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Exhibit CCWD-3 (1994 Workshops)

Letter, Contra Costa Water District
to
Environmental Protection Agency

Comments on
Proposed Bay-Delta Surface Water Quality Standards

March 10, 1994

Submitted to State Water Resources Control Board

Review of Standards for the
San Francisco Bay/Sacramento-San Joaquin Estuary
April, 1994

CONTRA COSTA
WATER DISTRICT

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March 10, 1994

Mr. Patrick Wright
Bay/Delta Program Manager
Water Quality Standards Branch, W-3
Water Management Division
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75 Hawthorne Street
San Francisco, California 94105

Subject: Proposed Bay-Delta Surface Water Quality Standards

Dear Mr. Wright:

Contra Costa Water District appreciates the opportunity to comment on the Environmental Protection Agency's proposed surface water quality standards for San Francisco Bay and the Sacramento-San Joaquin Delta. The proposed standards, published in the Federal Register on January 6, 1994, seek to remedy declines in the population of several fish species in the estuary.

Contra Costa Water District supports the development and implementation of water quality standards which will protect the fishery resources of the Bay-Delta estuary, together with the other vital beneficial uses of the estuary's waters. That has been our position for many years. Protection of fishery resources has become more important in recent years as populations of a number of species have declined. Standards should be adopted and implemented promptly. They should be accompanied by effective programs to measure the health of the estuary's fishery resources so that gaps in current knowledge can be closed and the balance among measures to protect all beneficial uses can be refined.

Prompt action on Bay-Delta standards should be accompanied by recognition of the significant uncertainties with respect to operational aspects as well as the effects to be expected on target biological communities. Achievement of the proposed standards will require California's major water projects to operate in ways that can be characterized accurately as experimental. No one can be sure of the actual degree of salinity control achievable at Roe Island, Chipps Island and the confluence of the Sacramento and San Joaquin Rivers near Collinsville under the highly variable hydrologic conditions typical of the February through June period. A series of studies commissioned by the California Urban Water Agencies have identified numerous uncertainties with respect to the biological efficacy of the standards. For those reasons, our comments urge EPA to approach this issue in an orderly, measured, flexible fashion. Our comments on specific issues follow.

1. Use of Smooth Function (Issue No. 1 in proposed rule)

   Contra Costa Water District supports the use of a smooth function relating salinity requirements to the hydrology of individual years. Basing the requirements on mean conditions during broad categories of year types will, in individual years, require expenditures of water greater that those required to achieve EPA's stated water quality goals. In other years, the goals will not be achieved. The goals can be achieved in a more balanced way by use of a smooth, continuous function.

   The approach to a smooth function given in the Federal Register notice of the proposed rule can be improved significantly. The published proposal suggests a function based on the current Sacramento River Index or, alternatively, the "40:30:30 index" proposed during the Bay-Delta Proceedings which concluded in 1993. These annual runoff indices introduce serious complications when applied to conditions during the February through June period. Consideration of runoff only during the regulated period, from February through June, on a real-time basis would provide a more accurate, more workable basis for determining requirements.

   The method for developing the smooth function suggested in the published notice involves drawing a smooth curve through four points representing mean conditions during four hydrologic year classes. A more comprehensive method of relating salinity to flow, based on historic data, could account for salinity as a function of each year's hydrology. CCWD has developed such a method, presented in Attachment A, which has the advantage of a function fitted to a larger number of data points, with a clearer picture of the range of uncertainty that might be involved in its use. We recommend the use of such a method in deriving a smooth function.

2. Use of Rolling Average (Issue No. 2)

   CCWD supports the use of a rolling average applied to any salinity criteria developed for the western Delta-

Suisun Bay region. Because of the principles usually applied in planning for Delta salinity control, use of an averaging period will sharply reduce the need for an operational "margin of error" or "confidence interval" and reduce unintended water costs associated with the standards. We recommend using a 14-day average to provide much-needed flexibility to the project operators responsible for achieving compliance with standards. Use of a longer averaging period could introduce operational complications due to persistence of the effects of adverse transient events.

3. Need for Confidence Interval (Issue No. 3)

CCWD believes the discussion over the need for a confidence interval in providing for compliance with the proposed standards can be resolved by providing, instead, a flexible compliance specification. We recommend that EPA consider defining compliance with its final standards to consist of achievement of any one of three conditions: (a) achievement of the specified salinity at a station on a rolling average basis; OR (b) achievement of the specified salinity on a daily average basis; OR (c) providing a daily Delta outflow judged to be equivalent to achievement of the salinity in the absence of some transient hydrologic event. This recommended definition of compliance will meet the goals of the proposed rule and, by providing significant operational flexibility, eliminate the need for a "margin of error" or "confidence interval".

The Delta outflow element of the recommended definition must be selected with care. We suggest that EPA consider using the procedure developed by Contra Costa Water District and described in Attachment B. The CCWD procedure, which is based on field experience, offers an important advantage, relative to available alternatives. It accounts for the varying response of salinity to outflow through a wide range of field conditions.

4. Level of Protection (Issue No. 4)

It is possible to produce a well-reasoned, well-defined level of protection expressed in terms of conditions during the late 1960's to early 1970's, or any other period for which necessary field data are available, using the procedures described in Attachment A (See "Use of Smooth Function", above). CCWD recommends use of the method of Attachment A to determine appropriate levels of protection. We note that this method suggests that the conditions that are the goal of the proposed standards require significantly fewer days of achievement of the target salinity than those given in the Federal Register notice. However, the method is consistent with the intent of EPA in that it produces an easily understandable, linear function which corresponds closely to observed data from a wide range of field conditions.

5. <u>Historical Reference Period</u> (Issue No. 5)

CCWD recommends use of a period beginning no earlier than water year 1968 for developing salinity standards. The reason for this recommendation is that the most reliable, complete data base for Delta salinity is that available for the period since October, 1967, when installation of a network of continuous conductivity recorders at Delta stations was initiated. We further recommend use of the method described in Attachment B for estimating relationships between salinity and flow, because the method is well founded in field experience and data, and covers an extremely wide range of hydrologic conditions.

6. <u>Roe Island Trigger</u> (Issue No. 6)

CCWD does not support the proposed 2 ppt salinity standard at Roe Island because its environmental benefits are uncertain and because compliance with this standard may conflict with operational requirements to protect endangered species in the Sacramento Valley. However, should EPA nevertheless adopt a Roe Island standard, CCWD recommends a triggering provision to ensure that the compliance period begins only after a natural storm event, rather than a short-term tidal fluctuation. The standard should be triggered by a period of seven consecutive days of salinity at or below the target salinity. We recommend use of a seven day period, rather than a single day, to recognize the effects of normal tidal variation and to minimize the likelihood of triggering an important and costly standard by an anomalous hydrologic or meteorological event. To maintain appropriate operational flexibility, we recommend that the standard be triggered only by events that occur during the February through June period. Use of a trigger based on January events poses unacceptable risk of imposition of a physically unattainable standard.

7. Alternate Operational Scenarios (Issue No. 17)

CCWD believes that the potential for unforeseen impacts on the environment or on other beneficial uses, including water supply, can be minimized by use of a flexible compliance specification. We recommend consideration of the specification suggested under "Need for Confidence Interval", above, which provides for multiple alternative methods of compliance. This proposed specification assures consistent efforts achieve EPA's goals while controlling uncertainties with respect to operation of projects providing the means of achievement of those goals.

8. Implementation Schedule (Additional Issue)

Contra Costa Water District recommends that EPA adopt Bay-Delta standards promptly so that they can be implemented by a joint state and federal partnership within the next six to nine months.

The District further recommends that the standards recognize the need for phased implementation. The proposed standards involve operational requirements whose effectiveness has not been demonstrated in the field. We believe operators should be given a period to acquire the field experience needed to achieve the desired levels of control.

To summarize, Contra Costa Water District recommends that EPA proceed with its standards-setting process in a deliberate, careful way that protects important environmental values while recognizing all of the interests dependent on the estuary and its continued well-being.

Sincerely,

Walter J. Bishop

Walter J. Bishop
General Manager

WJB/AWN/ce
Attachments

Attachment A

X2 Sliding Scale Methodology

Introduction

EPA has invited comment on the feasibility of setting water quality criteria based on a smooth function rather than on the mean value for each water year type category (Issue #1, Federal Register, Vol. 59, No. 4, January 6, 1994, page 834). EPA illustrated this approach with examples of smooth quadratic relations for the numbers of days of salinity of 2 ppt or less (also referred to as X2 days) at Roe Island and Chipps Island as a function of the Sacramento Basin 40-30-30 Index. The smooth quadratic relations were fitted to the number of days of 2 ppt or less, averaged for each water year type, for the period 1940 through 1975. In essence, EPA's methodology reduced the data from 36 years to four points: the average number of X2 days during wet, above normal, below normal, and dry years. The period, 1940-1975, contained no critical years.

EPA also invited comment on a modified Sacramento River index that is weighted more toward precipitation and unimpaired runoff February through June and the amount of carryover storage from the previous year (Issue #1, Federal Register, Vol. 59, No. 4, January 6, 1994, page 838). A 40-20-20 ratio or 50-0-50 index were suggested as a more appropriate basis for the criteria.

EPA has also asked for comments on the proper historical reference period for developing target numbers of days when the 2 ppt isohaline is at a particular point in the estuary (Issue #5, Federal Register, Vol. 59, No. 4, January 6, 1994, page 839). EPA recommended a level of protection for the Bay/Delta similar to that existing during the late 1960s to early 1970s. However, in setting the X2 standards, EPA used the longer 1940 through 1970 period.

This attachment addresses all three aspects of these issues. An improved sliding scale methodology is presented that shows that a sliding scale is feasible, although a simple linear relation for the variation of number of X2 days is found to be adequate. A February through June index is found to better predict the historical number of X2 days than a 40-30-30 index or similar ratios of Sacramento Basin unimpaired runoff. The improved sliding scale methodology allows X2 standards to be set using just the recommended late 1960s to early 1970s period.

This attachment presents an improved sliding scale methodology and illustrates the application of this methodology at Roe Island, Chipps Island and Collinsville. However, the presentation of this methodology does not represent a specific recommendation by CCWD of the numbers of days that should be met at any of the three locations or whether the X2 standards should be applied at all three locations.

An improved sliding scale methodology

The 40-30-30 index, which was developed as part of the SWRCB D-1630 process to define water year availability over a full water year (October-September) may not be representative of the salinity regime in Suisun Bay for the period, February-June. The 40% component of the 40-30-30 index is the sum of monthly unimpaired runoffs for April-July and July runoff cannot affect salinity in the previous period, February-June. Similarly, unimpaired runoff in October, November, and December that is not stored in upstream reservoirs will not significantly effect salinity in the February-June period.

Modifying the split of the April-July runoff, October-March runoff, and the previous water year's index in the Sacramento Basin 40-30-30 Index to 60-20-20 or 50-0-50 will not avoid the problem of including July's unimpaired runoff. A better approach is to use the sum of the monthly runoffs for the period, February through June, as this most directly affects salinity in the Delta and Suisun Bay. This index may be further refined by including January to account for antecedent effects of outflow on salinity and/or including an additional factor to account for carryover storage in upstream reservoirs at the end of January.

Number of Days 2ppt or Less as a function of February through June Index

Figures A1, A2, and A3 show the number of days salinity is less than or equal to 2ppt at Roe Island, Chipps Island, and Collinsville, respectively, as a function of the February through June Sacramento Basin Index for each year of the historical record, 1930 through 1992. The number of days were calculated from estimates of Delta outflow using an antecedent outflow-salinity model (Attachment B). In deriving the number of X2 days, it was assumed that 2 ppt bottom salinity requirement was met by a surface electrical conductivity of EC = 2640 μS/cm or less.

The data in figures A1, A2 and A3 are categorized into four historical periods: (1) 1930-1939 (pre-projects), (2) 1940-1967 (start of construction of CVP and from 1951 onwards CVP on-line), (3) 1968-1975 (representative of EPA's period of recommended protection), (4) 1976-1992. The period before initial operations of the CVP (1930-1939) has the greatest number of X2 days, as expected. The number of X2 days in the recent period, 1976-1992, is similar to the number of X2 days in the late 1960s to early 1970s period at similar levels of the February-June Sacramento Basin Index.

Historical Period

EPA has recommended a level of protection for San Francisco Bay and the Delta similar to that which existed during the late 1960s and early 1970s. In developing the Clean Water Act X2 standards, however, EPA used a longer period, 1940-1975, to determine the number of days of 2 ppt or less for specified year types. This longer period was deemed necessary to ensure sufficient data for the analysis. As discussed above, EPA's methodology reduced 36 years of data to only four points.

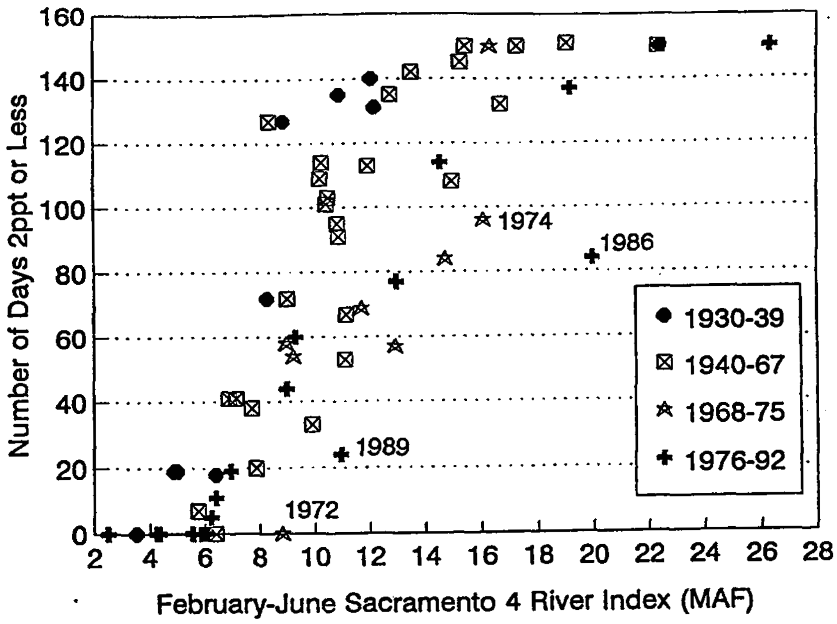

Figure A1. Relation between the number of X2 days at Roe Island and the February-June Sacramento Basin Index for the period, 1930-1992.

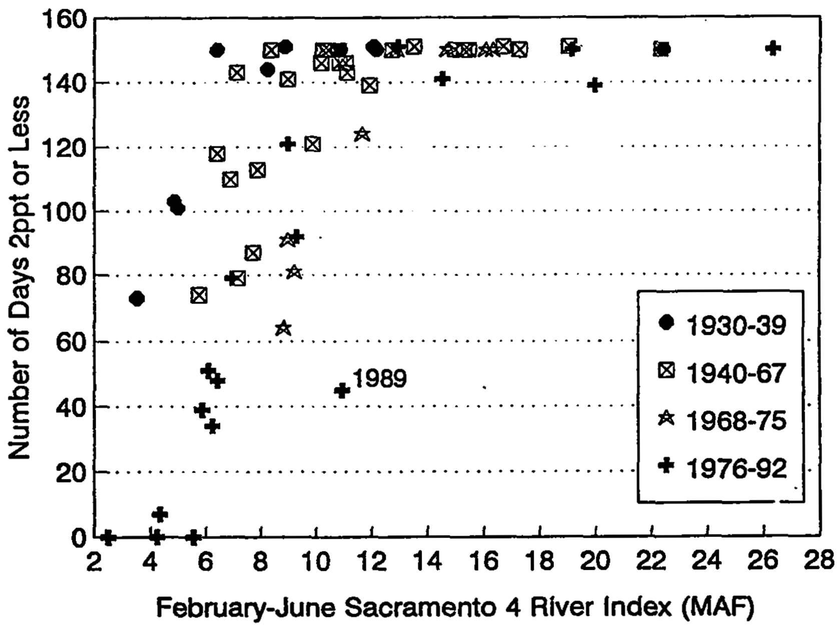

Figure A2. Relation between the number of X2 days at Chipps Island and the February-June Sacramento Basin index for the period, 1930-1992.

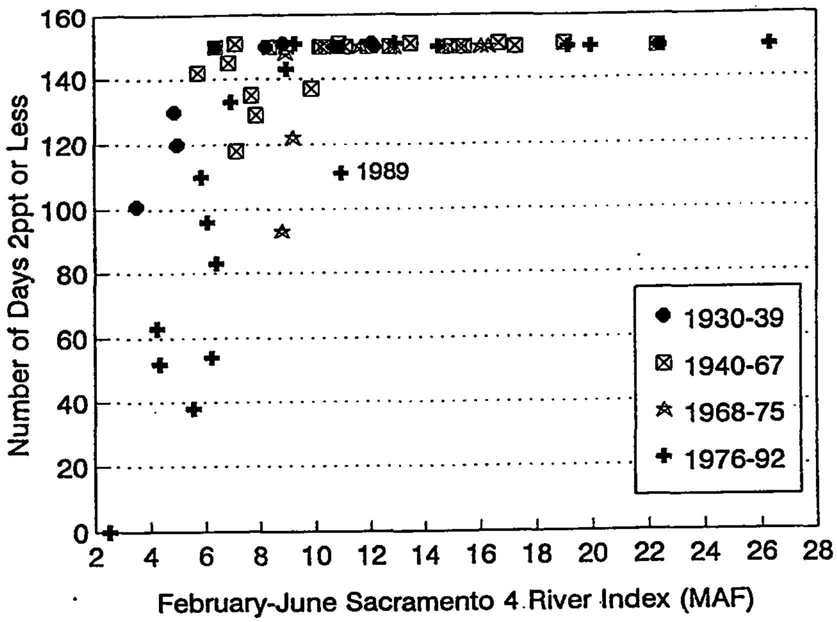

Figure A3. Relation between the number of X2 days at Collinsville and the Sacramento Basin index for the period, 1930-1992.

Plotting the number of X2 days for each individual year retains much more detail of the historical variation of X2 days with the February through June Sacramento Basin Index. This enables analysis of different historical periods such as 1968-1975 (8 points), 1964-1975 (12 points) or 1955-1975 (21 points), as suggested in EPA's Issue #5. A similar approach of plotting the number of X2 days for individual years was used by the California State Water Resources Control Board (Letter from Walt Pettit to Harry Seraydarian, dated November 15, 1993). SWRCB staff plotted data for 1964 through 1976 as a function of 40-30-30 index.

Figure A4 shows the number of X2 days at Roe Island for a period compatible with EPA's recommended level of protection, 1968-1975, along with a least squares linear fit. The data plotted in figure A4 and in figures A1 to A3 suggest that since a simple linear equation reasonably fits the data, use of a higher order polynomial appears unwarranted. Also shown in figure A4 are the number of X2 days required under the proposed Clean Water Act X2 standards. There is some overlap in required number of days because the water year types for the proposed Clean Water Act standards are based on the 40-30-30 index rather than a February through June unimpaired runoff index. The proposed X2 standards tend to require significantly greater number of days of compliance than the least squares linear fit through the 1968-1975 data.

Figure A5 shows the number of X2 days at Chipps Island for the period, 1968-1975, along with a least squares linear fit. Data for which the February through June index was greater than 14 MAF were not included in the least squares linear fit since they were at the maximum number of days (150 days). EPA's extrapolation to set a critical year standard (the period 1940-1975 used by EPA contains no critical years) appears to have overstated the necessary level of protection at Chipps Island. The linear fit through the 1968-1975 data shown in figure A5 suggests that very few days of 2 ppt or less would be required at Chipps Island during critical years for appropriate protection. The proposed below normal and above normal year X2 day requirements also appear to be overstated.

Figures A1, A2, and A3 indicate that the least squares linear fits are sensitive to the choice of historical period. Figure A6 shows X2 days at Chipps Island for the period, 1955 through 1992, with linear fits for the periods, 1955-1976, 1968-1975, and 1968-1992. Prior to 1968 (pre-SWP) there were fewer diversions upstream of the Delta and less exports and the number of days of X2 compliance were correspondingly higher. The linear fit for 1955 through 1976, therefore, reflects the correspondingly higher ratio of Delta outflow to unimpaired runoff relative to the period, 1968-1975. It is interesting to note that including the period, 1976 through 1992, with the period of desired level of protection, 1968-1975, results in only a small change to the least squares linear fit.

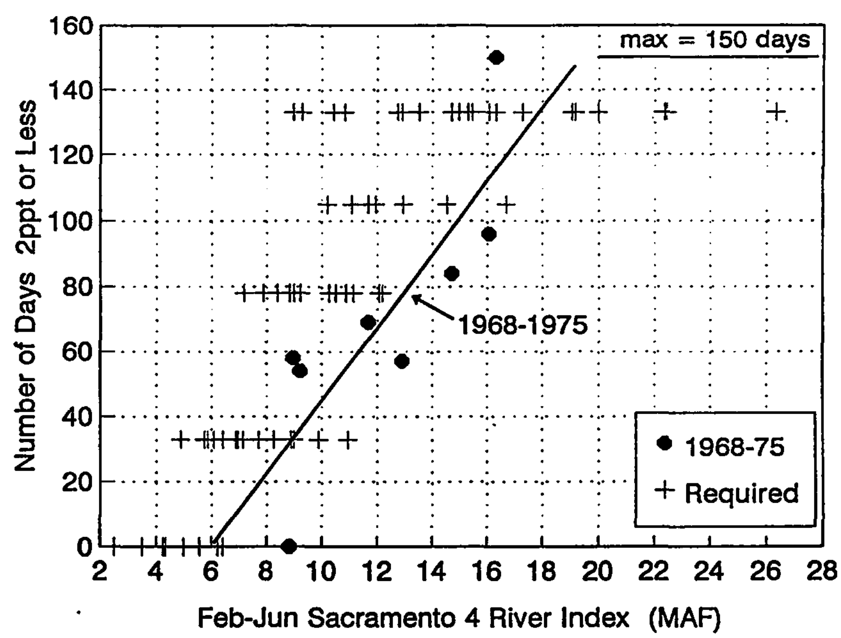

Figure A4. Number of X2 days at Roe Island for the period, 1968-1975. The solid line represents a least squares linear fit through the data. The crosses represent the required number of days under the proposed Clean Water Act X2 standards.

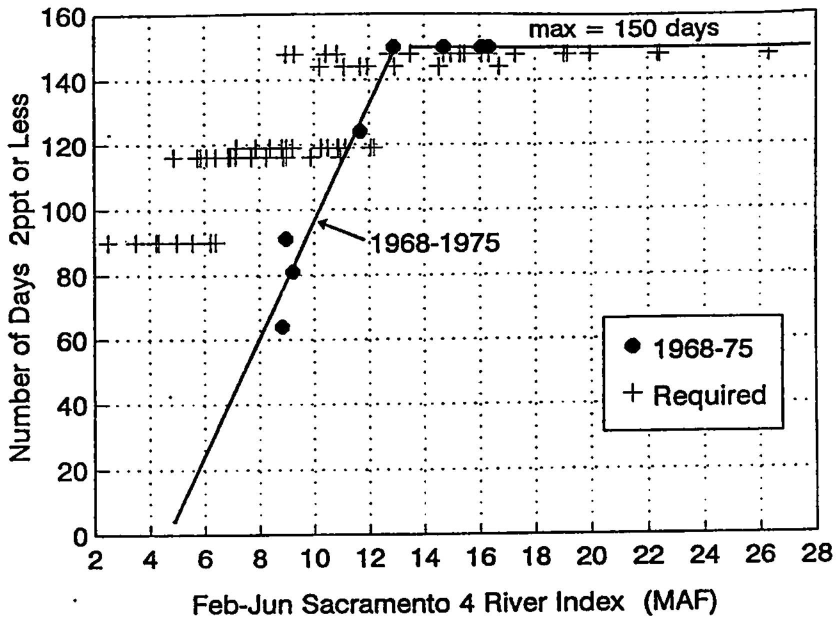

Figure A5. Number of X2 days at Chipps Island for the period, 1968-1975. The solid line represents a least squares linear fit through the data for values of the February-June Index less than 14 MAF. The crosses represent the required number of days under the proposed Clean Water Act X2 standards.

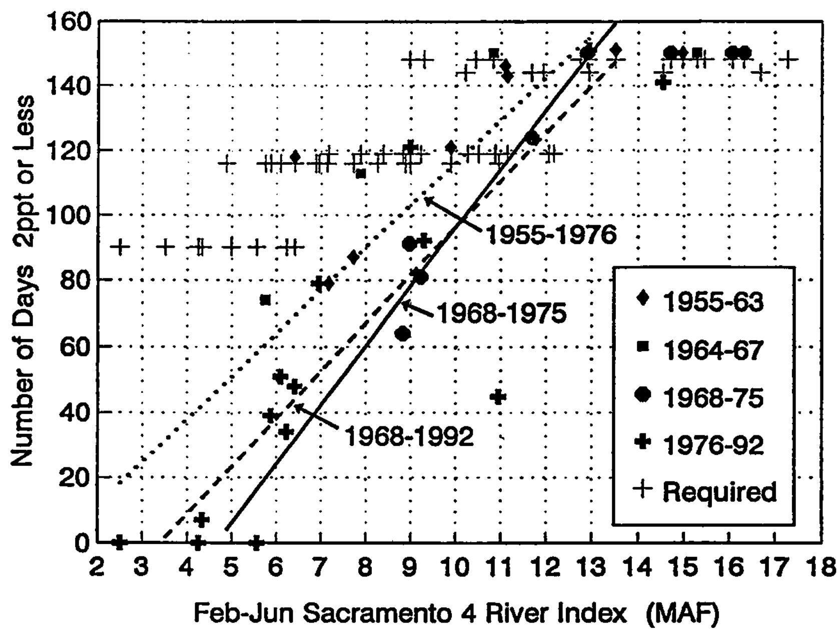

Figure A6. Number of X2 days at Chipps Island for the period, 1955-1992. The solid line represents a linear fit through the data for 1968-1975; the dashed line represents a linear fit through the data for 1968-1992; the dotted line represents a linear fit through the data for 1955-1976.

The proposed X2 day requirement at Collinsville is 150 days for all water year types. Figure A7 shows the number of X2 days at Collinsville for the period, 1964-1992. There were only two years during 1968-1975 when the number of X2 days was significantly less than 150 days. However, the data from the longer period, 1964-1992, suggest that in critical years (beyond the range of conditions in the 1968-1975 period) some relaxation in the proposed X2 day requirements may be warranted.

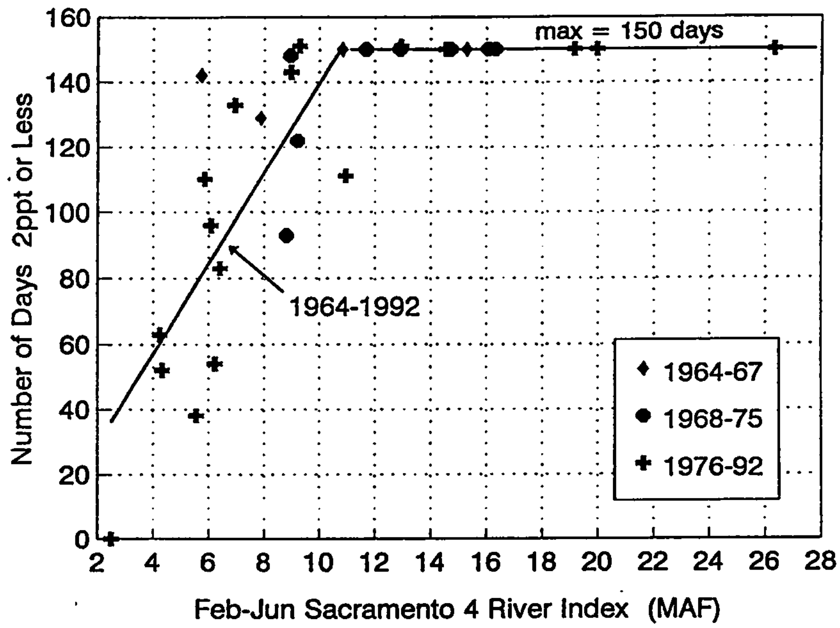

Figure A7. Number of X2 days at Collinsville for the period, 1968-1975.

The number of X2 days in figures A1 to A3 is highly correlated with both inflow into the Delta system (quantified by the February-June Sacramento Basin Index) and total diversions. As diversions increase for a given level of the Sacramento Basin unimpaired runoff, the net Delta outflow decreases and the number of X2 days decreases. The parameter which best determines the number of X2 days from February through June is the February-June net Delta outflow. Figure A8 shows the good correlation between X2 days at Chipps Island and the February-June net Delta outflow for the extended period, 1930-1992. (Anomalies still exist, e.g. 1970, a year in which the timing of outflow was skewed relative to other years with similar net February-June outflow.) NDO, however, cannot be used as a predictive index to define a sliding scale because Delta outflow is dependent on project operations.

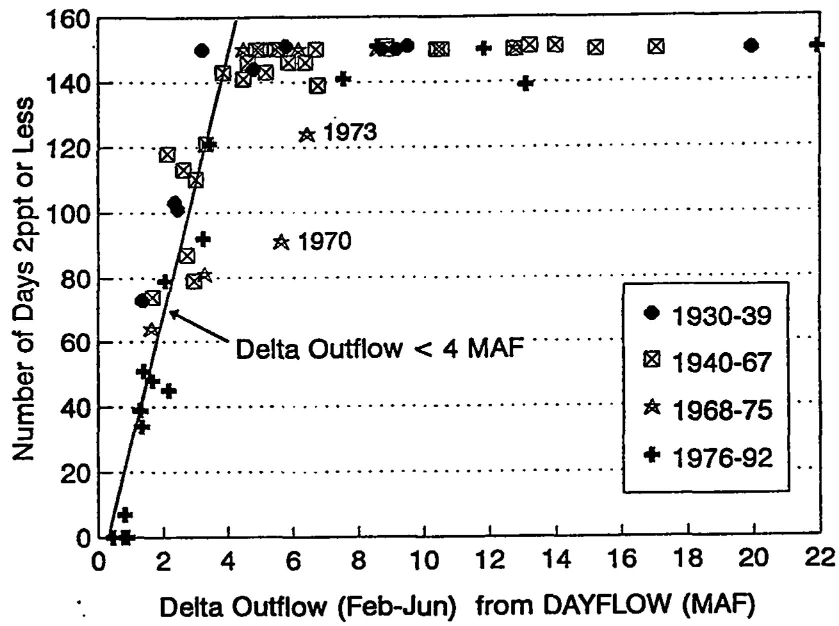

Figure A8. Relation between the number of X2 days at Chipps Island and the February-June net Delta outflow for the period, 1930-1992.

Summary

The data presented in figures A1-A8 suggest that a sliding scale methodology based on linear fits to data for individual years provides an effective way to define Clean Water Act requirements for the number of days of salinity of 2 ppt or less at a given estuary location. An index based on the February-June Sacramento Basin Index appears to correlate well with the historical number of X2 days.

Because the number of X2 days depends both on the runoff index and on the total amount of diversions from the system, an X2 standard based on a linear sliding scale equation would in effect impose a limit on the amount of total diversions from the whole watershed for the February-June period. While the period, 1968-1975, has been used to illustrate the sliding scale methodology, alternate periods might be selected, such as 1964-1976. In addition, January may be included in the runoff index to account for antecedent effects of outflow on salinity and an additional factor may be incorporated to account for carryover storage in upstream reservoirs at the end of January.

Attachment B

Procedure to Determine X2 Equivalent Flow

Antecedent Flow-Salinity Model

Empirical antecedent flow-salinity relations have been developed that were motivated by simple results from one-dimensional dispersion theory (Denton, 1993). The relations can be used directly to predict salinity at locations in the Western Delta and Suisun Bay given the prior time-history of net Delta outflow, or inverted to predict the flow required over some time interval to produce a given salinity.

A Simple Flow-Salinity Relation

Consider the simple case of a one-dimensional estuary in which flow quantities vary only with longitudinal position and time. In this case the tidally-averaged advection-dispersion equation for salinity transport is given by

$$A\frac{\partial S}{\partial t} - Q\frac{\partial S}{\partial x} = \frac{\partial}{\partial x}KA\frac{\partial S}{\partial x}, \qquad (1)$$

where A(x) is the estuary cross-sectional area, S(x,t) is the concentration of salt, Q(x,t) is the volumetric flowrate, K is the longitudinal dispersion coefficient, x is distance in the longitudinal direction (increasing in the upstream direction), and t is time (Denton 1993). The problem may be further simplified by assuming that the area, A, longitudinal dispersion coefficient, K, and flowrate, Q, are independent of longitudinal position.

Boundary conditions may be selected as constant ocean salinity, S_o, at $x=0$, and constant upstream river salinity, S_b, at $x=\infty$. For Q independent of time, the steady-state solution to this problem is

$$S = (S_o - S_b)e^{-Qx/KA} + S_b\,. \qquad (2)$$

Of course in natural environments, such as the San Francisco Bay-Delta estuary, the above assumptions may need modification. In particular, the tidally-averaged flowrate, Q, can fluctuate significantly on time scales ranging from days to months, and the estuary geometrical configuration can be tremendously complex. Geometrical complexities notwithstanding, a modified form of equation (2) is considered for use in modeling unsteady salinity response to variations in Q.

At a fixed position, a relationship of the form

$$S(t) = (S_o - S_b)e^{-\alpha G(t)} + S_b \tag{3}$$

is considered, where G(t) is a functional of the flow time-history (antecedent flow), and α, S_o, and S_b are empirically determined constants which can vary with position.

Antecedent Outflow G(t)

The antecedent outflow G(t) is updated at each time step according to the relation,

$$\frac{dG}{dt} = \frac{(Q - G)G}{\beta}, \tag{4}$$

where β is an empirically determined constant which can vary with position. (This formulation is similar to a relation used by Harder 1977.) In equation (4), β/G may be thought of as an effective time-constant, τ, which determines the rate of approach of G to Q. Equation (4) implies that the system response is relatively quick when G is large and relatively slow when G is small.

Solution for G(t) for a Step Change in Q(t)

In many applications, the Delta outflow Q(t) is a constant value for each time step Δt, i.e. a daily, 14-day or monthly average. For the case of a step change in outflow from one level to a second constant level, equation (4) has the solution

$$G = \frac{\bar{Q}}{\left(1 + (\bar{Q}/G_0 - 1)e^{-\bar{Q}t/\beta}\right)}, \tag{5}$$

where G_0 is the value of G just before the step increase in outflow, and $\bar{Q}$ is the (constant) value of Q over the time interval.

Equation (5) suggests that G(t) continuously tends toward the steady state solution corresponding to the present constant value of Q, but may not reach steady-state before the time interval ends and a new constant value of Q is set.

Equation (5) gives the solution for the variation in G(t) over the whole time interval t_1 to $t_2 = t_1 + \Delta t$. Because the salinity S and outflow Q are both expressed as average values for this time interval, the antecedent outflow should also be expressed as an average value for the same time interval. For example, if the Delta outflows are monthly-averaged values from a Central Valley operations model, monthly-averaged values of G should also be used.

From equation (5), the average value of G(t) over a time interval Δt is given by

$$\bar{G} = \bar{Q} + \frac{\beta}{\Delta t} LN\left(\frac{1 + (\bar{Q}/G_0 - 1)e^{-\bar{Q}\Delta t/\beta}}{\bar{Q}/G_0} \right). \tag{6}$$

Note that equation (6) contains the parameter G_0, the value of G(t) at the start of a given time interval. It is necessary to choose an initial value of G_0 at the very beginning of a simulation (at time t = 0) but the value of $\bar{Q}$ will eventually become independent of this initial value. Although $\bar{Q}$ is calculated using equation (6), it is also necessary to use equation (5) to calculate the corresponding value of G(t) at the end of the same time interval, so that this value can be used as G_0 at the start of the next time interval.

Parameter Estimation

Practical application of equations (3) and (4) requires that four constants be determined from field measurements for each Delta location of interest. In practice, the determination of empirical constants from measurements of Q and S may be done as follows. β may first be determined by choosing the value which best moves the measurements of S onto a single line in the S-G plane. S_b can then be determined by locating the horizontal asymptote of the single line for large outflows ($G \rightarrow \infty$). Here S_b represents the background salinity at high flowrates (large Q) from sources upstream and within the Delta, not from seawater intrusion. The remaining two parameters, S_o and α can be determined by minimizing the deviation between model estimated S and measured S, subject to some defined weighting system (some range of S or G may be more important than another for a particular application).

The parameter estimation procedure is illustrated in figures B1 and B2. In figure B1, 14-day average salinity is shown versus 14-day averaged net Delta outflow (Q). By selecting an appropriate value for β, the data from figure B1 can be moved horizontally to more closely represent a single line in the S-G plane as shown in figure B2. The parameters, S_o, S_b, and α, are determined from the "best-fit" line shown in figure B2.

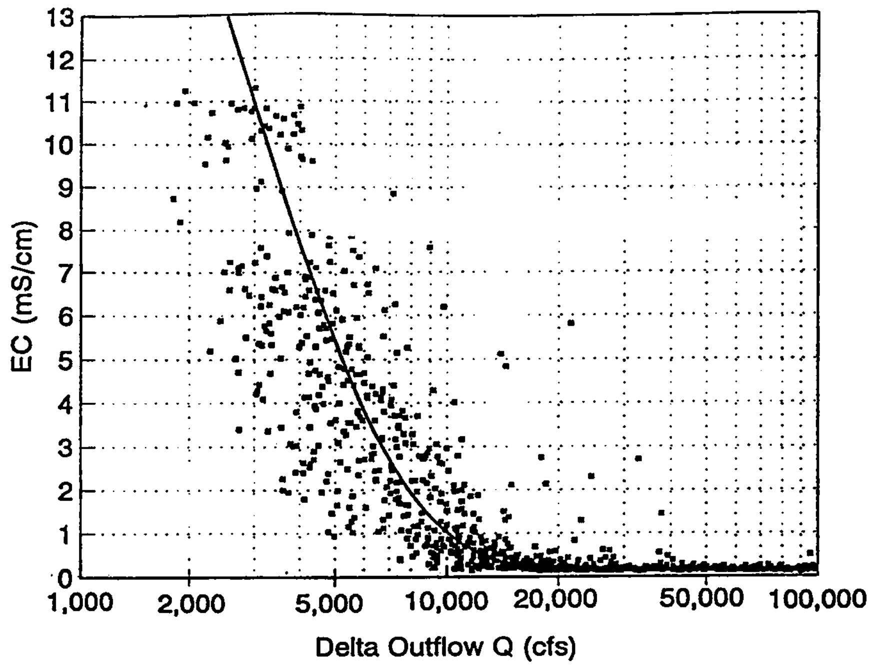

Figure B1. 14-day average salinity at Collinsville as a function of 14-day average net Delta outflow (Q). The data shown are for water years 1968 through 1986.

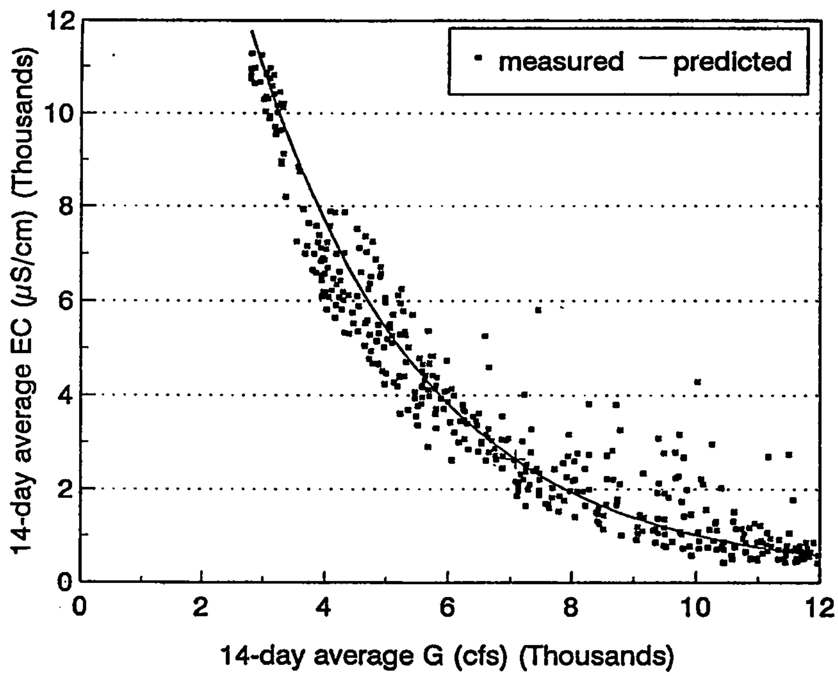

Figure B2. Predicted and measured 14-day average salinity at Collinsville. The solid line is the salinity predicted using Denton's antecedent flow relations and overall "best-fit" parameters. The cross indicates the model prediction at EC=2640 μS/cm using locally "best-fit" parameters in the vicinity of EC=2640 μS/cm.

X2 Flow Requirements

Equivalent steady-state flow requirements for EC=2640 μS/cm at Collinsville, Chipps Island, and Roe Island are given in Table B1 based on Denton's (1993) antecedent flow model using "best-fit" parameters in the vicinity of EC=2640 μS/cm.

Station Name	Location (km)	Steady-State Flow Required
Roe Island	64	29,220
Chipps Island	74	11,400
Collinsville	81	7,080

Table B1. Flow equivalent to EC=2640 μS/cm based on Denton's antecedent flow model using "best-fit" parameters in the vicinity of 2640 μS/cm.

References

Denton, R.A. (1993): "Accounting for Antecedent Conditions in Seawater Intrusion Modeling - Applications for the San Francisco Bay-Delta." *Hydraulic Engineering 93*, Vol. 1, pp. 448-453 Proceedings of ASCE National Conference on Hydraulic Engineering, San Francisco.

Harder, J.A. (1977): "Predicting estuarine salinity from river inflows." *Journal of the Hydraulics Division,* ASCE, Vol. 103, No. HY8, pp. 877-888.