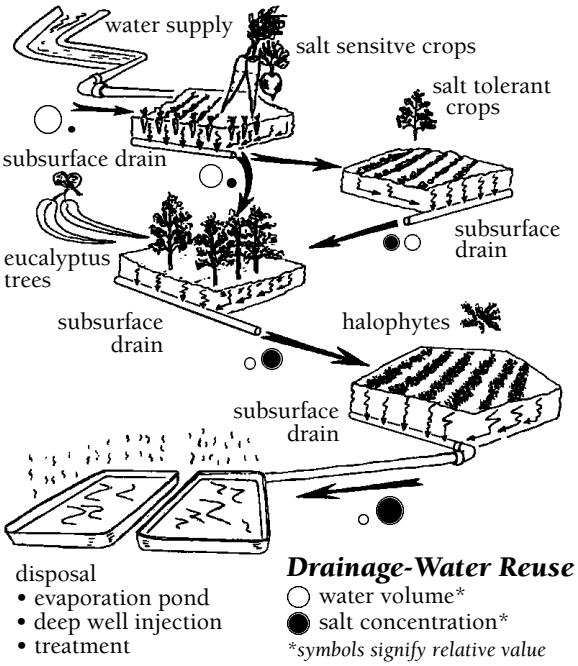
experimental drainage reuse project has been in place for several years at Red Rock Ranch in Fresno County. There, drainage water from irrigated crops is re-used to produce crops with different salinity tolerances. Drainage water from vegetables irrigated with canal or well water is used to irrigate alfalfa, cotton, and other salt-tolerant commercial crops. The drainage from those crops is then sent to irrigate salt-tolerant grasses and trees, after which it is sent once more to irrigate halophytes in the high-saline zone. This sequential process re-uses over 90 percent of the drainage water. A solar evaporator receives the final volume of drainage water; the water evaporates and the salt crystallizes. The selenium is taken up by the plants or volatilizes; any remaining selenium becomes a component of harvested salt. No salts or selenium are discharged into rivers or evaporation ponds; however, high levels of selenium can be present if the area is flooded in heavy rains, so there is a need for active management of the system. There is also a need for ongoing monitoring to determine whether the terrestrial food chain is being impacted by selenium.



A longer-term solution is land-retirement. An inter-agency land retirement program sponsored by the Bureau of Reclamation, the Fish and Wildlife Service, and the Bureau of Land Management is working with farmers in the Central Valley to retire and restore native habitat on up to 15,000 acres of land with drainage and selenium contamination problems. So far, 4,292 acres have been retired. The team initiated an 800-acre demonstration project in 1998 that attempts to recreate a more natural topography on the laser-leveled landscape, with the goal of facilitating the recovery of native plants and animals, and native vegetation is being reintroduced from seeds and plugs of grasses. The project will be monitored for five years to ensure that selenium in the soil and shallow groundwater does not become available to wildlife.

Pesticides

Existing regulations prohibit or restrict the use of toxic substances known to be long-lived and easily mobilized in drainage water. The Central Valley Regional Water Quality Control Board monitors water bodies receiving agricultural drainage, with a particular interest in organosphosphates. If new pesticides are found in surface water despite label instructions or use restrictions, the Board will follow up with special studies to determine whether regulatory action is needed.

Many farmers in the valley have reduced their use of synthetic pesticides and fertilizers by using integrated pest management techniques while at the same time conserving water. Some of the IPM techniques include releasing beneficial insects, growing cover crops that provide habitat for beneficial insects and reduce weed growth, rotating crops, and enriching their soil with the use of compost and other natural soil amendments (for detailed studies, see Agricultural Solutions, NRDC, March 1998—full citation under Resources).

Estuary Project

The Estuary Project's primary goal is to restore and maintain water quality and natural resources while promoting effective management of Bay and Delta waters. The Project's Comprehensive Conservation Management Plan (CCMP) includes the following actions to address pollution prevention in the Bay and Delta, as it pertains to agricultural drainage:

• Improve agricultural practices that reduce introduction of pollutants into the Estuary

• Reinforce existing programs and develop new incentives where necessary to reduce selenium levels in agricultural drainage

The Estuary Project is working cooperatively with other agencies, business, agriculture, and the public to develop implementation programs for the CCMP. For more information contact, SFEP, 1515 Clay Street, Suite 1400, Oakland, CA 94612, (510)622-2465, http://sfep.abag.ca.gov/