A master plan for drainage in the San Joaquin Valley

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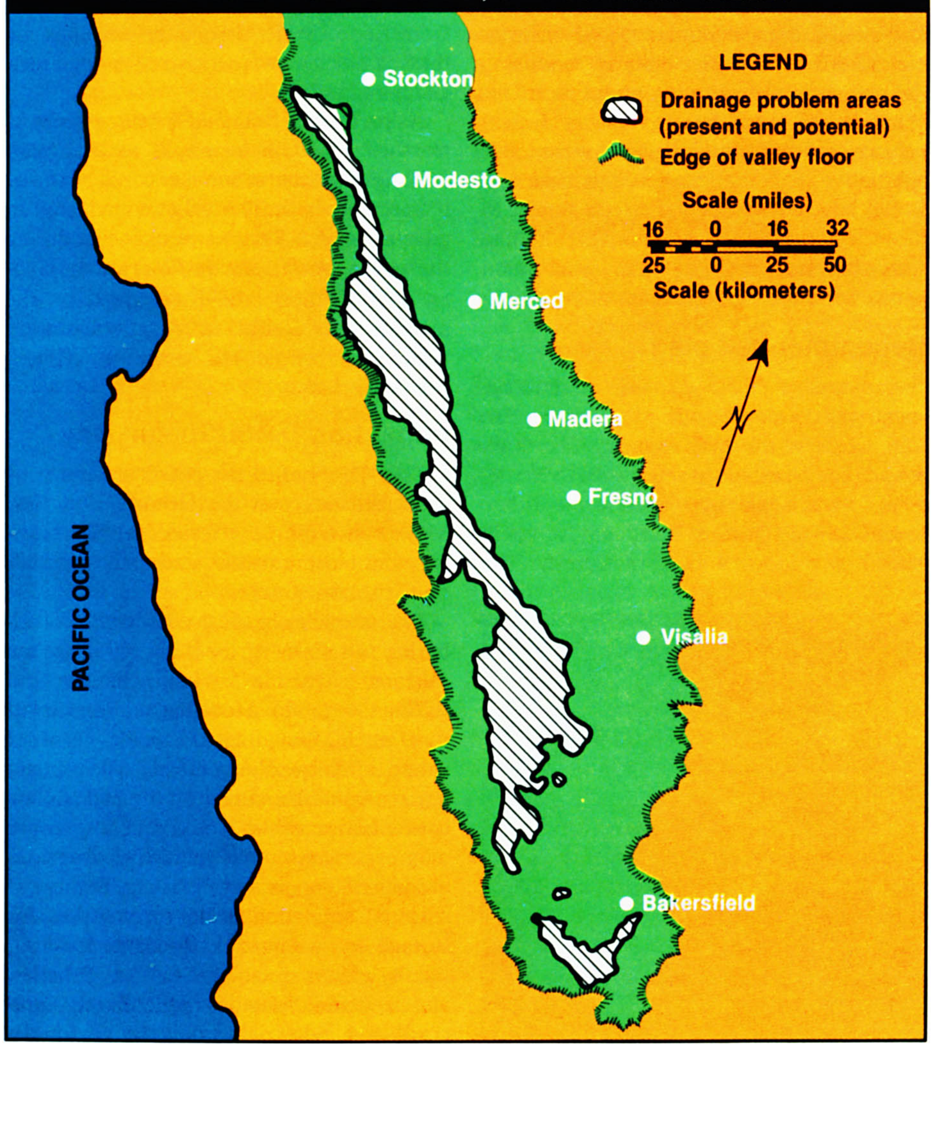
About 400,000 acres of irrigated land now have drainage problems, and affected acreage is increasing.

Irrigation is necessary where the natural water supply is insufficient to meet crop needs. However, because some deep percolation occurs during irrigation, a water table may develop where natural drainage of the subsoil is limited. If the water table rises too close to the land surface, it can affect crop production: excessive soil moisture or salt accumulation in the root zone can hinder plant growth and reduce yields.

Several phonomena cause salt accumulation. Salts in applied irrigation water remain in the soil as plants use the water and must be leached below the root zone by periodic irrigation in excess of crop needs. The excess water containing the leached salts percolates down to the water table. If subsurface drainage is poor and the water table close to the surface, leaching may be inadequate. Also, where water tables are near the ground surface, capillary action causes groundwater to move upward. If this water is saline, as is frequently the case in irrigated areas, this upward movement can contribute to salt accumulation in the root zone. Land once highly productive may thus become marginal.

The common solution for a high water table is a subsurface drainage system—perforated plastic pipe installed at regular intervals throughout a field at a depth of 5 to 7 feet. The system increases the subsurface drainage rate and controls water table depth but requires a method of disposing of the drainage water.

DRAINAGE PROBLEM AREA, SAN JOAQUIN VALLEY



The San Joaquin Valley

About 400,000 of the San Joaquin Valley's 4.5 million acres of irrigated land are affected by high water tables along the west side of the valley, extending from the southern part of San Joaquin County to Kern County. Studies by state and local agencies predict that affected acreage will eventually increase to over 1 million acres.

Because these problem areas generally lack adequate disposal facilities for subsurface drainage water, growers are faced with the choice of not draining their land, thus possibly reducing their crop yields, or discharging the water into the irrigation water supply or evaporation ponds. Discharging the drain water into the irrigation supply is often unacceptable, because it may degrade irrigation water quality, thus affecting downstream users. In some cases it may be possible to recirculate the drainage water to irrigate the drained acreage, but this simply recycles the salts and should be considered an interim measure only.

Evaporation ponds are another solution. The Tulare Lake Drainage District was formed to develop an areawide drainage-water disposal system using evaporation ponds. In other areas, some growers are using small, on-farm evaporation ponds. One problem with this approach is the acreage needed for adequate disposal: as much as 1 acre of evaporation pond may be required for every 4 to 5 acres of drained land in some locations. Unless unproductive land is available, the grower will have to give up productive acreage for an on-farm evaporation pond.

Increasing irrigation efficiency may also help growers cope with drainage problems. Studies are now being conducted to evaluate methods such as level basin irrigation for obtaining high on-farm efficiency with a minimum of energy and labor costs. Even with a properly designed and managed irrigation system, subsurface drainage will be needed in the problem areas, but the increased efficiency will reduce the volume of drainage water to be disposed of.

Salt-affected land in area where subsurface drainage is poor.

Valley drainage program

The San Joaquin Valley Interagency Drainage Program (IDP) was formed in 1975 to develop a feasible valleywide method of disposing of the drainage water. Agencies participating were the State Department of Water Resources, U.S. Bureau of Reclamation, and State Water Resources Control Board. A public advisory committee of individuals representing a wide range of interests was also formed to provide input.

A number of possible alternatives were evaluated:

☐ No valleywide action. Local entities would develop drainage disposal methods.

☐ Evaporation of drainage water. Possibilities included situating all ponds within the valley or locating those serving the southern valley on the Carrizo Plain. In the latter case, the water would have to be pumped to an elevation of about 2,000 feet.

☐ Direct discharge to the ocean, either at Monterey Bay (near Moss Landing) or Estero Bay (near Cajucos).

☐ Discharge to the San Joaquin River. Schemes considered included discharging drainage water as generated, discharging as generated but with dilution, and discharging only between November and February and storing the water during the nondischarge period.

☐ Discharge to the Delta/Suisun Bay. Possibilities were discharging untreated water near Antioch or Martinez without storage or regulation, treating water to remove nitrogen and discharging near Antioch, and discharging untreated water near Antioch but regulating discharge to minimize adverse impact.

Each alternative was analyzed for economic benefits, implementation costs, environmental effects, and flexibility in modifying the plan as implementation progressed. Discharge to the Delta/Suisun Bay was chosen, because, except for no valleywide action, this alternative was the most economical and would have environmental effects similar to those of the other alternatives. It had somewhat less flexibility than evaporation ponds but more than the other possibilities.

Recommended plan

A master plan for disposal of drainage water was developed, using the existing San Luis Drain as the first segment. The drain would then be extended southward to Kettlemen City to serve areas outside the Tulare Lake Drainage District. Eventually, it would extend to a location in Kern County. The drain would also be extended northward from Kesterson Reservoir, the terminus for the San Luis Drain, to a discharge point near Chipps Island.

Projected concentrations of major constituents of drain discharge for about the year 2000

Constituent	Concentration
Electrical conductivity (mmhos/cm)	7.51
Total dissolved solids (mg/l)*	6,010
Sodium (mg/l)	1,100
Calcium and magnesium (mg/l)	605
Chloride (mg/l)	795
Sulfate (mg/l)	1,910

*1 milligram per liter (mg/l) is about 1 ppm.

As part of the drainage system, a series of marshes would be managed so that peak drainage flows in the summer could be stored if discharges to the receiving water created an adverse impact. Releases would occur during the winter, when Delta outflows are the highest and dilution would be greatest. The marshes also would serve as evaporation ponds to concentrate drainage effluent before discharge.

Impact on Delta/Suisun Bay

The IDP studied the potential impact of drain discharge on the Delta/Suisun Bay. Major concerns were effects of salinity, nutrients and biostimulation, and toxic materials on the receiving water.

The primary chemical contituents contributing to salinity of the drain discharge are calcium, magnesium, sodium, chloride, and sulfate (see table). Modeling studies showed that moving the discharge point westward would minimize salinity effects. The primary impact would be caused by the high sulfate concentration, which would probably reduce or prevent continuous municipal diversions at Mallard Slough near Pittsburg. Because of seasonal regulation using the marshes for storage and a favorable discharge location, salinity effects on aquatic habitat, fisheries, and upstream diversions (agricultural, municipal, and industrial) would be nil for the year-2000 projected concentrations.

Modeling studies were also conducted to evaluate effects of the drain discharge on nutrient levels and algal growth. Results show that in receiving water near the discharge point, nitrogen levels would increase to a maximum of about 2 milligrams per liter (mg/l), but these concentrations would rapidly approach base conditions in both upstream and downstream directions. Thus, nitrogen in the drain water (projected concentration for year 2000 = 18 mg/l) is not expected to produce significant quantities of algal biomass. Predictions of chlorophyll concentration, an indicator of algal biomass, showed the largest amount of growth would occur in Grizzly Bay, a shallow segment of Suisun Bay. These projections, however, were within the range of levels observed in the bay without apparent adverse environmental effects. Projections were considered to be not significantly different from base conditions.

Although these studies indicated that nitrogen concentrations in the drain water would cause no adverse effects, caution was recommended in interpreting the results. Modeling did not predict the effect of additional nitrogen on shallow embayments. Model verification was less reliable in predicting adverse effects when the zone of entrapment (a zone at the saltwater/freshwater interface that concentrates particulate matter) is downstream from the discharge. Also, dynamics of the nutrient-phytoplankton relationship are not well understood.

A preliminary evaluation of toxicity effects of boron, chromium, copper, arsenic, cadmium, iron, lead, zinc, and pesticides was also conducted to identify concerns only. Projected concentrations of these constituents in drainage water were compared with historical concentrations in the receiving waters. If effluent concentrations were considerably higher than the background concentrations, concern would be warranted.

Of the minor elements, boron appeared to be of greatest concern. Projected boron concentration (20 mg/l) in the drain discharge was about 40 times greater than the median background concentration of the receiving waters and 4 times greater than 1972 U.S. Environmental Protection Agency (EPA) criteria (5.0 mg/l). Modeling studies showed, however, that because of the dispersive effect of the receiving waters, boron concentrations at locations beyond the discharge point were less than 5.0 mg/l.

Other minor elements warranting concern are chromium, iron, lead, and mercury. Projected concentrations of these elements exceeded background concentrations as well as federal and state water quality objectives and criteria.

In some parts of the southern San Joaquin Valley, drainage water contains arsenic in concentrations as high as 0.98 mg/l. However, projected arsenic concentrations in the drain discharge are uncertain. If future studies show arsenic to be a problem, evaporation ponds may be needed to dispose of drainage water from areas responsible for the arsenic concentrations.

Evaluation of pesticide concentrations shows that DDT, dieldrin, and toxaphene warrant concern. Projected concentrations of DDT (3 ng/l) and toxaphene (14 ng/l) are less than background concentrations but exceed 1976 EPA criteria (1 ng/l and 5 ng/l, respectively). (1 nanogram [ng] is one billionth of a gram.) Projected dieldrin concentrations (9 ng/l) exceed both background concentration and 1976 EPA criteria (less than 3 ng/l and 3 ng/l, respectively).

According to the IDP, these studies indicate that the discharge will not be toxic to the receiving waters. However, a recommendation was made that bioassay studies (in which aquatic organisms would be used to detect or measure presence or effect of a substance) and more intensive monitoring of the discharge of presently installed drainage systems be conducted before issuing any wastewater discharge requirements.

Subsequent activities

As a result of the IDP recommendation, actions have been taken to aid in implementation of the recommended plan. First, Assembly Bill 1376, signed by Governor Brown on February 17, 1982, establishes as law the requirement to protect receiving waters from adverse effects of the drain water. This bill provides that:

☐ No discharge from a San Joaquin Valley agricultural drain shall be allowed unless requirements of the Porter-Cologne Water Quality Control Act and the Federal Clean Water Act are satisfied.

☐ No discharge from a valley drain shall be allowed into the Monterey Bay.

☐ The drain shall be operated so as to protect beneficial uses of the Delta, Suisun Marsh, and bays westerly to the Golden Gate.

☐ No added financial burden shall be placed on those required to use a substitute water supply as a result of the drain.

☐ An acceptable comprehensive program shall be established to monitor receiving water before and during operation of drain.

☐ Surface and subsurface leakage from the drain shall be confined within the drainage facility right-of-way.

☐ Drainage water shall be made available for any beneficial uses, such as powerplant cooling, marsh development, and reuse for irrigation.

☐ Repayment schedule shall take into account the quantity of effluent discharged into the drain by a grower, concentration of salts in effluent, distance the effluent is carried in the drain, and quantity of water applied in areas contributing to the drainage problem.

Second, the U.S. Bureau of Reclamation queried the State Water Resources Control Board for information needed to issue a wastewater discharge permit for the San Luis Drain. Based on the reply, the bureau is developing proposed studies to obtain the needed information. Major studies would;

☐ Evaluate the impact of the drain on receiving waters for various levels of drain discharge rates, Delta outflow, Delta export, tide phase, operation of Delta cross-channel canal, and San Joaquin riverflow. Assumed discharge point will be near Chipps Island.

☐ Evaluate the effect of nutrients in drainage water on nutrient levels in receiving waters. This will also include developing parameters and threshold levels to indicate when treatment measures are needed to remove biostimulants from the effluent.

☐ Define the concentration of boron expected in the drainage water and define a method of achieving discharge criteria in the receiving waters.

The proposals do not cover potential toxicity effects. Programs to obtain this information will be developed in the near future.

As can be seen, the solution to the drainage problems in the San Joaquin Valley is complex. In addition to the environmental concerns about effects on receiving water, other matters such as financing the drainage, drain alignment, and effect of the drain on rare and endangered species must also be resolved. In meeting these concerns, one concept that should be considered is that the agricultural land of the San Joaquin Valley is a natural resource with a significant impact on the state's and nation's food supply and economic well-being. Preservation of this resource should be given at least the same priority and emphasis as preservation of the Delta and receiving waters. It is hoped a solution can be obtained that will allow agricultural land in the valley to be restored to full productivity with a minimum of impact on the Delta and other receiving waters.

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