

## **SAN JOAQUIN RIVER BASIN**

Water supply and irrigation development in the San Joaquin Valley and the Valley hydrologic and geologic characteristics are the principal reasons the Valley struggles with salinity management. The San Joaquin Valley is actually made up of two distinct and different hydrologic basins; the San Joaquin River Basin and the Tulare Lake Basin (Figure 1). The Tulare Lake Basin is a closed basin south of the San Joaquin River Basin and water only flows into the San Joaquin River Basin during high flood events. The San Joaquin River Basin on the other hand has an outlet to the Ocean. The San Joaquin River Basin (Basin) includes the entire area drained by the San Joaquin River. The San Joaquin River Basin drains 13,513 mi<sup>2</sup> (35,000 km<sup>3</sup>) before it flows into the Sacramento-San Joaquin Delta near the town of Vernalis. The Merced, Tuolumne and Stanislaus rivers are the three major tributaries that join the mainstream San Joaquin from the east before it flows into the Delta.

The San Joaquin River Basin is made up of three primary geologic zones; the western flank of the Sierra Nevada Mountains, the eastern flank of the Coast Range Mountains and the valley floor. The Sierra Nevada Mountains ring the eastern side of the valley floor and rise in elevation to over 4,000 m (13,000 ft). The Coast Range that lines the western edge of the Basin is much lower in elevation up to 1,830 m (6,000 ft). The valley floor lies between these two mountain ranges.

The San Joaquin River flows from the Sierra Nevada Mountains onto the valley floor near Fresno in an east to west direction. Near the valley trough, the River makes an abrupt turn north and flows 160 km (100 mi) to the Sacramento-San Joaquin Delta. At the point where it turns north, the San Joaquin River essentially divides the valley floor into an east and west side. There are only intermittent flows from the eastern flank of the Coast Range.

The Sierra Nevada Mountains are the primary source of both the valley's water supply and the alluvial material that forms the eastern side of the valley floor and along the San

Joaquin River as it moves through the valley trough. The Coast Range provides the alluvial material for a major portion of the western side of the River.

The geology of each of these mountain ranges has had a marked influence on the valley floor sediments and salinity. The granitic deposits from the drainage of the western slope of the Sierra Nevada Mountains have created large alluvial fans of low-salinity, well sorted gravels and sands on the eastern side of the Basin. This has resulted in coarse-textured alluvial material on the eastside of the San Joaquin River on the valley floor that is low in natural salinity. This coarse-textured material becomes finer as these alluvial deposits move toward the valley trough. In contrast, the Coast Range is made up of Jurassic and Cretaceous sandstones and shales of marine origin. These are known to be high in salt. The lower rainfall on the western side of the San Joaquin River Basin has resulted in poorly sorted sediments that, as a general rule, are of lower permeability and higher salinity when compared to those on the eastside.

## **SAN JOAQUIN RIVER BASIN HYDROLOGIC CHARACTERISTICS**

Typical of a Mediterranean climate, precipitation in the watershed varies annually, seasonally as well as by watershed elevation. Precipitation in the Basin ranges from as little as 5 inches/year on the valley floor to over 80 inches/year at the higher elevations of the Sierra Nevada (USGS, 1998). Most of the precipitation falls in the late fall, winter and early spring periods with a prolonged dry period in the remainder of the year.

Precipitation is predominately snow above 4 -5,000 feet elevation with rain in the middle and lower elevations of the Sierra Nevada and Coast Range. As a result, natural hydrology reflects a mixed runoff regime, dominated by winter-spring rainfall runoff and spring-summer snowmelt runoff (McBain and Trush, 2002). Snowmelt runoff generates a majority of the flow volume from the watershed with little runoff contributed from the western side of the Basin in the rain shadow of the Coast Range.

Winter or spring rain-on-snow events likely contributed the largest instantaneous flow events and played a major role in channel forming processes while the snow melt period

was probably the longest prolonged flow periods and contributed to overbank inundation and high water tables thus creating vast floodplain and wetland habitat that supported large populations of fish and wildlife (McBain and Trush, 2002).

### **EARLY WATER DEVELOPMENT**

The San Joaquin River Basin prior to 1850 was devoted largely to rain-fed grain and cattle production. Irrigation development began sporadically in the decade following the 1850s when individual farmers made diversions to lands lying immediately adjacent to the perennial eastside streams. Most of these areas were already natural overflow lands that had been used for pasture prior to that time (DWR, 1965). Most diversions during this period were made as water was available in the river for diversion.

Construction of the railroad through the San Joaquin Valley from 1869-1875 increased the demand for more intensive cultivation, as markets in the larger coastal cities were thus accessible to valley farmers. Large-scale irrigation began in the valley around 1870 and by 1880 almost 81,000 ha (200,000 ac) were planted to cereals and alfalfa in the San Joaquin Valley (includes both the San Joaquin River and Tulare Lake Basins) (DWR, 1931). Development was generally on the eastern side of the valley and proceeded from east to west across the valley, although some lands along the valley trough were irrigated during this period. Significant production began on the western side of the valley in 1872 when the San Joaquin River was diverted through the Miller and Lux canal system west of Fresno near where the San Joaquin River turns north when it reaches the valley trough (DWR, 1965).

By the 1890s and early 1900s sizeable areas in the trough of the Basin were being forced out of production by salt accumulation and shallow water tables. Early irrigation practices involved the intentional over-irrigation of fields to raise the local water table so that subsurface water would be available to crops during a portion of the dry summer season when river flows were too low for efficient diversions. Much of this land lay idle until the 1920s when development of reliable electric pumps and the energy to power them accelerated the expansion of irrigated agriculture by making available the vast

ground water resources under the valley floor. This ground water pumping lowered the water table in many areas (SWRCB, 1977 and Ogden, 1988) and allowed for adequate leaching of salts, especially near the valley trough and the western side of the San Joaquin River Basin.

## **SURFACE WATER DEVELOPMENT**

Present day hydrology is dominated by irrigation storage, irrigation delivery, and flood control releases. Water resources development in the San Joaquin River Basin began shortly after the discovery of gold and consisted of small-scale diversions to mining districts followed by diversions to riparian users for agricultural uses adjacent to the perennial streams. Few large scale storage and diversions projects were considered prior to 1915 as the valley was focused on groundwater development. By 1915 there were 11 storage reservoirs developed on the mainstream San Joaquin River and the three large eastside tributaries (Stanislaus, Tuolumne and Merced). These facilities however only captured 1-2% of the total runoff and likely did not have the capacity to significantly reduce the volume of spring snowmelt run-off. It is not clear whether they were large enough to reduce instream flows in the late summer and early fall, a period when very low flows occurred in the mainstream San Joaquin River and the three eastside tributaries.

Beginning about 1920, large-scale water storage and diversions were planned and developed by cooperative ventures of individual landowners and by local water agencies to extend water deliveries to additional land and provide hydroelectric power. Between 1923 and 1926, large-scale storage projects were completed on all three of the eastside tributaries (Stanislaus, Tuolumne, and Merced) significantly altering seasonal flow patterns. Similar water storage projects were developed on the mainstream San Joaquin River upstream of the valley floor but these were done primarily for hydropower production rather than for irrigation.

By 1940, the San Joaquin Valley (both the San Joaquin River and Tulare Lake Basins) had over 1,420,000 ha (3,500,000 ac) under irrigation, largely using ground water. Declining ground water elevations and the desire of land owners to bring new land into production and the desire of the United States government to expand population settlement in the western part of the nation led to the formulation of federally sponsored and licensed flood control dams as well as plans for a large-scale water resource development project called the Central Valley Project (CVP). A major component of the CVP was to import water from Northern California into the San Joaquin Valley via diversion from the Sacramento-San Joaquin Delta. This led to the construction of Friant Dam on the mainstream San Joaquin River in 1941 as part of the Federal CVP. Friant Dam diverted a major portion of the natural flow of the mainstream San Joaquin River south into the Tulare Lake Basin. Water users along the middle and lower San Joaquin River exchanged their existing water rights to divert San Joaquin River water for water supplied from the Delta via the Delta – Mendota Canal (DMC), a major component of the federal CVP.

A good discussion of the history of surface water development on the main stream San Joaquin River and the three eastside tributaries is presented in Chapter 5 (Water Resources Development) of Cain et al., 2003. Chapter 5 of that report is included as an appendix to this write-up.

### **Development of Salinity Problems in the San Joaquin River Basin**

Two components led to the salinity issues in the San Joaquin River Basin. The first was the exchange of high quality snow melt water from the San Joaquin River for more reliable, but poorer quality (saltier) water imported from the Delta. The second component was the intensification of irrigation on the upslope salt laden soils on the western side of the San Joaquin River that were formed from the marine formations of the eastern flank of the Coast Range mountains. This intensified irrigation quickly led to high water tables in both the new lands being brought under irrigation and the lands previously supplied with San Joaquin River water.

Major salt and drainage problems began to develop along the San Joaquin River as the new lands were being supplied with surface water for the first time. These lands had previously been irrigated with groundwater. Pumping of groundwater for irrigation from 1920 to 1950 drew the water table down as much as 200 feet in areas along the westside of the San Joaquin River (Belitz and Heimes, 1990). Declining water tables were causing high pumping costs, land subsidence and farmers were finding poorer quality water as water tables continued to decline. These issues created a desire for new surface water supplies. As soon as the surface water supplies arrived via the CVP's DMC, ground water pumping was minimized or abandoned. The result was that the water table began to rise in the areas being provided with DMC surface water.

Many of these salinity and drainage issues should have been considered in the original CVP project designs. Salt management however was not included in any of these early plans. As late as 1949, the U. S. Bureau of Reclamation's (USBR) Comprehensive Report on Planned Water Resources (USBR, 1949) made no mention of salt management (SWRCB, 1977). The only official reference to the problem was contained in the following 1946 comment by the U. S. Department of Agriculture on the draft report, which stated:

*“The plan does not discuss drainage or include costs relative to constructing or operating drainage systems. In the light of experience with lands that have been irrigated, we feel that properly integrated plans for drainage should be made a part of any proposed new irrigation development plans”* (SWRCB, 1977).

No consideration of drainage was taken during the development and implementation of the Delta Mendota Canal (DMC) and the lands it serves. The first consideration of salt management occurred in the 1950s and 1960s, as larger – scale water development projects began for other lands on the western sides of the San Joaquin River and Tulare Lake Basins. The 1955 Feasibility Report for the San Luis Unit of the CVP, which was

to be in the western side of the Valley in both the San Joaquin River Basin and Tulare Lake Basin, recognized the need for drainage and proposed an interceptor drain for the Unit (USBR, 1955). In addition, a California Department of Water Resources (DWR) report to the California Legislature recommended the State study a “*comprehensive master drainage works system*” for the valley. The California State Water Plan prepared by DWR included the concept of a Valley Master Drain (DWR, 1957).

## **USE OF THE SAN JOAQUIN RIVER FOR DRAINAGE AND SALINITY CONTROL**

Neither of these drainage efforts ever moved to full completion but final planning and implementation of the surface water supply portion of the federal San Luis Unit of the CVP and the State Water Project moved forward to completion. Each was authorized in 1960 and began delivering Northern California water to agricultural lands on the western side of the San Joaquin River Basin and the Tulare Lake Basin in 1968. A portion of the water supply went to new lands not presently irrigated by the Delta Mendota Canal (DMC) or it intensified irrigation on lands already being served by the DMC.

As soon as the first water arrived from the DMC, farmers on the Westside of the San Joaquin River Basin began to experience rising water tables and related salinity problems. Farmers began to install on-farm subsurface drainage systems and renovate existing open drainage ditches in the early to mid 1950s, soon after the initial deliveries of water from the DMC. Development of the on-farm drainage systems and collector drains was essentially complete by the mid to late 1970s (Johnston et al., 2011). Total drained area in the San Joaquin River Basin was about 25,000 ha (60,000 acres).

The only outlet for the drainage water was the San Joaquin River through Mud and Salt Sloughs in the Grassland Basin on the westside of the San Joaquin River. Drainage flows to the San Joaquin River increased as implementation of on-farm drainage systems increased. This increase occurred just as the flow in the River upstream of Mud and Salt

Sloughs was decreasing as diversions were increasing at Friant Dam for irrigation of the eastern side of the Tulare Lake Basin. These two actions occurring simultaneously resulted in a significant degradation of the River and prompted a declaration by the California Legislature in 1961 that the River was impaired and that no further impairment shall occur and this declaration was made part of the California Water Code (CWC § 12230 – 12232). According to Water Code §12230, “Legislative Findings and Declarations” for the San Joaquin River:

*“The Legislature hereby finds and declares that a serious problem of water quality exists in the San Joaquin River between the junction of the San Joaquin River and the Merced River and the junction of the San Joaquin River with Middle River; that by virtue of the nature and causes of the problem and its effect upon water supplies in the Sacramento-San Joaquin Delta, it is a matter of statewide interest and is the responsibility of the State to determine an equitable and feasible solution to this problem.”*

According to Water Code §12231, “State Policy: Diversions of Water from San Joaquin River and Tributaries”:

*“It is hereby declared to be the policy of the State that no person, corporation or public or private agency or the State or the United States should divert water from the San Joaquin River and its tributaries to which the users along the portion of the San Joaquin River described in Section 12230 are entitled.”*

According to Water Code §12232, “Duty of State Agencies Not to Cause Degradation of Quality of Water”:

*“The State Water Resources Control Board, the State Department of Water Resources, the California Water Commission, and any other agency of the state having jurisdiction, shall do nothing, in connection with their responsibilities, to*

*cause further significant degradation of the quality of water in that portion of the San Joaquin River described in Section 12230.”*

These three Water Code sections, adopted in 1961 only says the San Joaquin River has “a serious water quality” problem that the State should not allow to get any worse and should undertake actions to improve it. These Water Code sections do not describe the type of water quality problem or the severity, says nothing about salt or boron, and makes no factual findings regarding salinity or boron. The salinity problem on the river however has been implied as to the reasons for the addition of these sections in the Water Code. It is not clear whether these Water Code sections would apply to the CVP, because the permits for the CVP were issued before their effective date.

## **PLANNING FOR WATER QUALITY CONTROL ON THE SAN JOAQUIN RIVER**

During the late 1960s, the Central Valley Regional Water Quality Control Board developed several provisional water quality control policies for the San Joaquin River which included water quality objectives for salinity for the three tributaries and the main stream San Joaquin River (CVRWQCB, 1967; CVRWQCB, 1968; CVRWQCB, 1969a; CVRWQCB, 1969b). These provisional policies were never adopted by the Board as the Porter Cologne Water Quality Control Act (PC Act) and the Clean Water Act (CWA) were eminent and required a broader Basin Planning effort that would supersede these provisional policies. During the Basin Planning effort in 1972-1974 under the PC Act and the CWA, the salinity problem on the San Joaquin River was noted as significant. The 1975 Basin Plan for the San Joaquin River watershed recommended the construction of a separate collection and discharge drain for the subsurface drainage water to isolate it from the River system as the only feasible way to improve San Joaquin River water quality.

The federal government had already begun to move forward on construction of a drainage facility and by 1975 had completed 192 km (120 mi) of collector drains and the

first 136 km (85 mi) of what was to have been a valley wide drain. It was completed from a point near the Tulare Lake in the Tulare Lake Basin to Kesterson Reservoir in the Grassland watershed in the San Joaquin River Basin.

Even though portions of the main valley wide drain were being completed, the farmers on the westside of the San Joaquin River Basin were faced with a dilemma. Even though the Basin Plan called for an isolated facility, the farmers on the westside of the San Joaquin River Basin would need to continue to use the San Joaquin River as the outlet for its drainage water and salt as there was no planned capacity for these drainers in the federal facility which was for the San Luis Unit of the CVP which was primarily in the western portion of the Tulare Lake Basin.

Beginning in the early 1950s and continuing for almost three decades, CVP farmers in the Grassland watershed on the westside of the San Joaquin River Basin discharged their surface and subsurface drainage water into channels that led to the San Joaquin River. A large percentage of this water was captured by down slope wildlife refuge managers, prior to the drainage water entering the river. The captured drainage water was combined with other water supplies and used to maintain portions of a 40,500 ha (100,000 acre) wetland area within the Grassland watershed. This wetland area represented one of the largest remaining contiguous wintering waterfowl habitats on the Pacific Flyway.

There were additional subsurface drainage systems installed along the western side of the San Joaquin River from near the town of Newman downstream to near Tracy. All of these tile drainage systems discharged directly to the San Joaquin River without flowing through wetland areas as was the case in the Grassland watershed. As with the tile drainage systems in the Grassland watershed, most of these drains were developed and installed by the mid to late 1970s (Chilcott et al., 1988).

## **FOCUS ON SALINITY MANAGEMENT CHANGES**

The central focus of water management in the Grassland watershed and in the Lower San Joaquin River from the initial development of the CVP through the early 1980s had been on salt and salinity management. The discovery of selenium impacts at Kesterson Reservoir in the early 1980s changed this focus entirely. Findings at Kesterson Reservoir showed that subsurface drainage water containing elevated levels of the trace element selenium impaired sensitive waterfowl. A check of the drainage water entering the Grassland wetlands and the San Joaquin River via Mud and Salt Sloughs also showed elevated levels of selenium. Based on this information, the Grassland refuge managers discontinued the use of blended selenium-laden drainage water and bypassed the subsurface and surface drainage flows directly to the San Joaquin River. As a result of the bypass, selenium and salt loads likely increased as well as changed in the time that the salt loads entered the river. As a result of these diversions, the selenium loads to the San Joaquin River between 1984 and 1985 likely increased from about 1,180 kg (2,600 lbs) to 4,180 kg (9,200 lbs) per year, an increase of over 300 percent (SWRCB, 1986).

This dramatic change in the discharge pattern into the river prompted the regulatory agencies to begin the process of establishing water quality objectives for the River to protect downstream beneficial uses and to develop a regulatory program to limit the selenium loads in the drainage water discharges.

In February 1985, the State Water Board adopted Order WQ 85-1 to deal with the selenium problems in the San Joaquin River Basin. This Order addressed the waterfowl problems at Kesterson Reservoir arising from selenium laden subsurface agricultural drainage water being discharged into this facility. In the Order, the State Water Board also expressed concern over the discharge of similar type of water into the Grassland wetlands and the San Joaquin River. Of particular concern to the State Water Board was the serious lack of data on the quality and quantity of agricultural return flows being discharged to the Grassland wetlands and the San Joaquin River. The State Water Board directed the formation of the San Joaquin River Basin Technical Committee, made up of State Water Board and Central Valley Water Board staffs. The Technical Committee was tasked to investigate water quality concerns in the San Joaquin River Basin related to

agricultural drainage and to report back to the State Water Board on specific components of a Basin Plan Amendment including:

1. Proposed water quality objectives for the San Joaquin River Basin,
2. Proposed effluent limitations for agricultural drainage discharges in the Basin to achieve these objectives, and
3. A proposal to regulate these discharges including developing an estimate of the total cost of the proposed regulatory program and identify potential sources of financing.

### **ERA OF REGULATORY CONTROL**

The San Joaquin River Technical Committee report was accepted by the State Water Board in August 1987. The Technical Committee Report focused on selenium although recognizing that salt and salinity control on the San Joaquin River remained the longer-term issues. The Technical Committee's report formed the basis for the first of two Basin Plan Amendments related to regulation of agricultural drainage.

In 1988, the Central Valley Water Board adopted the first of two Basin Plan Amendments regulate agricultural subsurface drainage from the Grassland watershed. In addition to water quality objectives for selenium and boron, the amendment established several policy actions including:

- The control of selenium in the drainage water was set as the first priority rather than salinity;
- The San Joaquin River could continue to be used to remove salts from the basin provided water quality objectives for selenium were met;
- Any further increase in drainage water discharges to the San Joaquin River from the Grassland watershed were prohibited until load levels were shown to be within the water quality objectives;

- Regulation of discharges would be pursued on a regional basis rather than at individual farms;
- Reuse of drainage water would be encouraged; and
- A separate and isolated valley wide facility to take drainage water out of the basin would continue to be promoted as the best long-term alternative for salinity management.

This regulatory action in 1988 focused implementation on improved on-farm efficiency to reduce deep percolation thus reducing selenium and salt mobilization into the drainage water. This action was consistent with the recommendations of the San Joaquin River Technical Committee report. Immediately following the Basin Plan Amendment, extended drought conditions led to significant improvements in irrigation efficiencies within the Grassland watershed. The result was that discharges of selenium to the San Joaquin River were cut in half and the amount of selenium in the river water improved significantly (Karkoski, 1994; CVRWQCB, 1996). However, the selenium concentration in the internal channels in the Grassland watershed, that were dominated by these drainage flows, did not improve and in fact water quality in the channels deteriorated as a result of water conservation and improved irrigation efficiency. The end result was a significant reduction in drainage flows but concentrations of selenium in the drainage water increased although total load was reduced.

Recognizing how effective the program was toward reducing selenium, the State Water Board in adopting the 1991 Bay-Delta Water Quality Control Plan for Salinity (Report 91-15WR) by Resolution 91-34, directed the Regional Board to undertake a similar reduction for salt. Specifically the plan called for:

*“Upon Adoption of this Plan, the State Board will request the Central Valley Regional Board to develop and adopt a salt-load reduction program. The goal of this initial program will be to reduce annual salt-loads discharged to the San Joaquin River by at least 10 percent and to adjust the timing of salt discharges from low flow to high flow periods. During the Water Rights Phase of these*

*proceedings, the Regional Board should discuss how it intends to implement this program (for example, drainage operations plans and best management practices).*

*The goal of this program shall be to reduce the salt load discharged to the San Joaquin River by at least 10 percent. This amount should be achieved by increasing the irrigation efficiency on the west side of the San Joaquin River Basin to a target level of 73 percent with a five percent leaching fraction as recommended by the Agricultural Water Conservation Workgroup. This should reduce the annual subsurface drainage from tile drained portions of the west side by about 40 percent as envisioned by the State Board's Technical Committee and the San Joaquin Valley Drainage Program (see EDF, 11, V-13-20 and San Joaquin Valley Drainage Program, 1990). Since about 25 percent of the annual San Joaquin River salt load is from the west side subsurface drainage, this drainage reduction amounts to a 10 percent reduction in annual San Joaquin River salt load ( $0.40 \times 0.25 = 0.10$ ) based on State Board staff modeling results (see EDF, 11, Appendix C). Annual salt loads could be further decreased by reducing and recycling tailwater discharges to the San Joaquin River from the west side.*

*In addition to annual reduction in salt load, it would also be possible to adjust the timing of salt load discharge from the west side of the San Joaquin River Basin through storage of drainage flows (see Pickett and Kratzer, 1988). The need for dilution flows from the east side of the San Joaquin River Basin to meet seasonal water quality standards in the southern Delta would be reduced.*

*The salt load reduction policy, which would help to protect beneficial uses in the southern Delta, should be achieved through development of best management practices and waste discharge requirements for non-point source dischargers. The Central Valley Regional Board should present the policy to the State Board*

*no later than the Water Right Phase of the proceedings. If adequate progress is not being made, the State Board will proceed under its authorities.”*

It was thought that the drainage operations plan and best management practices that were being implemented in the Grassland watershed would accomplish both the selenium reduction envisioned by the Regional Board’s 1988 Basin Plan Amendment and the salt reduction envisioned by the State Board 1991 Bay-Delta Water Quality Control Plan (91-15WR). With the return of the wetter cycles after 1993 and a full water supply to each farm, the total load of selenium discharged returned to the 1988 levels, indicating that the irrigation efficiency improvements alone would not provide a long-term solution. Since the focus was on selenium, no one determined whether the salt load reductions accomplished during this period were continuing to be achieved after the full water supply returned. One of the major problems with the approach taken by the regulatory agencies was that the farmer had no control or knowledge over how their actions impacted water quality downstream of their individual farming operation.

It was found that, like the Imperial Valley, as irrigation efficiency improved, there was a significant reduction in the subsurface drainage flows, but also a significant reduction in the high quality surface runoff (irrigation tailwater) and operational spills from individual farms that previously diluted the agricultural subsurface drainage flows. The result was that the discharge from the individual farms was smaller, the total load of selenium and salt were reduced but the concentrations of salt and selenium in the return flows increased significantly as flow was now dominated by the poor quality subsurface drainage. At the district or larger level, improvements in how water is distributed and managed were also being made. However, the result of these actions was that operation spills and on-farm losses that previously had been available for dilution of the subsurface drainage water discharges were also no longer available. There did not appear to be any connection between the two operations, one at the farm level and one at the district level, nor was there any connection between these operations, flows in the collection channels, and River flows available for dilution. A more coordinated effort would be required.

The lack of compliance with selenium water quality objectives prompted the regulatory agencies to reconsider the direction established in 1988. To be consistent with the State Water Board direction in the 1985 WQ 85-1 Report on controlling agricultural drainage, the Central Valley Water Board focused on the three-step process to manage selenium as outlined in the 1990 San Joaquin Valley Drainage Program (SJVDP, 1990). The first step was to minimize selenium mobilization from the irrigated area, the second was to capture and reuse the selenium laden drainage water to the maximum extent possible and the final step was to isolate, treat and/or dispose of the remaining selenium-laden water. The latter was to be done under Waste Discharge Requirements.

The regulatory agencies established a new approach for these nonpoint source selenium discharges in 1996. The new focus continued source control efforts including improved distribution and delivery efficiency, improved on-farm efficiency and continued off-farm reuse of drainage water but expanded their efforts on controlling the final collected discharge runoff. The new focus would be done under a formal Waste Discharge Requirement (State equivalent of a federal NPDES permit for a surface water discharge) with monthly and annual load limits to specific water bodies. Because the mechanisms for controlling selenium were not well understood, the use of such a permit was not intended to be at each individual farm but rather at the final discharge point from the Grassland watershed. The permit would be issued to a responsible entity that would have the administrative power to implement the load limitations and control the discharge of the drainage water to the San Joaquin River.

The Central Valley Water Board in 1988 established that they would regulate selenium as a first priority. The 1996 program again focused on selenium reduction but recognized that salinity was the long-term issue on the San Joaquin River. The 1996 Basin Plan Amendment for selenium called for significant reduction in drainage water discharges through implementation of the Grassland Bypass Project (CVRWQCB, 1996). This Project was implemented in 1995 and continues today. It was also expected that the Grassland Bypass Project would also result in salt load reductions. Testimony to the State Water Board during the implementation phase of the 1995 Bay-Delta Plan showed

that between 1995 and 1997, the Grassland Bypass Project had decreased salt discharges by 100,000 tons per year. Recent information provided by the Central Valley Water Board has shown that the Grassland Bypass Project has reduced salt loads to the San Joaquin River by 182,000 tons per year since its implementation in 1995.

### **SHIFT OF FOCUS TO SALINITY CONTROL**

NEED A DISCUSSION ON THE LISTING OF THE LOWER SAN JOAQUIN RIVER FOR SALINITY AND BORON ON THE 303(d) LIST OF THE CWA FOR IMPAIRED WATER BODIES.

### **PROTECTION OF DOWNSTREAM WATER QUALITY**

California Water Code §12230-12232 recognize that salinity on the San Joaquin River also impacts beneficial uses in the South Delta. In February 1961, the State Water Rights Board (predecessor to the State Water Board) adopted Water Rights Decision 990 (D-990), which approved water rights for the federal CVP. This order did not have any water quality standards attached to it. The first South Delta salinity standards for protection of irrigated agriculture were adopted in 1967 under State Water Board Decision 1275 (D-1275), which approved the water rights for the State Water Project (SWRCB, 1967). In response to growing concerns for Delta water quality however, the State Water Board subsequently adopted Resolution 68-17 in 1968 which defined a water quality control policy for the Delta and supplemental salinity standards were adopted by D-1379 in 1971. State Water Board D-1379 required the Central Valley Project and SWP to meet water these quality objectives, although it was later stayed as a result of litigation.

The State Water Board eventually required the United States Bureau of Reclamation to meet a salinity objective of 500 parts per million (ppm or often referred to as milligrams per liter (mg/L)), at Vernalis when it adopted D-1422 and D-1616, the decisions issuing permits for New Melones Reservoir. The Bureau under its agreement with the Central Valley Water Board was to release up to 70,000 acre-feet of water in any one year as required to maintain a mean monthly TDS concentration in the San Joaquin River below

the mouth of the Stanislaus River at 500 ppm maximum, also to maintain at least five ppm of dissolved oxygen (DO) in the Stanislaus River.

The State Water Board reviewed and updated the South Delta salinity objective in 1978. During the 1978 review, the State Water Board focused on two salt-sensitive crops grown in the South Delta – beans for the irrigation season and alfalfa for the rest of the year. It was thought that if the salinity of the irrigation water was sufficient to protect these crops, then the salinity of the applied water would not be a limiting factor for other, less salt-sensitive crops grown in the south Delta. As such, the basis for any South Delta was to be the perceived maximum threshold salinity of irrigation water able to maintain 100% yield potential for beans, corn, and alfalfa. It was noted, however, that crop yields can vary by 10% due solely to variations in weather, seeds, field conditions, farming practices, and countless other variables.

When the State Water Board adopted Water Right Decision 1485 (D-1485) in August 1978, they continued the salinity objectives at Vernalis as established under D-1422. D-1485 also directed the USBR and the California Department of Water Resources (DWR) to meet these all in-Delta standards by either reducing pumping or releasing water stored in upstream reservoirs, or doing both. D-1485 was known as the Water Quality Control Plan for the Sacramento-San Joaquin Delta and Suisun Marsh (1978 Delta Plan). The State Water Board also committed to conducting a review of the 1978 Delta Plan within 10 years.

As discussed earlier, in February 1985, the State Water Board adopted Order WQ Order 85-1 to deal with the selenium problems in the San Joaquin River Basin. Pursuant to WQ Order 85-1, a technical committee prepared a report in 1987 on the San Joaquin River and Delta water quality and recommendations for the control of agricultural discharges, which was adopted pursuant to State Water Board Resolution 87-78. (State Water Board Order No. 85-1 Technical Report, “Regulation of Agricultural Drainage to the San Joaquin River” (“WQO 85-1 Technical Report”).) Increasing salinity caused by this subsurface agriculture drainage had long been a major concern in the LSJR Basin.

Furthermore, the 1975 Basin Plan had acknowledged water quality concerns caused by EC and classified the LSJR from Lander Avenue to below Vernalis a “water quality limited segment” due to excessive salinity. Therefore, the Technical Committee included salt among the “constituents of concern” in their review of the LSJR Basin. In developing water quality objectives, the Technical Committee requested the State Water Board’s Division of Water Quality to prepare water quality criteria which would prevent excessive selenium bioaccumulation and protect beneficial uses from direct toxicity caused by selenium, salt and other salinity constituents. For the agricultural beneficial use, the Technical Committee adopted recommendations previously developed by a University of California Committee of Consultants in 1974 for boron, molybdenum, selenium, and salinity. This Committee of Consultants was made up of specialists from the University of California with knowledge of salinity and salinity and toxicity impacts on irrigated agriculture.

The WQ 85-1 Technical Committee, based on the UC Committee of Consultants recommendations, used a criterion of 700  $\mu\text{mhos/cm}$  (equivalent to 0.7  $\text{mmhos/cm}$ ) as this would fully protect all crops in the LSJR Basin and in the South Delta. According to the Committee’s recommendations:

*“An EC of 0.7 mmhos/cm permits production of all crops on all soils with adequate drainage in the San Joaquin River Basin and downstream in the southern Delta. Salinity levels above this require special cropping or water management techniques. Above an EC of 3.0 mmhos/cm (about 2,000 mg/l TDS) water quality is generally too poor to support agriculture.”*

The WQ 85-1 Technical Committee also studied the soils and cropping patterns in other areas of the LSJR Basin and made more specific recommendations for such areas. For the segment from Lander Avenue on the LSJR down to Hills Ferry Road Bridge, just above the Merced River, the technical committee recommended an EC objective of 3,000  $\mu\text{mhos/cm}$ :

*“In Salt Slough and areas of the San Joaquin River downstream to Hills Ferry there are only a few agricultural diversions. These diversions are for the irrigation of pasture which is very salt tolerant. Historical maximum salinity concentrations in Salt Slough are typically as high as or higher than 3.0 mmhos/cm EC. An objective of 3.0 mmhos/cm EC supports the existing uses in Salt Slough and areas downstream to Hills Ferry consistent with the historic water quality and present agricultural practices. Therefore, an objective of 3.0 mmhos/cm EC is recommended as the water quality objective for this limited area.”*

For the San Joaquin River segment from Hills Ferry to Vernalis, the Technical Committee recommended an objective of 1,000  $\mu$ mhos/cm:

*“The Regional Board staff has evaluated the soil types and crops that are grown using diversions from the San Joaquin River in the areas immediately downstream of Hills Ferry. They have determined that a water quality objective of 1.0 mmhos/cm EC (about 620 mg/l TDS) would provide reasonable protection to these crops on the soils in this area.”*

In July 1987, the State Water Board began proceedings to reexamine the existing water quality objectives for the Bay-Delta Estuary. In May 1991, the State Water Board adopted the 1991 Bay-Delta Plan, pursuant to State Water Board Resolution No 91-34, with objectives for salinity, dissolved oxygen and temperature. The 1991 Bay-Delta Plan revised objectives for salinity in the San Joaquin River at Vernalis consistent with the WQ 85-1 Technical Committee recommendation. The objectives were set as an EC or salinity measurement of 700  $\mu$ mhos/cm as a 30-day running average for the irrigation season (April 1<sup>st</sup> – August 31<sup>st</sup>) and 1,000  $\mu$ mhos/cm as a 30-day running average for the non-irrigation season (September 1<sup>st</sup> – March 31<sup>st</sup>). No EC objectives for the LSJR upstream of Vernalis were adopted.

In 1995 the State Water Board reviewed the 1991 Water Quality Control Plan and the salinity objective at Vernalis and the interior South Delta channels and made only minor modifications. Water Right Decision 1641 was adopted in Dec 1999 and slightly revised in March 2000 to implement the 1995 WQCP. In D-1641, the State Water Board found that the USBR was solely responsible for the salinity problem at Vernalis. The basis of this decision was that 1) the USBR had cut off high quality flows at Friant Dam, 2) had provided higher salinity water to the Westside lands in lieu of the upstream higher quality flows and had not provided drainage water management for the subsurface drainage flows entering the San Joaquin River from the Grassland watershed. Based on the evidence presented at the hearing, the State Water Board found the salinity objective could not be met with releases solely from New Melones Reservoir. The SWRCB gave the USBR substantial latitude in choosing how it would meet the South Delta EC Objective, but nevertheless imposed the obligation for meeting it on the USBR.

The 1995 (Bay Delta Plan) and Decision 1641 directed the Central Valley Water Board to:

- 1) Continue its salt load reduction program, initiated in response to adoption of the 1995 Bay Delta Plan which asked for a reduction in annual salt loads to the San Joaquin River by at least 10 percent and to adjust the timing of discharges from low flow to high flow periods, and
- 2) Promptly develop and adopt salinity objectives and a program of implementation for the main stem of the San Joaquin River upstream of Vernalis.

Previously the LSJR had been placed on the CWA Section 303(d) list of impaired waters due to elevated concentrations of salt and boron. The CWA requires states to develop TMDLs for all impaired waters. The basis for the listing was that since the 1940s, mean annual salt concentrations in the LSJR at the Delta Boundary at Airport Way Bridge (Vernalis) had doubled and boron levels have increased significantly. Water quality monitoring data collected by the Central Valley Water Board and others indicates that water quality objectives for salinity and boron are frequently exceeded in the LSJR during certain times of the year and under certain flow regimes. The TMDL report,

which uses an updated unit of measurement for electrical conductivity (EC) of  $\mu\text{S}/\text{cm}$  (equivalent to the  $\mu\text{mhos}/\text{cm}$  ( $1,000 \mu\text{mhos}/\text{cm} = 1.0\text{mmhos}/\text{cm}$ ), states:

*“Water quality data collected during water years 1986 to 1998 indicates that the non-irrigation season salinity objective of  $1,000 \mu\text{S}/\text{cm}$  (Sept 1<sup>st</sup> – March 31<sup>st</sup>) was exceeded 11 percent of the time and the irrigation season salinity objective of  $700 \mu\text{S}/\text{cm}$  (April 1<sup>st</sup> – August 31<sup>st</sup>) was exceeded 49 percent of the time at the Airport Way Bridge near Vernalis. Consequently the river does not fully support all of its designated beneficial uses.”*

Development of a program of implementation to reduce salt loading and to achieve the Vernalis water quality objective required a revision to the Basin Plan. Federal law requires establishment of a TMDL for waters that are not attaining standards. Under the 303(d) listing for the lower San Joaquin River for salt and boron, a TMDL must be developed according to federal regulations. Though other methods may be available, a TMDL for both point and nonpoint sources may, in general, only be established by revising the Basin Plan.

A technical TMDL report for salt and boron in the LSJR was developed in January 2002 (CVRWQCB, 2004a; CVRWQCB, 2004b; CVRWQCB, 2004c; CVRWQCB, 2004d; CVRWQCB, 2004e; CVRWQCB, 2004f; CVRWQCB, 2004g; CVRWQCB, 2004h; CVRWQCB, 2004i; CVRWQCB, 2004j; CVRWQCB, 2004k; CVRWQCB, 2004l); it contains all the required elements of a TMDL, including; (1) a problem statement that describes the water body being addressed and reasons for the impairment; (2) numeric targets that set quantifiable end-points that the TMDL seeks to achieve; (3) a source analysis that identifies and describes the significant sources of pollutant loadings to the LSJR; (4) loading capacity of the water body; and (5) allocation of loads.

In 2004, the Central Valley Water Board adopted a Basin Plan Amendment for the Control of Salt and Boron Discharges into the Lower San Joaquin River. In November 2005, the State Water Board approved, by Resolution 2007-0087, the Basin Plan

Amendment establishing a TMDL, regulating the loading of salt and boron in the LSJR for the purposes of attaining the South Delta salinity objective at Vernalis that was adopted by State Water Board Resolution 91-34 for the Bay-Delta Plan.

## REFERENCES

McBain and Trush, 2002. San Joaquin Background Report. Prepared for the Bay-Delta Authority as Part of the San Joaquin Basin Ecological Flow Analysis Prepared by the Natural Heritage Institute, August 2003.

California Department of Water Resources (DWR). 1965. San Joaquin Valley Drainage Investigation – San Joaquin Master Drain. Department of Water Resources Bulletin No.127.

California Department of Water Resources (DWR). 1931. San Joaquin River Basin. Division of Water Resources Bulletin No.29 prepared as part of the Reports on the State Water Plan.

California State Water Resources Control Board (SWRCB). 1977. San Joaquin Valley Interagency Drainage Program Environmental Assessment – Phase I. Prepared for the California State Water Resources Control Board by Environmental Impact Planning Corporation.

Ogden, G. R. 1988. Agricultural Land Use and Wildlife in the San Joaquin Valley, 1769-1930: An Overview. SOLO Heritage Research. San Joaquin Valley Drainage Program, U.S. Department of Interior. Sacramento, California.

Cain, J.R., Walkling, R.P., Beamish, S., Cheng, E., Cutter, E., and M Wickland. 2003. San Joaquin Basin Ecological Flow Analysis. Prepared for the Bay-Delta Authority by the Natural Heritage Institute, Berkeley, California.

Belitz, K. and F.J. Heimes. 1990. Character and Evolution of Ground-Water flow System in the Central Part of the Western San Joaquin Valley, California. USGS Water-Supply Paper 2348.

United States Department of Interior (USBR). 1949. Central Valley Basin: Comprehensive Report on Planned Water Resources Development in the Central Valley. United States Bureau of Reclamation. Sacramento, CA.

United States Department of Interior (USBR). 1955. Feasibility Report for the San Luis Unit, Central Valley Project. United States Bureau of Reclamation. Sacramento, CA.

California Department of Water Resources (DWR). 1957. California Water Plan. Department of Water Resources Bulletin No. 3-35.

Johnston, W. R., Westcot, D.W. and M. Delamore. 2011. San Joaquin Valley: A Case Study. In Agricultural Salinity Assessment and Management (2<sup>nd</sup> Edition). ASCE Manual and Report on Engineering Practice No 71 (W.W. Wallender and K. Tanji, editors) (in press).

California State Water Resources Control Board (SWRCB). 1986. Regulation of Agricultural Drainage to the San Joaquin River; final Report by the SWRCB Order 85-1 Technical Committee.

Karkoski, J. 1994. A Total Monthly Load Model for the San Joaquin River. California Regional Water Quality Control Board, Central Valley Region.

Central Valley Regional Water Quality Control Board (CVRWQCB). 1996. Amendment to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for the Control of Agricultural Subsurface Drainage Discharges: Staff Report. California Regional Water Quality Control Board, Central Valley Region.

San Joaquin Valley Drainage Program (SJVDP). 1990. A Management Plan for Agricultural Subsurface Drainage and Related Problems on the Westside San Joaquin Valley, California: Final Report of the San Joaquin Valley Drainage Program. U. S. Department of Interior and California Resources Agency. Sacramento, CA.

Central Valley Regional Water Quality Control Board (CVRWQCB). 1967. Tentative Policy for Lower San Joaquin River Water Quality Objectives Below Friant Dam to Vernalis. November 1967 Staff Report. California Regional Water Quality Control Board, Central Valley Region.

Central Valley Regional Water Quality Control Board (CVRWQCB). 1968. Tentative Water Quality Control Policy for the Stanislaus River From Tulloch Dam to the Mouth and for the San Joaquin River From Maze Road Bridge to Durham Ferry Road Bridge. October 1968 Staff Report. California Regional Water Quality Control Board, Central Valley Region.

Central Valley Regional Water Quality Control Board (CVRWQCB). 1969a. Provisional Water Quality Control Policy for the San Joaquin River From Friant Dam to Fremont Ford. October 1969 Staff Report. California Regional Water Quality Control Board, Central Valley Region.

Central Valley Regional Water Quality Control Board (CVRWQCB). 1969b. Tentative Water Quality Control Policy for the Tuolumne River From New Don Pedro Dam to the Mouth and for the San Joaquin River From Grayson Road Bridge to Maze Road Bridge. February 1969 Staff Report. California Regional Water Quality Control Board, Central Valley Region.

Chilcott, J.E., Westcot, D.W., Werner, K., and Belden, K.K. 1988. Water Quality Survey of Tile Drainage Discharges in the San Joaquin River Basin, California. California Regional Water Quality Control Board, Central Valley Region. Sacramento, California.

Central Valley Regional Water Quality Control Board (CVRWQCB). 2004a. Amendments to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for the Control of Salt and Boron Discharges into the Lower San Joaquin River; Final Staff Report. 112 pp. California Regional Water Quality Control Board, Central Valley Region. September 2004.

Central Valley Regional Water Quality Control Board (CVRWQCB). 2004b. Amendments to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for the Control of Salt and Boron Discharges into the Lower San Joaquin River; Draft Final Staff Report, Appendix 1: Technical TMDL Report. 98 pp. California Regional Water Quality Control Board, Central Valley Region. July 2004.

Central Valley Regional Water Quality Control Board (CVRWQCB). 2004c. Amendments to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for the Control of Salt and Boron Discharges into the Lower San Joaquin River; Draft Final Staff Report, Appendix 2: Methods for Reducing Salt and Boron Concentrations in the Lower San Joaquin River. 6 pp. California Regional Water Quality Control Board, Central Valley Region. July 2004.

Central Valley Regional Water Quality Control Board (CVRWQCB). 2004d. Amendments to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for the Control of Salt and Boron Discharges into the Lower San Joaquin River; Draft Final Staff Report, Appendix 3: Evaluation of Control Option Consistency with Applicable Laws and Policies. 15 pp. California Regional Water Quality Control Board, Central Valley Region. July 2004.

Central Valley Regional Water Quality Control Board (CVRWQCB). 2004e. Amendments to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for the Control of Salt and Boron Discharges into the Lower San Joaquin River; Draft Final Staff Report, Appendix 4: Economic Analysis for the Implementation of a Control Program for Salt and Boron Discharges to the Lower San Joaquin River. 52 pp. California Regional Water Quality Control Board, Central Valley Region. July 2004.

Central Valley Regional Water Quality Control Board (CVRWQCB). 2004f. Amendments to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for the Control of Salt and Boron Discharges into the Lower San Joaquin River; Draft Final Staff Report, Appendix A: TMDL Methods and Data Sources. 61 pp. California Regional Water Quality Control Board, Central Valley Region. July 2004.

Central Valley Regional Water Quality Control Board (CVRWQCB). 2004g. Amendments to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for the Control of Salt and Boron Discharges into the Lower San Joaquin River; Draft Final Staff Report, Appendix B: Geographic Information System

Processing Information and Metadata Summary. 143 pp. California Regional Water Quality Control Board, Central Valley Region. July 2004.

Central Valley Regional Water Quality Control Board (CVRWQCB). 2004h. Amendments to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for the Control of Salt and Boron Discharges into the Lower San Joaquin River; Draft Final Staff Report, Appendix C: Municipal and Industrial Salt Loads. 160 pp. California Regional Water Quality Control Board, Central Valley Region. July 2004.

Central Valley Regional Water Quality Control Board (CVRWQCB). 2004i. Amendments to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for the Control of Salt and Boron Discharges into the Lower San Joaquin River; Draft Final Staff Report, Appendix D: Background Salt and Boron Loading. 53 pp. California Regional Water Quality Control Board, Central Valley Region. July 2004.

Central Valley Regional Water Quality Control Board (CVRWQCB). 2004j. Amendments to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for the Control of Salt and Boron Discharges into the Lower San Joaquin River; Draft Final Staff Report, Appendix E: Alternative Methods for Calculating Salt Loading from the Northwest Side of the Lower San Joaquin River Sub-Area. 15 pp. California Regional Water Quality Control Board, Central Valley Region. July 2004.

Central Valley Regional Water Quality Control Board (CVRWQCB). 2004k. Amendments to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for the Control of Salt and Boron Discharges into the Lower San Joaquin River; Draft Final Staff Report, Appendix F: DWRSIM Flow Data from CALFED Study 771 Used to Develop Load Allocations, Delta Mendota Canal Delivery Allocations, and Lower San Joaquin River Diversion Allocations. 158 pp. California Regional Water Quality Control Board, Central Valley Region. July 2004.

Central Valley Regional Water Quality Control Board (CVRWQCB). 2004l. Amendments to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for the Control of Salt and Boron Discharges into the Lower San Joaquin River; Draft Final Staff Report, Appendix G: Linkage Analysis Flows, Salt Loads, Electrical Conductivity, and Boron Concentrations. 22 pp. California Regional Water Quality Control Board, Central Valley Region. July 2004.