CONTRA COSTA
WATER DISTRICT

1331 Concord Avenue
P.O. Box H2O
Concord, CA 94524
(925) 688-8000 FAX (925) 688-8122
www.ccwater.com

September 16, 2009

Bay-Delta Conservation Plan Steering Committee
c/o Hon. Karen Scarborough, Undersecretary of Resources
1416 Ninth Street, Suite 1311
Sacramento, CA 95814

Subject: BDCP Operational Parameters and Effects Analysis
Follow-up to September 10, 2009, Steering Committee Meeting

Dear Members of the Steering Committee:

Contra Costa Water District (CCWD) would like to take this opportunity to offer comments on the BDCP operational parameters and effects analysis, as presented in the September 10, 2009 Steering Committee meeting. We have three areas of concern, as follows:

- **Evaluation and verification of modeling tools.**
  Models used for operations, hydrodynamics, and water quality have been extensively modified for BDCP studies. Before model results are relied upon to guide important BDCP decisions, the modified models must be carefully evaluated and verified. Furthermore, to provide context for model results, CCWD recommends that the historical data, as well as the pre-BO (i.e. D-1641) modeling results, and the current BO modeling results, be displayed together with results of BDCP proposed operations.

- **X2 requirements.**
  The use of a 5-month average for compliance with X2 requirements could have problematic results, such as a decrease in the temporal variability in salinity that historical conditions and the current standard provide.

- **Limitations on South Delta exports to prevent salvage.**
  The proposed Old and Middle River flow limits should be reviewed; preliminary analysis indicates the levels may be overly restrictive and not supported by the smelt or salmon data. Furthermore, installation of positive barrier fish screens at the south Delta export facilities will allow increased pumping of about 1,000 cfs or more while still protecting covered fish species.

More detailed discussion of the above-listed concerns is given below and in the attachments to this letter.

Evaluation and Verification of Modeling Tools

Modeling tools used in the BDCP analysis need to be verified and should be compared to historical data for context. The models have been modified extensively in the last year to calibrate for salinity and to incorporate new operational changes reflecting the current Biological Opinions (BOs) for the Central Valley Project (CVP) and State Water Project (SWP). They are being modified and the calibrations adjusted to reflect the proposed actions in the draft BDCP. These are not easy tasks.

The preliminary results of the long-term effects analysis presented to the Steering Committee on September 10 include some questionable results, especially the water quality results on slide 22 (see Attachment A). Before the modeling tools can be used to develop, analyze and refine BDCP proposed operations, there must be a demonstration that the models are behaving in a reasonably accurate manner.

The Reasonable and Prudent Alternatives (RPAs) in the current BOs are anticipated to alter upstream storage patterns as well as hydrodynamics and salinity within the Delta, creating a new baseline that is significantly different from the pre-2007 conditions. Monitoring data that represent the conditions anticipated under the current BOs is limited to the last one to two years, when operations included restrictions similar to some of the RPAs. Additionally, the VAMP period each year provides relevant data on expected flows and salinity within the Delta. Monitoring during these periods indicates that water quality in the Central and South Delta is likely to deteriorate during periods of low exports from the existing South Delta facilities. These conditions are unlike those we have seen in the past under prior BOs, but they are the current conditions.

To ensure a common understanding of *current* conditions, as opposed to pre-2007 conditions, CCWD suggests the following approach.

To provide context to the analyses to be presented to the Steering Committee and its subcommittees, CCWD recommends that the historical data, as well as the pre-BO (i.e. D-1641) modeling results, and the current BO modeling results, be displayed together to provide a general understanding of where we are now and what has changed. The modeling results for the proposed BDCP operations can then be compared to these results so that there is a complete understanding of where the system was and what is proposed.

Unfortunately, the modeling tools have previously performed poorly in simulating salinity within the Central and South Delta under conditions with low export pumping from the South Delta, such as imposed by the current BOs and anticipated in the BDCP long-term operations. Also, two years ago CCWD pointed out that the water quality model also has some accuracy problems in the Central and South Delta during periods of seawater intrusion. When these inaccuracies are trained into CALSIM, the degree of error introduced is compounded. CCWD is hopeful that the modifications made to the models have corrected these problems; however, this has yet to be demonstrated. CCWD recommends that the California Water and Environmental Modeling Forum (CWEMF) perform an independent verification of the modeling tools.

Finally, the additional tidal marsh to be created within the Restoration Opportunity Areas (ROAs) is likely to have significant affects on tidal stage, flow, and salinity. For instance, the preliminary results shown on September 10 (slide 8) seem to indicate that over 2,000 acres of existing intertidal habitat within Suisun Marsh will become subtidal and an additional 500 acres of existing intertidal habitat within Suisun Marsh will no longer be inundated with the tides. Combined with the additional proposed tidal marsh areas, the subsequent effect on water quality within the Delta is likely to be substantial and we must have confidence the models are correctly predicting the effects. As mentioned above, the current preliminary water quality results are suspect. Clearly, incorporation of the ROAs cannot be compared to historical data (the areas have not been inundated historically); therefore, the modeling tools must be carefully validated, and the results carefully evaluated at incremental steps by adding portions of the proposed tidal marsh individually and then evaluating the subsequent incremental change in hydrodynamics and water quality. As recommended above, an independent analysis by CWEMF would be appropriate given the level of uncertainty in modeling a completely new environment without any historical context.

X2 Requirements

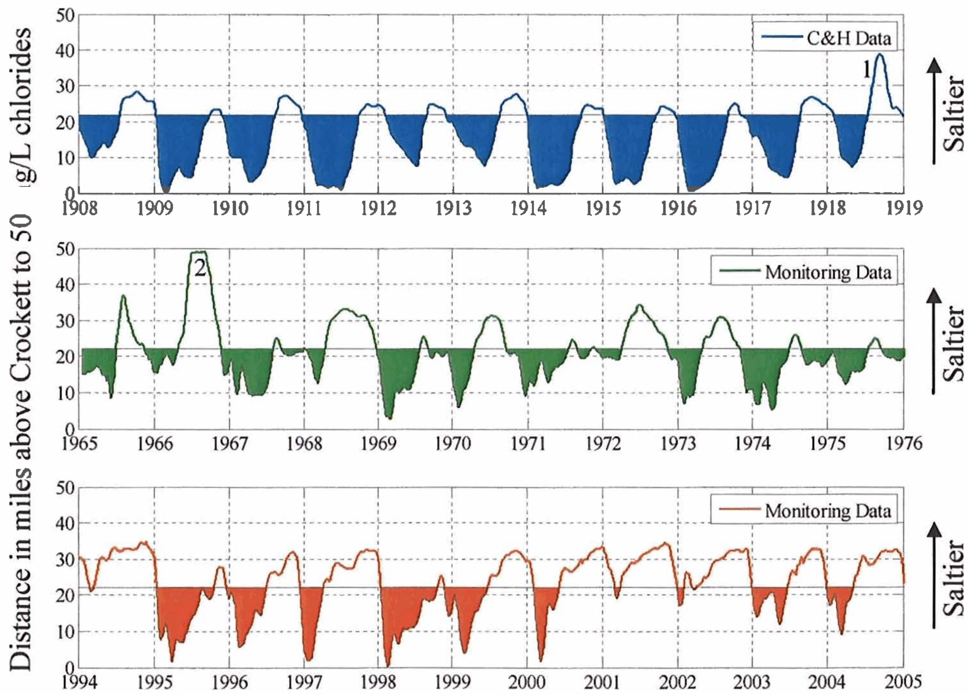
CCWD questions the implementation of the X2 requirement using a 5-month (February through June) average for several reasons. The current implementation of X2, including three methods to comply with the regulation, was carefully developed to avoid unnecessary water supply impacts, while providing water quality conditions at a level of the late 1960s through early 1970s, when fish populations were generally much healthier. Changes to this methodology are fraught with problems and can have unintended consequences. For example, an average may not provide the temporal variability in salinity that the current standard provides.

The X2 target levels (late 1960's to early 1970's) were chosen after consideration of a wide range of potential levels going back to the 1920's. As an illustration of how salinity variability has changed in the estuary, historical data, using three different decadal time periods with similar hydrological variability, are provided here.

Seasonal Variability

Observations from the California & Hawaiian Sugar Refining Corporation (C&H) and more recent monitoring data from two time periods of similar hydrology show how seasonal salinity fluctuations have changed since the early 1900s. The shading represents the amount of fresh water, with less than 0.2 ppt salinity, that is available below the confluence of the Sacramento and San Joaquin Rivers at Collinsville (approximately 22 miles above Crockett). While hydrological conditions were similar in the three periods, the sequence of wet and dry periods differs.

Fresh water was available below the confluence for a longer time period each year during the early 1900s. The period 1965-1976 is the period targeted by the X2 standard. The post-Accord period (1994-2005) shows overall similar winter and spring conditions, indicating some of the effect of the X2 standards. From 2001 to 2005, the initial POD years, fresh water was seldom available below the confluence. The change in summer and fall conditions is readily apparent.



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.

To evaluate the effect of the proposed BDCP operations, simulated salinity variability should be compared to the historical data presented above. A presentation of this sort makes both the average conditions and the variability readily apparent. The time period of 1965-1976 would be of particular interest.

Limitations on South Delta Exports to Prevent Direct Mortality (Salvage)
CCWD understands that the proposed restrictions on net flow in Old and Middle River represent the "mid-range" of the RPAs in the current BOs. However, these values are more restrictive than necessary based on the available data, and could be further modified with implementation of additional conservation measures in the South Delta including installation of positive barrier fish screens.

Limitations on net flow in Old and Middle River are based on the observations of increased salvage at the export facilities with large southerly monthly average net flow in Old and Middle River. The net flow in Old and Middle River is predominantly driven by the export pumping and the San Joaquin River inflow to the Delta at Vernalis. In fact, CCWD has shown that salvage at the export facilities is directly related to pumping at the export facilities and San Joaquin River inflow (Attachment C).

As previously stated in earlier comments, fish do not experience the net monthly average flow at two combined locations, but rather respond to the instantaneous velocity at the location of the fish. The correlation between net flow in Old and Middle River and salvage at the export facilities, therefore, cannot be a causal relationship, but simply represent two parameters that appear to co-vary. The cause of increased salvage is actually the elimination of the ebb (downstream) flow (Attachments C and D). The fundamental reason that salvage of delta smelt increases when exports exceed about 5,000 cfs plus half the San Joaquin flow (Attachment C, Figure 2), and salvage of salmon increases when exports exceed 7,000 cfs (Attachment C, Figure 3) is that the ebb tides begin to be lost at that level (Attachment C, Figure 4).

Relationships between salvage and export pumping are further complicated by whether the fish are present in the region in which the export pumping diminishes the ebb tide. Distribution of fish is dependent on a number of water quality parameters, including turbidity, temperature, and salinity. A recent paper by Gartrell and Herbold (Attachment D) examines the effect of flow and salinity on salmon migration.

All these factors come together to determine the effect of pumping on salvage. CCWD is currently evaluating relationships for salvage at the export facilities; preliminary results indicate the restrictions on Old and Middle River are possibly overly restrictive.

Furthermore, salvage can be reduced by the implementation of positive barrier fish screens at the export facilities. Similar screens have been proven effective at the CCWD Old River intake and will work in the south Delta if the exports are constrained (as required under current BOs and proposed in the long-term BDCP operations) to moderate levels, such that the ebb tide is maintained.

Ensuring the Delta is tidal (with flows reversing naturally approximately every six hours) will ensure that flows are available to transport fish away from the screens. Low, but still substantial, pumping rates allow modest screen sizes that will work with ebb tides to transport aquatic species away. Implementation of positive barrier fish screens would allow pumping to be increased by about 1,000 cfs or more while still ensuring protection of covered fish species.

The BDCP includes a conservation measure to install fish screens on agricultural intakes within the Delta. If implemented, the only intakes without fish screens will be the SWP and CVP export facilities in the South Delta. But with the low pumping rates proposed, screens will work and there is no reason not to install them, especially when they allow improved fishery protection and water supply reliability.

Thank you for you attention to these comments. If you have any questions, please call me at (925) 688-8100.

Sincerely,

Greg Gartrell
Assistant General Manager

Attachments:

- A Comparison of Preliminary BDCP Water Quality Results with Historical Data
- B Limitations on Exports to Prevent Direct Mortality (Salvage) at the South Delta Facilities
- C The Effect of Export Pumping on South Delta Flows
- D Flow, Salinity and Migration of Salmon (G. Gartrell and B. Herbold)

Comparison of Preliminary BDCP Water Quality Results with Historical Data

Preliminary results of water quality modeling presented to the Steering Committee on September 10, 2009, contain some questionable results (Figure 1):

1. Salinity in the Sacramento River at Emmaton is typically the same order of magnitude as salinity in the San Joaquin River at Jersey point. However, the modeling indicates Emmaton is approximately 20 times saltier than Jersey Point.

2. Salinity within the Delta is seldom less than 200 umohms/cm, yet the modeling results indicate average salinities as low as 50 umohms/cm.

3. Historically, when seawater intrusion is significant, Rock Slough salinity is generally about 40% of that found at Jersey Point (EC). This ratio does not hold in the modeling results shown.

4. Significant freshening (lower salinity) in September relative to August (at all stations) is counter-intuitive for dry years (Fall X2 measure is likely to reduce September salinity in wet and above normal water years).

These inconsistencies would certainly have been caught during the review process. However, this example illustrates the need for a historical reference to provide context for the modeling results. Figure 2 shows the average historical salinity at the same locations as the modeling results, for an historical period as close as possible to the modeling conditions (dry hydrologic period with current BO RPAs). The most recent three water years (October 1, 2006 to September 15, 2009) have been dry with some restrictions on exports, similar to the FWS RPAs.

Providing historical context is necessary to evaluate the effect of the new BO RPAs as well as the proposed BDCP habitat changes and operations. Additionally, historical context is helpful for individuals who are unfamiliar with the historical salinity patterns.

Figure 1: Preliminary water quality results presented to Steering Committee on September 10, 2009
Slide 22 from "Preliminary Physical Preliminary Physical Modeling off BDCP Proposed Project – Early Long-Term"

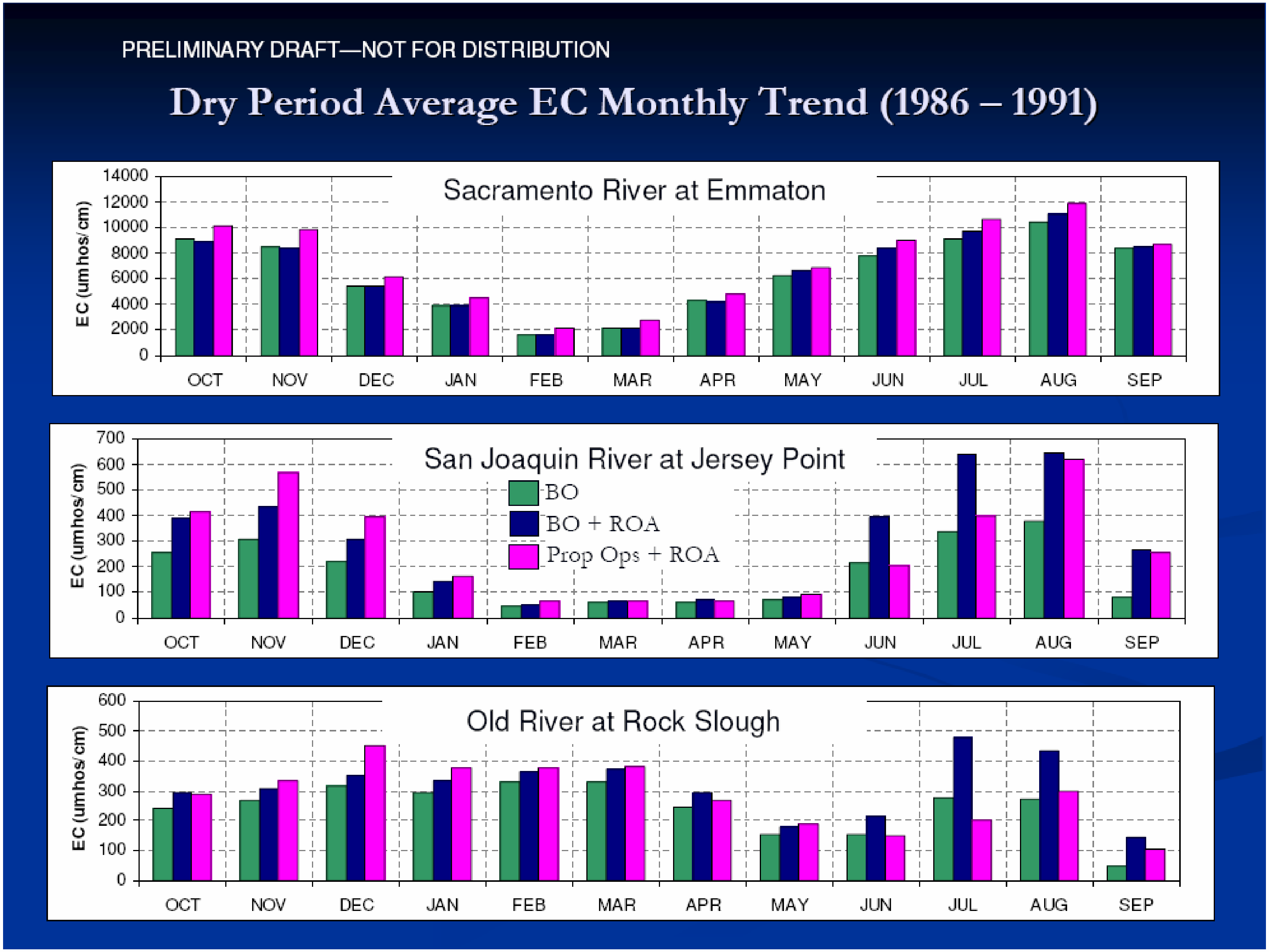
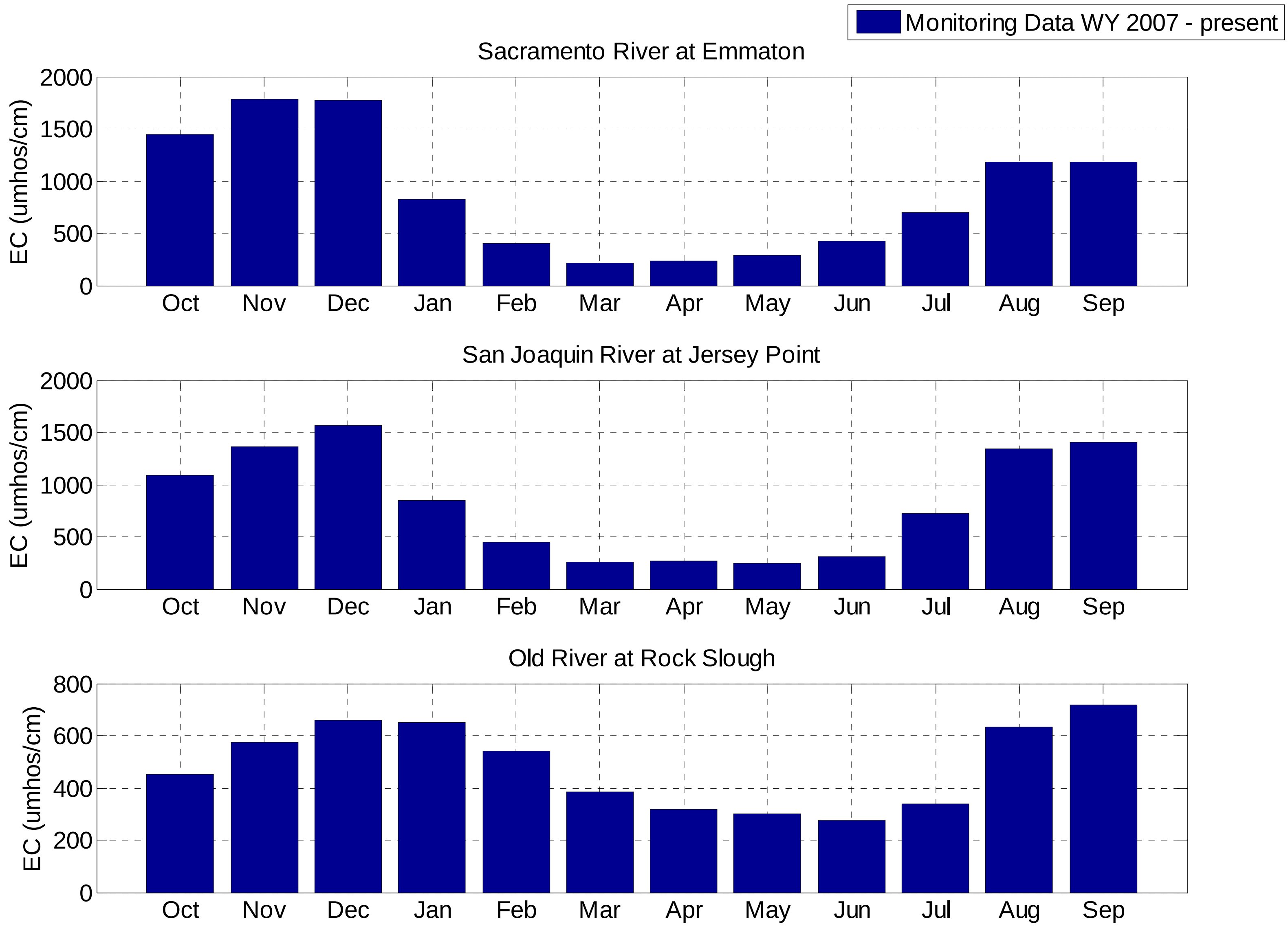


Figure 2: Historical water quality results to provide context for modeling results
Closest period within historical record to a "Dry Period" BO baseline is water year 2007 to present
(October 1, 2006 through September 15, 2009)



[blank page for double sided printing]

Limitations on Exports to Prevent Direct Mortality (Salvage) at the South Delta Facilities

The current BO RPAs restrict South Delta exports to meet net flow requirements in Old and Middle River (OMR), which is based on correlations between salvage of fish and monthly average instream flows. Figure 1 shows a typical relationship for salvage of adult delta smelt during January and February as a function of the average flow in Old and Middle River during each 2-month period. CCWD confirms a similar correlation (with a slightly better fit) between winter salvage at the export pumps and the quantity: one-half of the San Joaquin River inflow minus total exports (Figure 2). Likewise, for Chinook salmon, Dr. Wim Kimmerer found a similar relationship between total exports and percent salvage (Figure 3). The underlying physical basis for the relationships between export levels and salvage is that export pumping alters tidal flows in the South Delta (as manifested by OMR changes) by eliminating and reversing the ebb flows that normally exist (Figure 4). As flow becomes unidirectional, fish find it increasingly difficult to escape the influence of the pumps, leading ultimately to increased entrainment and salvage.

Figure 1: Salvage of adult delta smelt as a function of average Old and Middle River flow in January and February

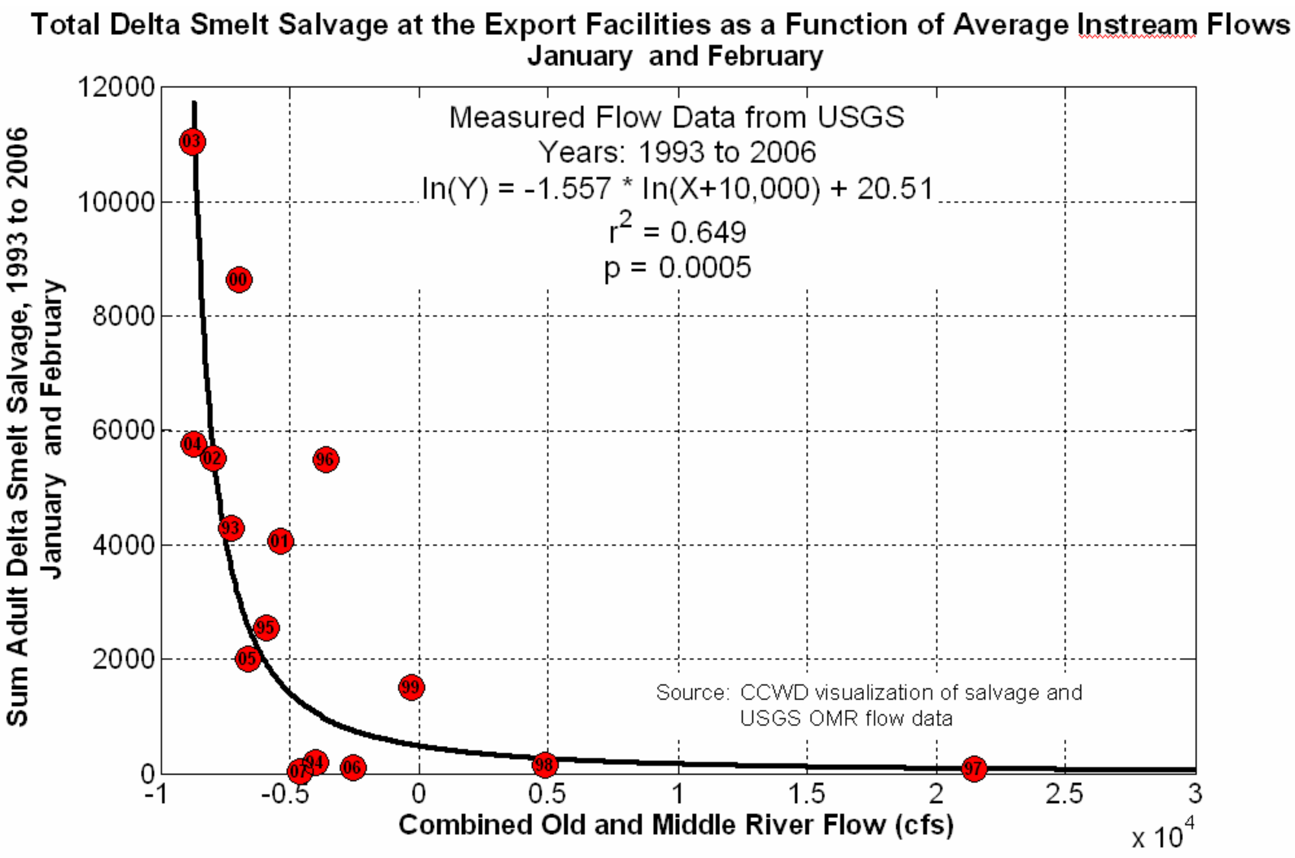


Figure 2: Salvage of adult delta smelt as a function of total exports (Banks and Jones) and San Joaquin River inflow into the Delta at Vernalis in January and February

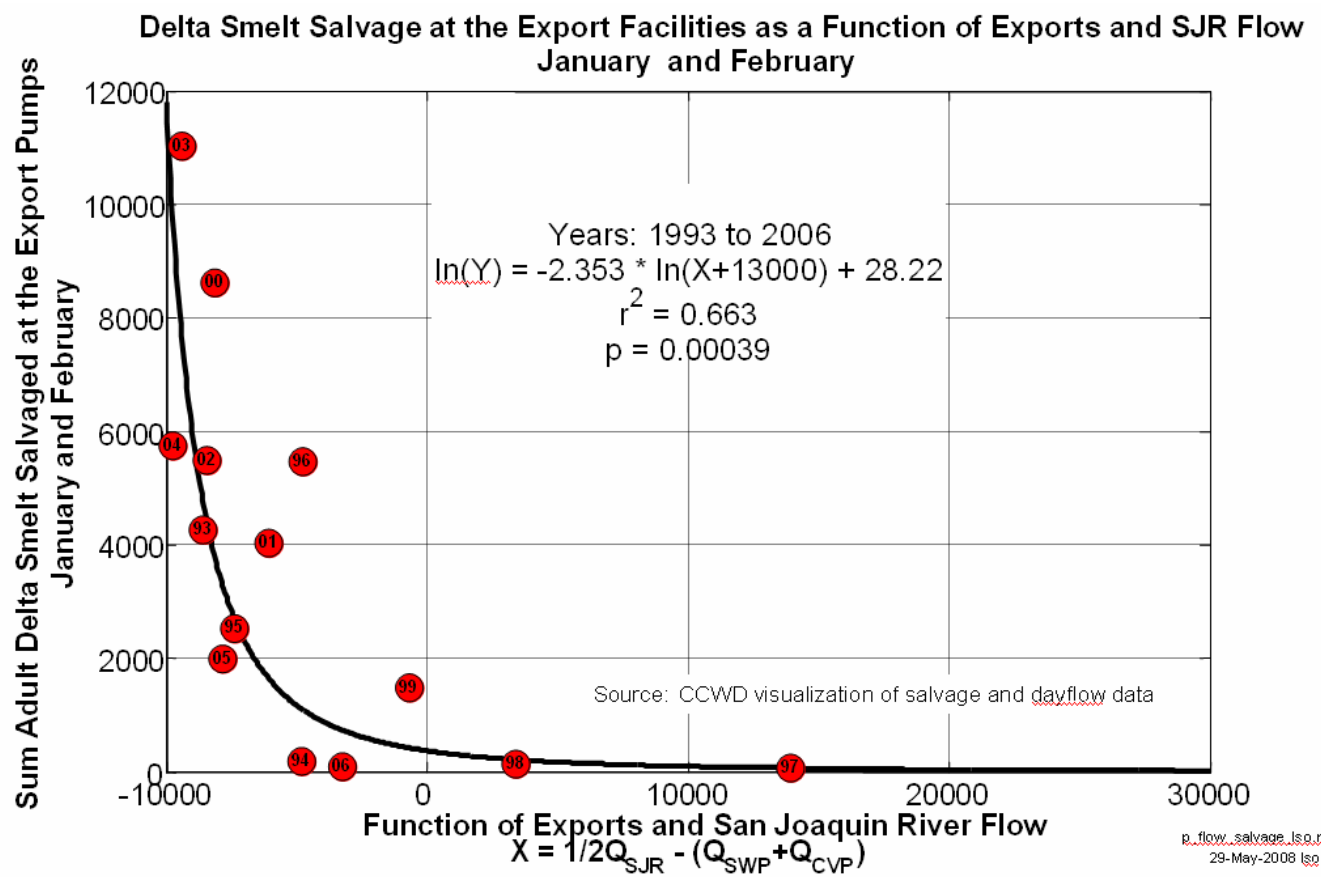


Figure 3: Salvage of Chinook salmon from the Livingstone Stone National Fish Hatchery (LSNFH) and the Coleman National Fish Hatchery (CNFH) as a function of total exports (from Kimmerer, W.J. 2008, "Losses of Sacramento River Chinook Salmon and Delta Smelt to Entrainment in Water Diversions in the Sacramento-San Joaquin Delta")

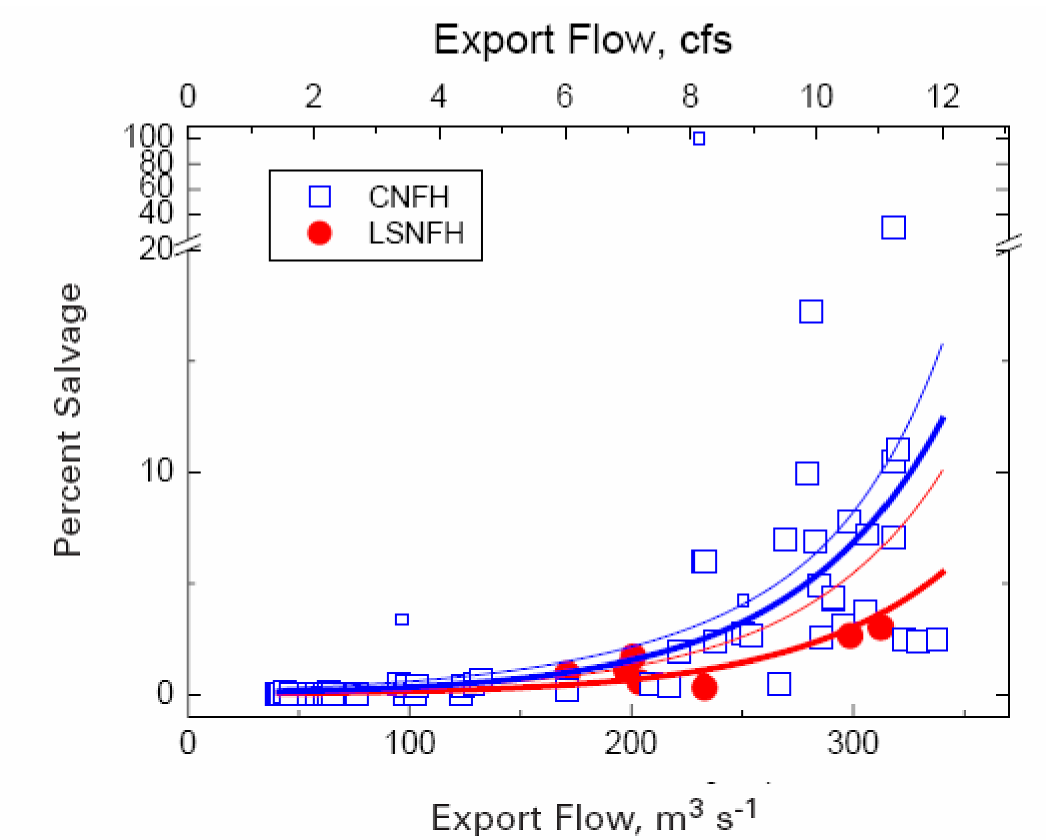
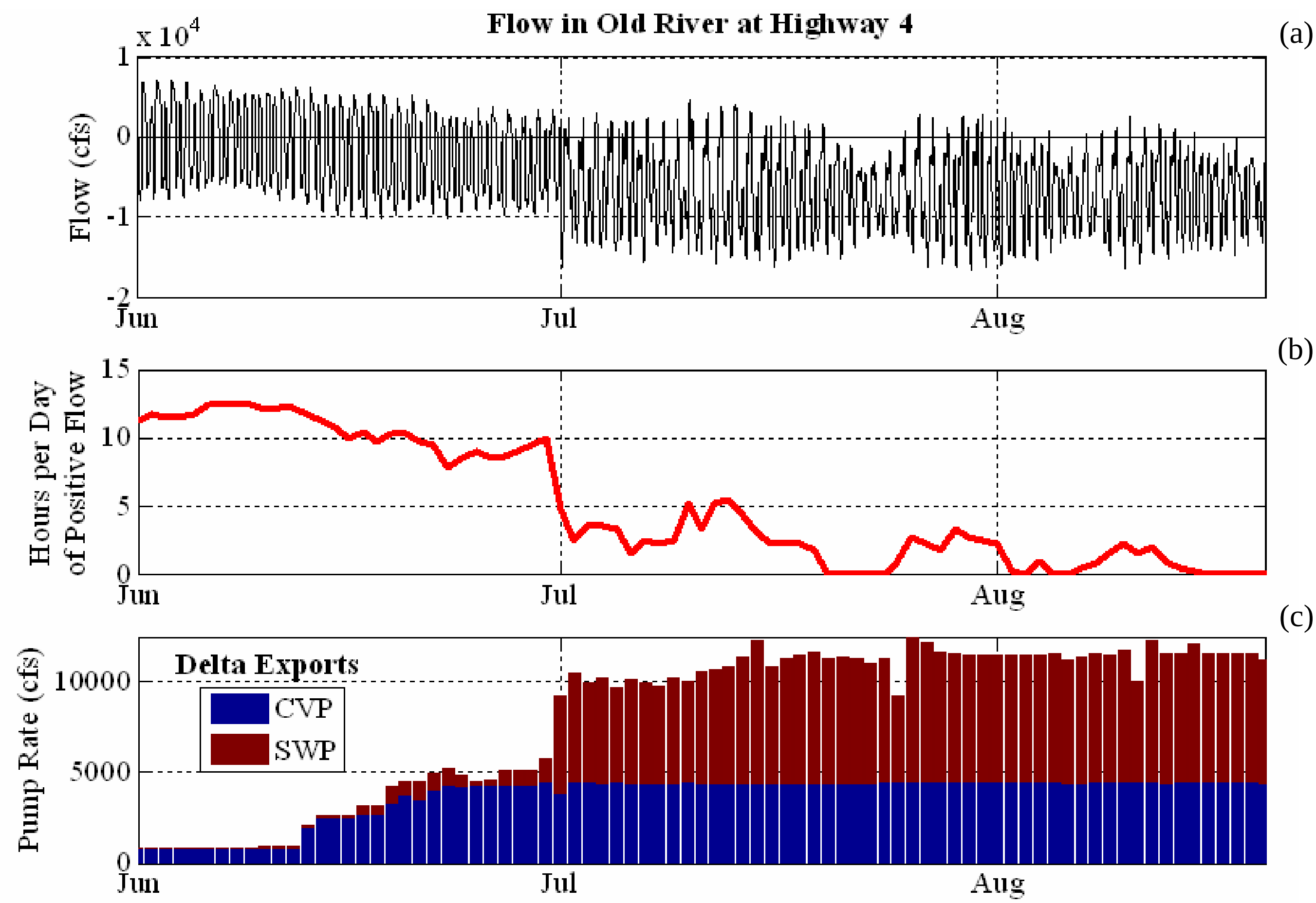


Figure 9. Chinook salmon. Relationship of estimated proportional salvage of tagged smolts at the fish facilities, P_S, to export flow. Small symbols represent data based on six or fewer fish caught, which were not used in determining the line. Lines are from a generalized linear model with log link function and variance proportional to the mean ($p < 0.0001$, 57 df), with source of fish as a categorical variable. Thick lines are predictions for fish from each hatchery; thin lines are upper 90% confidence limits of the predicted mean values.

Figure 4: Tidal flow in Old River as influenced by export pumping

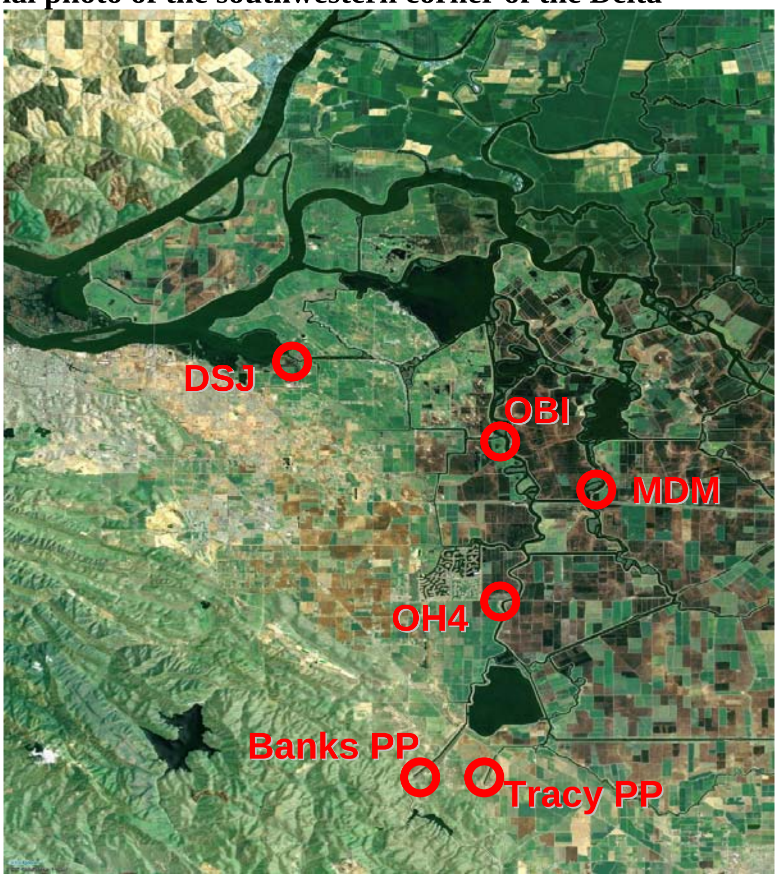
At Old River at Highway 4, just a few miles north of the export facilities, the effect of export levels on tidal flow in the river is evident. In early June 2007, when export levels were low, the flow was dominantly tidal, with both positive (flow to the north) and negative (flow to the south) oscillations of similar magnitudes with the tides, averaging to a net flow of approximately zero (top panel). As exports increase from mid- to late-June, the oscillations shift such that the net flow becomes negative (to the south), and the number of hours each day when the flow moves to the north is reduced to about 9 hours each day when exports are approximately 5,000 cfs (middle panel). This is followed by another drop to less than 5 hours of positive flow in the first part of July as exports are significantly ramped up. Then, from mid-July through August, when total exports continuously exceed 10,000 cfs, the flow becomes primarily to the south, effectively eliminating the ebb tidal flow, such that waters no longer oscillate between north and south, but simply flow constantly to the south, first fast, then slow.



The Effect of Export Pumping on Flows in the Delta

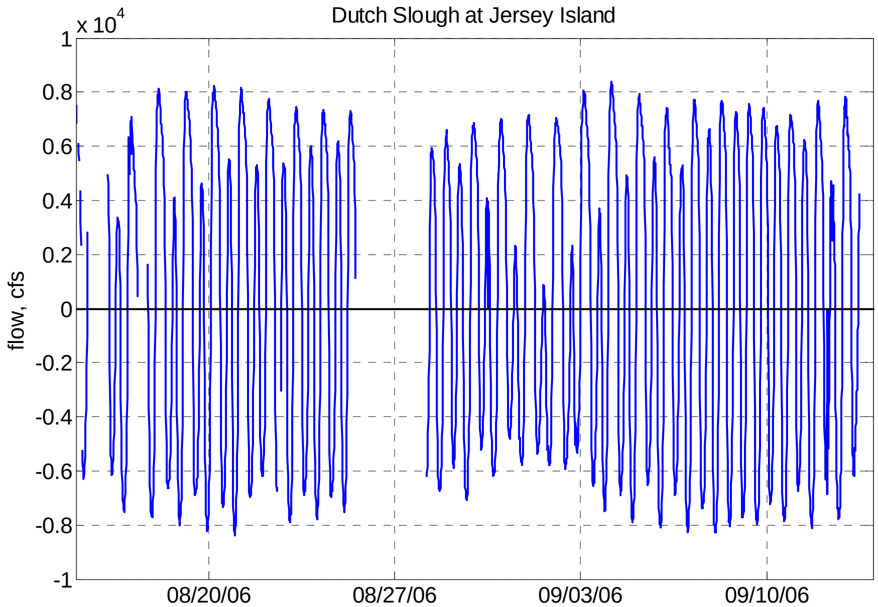
Flows in the San Francisco Bay and Sacramento-San Joaquin Delta are strongly influenced by ocean tides. The tides result in the typical two flood-ebb tidal cycles per day in the Delta, with a small net flow west towards the ocean due to river flows. Export pumping at Banks and Tracy Pumping Plants affects tidal flows in the South Delta by reducing ebb tides and increasing flood tides as will be seen below. The effect is clearly seen through visual inspection of the flow data from various stations in the Delta, available from the California Data Exchange Center (http://cdec.water.ca.gov). For example, we can look at data from four representative locations over the period August 15 to September 14, 2006. During this period, export pumping was high, with combined Tracy and Banks Pumping Plants averaging 11,500 cfs. The relevant locations are indicated in the map in Figure 1.

Figure 1. Aerial photo of the southwestern corner of the Delta



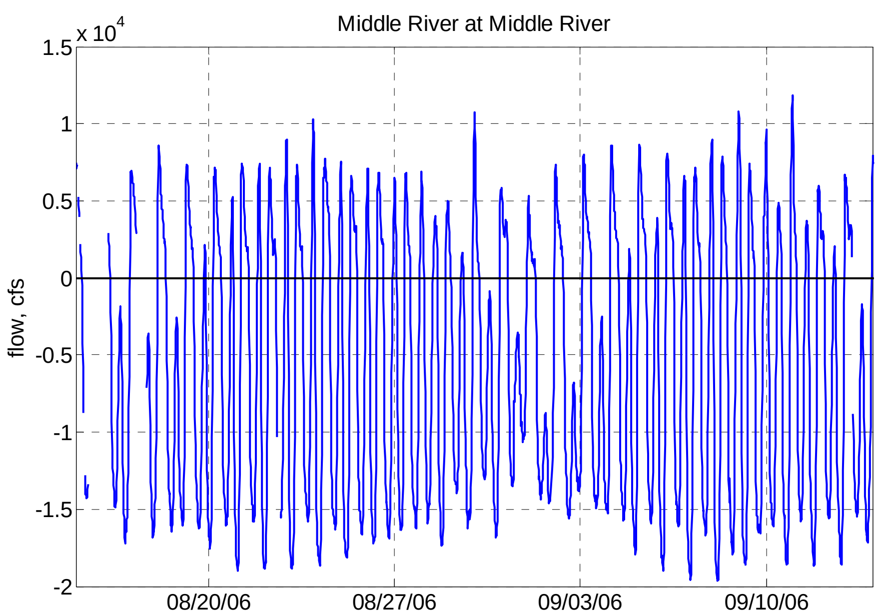
At Dutch Slough at Jersey Island (CDEC station DSJ), located near the western end of the Delta, flows are roughly centered around 0 cubic feet per second (cfs), with the ebb flows generally being of the same magnitude but in opposite direction as the flood flows (Figure 2). Flows at this location are not visibly affected by the export pumping.

Figure 2. Flow in Dutch Slough, 1 = 10,000 cubic feet per second



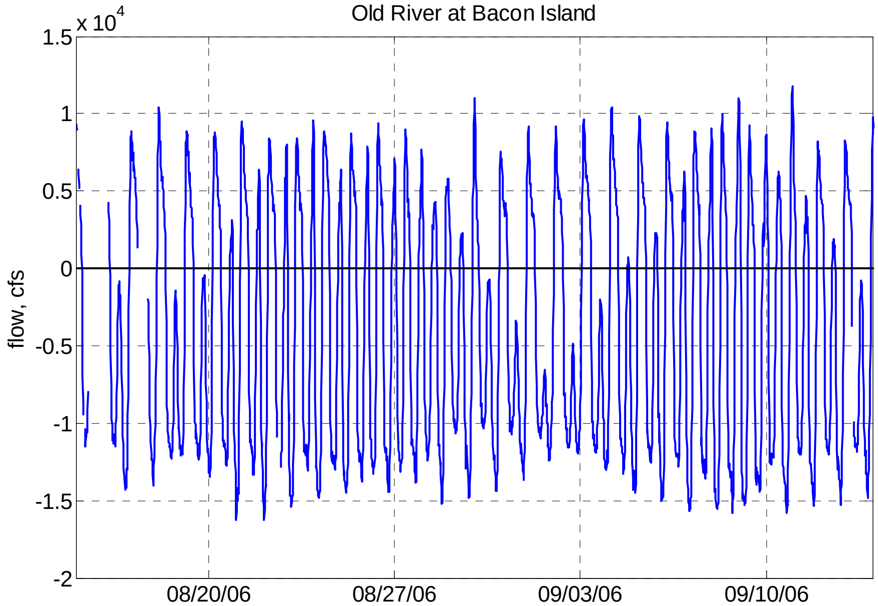
In the northern part of Middle River near the southeast corner of Bacon Island (CDEC station MDM), the flow still reflects the influence of the tides, but flows are stronger to the south than to the north, with negative values indicating southward flows (figure 3). The magnitude of ebb tides are significantly reduced while those of flood tides are magnified.

Figure 3. Flow in Middle River, 1 = 10,000 cubic feet per second



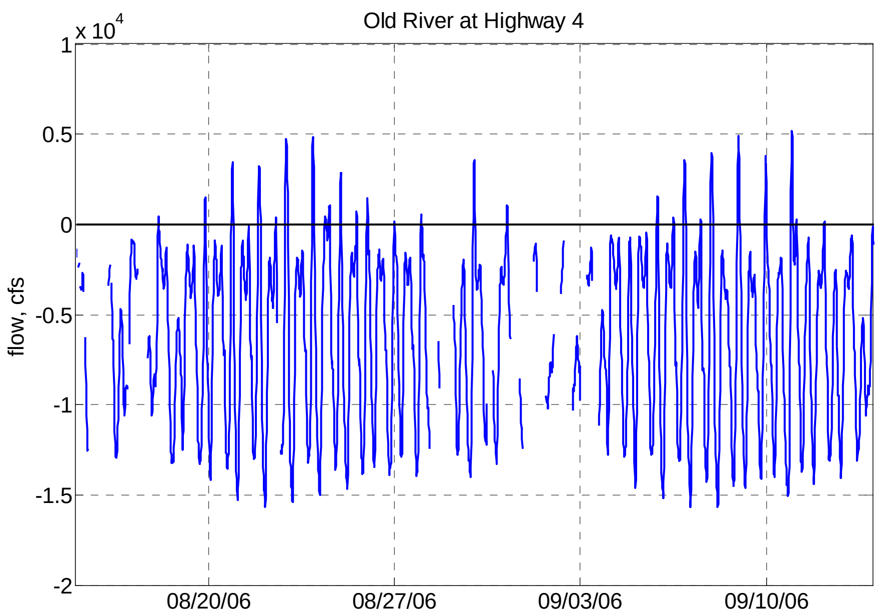
A similar shift in the net flow is observed at Old River at Bacon Island near Rock Slough (CDEC station OBI), which is also closer to the export pumps than the Dutch Slough station (figure 4). Again, a substantial reduction of the ebb tide and concurrent increase in flood tide is apparent.

Figure 4. Flow in Old River. 1 = 10,000 cubic feet per second



Finally, farther south at Old River at Highway 4 (CDEC station OH4), which is only a few miles north of the export pumps, the flow is almost always to the south (Figure 5). Instead of reversing direction on ebb tides, the flow merely transitions to being more or less southward, except when the tides are greatest.

Figure 5. Flow in Old River at Highway 4, 1 = 10,000 cubic feet per second



These results indicate that, not surprisingly, the export pumps have a greater influence on the direction of flow in areas that are geographically closer to the pumps in the South Delta. Of the four stations examined here, export pumping nearly eliminates flows in the ebb direction completely at Old River near Highway 4, while flows in Dutch Slough at Jersey Island are not visibly affected by even the high rates of export pumping that occurred during the period.

What is critical to the survival of aquatic organisms as they get closer to the export pumps is the magnitude of ebb flow and its duration in the vicinity of the pumps. The magnitude and duration of ebb flow in Old and Middle Rivers are determined primarily by a few parameters (the tidal cycle—which is predictable, exports from Banks and Tracy, San Joaquin River inflow, and barrier operations).

It is important to note that at about 5,000 to 6,000 cfs export pumping, the ebb tide actually begins to be lost near the pumps. It is no coincidence that at this same pumping level, adult delta smelt salvage starts to become significant in the January-February time period. Kimmerer also found that salvage of tagged salmon started to increase at export levels around 7,000 cfs. This threshold effect occurs for the same reason as with delta smelt: the ebb tides become weak at this level of pumping. When ebb tides are sufficiently large, fish have a chance to move out of the area. When ebb tides are small or nonexistent, fish must swim against a strong flood tide (strengthened by the exports) and do not get any real assistance from the weakened ebb tide.

Flow, Salinity and Migration of Salmon

Greg Gartrell[1] and Bruce Herbold[2]

This is a brief discussion of how flow and salinity likely affect salmon outmigration. The first section discusses the difference between average flow and tidal flow, and how the "net flow model" leads to incorrect conclusions. The second section applies a tidal view to salinity gradients to provide an alternative explanation of observations.

1) Net flow models versus a tidal view of the Delta

Net flow (whether QWEST or OMR net flow or any other net flow) in channels influenced by tides is a mathematical construct, not a physical factor felt by fish. QWEST was first used in an old "Carriage Water model" that attempted to describe how the outflow required to meet a given salinity level in the Delta increased with increasing exports. That model failed miserably: the hydrodynamics were wrong, the outflow levels the model predicted were wrong and the shape of the curve relating exports and outflow was backwards (predicting a monotonically increasing curve when the actual curve has a minimum value before increasing).

Net flows are averages of flows measured at a point (an Eulerian view), effectively the view of water movement from the river bank. This is not something that fish experience. This mathematical construct simplifies a complex flow field, and in the case of fish movement, confuses the picture just as the old Carriage Water Model confused the understanding of salinity in the Delta. Fish experience local velocity[3] as they move around (the fish-eye or Lagrangian view). Of course, to the extent that fish move with the flow, they experience no change in velocities any more than we sense the movement of the Earth through space, except that they feel accelerations due to factors like turbulence, fish body motion or changes in channel shape. However, the movement of water and fish with flow is very different when viewed without the averaging needed to calculate net flows. To give an idea of how badly a model based on average flows (Eulerian or Lagrangian average) in a tidal environment can be, consider the following:

a) Tagged salmon released north of Rio Vista have been caught after just a few days at Chipps Island where tidal flows are very high but net flows are very small. If the fish moved with the average flow, it would take them one to two months to arrive.
b) A salmon could start the day in Old River, travel with the instantaneous local flow down the river on the flood tide towards the export pumps, move across Woodward Cut and travel up Middle River on the ebb tide. The daily average flow (in this case Lagrangian average) would be pointing from Old River to Middle River, leading to the false conclusion that the salmon walked across the island. All information about the intermediate movement of the salmon is

---

[1] Contra Costa Water District
[2] U.S. Environmental Protection Agency
[3] Flow in a channel is the average velocity times the cross-section. The velocity in a channel varies across the width and depth of the channel. Fish will experience the local velocity (in space and time), not the cross-sectionally averaged velocity, nor the overall flow in the channel.

> lost in the averaging. On the other hand, using the (Eulerian) average of the measured water velocity at one location in the channel (the USGS velocity meter for example) could give an average velocity of a few millimeters per second (or about 300 meters per day), an equally false conclusion.

Two problems with net flows prevent them from reflecting conditions that directly affect fish: they throw out important information in the process of averaging and they are derived variables (not independent variables) both mathematically and physically.

The following graphs illustrate these problems. The graphs show instantaneous flows.

Figure 1 shows Delta flows with the ebb and flood flows generally of the same magnitude in opposite directions. The average net flow is much smaller than any flow affecting the fish at a given moment.

Figure 1. Flow with flood and ebb nearly balanced, 1 = 10,000 cubic feet per second

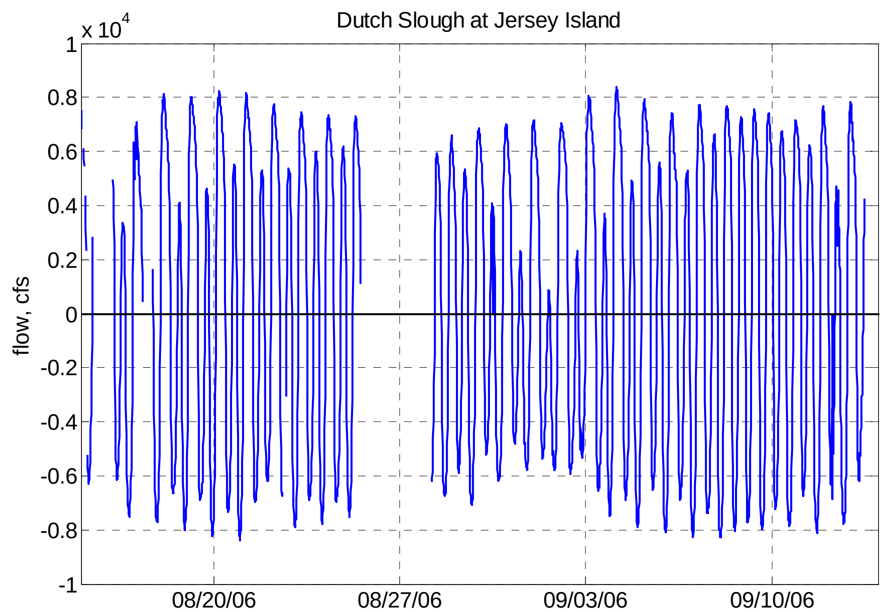
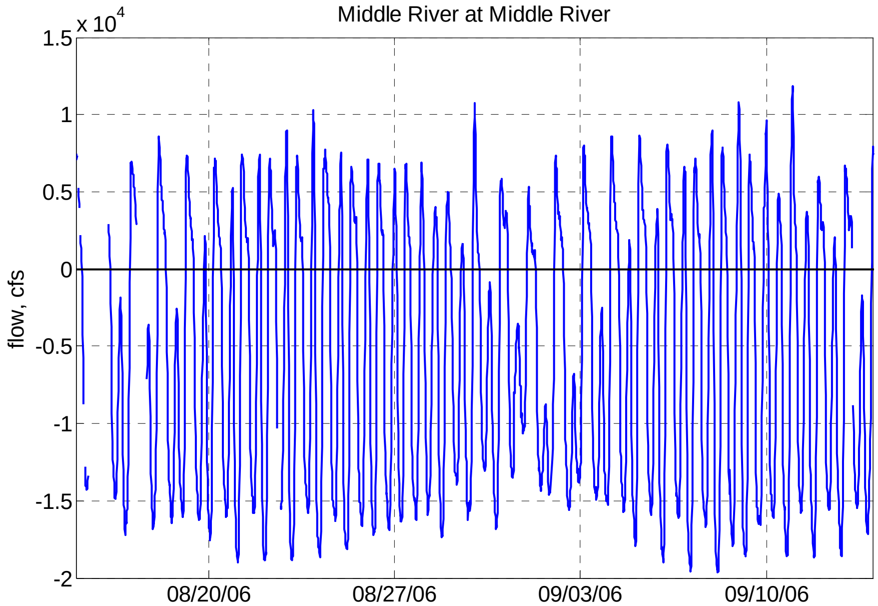


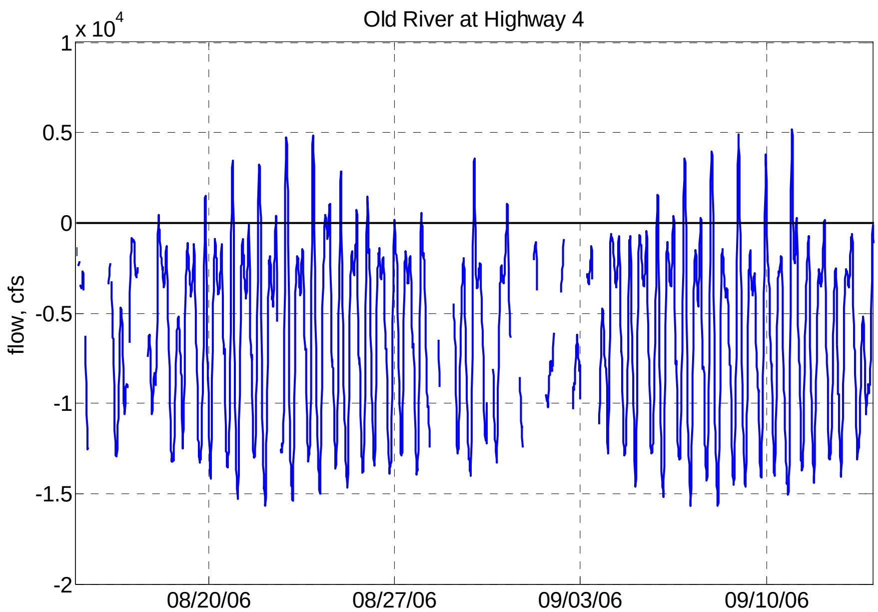
Figure 2 shows tidal flows with a stronger flood than ebb. While the direction of the average is obvious, the magnitude of the average is not. A fish experiencing this still has a chance to move in the opposite direction from the average if it uses the tides correctly (i.e., if it gets into the high velocity part of the channel on the ebb, and stays near the channel sides on the flood). Salmon clearly have the ability to pick the right tide based on cues, or they could not get from north of Rio Vista to Chipps Island in a few days.

Figure 2. Flow with strong flood tide compared to ebb, 1 = 10,000 cubic feet per second



Finally, Figure 3 shows a tidal flow where, at times, the ebb and flood are both less than zero. In this case, a salmon trying to surf the ebb will have a rough time of it. In fact, one can find no ebb tide at all for days at a time. This is a not a good situation if, in one flood tide, the salmon can end up in Clifton Court Forebay.

Figure 3. Flow in Old River at Highway 4, 1 = 10,000 cubic feet per second



Clearly, the situation in Figure 3 is going to result in high entrainment of fish: the export flows are so big that the ebb tide is lost and it is a one-way trip south, with tidal excursions double the normal 4 or 5 miles. When does this situation occur? It starts when exports are 5000 cfs to 7000 cfs. The Bay Institute argued in the OCAP lawsuit that high entrainment of salmon occurs when exports are over 7000 cfs: that is when the ebb tide is lost. That level of exports is also when delta smelt entrainment is high in January and February.[4] An examination of Figures 1 through 3 tells the story very quickly: this is about tides and export levels, not net flows. It is not the "net flow"; it's the "no ebb flow".

What about entrainment that occurs when net flows are small (or even positive)? The net flow view of the world fails completely (just like the old Carriage Water model) in this situation. When viewed with the tides in mind, the picture becomes clear, as the examples in the next section illustrate.

2) Salmon movement in a tidal environment

Consider salmon moving down the Sacramento River into the Delta. Some will make it to Chipps Island and beyond, but some will end up in the Lower San Joaquin River, via Georgiana Slough, through Three-Mile Slough or around Sherman Island. In this central delta area their advective (i.e. non-swimming) movement would be governed by tidal flows. Some will, even when export pumping is low and net flows are positive, go through False River into Franks Tract, where they (the survivors, anyway) have a good chance of being discharged out into Old River. Others can get sloshed into Middle River. This is their starting point for the scenarios that are described below.

For San Joaquin Salmon, the starting point for the scenarios below will be the San Joaquin River at the Head of Old River.

Scenario 1: High exports, typical San Joaquin River flow and salinity (i.e., low flow, high salinity).
In this case, exports are high and the ebb tide is very small or non-existent. It is a short trip down the river (the salmon simply cannot swim against 1 to 2 fps currents for long) to the export pumps for Sacramento salmon. San Joaquin salmon have two likely fates: those entering Old River have a quick trip to the export pumps; those moving down the San Joaquin River get to the Lower San Joaquin River and then some will make it to Chipps Island and some will move into Old and Middle Rivers and thence to the export pumps. In all cases salmon entrainment will be high.

Scenario 2: Low exports, typical San Joaquin River flow and salinity (i.e., low flow, high salinity).

---

[4] Pete Smith used OMR net flow to show this, but OMR net flow is a dependent, not independent variable. Exports and San Joaquin inflow are independent variables, and the correlation between delta smelt entrainment and exports/San Joaquin flows is better than the correlation between entrainment and OMR flows for the same time period.

Sacramento salmon coming from the north experience substantial ebb and flood tides. However, one thing is peculiar in the central and south Delta compared to what should be found in an estuary: San Joaquin River salinity (generally as much as 1 mS/cm, with chloride levels over 150 mg/l) is much higher than Sacramento River salinity (about 0.15 mS/cm with chloride levels around 10 mg/l).[5] An obvious cue in a tidal system for the ocean is salinity (electrical conductivity or specific ions; two obvious ions would be sodium and chloride). What salmon in the central and south Delta see is a reverse salinity gradient because of high San Joaquin salinity and saline discharges (ag and urban) within the Delta. Salmon attempting to follow the salinity gradient to the ocean would jump into the high velocity zone on the flood, rather than ebb. That takes them the wrong way, and exposes them to entrainment at the export pumps. (Even if export rates are very low, there is a good chance to get into the pumps).

The situation for San Joaquin salmon is probably very much worse: arriving in a low flow with high salinity and entering a reverse salinity gradient, the chances of a bad ending would lead one to wonder how any salmon at all find their way out. This is consistent with the extremely low survival rates reported by USFWS under all but flood conditions in the delta

In this case it is neither the “net reverse flow”, nor the “no ebb tide”; it is the “reverse salinity gradient”.

Scenario 3: Low exports, typical San Joaquin River flow and salinity (i.e., low flow, high salinity) with an Isolated Facility.
This case is little different from Scenario 2, except that the exports are liable to be less and the water quality situation could easily be worse. With apologies to our friends who authored the PPIC reports, it is likely to create an “Arkansas cesspool” from the “Arkansas Lake”. With drainage (from the San Joaquin River and in-Delta ag) and urban discharges ringing the area (clockwise: Sacramento Regional, Stockton, Manteca, Tracy, Discovery Bay, Ironhouse SD, Delta Diablo SD, Central Contra Costa SD), and little inflow, the central and south Delta are likely to become (with apologies to Thomas Friedman) “Hot (warm SJR water), Flat (gradients) and Crowded (with non-natives)”. Entrainment, in the absence of screens will be high at both export pumps and ag intakes (you only have to see the vortex spinning above a siphon to realize just how fast the velocity is in the siphon), and confusion will be high. The number of fish orienting correctly to the ocean would be very small and even for them the very long transit time would probably subject them to extremely high mortality rates within the delta.

Scenario 4: Good flows and high quality on the San Joaquin River. Salinity gradients are not reversed and fish orient correctly to the tidal salinity gradient and tidal flows. This is totally different from Scenario 1, 2 or 3. The key is improved San Joaquin River flow and salinity.

---

[5] As an example, with flows increasing during the VAMP period, SJR salinity is currently about 0.4 mS/cm today (April 20, 2009). That level is also found near Collinsville today, but in between it is as low as 0.2 mS/cm (Jersey Point area).