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August 14, 2007

The Honorable Phil Isenberg, Chair
and Members, Delta Vision Blue Ribbon Task Force
State of California Resources Agency
1416 Ninth St., Suite 1311
Sacramento, CA 95814

Subject: Comments on salinity variability and ecosystem health in response to the July 19, 2007 Meeting of the Delta Vision Blue Ribbon Task Force

Dear Chair Isenberg and Members of the Task Force:

During the Delta Vision Blue Ribbon Task Force ("Task Force") meeting on July 19, 2007, the Task Force asked relevant, essential questions concerning the hypothesis that increased variability in the Delta will improve ecosystem health. Recently, I presented information on historical salinity variability and participated with several scientists on a panel discussion at the CALFED Science Program Workshop "Defining a Variable Delta to Promote Estuarine Fish Habitat" held on June 11, 2007 ("workshop") [1]. I would like to take this opportunity to elaborate on two issues discussed at the Task Force meeting and direct your attention to relevant scientific information and conclusions from this workshop.

First, the notion that increased salinity in the Delta would emulate "natural conditions" is not supported by a review of the historical record, which clearly shows that upstream diversions and exports from the Delta have made the Delta significantly saltier than it had been under similar hydrological conditions. It is true that upstream diversions during the 1928-1934 drought made the Delta saltier than any records before or since, and that reservoir construction since the 1940's has allowed better salinity control, but the level at which salinity is now controlled is still saltier than it was historically, or than it would be in the absence of upstream water use and exports. The historical record clearly shows that the Delta is now far saltier than in any period in the past 800 years. The Delta is now just as salty in the fall of wet and normal years as it was previously only in dry years.

A brief summary of historical anthropogenic modifications and salinity observations is enclosed with this letter. The data sources and methods are detailed in a report entitled "Trends in Hydrology and Salinity in Suisun Bay and the Western Delta"[2], produced by Contra Costa Water District and circulated to other stakeholders for review in June 2007. The report shows that on the whole, the salinity line is farther inland than it was historically, and that if a more "natural" variability is desired, it will require that the

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[1] The presentations and final report for the Workshop are available on the CALFED Science website at http://science.calwater.ca.gov/workshop/workshop_variable.shtml

[2] Public Draft is available online at: http://www.ccwater.com/salinity/Historical_Salinity.pdf

Delta and Bay become significantly fresher, not saltier, for significant portions of every year. Obviously, that sort of regime will have significant consequences to both upstream and export water use.

Second, regardless of historical trends, there is no scientific consensus that major modifications to habitat in the Delta by increasing salinity would be beneficial on net. There is an abundance of data that link improved fish populations with fresher, not saltier, conditions.[3,4,5] A saltier regime would have significant redirected impacts to many species and would promote the overbite clam population. The report and presentations from the June 11 workshop address a number of uncertainties concerning ecosystem response and identify areas of vital research and analysis. A short summary of some of these issues is provided in a second attachment.

Workshop presenters agreed that habitat variability must include a broad range of attributes and that focusing on salinity variability alone as a comprehensive surrogate for habitat quality is too narrow and inappropriate. At the same time, the desired levels of variability, and the results of imposing a different variability regime, remain uncertain.

Sincerely,

Greg Gartrell, PhD, PE
Assistant General Manager

Attachments
Historical Salinity Variability Summary
Issues of Uncertainty Concerning the Proposed Salinity Regime

cc: Dr. Michael Healey, CALFED Lead Scientist

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[3] Feyrer F, Nobriga ML, Sommer TR. 2007. Multi-decadal trends for three fish declining fish species: habitat patterns and mechanisms in the San Francisco Estuary. Canadian Journal of Fisheries and Aquatic Sciences. (32, 6).

[4] Guerin M, Denton RD, Gartrell G. 2006. Linkages Between Fall Salinity, Delta Outflow and Delta Smelt Population Decline. CALFED Science Conference. Sacramento CA.

[5] The Bay Institute recently presented evidence to the State Water Board that their composite flow index, termed the 'Delta Flow Index', exhibits a strong correlation with the relative abundance of six Delta pelagic fish species. The presentation is available online at: http://www.waterrights.ca.gov/baydelta/docs/pelagicorganism/tbi_swanson_ppt_061907.pdf

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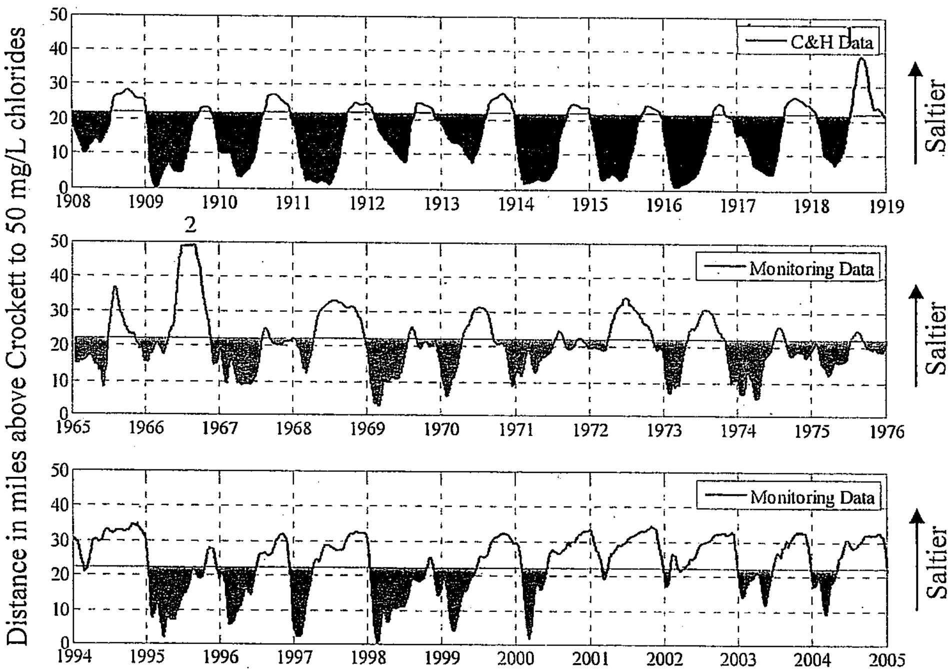
Historical Salinity Variability Summary

Seasonal Variability

Observations from the California & Hawaiian Sugar Refining Corporation (C&H) provide details on seasonal salinity fluctuation in the early 1900s. For comparison with recent observations, two time periods of similar hydrology are also shown below. The shading represents the amount of fresh water, with less than 50 mg/L chlorides, available below the confluence of the Sacramento and San Joaquin Rivers at Collinsville (approximately 22 miles above Crockett, see map on adjacent figure).

Fresh water was available below the confluence for a longer time period each year during the early 1900s. From 2001 to 2005, fresh water was seldom available below the confluence. Additionally, from 1994 to 2005, the distance to fresh water exceeded 30 miles (above Three Mile Slough) at some time during all years except wettest years (1995 and 1998).



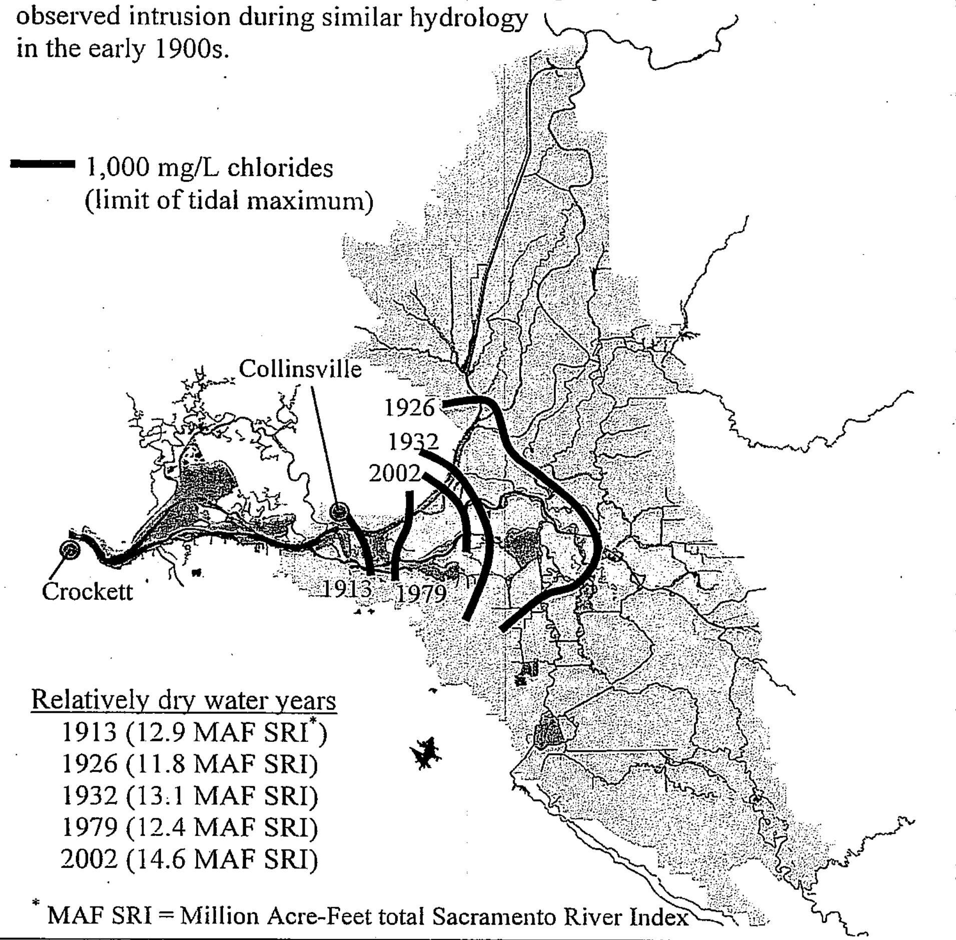
1 During August and September 1918, average water quality obtained by C&H exceeded 110 mg/L chlorides.

2 Salinity intrusion during 1966 is likely an overestimate due to inadequate spatial coverage of monitoring stations.

Annual Maximum Intrusion

Annual maximum salinity intrusion for relatively dry water years with similar total annual unimpaired runoff is illustrated by the location of the 1,000 mg/L chloride concentration. Water year 1913 experienced the least extent of intrusion, most likely because upstream diversions were significantly less than later years. Water years 1926 and 1932 were subject to extensive upstream agricultural diversions, while water years 1979 and 2002 had the benefit of the CVP and SWP to provide "salinity control".

Although "salinity control" limits the impact of upstream water diversions, annual maximum salinity intrusion during the post-Project era still exceeds the observed intrusion during similar hydrology in the early 1900s.



Relatively dry water years
1913 (12.9 MAF SRI*)
1926 (11.8 MAF SRI)
1932 (13.1 MAF SRI)
1979 (12.4 MAF SRI)
2002 (14.6 MAF SRI)

* MAF SRI = Million Acre-Feet total Sacramento River Index

Historical salinity variability as determined from a sediment core in northwestern Suisun Marsh broadly corresponds to independent climate indicators, with general agreement of higher salinity during the Medieval Warm Period and fresh conditions during the Little Ice Age. However, the recent increase in salinity since the mid-1800s observed in the sediment core does not correspond to regional climate change, but rather is primarily due to anthropogenic modifications.

The chronology of anthropogenic changes and salinity observations are summarized below. Up until 1917, the most significant impact on salinity was likely due to changes to the landscape of the Central Valley and Delta. Since 1917, flow management activities have the greatest impact on observed salinity.

Era	Anthropogenic Modifications	Salinity Characteristics
1860-1917 (Early Settlement)	Changes to the landscape of the Central Valley and Delta are significant. • Reclamation of marsh lands • Alluviation then erosion of mine-derived sediment • Deepening, widening, and straightening of Delta channels Water diversions increase throughout this period. (DPW, 1931) • By 1870, irrigation diversions noticeably reduce flow in the San Joaquin River • Gross annual irrigation diversions from the Sacramento and San Joaquin Rivers grow from 1.0 MAF in 1879 to 4.3 MAF in 1917	➢ Salinity intrusion is only reported during the drought of 1870. ➢ Earliest salinity measurements (1908-1917) indicate salinity of 1,000 mg/L chloride remained near the confluence of the Sacramento and San Joaquin Rivers, even during dry years.
1918-1944 (Pre-CVP)	Changes to the landscape are less substantial than the previous era. • Continued deepening of Delta channels • Continued erosion of mine tailings Water diversions continue to increase throughout this period. • Upstream storage capacity grows from 1.2 MAF in 1920 to 4.6 MAF in 1943 • Annual irrigation diversions exceed 6.5 MAF by 1944	➢ Salinity intrusion is greater than any other time period, likely caused by upstream diversions and lack of precipitation. ➢ Salinity retreats and fresh water reaches the confluence of the Sacramento and San Joaquin Rivers during the winter, even during dry years.
1945-1967 (Pre-SWP)	Changes to the landscape continue, but not as dramatic as earlier eras. Water diversions continue to increase with substantial increases in storage. • Shasta Reservoir (4.5 MAF) completed in 1945 • Upstream storage capacity increases to 17.5 MAF in 1966 • South of Delta exports begin in 1951, exceeding 1.6 MAF by 1966	➢ Salinity intrusion is "controlled" by reservoir releases, limiting the impact of upstream diversions but not returning to levels observed from 1908 to 1917, before significant upstream diversions altered the flow regime. ➢ Delta is generally saltier than would occur under unimpaired conditions during most months. ➢ Reservoir releases slightly freshen the Delta during February and September, primarily during wet years, likely due to flood control operations.
1968-1993 (Pre-ESA)	Water diversions continue to increase with substantial increases in storage. • Oroville reservoir (3.5 MAF) completed in 1968 • Upstream storage capacity increases to 30.4 MAF by 1979 • South of Delta exports increase to 6 MAF by 1990 Water quality, water rights, and other agreements impact timing of reservoir releases and south of Delta exports. • Water Rights Decision 1485 issued in 1978 • CVP Improvement Act approved by Congress in 1992	➢ Similar to the previous era, with increased reservoir capacity further freshening the Delta during September until the mid-1970s. Since the mid-1970s, the freshening effect of reservoir releases has been diminished. ➢ Starting in the mid-1970s, salinity during winter months at Collinsville often exceeds previously recorded levels, including the 1920s and 1930s.
1994-present (Post-ESA)	Water quality, water rights, and other agreements impact timing of reservoir releases and south of Delta exports. • Bay-Delta Accord sets interim water quality objectives in 1994	➢ Substantial increase in fall salinity in the western Delta during all but the wettest years; at Collinsville, fall salinity resembles the levels of the 1930s drought.

Issues of Uncertainty Concerning the Proposed Salinity Regime

How will the Ecosystem Respond to a New Salinity Regime?

As discovered with the X2 standard, recreating a previous salinity regime (or developing a new salinity regime) may not improve overall ecosystem health. One weakness of the X2 standard may be that it only regulates a portion of the seasonal cycle and has thus precipitated unforeseen consequences during the unregulated time period, increasing salinity in the fall. The increased fall salinity in Suisun Bay has improved the habitat conditions for the overbite clam (*Corbula amurensis*), an invasive species whose voracious feeding has been linked to a decrease in phytoplankton (precursor to "fish food") since it was first detected in Suisun Bay in 1987[1].

In the course of the Workshop, Dr. Peter Moyle presented the first quantitative suggestion of a new salinity regime. According to the Workshop report,

> [Moyle] argued that areas subjected to a salinity range of 0-12‰ for 1-2 years with the salinity lows and highs sustained for 4-5 months at a time would be unfavorable to overbite clam and Brazilian waterweed, while favoring desirable species adapted to the historical pattern of fluctuating Delta salinity regimes (e.g., delta smelt, longfin smelt, striped bass, mysid shrimp, splittail, and tule perch) (Moyle, slides 19-20).

The proposed range of salinity is currently observed in some areas of Suisun Bay that are part of the permanent habitat of the overbite clam[2]. It is unknown whether sustaining the low salinity for a longer period of time will kill the overbite clam. It is also unknown whether extending the low salinity time period will allow the Asiatic freshwater clam (*Corbicula fluminea*) to establish in the region.

Currently, the two clam populations, the overbite clam and the Asiatic freshwater clam, inhabit primarily different areas of the Bay-Delta, with a small region of overlap near the confluence of the Sacramento and San Joaquin rivers at Collinsville[3]; the overbite clam lives to the west of the confluence while the Asiatic freshwater clam lives to the east. At this time, we do not know how the clam populations will respond to a change in the salinity regime. The primary habitat may simply shift[4], with the possible consequence of increasing the area of overlap between the two species.

Shifting the habitat may increase the biomass of one clam species at the expense of the other. Recent research indicates that the overbite clam is likely more detrimental to the ecosystem than the Asiatic freshwater clam – the overbite clam filters water (including "fish food") faster and accumulates Selenium faster[5].

At this point in time, we cannot predict how the ecosystem will respond to a new salinity regime. The "dynamics of clam-phytoplankton interactions under different salinity regimes are not currently predictable. Therefore, the food web responses of fishes feeding on clams or competing with them for food are likewise not currently predictable."

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[1] Workshop presentation. Thompson, slides 8 and 9
[2] Workshop report. Pages 10 and 11.
[3] Workshop presentation. Thompson, slide 12
[4] Workshop presentation. Thompson, slide 12
[5] Workshop presentations. Thompson, slide 13

Issues of Uncertainty Concerning the Proposed Salinity Regime

In addition to the clam-related food-web issues, there is a great deal of uncertainty in the role of Brazilian waterweed in the food-limited ecosystem of the Delta. It is currently unknown whether the Brazilian waterweed, the algae that covers its leaves, or the invertebrates common within the beds are important in the food-web. If the change in salinity regime is successful in killing large quantities of Brazilian waterweed, it may adversely impact the food-web.

Will a New Salinity Regime Release Toxic Metals?

Sediment geochemistry may be altered by a change in salinity. It is currently unknown how these conditions will affect inorganic mercury-methylation.

Additionally, if the Brazilian waterweed dies quickly and settles, the bottom of the water column may become anoxic, with the potential to release toxic metals from sediments and plants. The response of the waterweed to increased salinity, including the rate of dieback and fate of dead vegetation is currently unknown.

How Could the Proposed Levels of Salinity be Achieved?

Historically, the greatest observed salinity in the Delta occurred in the 1920's and 1930's. Salinity investigations of the era found that the extreme salinity intrusion was larger than any previous intrusions known to local residents (dating back to the 1850's) and concluded the extent of intrusion was likely doubled due to upstream irrigation diversions[6].

During 1931, the direction of net flow at Carquinez Strait on the eastern edge of Suisun Bay reversed direction, such that Bay (or ocean) water flowed into the Delta for over two months from June to September; net Delta outflow reached approximately -3,300 cubic feet per second (negative indicating flow in the upstream direction)[7]. The daily peak salinity *at slack water after higher high tide* in the vicinity of Franks Tract reached 12‰ for approximately six weeks during August and September[8]. The daily average salinity at the same location was likely less than 8‰. With the existing Delta configuration (channel and island geometry), we expect similar freshwater flow depletions would be necessary to achieve similar salinity intrusion into the western and central Delta today. Initial studies indicate that without reversing flow at Carquinez, it would take four to five months of very low net Delta outflow (250 cubic feet per second) to reach a daily average salinity of 10‰ at Jersey Point (approximately 5 river miles west of Franks Tract). To hold this salinity level for four to five months, as proposed, would require a total of approximately nine continuous months of very low net Delta outflow. During this low flow period, residence times in channels would be very high, and they would accumulate any discharges from adjacent lands.

If this reduction of net Delta outflow is achieved by limiting releases from upstream reservoirs, ecosystem impacts that would result from the flow reduction or temperature increase in the upper watershed could be substantial. If a peripheral canal is built to achieve salinity intrusion, it may need to be far upstream to be located where the water is still fresh. Impacts to nearby aquatic regions, including Suisun Bay and Marsh, San Pablo Bay, central San Francisco Bay, and South Bay and potential impacts on terrestrial species in adjacent areas are not known.

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[6] [CDPW] State of California, Department of Public Works, 1931. Bulletin No. 27.
[7] State of California, Department of Water Resources. DAYFLOW
[8] CDPW 1931