DWR-3

California Department of Water Resources
Paul Marshall's Testimony Regarding
Enforcement Actions ENF01949 and ENF01951.

My name is Paul A. Marshall, and I am Chief of the Bay-Delta Office for the California Department of Water Resources (DWR). This testimony is provided in regard to the Draft Cease and Desist Order issued to The West Side Irrigation District (WSID), Enforcement Action ENF01949; and the Administrative Civil Liability Complaint issued to Byron-Bethany Irrigation District (BBID), Enforcement Action ENF01951. The purpose of my testimony is to rebut written testimony and exhibits submitted by WSID and BBID. A copy of my statement of qualifications has been submitted as Exhibit DWR-1. I am testifying as an expert based on my special knowledge, skill, experience, training, and education.

Contents

I. California Hydrology and Delta Hydrodynamics

California experiences a high annual variability in precipitation stemming from the role of a relatively small number of storms making up the state water supply. The practice of the State Water Resources Control Board (Board) is to employ a water year classification system to categorize annual precipitation and account for this variability. The Sacramento Valley 40-30-30 Index and the San Joaquin Valley 60-20-20 Index were developed by the Board for the Sacramento and San Joaquin River hydrologic basins as part of Board's Bay-Delta Plan and the Board's Water Right Decision D-1641 (D-1641). Figure 1 shows the number of years that the various water year hydrologic classifications occurred for water years 1967 through 2015 for the Sacramento and San Joaquin Valley hydrologic basins.

Water Year Classification	Wet	Above Normal	Below Normal	Dry	Critical
Number of Years (San Joaquin Valley Runoff)	17	7	3	8	14
Number of Years (Sacramento Valley Runoff)	17	7	6	9	10

Figure 1, Total Number of Years of Various Water Year Hydrologic Classifications, WY1967 through WY2015

Cumulatively, water years 2012-2015 stand as California's driest period since construction of the State Water Project (SWP) and Central Valley Project (CVP). Prior to construction of the SWP and CVP, California's most significant historical statewide drought was the six-year drought of 1929-34. The 1929-34 event occurred within the climatic context of a decades-plus dry period in the 1920s and 1930s whose hydrology rivaled that of the most severe dry periods in more than a millennium of reconstructed Central Valley paleoclimate data. That drought's impacts, however, were small by present-day standards, however, because the state's urban and agricultural development was far less than that of current times.

Generally, Delta hydrodynamics are defined by complex interactions between tributary inflows, tides, in-Delta diversions, and SWP and CVP operations. The degree to which a single variable impacts the overall hydrology of the Delta varies depending on its magnitude as compared to the other variables. Changes in any of the variables affect water quality in the Delta, particularly with regard to salinity. Each day two high and two low tides of differing magnitudes cause large fluctuations (flood and ebb tides) in flow in the various parts of the Delta estuary. Also, the strength of the tides varies within the month depending on the position of the Sun and the Moon (Spring-Neap cycle) and is also influenced by atmospheric conditions. Each flood tide has the potential to bring a large volume of high salinity ocean water into the Delta. Keeping saltwater from reaching the central Delta is crucial to protecting freshwater supplies for in-Delta and SWP/CVP water users.

To prevent saltwater from intruding deeper into the Delta during dry periods, SWP/CVP operators repel it with the tools available to them: either by reducing the exports of water from the south Delta; or by increasing the amount of water flowing into the Delta from releases of stored water from upstream reservoirs.

By far, the most important of the variables affecting salinity in the Delta is Delta outflow. Delta outflow refers to the flow leaving the Delta at Martinez. Net Delta Outflow (NDO) represents an average value over a tidal cycle and is an estimate of the water flowing through the system that can be used to push out the incoming tidal force.

Since the tidally driven flow at Martinez can vary to a great degree,[1] the magnitude of the tide has a strong ability to subsume direct measurements of the other variables at that location and a more manageable approach of a calculated index is used, known as the “Net Delta Outflow Index” (NDOI), in place of NDO. NDOI is an arithmetic summation of river inflows, precipitation, assumed agricultural consumptive demand, and project exports. It is an estimate of the net difference between ebbing and flooding tidal flows at Chipps Island converted to a daily average.[2] NDOI was introduced in the 1995 Bay-Delta Plan and is now part of D-1641, which sets specific minimum monthly NDOI objectives for the protection of fish and wildlife based on water year type.

The magnitude of NDOI determines how much it will impact water quality. Under high flow events (high NDOI), the Delta is flushed out and filled with fresh water, and there are only very small traces of ocean water. During such conditions, small changes in flows cause only negligible effects on water quality in the Delta. On the other hand, under very dry conditions (low NDOI), small changes in flows can have a noticeable effect on water quality in the Delta. This makes water quality management during drought conditions a much bigger challenge. Due to general lack of freshwater supplies within the Delta watershed in 2015, flows into the Delta were lower than are typically experienced, which resulted in salinity intrusion into the north Delta.

II. Regulatory Objectives

Water quality is measured through monitoring of objectives in D-1641, which are categorized by the beneficial uses they are intended to protect, including municipal, industrial, agricultural, and fish and wildlife. Figure 2 shows a map of the Delta with the various objective locations.

D-1641 contains agricultural salinity objectives that vary by location. The salinity objectives are based on both water year type and a 14-day running average during the irrigation season, from April to mid-August, at Andreas in the West and in the central Delta. The agricultural salinity objectives at these Delta locations become less stringent under dryer conditions. In the south Delta, the salinity objectives are based on a 30-day running average and measured by electrical conductivity (EC). The SWP and CVP are jointly required by D-1641 to meet EC objectives.

The estuarine habitat protection objectives incorporate modified X2 criteria (geographic isohaline) first established in the 1994 USFWS Delta Smelt Biological Opinion. The upstream movement of 2 ppt isohaline (2 parts per thousand of salt in the water), measured as 2.64 mS/cm at the surface, is maintained within a certain range of positions in the estuary by adequate Delta outflow. These positions (Collinsville, Chipps Island, Port Chicago, and Martinez) are associated with an abundance of fish and biota.

[1] DSM2 historical modeling indicates that the tidally driven flow at Martinez varies by 500,000 cfs.
[2] DSM2 historical modeling indicates that the tidally driven flow at Chipps Island varies by 400,000 cfs.

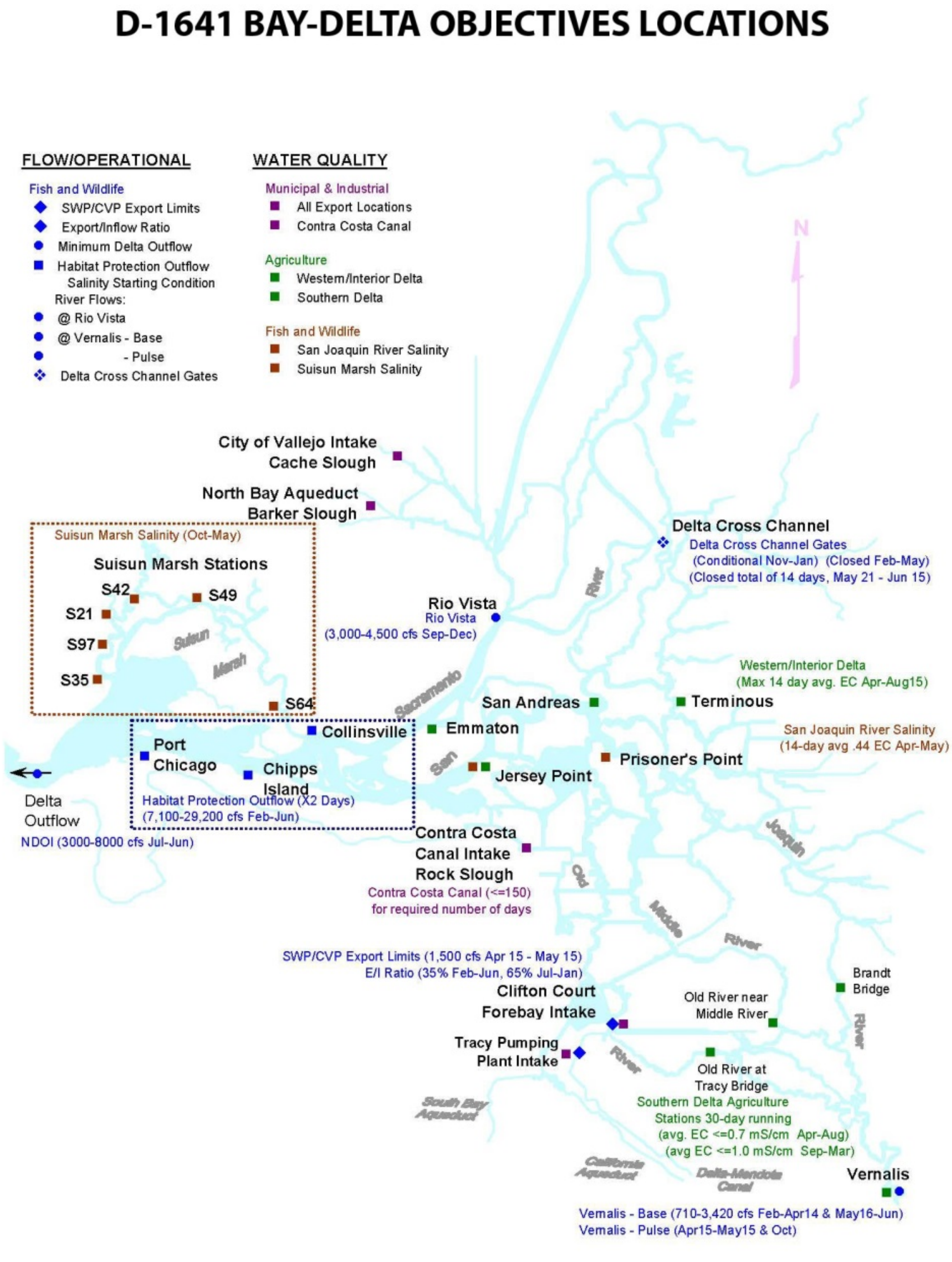

Figure 2, D-1641 Bay-Delta Objectives Locations

The Bay Delta Standards provide for less stringent flow and salinity objectives under dry and critically dry years. However, because of the exceptionally dry conditions existing over the past three years, there was insufficient supply to meet these requirements and to also meet all beneficial uses of water in the Sacramento-San Joaquin River basin.

In 2014 and 2015, due to serious drought conditions, DWR and the U.S. Bureau of Reclamation (Reclamation) petitioned the Board for temporary modifications to their water rights permits, requesting changes in the D-1641 objectives. In both years, after receiving a petition, an order was issued that allowed a reduced level of Delta outflow and/or a modified salinity objective, conditioned upon a reduction in SWP/CVP exports. The orders also required that stored water in the SWP and CVP reservoirs be used for ecosystem protection and health and safety needs and the order provided flexibility in operation of the Delta Cross-Channel gates in order to help manage interior Delta water quality. Project exports were restricted to serving health and safety purposes only, storage in reservoirs was at critically low levels, and releases were constrained to protect against the drought's continuation. Protections for public interest fish and wildlife values were cut back and urban water use was curtailed by 25% across the state in response to the drought emergency.

Term 91 conditions were in effect for much of the summer and fall of 2015. When the Board finds that Term 91 applies, this indicates a dry hydrologic scenario in which the SWP and CVP are making storage withdrawals of project water to meet some of the in-basin needs of the Delta's watershed. These needs include flow and water quality standards contained in D-1641, as necessary conditions of the Projects' water rights. Under Term 91 conditions, when project water is diverted without authorization, the amount of water releases that are available to meet authorized in-basin needs is reduced by a corresponding amount. This water must then be "made up" later by the projects with additional storage withdrawals.

III. Agricultural Diversions Affect the Ability of DWR and Reclamation to meet D-1641 Objectives – Especially during a Drought

To understand the impacts of unauthorized diversions, one must understand how the Delta is balanced for salinity. There are five basic factors that influence salinity in the Delta:

1. Delta Inflows;
2. Net Delta Outflow;
3. Exports;
4. Net Channel Depletions to meet Delta Consumptive Use; and
5. Tidal Flux.

Project operators have no control over most of these factors. Project operators are only able to control: (1) releases from water project reservoirs upstream of the Delta, which are a portion of Delta inflows; and (2) exports. When there are no excess flows and the projects are operating in balanced conditions to control salinity, either for a near term or seasonal objectives, operators adjust reservoir releases and export rates to meet the objectives. Operators must consider in advance how the other factors might influence the system in order to attempt to maintain balanced conditions to control salinity. This is further complicated because of the amount of time it takes for Project reservoir releases to reach the Delta.

NDO is a key index of the physical, chemical, biological state of the Delta.[3] It includes daily river inflows, water exports, rainfall, and estimates of Delta agriculture depletions to estimate the “net” flow at the confluence of the Sacramento and San Joaquin Rivers, nominally at Chipps Island. There are also flow gauges at Freeport, Vernalis, and on the Mokelumne and Calaveras Rivers. After water is released from Project reservoirs, water users upstream of and in the Delta divert various amounts of water as it makes its way to the Delta and through it. Agricultural diversions are generally not scheduled in advance, as irrigation needs depend on local weather and soil conditions. Warmer conditions can increase the need for irrigation or cause it to occur earlier. With each diversion, less water is available to contribute to Net Delta Outflow. In other words, there is less water to flush and dilute ocean and land-derived salts out of the Delta. Project operators adjust the exports scheduled at the SWP and CVP pumping plants to further prevent salinity incursion into the Delta.

Project operators forecast how temperature, humidity, wind conditions, and barometric pressure will affect the tides and the projected use patterns days in advance. On a typical summer day, the exports average about 9,000 cfs, because summer demands south of the Delta are usually high. When operators see salinity increasing at the various Delta EC measurement stations, they reduce or stop exports. If having already slowed Project exports to well below the capabilities of Delta Islands to take water, Project operators lose the ability to control salinity by reducing exports. For instance, in 2015, SWP and CVP exports were jointly limited to 1,500 cfs, and Project operators were also required to meet an NDOI of 3,000 cfs. (Exports were often less than 1,500 cfs and to meet the modified salinity objectives, the Net Delta Outflow Index was often higher than 3,000 cfs).

In 2015, tides and in-Delta diversions played a far larger role in determining the salinity of the Delta than exports. The remaining tools available to DWR for water quality control are reservoir releases, which may be constrained by regulatory agencies, and in extreme circumstances, the installation of physical barriers within the Delta. DWR and Reclamation cannot control the use of water by in-Delta diverters and these in-Delta uses will continue to impact delta water quality despite the tools available to Project operators.

Figure 3 below shows observed export and diversion data taken from the DAYFLOW[4] database in June for years 2009 and 2015. Year 2009 is classified as a below normal

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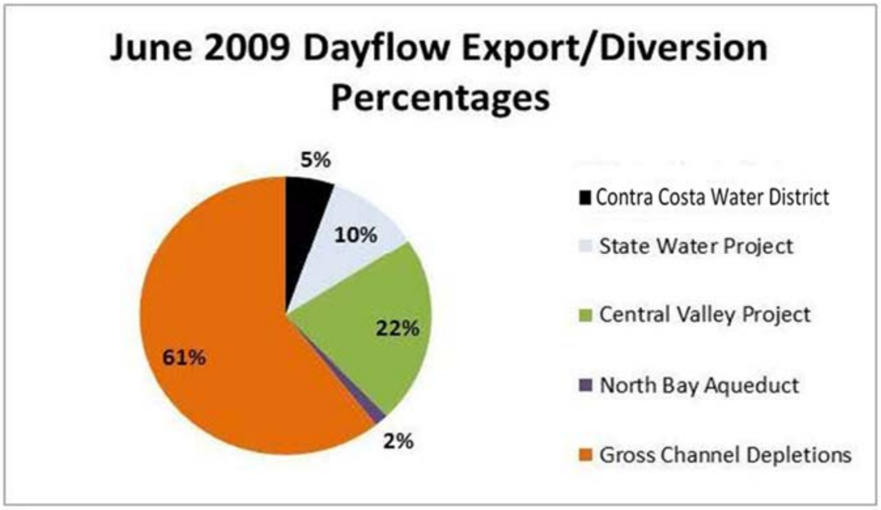
[3] See California Department of Water Resources, Dayflow, an Estimate of Daily Average Delta Outflow (accessed Nov. 1, 2015), available at http://www.water.ca.gov/dayflow/.

[4] DAYFLOW is a model that DWR uses to estimate Delta channel depletions. The Delta channel depletions in DAYFLOW are derived from a 1965 DWR study that was based on land use surveys from the late 1950s and early 1960s. In the 1960s, many of the crops grown in the Delta were row crops and not permanent crops. At that time, sugar beets were grown in many places and supplied the Clarksburg Sugar Mill.

year hydrologically, and 2015 is classified as a critical year. The graphics show that exports made up a small percentage of water removed from Delta channels in 2015.



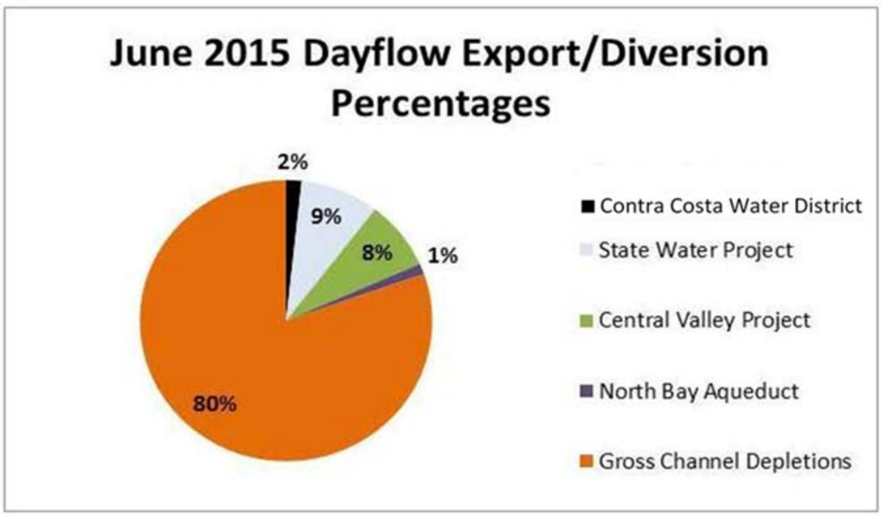


Figure 3, Export and Diversion Percentages for 2009 and 2015 Using DAYFLOW Data

Few diverters of water within the Delta use flow meters to monitor and report the amount of water that is diverted from or returned to the system. Non-project diversions are not coordinated with project releases or project exports. The channel depletions are estimated by first estimating Delta crop water use demands and then accounting for sources of water to meet these demands. Generating meaningful estimates of Delta channel depletion requires having accurate and timely land use surveys, an accurate estimate of seasonal variations in crop water use, and an accurate representation of relevant meteorological information. Each of these factors affects modeling Delta consumptive use and channel depletions.

Delta channel depletions are a significant factor considered in computer modeling of Delta salinity. Figure 4 below shows the results of several different methods of estimating net channel depletions in the Delta. Flow in cfs is shown on the left margin and each month is shown with its respective study along the horizontal axis. The one thing they have in common is that they are level for each month. Regardless of the temperature or moisture in any month, these consumptive uses remain level throughout the month. July is shown as the peak month in each study, topping out at nearly 5,000 cfs with one set of assumptions. June is the second most consumptive month with averages around 4,000 cfs, and August is the next highest month with a little over 3,000 cfs. Actual consumptive uses vary radically with weather and crop conditions, making it a major controlling factor for Delta salinity.

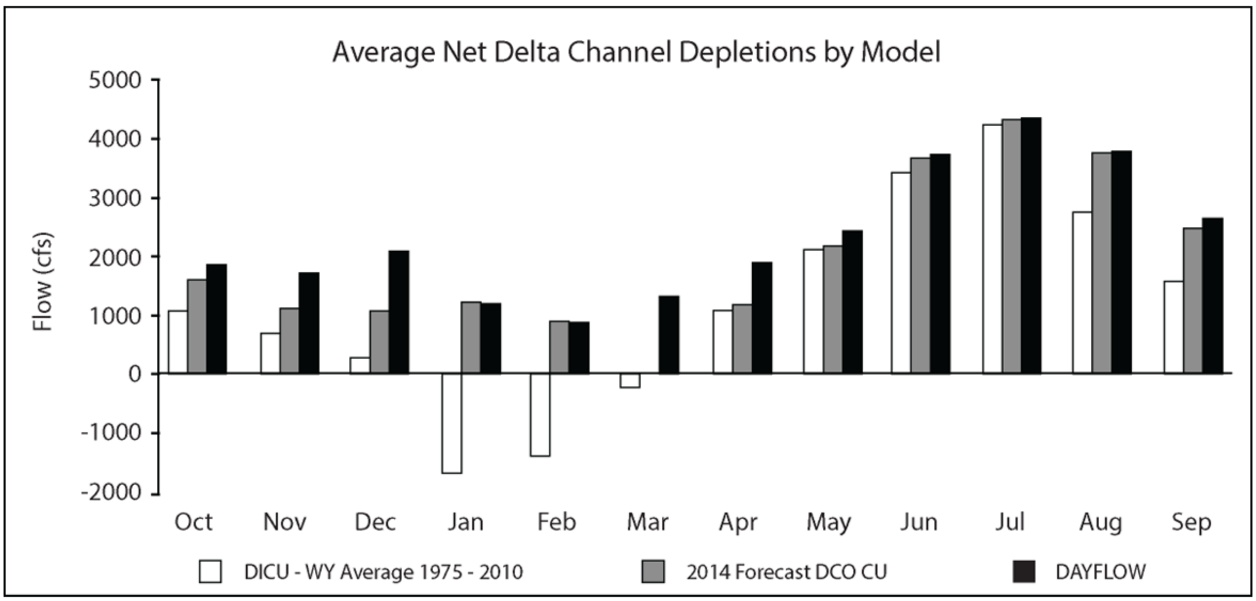


Figure 4, Graph of Estimated Net Channel Depletions, DWR 2015

Net Channel Depletions can be thought of as the water diverted from the channels and returned to the channels to help meet the consumptive use needs. Channel Depletions is the water diverted from the channels but does not include the return flow.

Figures 5 and 6 each show a pie chart of exports and channel diversions from the Delta in cfs and by percentage. The BBID diversions were separated out from the rest of the channel depletions to show their relative significance. As can be seen, agricultural diversions made up the largest portion of water taken from the Delta in June 2015.

Two additional notes for these figures: channel depletions were plotted rather than net channel depletions because of not knowing the return flows of BBID; and SWP exports, in addition to water exported to meet health and safety needs, reflect water exported as water transfers.

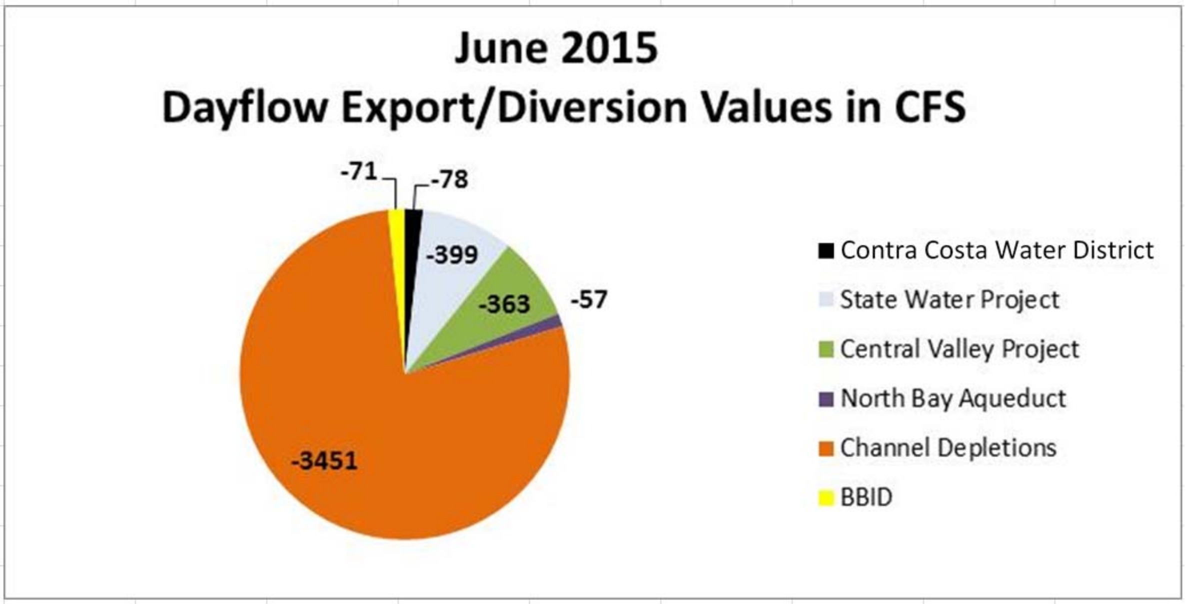


Figure 5, Exports and Diversions for June 2015 in cfs

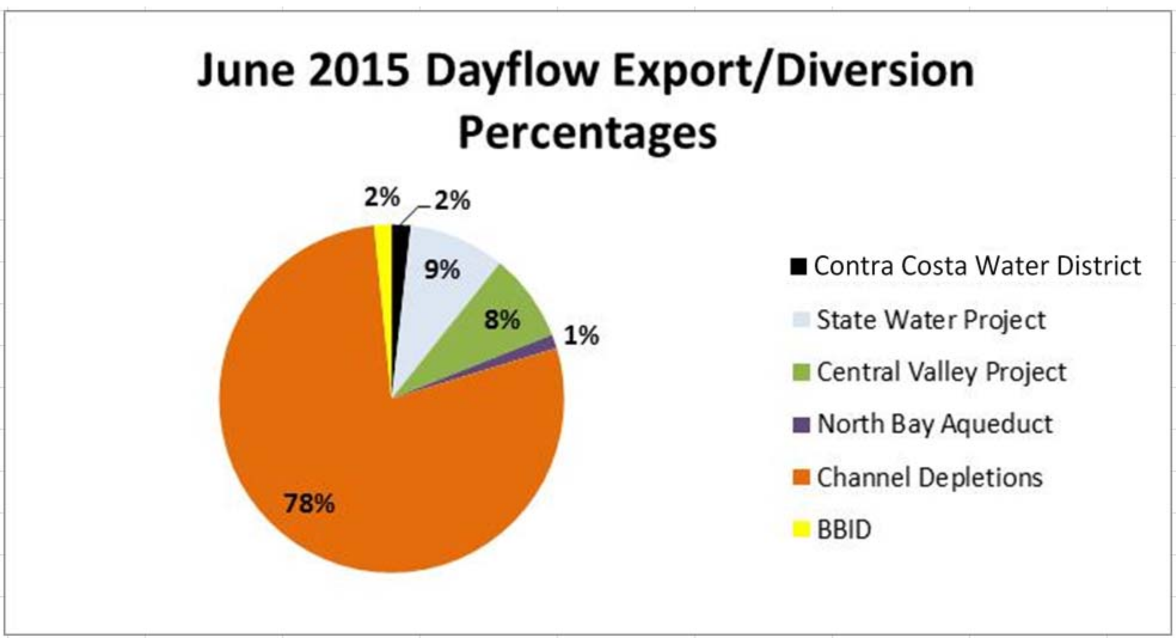


Figure 6, Exports and Diversions for June 2015 by percentage

Figures 7 and 8 are also graphs of values taken from DAYFLOW 2015 data. Figure 27 shows the additional monthly volume of water needed for net channel depletions to meet D-1641 objectives. The blue box chart bars represent the inflows minus the water needed for exports and diversions (Contra Costa, North Bay Aqueduct). The graph shows from 100 TAF to 260 TAF of additional upstream water was needed to flow into the Delta to meet agricultural demands. Figure 28 shows the same information but in cfs on a daily basis.

In 1931, the D-1641 objectives were not in place. Neither were there additional flow and storage requirements necessary to comply with the Endangered Species Act. This includes flows needed to meet X2 requirements for Delta Smelt and reservoir storage needed for temperature releases for Salmon. Especially during a series of drought years, these water quality and endangered species needs play a big part in water management.

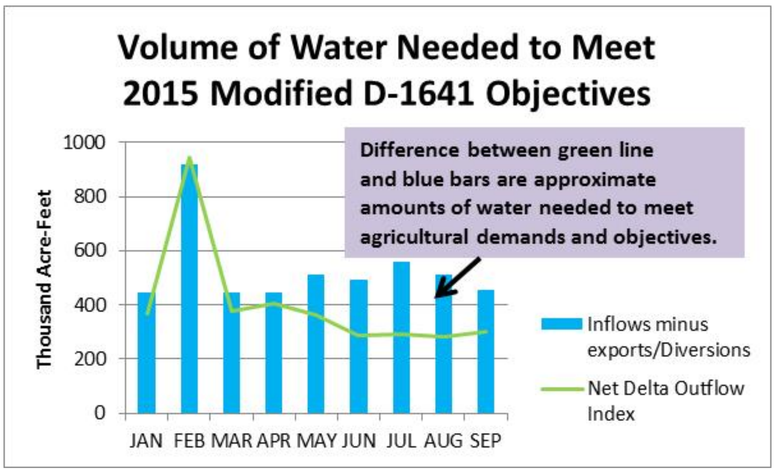


Figure 7, Volume of Water Needed to Meet 2015 D-1641 Objectives

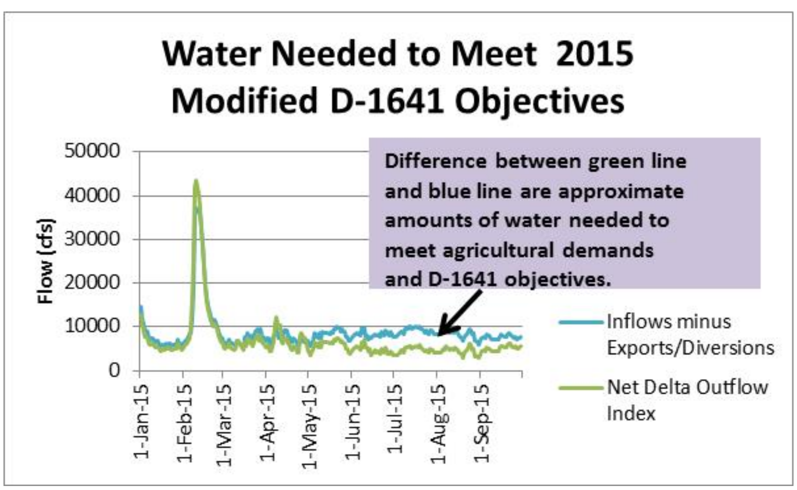


Figure 8, Amount of Water in CFS Needed to Meet 2015 D-1641 Objectives

IV. Effects of Unauthorized Diversions

Any water that is released from SWP/CVP storage for the purpose of meeting regulatory objectives will be negatively influenced by unfavorable tides and weather (such as high temperatures), which increases the difficulty for the Projects to maintain Delta water quality. This is particularly true during very dry periods where little additional buffer water is released due to the tension between competing demands for stored water. These circumstances are complex as salinity intrusion is not a one time event, but is recurring. Episodes of unfavorable tides and weather stretch for days and sometimes weeks, which can prolong and worsen salinity conditions by continually accumulating salts in the interior Delta.

Unauthorized diversions reduce outflow, reducing NDO. Combined with higher demands from authorized diversions, *un*authorized diversions can contribute to reductions of extra water that was added as a buffer that was released by Project operators to meet permit conditions. With each unauthorized diversion, less water is available than projected by Project operators to flush salt from the Delta and dilute salt within it.

Operators adjust project reservoir releases and exports to maintain water quality for both near-term and seasonal goals. When unauthorized diversions occur, the amount of water available to transport salts out of the Delta or dilute it is reduced, causing incrementally worse salinity conditions. Project operators must therefore increase reservoir releases or decrease exports to improve salinity conditions. These adjustments come from existing Project supplies, reducing them by a corresponding amount.

V. Sources of Water at WSID's Intake Channel

Figures 9 and 10 show the DSM2[5] (Delta Simulation Model 2) simulation of source of water in Old River at the WSID intake channel during April through October of 2014 and 2015 assuming 14 cfs for both City of Tracy Wastewater Treatment Plant (WWTP) discharge and WSID diversion. The City of Tracy WWTP discharge contributes about 1 to 2% of the water by volume in Old River at the WSID intake channel when the temporary barrier at the head of Old River is installed. At other times, the simulations indicate essentially no WWTP water is present at the intake channel.

[5] DSM2 is one of the main models used for modeling hydrodynamics and water quality in the Delta. DSM2 has three different modes of application: historical simulations, forecasts, and longer term planning simulations. In order to simulate historical or forecasted hydrodynamic conditions, DSM2 requires input data such as historical conditions, project conditions in the near future, and hypothetical Delta changes.

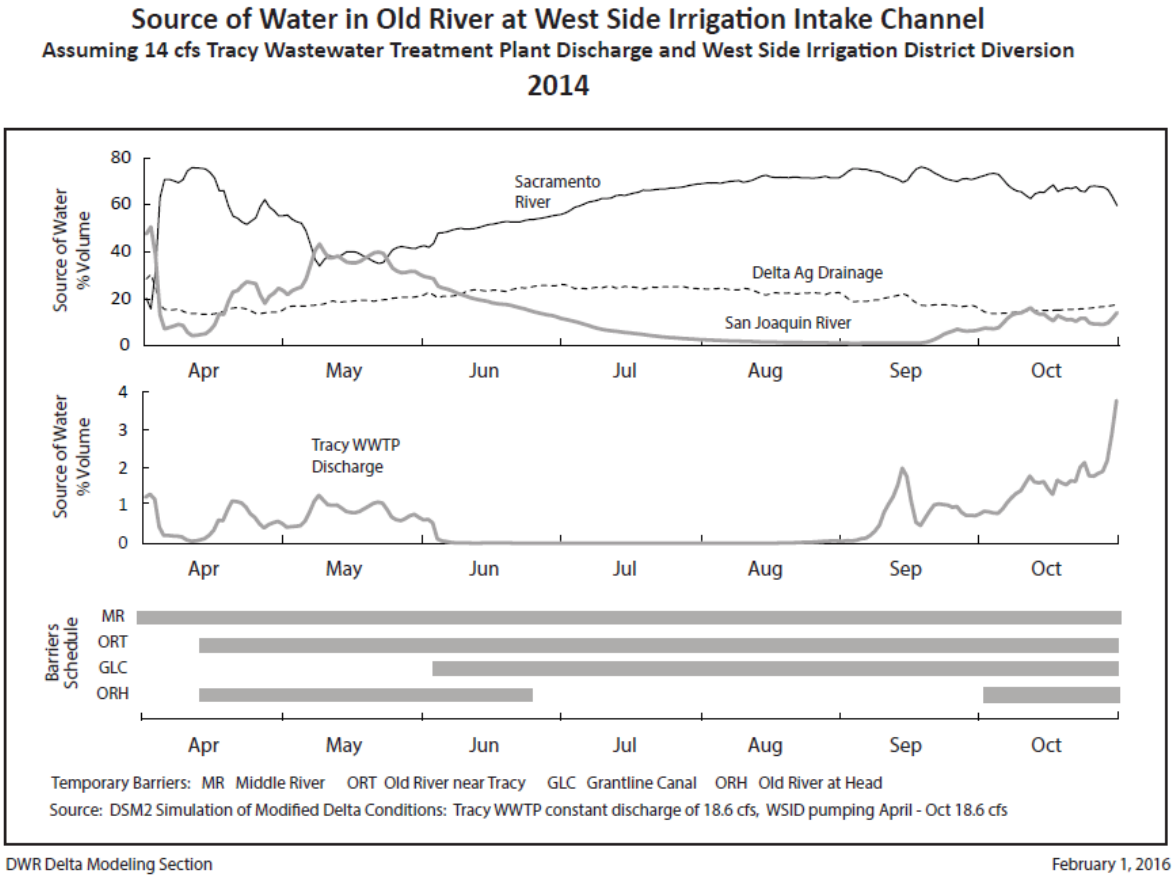


Figure 9, Source of Water in Old River at West Side Irrigation Intake Channel, 2014

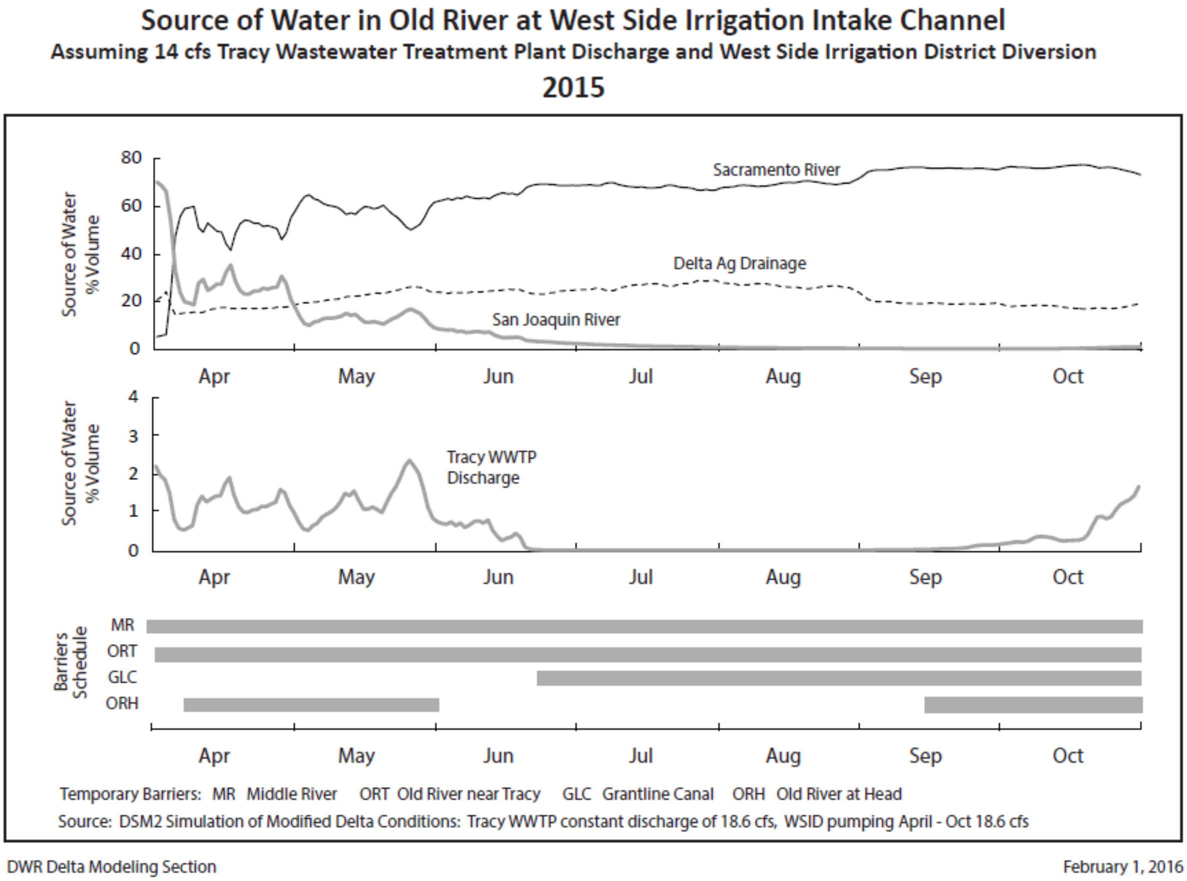


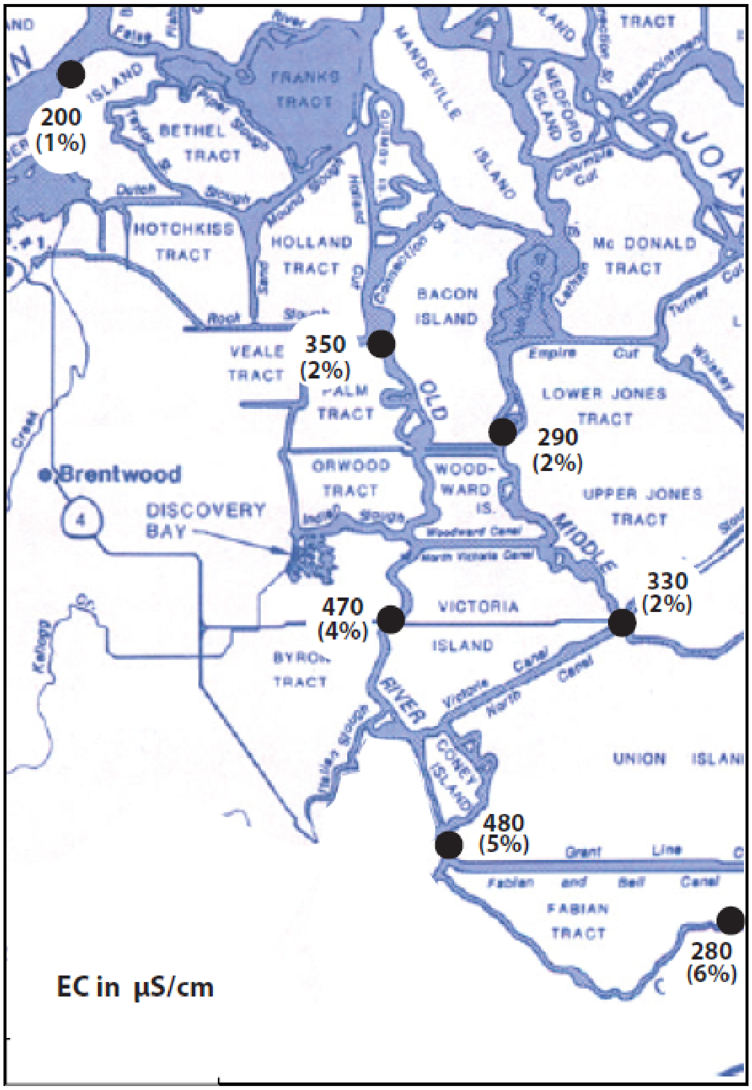
Figure 10, Source of Water in Old River at West Side Irrigation Intake Channel, 2015

VI. Effects of BBID's diversions in 1931

Figures 11 and 12, based on DSM2 simulations of historical and modified historical conditions, show the impact on peak daily average EC in Old and Middle Rivers in 1931 due to BBID's diversions that year. Peak EC in Old River upstream and downstream of Italian Slough increased 470 to 480 µS/cm. As shown in Figure 11, this increase was due to more of the water in Old River coming from Martinez where the salinity was high in 1931. These two graphs demonstrate that the diversion of water by BBID in 1931 influenced the salinity intrusion into the Delta.

Increase in Peak Daily Average EC for 1931 due to BBID Pumping

(Peak EC Occurs on Different Days for Different Locations: Sep 1 - Oct 4, 1931)



Source: DSM2 simulation of historical 1931 conditions with and without including BBID diversions as reported in DWR Bulletin 23.

February 2, 2016
Delta Modeling Section

Figure 11, Increase in Peak Daily Average EC for 1931 due to BBID Pumping

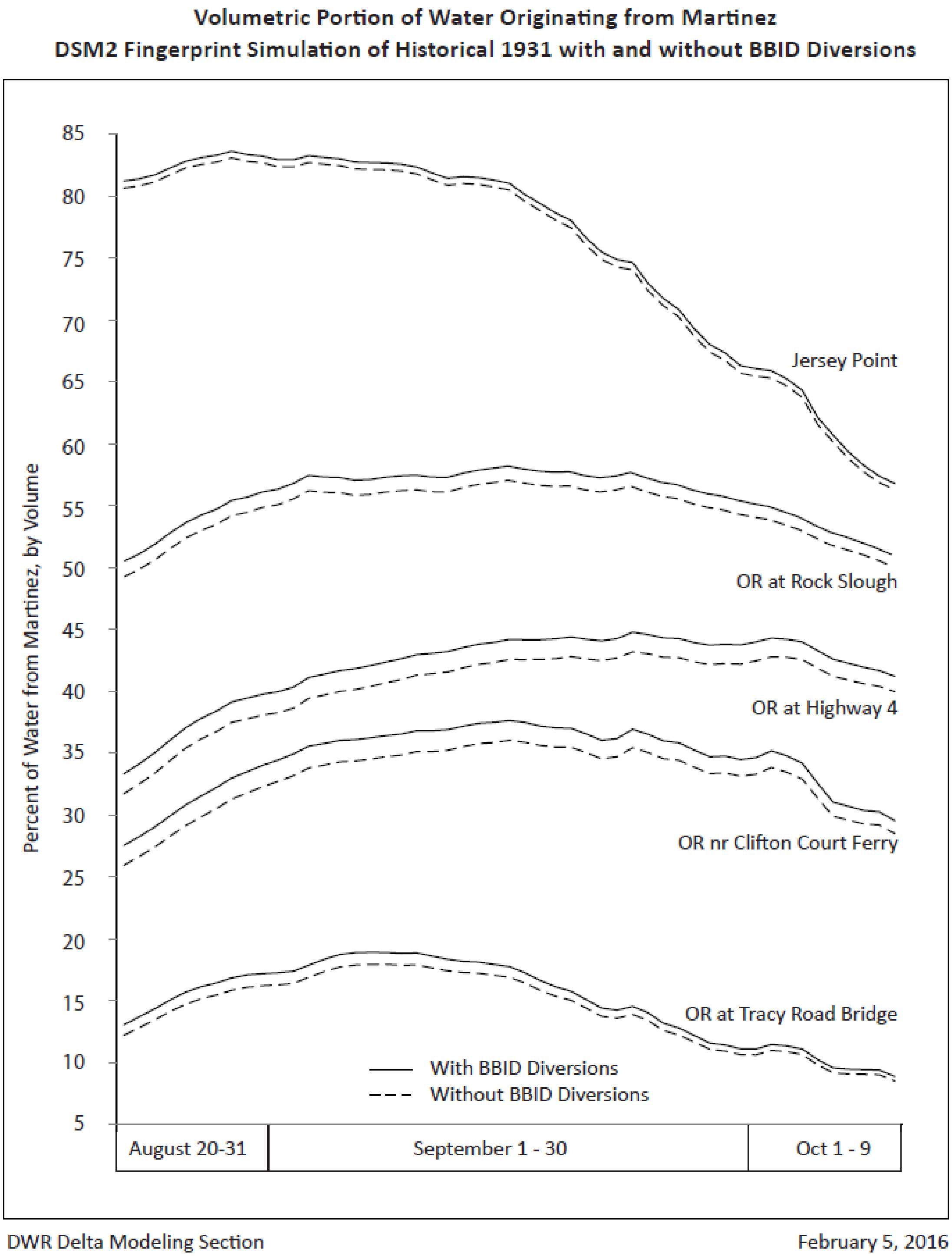


Figure 12, Volumetric Portion of Water Originating from Martinez

VII. Water Was Not "Fresh" in the Summer of 1931

Susan Paulsen's testimony (Exhibit BBID388, at 10:14-10:28) states that the peak Chloride concentration in 1931 reached 1,300 mg/L Chloride. Thomas Burke's testimony states that the salinity levels did not rise until later in year at the end of the prime growing season (Exhibit WSID123, at p. 6). Using the conversion equations for Clifton Court Forebay from the May 29, 2001 memorandum from Bob Suits (Exhibit DWR-5) and the1986 memorandum from Kamyar Guivetchi (Exhibit DWR-6), the following equivalent EC values were obtained and are shown in Figure 13.

Peak Chloride (mg/L)	Equivalent EC (mmhos/cm)[6] Bob Suits Memorandum	Equivalent EC (mmhos/cm)[6] Kamyar Guivetchi Memorandum
1,000	3.8	4.0
1,300	4.9	5.1

Figure 13, Equivalent EC for Peak 1931 Salinity

Figure 3 on page 4 shows the D-1641 objectives and locations. The peak salinity values reached in 1931 are four to five times greater than the current agricultural objectives in the south Delta. So even if salinity rose after "the prime growing season," the agricultural objectives extend throughout the year. Dr. Paulsen's and Mr. Burke's testimony implies that higher EC water is acceptable to agricultural users, which contradicts the current objectives.

In a January 2010 report to the Board's Division of Water Rights, Dr. Glenn J. Hoffman investigated the impacts of Sodium Chloride on various crops. (Exhibit DWR-7.) As Table 3.8 (Page 39 of the report) shows, the foliar injury from saline sprinkling water for various crops would range between 5 and 20 mol/m^3 for Sodium or Chloride concentration (Figure 14). To change mol/m^3 to mg/l, the table is suggests dividing the concentration by 0.02821. Therefore, chloride concentrations of between 177 and 710 mg/l would cause foliar injury to sample crops shown on the table below. In contrast to Dr. Paulsen's statement that water with chloride levels at 1,000 mg/L chloride is relatively fresh, Dr. Hoffman's report shows how potentially detrimental this might have been to crops in 1931.

Figure 15 is an excerpt from DWR Bulletin 23 for 1931 regarding the crop losses experienced in the Delta that year. This excerpt shows that Delta crops were negatively impacted by the salinity levels in the Delta, which also contradicts Dr. Paulsen's and Mr. Burke's testimony.

[6] The units of mS/cm are equivalent to mmhos/cm.

Table 3.8. Relative susceptibility of crops to foliar injury from saline sprinkling waters (Maas and Grattan, 1999).

Na or Cl concentration causing foliar injury, mol/m³*			
<5	**5-10**	**10-20**	**>20**
Almond	Grape	Alfalfa	Cauliflower
Apricot	Pepper	Barley	Cotton
Citrus	Potato	Corn	Sugar beet
Plum	Tomato	Cucumber	Sunflower
		Safflower	
		Sesame	
		Sorghum	

**To convert mol/m³ to mg/l or ppm divide Cl concentration by 0.02821 and Na concentration by 0.04350. The conversion from mg/l to EC is EC = mg/l / 640.*

Note: These data are to be used as general guidelines for daytime sprinkling. Foliar injury is also influenced by cultural and environmental conditions.

Figure 14, Relative Susceptibility of Crops to Foliar Injury, Hoffman Report, 2010

Tangible Crop Losses

To arrive at the tangible losses as outlined, all of the data of the field forms were thoroughly reviewed, summarized by islands and crops and compiled as shown in Table 92. Under the three classifications of tangible crop losses, this table shows, segregated by crops, the total losses, in production and money. It is to be noted that the estimates of loss in money represent the market value of the lost production and as such might be termed the gross loss as distinguished from net loss represented by the net profit which the grower might have realized had he been able to market the crops lost. As shown by Table 92, the market value of the Delta crops estimated to have been lost because of salinity in 1931 totals $1,263,716. Of this amount, $890,906, or 70 per cent of the total, is the loss estimated to have resulted from curtailment of irrigation, $357,640 or 29 per cent, the loss due to actual application and use of water of too high salinity and $15,170 or one per cent, the loss due to destruction of permament plantings and to abandonment of crops or plans therefor because of high salinity.

Figure 15, Crop Losses in 1931 due to Salinity Intrusion, Bulletin 23, 1931

Dr. Paulsen's testimony (Exhibit BBID388, at 11:1-11: 12) emphasizes that water was of "suitable quality" during June 1931, but does not discuss the quality of the water in later summer months even though Bulletin 23 for 1931shows that BBID diverted water into October at the much higher salinity levels mentioned previously (Figure 16, see Exhibit DWR-8, at. p. 85). The availability of water in terms of quality and quantity is questioned due to the poor water quality later in the summer.

TABLE 39

DELTA UPLANDS DIVERSIONS FROM OLD SAN JOAQUIN RIVER

WATER USER	*MILE AND BANK	NUMBER AND SIZE OF PUMP	MONTHLY DIVERSIONS IN ACRE-FEET								TOTAL DIVERSION APRIL TO OCTOBER ACRE-FEET	** ACREAGE IRRIGATED
			MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.		
EAST CONTRA COSTA IRRIGATION DISTRICT	36.5 L (1)	2-30" 1-24" 1-18"	2717	6387	5423	3224	5383	3596	227	17	26974	13357
BYRON-BETHANY IRRIGATION DISTRICT (2)	40.9 L	1-26" 1-30"	1176	3485	1888	2469	2847	2652	1139	140	15796	7853
JOE F. COSTA	(3)44.6 L	1-7"					58				58	20
E. H. STEVENSON (RAY BROS.)	(4)45.3 L	1-12"		80			39	63			182	111
H. LINDEMAN	47.2 L	1-12"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]

Figure 16, Bulletin 23 - 1931 BBID Diversions

VIII. BBID Diverted Less Water in 1931 Than It Did in 1930

Dr. Paulsen's testimony (Exhibit BBID388, starting at 10:14) indicates that the peak Chloride concentration reached 1,300 mg/L Chloride and implies that BBID diverted as much water as it desired. Mr. Burke, in his testimony (Exhibit WSID123, at p. 7), says:

> Based on the fact that during the 1931 and 1939 drought years measured salinity levels did not rise until late in the year (at the end of the prime growing season), and there was no noticeable decline in irrigation diversions or irrigated acreage at BBID or WSID (when compared to normal or wet years) it is my opinion that the water quality during these two drought years did not hinder irrigation diversions.

Bulletin 23 for 1930 indicates that BBID diverted more water from May to October 1930 compared to from May to October 1931. (Exhibit DWR-9, at p. 58.) The decreases in diversions from 1930 to 1931 could have been due to conservation methods done earlier in 1931 (Exhibit DWR-9, at pp. 5-19.), a change in the "freshness" of the water from 1930 to 1931, or some other reason. Figure 17 shows the 1930 diversions. Figure 18 shows both the 1930 and 1931 diversions in the same table with percentage of reduction in diversions in 1931. July was the only month that could possibly be considered close in terms of the amount of the diversions between the two years. Otherwise, in 1931, diversions were 17% to 97% lower than they were in 1930. That BBID diverted less in 1931 than it did in 1930 indicates that it did not divert as much as it could have desired. Figure 19 is an excerpt from Bulletin 23 for 1931 that describes how the Delta farmers were made aware of the salinity encroachment. (Exhibit DWR-9, at p. 150.)

TABLE 23

DELTA UPLANDS DIVERSIONS FROM OLD SAN JOAQUIN RIVER

Water User	*Mile and Bank	Number and size of pump	Monthly Diversions in Acre-feet: Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Total Diversion: April to: October Acre-feet	Acreage Irrigated
East Contra Costa Irrigation District	36.5 L (1)	2-30"; 1-24"; 1-18"	1520	7070	5783	5481	5019	2613	1314	28800	13929
Byron-Bethany Irrigation District	[illegible] (2)	[illegible]; 1-30"	273	3198	3387	3276	3071	2787	569	16561	9200

SACRAMENTO-SAN JOAQUIN

Figure 17, Bulletin 23 - 1930 BBID Diversions

	May	June	July	August	September	October
1930 BBID	**3198**	**3387**	**3276**	**3071**	**2787**	**569**
1931 BBID	**1888**	**2459**	**2947**	**2552**	**1139**	**17**
Difference in Diversion	**1210**	**928**	**329**	**519**	**1648**	**552**
Percent Reduction in 1931 Diversions	**41%**	**27%**	**10%**	**17%**	**59%**	**97%**

Figure 18, BBID Diversions 1931 and 1930 (from Bulletin 23)

Salinity Bulletins

With the unusually early encroachment of salinity in the 1931 season, water users throughout the Delta were anxious to obtain the results of the tests in order that their irrigation operations might be governed to prevent the use of water of injurious salinity content. In the period from May 1st to November 15th therefore, bulletins reporting the salinity at the various stations were mailed to a large list of Delta water users at weekly or ten-day intervals. This service as well as that in testing many samples taken at points other than the regular stations, was in great demand and was probably instrumental to a considerable extent in reducing or preventing damage from the use of water of too high salinity.

Figure 19, Bulletin 23, 1931 – Delta Users informed of salinity encroachment

IX. Delta Diversions Influenced Salinity Intrusion in 1931

Dr. Paulsen's testimony (Exhibit BBID388, at 12:14-12:20) discusses that the 1931 modeling indicated that some of the Sacramento River water found at BBID entered the Delta during February to May. Building upon the idea that water movement in the Delta has a memory or is influenced by previous hydrodynamic circumstances, a similar case can be made that increased net channel depletions in the earlier summer months significantly contributed to the higher levels of chloride later in the season. Figure 20 shows the volumetric fingerprint for Old River at Highway 4 (Exhibit BBID384, Figure 4-11, at p. 49). Page 85 of the exhibit shows volumetric fingerprint broken out by months for the Sacramento source but neglects to show it for Martinez. Even without that information, it is easy to see from that figure that the percent by volume of Martinez salinity increases overtime. Under D-1641, Martinez EC by volume would be closer to 2% or 3% (see Exhibit BBID384, Figure 4-11, at p. 49). DWR also modeled 1931 using the Bulletin 23 data. Figure 21 below shows the difference between NDOI and the inflows to the Delta. The difference between these two lines reflects the agricultural net channel depletions. Inflows into the Delta drop, but it is the net channel depletions that cause a negative NDOI, close to -5,000 cfs, and this inflow to the Delta from the ocean starts in June 1931. This inward movement of salt is also reflected in Figure 22. (See Exhibit BBID384, Figure 6-4, at p. 81.) The graphs show the movement of the peaks of salinity over time from the western Delta into the southern Delta. Net Channel Depletions in the summer cause the strong salinity intrusion through the summer and fall months.

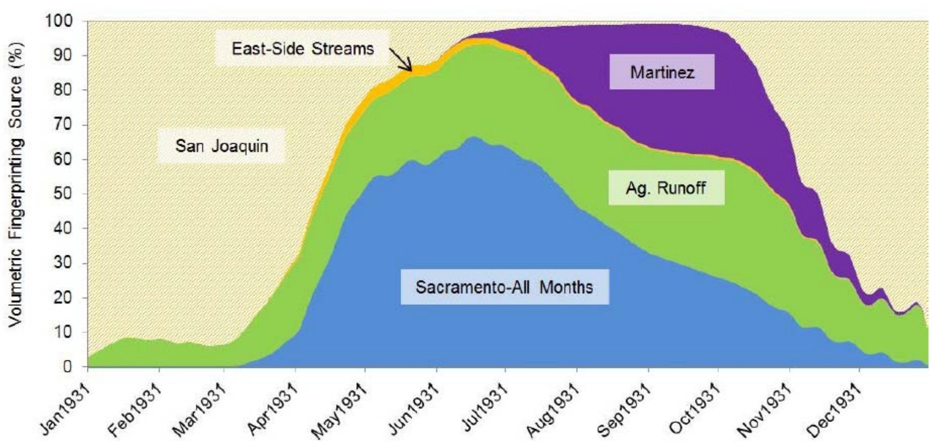


Figure 20, Exhibit BBID-384, Figure 4-11, at page 49

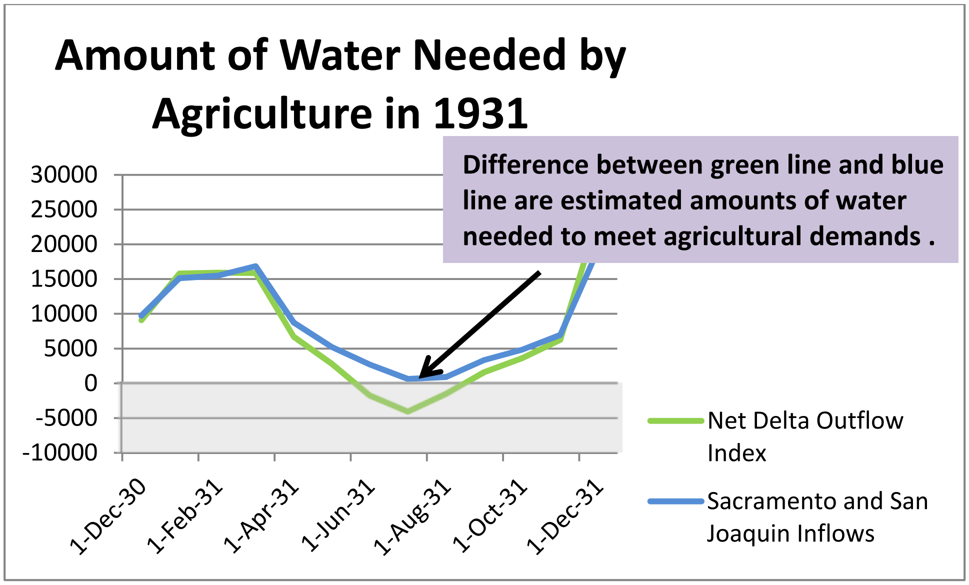


Figure 21, Amount of Water Needed by Agriculture in 1931

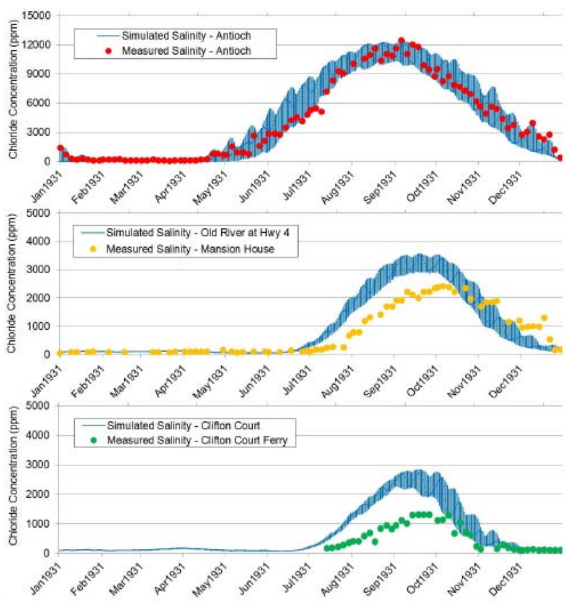


Figure 6-4. Comparison of measured and modeled salinity at Antioch (top), Old River at Highway 4 (middle), and Clifton Court Ferry (bottom) (measured data from DWR 1931 Bulletin 23, DWR 1932)

Figure 22, Exhibit BBID-384, Figure 6-4, at page 81

X. Salinity Intrusion Impacts of Zero Net Delta Outflow Index

Below are plots (Figures 23-28) from DSM2 simulations showing EC contours of progression of salinity intrusion under initial conditions of June 1, 2015 and then 30, 60, 90, 120, and 150 days of no Delta inflow and no Delta diversions or exports. This reflects a zero NDOI over a five month time period. The salinity intrusion over time shows the impact of not having enough outflow to push back salinity. It also shows that after five months, salinity did not reach the higher peak salinities of 1931, which had negative net Delta Outflow (Figure 21) due to low inflows and agricultural net channel diversions.

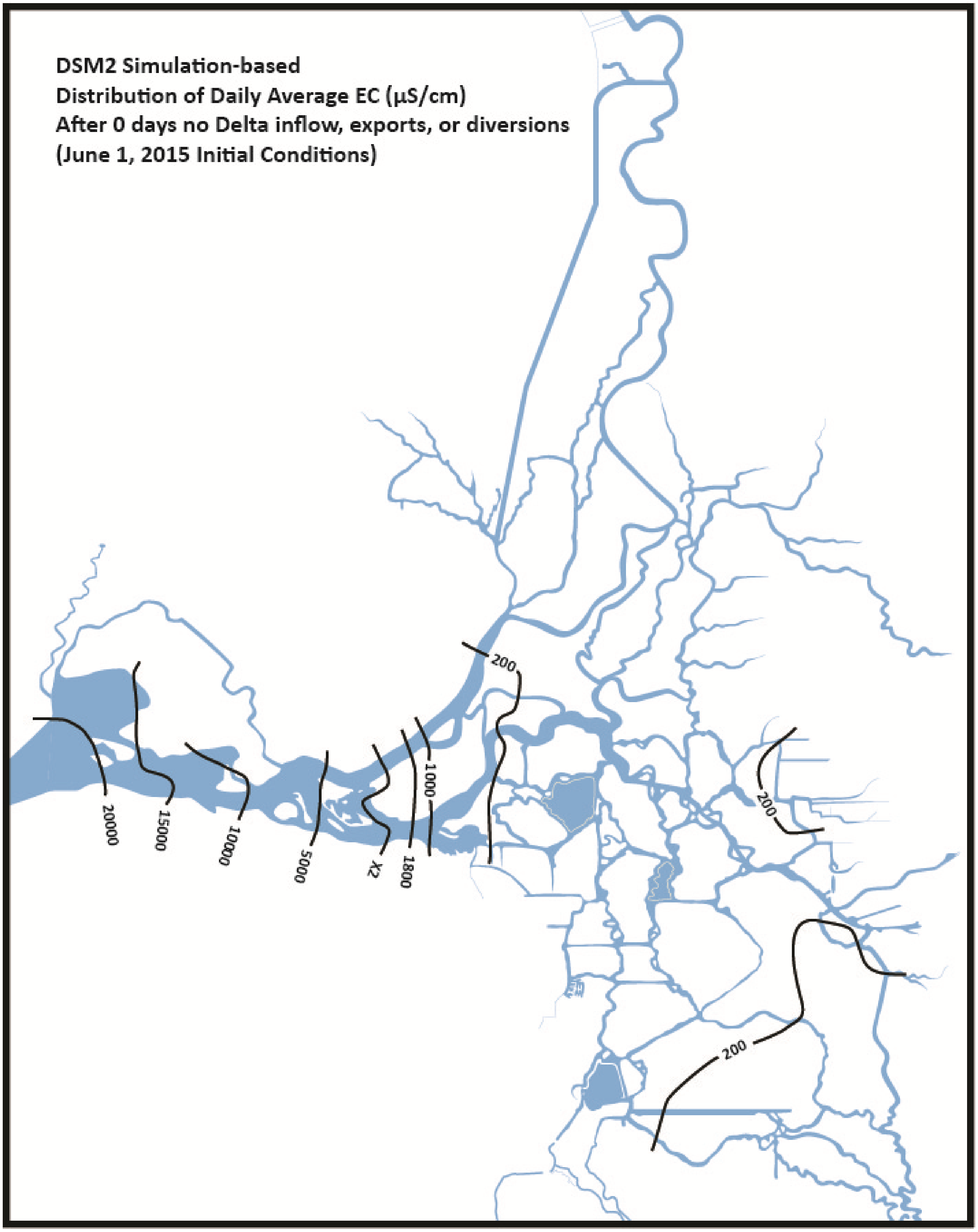


Figure 23, DSM2 Simulation, Distribution of Daily Average EC with NDOI =0, Initial Condition June 1, 2015

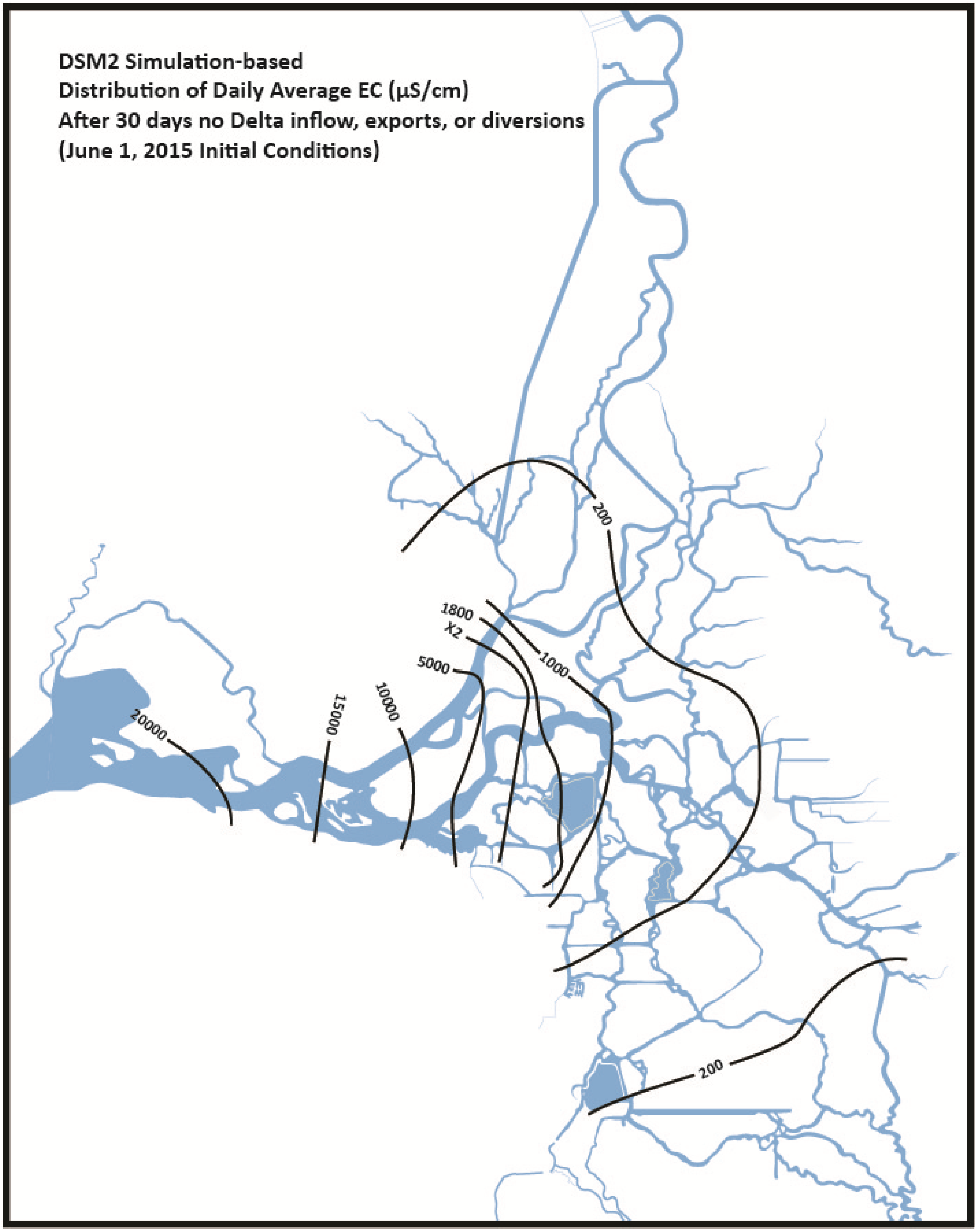


Figure 24, DSM2 Simulation, Distribution of Daily Average EC with NDOI =0, Day 30

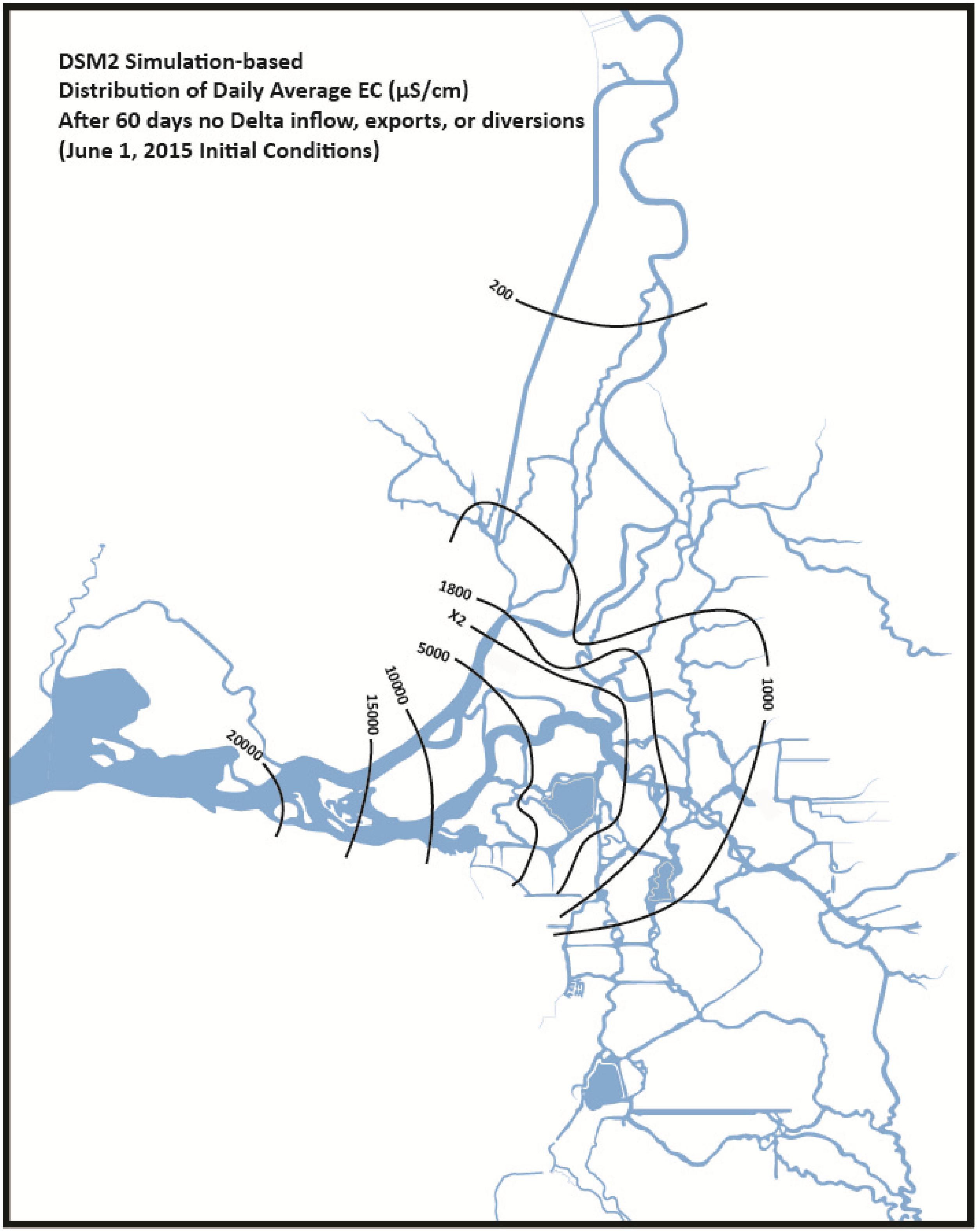


Figure 25, DSM2 Simulation, Distribution of Daily Average EC with NDOI =0, Day 60

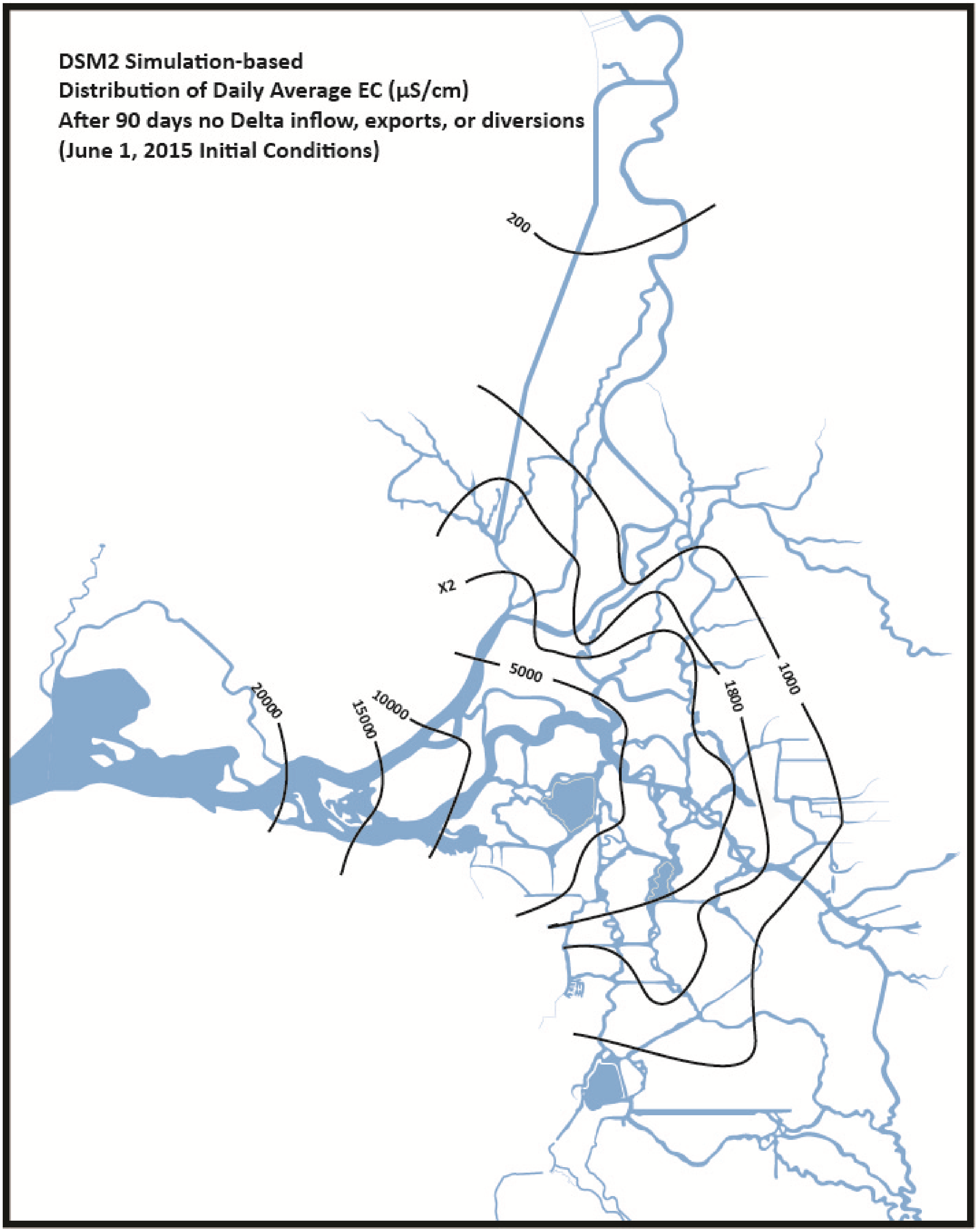


Figure 26, DSM2 Simulation, Distribution of Daily Average EC with NDOI =0, Day 90

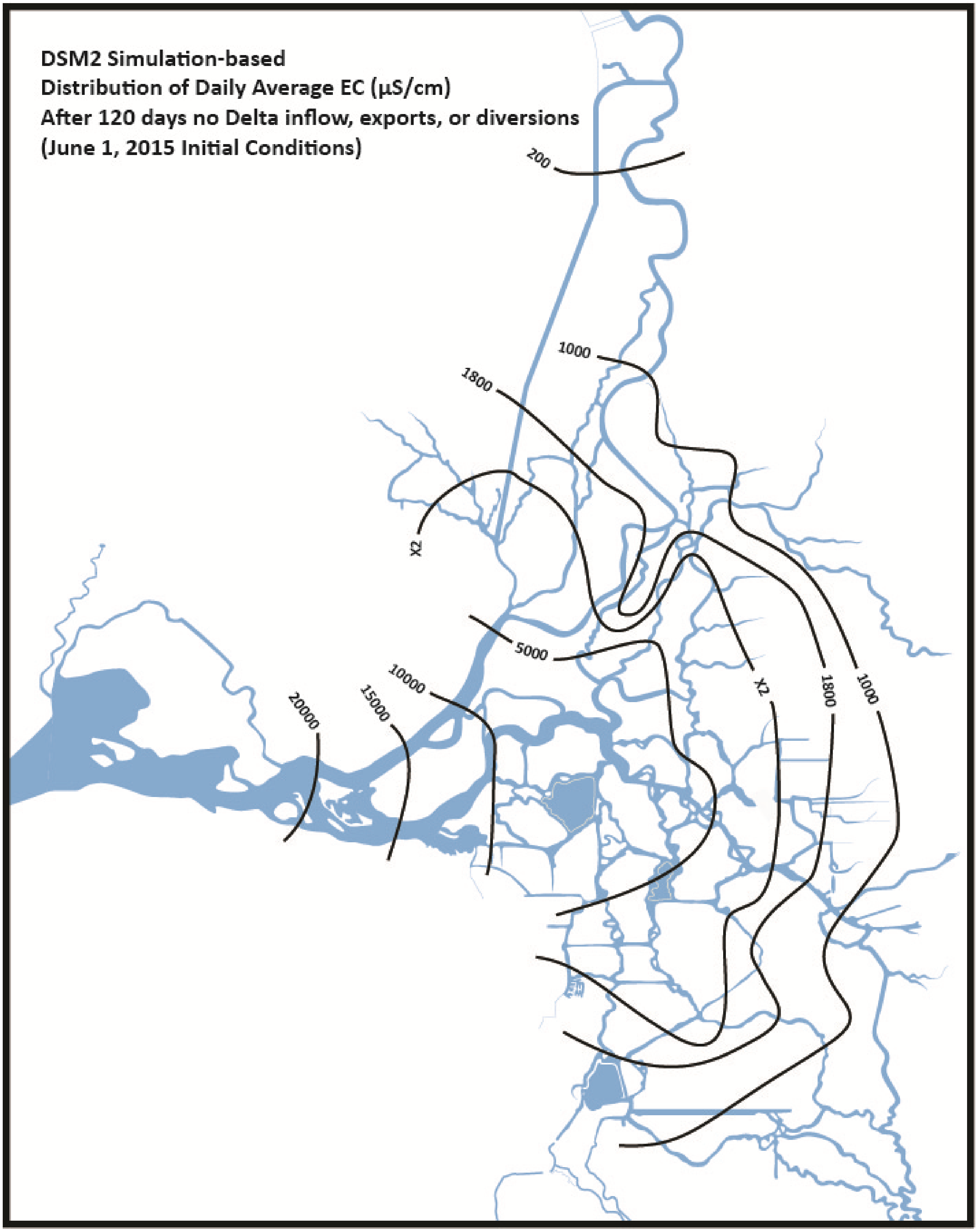


Figure 27, DSM2 Simulation, Distribution of Daily Average EC with NDOI =0, Day 120

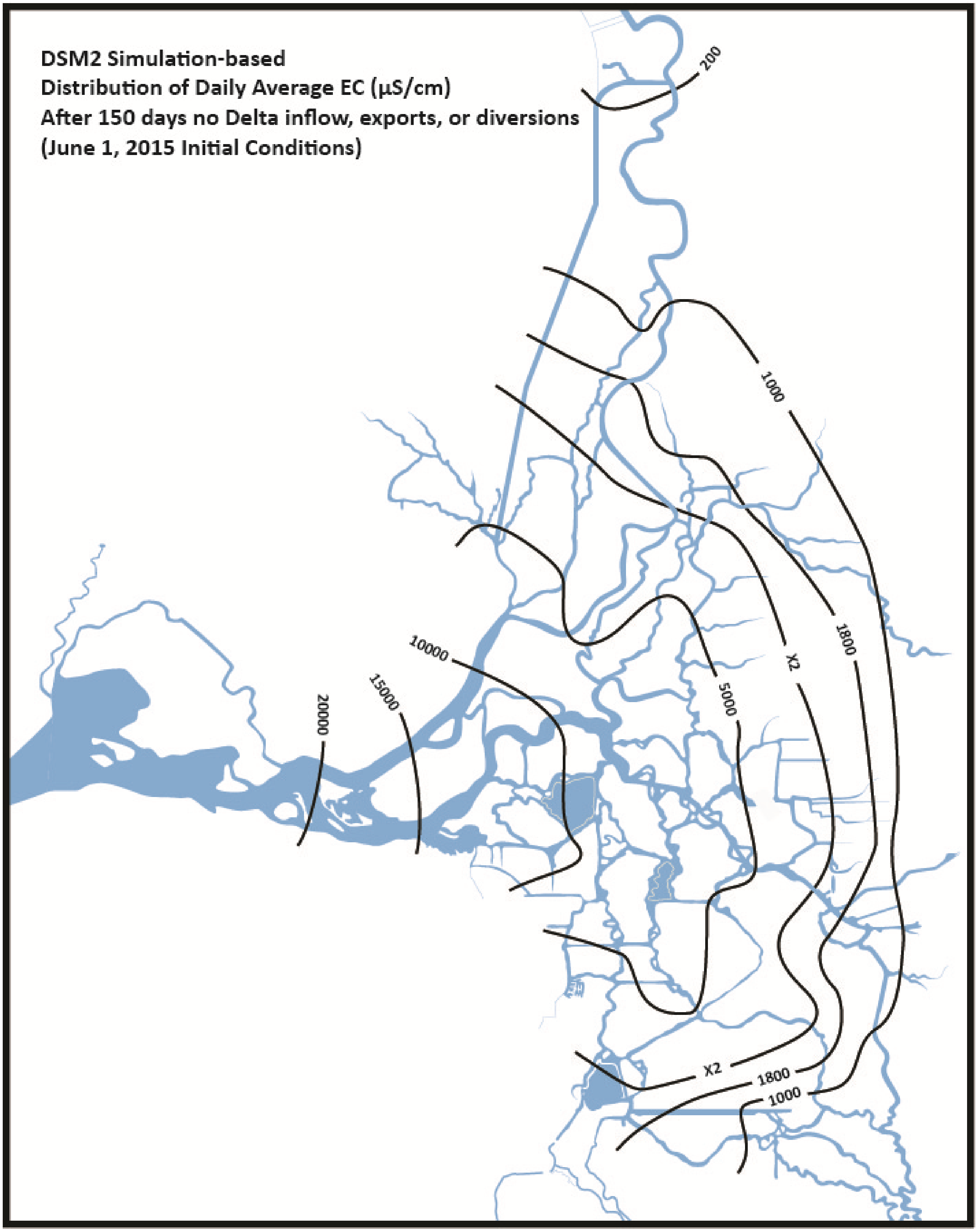


Figure 28, DSM2 Simulation, Distribution of Daily Average EC with NDOI =0, Day 150