Public Workshop (9/5-6/12)
Bay-Delta Workshop 1
Deadline: 8/17/12 by 12 noon

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# Testimony on Recent Salinity and Selenium Science and Modeling for the Bay-Delta Estuary

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**for**

**Workshop #1**
**Ecosystem Changes and the Low Salinity Zone**
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The State Water Resources Control Board called for workshops to receive information from and discuss with participating parties the scientific and technical bases for considering potential changes to the 2006 Water Quality Control Plan for the San Francisco/Sacramento-San Joaquin Delta Estuary for Phase II of the Board's comprehensive review of this plan.

According to the State Board's public notice for these workshops, the prompts for Workshop 1 testimony are:

1. What additional scientific and technical information should the State Water Board consider to inform potential changes to the Bay-Delta Plan relating to ecosystem changes and the low salinity zone that was not addressed in the 2009 Staff Report and the 2010 Delta Flow Criteria Report? For large reports or documents, what pages or chapters should be considered? What is the level of scientific certainty or uncertainty regarding the foregoing information? What changes to the Bay-Delta Plan should the State Water Board consider based on the above information to address existing circumstances and changing circumstances such as climate change and BDCP?

2. How should the State Water Board address scientific uncertainty and changing circumstances, including climate change, invasive species and other issues? Specifically, what kind of adaptive management and collaboration (short, medium, and long-term), monitoring, and special studies programs should the State Water Board consider related to ecosystem changes and the low salinity zone as part of this update to the Bay-Delta Plan?

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First I examine persistent salinity violations by the California Department of Water Resources and the US Bureau of Reclamation in the South Delta and describe studies they performed and submitted to comply with the State Water Resources Control Board's 2010 modified Cease and Desist Order (State Water Resources Control Board 2010: Condition 7, 24). Their results point to the need for dramatic changes in how Bay-Delta and San Joaquin River water diversions occur. Background information provides context for the studies performed by the Bureau and the Department. Supporting evaluation of Board inaction on salinity issues relating to the South Delta is presented in Appendix A to this testimony.

Next, I describe recent studies by US Geological Survey researchers of selenium behavior under a variety of flow regimes and hydrologic environments, and applies these various regimes to how selenium fate manifests over time in specimens of *Corbula* clams near Chipps Island in eastern Suisun Bay. Our findings strongly suggest that the Board consider its proposed new inflow objectives for tributaries from a water quality and anti-toxics contamination perspective, as well as integrating selenium-focused water quality regulation into the next Bay-Delta Plan. Supporting selenium uptake, hydrologic flow, and X2 (isohaline) data are presented in Appendix B of this testimony. There is not only a reasonable scientific basis for increased San Joaquin and Sacramento River flows to the Bay-Delta Estuary to benefit fish, there is reasonable basis as well for prevention of selenium contamination associated with local and region-scale slow or slack water environments in the Estuary.

Past Bay-Delta Estuary Water Quality Control Plans have failed to incorporate and evaluate the Board's efforts to study and acknowledge salinity and selenium problems that affect the Bay-Delta Estuary. In our scoping comments from April 25, 2012, C-WIN urges the State Board to carefully and thoroughly evaluate each of its salinity and selenium control programs as well as those of the Central Valley Regional Water Quality Control Board. (California Water Impact Network 2012: "Program of Implementation," pp. 10-14) Appendices C and D provide chronologies of salinity and selenium regulation in the watershed of the Bay-Delta Estuary and its Central Valley watershed.

Increased Delta inflow regimes from both the Sacramento and San Joaquin Rivers will do much to combat salinity problems and prevent uptake of toxic selenium by invasive species such as *Corbula*, and in aquatic food webs of the lower San Joaquin River and the Bay-Delta Estuary generally. Other actions on salinity and selenium will be needed to complement increased flow regimes. By using inflow increases to complement other strengthened regulatory and implementation actions the Board will find it possible to solve salinity and selenium problems in the Bay-Delta Estuary watershed.

# I. South Delta Salinity and the Central Valley Project

In 1960, California voters approved State Water Project which included funds for San Joaquin Valley drainage service, although specific facilities were not identified for the voters. Congress required of the Bureau of Reclamation that construction of the San Luis Unit would hinge on the provision of drainage services to the San Luis Unit service area.[1] The State backed out of the San Joaquin Valley Master Drain in 1967 when irrigators balked at its cost. The US Bureau of Reclamation stopped further construction of the San Luis Drain at Kesterson Reservoir when it could not complete the Drain to the Delta.

No one—particularly federal and state agencies—with the power to decide made the hard choice to stop water deliveries to the San Luis Unit as Congress originally intended in 1960, since construction was well under way by 1967. Instead, the drainage problems of the San Luis Unit service area have been allowed to fester to the point that the State Water Resources Control Board itself found that:

> ...the actions of the [Central Valley Project, CVP] are the principal cause of the salinity concentrations exceeding the objectives at Vernalis. The salinity problem at Vernalis is the result of saline discharges to the [San Joaquin] river, principally from irrigated agriculture, combined with low flows in the river due to upstream water development. The source of much of the saline discharge to the San Joaquin River is from lands on the west side of the San Joaquin Valley which are irrigated with water provided from the Delta by the CVP, primarily through the Delta-Mendota Canal and the San Luis Unit. The capacity of the lower San Joaquin River to assimilate the agricultural drainage has been significantly reduced through the diversion of high quality flows from the upper San Joaquin River by the CVP at Friant. (State Water Resources Control Board 2000: 83)

The State Water Resources Control Board then designated the US Bureau of Reclamation as "responsible for significant deterioration of water quality in the southern Delta," adding that the Bureau's actions "have caused reduced water quality of the San Joaquin River at Vernalis." (State Water Resources Control Board 2000: 86) This chapter describes how the activity of the Central Valley Project causes water quality to deteriorate in the San Joaquin River Basin and the South Delta, and the continuing record

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[1] See Appendix A and Appendix C to this testimony for additional information about the background of drainage services and salinity problems in the watershed of the Bay-Delta Estuary. Public Law 86-488 states in pertinent part that:

> "...Construction of the San Luis unit shall not be commenced until the Secretary has (1) secured, or has satisfactory assurance of his ability to secure, all rights to the use of water which are necessary to carry out the purposes of the unit and the terms and conditions of this Act, and (2) received satisfactory assurance from the State of California that it will make provision for a master drainage outlet and disposal channel for the San Joaquin Valley, as generally outlined in the California water plan, Bulletin Numbered 3...which will adequately serve, by connection therewith, the drainage system for the San Luis unit or has made provision for constructing the San Luis interceptor drain to the delta designed to meet the drainage requirements of the San Luis unit as generally outline in the report of the Department of the Interior, entitled "San Luis Unit, Central Valley Project," dated December 17, 1956."

of inaction by the State Water Resources Control Board to reduce salt drainage problems along the lower San Joaquin River and in the South Delta.

## Importing and Recirculating Salts

In the San Joaquin River Basin, the salinity (the salt concentration in water) of its water bodies was historically very low, and in some of its water bodies continues to be of high quality. This is because the Basin's river flows were dominated by higher quality runoff from the snowpack of the Sierra Nevada, while natural flows on the west side were low as a result of the Coast Range rain shadow. Prior to 1951, according to the California Department of Water Resources, salt concentrations in the upper San Joaquin River near Mendota were typically less than 50 parts per million (sea water salt concentrations are generally about 3.5 percent salt or about 35,000 parts per million). (California Department of Water Resources 1965: 8) On the Stanislaus River, a 1953 pollution study found chloride concentrations ranging between 1 to 10 parts per million of chloride in that river. (Central Valley Regional Water Pollution Control Board 1953: Table ST-1) However, additional salts are imported to the San Joaquin River Basin as a result of mixing with salty tidal flows with water in the western Delta before being exported by large pumps located near Tracy. These saltier supplies arrive in the western San Joaquin Valley via the Delta Mendota Canal.

The conveyance of water through the Delta Mendota Canal is made possible legally by State Water Board-issued water rights permits to the US Bureau of Reclamation to operate the Central Valley Project and by the Exchange Contract by which senior San Joaquin River water rights holders "exchange" their upper San Joaquin River water rights for imported Sacramento River water delivered to them via the Delta Mendota Canal. The "Exchange Contract" for this imported water recognized from the outset that salinity in the imported water would be greater than salts naturally occurring in San Joaquin River water. The original Exchange Contract stated that it should not exceed a five-year mean salt concentration of 400 parts per million (see Table A-1 in Appendix 1). Thus, planned importation of water into the San Joaquin River Basin would allow as much as a *nine-fold increase in salt concentration* in water applied to western San Joaquin Valley lands. This is the direct water quality impact of the exchange arrangement at the heart of the creation of the Central Valley Project's Friant Division, the Delta Mendota Canal, and the Jones Pumping Plant. Large amounts of imported water brought large loads of salt to the Basin as well.

Central Valley water regulators acknowledge that "salinity impairments" of the state's water bodies "are occurring with greater frequency and magnitude. Such impairments in the past have led to the fall of civilizations." (Central Valley Regional Water Quality Control Board 2006: 5) The Central Valley Regional Water Quality Control Board estimates that the Delta Mendota Canal imports about 900,000 to 1 million tons of salt each year into the San Joaquin River Basin while the San Joaquin River returns about 922,000 tons of salt to the Delta annually. (California Regional Water Quality Control Board 2006: Tables 2 through 5) The Central Valley Regional Board is clearly concerned about salts building up in western San Joaquin Valley soils, but it has estimated no timetable by which the productivity of these soils would be exhausted from salinization. See Appendix C for a chronology of State Water Resources Control Board inaction on salinity problems.

However, in 1981 the White House Council on Environmental Quality offered an estimate. The Council found at that time that some 400,000 acres of land in the San Joaquin Valley were poorly drained, and that crop yields had declined 10 percent since 1970. The Council stated that with no action the amount of poorly drained land would increase to about 700,000 acres by 2000. The Council reported too that "over the next 100 years" (or by about 2080) "about 1 million acres of agricultural land in the San Joaquin will undergo desertification" if groundwater salinization is not addressed. (Sheridan, 1981: 42-43)

The salinization of the western San Joaquin Valley keeps pace with the Council on Environmental Quality's projection: From sworn testimony it received in preparing its Water Rights Decision 1641 (D-1641) in 2000, the State Water Resources Control Board found that "the total acreage of lands impacted by rising water tables and increasing salinity is approximately 1 million acres. (State Water Resources Control Board 2000: 82) The San Joaquin Valley Drainage Monitoring Program reported to the Department of Water Resources for 2005 that there are about 1.324 million acres of land with present and potential drainage problems. About three-tenths (30.4 percent) of these lands (about 403,000 acres similar to findings of the Council on Environmental Quality in 1981) has very shallow groundwater levels of between 0 to 5 feet. These lands can be considered to have current drainage problems, while another 857,000 acres have water tables between 5 and 15 feet below the surface, or about 65 percent of lands. These lands can be considered to have present and potential drainage problems. (California Department of Water Resources, 2010: Table 1)

The Central Valley Project's importation of Delta water establishes a vicious cycle of cropland salinization. The lands of the western San Joaquin Valley (on which Delta Mendota Canal water is applied largely for irrigation) seldom experience a net leaching of salts out to the ocean through the Delta because the imported water applied to it always has a relatively high salt content. And irrigating with that water serves to further concentrate salts in the soils and return flows. The Central Valley Regional Water Quality Control Board describes this as "recirculation":

> Such recirculation can have a large effect on salt fluxes [i.e., movement] because rather than completely leaving the system, such recirculated salts continued to contribute to any impairments and costs associated with elevated salinity in supply water. (California Regional Water Quality Control Board 2006: 36)

Echoing the State Water Resources Control Board's finding in 2000, salts in the Delta Mendota Canal are found by the Central Valley Regional Board to be the primary source of salt circulating in the San Joaquin River Basin. While the Canal supplies most of the surface irrigation water to this part of the Basin, the Board states that "the quality of this supply may be impaired by the recirculation of salts from the San Joaquin River to the [Canal's] Delta pumping plant." (California Regional Regional Water Quality Board 2006: 41) In addition to 1 million tons per year of salt recirculating through the San Joaquin River and the Delta Mendota Canal, the Board estimates that application of salts from soil amendments and groundwater pumping for irrigation in the River Basin adds an *additional 500,000 tons of salt per year* to the River.

Table 1 summarizes how the degree to which the San Joaquin River Basin's hydrology has been dramatically altered by water development over the period 1984-2009. It does this in two key ways.

**Table 1**
**Changes in Flows of San Joaquin River Basin Tributaries, Unimpaired and Observed Conditions, 1984 to 2009**

| Statistics for 1984-2009 | Stanislaus River | Tuolumne River | Merced River | San Joaquin River | Chowchilla, Fresno, Valley Floor, Tulare Combined | San Joaquin River at Vernalis (Sum of flows) |
|---|---|---|---|---|---|---|
| Median Unimpaired Flows | 922 | 1,514 | 721 | 1,311 | 231 | 4,699 |
| Percent of Flow at Vernalis | 20% | 32% | 15% | 28% | 5% | |
| Median Observed flows | 429 | 398 | 271 | 137 | 416 | 1,651 |
| Percent of Flow at Vernalis | 26% | 24% | 16% | 8% | 25% | |
| **Percent Flow Change from Unimpaired Conditions** | **-53%** | **-74%** | **-62%** | **-90%** | **80%** | **-65%** |

Source: State Water Resources Control Board 2011: Tables 2.9 through 2.14); California Water Impact Network.

*First*, when comparing unimpaired with observed (that is, actually measured) flow conditions for the Basin's rivers, it is apparent that the unimpaired flow conditions have been greatly reduced on the major tributaries by water project operations. For the Stanislaus, actual median flow has fallen relative to unimpaired flows by about 53 percent; on the Tuolumne, by 74 percent; on the Merced by 62 percent; and on the Upper San Joaquin River (above the Merced River confluence) by 90 percent. (Median flows are employed for this analysis to avoid the skewing effects of the statistical averages.)

For the Chowchilla, Fresno, Valley floor, and Tulare (e.g., Fresno Slough and Kings River) streams combined, observed flow conditions *dramatically increased* over their unimpaired conditions—*by 80 percent* during this 25-year period. Table 1 includes median unimpaired and observed flow conditions for an aggregation of the flows of the much smaller Chowchilla, Fresno, Valley floor, and Tulare (Fresno Slough) streams in the San Joaquin River Basin. According to US Geological Survey data available online, the largest Valley floor sources of median observed annual flows were from Salt Slough, Mud Slough, the Fresno River, and Chowchilla River, from largest to smallest. Median annual flows for other west side creeks (Pacheco, Orestimba, and Del Puerto) are only about about one-eighth of Mud and Salt Slough observed flows. Median observed flows along the James Bypass to Fresno Slough are likewise small.

The median observed annual flow of the San Joaquin River at Vernalis during 1984 to 2009 is just 1.65 million acre-feet, just 35 percent of median unimpaired annual flow of

4.7 million acre-feet at Vernalis. (Table 1 sums the flows from only the major tributaries in the table as an approximation of unimpaired and observed flow conditions at Vernalis.)

*Second*, Table 1 shows that the composition (or stream source) of flows reaching Vernalis, (unimpaired compared with actual observed flows) also changed dramatically. (Keep in mind that observed flows are actually *decreasing* from unimpaired conditions.) The Stanislaus River's *share of flow* at Vernalis increases under water development from 20 percent of unimpaired flow to 26 percent of observed flow. The Tuolumne decreases from 32 percent of unimpaired flow to 24 percent of observed flow conditions under water development. The Merced River's *share of flow* at Vernalis barely changes (15 percent of unimpaired; 16 percent of observed), while the Upper San Joaquin River's share of Vernalis flow decreases dramatically from 28 percent under unimpaired conditions, to just 8 percent under developed flow conditions. The Valley floor sources, however, represent a sharply increased share of flow at Vernalis, rising from just 5 percent of unimpaired flow conditions to 25 percent of actual observed flows under developed conditions.

This radically changed flow pattern from unimpaired to observed flow in the San Joaquin River Basin change the Basin's handling of salt circulation as well. According to the California Department of Water Resources, the sources of salt loads recirculating through the San Joaquin River measured at Vernalis as shown in Table 2. Agriculture's use of both surface and groundwater sources is the largest source by which salt is mobilized. Adding together groundwater, and surface and subsurface return flows, these sources account for 71 percent of the salt load in the San Joaquin River as measured at Vernalis.

**Table 2**
**Sources of Salt in the San Joaquin River as Measured at Vernalis**

| Approximate Sources of Salt | Share of Load |
|---|---|
| Sierra Nevada Tributaries | 18% |
| Groundwater | 28% |
| Agricultural Surface Return Flow | 26% |
| Agricultural Subsurface Return Flow | 17% |
| Managed Wetlands | 9% |
| Municipal and Industrial Discharges | 2% |

Source: California Department of Water Resources, 2006: Table C-3; California Water Impact Network.

The geographic origins of the river basin's salt loads are illustrated in Figure 1 and summarized in Table 3. This figure shows the "effective" drainage area of the San Joaquin River Basin and its subbasins while tacitly acknowledging the export of upper San Joaquin River flows from the Basin via the Friant-Kern Canal. For the "San Joaquin River upstream of Salt Slough" subregion in Table 3, Figure 1 indicates that the "effective drainage area" for this watershed is a handful of creeks together with the Chowchilla River area. Flows in this area amount to just 9 percent of all salt contributions to total flows at Vernalis. In dark blue-green are "East Valley Floor" creeks that drain the plains between the Merced, Tuolumne, and Stanislaus rivers, which in turn drain the Sierra Nevada. The East Valley Floor creeks contribute just 5 percent of the salt detected at Vernalis on an annual basis. The combined salt loads of the Merced, Tuolumne, and Stanislaus rivers are also just 19

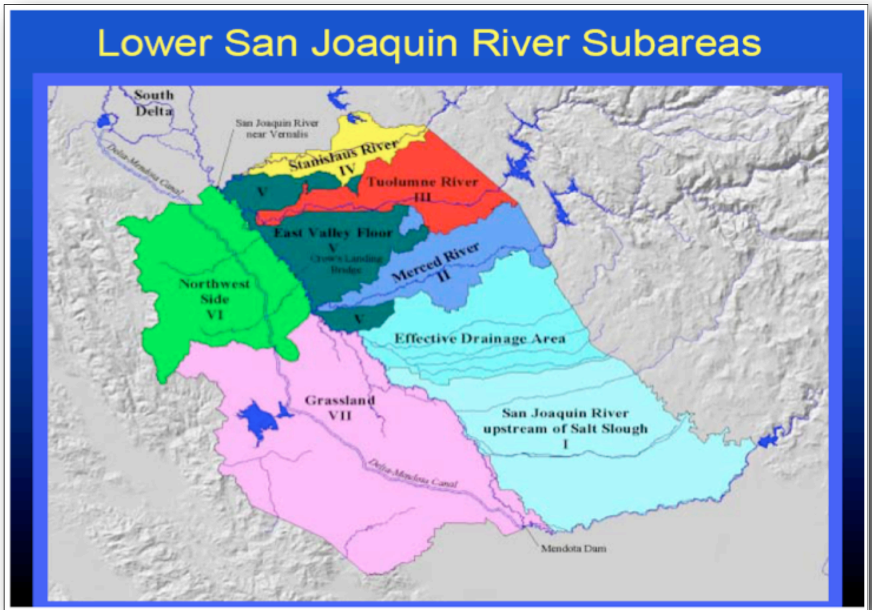


*Figure 1: Geographical sources of salt in the San Joaquin River Basin. Source: California Department of Water Resources, 2006.*

percent of the total salt load measured at Vernalis. Combined, the streams that "effectively" drain the east side of the San Joaquin River Basin contribute just 33 percent of the total salt load at Vernalis.

Meanwhile, the two west side subareas (the Northwest Side and Grasslands) contribute 67 percent—*two-thirds*—of the salt load measured at Vernalis on an annual basis. Recall from Table 1 above that the Valley floor streams entering the San Joaquin River above the Merced River confluence contribute just 25 percent of observed flow at Vernalis (essentially accounting for much of "Grasslands" flows in Table 2). ***This means that just one-quarter of flows reaching Vernalis carries about two-thirds of the salt load of the San Joaquin River as measured at Vernalis***.

**Table 3**
**Sources of Salt in the San Joaquin River Basin as Measured at Vernalis by Contributing Geographic Area of the Basin**

| Approximate Source of Salt | Share of Load by Contributing Area |
|---|---|
| I. San Joaquin River upstream of Salt Slough | 9% |
| II. Merced River<br>III. Tuolumne River<br>IV. Stanislaus River | 19% |
| V. East Valley Floor Streams | 5% |
| VI. Northwest Side | 30% |
| VII. Grasslands | 37% |
| Source: California Department of Water Resources, 2006: Table C-4; California Water Impact Network. | |

Historical data, illustrated in Figure 2, strongly suggest that higher proportions of unimpaired fresh water flows in the San Joaquin River earlier in the 20th century maintained lower salinity conditions before completion and operation of the Central Valley Project in the 1950s and 1960s. The 1930s and 1940s had lower average annual and monthly salinities than the 1950s

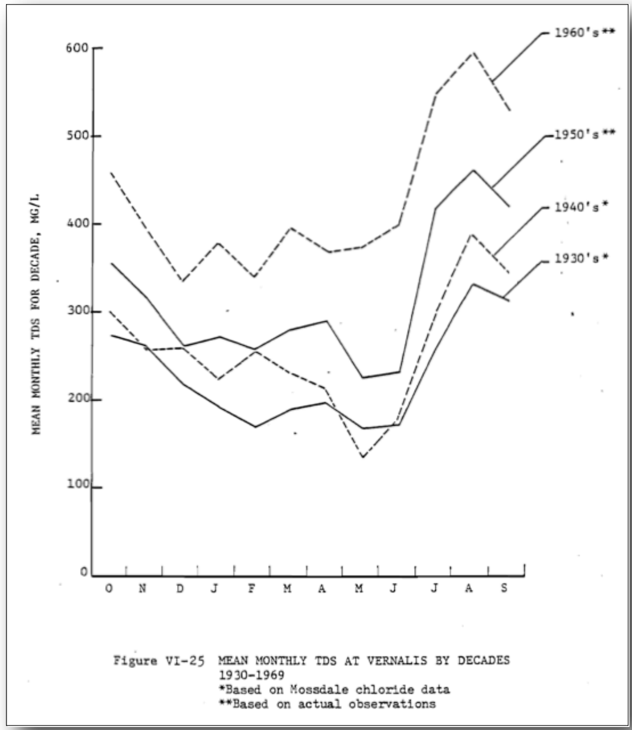


*Figure 2: Decadal changes in salinity conditions for the San Joaquin River as measured at Vernalis, 1930s through 1960s. Source: US Water and Power Resources Service and South Delta Water Agency, 1980.*

and 1960s when the Central Valley Project facilities of the San Joaquin Valley were completed and began operating. Figure 2 shows that while total dissolved solids (or TDS, a measure of salinity in units of milligrams per liter [mg/L]) generally declined in high flow spring months when snowmelt runoff is peaking, there occurred across-the-board increases in average salinity conditions on the timescale of decades as Central Valley Project development reached full operation. The average salinity for the 1930s was 228 mg/L; for the 1940s it increased about 13 percent to 257 mg/L. But with the advent of Friant Dam and Friant-Kern Canal exports of low salinity San Joaquin River water to Kern and Tulare counties, and the arrival of saltier Delta imported water to the west side of the San Joaquin Valley in the 1950s, average salinity of the River in the 1950s jumped 23 percent over the 1940s to 315 mg/L (38 percent higher than the 1930s salinity levels). By the end of the 1960s, the average salinity level for that decade was 427 mg/L, an 87 percent increase in salinity levels over the 1930s (and the 1930s had five drought years in it, 1930-1934; US Water and Power Resources Service and South Delta Water Agency 1980: Table VI-17, 107). ***In other words, salinity conditions in the San Joaquin River at Vernalis nearly doubled in 30 years, a period in which export of high quality and low salinity San Joaquin River water coincided with import of similar quantities of saltier Delta Mendota Canal imports from the Delta, which were, in turn, applied to lands heavily burdened with salts.***

The burdens of salt loads increased over time. Salinity is a function of both available salt load and the river flows available to carry it. The share of salinity effects attributable to reduced flows declined relative to the growth of salt loads in return flows in the San Joaquin River:

> Comparing the average monthly TDS (over the entire year), load-flow regressions show a 1950-1969 increase of 43 percent—from 259 mg/L to 371 mg/L. For the 1950s alone the percentage increase is about 22 percent and for the 1960s, 65 percent....Thus, according to this analysis, in this first decade after the CVP went into operation, about 56 percent of the increase in average TDS was caused simply by a reduction in flow from upstream sources; the remaining 44 percent was a result of increased salt burden, perhaps associated with an expansion of irrigated lands in the basin. Similarly in the 1960s (compared to thee 1930s and

> 1940s) about 27 percent of the average increase in TDS...can be accounted for by a reduction in flow and 73 percent attributed to increased salt burden. It is of interest to note here that the absolute change apparently caused by reduction in flow changed relatively little from the 1950s to the 1960s...while that charged to an increase in salt burden increased about four times [...]. This is consistent with other analyses that indicate a progressive buildup in salt load in the San Joaquin system. (US Water and Power Resources Service and South Delta Water Agency 1980: 126)

Salt concentrations in the San Joaquin River reaching the Delta are greatly increased by the loss of San Joaquin River Basin fresh water flows to exports. The major exports of water from the San Joaquin River basin are from the Upper San Joaquin River via the Friant-Kern Canal to Tulare and Kern counties, and via San Francisco's Hetch Hetchy Aqueduct to the San Francisco Bay Area. (By far, the larger of the two exports is that of the Friant-Kern Canal.)

What if water now exported from the San Joaquin River Basin was brought back to flow into the Delta? The Central Valley Regional Water Quality Control Board explored this question briefly in 2006. If the City and County of San Francisco's exports of 250,000 acre-feet of Tuolumne River flows and 17,000 tons of salt were hypothetically reintroduced to the San Joaquin River, it would "have a large cumulative effect," according to the Central Valley Regional Board:

> Removal of this high quality, low salinity, water has a relatively large impact on water quality in the San Joaquin River. If this 250,000 acre-feet of water per year were added to the mean annual discharge for the San Joaquin River from 1985-to 1994, mean annual [electrical conductivity, a direct measure of the presence of salts in water] would have been reduced from 570 to 506 [microSiemens, the unit of electrical conductivity]. Similar results could be expected with flow augmentation from other high quality sources or reduced consumptive use of water in the Basin. (California Regional Water Quality Control Board 2006: 44-45)[2]

The reduction in salinity concentration is significant: the Central Valley Regional Board finds it would result in an 11 percent average decrease in salinity from the addition of 250,000 acre-feet annually of high quality water during a hydrologic period in which 7 of 10 years were dry or critically dry (1985, 1986 and 1993 were the exceptions).

What if Upper San Joaquin River flows could be returned to the San Joaquin River Basin, the Bay-Delta Estuary, and San Francisco Bay? Returning an average of over 800,000 acre-feet of Upper San Joaquin River flows that are exported under the Bureau's Friant Dam water rights via the Friant-Kern Canal would also reduce salinity concentrations from imports substantially. Assuming a linear extrapolation of the electrical conductivity relationship the Regional Board identifies above (that is, for every 250,000 acre-feet of fresh water returned to the river, an 11 percent decrease in salinity would result), a cumulative 46 percent reduction in average annual salinity concentration would result

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[2] C-WIN presents this example to illustrate the effect of returning a large bloc of dilution flows on San Joaquin River salinity conditions; we do not advocate this specific action for the City and County of San Francisco's Tuolumne River supplies at this time.

from returning about 800,000 acre-feet of Upper San Joaquin River water from Friant Dam to the Delta from this extrapolation, a decrease from 570 to about 307 microSiemens of salinity. *Such an action would reduce salinity by nearly one-half in the San Joaquin River.*

In addition to such water quality improvements from returning unimpaired flows from the Upper San Joaquin River to the Delta, other gains in salinity reduction would occur from retiring saline irrigated lands in the western San Joaquin Valley and ending Delta imports of salty water there.

## II. Interior South Delta Salinity Objectives

The federal Clean Water Act states America's most basic water quality goals: 1) to ensure that no activity will lower water quality to support existing uses, and 2) to maintain and protect high quality waters. If the SED proceeds with the proposed relaxation of salinity objectives, both the Bay-Delta Water Quality Control Plan and its Supplemental Environmental Document must state how the proposed relaxation complies with this long-established and venerable policy.

The State Water Resources Control Board's "Statement of Policy with Respect to Maintaining High Quality of Waters in California," provides in relevant part, that:

> Any activity which produces or may produce a waste or increased volume or concentration of waste and which discharges or proposes to discharge to existing high quality waters will be required to meet waste discharge requirements which will result in the best practicable treatment or control of the discharge necessary to assure that (a) a pollution or nuisance will not occur and (b) the highest water quality consistent with maximum benefit to the people of the State will be maintained. (State Water Resources Control Board 1968)

In Water Rights Decision 1641 (D-1641) the Board placed responsibility for meeting South Delta salinity objectives to protect South Delta agricultural beneficial uses on the US Bureau of Reclamation and the California Department of Water Resources. In addition to the compliance point at Vernalis on the San Joaquin River, there are three other compliance points in the interior Delta: Old River at Tracy Boulevard Bridge, Middle River at Old River, and the San Joaquin River mainstem station at Brandt Bridge, not far from the head of Old River. Between April 1 and August 31, the salinity standard for each of these compliance points is 0.7 EC, and the rest of the year it is 1.0 EC. The Board proposes to relax these standards at the compliance points below Vernalis to 1.0 EC between April 1 and August 31 and 1.4 EC the rest of the year. The Board propose that the salinity objectives at Vernalis would remain unchanged at these same levels.

Figure 3 illustrates that the salinity concentrations of water flowing in South Delta channels exceeded D-1641 salinity objectives every year since 2007, through the winter of 2010. Figure 3 shows that the Bureau and the Department violated *both* the winter and summer salinity standards repeatedly during this four-year period (violation regions are shown in yellow). These D-1641 salinity objectives are applied at interior south Delta monitoring stations, where the specific characteristics of flow can be quite complex (and their study is referred to as "hydrodynamics").

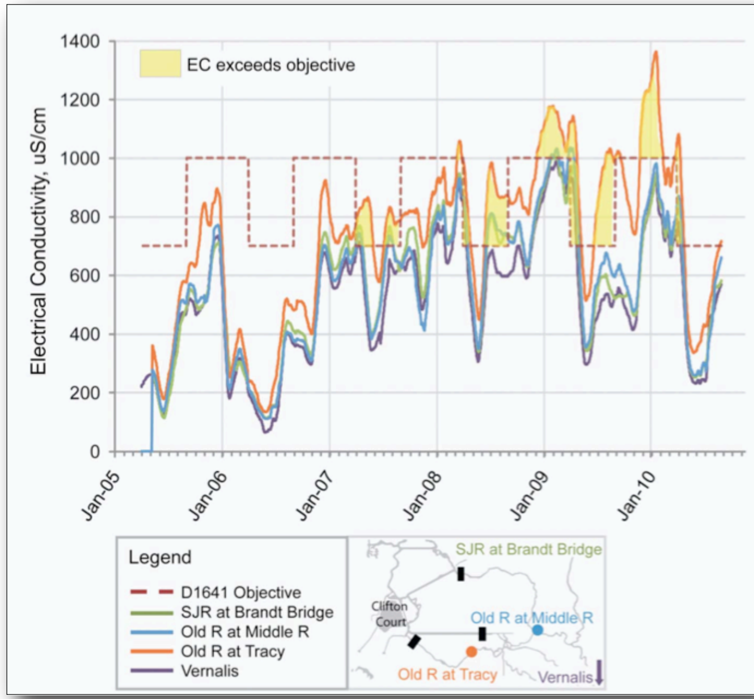


*Figure 3: Salinity objective exceedences at South Delta compliance stations by the California Department of Water Resources and the US Bureau of Reclamation shown in yellow. Source: California Department of Water Resources, 2011.*

In the wake of assigning responsibility in D-1641 to the Department and the Bureau for meeting interior south Delta salinity objectives, the Department and the Bureau's attention focused on the quality of the waters immediately around the three monitoring and compliance sites rather than on addressing squarely the largest sources of salinity entering the Delta from the San Joaquin River from upstream. In 2007, the Board held a workshop on salinity in the south Delta, specifically how salt sources within the south Delta could be reduced and controlled near the interior South Delta compliance points. The logic of this seemed to be that if the Department and the Bureau were going to be responsible for not violating the salinity objectives at these sites, then there better not be any other point sources of salinity being discharged within the Delta for which they might be otherwise held responsible.

## How Important are In-Delta Salinity Sources?

*Not very.* The State Water Resources Control Board, as the state's steward of the public trust on water quality matters, in 2007 paid attention to small polluters rather than also devise and implement strategies that create compliance by major upstream dischargers of saline agricultural drainage to the San Joaquin River, the major source of both water and salts entering the south Delta from Vernalis. Most of the discharges revealed by a Department of Water Resources study of in-Delta salinity sources have extremely low, if saline, discharges compared with the sources upstream of Vernalis. Some appear to be natural in origin, as shown in Table 4. (California Department of Water Resources 2007: 3-12) Table 4 suggests that these in-Delta saline flows of about 72,900 acre-feet annually are about four percent of observed Delta inflow at Vernalis and would be about one percent of unimpaired flow.

The State Water Board's determination to police salinity discharges interior to the south Delta on behalf of the Projects does not make the upstream region-scale problems of saline agricultural drainage go away.

The Board's in-Delta enforcement distraction in this period ignores conscious Delta farmer practices that manage salt and keep their lands sustainable for cultivation. The Department studied application of irrigation water and associated drainage in the Delta in the 1954 and 1955 prior to the State Water Project. It found that salt in Delta lowlands (a substantial portion of which occur in the South Delta) varied widely by month, with most of it accruing in Delta island soils during the irrigation season. By applying water to Delta island fields during winter months, however, farmers leached salts out of Delta soils. Department engineers concluded at the time that:

> The Delta Lowlands act as a salt reservoir, storing salts obtained largely from the channels during the summer, when water quality in such channels is most critical and returning such accumulated salts to the channels during the winter when water quality there is least important. Therefore agricultural practices in that area enhanced rather than degraded the good quality Sacramento River water enroute [*sic*]to the [Central Valley Project's] Tracy Pumping Plant. (California Department of Water Resources 1956: 30)

## The 2006 Cease and Desist Order

The need to reduce salt-laden flow in the San Joaquin River is also evident from the State Board's experience prosecuting a Cease and Desist Order against the Bureau and the Department for their violations of the interior south Delta salinity objectives, and its subsequent modification in 2010. In 2005, the Department and the Bureau informed the State Water Resources Control Board they would not be able to comply with the salinity objectives in the South Delta. The Board adopted a Cease and Desist Order in 2006, giving the Department and the Bureau until July 1, 2009, to comply or face additional enforcement actions.

The State Water Resources Control Board allows the Bureau and the Department to divide the responsibilities of complying with these salinity objectives. The Department has three main facilities in or directly affecting the San Joaquin River Basin: the San Luis Reservoir, the California Aqueduct's northern reach, and the Banks Pumping Plant, which exports Delta water into the Basin through the Aqueduct's northern reach (ultimately to some water contractors along the way and to the San Luis Reservoir for later export out of the Basin). Consequently, the Department's activities directly concerning the San Joaquin River occur mainly in the Delta where it operates Banks Pumping Plant. In the Delta itself, the Department attempts to manage the hydrodynamics of Delta flow and salinity conditions, some of which are caused by Banks Pumping Plant. Delta channel hydrodynamics affect:

- The salinity of the water exported at Banks.

**Table 4**
**South Delta Discharges as Sources of Salinity**

| Source | Estimated Discharge | General Location | Salinity Reported |
|---|---|---|---|
| 22 discharges of either stormwater or agricultural origin | None provided. | Vernalis to Head of Old River | None provided. |
| Reclamation District No. 2075 | 25 cfs (up to 18,112 AF/year) | Vernalis to Head of Old River | "above 2,000 μS/cm" |
| Watershed of unknown size drained by Walthall Slough | None provided. | Vernalis to Head of Old River | None provided. |
| Cities of Manteca and Lathrop | 5.72 million gallons per day (up to 6,407 AF/year) | Vernalis to Head of Old River | "Averaging above 1,000 μS/cm." |
| Brown Sand, Inc. | 6.2 million gallons per day (between January 2001 and December 2004) (up to 6,950 AF/year) | Vernalis to Head of Old River | None provided; groundwater seepage and excess stormwater discharge from historical mining pit operation. |
| Four sump pumps at Clifton Court Forebay | None provided. | Head of Old River to Export Sites | None provided; considered "relatively minor" though "they do contribute to the cumulative influence of all sources of salt in the South Delta." |
| City of Tracy | 7.09 million gallons per day (up to 7,947 AF/year | Head of Old River to Export Sites | Conductivities range from 1,000 to 2,400 μS/cm |
| Deuel Vocational Institution | 0.589 million gallons per day (up to 660 AF/year) | Head of Old River to Export Sites | Conductivities range from 1,000 to 2,400 μS/cm |
| Mountain House Community Services District | 3.0 million gallons per day, increasing to 5.4 million gallons per day when Phase III completed. (up to 6,053 AF/year) | Head of Old River to Export Sites | None provided. |
| Three urban/ agricultural drains reaching dead end sloughs connected to Old River | 1 to 2 cfs each in December 2006 "before any appreciable rainfall had fallen during water year 2007" (up to 1,449 AF/year) | Head of Old River to Export Sites | 2,100 and 2,600 μS/cm during December 2006 inspections. |

**Table 4**
**South Delta Discharges as Sources of Salinity**

| Source | Estimated Discharge | General Location | Salinity Reported |
|---|---|---|---|
| Groundwater effluence to drainage channels - Westside Irrigation District | "agreement with City of Tracy to pump as much as 35 cfs (22.6 mgd)" but no firm estimate of regular discharge (up to 25,333 AF/year) | Head of Old River to Export Sites | None provided. |
| Wastewater ponds next to Sugar Cut | "may be one specific source of saline groundwater accretion to Old River" but no firm estimate of regular discharge | Head of Old River to Export Sites | None provided. |
| Estimated Maximum Total Discharge, In-Delta Sources | up to 72,910 AF/year | | |

Source: California Department of Water Resources 2007; California Water Impact Network.

- Water levels in neighboring channels that are used by Delta farmers to divert water to irrigate their fields. (If water levels are too low, their pumps may not connect and they cannot divert.) Many of these farmers are water right holders whose rights are either paramount (that is, riparian) or senior (that is have earlier appropriation dates) to those of the Department for Banks Pumping Plant and must not be harmed.
- Finally, the Department has obligations to minimize impacts to fish and wildlife from its diversions and their effects on neighboring channels.

When the salinity objective violations at interior South Delta monitoring stations were reported to the State Water Resources Control Board, the Department of Water Resources and the Bureau of Reclamation were completing planning and environmental documents for a "South Delta Improvement Program" which would, among other things, install permanent operable tidal barriers intended to influence hydrodynamics and interior South Delta salinity conditions. Through operation of the barriers, it was hoped that salinity, water level, and fish passage issues could be addressed.

The Board issued draft Cease and Desist Order, held evidentiary hearings led by Board prosecution team, and adopted the Order in February 2006. The Order required, among other things, that:

- The Department and the Bureau "obviate the threat of non-compliance with the 0.7 EC [electrical conductivity] interior southern Delta salinity objectives by July 1, 2009.

- The two agencies prepare within 60 days of issuing the Order a "detailed plan and schedule" for the Board that would obviate the threat of salinity violations by providing for "equivalent measures" that "will provide salinity control at the three compliance stations equivalent to the salinity control that would be achieved by permanent barriers."
- The two agencies were also to prepare "an operations plan that will reasonably protect southern Delta agriculture" for Board approval no later than January 1, 2009.
- Corrective actions may include "but are not limited to additional releases from upstream Central Valley Project facilities or south of the Delta State Water Project or Central Valley Project facilities, modification in the timing of releases from Project facilities, reduction in exports, recirculation of water through the San Joaquin River, purchases or exchanges of water under transfers from other entities, modified operation of temporary barriers, reductions in highly saline drainage from upstream sources, or alternative supplies to Delta farmers (including overland supplies)." (State Water Resources Control Board 2006: 29, 30)

Even the State Board's Cease and Desist Order could not help noticing the absurd delays by the Department and the Bureau in achieving compliance with south Delta salinity objectives:

> Considering that the objectives were first adopted in the water quality control plan in 1978 [in D-1485], and there is evidence that salinity is a factor in limiting crop yields for southern Delta agriculture, the State Water Board will not extend the date for removing the threat of non-compliance beyond July 1, 2009. (State Water Resources Control Board 2006: 27)

Despite the array of "corrective actions" the Board suggested in the Cease and Desist Order to the Department and the Bureau, the two water agencies fixed on the permanent operable barriers of the South Delta Improvement Program serve as their solution to their salinity control problems near the export pumps. The Department informed the State Board in February 2007 that its consultation process with US Fish and Wildlife Service and National Marine Fisheries Service was delayed due to the fishery agencies' concerns about the interrelatedness of the South Delta Improvement Program and the long-term operation of the CVP and SWP. Ultimately, neither the Bureau nor the Department would lift a finger for any other "corrective action" available to them to try to address south Delta salinity objective compliance. Figure 3 above records the extent of violations the two water agencies allowed to occur during dry years.

## The Modified Cease and Desist Order of 2010

By June 2009, less than 30 days before deadlines in the 2006 Cease and Desist Order were to lapse, the Department on behalf of the Bureau announced to the State Water Board that the agencies were about to violate interior south Delta salinity objectives once again, and requested that the Board hold hearings to modify the Order.

The Board hastily convened an evidentiary hearing to modify the Cease and Desist Order. (The California Water Impact Network participated as a protestant in the Cease and Desist Order proceeding in the summer of 2009.) As part of compliance with a modified

Cease and Desist Order that the Board issued in January 2010, the State Board required the Department and the Bureau to "study the feasibility of controlling salinity by implementing measures other than the temporary barriers project, recirculation of water through the San Joaquin River, and construction of permanent operable gates." (State Water Resources Control Board 2010: Condition 7, 24)

## The Department of Water Resources' South Delta Low Head Pumping Study

The Department agreed to study "low head pumping" as a method for controlling salinity at key compliance monitoring stations in the South Delta (shown in the inset to Figure 3). The Bureau evaluated dilution flow needs and the potential for achieving interior South Delta salinity objectives. The goal for the study was to determine what flows and at which locations low head pumping would significantly reduce or eliminate the salinity objective violations by the Department and the Bureau. Water years 2007, 2008 and 2009 were dry or critically dry years, and so as time went on, fresh water flows with low salinity became harder to come by, and exceedances piled up. These "low head pumps" would in theory shunt high quality Sacramento River water upstream (eastward) around the temporary rock barriers with culverts through them that the Department installs each year in key interior Delta channels. It was hoped that low head pumping might improve the Department and the Bureau's compliance record on salinity objectives with little cost of high quality fresh water from upstream sources.

The Department's study results indicate that low head pumping could increase the dilution effects on salinity in south Delta channels by shifting higher quality Sacramento River water upstream of the barriers where the compliance points are. However, their effects appear to be small at best, even at pumping rates of from 500 to 1,000 cubic feet per second. (California Department of Water Resources 2011: 25-31) *The most important factor in South Delta salinity, the Department acknowledged, was the sources of water reaching each south Delta compliance monitoring site.* From modeling results, the Department found that 83 to 93 percent of the salty water reaching the interior South Delta compliance monitoring sites originated from the San Joaquin River. While low head pumping at one location could move large proportions of Sacramento River water upstream of the barriers and improve water quality there, salinity concentrations at other (non-pumped) compliance points saw little or no improvement; the salty flows of the San Joaquin River continued to predominate elsewhere in the South Delta. Even joint low head pumping at both Old and Middle River sites (see inset of Figure 3) would not result in significant reductions in the likelihood of continued salinity violations by the Bureau and the Department. After trying almost 60 different modeling scenarios, the Department concluded that, while low head pumping can reduce salinities on the upstream side of the Delta's temporary barriers near salinity compliance points, this approach's ability to reduce salinity objective violations was minimal, and posed high costs for fish screens. Cost estimates also had very high ranges of uncertainty in the absence of more definite engineering designs. (California Department of Water Resources 2011: Tables III.3 through III.6 and Figures III.5 and III.6; cost data shown in Tables ES.1 and ES. 2)

## The Bureau's Dilution Flow Study

The Bureau of Reclamation's 2011 study for the State Water Resources Control Board addresses the ability of such upstream dilution flows to attain salinity control and compliance at the interior South Delta monitoring sites. Recall from Table 1 above that fresh water flows from the major east side tributaries to the San Joaquin River exhibit sharp declines in flow from unimpaired to observed conditions, ranging from 53 percent on the Stanislaus River to 90 percent on the Upper San Joaquin River (State Water Resources Control Board 2011). Higher unimpaired fresh water flows would contribute larger volumes of low salinity water that would help to dilute salinity concentrations from west side and Valley Floor drainage sources.

The Bureau acknowledges in its dilution flow study that the best watersheds from which to get ideal dilution flows would have salinity conditions that are "60% or lower" than the salinity targets with which the Bureau wants to comply. In other words, the Bureau recognizes in the study's methodology that the lower the salinity and hence the better the water quality of the dilution flows to be used for compliance, the more likely the Bureau could use less water to achieve compliance with the State Board's salinity objectives.

For its study, the Bureau assumed that the salinity of dilution flow would be 60 micro-mhos per centimeter of electrical conductivity, a very low salt concentration "representing eastside reservoir water quality." (US Bureau of Reclamation 2011: 39) (This salinity is equal to about 38.4 mg/L (milligrams per liter) of salt as Total Dissolved Solids.[3]) This would approximate the salinity of water originating from snowmelt in the High Sierra.

The Bureau found that the tributaries with the best water quality for dilution flows are the Stanislaus and the Tuolumne rivers. While the Merced River's flows are of better quality than the those of the Bureau's recirculation scenario (in which Delta water is imported into the Delta Mendota Canal, then released down eastbound "wasteways" to the San Joaquin River without being used for irrigation), its water quality is not as good as the Stanislaus and the Tuolumne and would therefore require greater volumes of water to achieve compliance.

The recirculation scenario would continue importing some Delta salt loads and yielded results in critically dry, dry, and below normal water years where compliance could not be achieved by the Bureau for weeks and months at a time. The Bureau effectively rejected recirculation as a feasible option for salinity compliant dilution flows.

The Bureau found that using high quality water from an eastside reservoir (as yet unnamed), it would take about 100,000 to 200,000 acre-feet to comply with the most lenient of water quality objectives, and as much as 1.4 million acre-feet in dry years to meet "the most stringent" water quality objectives at Vernalis, which of course are years when such a supply of water is unlikely to be available. (US Bureau of Reclamation 2011: 40)

At this time, the National Marine Fisheries Service in its just-issued biological opinion on the coordinated operations of the State Water Project and the Central Valley Project,

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[3] Conversion from micromhos per centimeter to total dissolved solids (expressed in mg/L) is based on criteria conversions provided in Bauder et al 2011.

rejected permanent operable barriers as essentially magnets for predators consuming juvenile salmon and salmon smolts migrating to the ocean. Throughout this hearing, the Department and the Bureau held to their belief that pursuing the permanent operable barriers, and won from the State Water Board a modified Cease and Desist Order that postpones any enforcement action by the Board against them until at least 2014. There is no prospect at this time that National Marine Fisheries Service will alter its opinion of the permanent operable barriers, but by 2014, at least nine years will have elapsed during which the Department and the Bureau are and are not held responsible for complying with interior South Delta salinity objectives of the 1995 Bay-Delta Water Quality Control Plan, D-1641, and the subsequent 2006 Bay-Delta Water Quality Control Plan.

Salinity violations continue during 2012 in the South Delta. Figure 4 shows the trends in actual electrical conductivity at monitoring station P-12 (Old River at Tracy Boulevard), the calculated 30-day average of EC values at this location, and the salinity objective of 1000 microSiemens per centimeter (mS/cm) through March 31 and the 700 mS/cm from April 1 through August 31. The red curve in Figure 4 shows that the 30-day running average for electrical conductivity exceeded the P-12 EC objective for 84 consecutive days between March 4 and May 26, nearly three months of compromised water rights for South Delta diverters.

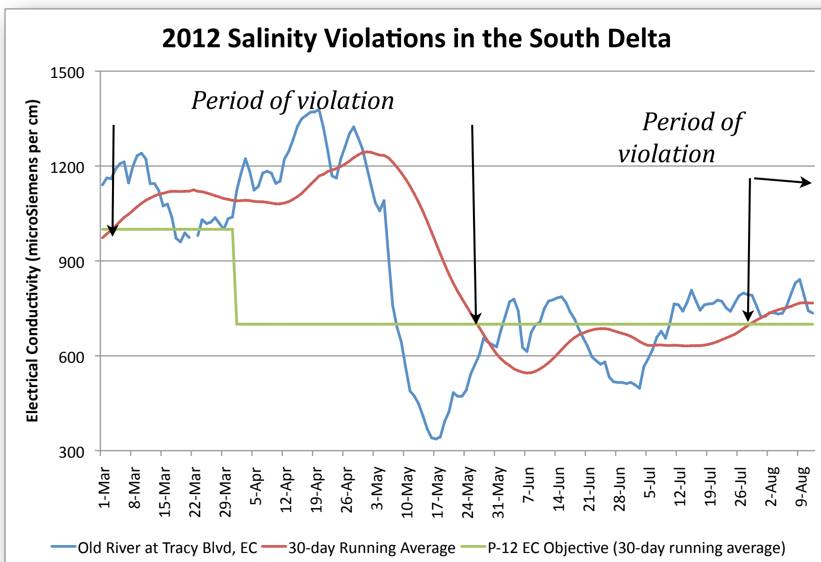


*Figure 4: Salinity violations in the South Delta between March 1 and August 12, 2012. Source: California Data Exchange Center, California Water Impact Network. See Appendix E for supporting data.*

The western San Joaquin Valley is the logical place to focus the State Water Resources Control Board's source control enforcement efforts, and has been the logical place for decades, rather than in the South Delta. Salts from this area contribute significantly to the compliance problems in the interior South Delta, as DWR's Low Head Pump and the Bureau's dilution flow studies show. They also compromise water rights of Delta farmers.

The South Delta salinity objectives are intended to protect South Delta agricultural beneficial uses, which includes protection of the water rights of South Delta agricultural water users. The current objectives protect these water rights by providing that level of salinity (as measured in terms of electrical conductivity) that meets the quality requirements of those rights. To relax these objectives would be a conscious State Water Resources Control Board choice to directly reduce and injure water rights and agricultural beneficial uses in the South Delta. C-WIN believes this proposed action would violate the federal Clean Water Act's antidegradation policy and the Board's own 1968 resolution protecting against antidegradation of the state's waters.

The efficacy of water rights and the quality of agricultural beneficial uses in the South Delta are determined largely by salinity of Delta inflows from the San Joaquin River. Studies and reports by the Department, the Bureau, and the Central Valley Regional Board confirm this.

Dilution flows are already part of the overall strategy the State Water Resources Control Board relies on to address South Delta salinity issues. The Board's existing dilution flow strategy in the Bay-Delta Plan to date has focused almost exclusively on releases from New Melones Reservoir, owned by the Bureau of Reclamation, on the Stanislaus River. (This strategy accounts for the increase in the Stanislaus River's share of flows at Vernalis from unimpaired to observed, developed conditions, as shown in Table 1, above.) Water Rights Decision 1422, which governs operation of New Melones, called for water quality releases amounting to 98,000 acre-feet of releases for fish and wildlife beneficial uses and such releases as necessary to maintain 500 parts per million of salinity at Vernalis. Given the Bureau's continuing lack of compliance with D-1641's South Delta salinity objectives, these releases are neither enough to maintain compliance by the Bureau at interior South Delta salinity compliance points, nor do they provide sufficient instream flow protection to listed aquatic species in South Delta channels.

The Board's past willingness to regulate New Melones Reservoir operations dates back to the 1970s. It clearly demonstrates the Board's authority and capacity to regulate upstream inflows to the Delta to protect beneficial uses downstream. Hence the State Water Resources Control Board's apparent interest in looking to additional sources of dilution flows from other San Joaquin River tributaries has both merit and precedent.

## III. The Toxicity of Selenium

The problem of salt loading in flows returning to the Delta via the San Joaquin River is compounded by the presence of selenium. Selenium is typically found as a very small component of total dissolved solids (TDS), a commonly used measure of salinity and salts. But the larger the salt load the larger the selenium load.

Selenium occurs naturally in mineral deposits like coal and oil, as well as other marine-derived sediments. (Presser 1999) Wastes from agriculture, industry, mining, and gas and oil refineries can increase selenium contamination in estuaries and bays.

Selenium is necessary to the health of most vertebrate species and for human health when provided in small doses. Adequate amounts of selenium are found in a well-balanced human diet. But at just slightly elevated levels, selenium becomes actively poisonous. As concentrations rise further, selenium can cause embryonic defects, reproductive problems, and death in vertebrate animals.

As a chemical element, selenium is chemically similar to sulfur in how they both react with both mineral and organic compounds. Selenium can readily substitute for sulfur in salts (such as selenates for sulfates) as well as in certain amino acids (e.g., seleno-cysteine and seleno-methionine; Presser 1999; Presser and Luoma 2006: 40), the building blocks of proteins. Selenium's ability to substitute chemically for sulfur in both salt chemistry and organic amino acids clears pathways to toxicity, increased gene mutation, and ecological damage.

At higher tissue concentrations, selenium can substitute for sulfur in amino acids, altering the structure of proteins in metabolic and reproductive systems of the body. When proteins in predator species mutate from excessive exposure to selenium, it can lead to sterility and suppression of the immune system "at critical development stages when rapid cell reproduction and morphogenic movement are occurring." Changes in the structure of many antibodies (such as from substitution of selenium atoms for sulfur atoms) can compromise the organism's immune defenses, making it more susceptible to disease.(Presser 1999: 555).

In the spring of 1983, federal wildlife biologists found that a majority of birds nesting at Kesterson National Wildlife Refuge had deformed embryos and chicks. Nearly two-thirds of Refuge birds had missing eyes and feet, protruding brains, and twisted beaks, legs and wings. The number of breeding birds able to reproduce collapsed. These birds had been poisoned and the reservoir at Kesterson became synonymous with "toxic disaster," a western Love Canal.

The direct culprit for these disfiguring effects on wildlife was selenium. (Ohlendorf 1985; Saiki 1985; Sylvester 1985; Barnes 1985; Kilness and Simmons 1985) This contaminant was brought to Kesterson by agricultural drain water from a wastewater canal called the San Luis Drain, which was constructed by the US Bureau of Reclamation.

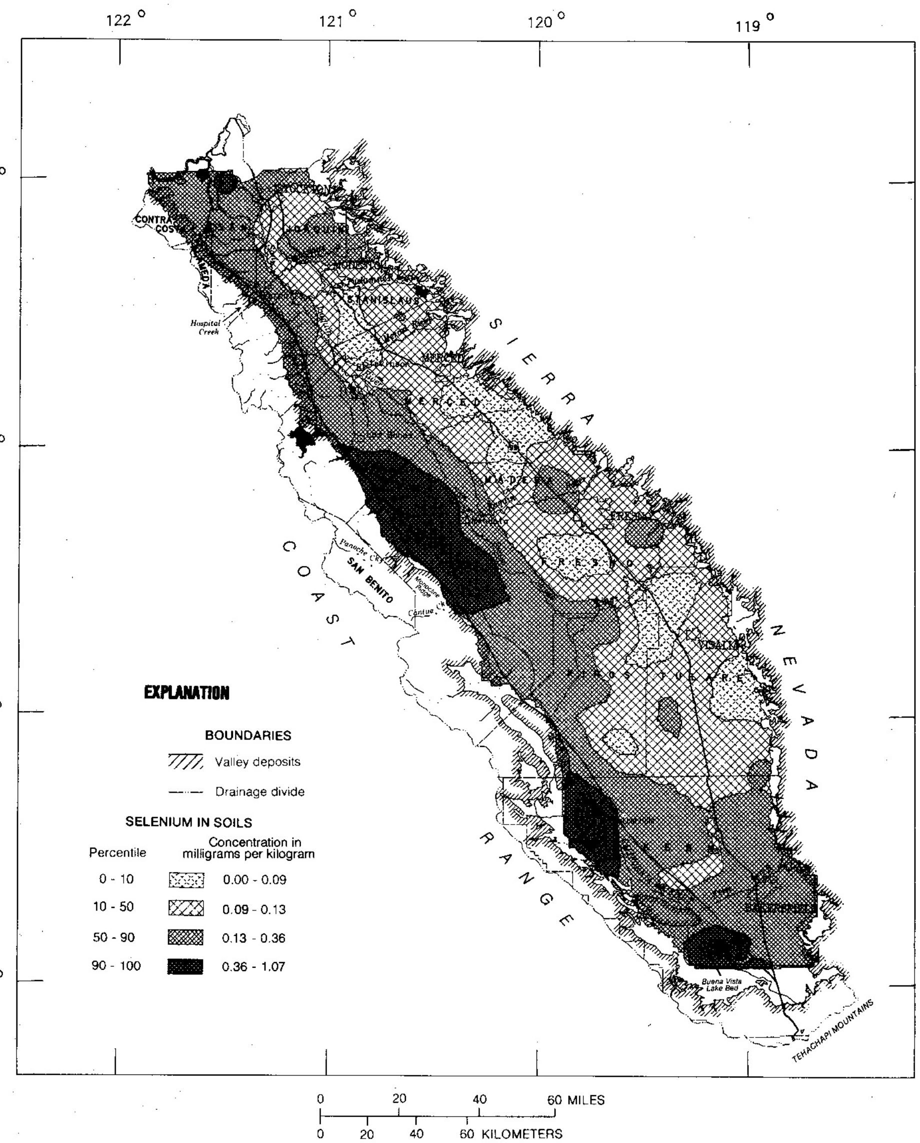


**FIGURE 2.— Areal distribution of estimated total selenium concentrations for the 0- to 12-inch depth interval in soils of the San Joaquin Valley. (Adapted from Tidball and others, 1986a.)**

*Figure 5: Selenium concentrations in San Joaquin Valley soils. The darkest areas contain the highest selenium concentration in soils. Source: Gilliom 1988.*

## The "Unlimited Reservoir" of Selenium

The western San Joaquin Valley and its Coast Range foothills have naturally high levels of selenium in the rocks and soils. (Tidball et al 1986; Gilliom 1988) Three areas of the western San Joaquin Valley have the highest soil selenium concentrations:

- The alluvial fans near Panoche and Cantua creeks in the central western valley (near Gustine and Firebaugh; see Figure 5).

- An area west of the town of Lost Hills.
- The Buena Vista Lake Bed Area, west of Bakersfield. (San Joaquin Valley Drainage Monitoring Program 2010)

The disaster at Kesterson National Wildlife Refuge was the earliest and most vivid example of the western San Joaquin Valley's toxic legacy due to selenium. It was caused by the west side growers' obtaining and applying a large supply of irrigation water from Delta imports to lands of the San Luis Unit. Presser and Luoma (2006) identify a unit of measure they refer to as the "kesterson." It is equivalent to 17,400 pounds of selenium, the load of selenium that is believed to have accumulated at Kesterson reservoir between 1981 and 1985, the period when the Westlands Water District's drain water was connected to the reservoir. This is the mass of selenium loading from agricultural drainage water to which scientists attribute the deformities and deaths affecting 64 percent of waterfowl there in 1983.

Other parts of the San Joaquin Valley are also naturally contaminated with salts, selenium, and high levels of other toxic elements like boron, arsenic, and molybdenum (Figure 5; San Joaquin Valley Drainage Program 1990: 58-63). Because of the extent of the geologic deposits and rocks containing selenium in the western San Joaquin Valley, it is important to recognize that at time scales relevant to society, "there are, for all practical purposes, unlimited reservoirs of selenium and salt stored within the aquifers and soils of the valley and upslope in the Coast Ranges." (Presser and Schwarzbach 2008: 2) The selenium reservoir will be with Californians for a very long time to come.

Presser and Luoma (2006) quantify this reservoir by conceiving the reservoir of selenium as a stream of yearly time-step flows that can be modeled using reasonable assumptions about drainage projections, selenium concentrations and loadings from recognized plans and studies (such as San Joaquin Valley Drainage Program 1990; US Bureau of Reclamation 2005a, 2006, California Regional Water Quality Control Board, Central Valley Region 2000, 2001).

Their projections of selenium loads over time are shown in Table 5. Their scenarios are as follows:

- Existing discharges from the Grassland subarea (the northern part) through extension of the San Luis Drain to the Delta.[4]
- Westlands Water District subarea-only use of a San Luis Drain extension to the Delta or San Joaquin River.
- Grassland subarea plus Westlands subarea, both carried to the Bay-Delta.[5]
- Drainage is collected valleywide from all five subareas (Northern; Grassland, Westlands; Tulare, and Kern subareas).[6]

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[4] "It seems unlikely that demand [for use of the San Luis Drain] would remain at this level once an out-of-valley conveyance was available. Increasing acreages of saline soils, rising ground water tables, and the availability of a conveyance facility are likely to generate strong pressures from other areas to use the facility." (Presser and Luoma 2006: 31)

[5] "This seems a likely outcome if a conveyance is constructed." (Presser and Luoma 2006: 31)

[6] "This would require extensions of the San Luis Drain into Kern and Tulare subareas, in addition to an extension to the Bay-Delta." (Presser and Luoma 2006: 31-32)

- Two other scenarios that include all potential problem lands estimated for the year 2000. The first shows the range of selenium loads expected if drainage management follows the 1990 Rainbow Report of the San Joaquin Valley Drainage Program (1990). The second of the two forecasts lists load targets of the Total Mean Monthly (TMML) management plans for discharge to the San Joaquin River from the Grassland subarea, which ramp down over time.

Using load targets (Table 5's bottom scenario) as the basis for the future stream of selenium drainage results in the lowest loading (about 1,400 to 6,500 pounds per year, or 0.08 to .38 "kestersons" per year) selenium discharges could be heavily regulated. By comparison, encouraging drainage of selenium and salts to the Bay-Delta either via a San Luis Drain extension or use of the San Joaquin River would result in a far larger range of nearly 15,000 to 42,800 pounds per year (or about 0.86 to 7.36 "kestersons" per year).

**Table 5**
**Projections of Selenium Loads from the Western San Joaquin Valley for Different Drainage Scenarios**

[A kesterson (kst) is defined here as 17,400 lbs selenium, the cumulative load that caused ecological damage when released to Kesterson National Wildlife Refuge, California) (Presser and Piper, 1998)].

| Scenario (subarea(s) discharging to a proposed San Luis Drain extension) | Selenium load (lbs/year) | Selenium load (kestersons/ year) | Cumulative 5-year selenium load (kestersons) |
|---|---|---|---|
| Grassland (based on current data) | 6,960 – 15,500 | 0.4 – 0.89 | 2.0 – 4.45 |
| Westlands (based on 50 – 150 µg selenium in drainage and 60,000 acre-feet) | 8,000 – 24,500 | 0.46 – 1.41 | 2.3 – 7.05 |
| Grassland and Westlands (from above) | 14,960 – 40,000 | 0.86 – 2.30 | 4.3 – 11.5 |
| Valleywide Drain (current conditions and Westlands from above) | 16,490 – 42,785 | 0.95 – 2.46 | 4.75 – 12.3 |
| Valleywide Drain (all potential problem lands with management of drainage quantity and quality) | 19,584 – 42,704 | 1.12 – 2.45 | 5.6 – 12.2 |
| Valleywide Drain (all potential problem lands with minimum management of quality and quantity) | 42,704 – 128,112 | 2.45 – 7.36 | 12.2 – 36.8 |
| Total Maximum Daily or Monthly Load Model management (load *targeted* for environment safeguards, Grassland subarea or drainage basin) | 1,394 – 6,547 | 0.08 – 0.38 | 0.4 – 1.9 |

Source: Presser and Luoma 2006: Table 8, 33.

Presser and Luoma also examine scenarios in which constant concentrations of selenium in drainage flows (either in the San Luis Drain or in the San Joaquin River) are maintained. In Table 6, these projections show that at high flows selenium loads may differ significantly depending on the concentration maintained either in the river or the drain. At the current Total Mean Monthly Load (TMML) level for the lower San Joaquin River (California Regional Water Quality Control Board 2000) of 5 micrograms per liter (µg/L) can yield large loads in high flows (up to 40,800 pounds during a 3 million acre-feet wet year) or small loads in low flows (or nearly 3,000 pounds during low flow in the San Joaquin River or capacity flow of the San Luis Drain).

Table 6 also shows that relaxing selenium concentration assumptions in the drainage flows to the Bay-Delta for purposes of carrying larger loads in the San Luis Drain from 50 to 300 µg/L can enable the Drain to carry much more selenium out of the San Joaquin Valley to the Delta (from nearly 30,000 pounds pear year to nearly 180,000 pounds per year, thereby easing the buildup of stored selenium in western San Joaquin Valley soils and groundwater (the "reservoir" alluded to earlier). Yet these cumulating loads would likely be highly toxic, especially in dry and drought years, of which more are expected as

California's climate changes. Expressed in kestersons, these load projections by Presser and Luoma convert to *1.7 to 10.3 kestersons per year* in the San Luis Drain under relaxed assumptions of selenium concentration.

**Table 6**
**Selenium Loads Conveyed to the Bay-Delta Under Different Flow Conditions by Maintaining Constant Concentration in Either San Joaquin River or San Luis Drain**

[Flow conditions: high flow (3.0 million acre-feet/year); low flow (1.1 million acre-feet/year); and annual flow assumed for a proposed San Luis Drain extension at maximum capacity or a small San Joaquin River input in a dry year (approximately 220,000 acre-feet/year)].

| Selenium concentration in river or drain extension (µg/L) | Selenium load (lbs/year) | | |
|---|---|---|---|
| | 3.0 million acre-feet/year | 1.1 million acre-feet/year | 216,810 acre-feet/year (300 ft³/s) |
| 0.1 | 816 | 299 | 60 |
| 1.0 | 8,160 | 2,990 | 598 |
| 2.0 | 16,320 | 5,980 | 1,197 |
| 5.0 | 40,800 | 14,960 | 2,992 |
| 50 | – | – | 29,920 |
| 150 | – | – | 89,760 |
| 300 | – | – | 179,520 |

Source: Presser and Luoma 2006: Table 9, 33.

## Selenium Behavior Across Aquatic Environments

Selenium concentrates naturally in the depositional environments of estuaries and marshes. Hydrologic conditions provide important reasons for this. Selenium dissolved in water represents only a small proportion of exposures. (Presser and Luoma 2006; Presser and Luoma 2009: 8485; Schlekat et al 2004; Roditi et al 1999; Alquezar et al 2008) Selenium can undergo "partitioning" reactions in the water column that determine whether selenium remains dissolved or enters what chemists refer to as its "particulate phase." (Presser and Luoma 2006: 41; Presser and Luoma 2010)

Selenium in the water column of a flowing river can become problematic when flows slow down due to changing geomorphology of the stream channel, or at conclusion of a runoff event. (Presser and Luoma 2006: 6) Incorporated into detritus or suspended sediments, selenium may then get deposited to the bed of the quiet water body. Incorporated into bacteria or phytoplankton, selenium gains immediate entry into an aquatic food web when these organisms are consumed by their immediate predators (such as zooplankton and other open water or bottom-dwelling consumers).

Presser and Luoma (2010: 703) catalog a range of hydrologic environments and selenium's partitioning behavior, summarized in Table 7. The relative calm of water in marshes, wetlands and estuaries facilitate this partitioning process by which selenium finds its way from the water column, aquatic organisms and animals connected by predation to aquatic food webs. Once consumed by prey organisms, predators can then bioaccumulate selenium at varying rates that depend on the assimilative efficiencies of prey in their diet choices.

**Table 7**
**Examples of Ecosystem and Hydrologic Environment-Specific Selenium Criteria in Tissue and in Water Column**

| Hydrologic Environment | Selenium Partitioning Factor ($K_d$) | Target Selenium Concentration in Tissue (µg/g, dry wt) | Hypothetical Selenium Concentration in Water Column (µg/L) | Protected Fish or Birds in Hydrologic Environment |
|---|---|---|---|---|
| Mainstream River | 150 | 5 (fish tissue) | 10.8 to 34 | Bluegill; Trout |
| Backwater | 350 | 5 (fish tissue) | 4.6 to 14.4 | Bluegill; Trout; Bass |
| Reservoir | 1,800 | 5 (fish tissue) | 0.89 to 1.7 | Blackfish; Redear |
| Estuary | 3,000 | 5 (fish tissue) | 0.24 to 1.2 | Starry Flounder; White Sturgeon |
| Estuary | 3,000 | 8 (bird tissue) | 0.24 | Scaup |
| Wetland | 900 | 8 (bird tissue) | 1.8 | Grebe |
| Stream | 350 | 8 (bird tissue) | 4.5 | Dipper |
| Saline Lake or Pond | 1,500 | 8 (bird tissue) | 0.70 to 1.8 | Blacknecked Stilt |

Source: Presser and Luoma (2010a: Figure 6, 703); California Water Impact Network.

## Selenium and the Invasive Clam, *Corbula*

One such food web is based on predators consuming large quantities of bottom dwelling (benthic) organisms. Once deposited at the bottom of the water column, benthic organisms may consume selenium-containing detritus or sediments as part of their grazing behaviors. Filter-feeding behavior by clams in the water column can also be an important pathway by which bottom-dwelling organisms consume and incorporate selenium into their tissues directly from the water column before particulates fall into sediments. The invasive Asian clam, *Corbula amurensis,* assimilates selenium into its tissues with high efficiency. (Linville, et al 2002; Stewart et al 2004)

C-WIN examined this relationship between flow rate and selenium uptake by benthic organisms. Field research by Kleckner, *et al* (2010) measured selenium uptake in *Corbula* tissues over a 15-year span (1996-2010) from several sites in Suisun Bay and Carquinez Strait immediately west of the Delta. Kleckner *et al*'s data on selenium uptake by these clams is used to illustrate the relationship to Delta outflow and the position of the X2 isohaline (which scientists use as the western boundary of the Delta estuary's "low salinity zone").

By comparing the selenium uptake of Kleckner's clams near Chipps Island to various flow indicators, C-WIN hoped to provide empirical corroboration of selenium behavior in slower moving aquatic environments as found by Presser and Luoma (2010a). C-WIN identified three flow and salinity indicators to compare with the selenium uptake by clams. These indicators included: net Delta outflow; the ratio of San Joaquin flows at Jersey Point to net Delta outflow; and the position of X2, an isohaline marking the position of water with a salinity concentration of 2 parts per thousand (2 ppt). C-WIN chose Chipps Island as the site for comparison purposes because the island is located at a bathymetric and geographic transition in flow from more narrow channels of the Sacramento and San Joaquin River confluence into the eastern edge of the widening of Suisun Bay. (Kleckner et al 2010: Site 4.1 in Figure 1, Table 3) Such a location is presumed to exhibit where flow velocities for a given volume of water will slow down as the underlying channel bathymetry flattens and widens. Streams and rivers at such transitions lose their competence to hold sediment. Deposition of suspended particles occurs readily.

Net Delta outflow is a calculated estimate of flow at the confluence of the Sacramento and San Joaquin Rivers at the east end of Suisun Bay. These calculations are done at daily time-steps as part of the output of the Interagency Ecological Program's Dayflow model of Delta flows. As with Net Delta outflow, San Joaquin River flows and the position of X2 are also obtained from Dayflow.

Approximately monthly samples of *Corbula* were taken by Kleckner's team between 2002 and 2010 to study selenium concentrations in the clams' tissues. Weighted average monthly selenium loads were calculated from Kleckner et al's data by C-WIN based on the number of individual clams in each sample for each respective month in Kleckner, et al's dataset (that is, the data in the next few charts are "sample-weighted"). (C-WIN's sample weighting of the selenium uptake data by *Corbula* and Dayflow hydrology data for Net Delta Outflow, San Joaquin River at Jersey Point, Sacramento River at Rio Vista, and X2 are all presented in Appendix B to this testimony.)

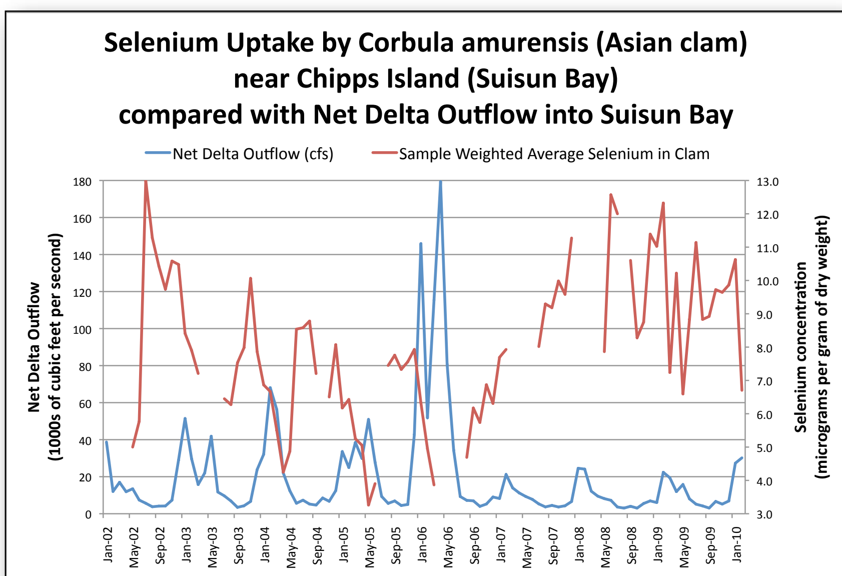


*Figure 6*
*Sources: Kleckner, et al, 2010; Dayflow; California Water Impact Network.*

Figure 6 presents a side-by-side comparison of *Corbula*'s selenium uptake with the time series of net Delta outflow at monthly time-steps. There is an observable inverse relationship between these datasets, but it does not appear strong. But the comparison does reveal that when net Delta outflow is high as in the winter of 2006, tissue concentrations of selenium in *Corbula* appear to fall. At lower net Delta outflows, selenium tissue concentrations conversely appear to climb.

A significant rise in selenium uptake occurred during critically dry and dry years of 2007 through 2009. This three year interval was an extended drought period in California. Selenium loads in clam tissues there at Chipps Island rose in 2006 from about 4.5 μg/g (dry weight) to levels approaching 13 μg/g (dry weight) by 2009. With the onset of early storms in water year 2010, an above normal year, selenium in the tissues of Chipps Island *Corbula* clams decreased to about 6.5 μg/g (dry weight), as shown in Figure 6. In these years, extended periods of low flows and relatively low wintertime floods seem to correlate with persistent and chronic elevated levels of selenium uptake by *Corbula* at Chipps Island.

Net Delta outflow, however, does not directly reflect the relative presence or absence of salts and selenium in source waters reaching the Chipps Island *Corbula* clams. As shown earlier, however, the San Joaquin River is a major source of salts (including selenium) reaching the South Delta, and at higher flows, beyond.

Figure 7 shows the same data on selenium uptake by *Corbula* compared with tracking of the monthly ratio of San Joaquin River at Jersey Point to the sum of Sacramento and San Joaquin River flows. This comparison shows selenium uptake in *Corbula* varying more directly with the relative volume of San Joaquin river flows making it to Suisun Bay. Figure 7 reveals a similar inverse relationship as with net Delta outflow, but the signal from the San Joaquin River in this inverse relationship appears stronger than the signal for net Delta outflow alone. C-WIN suggests this is likely because the ratio captures the oscillating signal of San Joaquin River flows (which are well-known to be of far saltier concentration than those of the Sacramento River). The San Joaquin River's salt loads thus would figure more prominently than it would in net Delta outflow by itself. Seasonal variation in selenium uptake by *Corbula* also is visible in Figure 7. The strong climb from 2006 through 2008 in selenium tissue

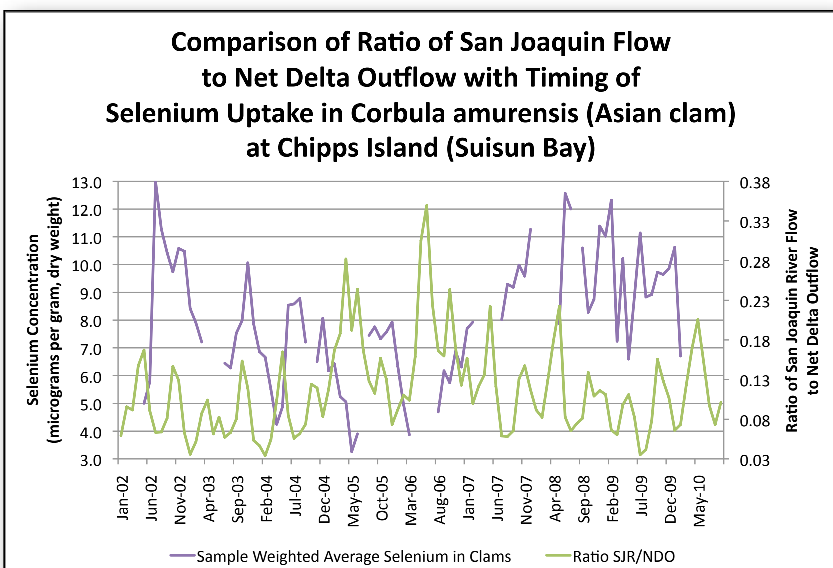


*Figure 7*
*Sources: Kleckner et al, 2010; Dayflow; California Water Impact Network.*

concentrations in *Corbula* in the wake of large loads transported by high 2006 spring flows from the San Joaquin is also evident in Figure 7.

The analysis presented from Figure 7, however, does not capture the oscillation of salinity conditions specific to Chipps Islands. So C-WIN next compared the *Corbula* clam selenium uptake data with X2 monthly data, a measure of the position of the 2 parts per thousand isohaline in the western Delta and northern San Francisco Bay Estuary.

The X2 isohaline is a region of water whose salinity is approximately 2 parts per thousand (2 ppt). Waters upstream of X2 are fresher, while those downstream are saltier. Scientists observe that this isohaline marks a distinct ecological boundary between species preferring fresher water environs and those that prefer greater salinity. This region indicates the overall size of freshwater habitat in the Delta as it oscillates its position between, generally, the east and west ends of Suisun Bay (that is, between Chipps Island and the eastern mouth of Carquinez Strait, a distance of about 20 kilometers). X2 is described as a distance (measured in kilometers) from the Golden Gate. Chipps Island is approximately 75 kilometers from the Golden Gate, while Carquinez Strait's eastern edge is about 55 kilometers from the Golden Gate. (San Francisco Estuary Project 1993: Figure 1, A-11)

X2 can thus be used as a proxy for the relative presence or absence of salinity in the Bay-Delta estuary. It marks the mobile boundary of what scientists call the "Low Salinity Zone" in the Bay Delta Estuary. Figure 8 shows that X2 has a relatively direct correlation in its movements with flow as does the uptake of selenium by *Corbula* clams at Chipps Island. Recall that selenium is a component of salinity concentrations in the water column. It follows that when X2 is further west of Chipps Island, salinities and selenium concentrations and bio-availability are reduced. Consequently, clam uptake of selenium is reduced because of elevated downstream fresh water flows with high volumes and velocities, as Figure 8 indicates. On the other hand, when flows are low, X2 recedes eastward, upstream into the separate channels of the Sacramento and San Joaquin River. The value of X2 increases as the western boundary of the low Salinity Zone moves east. This means that greater salinities and selenium uptake occur in the vicinity of Chipps Island, both seasonally and in the course of interannual dry

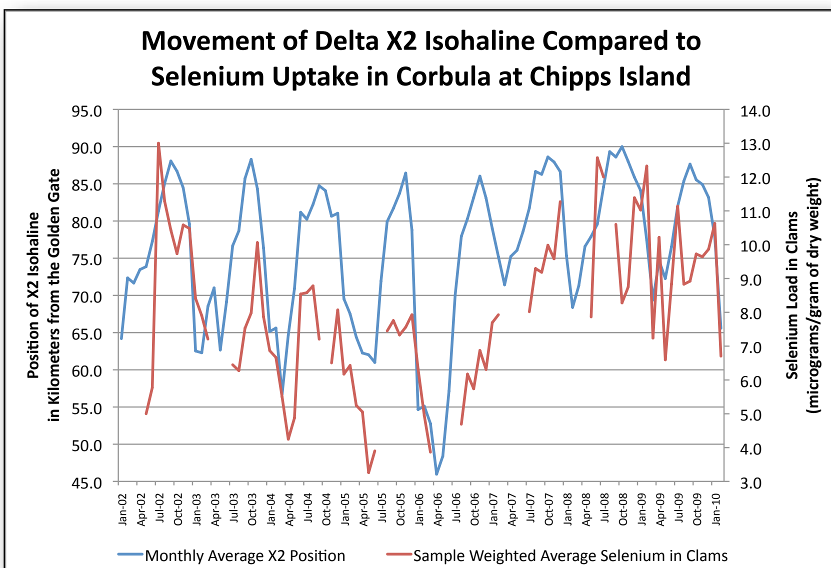


*Figure 8*
*Sources: Kleckner, et al, 2010; Dayflow; California Water Impact Network.*

spells, such as occurred in 2007 through 2009.
In Figure 8, the same selenium uptake data derived from Kleckner et al (2010) are plotted along with X2 isohaline data also provided by the Interagency Ecological Program's Dayflow output. X2 daily data were converted into monthly averages for ease of comparison with the sample-weighted monthly data on selenium uptake by the clams.

When net Delta outflow is high, the X2 isohaline is pushed west into Suisun Bay. As Figure 8 illustrates, during the wet year of 2006, spring flows pushed X2 almost to 45 kilometers from the Golden Gate, well into Carquinez Strait. On the other hand, at the low point of low flows in the fall of 2008, X2 receded to 90 kilometers upstream of the Golden Gate (or about to a point just east of Antioch on the San Joaquin River and a point midway between Collinsville and Rio Vista in southern Solano County along the Sacramento River).

The relationship of selenium in the water column of the Delta to residence time and bio-availability is further suggested by the use of temporary barriers in the South Delta. In particular, the Head of Old River Barrier is intended to close off Old River from San Joaquin flows during high flow periods such as spring (snowmelt) peak flows so that salmon smolts are diverted away from Old River and possible entrainment at the state and federal export pumps. In the fall, this barrier amplifies low flows through the Stockton Deepwater Ship Channel to help prevent sags in dissolved oxygen concentration that occur during otherwise stagnant hydraulic conditions there. Monsen *et al*'s modeling simulations of the Barrier's effects (particularly in the fall) indicate that when the Barrier is in place the "flushing time for the Stockton Ship Channel during autumn periods is on the order of days...and on the order of weeks when this barrier is removed." Without endorsing use of the Barrier, this example makes plain that when mainstem San Joaquin River flows through Stockton are greater, residence time (the obverse of "flushing time") decreases significantly. When these flows are laden with selenium, they are shunted beyond direct reaches of the South Delta into Central Delta mixing zone areas and for eventual deposition in Delta sediments or exit from the Delta past Chipps Island. (Monsen et al 2007: 11)

The relationship between selenium concentrations in the water column and invertebrate uptake of selenium is confirmed by a selenium ecological risk assessment performed for the Grassland Bypass Project for wetlands along the lower San Joaquin River. (San Luis Delta Mendota Canal Authority and US Bureau of Reclamation 2009: Appendix E2) In that assessment, the best predictor of fish selenium concentrations relative to water column selenium concentrations is provided by a logarithmic function that lags fish tissue samples 1 to 7 months after the water column concentration is measured. (Correlation coefficient [$R^2$] equals 0.76.) The same assessment also found that selenium levels in aquatic invertebrates in these wetlands (including crayfish) "are broadly correlated with selenium concentrations in water." The correlation was strongest ($R^2$ equals 0.68) when invertebrate selenium tissue concentrations were lagged 30 to 60 days after measurement of the water column selenium concentration. (San Luis Delta Mendota Canal Authority and US Bureau of Reclamation 2009: Appendix E2: E.2-10) In other words, it takes just a few weeks for selenium in the water column to become bioavailable through partitioning and deposition in sediments. This is why residence time of selenium in the water body is so important to its fate and to selenium's toxicity in aquatic food webs.

## Selenium's Ecological Risks

Once consumed, selenium can quickly build up in the tissues of their predators, the fish, birds, and even humans higher up in aquatic food webs. Beckon and Maurer (2008) surveyed potential for selenium effects on a variety of fish and wildlife species in the San Joaquin River Basin and the San Joaquin Valley. They found that:

- The **San Joaquin Kit Fox** is "potentially at risk from dietary intake" of selenium by virtue of consuming small rodents (voles, mice, shrews) that may frequent evaporation ponds and selenium reuse areas (where selenium and salt-tolerant crops are grown to remove selenium from drain water).

- **Kangaroo rats** in the San Joaquin Valley are potentially at risk from consuming seeds enriched with selenium in their diets. If so, Beckon finds kangaroo rats are "likely to exceed thresholds for adverse effects" from consuming such seeds.

- **Giant Garter Snakes** are potentially at risk, though that risk is unknown because this snake is rare and endangered.

- **Blunt-Nosed Lizards** are also considered by Beckon to be at risk from feeding on aquatic insects in the vicinity of agricultural drainage ditches, evaporation ponds, reuse areas, and retired seleniferous (selenium-contaminated) lands. Beckon states that reuse areas may pose the greatest selenium-related risks for this lizard.

- **California Least Terns** have been seen at selenium-treating evaporation ponds in the San Joaquin Valley, but have as yet shown no toxic effects from exposure. However, Beckon observes that "if California least terms learn to eat brine shrimp and other invertebrates in evaporation ponds" then their exposure to selenium could dramatically increase.

- **Chinook Salmon** are among the most sensitive fish and wildlife to selenium exposure. In particular, Beckon warns there is substantial ongoing risk to juvenile salmon. For fall-run juvenile Chinook salmon, their migration commences with late winter and spring snowmelt flows along the major tributaries of the San Joaquin River (Stanisaus, Tuolumne, and Merced rivers). In low flow years on the San Joaquin River, this can mean, however, that otherwise compliant selenium concentrations in the river may prove toxic to young salmon beginning their migration. Beckon and Maurer estimate that up to 20 percent of all juvenile salmon at a tissue concentration of 2.45 μg/g dry weight reaching the San Joaquin River from the Merced River die in low flow years. (Beckon and Maurer 2008; Beckon 2009; Presser and Luoma 2010, 2011) Presser and Luoma (2006) warn that San Joaquin River Restoration Program efforts to reintroduce fall-run Chinook salmon must address the potential for selenium poisoning of reintroduced salmon between Sack Dam and reaches of the River downstream of Mud Slough (north, which releases Grassland Bypass Project drainage flows that have passed through the San Luis Drain; Presser and Luoma 2006, 2010; 2011).

- **Steelhead (Rainbow) Trout** are also believed by Beckon to be at risk from selenium exposure, which could confound efforts to restore this fish to the upper San Joaquin River as well.

- **White Sturgeon**, another migratory fish eats a major portion of its diet from bottom-dwelling (benthic) organisms, such as clams, which predominate in their diet (Beckon 2008). Beckon expresses hope that the exposure of white sturgeon to selenium will diminish as the State Water Resources Control Board's Total Monthly Mean Load regulations for selenium are implemented.

- **Sacramento Splittail**, of which some 7 million individuals were killed after being entrained by state and federal pumps in the Delta during 2011, face important risks of selenium exposure. They reside mainly in slow-water estuarine habitat and rely on the Asian clam and other mollusks as about one-third of their diet. Beckon expresses hope that the exposure of Sacramento splittail to selenium will diminish as the State Water Resources Control Board's Total Monthly Mean Load regulations for selenium are implemented.

Beckon and Maurer included the Delta smelt in their survey of selenium exposure to listed species. In the case of Delta smelt, there is disagreement in the literature about the role selenium exposure may play in the decline of Delta smelt abundance in the last decade or so. Beckon and Maurer (2008: 31) characterize the risk of selenium exposure by Delta smelt to be low. Delta smelt adults reach a maximum of about 4.7 inches in length. They feed on zooplankton, primarily which is not a significant selenium partitioning pathway into Delta food webs, but Delta smelt also consume aquatic insect larvae when available (McGinnis 2006: 197). Moreover, their spawning takes place in April and May in slow-water environments (e.g., side channels and sloughs) of the upper Delta and the lower Sacramento River in periods of low tidal activity. Beckon and Maurer (2008) report that Delta smelt larvae are "ecologically similar to larval and juvenile striped bass" in that they are not motile, but instead float in the water column where feeding occurs through random particle interactions.[7] (Bennett 2005: 18) Beckon and Maurer further note that Delta smelt obtained from the area of Chipps Island during the springs of 1993 (a wet year) and 1994 (a dry year, the seventh out of the previous eight) had whole body selenium concentrations of 1.5 μg/g dw (n=41, range from 0.7 to 2.3 μg/g dw; Beckon and Maurer 2008: 32), which are substantially lower than concentrations found in clams in the same region.

Delta smelt are known to prefer low salinity environments of from 2 to 7 parts per thousand salinity, such as is found in Suisun Bay and the northern and central Delta (McGinnis 2006). In drier years, the low salinity zone of the Delta estuary shrinks, however, and consequently Delta smelt habitat shrinks accordingly. Delta smelt eggs are spawned, fertilized, and attach initially during the April and May spawning season to the bottoms of slow-water hydrologic environments (e.g., backwaters in Table 7) prior to developing into larvae that then float in the water column in open water. These stages of Delta smelt life history take place in intimate proximity to hydrologic locations that are typical of selenium chemical speciation and partitioning, especially in lower flow

[7] Bennett has observed directly that in the water column Delta smelt larvae "swim continuously, and feeding success requires practically bumping into prey items rather than a coordinated attack behavior."

regimes. Beckon states that Delta smelt spawning sites are now found largely in the north Delta channels associated with "the selenium-normal Sacramento River." However, Beckon appears to base his assessment of Delta smelt risk on a 1996 US Fish and Wildlife Delta smelt recovery plan, stating that Delta smelt "are nearly absent from the south-Delta channels associated with the selenium-contaminated San Joaquin River." This assessment appears to ignore at least two consecutive years (2000 and 2001) in which thousands of Delta smelt were killed at the state and federal project's pumping plants in the south Delta during the winter. (Swanson 2001; Swanson 2002) Beckon does not report on what if any selenium sensitivity studies have been done on Delta smelt in the field or in laboratory conditions.

Presser and Luoma (2010b) and Beckon and Maurer (2008) both consider the Delta smelt to be at risk of selenium exposure in the Bay-Delta estuary. Presser and Luoma cite as reasons for its at-risk classification that its overall threatened status as an endemic Delta fish species, and the fact that it feeds on insect larvae that may take up selenium (2010b: Table 4, 8). They agree with Beckon that it does not feed in a clam-based food web since zooplankton are the more important component of Delta smelt diets. They write, "the sensitivity of delta smelt to selenium is unknown; population numbers are alarmingly low, so this species is particularly vulnerable to any adverse effect." (Presser and Luoma 2010b: Table 4, 8, footnote 10)

Presser and Luoma (2006) earlier concluded from their selenium loading projections that white sturgeon (an Endangered Species Act-listed species) and greater and lesser scaup, surf and black scoters are at risk of significantly elevated selenium exposure given these selenium loading projections. (Presser and Luoma 2006: Table 33: 93; 2010a; 2010b) White sturgeon is a migratory fish, while the scaups and scoters are migratory estuary-based water birds that dive to prey on clams and other bottom-dwelling organisms.

## IV. Regulation and the Future of the "Selenium Reservoir"

Presser and Luoma (2010a and 2010b) continue to develop a modeling methodology by which regulators may reasonably set protective water column selenium concentrations that are appropriate to the ecosystems and hydrologic environments that need protection. They examine a broad spectrum of environments and identify partitioning factors ($K_d$) that characterize the relative rates of selenium partitioning (wherein selenium comes out of solution into particulate phase, available for bioaccumulation into food webs). Their broad characterizations of hydrologic environments and food webs is summarized in Table 7 (above).

Their method links the detailed biogeochemistry of selenium in different environments to their food web relationships. Using these relationships, they expect to derive water column-based selenium criteria that link ecological relationships and hydrologic environments through which selenium moves. (Presser and Luoma 2010a: 704, 707) Selenium has multiple routes through which it can expose fish and wildlife to its toxicity.

Policy choices are critical when applying Presser and Luoma's selenium model to the setting of protective selenium criteria. See Appendix D for a chronology of selenium regulation in the Bay Delta Estuary and its Central Valley watershed.

> Policy choices such as 1) the predator species [meant] to represent an ecosystem (e.g., toxicologically sensitive, ecologically vulnerable based on food web, resident or migratory, commercially or esthetically valuable) and 2) the food web [used] to represent an ecosystem (e.g., potentially restored food webs in addition to current food webs) also serve as important initial inputs into the development of protective scenarios for a site or watershed. (Presser and Luoma 2010a: 707)

These potential policy choices illustrate some of the many options for key species and ecosystems needing protection. There are many sensitive species for whom selenium exposures and possible food web pathways to selenium exposure have not been identified. Two key listed species in the Delta for which either no or limited data are available are the Delta smelt and Chinook salmon, discussed above. They deserve consideration by the State Water Resources Control Board and the US Environmental Protection Agency as sensitive listed species whose protection should be an important foundation on which selenium regulation should be revised in the San Joaquin River Basin and the Bay-Delta Estuary. The Bay-Delta Water Quality Control Plan has not yet had specific criteria pertaining to toxic contaminants. C-WIN believes the time is long past due for the State Water Resources Control Board to integrate the management of toxic contaminant threats such as selenium into its Bay-Delta estuary regulatory framework.

A great risk to the Delta's future health and quality are systemic changes that are likely to lengthen the residence time of waters passing through the Bay-Delta Estuary on their way to the Pacific Ocean, and in so doing increase risks of selenium poisoning and ecological damage in the Bay-Delta Estuary (Presser and Luoma 2006, 2010). These risks originate with agricultural drainage accumulating in the San Joaquin River Basin due to irrigation of lands with soils impregnated with naturally occurring high selenium, salt, and other toxic contaminant concentrations and loads that must eventually be disposed of, else cultivation of western San Joaquin Valley lands will eventually go out of production.

There are three principal large-scale changes that each contribute to the prospect of increasing residence time in the Delta:

1) Construction and operation of a peripheral canal or tunnel that would change the point of diversion for the south Delta pumping plants of the state and federal projects to the inflows of the Sacramento River at a north Delta diversion.
2) Rising sea level in the Delta; and
3) Climate change affecting the volume, timing, and amount of inflows to the Bay-Delta Estuary from its major tributary watersheds, the Sacramento River Basin (including the Trinity River) and the San Joaquin River Basin

Under current hydrologic regimes, residence times of water in the south Delta and the North Bay can last from 16 days to three months in Suisun Bay during low flow, depending on levels of through-Delta discharge and mixing activity. (Presser and Luoma 2006: 17; Smith 1987; Presser and Luoma 2010: 707) Removal of Sacramento River flows from the Delta will result in less overall fresh water reaching central Delta channels, such as through Georgiana Slough (or via the Delta Cross Channel, a Central Valley Project facility that serves the same purpose to get fresh water across the central Delta to the pumping plants in the south Delta). To compensate, far more water would have to flow into the Delta from the San Joaquin River, but this river on average has the capability of delivering only a fraction of Sacramento River flows under unimpaired conditions.

While San Joaquin flows need to be increased from its major tributaries to provide dilution flows (discussed above and in the Instream Flows chapter below), the San Joaquin can never fully replace Sacramento river flow volumes or timing. As a result, longer residence times should be expected for water containing selenium even in current selenium Total Mean Monthly Load (TMML)-compliant concentrations. The longer the residence time of flows from the San Joaquin River, the more opportunity there is for selenium to transfer chemically from its dissolved phase to particulate forms and become "bio-available." Once it becomes bio-available, selenium is readily accumulated by aquatic food webs in low- or no-flow areas of the Delta and Suisun Bay. If San Joaquin River Restoration Program activities restoring floodplain and riparian habitat where slow-water environments are created for rearing juvenile salmon and steelhead and Sacramento splittail, these environments may also become sites for growing selenium exposure and its damaging ecological effects. It will be vital to keep flows moving to avoid selenium toxicity exposures in the lower San Joaquin River and south and central Delta regions.

Mud Slough (north) on the west side, the lower San Joaquin River, and Suisun Bay are hydrologically connected. Rising selenium levels threaten many species, including salmon, white sturgeon, green sturgeon, and migratory birds that feed on bottom-dwelling organisms like clams and worms burrowing through sediments where selenium collects. As Figure 9 shows[8], selenium concentrations in subsurface drain water in the San Joaquin River Basin exceed US Environmental Protection Agency aquatic selenium criterion for rivers and streams by 13 to 20 times (depending on whether the arithmetic or geometric mean is compared); by 32 to 50 times the aquatic criterion for westlands in California, and 130 to 200 times the level recommended as non-toxic in animal tissues by the US Geological Survey in recent research. (Presser and Luoma 2010, 2011; California Department of Water Resources 2010: see data in Table B-3, Appendix B, this testimony) This is the reservoir of selenium toxicity that builds up. Selenium regulation needs to catch up with this reality.

Sea level rise also poses toxic challenges to the Delta's future. With the water in Delta channels at present sea level, direct concerns focus on additional hydrostatic pressures that rising sea levels will place on Delta levees. For this discussion, however, sea level rise is likely to result in two other aspects of hydraulic pressures upstream of the Delta:

- Larger and deeper (hence heavier) volumes of tidally influenced sea water reaching the Delta is expected to slow the rate at which subsurface flows into the Delta from both the Sacramento and San Joaquin River Basins can drain into the Delta.
- Larger volumes of tidally influenced sea water in the Delta will also slow the rate at which surface inflows to the Delta from major tributary watersheds will reach the Delta. (This potential effect could be compounded if the Sacramento River is diverted in the North Delta for direct delivery to the south Delta pumps.) (Hanson, et al, 2012: Slide 42)

Slowing the escape of subsurface flows from the tributary valleys may result in slowed

[8] See Appendix B, Table B-3 for supporting data for Figure 8.

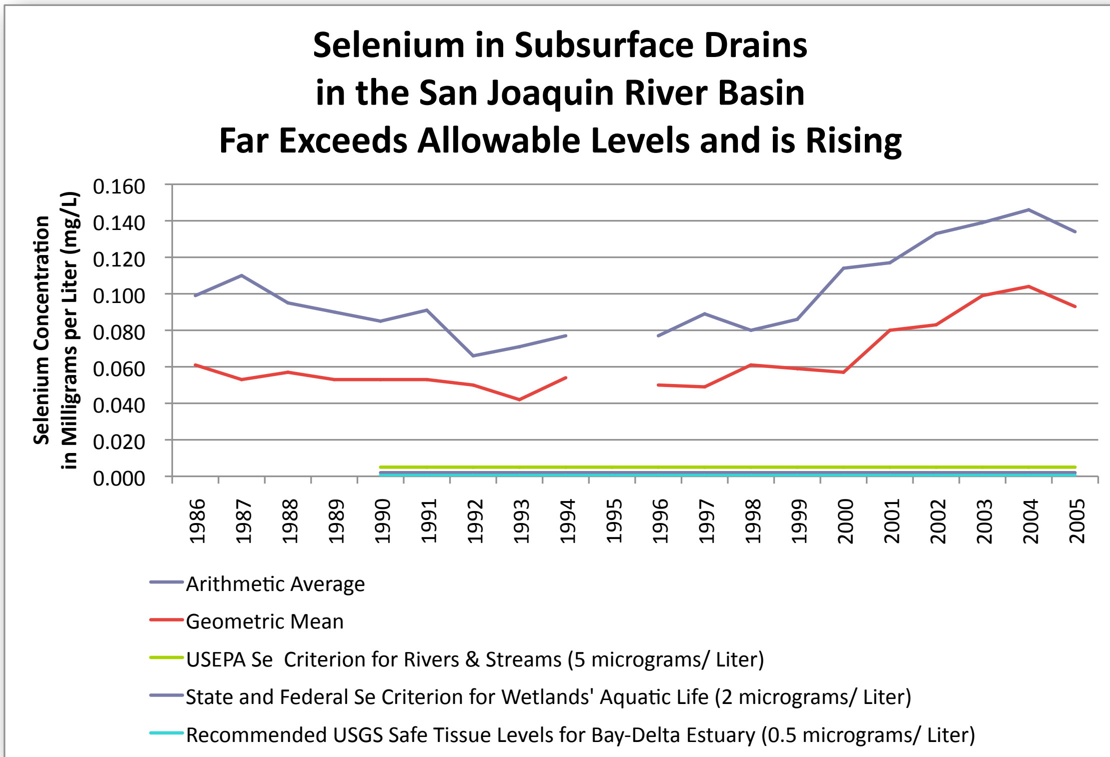


*Figure 9*
*Sources: California Department of Water Resources 2010; Presser and Luoma 2010, 2011.*

subsurface flow in both valleys, which could contribute to rising water table elevations. If groundwater elevations get to close to root zones, agricultural production can be disrupted. In areas where groundwater tables may be relatively deep, however, having them rise could be a benefit to some groundwater pumpers.

But in the San Joaquin River Basin, west side groundwater elevations are already very close to the surface, as discussed above. Having them rise further, with their saline and selenium-tainted water quality could be detrimental to irrigated cultivation in this part of the Basin.

This potential impact of climate change in the San Joaquin River Basin and the Delta would be further compounded by the trend, now seen in reduced snowpack and spring snowmelt, and increased rainfall and runoff. While extreme events like flooding and droughts may occur with greater frequency in the future in California, it is also anticipated that overall water supplies will decrease. In that event, residence time of waters in the Delta can be expected to increase as well with its implications of toxic damage in slow-water environments of the lower reaches of the San Joaquin River Basin and the Bay-Delta Estuary.

## References

Alquezar, R., S.J. Markich; and J.R. Twining. 2008. Comparative accumulation of $^{109}Cd$ and $^{75}Se$ from water and food by an estuarine fish (*Tetractenos glaber*). *Journal of Environmental Radioactivity* 99(1): 167-180.

Barnes, I. 1985. Sources of Selenium, in *Selenium and Agricultural Drainage: Implications for San Francisco Bay and the California Environment.* Proceedings of the Second Selenium Symposium, March 23, 1985, Berkeley, California, pp. 41-47.

Bauder, T.A., R.M. Waskom, P.L. Sutherland, and J.G. Davis. 2011. Irrigation Water Quality Criteria, Colorado State University Extension, "Salinity Hazard," Table 3, page 3. Accessible online at http://www.ext.colostate.edu/pubs/crops/00506.html.

Beckon, W.N. and T.C. Maurer. 2008. *Potential Effects of Selenium Copntamination on Federall-Listed Species Resulting from Delivery of Federal Water to the San Luis Unit*, prepared for U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office, Environmental Contaminants Division, for the US Bureau of Reclamation under Agreement #05AA210003, March, 46 pages. Accessible online at http://wwwrcamnl.wr.usgs.gov/Selenium/Library_articles/Beckon_and_Maurer_Effects_of_Se_on_Listed_Species_SLD_2008.pdf.

Bennett, W.A. 2005. Critical Assessment of the Delta Smelt Population in the San Francisco Estuary, California. *San Francisco Estuary and Watershed Science* 3(2), Article 1, September, 71 pages.

California Department of Public Works, Division of Water Resources. 1930. *Bulletin No. 23: Report of Sacramento-San Joaquin Water Supervisor for the Period 1924-1928*. Harlowe M. Stafford, Water Supervisor. 413 pages.

California Department of Water Resources. 1956. *Investigation of the Sacramento-San Joaquin Delta. Report No. 4, Quantity and Quality of Waters Applied to and Drained from the Delta Lowlands*, July, 30 pages.

California Department of Water Resources. 1965. *Bulletin No. 127: San Joaquin Valley Drainage Investigation: San Joaquin Master Drain*, Preliminary Edition, January, 41 pages.

California Department of Water Resources. 1974. *Bulletin 200: California State Water Project: Volume I: History, Planning, and Early Progress*, November, 173 pages.

California Department of Water Resources. 2006a. *Description of Department of Water Resources Compliance with State Water Resources Control Board Water Right Decision 1641*, Response to Senate Bill 1155 enacting California Water Code Section 138.10, January, 49 pages including appendices. Accessible online at http://baydeltaoffice.water.ca.gov/announcement/D1641_final.pdf.

California Department of Water Resources. 2007b. *Sources of Salinity in the South Sacramento-San Joaquin Delta,* Memo Report, Division of Operations and Maintenance, Environmental Assessment Branch, May, 46 pages.

California Department of Water Resources. 2010. *San Joaquin Valley Drainage Monitoring Program, 2003-2005 District Report*, December. 132 pages, including appendices. Accessible online at http://www.water.ca.gov/pubs/drainage/2003-2005_drainage_monitoring_report__san_joaquin_valley/sjv_dmr_2003-2005_final.webfile.pdf.

California Department of Water Resources. 2011. *Low Head Pump Salinity Control Study: Prepared to meet requirements of the State Water REsources Control Board Water Rights Order WR 2010-0002, Condition A.7.* Bay-Delta Office, April, 61 pages plus appendices. Accessible online at: http://www.swrcb.ca.gov/waterrights/water_issues/programs/bay_delta/docs/lhscs_rpt.pdf.

## References

California Regional Water Quality Control Board, Central Valley Region. 2000. *Selenium TMDL for Grasslands Marshes*. Staff Report, April. 13 pages. Accessible online at http://www.swrcb.ca.gov/rwqcb5/water_issues/tmdl/central_valley_projects/grasslands_se/grasslands_se_tmdl.pdf.

California Regional Water Quality Control Board, Central Valley Region. 2000. *Selenium TMDL for Grasslands Marshes*. Staff Report, April. 13 pages. Accessible online at http://www.swrcb.ca.gov/rwqcb5/water_issues/tmdl/central_valley_projects/grasslands_se/grasslands_se_tmdl.pdf.

California Regional Water Quality Control Board, Central Valley Region. 2001a. *Total Maximum Daily Load for Selenium in the Lower San Joaquin River*, August, 32 pages. Accessible online at http://www.swrcb.ca.gov/rwqcb5/water_issues/tmdl/central_valley_projects/san_joaquin_se/se_tmdl_rpt.pdf.

California Regional Water Quality Control Board, Central Valley Region. 2001a. *Total Maximum Daily Load for Selenium in the Lower San Joaquin River*, August, 32 pages. Accessible online at http://www.swrcb.ca.gov/rwqcb5/water_issues/tmdl/central_valley_projects/san_joaquin_se/se_tmdl_rpt.pdf.

California Regional Water Quality Control Board, Central Valley Region. 2001b. *Waste Discharge Requirements Order No. 5-01-234 for San Luis & Delta Mendota Water Authority and United States Department of the Interior, Bureau of Reclamation, Grassland Bypass Channel Project (Phase II), Fresno and Merced Counties*, September 21, 29 pages. Accessible online at http://www.swrcb.ca.gov/rwqcb5/board_decisions/adopted_orders/fresno/5-01-234.pdf.

California Regional Water Quality Control Board, Central Valley Region. 2006. *Salinity in the Central Valley: An Overview*, May, 131 pages. Accessible online at http://www.waterboards.ca.gov/centralvalley/water_issues/salinity/centralvalley_salinity_alternatives_archives/initial_development/swrcb_02may06_ovrvw_rpt.pdf.

California Regional Water Quality Control Board, Central Valley Region. 2010a. *Resolution No. R5-2010-0046 Amending the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for the Control of Selenium in the Lower San Joaquin River Basin*, 27 May. Accessible online at http://www.waterboards.ca.gov/centralvalley/board_decisions/adopted_orders/resolutions/r5-2010-0046_res.pdf.

California Regional Water Quality Control Board, Central Valley Region. 2010b. *Amendments to the Water Quality Control Plan for the Sacramento River andd San Joaquin River Basins to Address Selenium Control in the San Joaquin River Basin*, Final Staff Report, May, 61 pages. Accessible online at http://www.waterboards.ca.gov/centralvalley/water_issues/grassland_bypass/sac_sj_basins_salinity_staffrpt.pdf.

California Sportfishing Protection Alliance. 2010. *Comments on Draft Irrigated Lands Regulatory Program - Program Environmental Impact Report*. Joint letter To Pamela Creedon and Adam Laputz, California Regional Water Quality Control Board, Central Valley Region, with the California Water Impact Network, September 27, 63 pages.

California Water Impact Network. 2008. *Comments on the Draft Strategic Workplan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary.* Joint letter to the State Water Resources Control Board with California Sportfishing Protection Alliance, July 8, 25 pages.

California Water Impact Network. 2012. *Comment Letter—Bay-Delta Plan Supplemental NOP—Comprehensive Review*, addressed to Jeanine Townsend, Clerk to the Board, State Water Resources Control Board, April 25, co-signed by California Sportfishing Protection Alliance, AquAlliance, and Center for Biological Diversity, 28 pages. Accessible online at http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/bay_delta_plan/comments_042512/carolee_krieger.pdf.

## References

Central Valley Regional Water Pollution Control Board. 1953. *Pollution Study, Stanislaus River, San Joaquin River Watershed*, Sacramento, CA, 72 pages plus maps.

CH2M Hill. 2010. *Review of Available Technologies for the Removal of Selenium from Water*, prepared by Tom Sandy, P.E., and Cindy DiSante, P.E. for North American Metals Council. Accessible online at http://www.namc.org/docs/00062756.PDF.

Environmental Sciences Associates. 2004. *Broadview Water Contract Assignment Project Environmental Assessment/Finding of No Significant Impact,* prepared for US Bureau of Reclamation, April. Accessible online at http://www.c-win.org/webfm_send/195.

Environmental Working Group. 2011. *Throwing Good Money at Bad Land*, online report, accessible at http://ewg.org/Throwing-Good-Money-at-Bad-Land.

Gilliom, R.J. 1988. Geologic Source of Selenium and Its Distribution in Soil, in Gilliom, R.J.. and others. 1989. *Preliminary Assessment of Sources, Distribution, and Mobility of Selenium in the San Joaquin Valley, California*, US Geological Survey Water-Resources Investigations Report 88-4186, Regional Aquifer System Analysis, prepared in cooperation with the San Joaquin Valley Drainage Program, pp. 7-11.

Hanson, R., C. Faunt, M. Dettinger, and F. Munoz-Arriola. 2012. *Climate Data for CVHM [Central Valley Hydrologic Model]*. Presentation for US Bureau of Reclamation's Central Valley Hydrologic Modeling Workshop, Sacramento California, January 24th and 31st, 2012, 46 pages.

Hoffman, G.J. 2010. *Crop Salt Tolerance in the Southern Sacramento-San Joaquin River Delta*, Final Report for California Environmental Protection Agency, State Water Resources Control Board, Division of Water Rights, 137 pages. Accessible online at http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/bay_delta_plan/water_quality_control_planning/docs/final_study_report.pdf.

Howitt, R.E., J. Kaplan, D. Larson, D. MacEwan, J. Medellin-Azuara, G. Horner, and N.S. Lee. 2009. *The Economic Impacts of Central Valley Salinity.* University of California, Davis, Final Report to the State Water Resources Control Board Contract 05-417-150-0, March 20, approx. 200 pages. Accessible online at http://swap.ucdavis.edu/SWAPfiles/ReportsPapers/MainDocument_031909.pdf.

Jackson, W.T. and A.M. Paterson. 1977. *The Sacramento-San Joaquin Delta: The Evolution and Implementation of Water Policy: An Historical Perspective*, University of California, Davis, California Water Resources Center Contribution No. 163, June, 192 pages.

Kelley, R.L., and R.L. Nye. 1984. *Historical perspective on salinity and drainage problems in California*, in *California Agriculture* October, pp. 4-6. Accessible online at http://ucanr.org/repository/CAO/fileaccess.cfm?article=72377&p=ROVQYW&filetip=pdf.

Kilness, A.W. and J.L. Simmons. 1985. Toxic Effects of Selenium on Wildlife Species and Other Organisms, in *Selenium and Agricultural Drainage: Implications for San Francisco Bay and the California Environment.* Proceedings of the Second Selenium Symposium, March 23, 1985, Berkeley, California, pp. 52-59.

Kleckner A.E., A.R. Stewart, K. Elrick, and S.N. Luoma. 2010. *Selenium Concentrations and Stable Isotopic Compositions of Carbon and Nitrogen in the Benthic Clam* Corbula amurensis *from Northern San Francisco Bay, California: May 1995-February 2010*, US Geological Survey Open-File Report 2010-1252 34 pages. Accessible online at http://pubs.usgs.gov/of/2010/1252/.

## References

Lee, G.F. and A. Jones-Lee. 2003. *Synthesis and Discussion of Findings on the Causes and Factors Influencing Low DO in the San Joaquin River Deep Water Ship Channel near Stockton, CA: Including 2002 Data*, March, 284 pages. Accessible online at http://www.gfredlee.com/SynthesisRpt3-21-03.pdf.

Linville, R.G., S.N. Luoma, L. Cutter, and G.A. Cutter. Increased selenium threat as a result of invasion of the exotic bivalve *Potamocorbula amurensis* into the San Francisco Bay-Delta. *Aquatic Toxicology* 57: 51-64.

McGahan, J.C. 2010. *Waste Discharge Requirement Order No. 5-01-234, Long-Term Drainage Management Plan*, Drainage Coordinator, Grassland Area Farmers and San Luis Delta-Mendota Water Authority, letter to Rudy Schnagl, Central Valley Regional Water Quality Control Board, December 29, 16 pages. Accessible online at http://www.waterboards.ca.gov/centralvalley/water_issues/grassland_bypass/2010_longterm_drainage_plan.pdf.

McGinnis, S.M. 2006. *Field Guide to Freshwater Fishes of California*, revised edition, California Natural History Series No. 77, Berkeley, CA: University of California Press, 2006.

Monsen, N.E., J.E. Cloern, and J.R. Burau. 2007. Effects of Flow Diversions on Water and Habitat Quality: Examples from California's Highly Manipulated Sacramento-San Joaquin Delta, *San Francisco Estuary and Watershed Science* 5(3), Article 2, July, 16 pages. Available online at http://repositories.cdlib.org/jmie/sfews/vol5/iss3/art2.

Ohlendorf, H.M. 1985. Aquatic Birds and Selenium in the San Joaquin Valley, in *Selenium and Agric*

Presser, T.S. 1999. Selenium Pollution, in *Encyclopedia of Environmental Science*, ed. D.E. Alexander and R.W. Fairbridge, Kluwer Academic Publishers, pp. 554-556. Available online at http://wwwrcamnl.wr.usgs.gov/Selenium/Library_articles/TSPresserEncyclo.pdf.

Presser, T.S. and S.E. Schwarzbach. 2008. *Technical Analysis of In-Valley Drainage Management Strategies for the Western San Joaquin Valley*, US Geological Survey Open File Report 2008-1210. Accessible online at http://pubs.usgs.gov/of/2008/1210/.

Presser, T.S. and S.N. Luoma, 2010a. A Methodology for Ecosystem-Scale Modeling of Selenium, *Integrated Environmental Assessment and Management* 6(4): 685-710. Accessible online at http://www.epa.gov/region9/water/ctr/selenium-modeling_full.pdf.

Presser, T.S. and S.N. Luoma, 2010b. *Ecosystem-Scale Selenium Modeling in Support of Fish and Wildlife Criteria Development for the San Francisco Bay-Delta Estuary, California*, US Geological Survey Administrative Report, December, 46 pages. Accessible online, with attachments, charts and appendices, at http://www.epa.gov/region9/water/ctr/.

Roditi, H.A., and N.S. Fisher. 1999. Rates and Routes of trace elements uptake in zebra mussels. *Limnology and Oceanography* 44(7): 1730-1749.

Saiki, M.K. 1985. Concentrations of Selenium in Aquatic Food-Chain Organisms and Fish Exposed to Agricultural Tile Drainage Water, in *Selenium and Agricultural Drainage: Implications for San Francisco Bay and the California Environment.* Proceedings of the Second Selenium Symposium, March 23, 1985, Berkeley, California, pp. 25-32.

San Francisco Estuary Project. 1993. *Managing Freshwater Discharge to the San Francisco Bay/Sacramento-San Joaquin Delta Estuary: The Scientific Basis for an Estuarine Standard.* Conclusions and Recommendations of Members of the Scientific, Policy, and Management Communities of the Bay/Delta Estuary, 17 pages plus five appendices. Accessible online at http://www.epa.gov/region9/water/watershed/sfbay-delta/pdf/Schubel-Report.pdf.

## References

San Joaquin Valley Drainage Program. 1990. *A Management Plan for Agricultural Subsurface Drainage and Related Problems on the Westside San Joaquin Valley*. September, 183 pages. (Also known as the "Rainbow Report.") Accessible online at http://esrp.csustan.edu/projects/lrdp/documents/rainbowreport.pdf.

Schlekat, C.E., D.G. Purkerson, S.N. Luoma. 2004. Modeling selenium bioaccumulation through arthropod food webs in San Francisco Bay, California. *Environmental Toxicology and Chemistry* 23 (12): 3003-3010.

Sheridan, D. 1981. *Desertification of the United States*. White House Council on Environmental Quality, 142 pages.

Smith, L.H. 1987. *A Review of Circulation and Mixing Studies of San Francisco Bay, California*. US Geological Survey Open-File Report 87-534, 38 pages.

State Water Resources Control Board. 1968a. *Water Rights Decision 1308: In the Matter of Application 22316 by Unite States Bureau of Reclamation, Applicant; Delta Water Users Association, et al, Protestants, Rock Slough in Contra Costa County*, July 18; amended September 5, 1968; 24 pages. Accessible online at http://www.swrcb.ca.gov/waterrights/board_decisions/adopted_orders/decisions/d1300_d1349/wrd1308.pdf and amended order at http://www.swrcb.ca.gov/waterrights/board_decisions/adopted_orders/orders/1968/wro68_wrd1308.pdf.

State Water Resources Control Board. 1968b. Resolution No. 68-16 (Oct. 28,). Accessible online at http://www.waterboards.ca.gov/centralvalley/water_issues/salinity/laws_regs_policies/rs68-016.pdf.

State Water Resources Control Board. 1970. *Water Rights Decision 1356: In the Matter of Applications 18721, 18722, 18723, 21636, and 21637 by United States Bureau of Reclamation; Applicant M.V. and W.E. Holthouse, et al, Protestants; and In the Matter of United States Bureau of Reclamation for Release from Priority of Application 7936 in Favor of Applications 18723 and 21636 and of Application 7937 in Favor of Applications 18271, 18722, and 21637; Decision Approving Applications in Part and Granting Release from Priority*, February 5, 18 pages and amended order of December 17, 1970, 7 pages. Accessible online at http://www.swrcb.ca.gov/waterrights/board_decisions/adopted_orders/decisions/d1350_d1399/wrd1356.pdf and amended order at http://www.swrcb.ca.gov/waterrights/board_decisions/adopted_orders/orders/1970/wro70_wrd1356.pdf.

State Water Resources Control Board. 1985. *In the Matter of the Petition of Robert James Claus for Review of Inaction of California Regional Water Quality Control Board, Central Valley Region, Order No. WQ 85-1*, February 5, 65 pages. Accessible online at http://www.swrcb.ca.gov/board_decisions/adopted_orders/water_quality/1985/wq1985_01.pdf.

State Water Resources Control Board. 2000. *Revised Water Right Decision 1641: In the Matter of Implementation of Water Quality Objectives for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary; A Petition to Change Points of Diversion of the Central Valley Project and the State Water Project in the Southern Delta; and A Petition to Change Places of Use and Purposes of Use of the Central Valley Project*, December 29, 1999, revised in accordance with Order WR 2000-02, March 15, 193 pages. Accessible online at http://www.waterboards.ca.gov/waterrights/board_decisions/adopted_orders/decisions/d1600_d1649/wrd1641_1999dec29.pdf

## References

State Water Resources Control Board. 2006a. *Order WR 2006-0006: In the Matter of Draft Cease and Desist Order Nos. 262.31-16 and 262.31-17 Against the Department of Water Resources and the United States Bureau of Reclamation Under their Water Right Permits and License*, adopted February 15, 33 pages. Accessible online at http://www.waterboards.ca.gov/waterrights/board_decisions/adopted_orders/orders/2006/wro2006_0006.pdf.

State Water Resources Control Board. 2006b. *Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary*, December 13, 49 pages. Accessible online at http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/wq_control_plans/2006wqcp/index.shtml.

State Water Resources Control Board. 2010a. *Order WR 2010-0002: In the Matter of Cease and Desist Order WR 2006-0006 against the Department of Water Resources and the United States Bureau of Reclamation in Connection with Water Right Permits and License for the State Water Project and Central Valley Project, Order Modifying Order WR 2006-0006*, 27 pages. Accessible online at http://www.waterboards.ca.gov/waterrights/board_decisions/adopted_orders/orders/2010/wro2010_0002.pdf.

State Water Resources Control Board. 2011d. *Technical Report on the Scientific Basis for Alternative San Joaquin River Flow and Southern Delta Salinity Objectives*. October, 170 pages, including appendices. Accessible online 6 December 2011 at http://www.swrcb.ca.gov/water_issues/programs/peer_review/docs/sanjoaquin_river_flow/technical_report.pdf.

State Water Rights Board. 1958. *Water Rights Decision 893: In the Matter of Applications 12140, et al, [and other applications by the City of Sacramento and other applicants to appropriate water of the American River and its tributaries].* March 18. 76 pages. Accessible online at http://www.swrcb.ca.gov/waterrights/board_decisions/adopted_orders/decisions/d0850_d0899/wrd893.pdf.

State Water Rights Board. 1959. *Decision No. D-935: In the Matter of Applications 234, 1465, 5638, 5817,5818, 5819, 5820, 5821, 5822, and 9369, United States of America; Applications 6771, 6772, 7134, and 7135, City of Fresno; Application 6733, Fresno Irrigation District; and in the Matter of Petitions to Change the Point of Diversion and Place of Use under water right License 1986 (Application 23) of United States of America*, June 5, 109 pages. Accessible online at http://www.swrcb.ca.gov/waterrights/board_decisions/adopted_orders/decisions/d0900_d0949/wrd935.pdf.

State Water Rights Board. 1961a. *Water Rights Decision 990: In the Matter of Applications 5625, 5626, 9363, 9364, 9365, 9366, 9367, 9368, and 10588, United States of America Bureau of Reclamation, Applicant, and Sacramento River and Delta Water Association, Protestants*. February 9, 90 pages. Accessible online at http://www.swrcb.ca.gov/waterrights/board_decisions/adopted_orders/decisions/d0950_d0999/wrd990.pdf.

State Water Rights Board. 1961b. *Water Rights Decision 1020: In the Matter of Application 15764, United States of America, Bureau of Reclamation, Applicant; and Union Properties, Inc., et al, Protestants*, June 30. Accessible online at http://www.swrcb.ca.gov/waterrights/board_decisions/adopted_orders/decisions/d1000_d1049/wrd1020.pdf.

State Water Rights Board. 1961c. *Water Rights Decision 1100: In the Matter of Applications 18115 and 19451 of the United States Bureau of Reclamation to Appropriate from Stony Creek in Tehama County (Decision Approving Application 18115 in Part and Denying Application 19451)*, September 26, 18 pages. Accessible online at http://www.swrcb.ca.gov/waterrights/board_decisions/adopted_orders/decisions/d1100_d1149/wrd1100.pdf.

## References

State Water Rights Board. 1966. *Water Rights Decision 1250: In the Matter of Application 21542: United States Bureau of Reclamation to Appropriate from Old River in Alameda County*, June 1, 7 pages. Accessible online at http://www.swrcb.ca.gov/waterrights/board_decisions/adopted_orders/decisions/d1250_d1299/wrd1250.pdf.

Stewart, A.R., S.N. Luoma, C.E. Schlekat, M.A. Doblin, and K.A. Hieb. 2004. Food Web Pathway Determines How Selenium Affects Aquatic Ecosystems: A San Francisco Bay Case Study. *Environmental Science and Technology* 38: 4519-4526.

Strauss, A. 2011. *Letter to Tom Howard, Executive Director, State Water Resources Control Board*, Director, Water Division, US Environmental Protection Agency, Region IX, San Francisco, 3 pages. Accessible online at http://www.c-win.org/webfm_send/227.

Swanson, C. 2001. The State of the Environmental Water Account, Bay Institute of San Francisco, 39 pages. Accessible online at http://www.bay.org/assets/EWA01-4.pdf

Swanson, C. 2002. The State of the Environmental Water Account, Bay Institute of San Francisco, 33 pages. Accessible online at http://www.bay.org/assets/EWA2002.pdf

Sylvester, M.A. 1985. Results of U.S. Geological Survey Studies Pertaining to the Agricultural Drainage Problem of the Western San Joaquin Valley, in *Selenium and Agricultural Drainage: Implications for San Francisco Bay and the California Environment.* Proceedings of the Second Selenium Symposium, March 23, 1985, Berkeley, California, pp. 34-40.

Tidball, R.R., R.C. Severson, J.M McNeal, and S.A. Wilson. 1986. "Distribution of Selenium, Mercury, and Other Elements in Soils of the San Joaquin Valley and Parts of the San Luis Drain Service Area, California," in A.Q. Howard, ed., *Selenium and Agricultural Drainage: Implications for San Francisco Bay and the California Environment*, Proceedings of the Third Selenium Symposium, March 15, Berkeley, California, pages 71-82.

Tidball, R.R., R.C. Severson, J.M McNeal, and S.A. Wilson. 1986. "Distribution of Selenium, Mercury, and Other Elements in Soils of the San Joaquin Valley and Parts of the San Luis Drain Service Area, California," in A.Q. Howard, ed., *Selenium and Agricultural Drainage: Implications for San Francisco Bay and the California Environment*, Proceedings of the Third Selenium Symposium, March 15, Berkeley, California, pages 71-82.

United States Bureau of Reclamation and San Luis & Delta-Mendota Water Authority. 2009. *Final Environmental Impact Statement/Environmental Impact Report on Grassland Bypass Project, Appendix E.2: Selenium Ecological Risk Assessment*, 12 pages.

United States Bureau of Reclamation. 1991. *San Luis Unit Drainage Program, Central Valley Project, Draft Environmental Impact Statement*, Filed December 20th. 290 pages including appendices.

United States Bureau of Reclamation. 2005. Draft Environmental Impact Statement on the San Luis Drainage Feature Re-Evaluation, Mid-Pacific Region, Sacramento, California, May, 1,591 pages. Accessible online at http://www.usbr.gov/mp/sccao/sld/docs/index.html.

United States Bureau of Reclamation. 2006. Final Environmental Impact Statement on the San Luis Drainage Feature Re-Evaluation, Mid-Pacific Region, Sacramento, California, Accessible online at http://www.usbr.gov/mp/sccao/sld/docs/index.html.

United States Bureau of Reclamation. 2008. *San Luis Drainage Feature Re-evaluation Feasibility Report*, March, 104 pages, plus appendices. Accessible online at http://www.usbr.gov/mp/sccao/sld/docs/sldfr_report/index.html.

## References

United States Bureau of Reclamation. 2011b. *Reclamation Awards Nearly $3 Million in CALFED Water Use Efficiency Grants*, Media Release, October 18, 2 pages. Accessible online at http://www.usbr.gov/newsroom/newsrelease/detail.cfm?RecordID=38023.

United States Bureau of Reclamation. 2011b. *Special Study: Evaluation of Dilution Flow to Meet Interior South Delta Water Quality Objectives: To Meet Water Rights Order 2010-002 Requirement 7*, April 8, 47 pages plus appendices. Accessible online at http://www.swrcb.ca.gov/waterrights/water_issues/programs/bay_delta/docs/spcl_stdy1.pdf for Main Report through Appendix C and http://www.swrcb.ca.gov/waterrights/water_issues/programs/bay_delta/docs/spcl_stdy2.pdf for Appendices D through G.

United States Court of Federal Claims. 2012. Complaint of Westlands Water District in *Westlands Water District v. The United States*. Case 1:12-cv-00012-ECH, Document 1, 58 pages.

United States Department of the Interior, Bureau of Reclamation. 1939. *Contract for Exchange of Waters*, August 26, Contract Symbol Il r 1144, 18 pages.

United States Department of the Interior, Bureau of Reclamation. 1956. *Amended Contract for Exchange of Waters*, March 17, Contract Symbol Il r 1144 Amendatory, 47 pages, with Exhibit A: Map of the service areas of Central California Irrigation District, Columbia Canal Company, San Luis Canal Company, Firebaugh Canal Company, State Game Refuge.

United States Department of the Interior, Bureau of Reclamation. 1968. *Second Amended Contract for Exchange of Waters*, February 14, Contract Symbol Il r 1144 Second Amendatory, 34 pages, with Exhibit A Map of the service areas of Central California Irrigation District, Columbia Canal Company, San Luis Canal Company, Firebaugh Canal Company, State Game Refuge.

United States District Court for the Eastern District of California. 2011. *Supplemental Declaration of Donald R. Glaser re: Revised Control Schedule in the case of Firebaugh Canal Water District and Central California Irrigation District v. United States of America et al*. Case 1:88-cv-00634-LJO-DLB Document 921-1, filed November 4, 7 pages. Accessible online at http://www.c-win.org/webfm_send/226.

United States Water and Power Resources Service and South Delta Water Agency. 1980. *Effects of the CVP [Central Valley Project] Upon the Southern Delta Water Supply, Sacramento-San Joaquin River Delta, California*, June, 179 pages.

Water Education Foundation. n.d. Westside Resource Conservation District, maps of selenium and salinity impacted soils. 5 pages. Accessible online at http://www.watereducation.org/userfiles/WestsideResourceConservationDistrict.pdf.

Enhanced Delta Flows Needed to Help Control
Water Quality Impacts of Delta Pollutants

Testimony for CA State Water Resources Control Board Public Workshop:
Comprehensive (Phase 2) Review & Update to Bay-Delta Plan
Workshop 1: Ecosystem Changes and the Low Salinity Zone
September 5, 2012

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August 17, 2012

**Synopsis**

**Overall Finding:**
**In establishing Public Trust flows into and through the Delta channels, the SWRCB should incorporate flow levels necessary for mitigating water quality impacts of Delta pollutants.**

**Issue 1:**
It is important to establish tributary flow into the Delta and through the Delta channels that is sufficient to minimize water quality impacts of pollutants discharged to the Delta tributaries and within the Delta

- Delta waters are polluted with wide variety of known regulated, as well as known unregulated, and unrecognized pollutants from agricultural tailwater and stormwater discharges, municipal wastewater, and stormwater runoff that are a threat to Delta water quality – aquatic life, other beneficial uses, and protection of the Public Trust Resource
- Clean Water Act pollution control approach will not adequately control pollution of Delta waters from agricultural and urban sources
    - Clean Water Act approach based on exceedance of water quality objectives (WQOs) and establishment of total maximum daily loads (TMDLs) for known, regulated pollutants
        - Applicable to known, regulated pollutants from discrete readily controllable sources
            - Some pollutants in Delta are:
                - known pollutants but not regulated by water quality objectives
                - presently unrecognized pollutants – new and expanded-use chemicals
                - not amenable to cost-effective control
            - Inadequate screening of chemicals and materials that can be in urban and agricultural wastes/runoff added to Delta waters
            - Impacts of some pollutants in Delta greatly affected by flow
    - Inadequate scope of monitoring and funding
    - No water quality criteria, standards, objectives for all known and potential pollutants
- CVRWQCB "balance" approach to reduce cost of pollution control for discharges from irrigated agriculture and dairies allows pollution of SJR and Delta waters
- Impact of Flow on low-DO problem in Delta
    - Low SJR flow through DWSC is major cause of DO WQO violations

- Low DO in SJR DWSC
  - blocks fall run of Chinook salmon to home stream waters
  - associated with & exacerbated by diversions of Delta flow by export projects
  - will be essentially eliminated by establishment of adequate SJR DWSC flow of about 1,000 cfs, which will greatly reduce the cost of other measures for controlling the low-DO WQO violations
- South Delta low-DO problem
  - DWR export project and its channel barriers
    - create stagnant zones in South Delta channels
    - result in violations of DO WQO
    - cause/contribute to documented fish kills
- Current federal and state water diversion projects in South Delta cause loss of SJR watershed home-stream water signal to guide fall-run of Chinook salmon to home stream for spawning

- SWRCB and IEP Delta monitoring to assess impacts of South Delta water export projects under D-1641 grossly inadequate to evaluate the impacts of the Delta water export on Delta water quality
  - Must understand and monitor the impacts of altering Delta flows on Delta water quality as part of implementing Water Rights permit

Conclusions:

- Dilution-flows into and through the Delta channels are needed to reduce impacts of regulated pollutants, unregulated known pollutants, and unrecognized pollutants in Delta waters

Recommended Approach:

- Implement Clean Water Act pollution control approach to the maximum extent possible based on reliable technical information and assessment, and available funding
- Establish Public Trust flows in the Delta that are sufficient to help reduce the impacts of inadequately controlled pollutants

**Issue 2:**
The proposed BDCP tunnel Sacramento River diversion project has the potential to result in significant adverse impacts on water quality/beneficial uses in Delta channels and Delta Public Trust resources.

- Thus far the BDCP and Delta Stewardship Council Plan have not adequately addresses this issue
- Diversion project should not proceed until the potential impacts of the alterations in Delta channel flows on water quality in the Delta are fully known.

As part of consideration of Delta flow alterations, such as the BDCP-proposed tunnel diversion of Sacramento River water under the Delta, it is critical to:

- evaluate the impacts of the proposed flow alterations on water quality in the Delta channels and Delta, and
- adequately mitigate for adverse impacts on flows and water quality in Delta channels

The impact of this diversion project must be closely, **independently** monitored and corrective action should be implemented if major adverse impacts on Delta water quality begin to result from the BDCP tunnel diversion project

**Qualifications of G. Fred Lee:**

- 5 decades of research documented in more than 1,100 publications, many of which can be downloaded from www.gfredlee.com
- More than 20 years of investigation on Delta water quality documented in about 100 professional papers and reports
- Detailed qualifications described at www.gfredlee.com

## Discussion

### Introduction

This testimony provides an overview of some of the ways in which flow into and through the Delta impacts the manifestation of water quality problems in the Delta, and how manipulation of that flow, such as would occur with the proposed Sacramento River tunnel diversion project, can be expected to exacerbate those problems. It addresses technical foundation for the importance of establishing adequate flow into the Delta and through the Delta channels as a valuable component in minimizing water quality impacts of known, unregulated, and unrecognized pollutants discharged to Delta tributaries and within the Delta. It summarizes information and findings we have discussed in more than 100 professional papers and reports we have written during our more than two decades of work on Delta water quality issues; much of that work has focused on understanding how the flow in the Delta channels and tributaries impacts Delta water quality/aquatic life-related beneficial uses. Citations are provided to selected pertinent professional publications, reports, and comments that we have published (which contain references to other professionals' work as well) on the issues raised.

Dr. Lee anticipates highlighting key elements of this written testimony at the State Water Resources Control Board (SWRCB) hearing on "Developing Flow Criteria for Protection of the Public Trust Aquatic Life Resources of the Delta." There he will also note technical inadequacies and unreliability of recent discussions of Delta flow/water quality issues provided by the BDCP consultant and Delta Stewardship Council staff.

It is critical that the planning and implementation of the proposed changes in the flow into and through the Delta include technically reliable evaluation of the impacts of the proposed manipulations on Delta water quality/beneficial uses. As part of establishing Public Trust protection of the designated beneficial uses of the Delta, it is essential that the SWRCB establish adequate flows into the Delta and within the Delta channels to enable reliable protection of water quality/beneficial uses through the dilution and more-rapid transport of pollutants in the Delta.

In establishing appropriate Delta flow objectives, the SWRCB should include consideration of benefits of enhanced Delta tributary flows into the Delta and in-channel flows for mitigating water quality impacts of Delta pollutants. The Sacramento San Joaquin Delta contains some known but unregulated pollutants, presently unrecognized pollutants, as well as regulated pollutants, that are impairing the aquatic-life-related and other beneficial uses of the Delta and its tributaries. Enhanced water flow through the Delta provides important dilution to reduce the concentrations of those pollutants and hence their impacts on aquatic life. Enhanced flows also contribute to protection of water quality by shortening the residence time of pollutants in the Delta, and by reducing the areas over which pollutants exert adverse impacts.

It can be argued that enhancing Delta flows for this purpose is tantamount to the control of water pollution through dilution, and that it is more appropriate to control pollutants in the Delta at their sources. However, the reality is that it is doubtful that agricultural and municipal sources of pollutants to the Delta can be controlled through the current Clean Water Act–TMDL approach of identifying violations of water quality criteria/standards and implementing workable TMDLs that can, in fact, eliminate the causes of water quality impairment.   This is true even for known, regulated pollutants from point sources in the Delta.  Even less likely is the ability to control, in the foreseeable future, point sources of presently unregulated and/or unrecognized pollutants to the Delta that impact water quality near the source much less within the Delta channels where pollutants from a number of sources are mixed.   Further, and most important with regard to Delta water quality, while the Clean Water Act water quality criteria/standards–TMDL approach has been somewhat effective for controlling a number of known, regulated pollutants from municipal and industrial wastewater sources, it is not effective in controlling nonpoint sources of pollutants in agricultural tailwater and stormwater runoff sources or in urban stormwater runoff.

The importance of the amount of flow in Delta channels in influencing water quality in Delta channels became clear to us as we became involved in reviewing Delta water quality issues in 1989.   Since that time we have developed about 100 professional papers and reports on Delta water quality issues, many of which specifically address impacts of Delta flows on water quality in Delta channels; a summary of those publications is presented in:

> Lee, G. F., and Jones-Lee, A., "Experience in Reviewing Delta Water Quality Issues," G. Fred Lee & Associates, El Macero, CA, April 3 (2011).
> http://www.gfredlee.com/SJR-Delta/GFLAJL-Delta-EXP-REV.pdf

Presented herein is a summary of a number of key issues with particular reference to post-August 2010 activities that reflect inadequacies in consideration of the impact of Delta flow on water quality.

**Previous Comments on Delta Flow Water Quality Issues**

We became aware of impacts of Delta flow on Delta water quality in 1989 when, as consultants to the Delta Wetlands Delta Island water storage project, we reviewed Department of Water Resources (DWR) and US Geological Survey (USGS) data and observed the marked differences in pollutant concentrations in Delta channels.  It was clear that with Delta water as their supply, the proposed island storage reservoirs would release poor-quality water.

In the late 1990s, as advisors to the San Joaquin River Dissolved Oxygen TMDL Steering Committee, we became involved in reviewing the low dissolved oxygen (DO) problem in the San Joaquin River (SJR) Deep Water Ship Channel (DWSC) near the Port of Stockton.  That committee and CALFED selected us to serve as the principal investigators for the CALFED-supported, $2-million, two-year Low-DO Project.  In that capacity we coordinated the studies of the 12 project investigators on various aspects of the causes of the low DO in the DWSC and developed overall project synthesis reports.  As discussed in our synthesis report cited below, that work revealed that low flow in the SJR through the DWSC was a key factor contributing to the low-DO conditions in the DWSC.

> Lee. G. F., and Jones-Lee, A., "Synthesis and Discussion of Findings on the Causes and Factors Influencing Low DO in the San Joaquin River Deep Water Ship Channel near Stockton, CA: Including 2002 Data," Report Submitted to SJR DO TMDL Steering Committee/Technical Advisory Committee and CALFED Bay-Delta Program, G. Fred Lee & Associates, El Macero, CA, March (2003).  http://www.gfredlee.com/SJR-Delta/SynthesisRpt3-21-03.pdf

Lee, G. F. and Jones-Lee, A., “San Joaquin River Deep Water Ship Channel Low DO Problem and Its Control,” PowerPoint slides presented at SETAC World Congress Portland, OR, November 2004. Updated December (2004). http://www.gfredlee.com/SJR-Delta/LowDOSummaryDec2004.pdf

Following the completion of the synthesis report we developed a series of supplemental reports, including the report cited below, that specifically addressed the impact of the flow in the SJR through the DWSC on the magnitude, extent, and location of the low-DO problem.

Lee, G. F. and Jones-Lee, A., “Supplement to Synthesis Report on the Low-DO Problem in the SJR DWSC,” Report of G. Fred Lee & Associates, El Macero, CA, June (2004). http://www.gfredlee.com/SJR-Delta/SynthRptSupp.pdf

In August 2004, with the aid of the Deltakeeper’s boat and staff, we also conducted a series of cruises on the South Delta channels to specifically examine South Delta channel flow patterns relative to the flows of the SJR and Sacramento River in those channels. Our reports on that work include:

Lee, G. F., and Jones-Lee, A., "Impact of State and Federal Delta Water Export Projects on Delta Water Quality and Aquatic Resources: Issues That Need to Be Addressed," Report of G. Fred Lee & Associates, El Macero, CA, October (2004). http://www.gfredlee.com/SJR-Delta/ImpactDelExpProj.pdf

Several other reports of ours on these issues are posted on our website, www.gfredlee.com, in the Watershed Studies – San Joaquin River Watershed–Delta subsection, http://www.gfredlee.com/psjriv2.htm.

It was clear from our studies that the low-DO problem in the DWSC is due in part to low flow in the SJR through the DWSC. It was also well-established that the state and federal export projects in the South Delta were a major contributor to the low flows of the SJR through the DWSC that led to low DO in the DWSC. We found that as long as the flows of the SJR through the DWSC were above about 1,200 cfs low DO conditions did not develop in the DWSC.

The low-flow-related low-DO problems that have been documented in the SJR DWSC have also been found to occur in the South Delta channels, especially the southern-most Old River channel. The DWR Banks export pumps of the state water project have been found to draw water from the South Delta channels faster than that water is replaced by natural flow. This results in the lowering of water levels in the channels to a sufficient extent to prevent Delta island agricultural water intakes from drawing water from the channels. The low water levels in some of the channels also inhibit recreational boating. In an effort to try to correct that problem, in the summer DWR constructs temporary rock barriers across several South Delta channels to maintain water levels in the channels. Those barriers, however, also limit flow through some of the South Delta channels, which increases the residence time of the water as well as of oxygen-demand loads developed from increased algal growth supported by algal nutrients and longer residence times. This situation is especially acute in the southern most section of the Old River channel where violations of the DO water quality objective frequently occur. During our August 2004 DeltaKeeper-supported cruise on the Old River channel we observed a large number of dead fish floating on the water’s surface. Based on the records of a nearby water quality monitoring station, the DO in the Old River channel near the fish kill had been near zero for several hours the night before the fish kill. In order to correct such problems it will be necessary to establish and maintain sufficient flow through that channel to reduce the residence time of water in the channel.

We also found through our supplemental studies of the South Delta channels that the state and federal export projects' pumps bring Sacramento River water into the South Delta through SJR DWSC to Columbia Cut and especially Turner Cut. The drawing of high-quality Sacramento River water into the South Delta by the export projects has been a major factor limiting the extent and duration of the low-DO problem in the DWSC to Turner and Columbia Cuts. It also greatly improves the quality of the water in the South Delta channels compared with that which would be present if only the much poorer-quality SJR water were present in those channels. The water of the SJR contains high concentrations of a number of pollutants from agricultural tailwater and stormwater runoff discharges. We have developed several reports that discuss these SJR water quality issues, including the following:

> Lee, G. F., Jones-Lee, A., "San Joaquin River Water Quality Issues," Report of G. Fred Lee & Associates, El Macero, CA, June (2006). http://www.gfredlee.com/SJR-Delta/sjr-WQIssues.pdf

> Lee, G. F., and Jones-Lee, A., "Water Quality Issues of Irrigated Agricultural Runoff/Discharges—San Joaquin River, Central Valley, California," Presented at Agriculture and the Environment - 2007 Conference, Central Coast Agricultural Water Quality Coalition, Monterey, CA, November (2007). http://www.gfredlee.com/SJR-Delta/SJR-WQ-Ag-Monterey.pdf

> Lee, G. F., and Jones-Lee, A., "Potential Water Quality Impacts of Agriculture Runoff/Discharges in the Central Valley of California," Presented at Central Coast Agricultural Water Quality Coalition's 2007 National Conference on Agriculture & the Environment, Monterey, CA, PowerPoint Slides, G. Fred Lee & Associates, El Macero, CA, November (2007). http://www.gfredlee.com/SJR-Delta/SJRAgImpactsMontereyNov2007.pdf

Those papers/reports and others on our website also discuss current violations of water quality objectives and known pollutants in the SJR that are adversely impacting SJR and Delta water quality, unregulated pollutants in the SJR for which water quality objectives have not been established, and other potential pollutants in the SJR that have not yet been identified as chemicals that are impairing SJR/Delta water quality.

**Delta Water Quality Issues**

During the year following the completion of the SJR DWSC synthesis report we developed the following, unsponsored, comprehensive report concerning water quality in the Delta:

> Lee, G. F. and Jones-Lee, A., "Overview of Sacramento-San Joaquin River Delta Water Quality Issues," Report of G. Fred Lee & Associates, El Macero, CA (2004). http://www.gfredlee.com/SJR-Delta/Delta-WQ-IssuesRpt.pdf

A number of key elements of that overview that are pertinent to this testimony are described below.

- That overview report, based on our review of Central Valley Regional Water Quality Control Board (CVRWQCB), SWRCB, and US Environmental Protection Agency (US EPA) reports of violations of water quality objectives that have been found in Delta Channel waters, was the first comprehensive report on Delta water quality to focus on known violations of water quality standard in the Delta. Dr. Lee's five decades of professional expertise and experience in the development and implementation of water quality criteria and state water quality standards, and their appropriate use (as well as common misuse) for the evaluation and regulation of water quality are summarized in:

    G. Fred Lee and Anne Jones-Lee Expertise and Experience in Water Quality Standards and NPDES Permits Development and Implementation into NPDES Permitted Discharges http://www.gfredlee.com/exp/wqexp.htm

    Lee, G. F., and Jones-Lee, A., "Clean Water Act, Water Quality Criteria/Standards, TMDLs, and Weight-of-Evidence Approach for Regulating Water Quality," Water Encyclopedia: Water Law and Economics, Wiley, Hoboken, NJ, pp 598-604 (2005). http://www.gfredlee.com/SurfaceWQ/WileyCleanWaterAct.pdf

    Lee, G. F. and Jones-Lee, A., "Appropriate Use of Numeric Chemical Water Quality Criteria," Health and Ecological Risk Assessment, 1:5-11 (1995). http://www.gfredlee.com/SurfaceWQ/chemcri.htm

- Our overview also addressed known pollutants in the Delta that are adversely impacting Delta water quality but for which water quality objectives have not been established, and other potential pollutants in the SJR and Delta that have not yet been identified as chemicals that are impairing SJR/Delta water quality. As discussed below, because of this wide array of recognized as well as undefined pollutants that are not amenable to straightforward regulation, it is important to maintain high flows into and through the Delta channels in order to reduce their impacts on Delta water quality.

- During 2004 Dr. Lee was appointed to a panel to review the Interagency Ecological Program (IEP) monitoring program that, according to its charge by SWRCB Water Right Decision D-1641, was supposed to evaluate the impacts of the South Delta water diversions by the state and federal export projects on aquatic resources of the Delta. In the panel discussions Dr. Lee noted that the current IEP monitoring program was not addressing the issues of its charge; the SWRCB member of the review panel was aware of this deficiency in the IEP D-1641 Delta monitoring program. It became evident that water diversions by the state and federal export projects were allowed to take place without proper evaluation of their impacts on water quality/beneficial uses of the Delta.

Our writings concerning impacts of flow diversions on Delta water quality include:

    Lee, G. F., and Jones-Lee, A., "Impact of SJR & South Delta Flow Diversions on Water Quality," PowerPoint Slides, Presentation to CA Water Resources Control Board, D1641 Water Rights Review, January 24 (2005). http://www.gfredlee.com/SJR-Delta/D1641SlidesSWRCBJan2005.pdf

Lee, G., F., and Jones-Lee, A., "Need for Reliable Water Quality Monitoring/Evaluation of the Impact of SWRCB Water Rights Decisions on Water Quality in the Delta & Its Tributaries," PowerPoint Slides Submitted to CA Water Resources Control Board Workshop on D-1641 Water Rights, Sacramento, CA, March 22 (2005). http://www.gfredlee.com/SJR-Delta/DeltaWaterExportImpactsPowerPoint.pdf

Lee, G., F., and Jones-Lee, A., "Need for Reliable Water Quality Monitoring/Evaluation of the Impact of SWRCB Water Rights Decisions on Water Quality in the Delta and Its Tributaries," Submitted to CA Water Resources Control Board Workshop on D-1641 Water Rights, Sacramento, CA, March 22 (2005). http://www.gfredlee.com/SJR-Delta/DeltaWaterExportImpactsPaper.pdf

- Our 2004 Delta water quality overview report also discussed the fact that that CALFED program was not addressing the impacts of pollutants in the Delta on aquatic life resources of the Delta. Except for supporting the SJR DWSC low-DO project driven by political pressure, CALFED had no program to evaluate the impacts of the large number of well-documented pollutants in Delta waters on aquatic life. Rather, the CALFED "water quality" program was directed solely toward improving the quality of Delta water that was to be exported to municipalities for domestic water supply use.

- Our 2004 Delta water quality report discussed significant inadequacies in the water quality monitoring program for Delta waters. While several years earlier a CALFED committee had developed a proposed water quality monitoring program, it was never funded. The CVRWQCB recognized many of the deficiencies in its water quality monitoring and management program for the Delta but efforts to correct those deficiencies were also not funded. It was not until 2005, associated with the pelagic organism decline (POD), that attention began to be devoted to addressing those deficiencies. Even today, however, the monitoring of Delta waters for water quality impacts of pollutants is far less than needed to begin to develop the data required to understand the impacts of flow alterations on water quality. The CVRWQCB is now attempting to develop, and identify funding for, a comprehensive Delta water quality monitoring program similar to that being conducted in the San Francisco Bay. It will be important that such a program include studies of the impacts of Delta channel flows on Delta water quality. Information on that CVRWQCB Delta water quality monitoring program is available at: http://www.waterboards.ca.gov/rwqcb5/water_issues/delta_water_quality/comprehensive_monitoring_program/index.shtml

- We have developed several follow-up reports to our 2004 overview concerning Delta water quality issues, including:

Lee, G. F., and Jones-Lee, A., "Overview—Sacramento/San Joaquin Delta Water Quality," Presented at CA/NV AWWA Fall Conference, Sacramento, CA, PowerPoint Slides, G. Fred Lee & Associates, El Macero, CA, October (2007). http://www.gfredlee.com/SJR-Delta/DeltaWQCANVAWWAOct07.pdf

Lee. G. F., "Comments on the CVRWQCB Review of Delta Water Quality Issues," Comments submitted to K. Longley, Chair Central Valley Regional Water Quality

Control Board, by G. Fred Lee & Associates, El Macero, CA, March (2008). http://www.gfredlee.com/SJR-Delta/DeltaIssuesLongleyMarch08.pdf

Lee, G. F., "New & Updated Presentations/Publications on Delta and SJR Water Quality Issues," Comments to J. Grindstaff, Director CALFED, Sacramento, CA, G. Fred Lee & Associates, El Macero, CA, October 2 (2007). http://www.gfredlee.com/SJR-Delta/PubsPresentsDeltaSJR.pdf

Lee, G. F., and Jones-Lee, A., "Delta Water Quality Standards Violations" and "Comments on Water Quality Sections of the Delta Vision Strategic Plan, Third Staff Draft – dated August 14, 2008," Submitted to Delta Vision Blue Ribbon Task Force, Sacramento, CA. Report of G. Fred Lee & Associates, El Macero, CA, September 1 (2008). http://www.gfredlee.com/SJR-Delta/DeltaVisionWQViolations.pdf

**Impact of Flow on Fish Homing**

The primary justification for CALFED's support of the SJR DWSC low-DO project was that California Department of Fish and Game (DFG) had reported that the low DO in the DWSC blocked the migration of the fall run Chinook salmon to their home-stream waters for spawning. Water quality aspects of that issue were discussed in our 2004 synthesis report cited above. We also found that the manipulations of Delta flows by the South Delta export projects that draw all SJR water down Turner Cut and Columbia Cut prevented SJR watershed home-stream chemical signals from reaching San Francisco Bay. This issue was discussed in a number of our papers including:

Lee, G. F., and Jones-Lee, A, "Review of Impacts of Delta Water Quality and Delta Water Exports on the Decline of Chinook Salmon in the SJR Watershed," Comments submitted to NMFS Southwest Fisheries Science Center, NOAA, Santa Cruz, CA, by G. Fred Lee & Associates, El Macero, CA, August (2008). http://www.gfredlee.com/SJR-Delta/Salmon-NOAAcom.pdf

Lee, G. F., and Jones-Lee, A., "Water Quality Issues That Could Influence Aquatic Life Resources of the Delta," Comments submitted to CALFED Science Program, Sacramento, CA, by G. Fred Lee & Associates, El Macero, CA, November 28 (2005). http://www.gfredlee.com/SJR-Delta/POD-Com.pdf

Lee, G. F., and Jones-Lee, A., "Need for SJR Watershed Water to Reach San Francisco Bay," Comments submitted to Delta Stewardship Council, Sacramento, CA by G. Fred Lee & Associates, El Macero, CA, May 22 (2011). http://www.gfredlee.com/SJR-Delta/NeedSJRtoSFBay.pdf

The following report discussed the significance of SJR DWSC flows to maintaining adequate DO with particular reference to impacts on fisheries and Chinook salmon home-stream migration for spawning:

Lee, G. F., "Impact of San Joaquin River Deep Water Ship Channel Watershed and South Delta Flow Manipulations on the Low-DO Problem in the Deep Water Ship Channel," Submitted to the US Bureau of Reclamation OCAP Biological Assessment, Sacramento, CA, Report of G. Fred Lee & Associates, El Macero, CA, July 10 (2003). http://www.gfredlee.com/SJR-Delta/FlowImpact.pdf

**Delta Water Quality Flow Issues**

Associated with SWRCB's efforts to develop appropriate Delta flow standards to protect the Public Trust, we have developed and offered to the Board our comments, findings, and perspective on key pertinent water quality issues, out of our experience and understanding of that system, including the following:

Lee, G. F., and Jones-Lee, A., "Discussion of Water Quality Issues That Should Be Considered in Evaluating the Potential Impact of Delta Water Diversions/Manipulations on Chemical Pollutants on Aquatic Life Resources of the Delta," Report of G. Fred Lee & Associates, El Macero, CA, February 11 (2010). http://www.gfredlee.com/SJR-Delta/Impact_Diversions.pdf

Lee, G. F., and Jones-Lee, A., "Comments on Water Quality Issues Associated with SWRCB's Developing Flow Criteria for Protection of the Public Trust Aquatic Life Resources of the Delta," Submitted to CA State Water Resources Control Board as part of Public Trust Delta Flow Criteria Development, by G. Fred Lee & Associates, El Macero, CA, February 11 (2010). http://www.gfredlee.com/SJR-Delta/Public_Trust_WQ.pdf

Dr. Lee was appointed to a University of California Davis expert panel that reviewed the DFG draft flow criteria report. In the panel's report, cited below, Dr. Lee specifically discussed water quality issues that DFG should include in its recommended flow report.

Gross, E.S., Lee, G. F., Simenstad, C. A., Stacey, M., Williams, J.G., (Expert Panel Members), "Panel Review of the CA Department of Fish and Game's Quantifiable Biological Objectives and Flow Criteria for Aquatic and Terrestrial Species of Concern Dependent on the Delta," DFG Water Rights Program Documents Senate Bill X7 1 DFG Implementation, Submitted to California Department of Fish and Game, October (2010). Available through http://www.dfg.ca.gov/water/water_rights_docs.html or http://www.gfredlee.com/SJR-Delta/Final_Panel_Review_DFG_BOFC_Draft.pdf

**Delta Stewardship Council (DSC) and Bay Delta Conservation Plan (BDCP) Fall Short of Adequately Addressing Impacts of Flow on Water Quality**

We have closely followed the deliberations of the Delta Stewardship Council in its development of a Delta Plan. We have submitted several sets of comments on drafts of the plan to identify and discuss technical inadequacies and unreliable aspects, with particular emphasis on managing Delta water quality issues. Comments we submitted include:

Lee, G. F., Comment on Delta Stewardship Council Discussion of Cause of SJR Low-DO Problem, email to J. Grindstaff, Executive Director, Delta Stewardship Council, Comments from G. Fred Lee & Associates, El Macero, CA, February 10 (2012). http://www.gfredlee.com/SJR-Delta/DSC-LowDO-Comment.pdf

Lee, G. F., and Jones-Lee, A., "Comments on the DSC Staff Fifth Draft of Chapter 6 Devoted to Delta Water Quality Issues in the Delta Plan," Comments Submitted to Delta Stewardship Council, Sacramento, CA, by G. Fred Lee & Associates, El Macero, CA, August 21 (2011). http://www.gfredlee.com/SJR-Delta/DeltaPlan5DraftCh6Comm.pdf

Lee, G. F., and Jones-Lee, A., "Comments on Delta Stewardship Council Staff May 14, 2012 Draft of the Delta Plan," Comments to Delta Stewardship Council by G. Fred Lee & Associates, El Macero, CA, June 13 (2012). http://www.gfredlee.com/SJR-Delta/DSC-Comments-May2012-StaffDraft.pdf

Lee, G. F., Comments to Delta Vision Foundation on Implementation Progress for the Delta Vision Strategic Plan, email to C. Gardiner. Comments submitted by G. Fred Lee & Associates, El Macero, CA, May 6 (2012). http://www.gfredlee.com/SJR-Delta/DeltaVisionFoundationComments.pdf

We have found, and continue to find, inadequacies and unreliability in technical information put forth in the DSC staff drafts concerning issues that need to be addressed by the DSC in managing Delta aquatic resources. Many of those deficiencies have gone unaddressed. For example, we have repeatedly recommended in our comments that the DSC include information on the impacts of Delta flows on water quality with particular reference to the impacts of altering Delta flows on Delta water quality/beneficial uses. Thus far the DSC has not discussed those issues in a public meeting.

We have also followed the BDCP public meetings and have found that in developing the proposed tunnel diversion of Sacramento River water around the Delta BDCP has thus far failed to address the significant water quality problems that will occur in the South and Central Delta as a result of that diversion.

We recently provided comments to the CA Natural Resources Agency and the DSC pointing out unreliable information provided by a BDCP consultant concerning the current state of management of the residual low-DO problem in the SJR DWSC.

Lee, G. F., "Comments on Chris Earle's Brief Summary of Conservation Measures as presented in Chapter 3 of the BDCP," Comments to Karla Nemeth, CA Natural Resources Agency, G. Fred Lee & Associates, El Macero, CA, March 28 (2012). http://www.gfredlee.com/SJR-Delta/BDCP_ConservationMeasures_Com.pdf

Lee, G. F., Comments on SJR DWSC Low-DO issues discussed at March 28, 2012 BDCP meeting. Comments submitted to J. Grindstaff, Executive Officer, Delta Stewardship Council, by G. Fred Lee & Associates, El Macero, CA, April 28 (2012). http://www.gfredlee.com/SJR-Delta/Comments_SJR_DO_Issues_DSC.pdf

We have discussed technical aspects of current issues in managing the residual low-DO problem in the SJR DWSC:

Lee, G. F., and Jones-Lee, A., “Issues in Controlling the Residual Oxygen Demand in the SJR DWSC That Leads to DO WQO Violations,” Report of G. Fred Lee & Associates, El Macero, CA, November 3, 2010; updated February 6 (2011). http://www.gfredlee.com/SJR-Delta/Residual-Ox-Demand-DWSC.pdf

Lee, G. F., and Jones-Lee, A., “Background Information on SJR Upstream Oxygen Demand Control Issues,” Prepared for San Joaquin River Technical Work Group, Report of G. Fred Lee & Associates, El Macero, CA, July 11 (2010). http://www.gfredlee.com/SJR-Delta/Bkgrnd-SJR-DO.pdf

Lee, G. F., “Comments on SWRCB Review of South Delta Channel Water Quality,” Report of G. Fred Lee & Associates, El Macero, CA, January 15 (2011). http://www.gfredlee.com/SJR-Delta/SoDeltaWQ1-11.pdf

Lee, G. F., and Jones-Lee, A., “Issues in Controlling Residual Oxygen Demand in SJR DWSC That Leads to Violations of DO WQO,” PowerPoint Slides, G. Fred Lee & Associates, El Macero, CA, February (2011). http://www.gfredlee.com/SJR-Delta/Issues-Ox-Demand-DWSC-Ppt.pdf

With the control of most of the ammonia in the city of Stockton’s domestic wastewater discharges to the SJR just upstream of the DWSC, the low-DO problem in the SJR DWSC has become less severe, but it still occurs. One of the keys to controlling the residual low-DO problem in the SJR DWSC will be maintaining a flow of at least 800 to 1,000 cfs in the DWSC past the Port of Stockton. The elimination of the South Delta export projects’ pumping of Delta water, which will come with the tunnel diversion of Sacramento River water, will exacerbate the residual low-DO problem and cause it to extend much farther down the DWSC than occurs now.

**Managing the Pollutant Load to the Delta**

As discussed above, the current drawing of Sacramento River water through the Delta greatly dilutes pollutants that enter the South and Central Delta from the SJR and in-Delta agricultural sources. The proposed tunnel diversion project would eliminate that dilution, which would intensify water quality impacts of pollutants that enter the Delta. The supporters of the Sacramento River tunnel diversion approach assert that when the agricultural wastewater discharges and municipal stormwater runoff to the Delta and its tributaries are controlled, the water quality problems enhanced by the diversion of the Sacramento River water around/under the Delta will be controlled. However based on our experience in reviewing the sources of pollutants in agricultural discharges and the potential for their control, it will be difficult to control agricultural discharges sufficiently to achieve high water quality in the San Joaquin River and the Delta; it could well be cost-prohibitive to achieve adequate control of pollutant loads from irrigated agriculture and urban stormwater runoff. While it may be possible to increase the cost of agricultural crops to cover additional pollution control, competition with the same agricultural products in other areas and in other counties will make it very difficult to increase the costs sufficiently to achieve complete control while maintaining the agricultural operations.

**Regulating Irrigated Agriculture Runoff**

Dr. Lee has been involved in evaluating and developing water quality management approaches for urban-area stormwater runoff and agricultural stormwater runoff and discharges throughout most of his five-decade-long career. In the early 2000s we developed several reports on behalf of the CVRWQCB/SWRCB that addressed the evaluation and management of pollution from nonpoint sources, including:

Lee, G. F. and Jones-Lee, A., "Organochlorine Pesticide, PCB and Dioxin/Furan Excessive Bioaccumulation Management Guidance," California Water Institute Report TP 02-06 to the California Water Resources Control Board/Central Valley Regional Water Quality Control Board, 170 pp, California State University Fresno, Fresno, CA, December (2002). http://www.gfredlee.com/SurfaceWQ/OClTMDLRpt12-11-02.pdf

Lee, G. F. and Jones-Lee, A., "Issues in Developing a Water Quality Monitoring Program for Evaluation of the Water Quality - Beneficial Use Impacts of Stormwater Runoff and Irrigation Water Discharges from Irrigated Agriculture in the Central Valley, CA," California Water Institute Report TP 02-07 to the California Water Resources Control Board/ Central Valley Regional Water Quality Control Board, 157 pp, California State University Fresno, Fresno, CA, December (2002). http://www.gfredlee.com/SurfaceWQ/Agwaivemonitoring-dec.pdf

Lee, G. F. and Jones-Lee, A., "Review of Management Practices for Controlling the Water Quality Impacts of Potential Pollutants in Irrigated Agriculture Stormwater Runoff and Tailwater Discharges," California Water Institute Report TP 02-05 to California Water Resources Control Board/Central Valley Regional Water Quality Control Board, 128 pp, California State University Fresno, Fresno, CA, December (2002). http://www.gfredlee.com/SurfaceWQ/BMP_Rpt.pdf

From our expertise and experience we have found that the current CVRWQCB program to manage the water quality impacts of pollutants in irrigated agricultural discharges in the Central Valley is inadequate. The following reports and comments address some of the significant deficiencies:

Lee, G. F., and Jones-Lee, A., "Comments on 'Draft Program Environmental Impact Report for a Waste Discharge Regulatory Program for Irrigated Lands within the Central Valley Region,'" Submitted to Irrigated Lands Regulatory Program (ILRP), Sacramento, CA, September 25 (2010). http://www.gfredlee.com/SurfaceWQ/ILRPcomments.pdf

Lee, G. F., and Jones-Lee, A., "Comments on the Tentative California Regional Water Quality Control Board Central Valley Region Monitoring and Reporting Program Order No. R5-2008-__for Coalition Groups under Amended Order No. R5-2006-0053 Coalition Group Conditional Waiver of Waste Discharge Requirements for Discharges from Irrigated Lands, Revision 26 November 2007," Submitted to Central Valley Regional Water Quality Control Board, Sacramento, CA, by G. Fred Lee & Associates, El Macero, CA, December 28 (2007). http://www.gfredlee.com/SurfaceWQ/AgWaiverMRPNov07.pdf

Lee, G. F., and Jones-Lee, A., “Issues in Regulating Water Quality Impacts from Irrigated Agricultural Runoff and Discharges in the Central Valley of California,” Report of G. Fred Lee & Associates, El Macero, CA, February 4 (2009). http://www.gfredlee.com/SurfaceWQ/Impacts-Ag-Runoff.pdf

Lee, G. F. and Jones-Lee, A., “Background Information on Evaluating the Water Quality Impacts of Irrigated Agricultural Discharges/Runoff,” Report of G. Fred Lee & Associates, El Macero, CA, January, 2005. Updated May (2005). http://www.gfredlee.com/SurfaceWQ/BG-WQImp-IrrigAg.pdf

Lee, G.F. and Jones-Lee, A., "Developing Central Valley, California, Agricultural Runoff/Discharges Water Quality Monitoring Programs," Proceedings of 2003 AWRA Spring Specialty Conference," Agricultural Hydrology and Water Quality," American Water Resources Association, Kansas City, MO, May (2003). http://www.gfredlee.com/SurfaceWQ/AWRA_KC_Pap-Lee-web.pdf

As discussed in those papers/reports, the current CVRWQCB irrigated lands runoff monitoring program falls far-short of being able to generate the information needed to define the current pollution by irrigated agriculture’s stormwater runoff and tailwater discharges. Without a substantial expansion of the evaluation program for runoff and its impact, it will not be possible to control the water quality impacts of known, regulated pollutants in agriculture runoff, much less the known but unregulated pollutants and currently unrecognized pollutants.

The limited nature of the runoff monitoring and impact evaluation program has been justified on the basis that a comprehensive program would be too expensive for many agricultural interests to undertake and stay in business. As discussed in our reports and noted above, it will be very difficult, if not impossible, to control agricultural runoff/discharges in the Central Valley sufficiently to meet water quality objectives with no more than one exceedance every three years (the current Clean Water Act requirement). Moving to such a level of pollutant control for that industry will greatly change the ability to undertake profitable agriculture in the Central Valley.

***Control of Nutrients in Ag Discharges.*** Aquatic plant nutrients (nitrogen and phosphorus compounds) comprise a group of pollutants of great concern for impairment of water quality in the Delta. We have been involved in the investigation and management of water quality impacts of nutrients – excessive fertilization – in many areas of the US and abroad since 1960s. A summary of our expertise and experience, as well as access to many of our papers and reports in this area, is provided on our web site, www.gfredlee.com, in the Excessive Fertilization section at http://www.gfredlee.com/pexfert2.htm. We have been active in excessive fertilization issues in the Delta since 1989. In 2008 we organized a one-day workshop for the California Water and Environmental Forum devoted to Delta nutrient water quality issues; information on that workshop is available in:

Lee, G. F., and Jones-Lee, A., “Delta Nutrient-Related Water Quality Problems,” PowerPoint Slides Presented at CALFED Science Conference, Sacramento, CA, October 24 (2008). http://www.gfredlee.com/SJR-Delta/CALFED_SciConf10-08.pdf

Lee, G. F., and Jones-Lee, A., "Synopsis of CWEMF Delta Nutrient Water Quality Modeling Workshop – March 25, 2008, Sacramento, CA," Report of G. Fred Lee & Associates, El Macero, CA, May 15 (2008). http://www.gfredlee.com/SJR-Delta/CWEMF_WS_synopsis.pdf

"Overview of Delta Nutrient Water Quality Problems: Nutrient Load – Water Quality Impact Modeling," Agenda for Technical Workshop sponsored by California Water and Environmental Modeling Forum (CWEMF), Scheduled for March 25, 2008 in Sacramento, CA (2008).
http://www.gfredlee.com/SJR-Delta/CWEMF_Workshop_Agenda.pdf

That workshop provided a good overview of issues by a variety of experts on Delta nutrient water quality issues. We have pointed out to the DSC that much of the technical information presented and discussed at that workshop has been ignored in the development of the DSC staff draft reports on the Delta Plan.

Lee, G. F., and Jones-Lee, A., "Comments on the Adequacy of C. Dahm's Discussion of Delta Eutrophication Issues & Delta N/P Rations as a Cause of Adverse Impact on Delta Fish," Comments to Delta Stewardship Council, Report of G. Fred Lee &Associates, El Macero, CA, November 17 (2011). http://www.gfredlee.com/SJR-Delta/DSC-Comments-Dahm-Eutroph.pdf

In our writings on water quality impacts of irrigated agriculture and on Delta water quality issues we have commented on the need to develop nutrient water quality objectives. While various staff drafts have made recommendations for the DSC to require the CVRWQCB to develop nutrient water quality objectives for the Delta, those recommendation have not reflected an understanding of approaches that will have to be followed to develop technically reliable and implementable nutrient water quality objectives for Delta waters. We provided comments on this matter to the CVRWQCB and discussed a range of nutrient-related water quality problems that need to be considered in:

Lee, G. F., "Comments on Developing Nutrient Criteria for SJR Delta," email to Christine Joab, Central Valley Regional Water Quality Control Board, Rancho Cordova, CA, March 29 (2011). http://www.gfredlee.com/SJR-Delta/Delta-Nutr-Criteria-Com.pdf

While the SWRCB is developing nutrient water quality criteria, it will require extensive research and many years to develop comprehensive water quality objectives for nutrients in the Delta. Even once they are developed and implemented, however, it will be extremely difficult for irrigated agriculture in the SJR watershed and within the Delta to meet such objectives in accord with Clean Water Act requirements.

A key issue that will need to be evaluated in developing phosphorus nutrient criteria for the Delta is that decreasing the phosphorus loads to the Delta will also reduce the production of phytoplankton in Delta waters, which in turn can be expected to reduce fish production in the Delta. As discussed in our writings on nutrient management issues in the Delta, decreasing the phosphorus load in the Sacramento Regional County Sanitation District wastewater treatment plant discharge to the Sacramento River decreased the phytoplankton concentrations in the Delta. The relationships among phosphorus load, phytoplankton production, and fish biomass found in many waterbodies worldwide are discussed in detail in our paper:

Lee, G. F. and Jones, R. A., "Effects of Eutrophication on Fisheries," Reviews in Aquatic Sciences, 5:287-305, CRC Press, Boca Raton, FL (1991). http://www.gfredlee.com/Nutrients/fisheu.html

The development of nutrient criteria for the Delta will need to balance the control of excessive fertilization of the Delta channels with maintaining adequate phytoplankton production to support the aquatic food web. Altering the flows in the Delta channels will significantly impact how nutrients loads to the Delta impact water quality.

**Dairy Waste Regulation Balance**

There has been considerable interest in the impacts of dairy wastes in the Central Valley on surface and groundwater quality. We discussed approaches that the CVRWQCB recently adopted to regulate the water quality impacts of dairy wastes, particularly animal manure, in the following report:

Jones-Lee, A., and Lee, G. F., "Impact of Dairy Wastes on San Joaquin River and Delta Water Quality Issues," Report to As You Sow, San Francisco, CA, Report of G. Fred Lee & Associates, El Macero, CA, January 24, (2012). http://www.gfredlee.com/SJR-Delta/Dairy_Waste_Impact_Issues.pdf

Dairy herds are treated with hormones, steroids, and pharmaceuticals that have the potential to be present in manure and hence in runoff from lands on which dairy wastes have been disposed; it has recently been found that dairy manure contains steroid hormones. Those compounds are part of the vast array of unregulated chemicals in wastes in the Central Valley that have the potential to impact Delta water quality.

As discussed in our report, the CVRWQCB has adopted a "balance" approach toward regulating nutrients and other pollutants in runoff from areas in which dairy wastes (manure) are managed by land application. CVRWQCB has acknowledged that it "balances" the control requirements with the ability of the dairy industry to meet the requirements and still stay in business. This so-called balanced approach, which allows exceedances of water quality objectives for nutrient components and other pollutants in order to safeguard the dairy industry, is not in keeping with Clean Water Act requirements for regulating pollutants for which there are water quality objectives.

**Regulating Water Quality Impacts of Urban Stormwater Runoff**

Dr. Lee has been involved in the investigation and management of water quality impacts of urban stormwater runoff since the mid-1960s and has published extensively on these issues. A summary of our experience (http://www.gfredlee.com/exp/stmwatrv.htm) and many of our publications on these issues (http://gfredlee.com/pswqual2.htm#runoff) are available on our website. In addition, for 13 years we have written and published our *Stormwater Runoff Water Quality Newsletter*. That newsletter, which is distributed at no-cost to more than 8,000 subscribers, provides technical information on various issues pertinent to evaluating and regulating water quality impacts of urban stormwater runoff. Past *Newsletter* issues are available at: http://www.gfredlee.com/newsindex.htm.

The following is one of our papers that discusses some of the issues that need to be evaluated to regulate water quality impacts of urban stormwater runoff in a technically valid, cost-effective manner:

> Jones-Lee, A., and Lee, G. F., "Modelling Water Quality Impacts of Stormwater Runoff: Why Hydrologic Models Are Insufficient," Chapter 4 IN: Modelling of Pollutants in Complex Environmental Systems, Volume I, ILM Publications, St. Albans, Hertfordshire, UK, pp.83-95 (2009).
> http://www.gfredlee.com/Runoff/HydrologicModelsInadeq.pdf

Many of our writings have addressed why the conventional Clean Water Act water quality criteria/standards-based regulatory approach is not appropriate for regulating stormwater runoff. Contrary to recommendations made by DSC staff in its draft Delta Plans, even if it were appropriate it is not possible to achieve compliance with Clean Water Act requirements applied to urban stormwater runoff – of having no more than one violation of a water quality objective every three years – owing to the cost alone. Given the nature of runoff events, such regulation would have to make storage and treatment provisions scaled to peak flows that occur during the comparatively infrequent major runoff events. To do so would cost on the order of a dollar per person per day for those served by the urban stormwater collection system and effect no improvement in receiving water quality beyond that which could be achieved with a less expensive more targeted approach. This situation is well-understood by the US EPA and is the primary reason that the US EPA has not required that urban areas control potential pollutants in stormwater runoff in accord with Clean Water Act requirements. In writings on our website we have discussed approaches to gather needed information to develop technically valid, cost-effective control programs for real, significant water quality impacts of potential pollutants in urban-area stormwater runoff, including developing wet-weather water quality standards that reflect the conditions that occur in urban stormwater runoff situations.

> Lee, G.F. and Jones-Lee, A., "Evaluation Monitoring for Stormwater Runoff Water Quality Impact Assessment and Management," Presented at Society of Environmental Toxicology & Chemistry 18th Annual Meeting, San Francisco, CA, November (1997).
> http://www.gfredlee.com/Runoff/setace.html
>
> Lee, G. F. and Jones-Lee, A., "The Appropriateness of Using US EPA Water Quality Criteria as Goals for Urban Area and Highway Stormwater Runoff Water Quality Management," Report G. Fred Lee & Associates, El Macero, CA, May (1997).
> http://www.gfredlee.com/Runoff/wqstgoal.htm
>
> Lee, G. F. and Jones, R. A., "Suggested Approach for Assessing Water Quality Impacts of Urban Stormwater Drainage," IN: Symposium Proceedings on Urban Hydrology, American Water Resources Association Symposium, November 1990, AWRA Technical Publication Series TPS-91-4, AWRA, Bethesda, MD, pp. 139-151 (1991).
> http://www.gfredlee.com/Runoff/storm_wa.html

**Unrecognized Pollutants**

Our 2004 Delta water quality report contained a section concerning unrecognized pollutants in Delta waters. As discussed there, and in other of our writings, at this time the current regulatory approach of developing water quality criteria that are implemented through water quality standards and control of violations through the TMDL approach, addresses a very small portion of the potential pollutants in wastewaters. This is discussed further in the following publication:

> Lee, G. F., and Jones-Lee, A., "Unrecognized Environmental Pollutants," Water Encyclopedia: Surface and Agricultural Water, Wiley, Hoboken, NJ pp 371-373 (2005). http://www.gfredlee.com/SurfaceWQ/WileyUnrecognizedPollutants.pdf

The topic index to our *Stormwater Runoff Water Quality Newsletter* (http://www.gfredlee.com/swnews_indexa.pdf) contains links to additional information on the unrecognized pollutants in surface and groundwaters. Of particular relevance are Newsletter Volume 13 numbers 1 and 4 (http://www.gfredlee.com/Newsletter/swnewsV13N1.pdf and http://www.gfredlee.com/Newsletter/swnewsV13N4.pdf).

In the early 1970s Dr. Lee was an advisor to the Council on Environment Quality on developing a regulatory program for screening new chemicals for public health and environmental impacts. That work led to the development of the Toxics Substances Control Act (TSCA). While the original intent of TSCA was to provide a framework for effectively screening new chemicals, the version that was adopted was weakened and has been largely ineffective in screening new and expanded-use chemicals for environmental impact. At this time there is no effective program at the federal or state level to screen new and expanded-use chemicals for potential impacts. The failure of the regulatory system to address unrecognized and otherwise unregulated potential pollutants is increasingly significant.

The California Department of Toxic Substances Control (DTSC) recently proposed program, "Safer Consumer Products Alternatives" Title 22 California Code of Regulations Department Reference Number R-2011-02 dated July 2012, for screening new commercial chemicals is a step in the right direction, although it needs to be expanded to include evaluation of the environmental impacts for all new and expanded-use chemicals.

In its description of the proposed "Safer Consumer Products Alternatives" program the DTSC noted that there are more than 80,000 approved chemicals for federal use in the US, and made the following statement:

> "*Each day a total of 42 billion pounds of chemical substances are produced or imported in the US for commercial and industrial uses. And that each year 1,000 chemicals are introduced into commerce each year. Approximately one new chemical comes into market every 2.6 second. The average U.S. consumer today comes into contact with 100 chemicals per day. In 2009, the U.S. Centers for Disease Control and Prevention conducted the Fourth National Report on Human Exposure to Environmental Chemicals, which measured 212 chemicals in the blood and urine of a representative population of California."*

Some of those chemicals are present in domestic and animal wastewaters and are part of the vast array of unrecognized chemicals that are a threat to Delta water quality.

**Overall**
A critical review shows that the ability to manage water quality in the Delta to comply with Clean Water Act requirements for eliminating violations of water quality objectives in agricultural and urban area stormwater runoff/discharges is many decades away, if it can ever be achieved. This means that dilution flows into and within the Delta will be needed to minimize the water quality impacts of pollutants that are added to Delta tributaries and within Delta channels. To begin to control the water quality problems that occur in Delta channels due to unregulated and unrecognized pollutants it will be necessary to add sufficient flows to the Delta channels to dilute the pollutants. As part of it review and establishment of Delta flows to enhance and protect the Public Trust resources of the Delta, the SWRCB should include the need for adequate Delta flows to provide substantial Delta inflow and channel flows.

# Flow and Export Limitation Standards

Testimony for CA State Water Resources Control Board Workshop:
Comprehensive (Phase 2) Review and Update to Bay-Delta Plan
Workshop 1: Ecosystem Changes and the Low Salinity Zone
September 5 and 6, 2012

Tom Cannon
Representing: California Sportfishing Protection Alliance

**Relevant Background and Experience**: I am an estuarine fisheries ecologist and have been involved in Delta fishery issues for more than 35 years. I began my study of striped bass in estuaries as the statistician and technical director of the Hudson River Estuary Ecological Studies from 1972-1977. I have been involved in the Bay-Delta from 1977 to the present. During my years on the Hudson River, I consulted on several occasions with CDFG scientists working on striped bass in the Bay-Delta. Pete Chadwick, DFG's lead Delta scientist, was a consultant to the Hudson River program. From 1977-1980 I was project director of Bay-Delta ecological studies for PG&E's Bay-Delta power plants impact programs. From 1980-82, I was a consultant to the State Water Contractors, the National Marine Fisheries Service, the Electric Power Research Institute (ERPI), and State Water Resources Control Board focusing on evaluating the effectiveness of the D-1485 Bay-Delta Water Quality Standards in protecting the Bay-Delta ecosystem and the striped bass population. From 1986-1987 I was a consultant to the State Water Contractors and US Bureau of Reclamation during the SWRCB hearings on water quality standards. From 1994-1995, I was a consultant to the State Water Contractors and the California Urban Water Agencies, working on the 1995 Bay-Delta Water Quality Standards and how the new standards would affect the Bay-Delta ecosystem and striped bass population (and water supplies). From 1995-2003, I was a consultant to the CALFED Bay-Delta Program where I worked on various projects including the Ecosystem Restoration Program Plan (ERPP), the Delta Entrainment Effects Team (DEFT), the Tracy Technical Advisory Team (TTAT), the Environmental Water Account (EWA), and the Delta Cross Channel – Through Delta Facility (DCCTDF) evaluation team, where again potential effects on the fish populations and the ecosystem were subjects of interest. I prepared a comprehensive review of impacts from the south Delta pumping plants, the uses and benefits of an Environmental Water Account, and the potential effects from a Through Delta Facility. I also participated in project planning and development of the Delta Wetlands Project, the Montezuma Wetlands Project, and many other Bay-Delta development and restoration projects. In 2002 I participated in a DFG review of the status of the striped bass population. From 2002 to 2005, I was involved in activities related to the Striped Bass Stamp Program including stocking and tagging striped bass, continuing coordination with DFG on Delta issues, and as CSBA's representative on the DFG/DWR Four Pumps Mitigation Committee. More recently I have advised California Striped Bass Association on proposed new striped bass fishing regulations, and advised USBR staff on the merits of proposed new Fall X2 Standards. From 2005 through 2010 I undertook several new estuary habitat restoration projects in the Sacramento River, Yolo Bypass, and Suisun Bay.

I am very familiar with how the state and federal projects operate and how water project operators game the system to their advantage.

## *Summary and Conclusions*

The 1978 Standards had numerous flaws but the major one was monthly average criteria. This flaw was addressed with the 1995 Standards. Unfortunately, the 1995 Standards had two major flaws – almost no export restrictions and new export/inflow ratio criteria. Revised standards that incorporate some of the recommendations of the Draft 1982 Two Agency Agreement and the Draft 1993 (D1630) Standards would significantly eliminate many of the Delta's ongoing problems. These essentially involve reducing exports and increasing outflow, but they are well within the findings and recommendations of the Board's own 2010 Delta Flow Report. The key solutions involve (1) not exporting the Low Salinity Zone at any time of the year, (2) keeping it as far down in the Bay as long as possible, (3) minimizing movement of the LSZ into the Central and South Delta, (4) focusing on natural flow regimes and salt movements by not causing dramatic one-day shifts because of Standards, and (5) limiting high inflows of reservoir water just to maximize exports and meet E/I standards. The history of fisheries decline in the Delta is a history of inadequate and non-protective Standards and a refusal to subsequently apply the knowledge learned from previous failures.

My focus is on the Low Salinity Zone because it is so important to the estuary ecosystem and production of all the major fish species including all the ESA listed species. Any new adopted Standards should focus on maintaining the health of this critical zone of the estuary.

## *Introduction*

The 1978 and 1995 Delta Standards brought about classic adaptive management experiments in the Delta, essentially one for each year in which the standards were employed. These experiments along with many years of monitoring, research, and analyses brought volumes of technical documents and testimony, restoration programs, and biological opinions. So when the State Board asked for input on what is new or what have has been learned since 2010 that might have a bearing on revising the 2006 Standards, it seemed appropriate to identify the problems and solutions once again.

Basically, we learned a lot over the 34 years since 1978, but along the way the lessons were ignored at least when it comes to adopting standards. So what is new? Well there are a few more years of experiments under the 95-06 standards. However, the 95 (and 06) Standards ignore most of the knowledge gained from past experiments and continue to cause declines in the valued fish populations that depend on the Delta. With each year of new "experiments" we see the consequences of the underlying problems with the old standards, yet we ignore obvious long-proposed solutions.

The first adaptive management experiments involved the early use of the State Delta Pumps in the South Delta during the period of 1969-1977. Massive numbers of fish were sacrificed to find out how the new pumps and Delta flows should be managed. The 1978 Standards (D-1485) were the consequences of that learning. These Standards provided considerable protection in terms of flow and export criteria and helped ameliorate the Delta fish facility massacres of the early 70s and the effects of the 76-77 drought.

The 1978 Standards were designed to protect striped bass and salmon, as well as other fish and the major elements of the Delta food chain. During the first several years of that "experiment" it was obvious to everyone that the standards helped in some respects, but "gaming of the system" by water project operators caused major problems. I managed two years of comprehensive Delta surveys in 78-79 to determine how the Delta power plants might fit into the new Standards. I oversaw a comprehensive review of the data to determine the very specific day-to-day, week-to-week, and month-to-month effects of the Standards in those two years. I wrote reports and communicated my findings in a variety of forums. The State Board assembled a group of experts in 1982 to provide advice as to why the 1978 Standards were not meeting their objectives. I was a part of this group, chaired by Don Kelly, retired DFG Delta biologist. Our group prepared a report and submitted it to the Board. DFG and DWR in conducted their own review and drafted a new Two-Agency Agreement as to how to operate the State Water Project and how to revise the 78 Standards. I also advised the State Water Contractors and NMFS at that time as to what was wrong with the Standards, how they could be fixed, and what I thought about the Draft 1982 Two Agency Agreement.

It was obvious to all these reviews that the 78 Standards needed to be revised very much along the lines of the Draft 1982 Two Agency Agreement. The basic problem was the monthly standards. The 1982 Draft Two Agency Agreement documented the problem and prescribed solutions. The goals included maintaining fish populations at average 1970-1981 levels until the goal could be raised to historical levels. The changes recommended included weekly or 14-day running averages for many of the monthly standards, substantial modification of export levels and recognition that "some reservation of presently unregulated flows may be necessary to accomplish the goals of this Agreement. Such reservations could be accomplished either by increasing minimum outflows or by limited future exports and diversions to storage." The parties believed that the 78 Standards with the added protections provided by the Two Agency Agreement would protect striped bass and other estuary fish at the 1980's export level of 4.5 MAF. The final EIR for the proposed Two Agency Agreement stated that the proposed agreement would provide greater protections than the 78 Standards but that any increase in exports beyond the current level would cause further impacts. Indeed, the EIR concluded that expansion of the SWP Banks Pumping Plant (four new pumps) would create additional adverse impacts. Consequently, the Two Agency Agreement stated that expansion, beyond the existing US Army Corps of Engineers constraints that allowed some higher winter exports, would only occur if (1) the parties agreed upon additional operational constraints; **and** (2) fish screens at the SWP fish facility were upgraded. It should be noted that NMFS had commented on an earlier draft of the Two Agency

Agreement that existing exports of 3 MAF had caused adverse impacts and plans to export 4.3 MAF posed the greatest of threats to remaining resources.

Unfortunately, the water contractors refused to agree to the recommendations despite the DWR, DFG, FWS, NMFS, USBR, and State Board staff all endorsing them. More hearings, much analysis and testimony, and more years of "experiments" followed. An attempt was made to formally revise the standards again in 1986-88. But, because of strong opposition by water contractors, no changes were made.

The arguments and "experiments" continued until new draft standards were proposed in the Draft D-1630 Standards in 1993. These too were not adopted. More intensive negotiations followed leading to new 1995 Standards and the eventual adoption of D-1641. These Standards are the basic standards we have today. The 1995 Standards have two major flaws – summer export restrictions in the 78 Standards were removed and export/inflow ratio criteria were added. The resulting higher summer exports (11,500 cfs versus 6,000-7,600 cfs) have been devastating to the LSZ, the Bay-Delta ecosystem, and the populations of many native and valuable sport fishes.

The conflict over the adequacy of the Standards continued in the CALFED process and then again in hearings and workshops for the 2006 Standards. The drought of 07-09 exacerbated conditions and the Standards did not provide protection - fish populations crashed. Efforts in the past few years to find the "cause" and the "solution" within the BDCP process have not resolved the age-old issues. The BDCP program now proposes to proceed with constructing massive new Delta infrastructure that will fundamentally alter the hydrology of the estuary while we spend many more years figuring out how to best operate the new system under export demands of 6-8 million acre-ft. This language is reminiscent of the rhetoric from the 1960s and 1970s when the State Water Project was coming on line, and fish populations were crashing under exports of 3-4 million acre-ft.

I now address several specific problems with the 1978 and 1995 Standards and their effects on the LSZ and then compare events of 2011-12 with 2002. Mistakes of the past, if left uncorrected, have a habit of reoccurring.

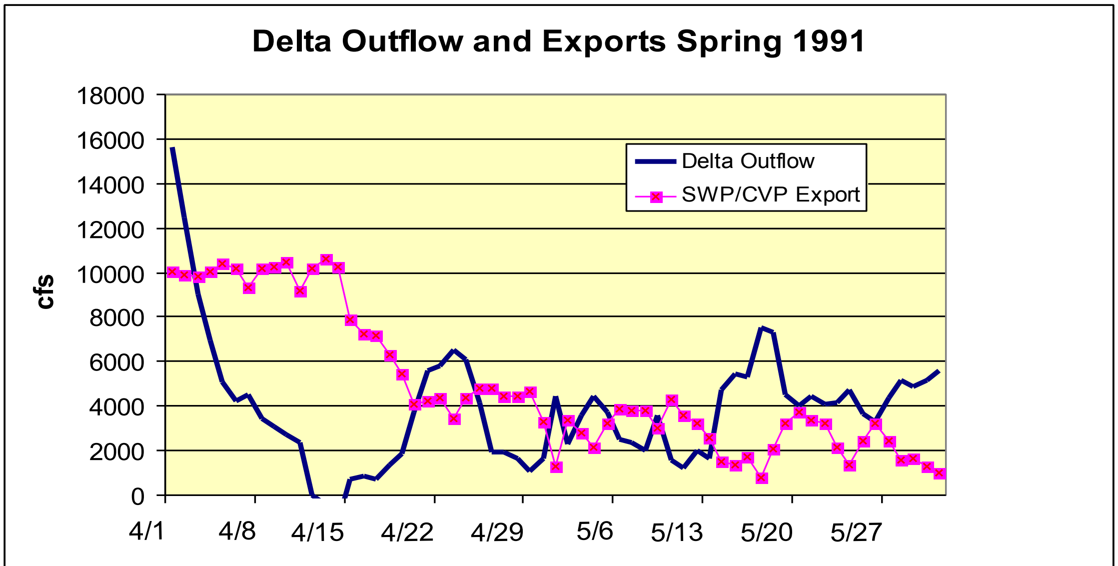
## *1978 Standards (D-1485)*

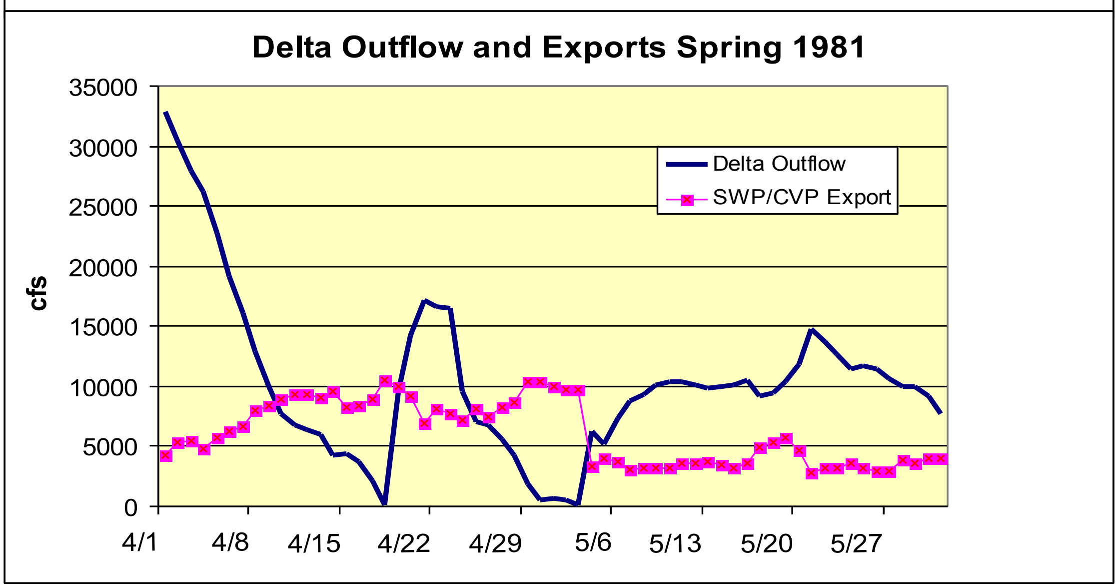
The 78 monthly Delta outflow standards were 6700 cfs for early April, and 3,000 to 14,000 cfs for May through July depending on year type (see table below). Exports restrictions were 6,000 cfs in May and June, and 7,600 cfs in July.

**Table III-1.** Water Right Decision 1485 (D-1485) water quality standards for the Sacramento-San Joaquin Delta and Suisun Marsh[1] (continued).

| BENEFICIAL USE PROTECTED and LOCATION | PARAMETER | DESCRIPTION | YEAR TYPE[2] | VALUES | | |
|---|---|---|---|---|---|---|
| **FISH AND WILDLIFE** | | | | | | |
| • STRIPED BASS SPAWNING | | | | | | |
| Prisoners Point on the San Joaquin River | Electrical Conductivity | Average of mean daily EC for the period not to exceed | All | April 1 to May 5<br>0.550 mmhos | | |
| Chipps Island | Delta Outflow Index in cfs | Average of the daily Delta outflow index for the period, not less than | All | April 1 to April 14<br>6700 cfs | | |
| Antioch Waterworks Intake on the San Joaquin River | Electrical Conductivity | Average of mean daily EC for the period, not more than | All | April 15 to May 5<br>1.5 mmhos | | |
| Antioch Waterworks Intake | Electrical Conductivity (Relaxation Provision — replaces the above Antioch and Chipps Island Standard whenever the projects impose deficiencies in firm supplies 5/ | Average of mean daily EC for the period, not more than the values corresponding to the deficiencies taken (linear interpolation to be used to determine values between those shown) | All — whenever the projects impose deficiencies in firm supplies 5/ | Total Annual Imposed Deficiency MAF | April 1 to May 5 EC in mmhos | |
| | | | | 0 | 1.5 | |
| | | | | 0.5 | 1.9 | |
| | | | | 1.0 | 2.5 | |
| | | | | 1.5 | 3.4 | |
| | | | | 2.0 | 4.4 | |
| | | | | 3.0 | 10.3 | |
| | | | | 4.0 or more | 25.2 | |
| • STRIPED BASS SURVIVAL | | | | | | |
| Chipps Island | Delta Outflow Index in cfs | Average of the daily Delta outflow index for each period shown not less than | | May 6–31 | June | July |
| | | | Wet | 14,000 | 14,000 | 10,000 |
| | | | Ab. Normal | 14,000 | 10,700 | 7,700 |
| | | | Bl. Normal | 11,400 | 9,500 | 6,500 |
| | | | Subnormal Snowmelt | 6,500 | 5,400 | 3,600 |
| | | | Dry 6/ | 4,300 | 3,600 | 3,200 |
| | | | Dry 7/ or Critical | 3,300 | 3,100 | 2,900 |
| • SALMON MIGRATIONS | | | | | | |
| Rio Vista on the Sacramento River | Computed net stream flow in cfs | Minimum 30-day running average of mean daily net flow | | Jan. | Feb. 1– Mar. 15 | Mar. 16– June 30 |
| | | | Wet | 2,500 | 3,000 | 5,000 |
| | | | Ab. Normal | 2,500 | 2,000 | 3,000 |
| | | | Bl. Normal | 2,500 | 2,000 | 3,000 |
| | | | Dry or Critical | 1,500 | 1,000 | 2,000 |
| | | | | July | Aug. | Sept. 1– Dec. 31 |
| | | | Wet | 3,000 | 1,000 | 5,000 |
| | | | Ab. Normal | 2,000 | 1,000 | 2,500 |
| | | | Bl. Normal | 2,000 | 1,000 | 2,500 |
| | | | Dry or Critical | 1,000 | 1,000 | 1,500 |
| • OPERATIONAL CONSTRAINTS | | | | | | |
| Minimize diversion of young striped bass from the Delta | Diversions in cfs | The mean monthly diversions from the Delta by the State Water Project (Department) not to exceed the values shown. | All | May<br>3,000 | June<br>3,000 | July<br>4,600 |
| | | The mean monthly diversions from the Delta by the Central Valley Project (Bureau), not to exceed the values shown | All | May<br>3,000 | June<br>3,000 | |
| Minimize diversion of young striped bass into Central Delta | | Closure of Delta cross channel gates for up to 20 days but no more than two out of four consecutive days at the discretion of the Department of Fish and Game upon 12 hours notice | All — whenever the daily Delta outflow index is greater than 12,000 cfs | April 16–May 31 | | |
| Minimize cross Delta movement of Salmon | | Closure of Delta Cross Channel gates (whenever the daily Delta outflow index is greater than 12,000 cfs) | All | Jan. 1–April 15 | | |

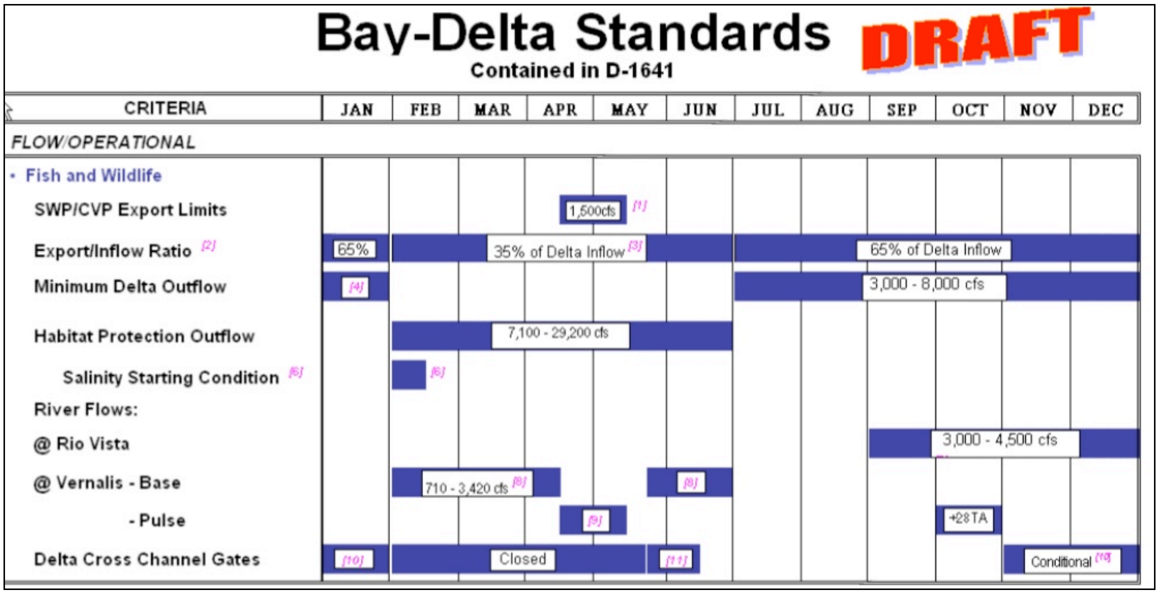
The problem with the 1978 Standards was that they were monthly average and thus subject to within month gaming by water project operators. As seen in the figure below, a monthly average is not very representative of what can really happen over a month. There were also no limits on April exports.



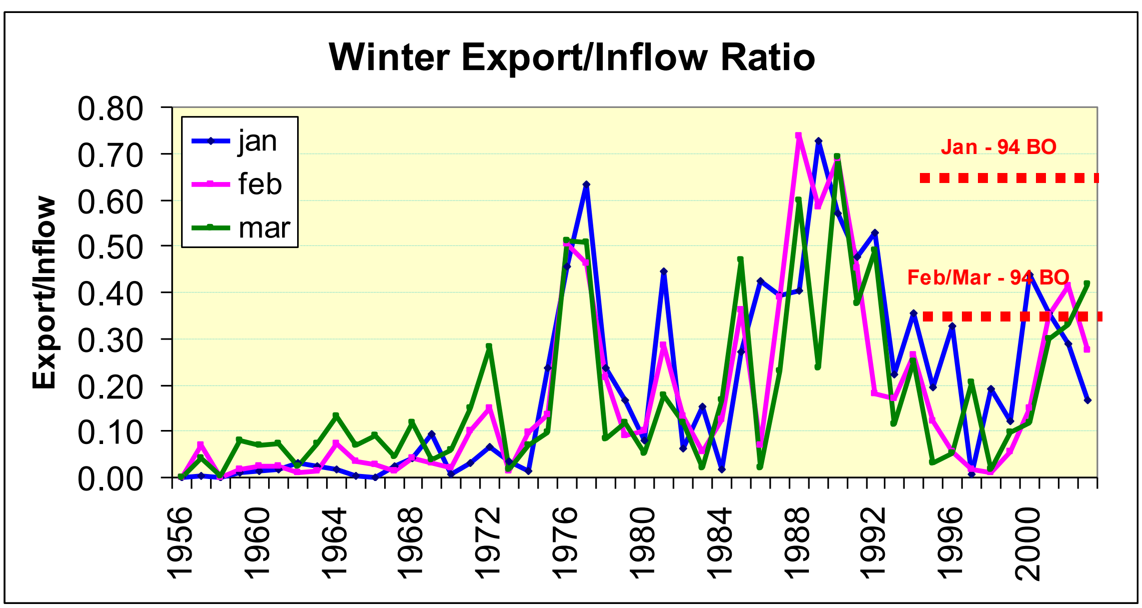



## 1995 Standards (D-1641) and Newer Constraints

The 1995 Standards alleviated the monthly average problem but replaced export limits with Export to Inflow ratio limits. An export limit of 1500 cfs was added for the "VAMP" period from April 15 to May 15. Minimum Delta outflows were set at 3,000 to 8,000 cfs, varying with month and year type.



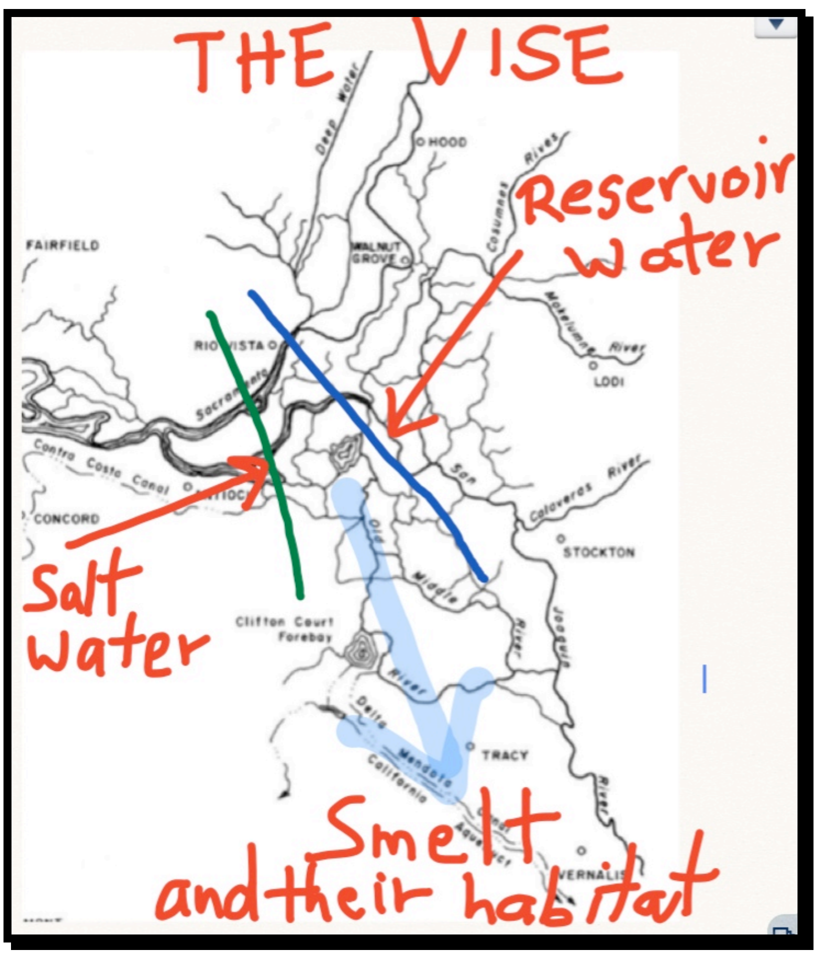

Some of the Biological Opinions in the last decade also added some restrictions on flow and exports. For example see the figure below showing the restrictions on the E/I in winter. High winter E/I ratios during droughts are a concern to all the species, because they lead to high salvage rates of older fish including delta smelt adult spawners as well as winter run Chinook smolts and spring run Chinook fry.



The major problem with the E/I Standard is that it allows exports up to the maximum of 11,500 cfs as long as there is sufficient inflow to maintain the target ratio limit. The standard results in maintaining relatively low May through June exports, as the ratio is 35% for these months. But in July, with a ratio of 65%, exports could easily be raised to the maximum, and often have been, and rather abruptly usually on July 1.

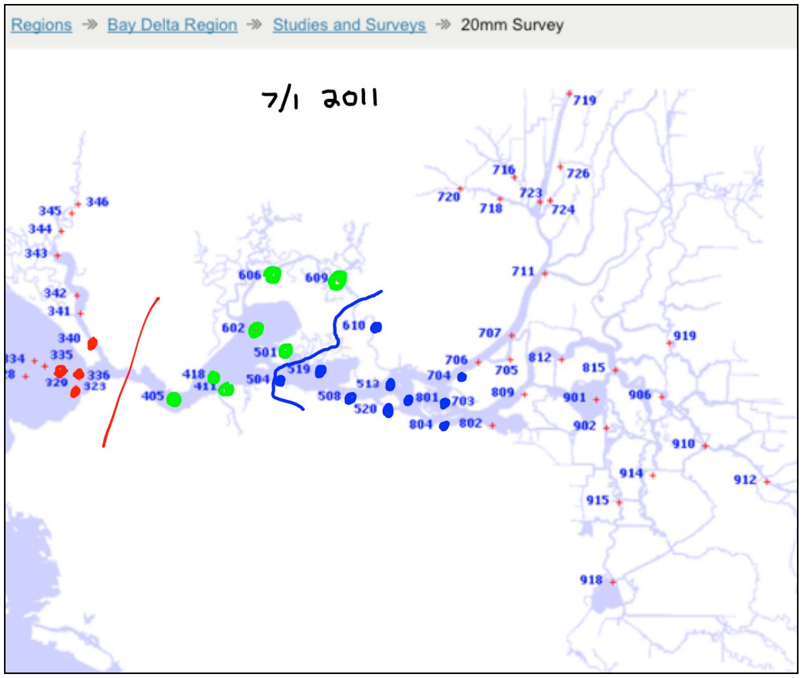
The consequence of the E/I Standards is what I term the "Vise" ("tooth past tube" is another good analogy) (see figure below). The LSZ is caught in the vise or tube and is slowly squeezed by the encroaching salt water and reservoir water inflows. The combination of high inflows and high exports actually pushes and pulls, respectively, the LSZ habitat into the Central and South Delta, and eventually out the pumping plants. The process leaves behind only a small remnant of the LSZ habitat so critical to all the POD species. Historically, this may have occurred in April-May prior to and after 1978 (D1485). After 1995 (D1641), this phenomenon was more likely to occur in July with the sharp shift in the E/I Ratio and the high export rates.

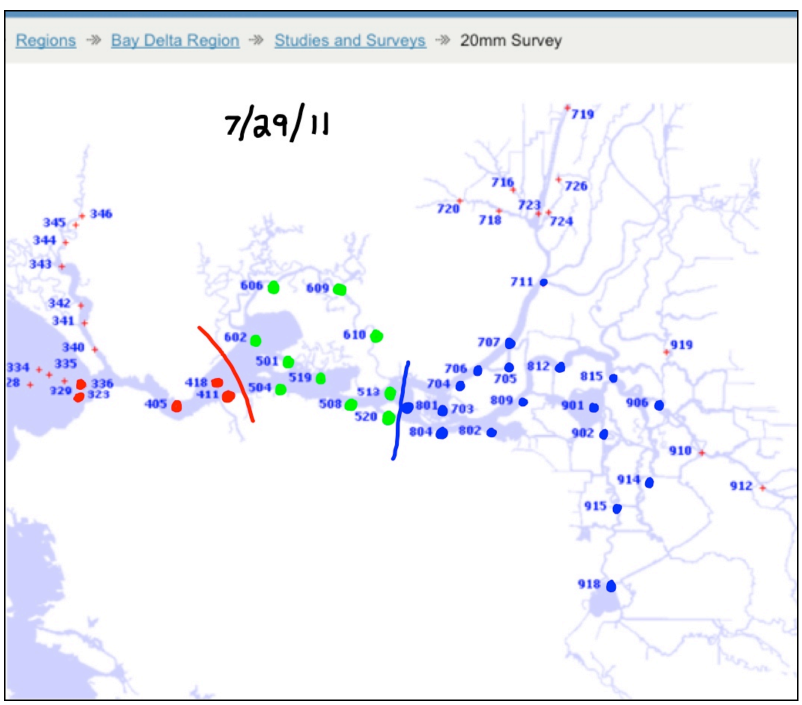
Some example years follow. These are only a few of the stories available.



## Year 2011

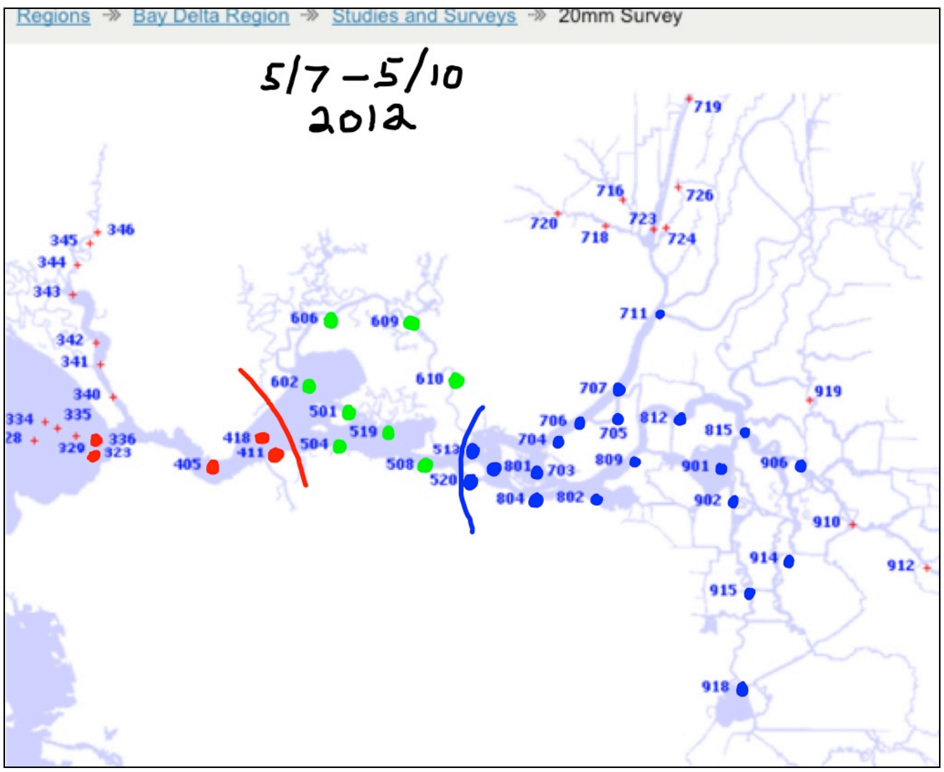
In 2011 early July inflows were 30,000 to 50,000 cfs, thus keeping the LSZ (green dots) far into Suisun Bay. Despite maximum exports the entire month, there was only a small movement of salt (red dots) toward the Delta in late July when outflow fell to 8,000 cfs. Needless to say, these conditions led to a 10-year high in the smelt fall index. I will discuss these events more in the next workshop.

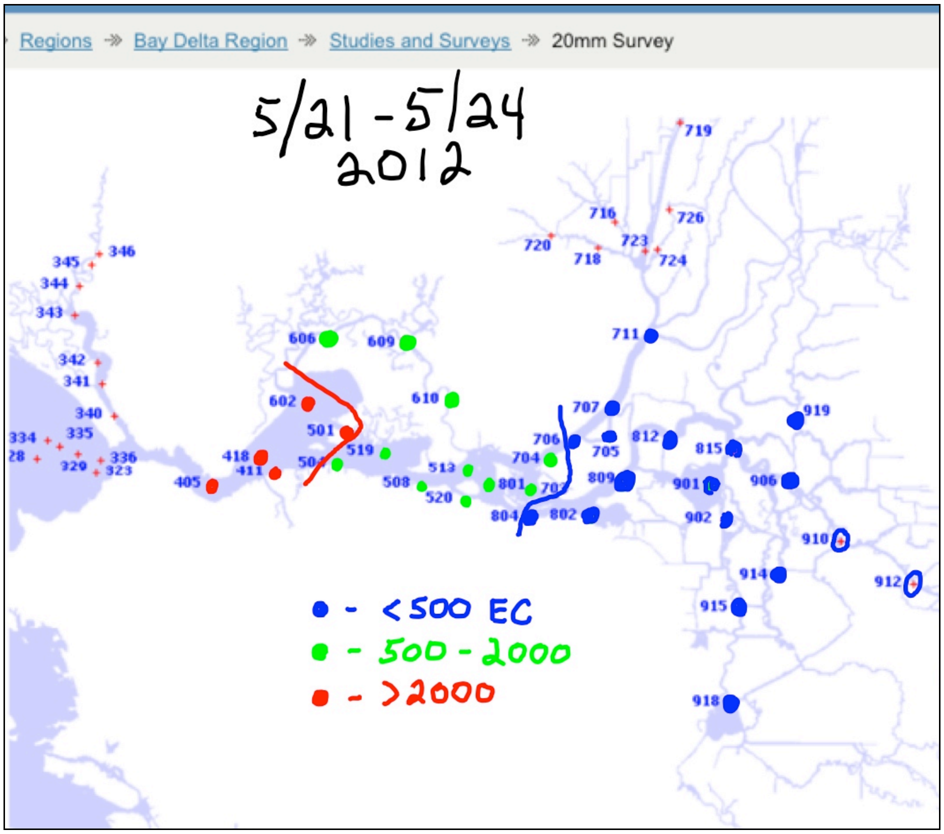


## Year 2012

This year, 2012, started well for smelt (as can be seen in the 20-mm Survey data) with the LSZ located in Suisun Bay in May (see figures below with 20-MM Survey EC data). During May Delta outflow dropped from 28,000 to 13,000 cfs, exports rose from 2,000 to 5,000 cfs and E/I rose from 6% to 33%. Delta inflow dropped from 32,000 to 14,000 cfs. In June Delta inflow gradually rose from 14,000 to 22,000 cfs, while exports gradually rose to 6,000 cfs. By early June the Vise was strong with much of the LSZ confined in a small area of the lower Western Delta. (Early indication for the Smelt Summer Index from a survey in early June is that the index will be much lower than expected given the high index last fall. July survey data is not yet available.) The Vise slackened in mid June with higher outflows, only to press again at the beginning of July. In July, Delta inflow rose to 25,000 cfs as exports rose to 9,500-11,500 cfs range.

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20mm Survey
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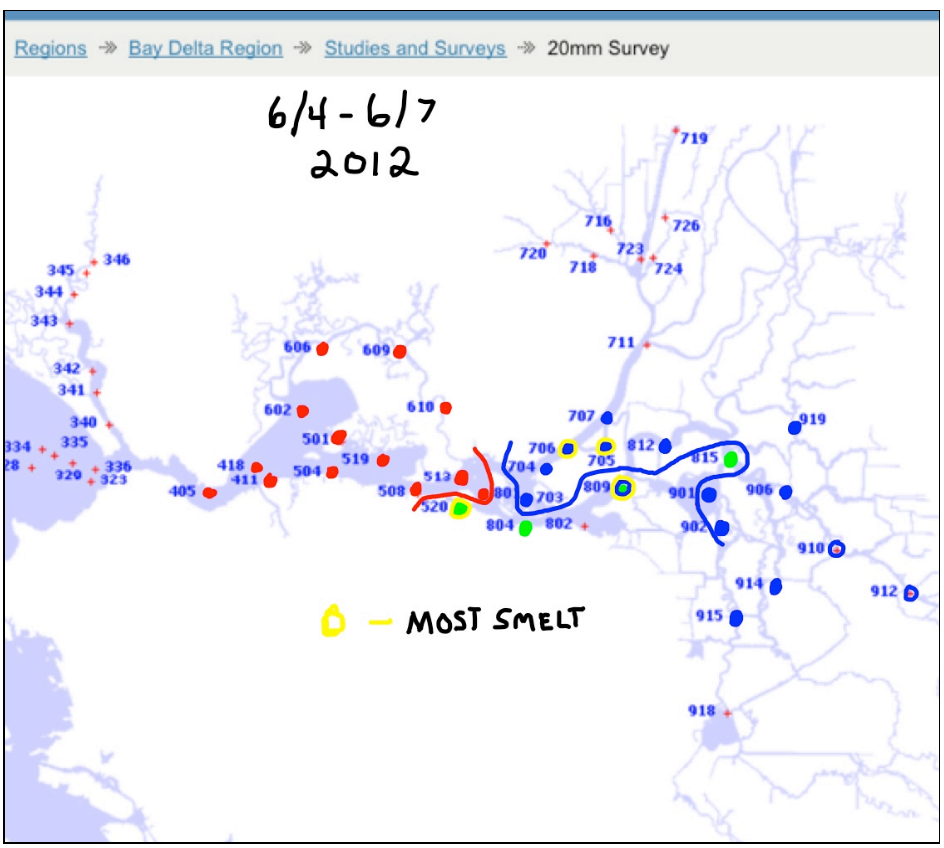
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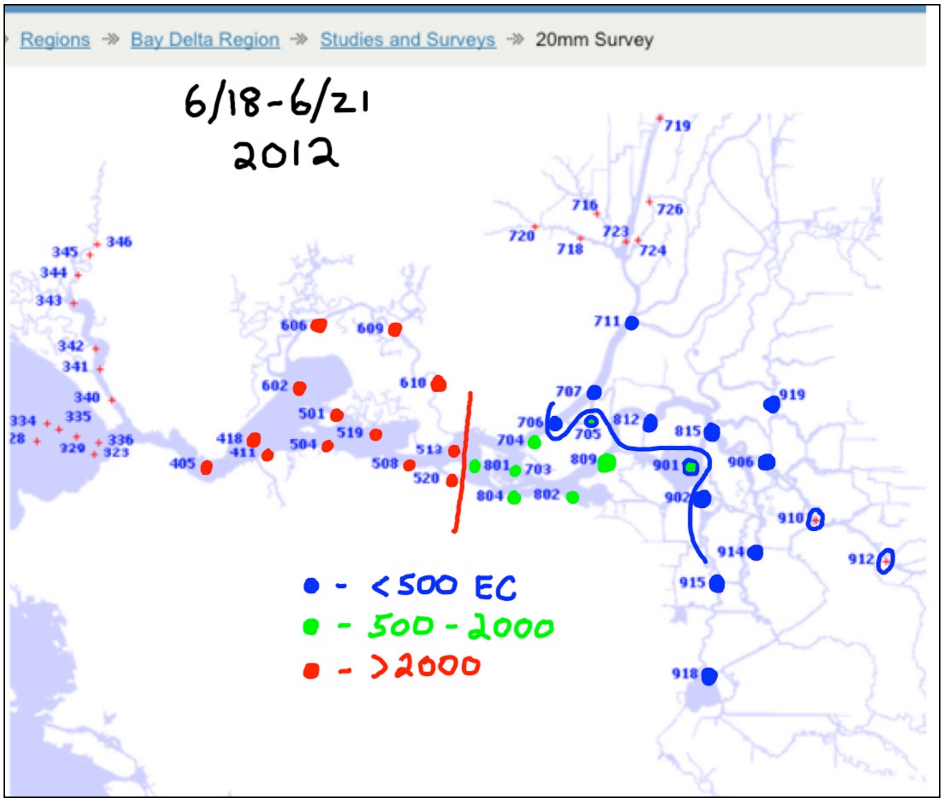
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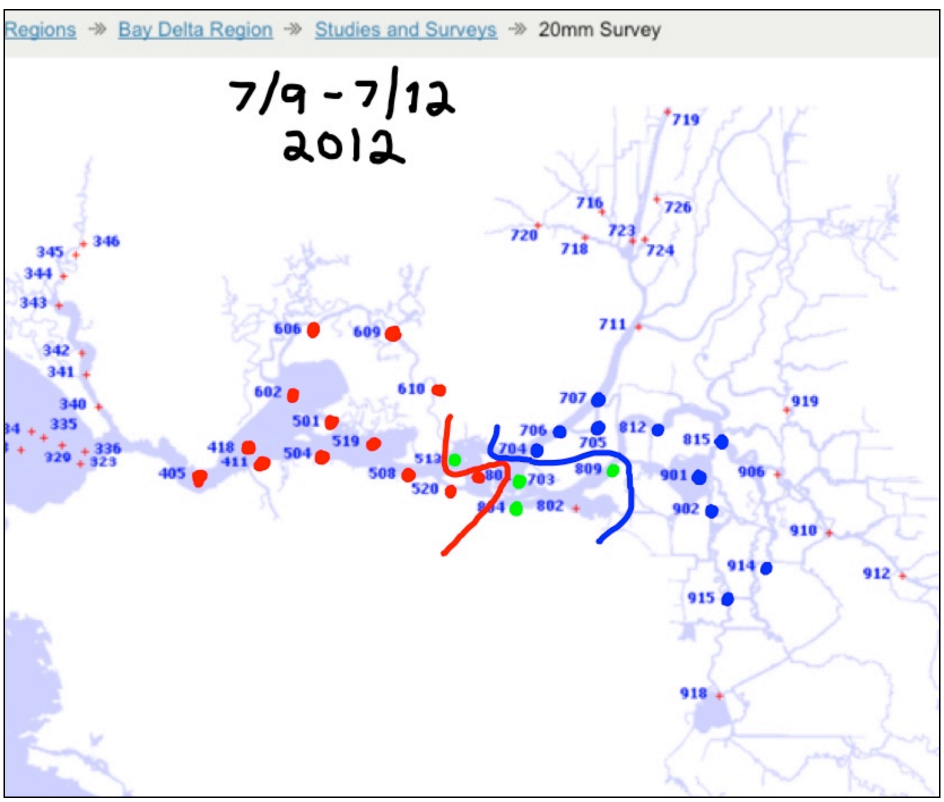
Regions » Bay Delta Region » Studies and Surveys » 20mm Survey
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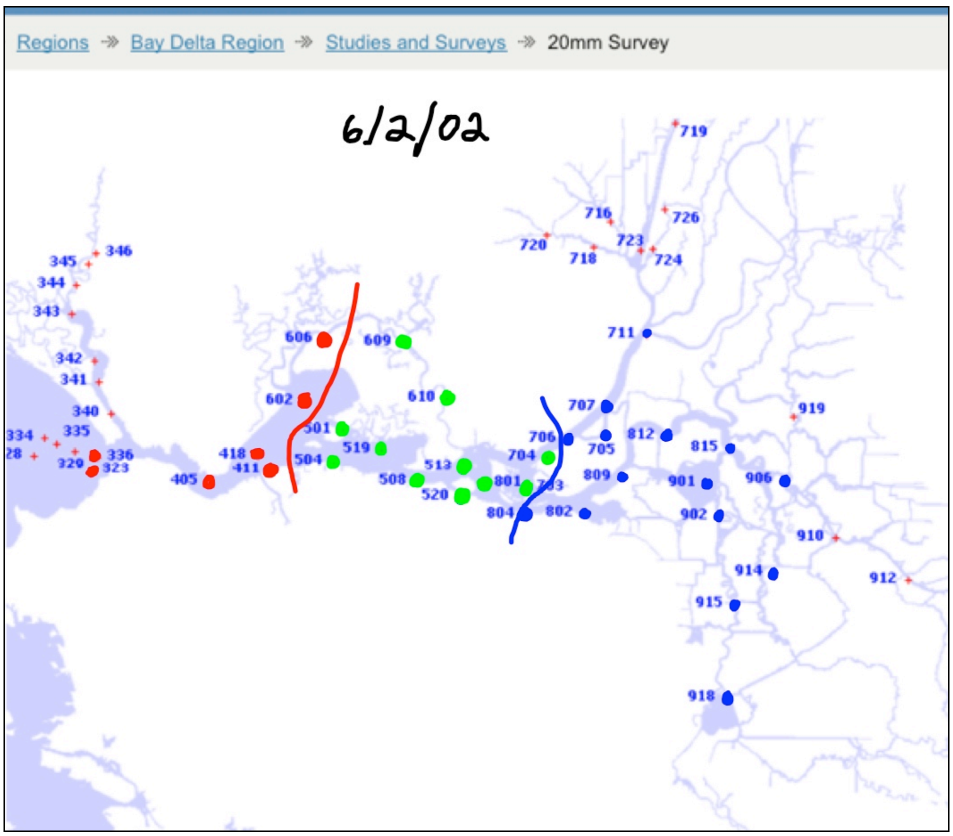
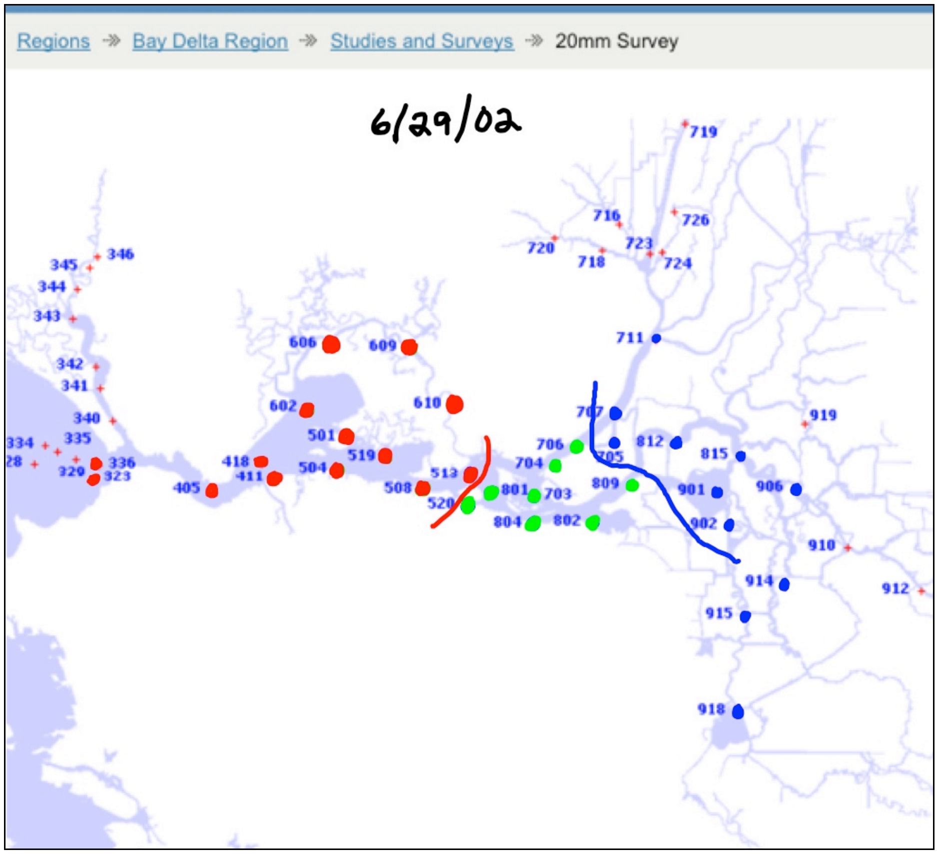
## Year 2002

In contrast to 2011 but similar to 2012, June 2002 saw the LSZ move upstream into the western Delta during June under moderate exports, and then move more sharply in July as the Vise grip strengthened. The movement was gradual during June as exports rose from 2,000 to 6,000 cfs, inflow rose from 15,000 to 19,000 cfs, and outflow was low and steady at 6,000-7,000 cfs. On July 1 exports rose immediately above 10,000 cfs and reached 11,500 cfs in the last ten days of the month. Delta inflow rose to 22,000 cfs, while outflow fell into the 4,000-6,000 cfs range.

It is this sharp change at the end of June that suddenly drives the LSZ into the western Delta out of eastern Suisun Bay. In the next workshop I will show that this is probably the primary cause of many of the sudden drops in the smelt fall index as in 2002, the year that marked the beginning of the POD. The culprits here are the sudden change, the low outflow, high inflow, and very high exports – the Vise. Under D-1485 the July export limit would have been 7,600 cfs.






Another example from 2002 that helps describe the negative consequences of the E/I standards is shown in the next figure for January 2002. Here the closure of the Delta Cross Channel (DCC) during high export periods brought about dramatic changes to Central Delta hydrodynamics. Any fish in the Central, South, and East Delta including all the young salmon coming from the San Joaquin River system become very susceptible to Delta export. Any adult smelt migrating upstream from the Bay into the Central Delta are also susceptible. The problem here is high exports in combination with DCC operations under the 95 E/I standards.