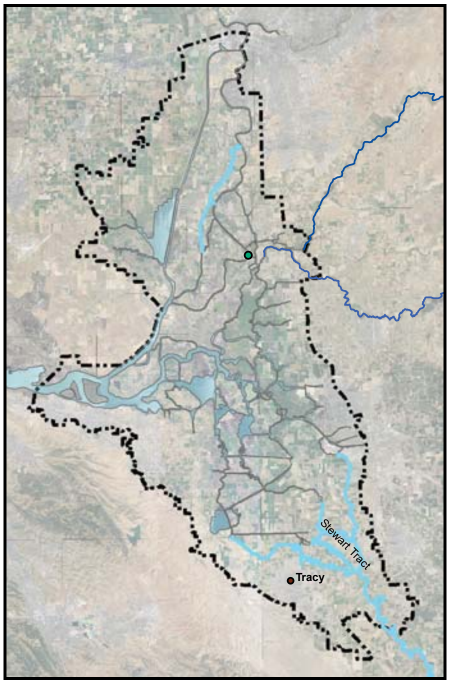
Technical Report

January 2016



WSID and BBID

Water Availability Analysis

Prepared By:

HSI Hydrologic Systems
936-B 7th Street, Suite 303
Novato, California 94945

Prepared For:

Harris, Perisho and Ruiz

on behalf of

West Side Irrigation District (WSID),
Central Delta Water Agency (CDWA) and,
South Delta Water Agency (SDWA)

WSID CDO/BBID ACL
WSID0124

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Signed: Thomas K. Burke Date: January 19, 2016

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1 Introduction

1.1 Introduction

This report has been developed to analyze flow and water quality conditions in the California Delta. There have been numerous studies conducted over the past 50 years analyzing different aspects of the Delta and its flow and water quality conditions. This report has been specifically developed to address the availability of water and water quality at two separate locations in the Delta. The first is the West Side Irrigation District's (WSID) point of diversion on Old River. The second is Byron Bethany Irrigation District's (BBID) point of diversion off of the Clifton Court Forebay. Figure 1-1 is a map showing the location of the two diversion points.

1.2 The California Delta

The California Delta is formed where the steep gradient rivers of the Sierra Mountains transition to the relatively flat central valley of California. Figure 1-2 is a map of central California showing the location of the Delta. The Delta is bounded by the Sierra Mountains to the east and the coastal range to the west. The outlet from the Delta is through the Carquinez Straights, which connects the Delta to San Pablo and San Francisco Bay and ultimately to the Pacific Ocean. At the change from steep to shallow gradient, the well defined river and creek channels which flow into the Delta, transition into a network of wide slow-moving interconnected channels and sloughs. These delta channels collect flow from the contributing rivers as well as tidal inflow and outflow from the interconnected bays west of the Delta. The flow in the Delta is generally westward, ultimately flowing into San Pablo Bay and San Francisco Bay, and then out to the Pacific Ocean. All of the channels within the Delta are tidally influenced. All of the major channels are below sea level, resulting in the channels always being filled with water. The legal boundary of the Delta was established in 1959 pursuant to Water Code Section 12220 and was determined by the outermost reach of the tidal zone.

The relatively flat topography, which is characteristic of most deltas has historically resulted in the contributing streams depositing sediment within the delta. This deposition of sediment results in a highly fertile zone. Due to this high fertility, the primary land use in the Delta is agriculture. Portions of the Delta have been cultivated since the early to mid 1800's, as areas within the Delta were gradually protected by a system of levees. These reclaimed areas are now referred to as delta islands or tracts. Figure 1-3 is a map showing the transformation to the Delta that has occurred since the 1800's as the delta islands were reclaimed.

The water quality in the Delta is influenced by the volume and timing of water that enters the system from contributing streams, irrigation return flow from existing agricultural activities, and tidal inflow from San Pablo Bay. From an agricultural standpoint, because there is always water available in the delta channels, the salinity of the water in the Delta is the primary concern (see NDWA Contract, Appendix A). Salinity in the Delta is primarily influenced by tidally driven salts from the West (the Bay and San Pablo Bay) and by high salt loads from the San Joaquin River. As might be expected, the salinity level in the Delta varies markedly, depending on location and water year type. During wet years high inflow from the contributing streams tends to bring in additional fresh water to help freshen the delta channels and repel salinity intrusion. This occurs to a lesser degree during dry years.

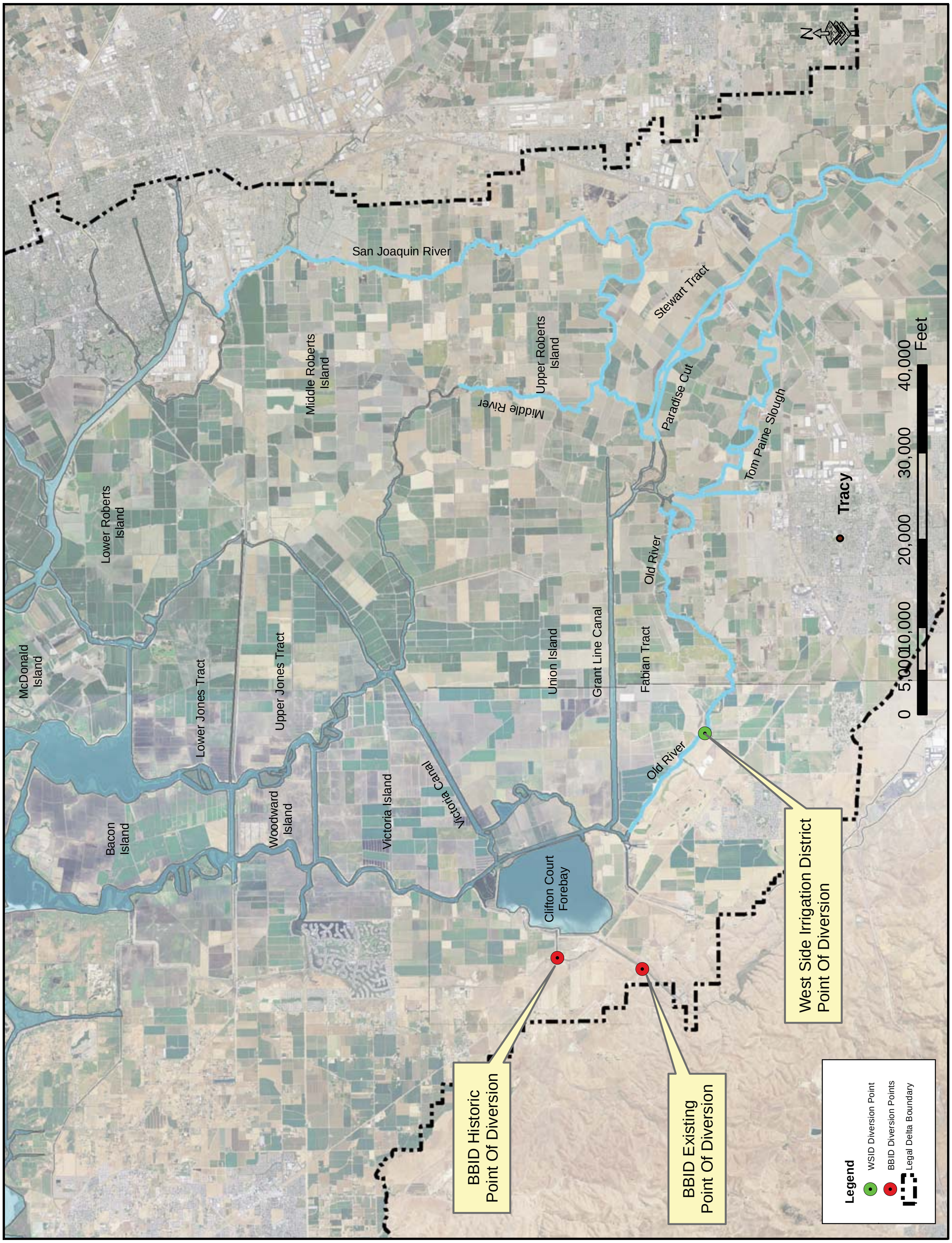

Figure 1-1 Location of BBID and WSID Diversion Points.

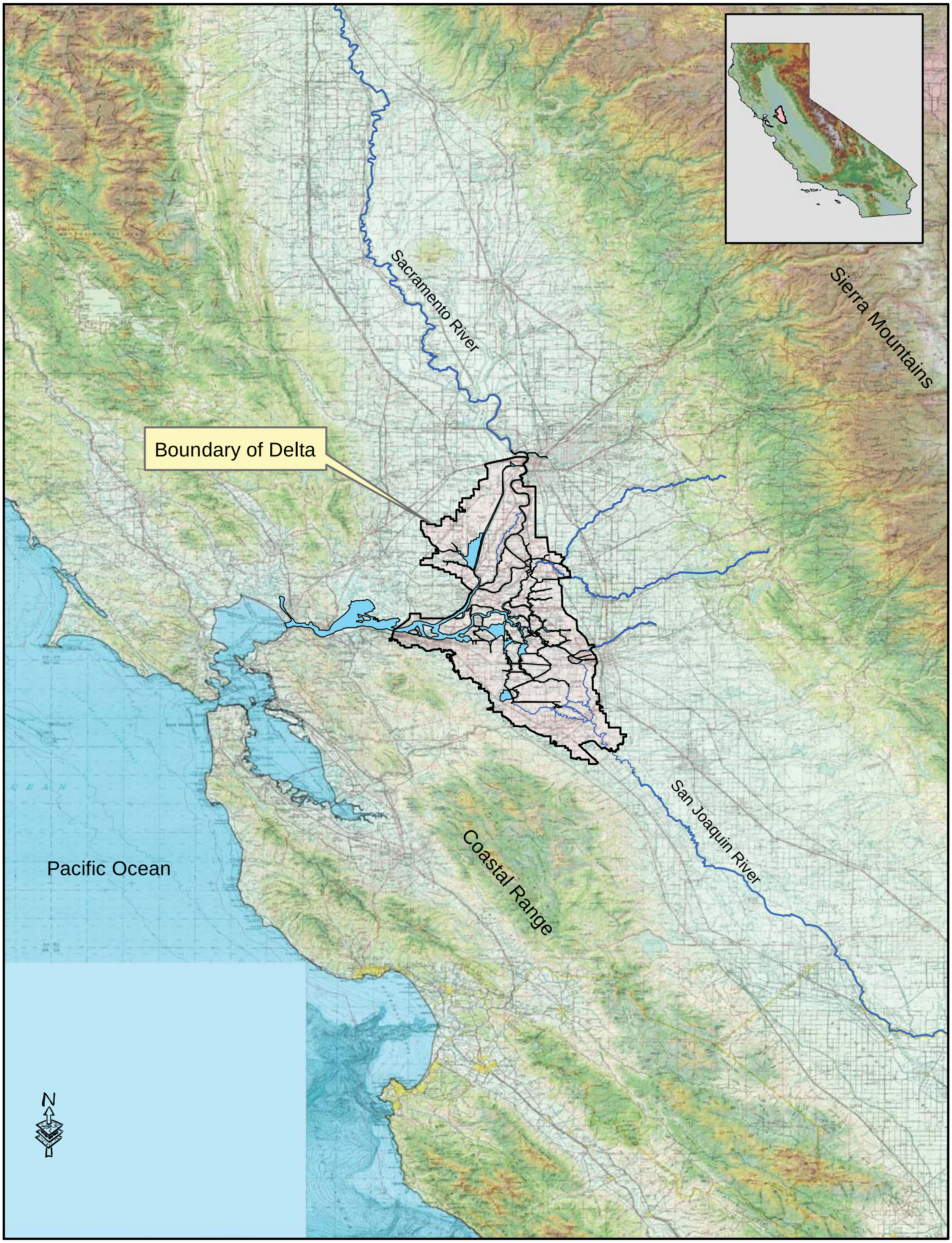

Figure 1-2 Location of the Delta Within the California Central Valley.

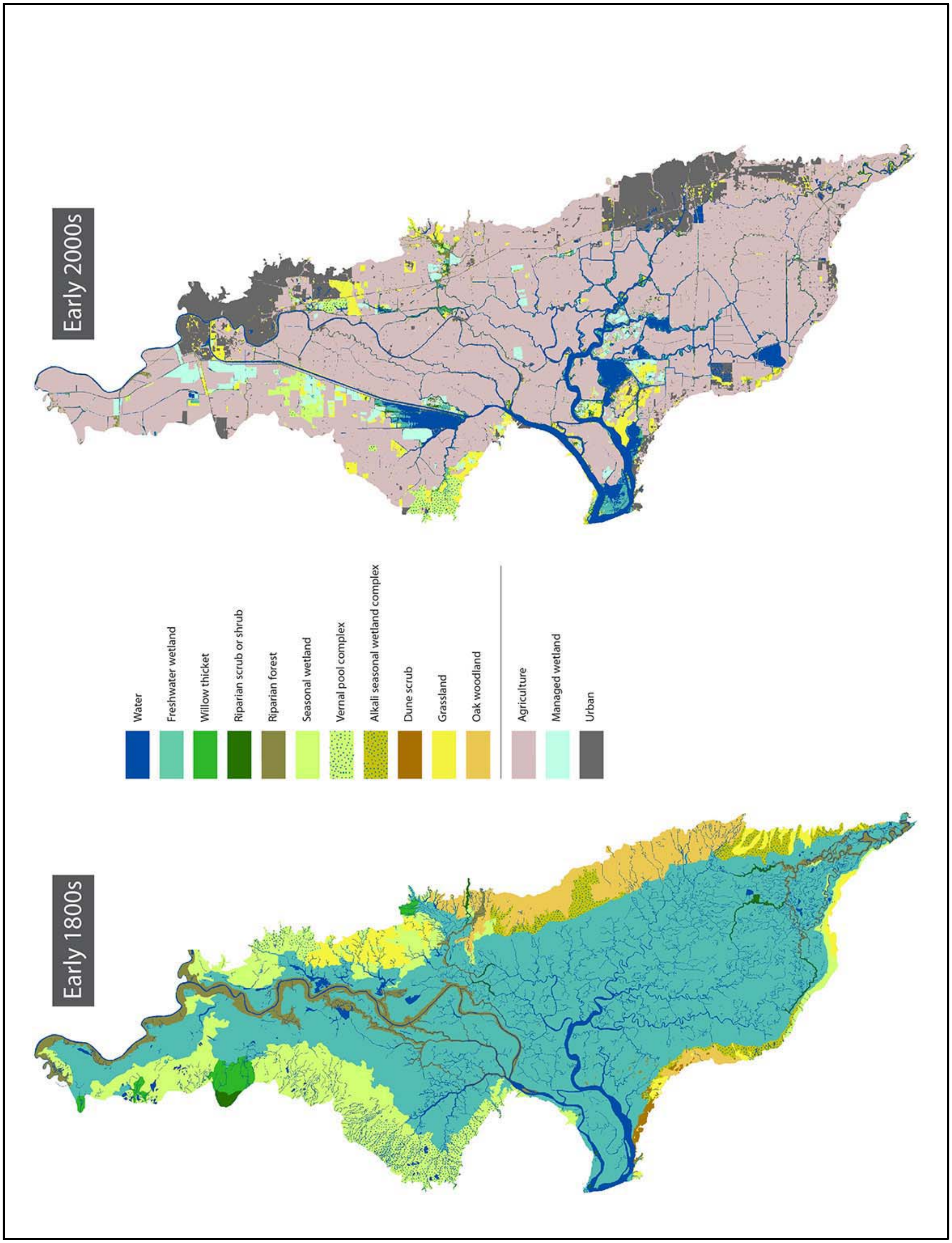

Figure 1-3 Comparison of Land Use Changes. (Source: SFEI, A Delta Transformed)

1.3 Purpose of the Report

In the summer of 2015 the State Board determined there was insufficient water available for WSID and BBID to divert at their respective points of diversion within the south Delta. The State Board alleges that as of May 1, 2015, there was insufficient water available at WSID's point of diversion to support its rights pursuant to its license. The State Board issued a draft Cease and Desist Order (CDO) against the WSID. The State Board alleges that between June 13 and 23rd 2015, there was insufficient water for BDID to divert pursuant to its pre-1914 right. The State Board issued an Administrative Civil Liability Complaint against BBID.

In fact, there was water available for diversion at the WSID and BBID POD’s. It has been asserted, that the only reason that irrigation water was available at the two POD’s is that the State and Federal water projects (“Projects”) were releasing water into the Delta. It is claimed that without those releases, water would not have been available to meet the water rights of the two diverters.

This report examines whether there was sufficient water available for WSID and BBID to divert pursuant to their respective water rights during the relevant time frames, and, if so, the source of the water and the relative quality of the water.

1.4 Approach

To evaluate the SWRCB’s position, that during drought years water would not be available without the State and Federal water projects, an analysis of water availability and water quality in the Delta was conducted. The analysis compared the pre-Projects condition that existed in the 1930’s to the existing water availability and quality that exists with the Delta with the Projects today.

The first part of this analysis involved evaluating the flow characteristics in the Delta and the influence that both tributary flows and tidally driven inflow from the west has on water in the Delta channels. The details of this analysis are provided in Section 3 of this report. The second part of the analysis was evaluating the water quality characteristics in the Delta channels during the pre-Projects 1930’s period. The 1931 and 1939 water years were drought years that were very similar to the 2014 and 2015 drought years. Although they were a little dryer than the two most recent years, they provide information on how the Delta responds to droughts prior to the development of the State and Federal Water Projects (“Projects”)

The major elements of the Federal Water Project did not start to come on-line in until 1944, therefore, the 1930 through 1943 period was chosen to evaluate the water quality conditions that existed prior to construction of the water projects. This period contained both very dry and very wet water years. The Water Year 1931 specifically was one of the driest years on record, with less runoff than both the 2014 and 2015 water years. This period also contains one of the wettest years on record, 1938.

The hydrodynamic model DSM2 (DWR 2013) was used to evaluate flow and water quality conditions in the Delta. This model can evaluate the flow and water quality within the various Delta channels given the inflow to the Delta from the tributary streams, the tidal inflow and outflow to the Delta from the west, consumptive use within the Delta, and exports from the Delta. The model was developed by the California Department of Water Resources and the Bureau of Reclamation, and has been used to evaluate flow in the Delta for over 20 years.

This report has been divided into six sections, 1. Introduction, 2. Delta Background, 3. Delta Water Availability, 4. Water Quality, 5. Summary, and 6. Bibliography. Appendices containing detailed information from the analysis are provided at the end of the report.

2 Delta Background

2.1 Introduction

The California Delta lies at the junction of the Sacramento and San Joaquin Rivers, within the Great Valley of California. The jurisdictional area of the Delta covers approximately 1,150 square miles. The San Joaquin and Sacramento rivers drain a significant portion of the central valley, discharging through the Delta to San Francisco Bay. The drainage areas of the Sacramento and San Joaquin River basins are roughly 27,000 and 32,000 square miles respectively. The ecological, agricultural, and water supply benefits from these two river systems and their shared delta are a major component of California's economy. In addition to the Sacramento and San Joaquin rivers, the Calaveras, Mokelumne and Cosumnes rivers drain to the Delta from the east. Water flowing through the Delta consists of approximately 50 percent of California's runoff.

The Delta as we know it, started forming approximately 18,000 years ago. Through a combination of rising sea level, uplift of the coastal range, and sediment deposition, the central valley gradually filled in, creating the extensive delta and its network of interconnected channels that we see today.

2.2 Geology

The Sacramento-San Joaquin River Delta is one of the few tectonically controlled inverted deltas in the world. A typical delta has a wide depositional fan region extending outward from the mouth of the river into a body of water. An inverted delta forms where the delta is confined to a semi-enclosed valley floor.

The Delta today is contained within the Central Valley, which millions of years ago was an inland sea. Rising and falling sea levels through successive glacial events left layers of marine deposits overlying the bedrock foundation of the valley. Approximately 18,000 years ago, the sea level was roughly 390 feet lower than it is today, Figure 2-1. At that time, the Sacramento and San Joaquin Rivers flowed freely to the Pacific Ocean. Figure 2-2 is a map showing a likely scenario of the river system prior to the formation of the Delta (Rogers 2011). The river outlet to the Pacific Ocean is roughly where the Farallon Islands are today. Over time the sea level gradually rose along with a seismic uplifting of the coastal range. The rising sea level resulted in the natural delta of the combined rivers being pushed further and further inland. The shifting and rising coastal range gradually confined the delta to the central valley. During this time, discharge from the river system continuously eroded a channel through the rising coastal range resulting in the Carquinez straights. This channel allowed runoff from the central valley to discharge into the ocean, and also ensured that tidal water continued to flow into and out of the delta with each tidal cycle.

Figure 2-3 shows the configuration of the Delta approximately 2000 years ago. At that time, the sea level was approximately what it is today. The light blue areas show the areas of wetland. The darker blue areas show the open water areas. Under the present day condition, most of the wetlands have been reclaimed and the primary water features are open water channels. This configuration can be seen in Figure 2-4.

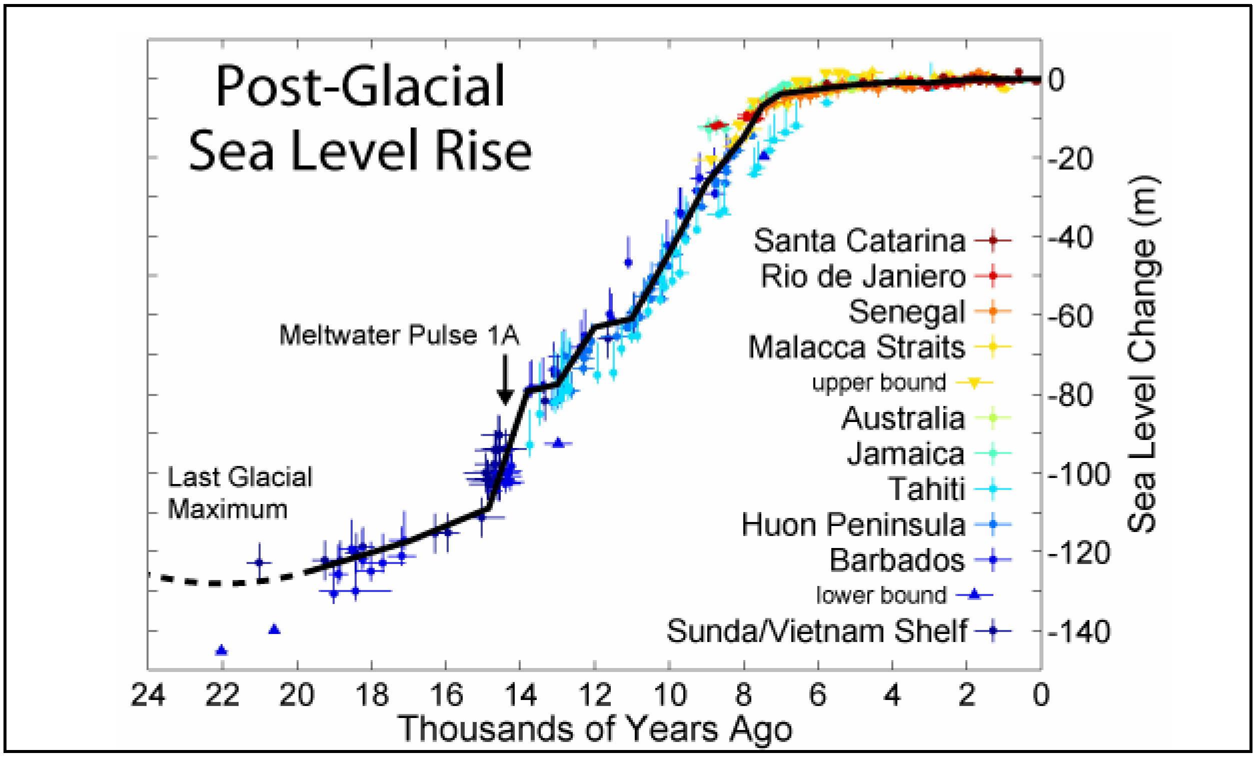

Figure 2-1 Sea Level Change Since The Last Glacial Maximum, (Rogers 2011)

Figure 2-2 Reconstruction of the Sacramento and San Joaquin Rivers Alignment 18Ka, (From Rogers 2011)

Figure 2-3 Delta Formation, 2000 Years Ago. (Rogers 2011)

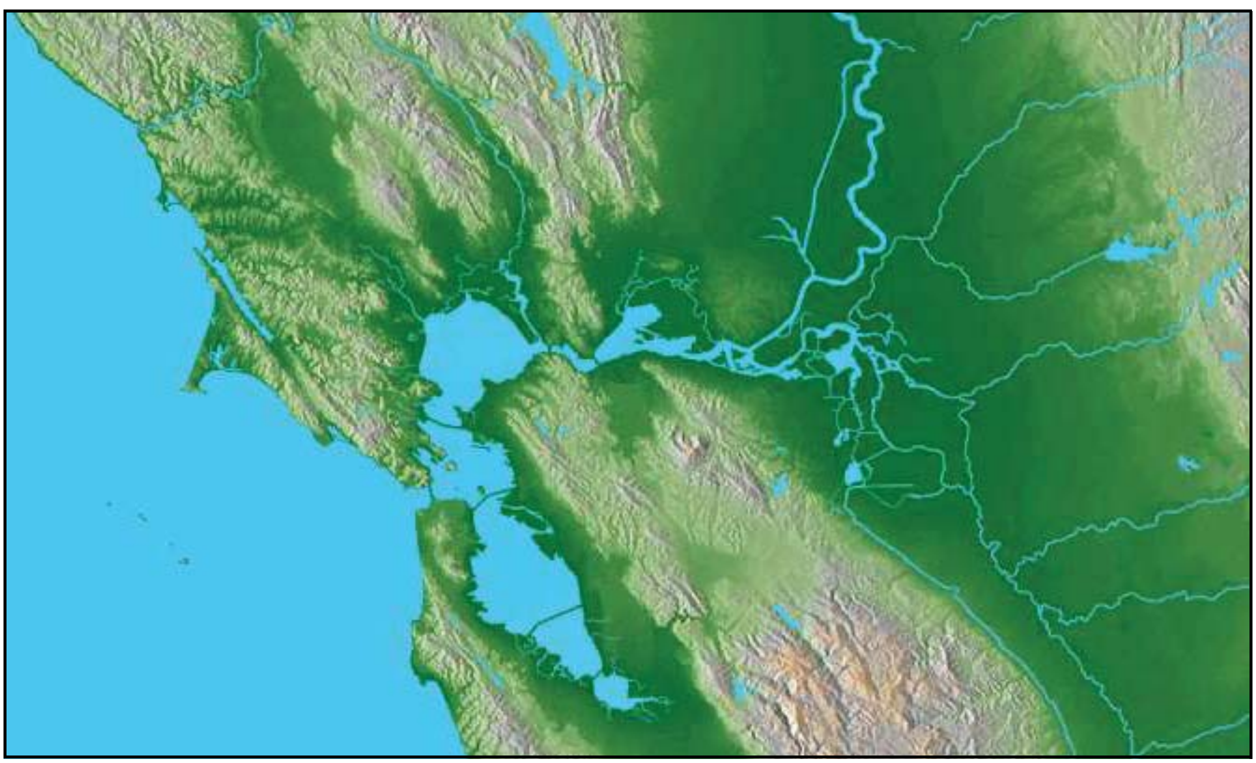

Figure 2-4 Delta Formation, Present Day. (Rogers 2011)

The confinement of the Delta to the central valley has resulted in numerous layers of sediment that have accumulated in the once deep valley. Prior to the uplift of the coastal range marine sediments were also accumulating over the valley floor. In some areas the alluvial deposits that have washed out of the surrounding mountains are several thousand feet deep. Successive periods of vegetative growth have resulted in an interbedding of peat and clay soils between the alluvial deposits, making the valley floor a very heterogeneous mix of sand, grave, clay and peat layers. The peat is primarily found within the lower, most downstream areas of the Delta. Those lenses that are dominated by sand and gravel layers can be very pervious, collecting groundwater inflow from the surrounding mountain ranges and conveying it through the valley to the Delta. Figure 2-5 is a graphic showing the general configuration of the various geologic strata on the valley floor.

The uppermost layers of alluvial deposits overlie a clay layer referred to as the Corcoran Clay layer. Above this layer groundwater can move into and out of the Delta depending on the local groundwater conditions. Figure 2-6 is a schematic developed by the USGS showing the water bearing layers in a typical valley cross-section (USGS 2009). In the USGS report Groundwater Availability of the Central Valley Aquifer, California (USGS 2009) they estimate that between 1962 and 2003 on an average water year, there was roughly 2.4 million acre feet of water moving from the groundwater into central valley streams flowing to the Delta.

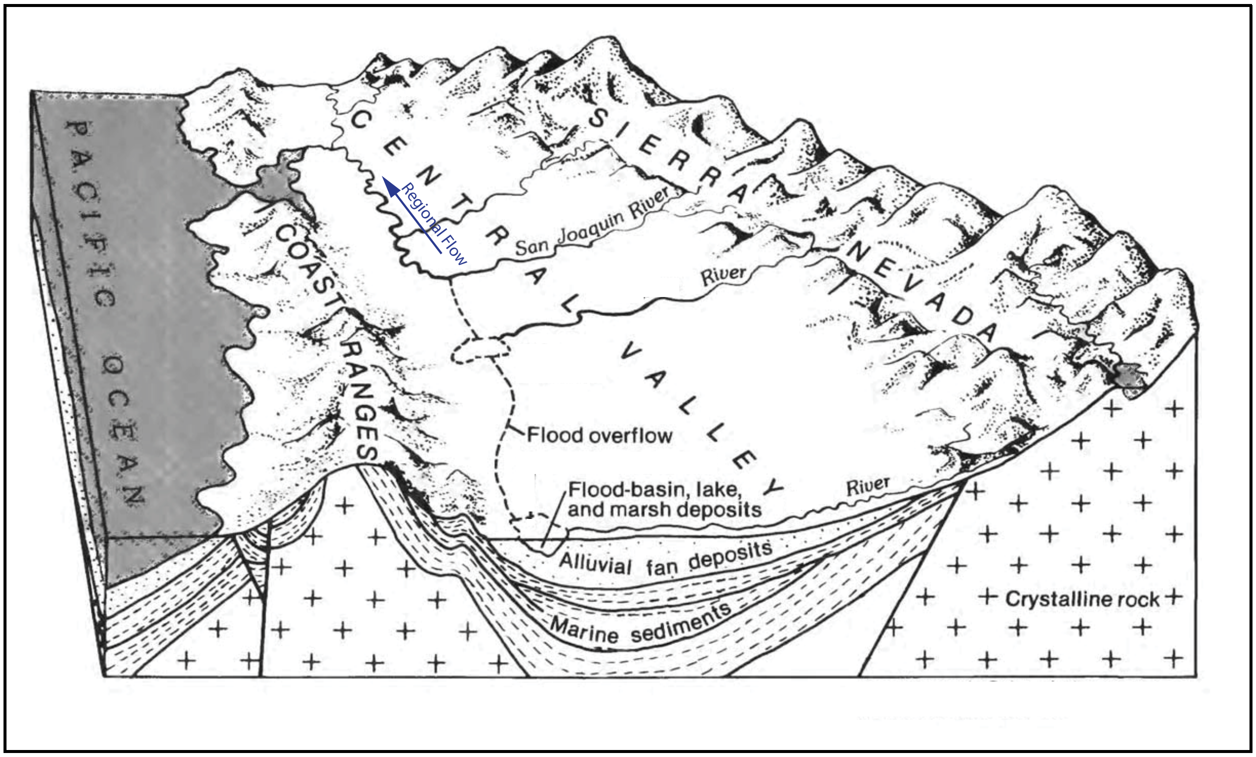

Figure 2-5 Geologic Cross-Section Through The Central Valley. (USGS 1986)

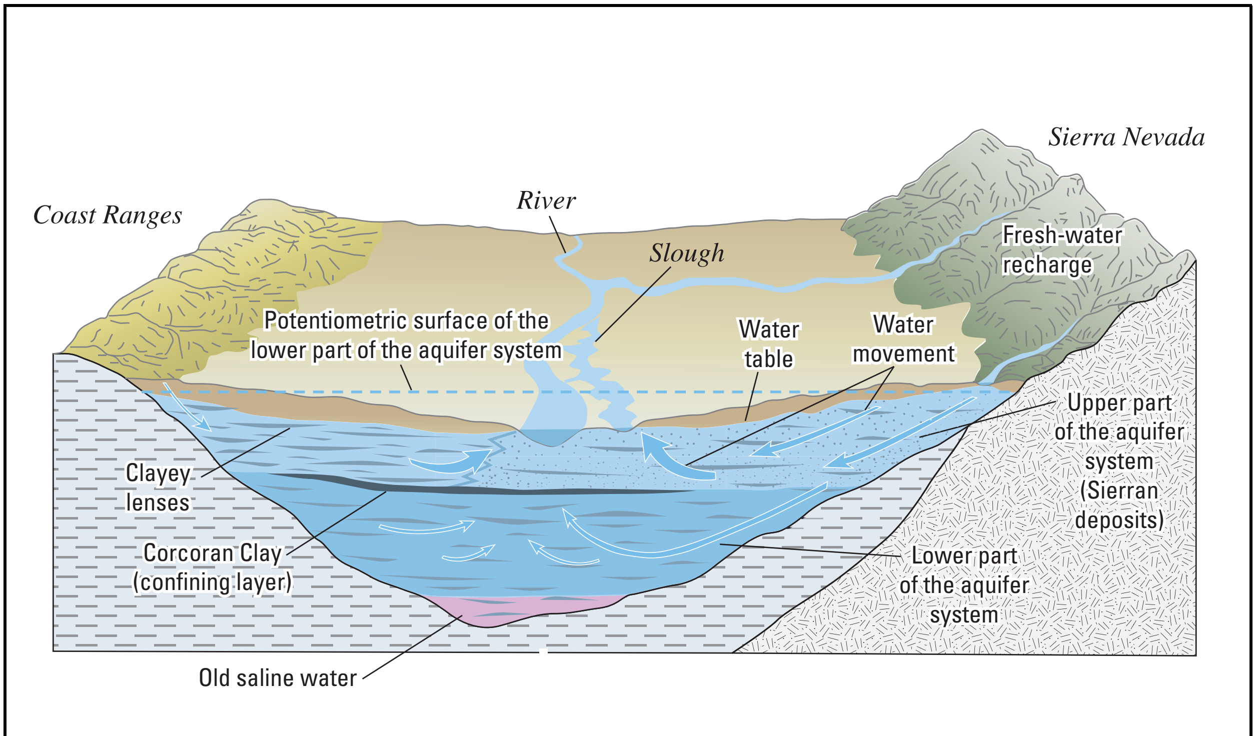

Figure 2-6 Cross-Section Showing Typical Groundwater Configuration. (USGS 2009)

2.3 Hydrology

Runoff to the Delta is driven by precipitation over the drainages contributing flow to the central valley. These drainages extend from the crest of the Sierra Mountains on the east side of the valley to the coastal range on the west. Precipitation over the central valley varies by elevation as well as north to south through the valley. The northern end of the valley receives between 51 and 125 inches per year. The southern end of the valley receives approximately 7 inches per year. Direct precipitation on the Delta is roughly 15 inches per year. Figure 2-7 is a precipitation isohyet map of the state showing the different zones of precipitation intensity (Conservation Biology Institute 2015). The runoff from the streams discharging to the Delta have been significantly altered by the construction of numerous dams and reservoirs.

Water flowing into the Delta is primarily from the Sacramento and San Joaquin Rivers. The streams on the east side of the Delta, Cosumnes, Mokelumne, and Calaveras provide runoff into the Delta, but to a much lesser degree than the Sacramento and San Joaquin Rivers. The Sacramento river under existing conditions averages 20,500 cfs, with a recorded maximum of 650,000 cfs (Ellis 2010) and a minimum of 1,000 cfs (Buer 1988). The San Joaquin River averages approximately 5,800 cfs, with a maximum recorded flow of 325,000 cfs and a minimum of 30 cfs (Dep of Eng).

The development of the State and Federal Water Projects from 1943 through the 1970's resulted in the most significant flow changes in both river systems. The projects generally hold back and store water during the winter rainy season, and then release additional water during the summer months. This results in a reduction of freshwater flow through the Delta during the winter and spring months. Figures 2-8 and 2-9 show the difference in mean monthly discharge in each of the river system before and after the projects were implemented. The data used in this comparison were taken from the California Department of Water Resources (DWR) Dayflow Database.

An average annual water budget for the surface water components flowing into and out of the Delta was developed by Ingebritsen (USGS 2000). His analysis showed approximately 76 percent of the inflow from the Sacramento River and 15 percent from the San Joaquin River. For outflows form the Delta, he computed 78 percent flowing to west past Martinez, 6 percent consumptive use within the Delta, and 19 percent were Delta exports. Figure 2-10 is a graphical depiction of the water budget components.

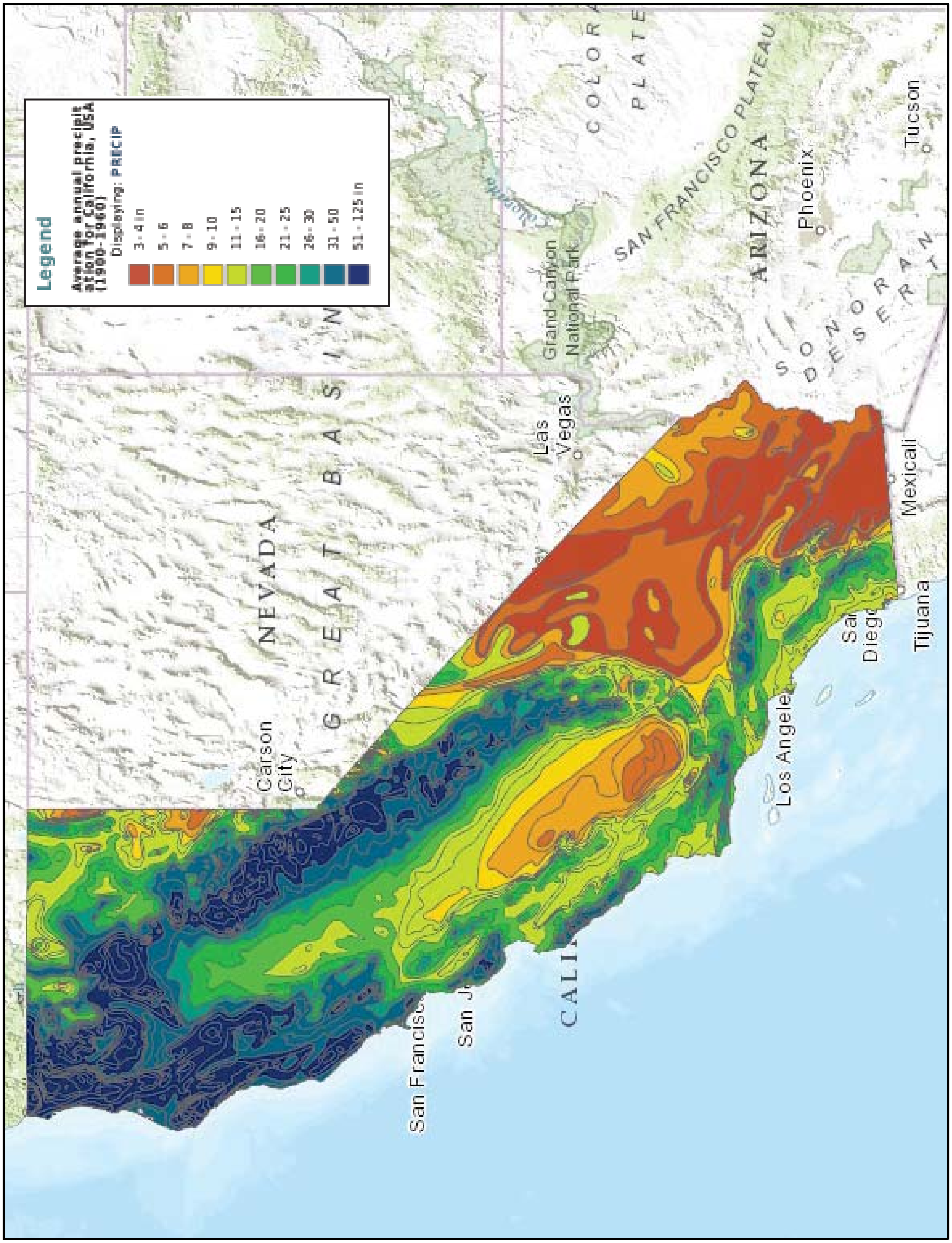

Figure 2-7 California Mean Annual Precipitation Isohyet Map. (Conservation Biology Institute)

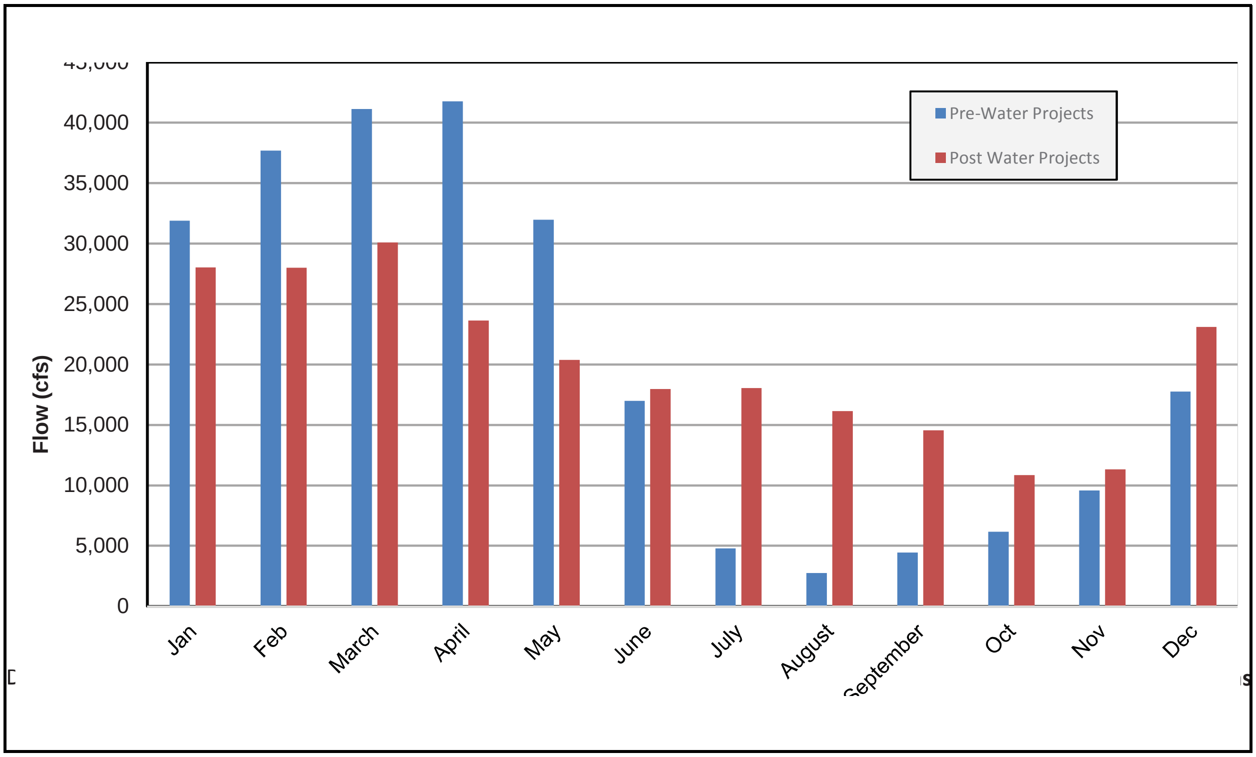

Figure 2-8 Sacramento River Pre-, and Post-Water Project Mean Monthly Flow

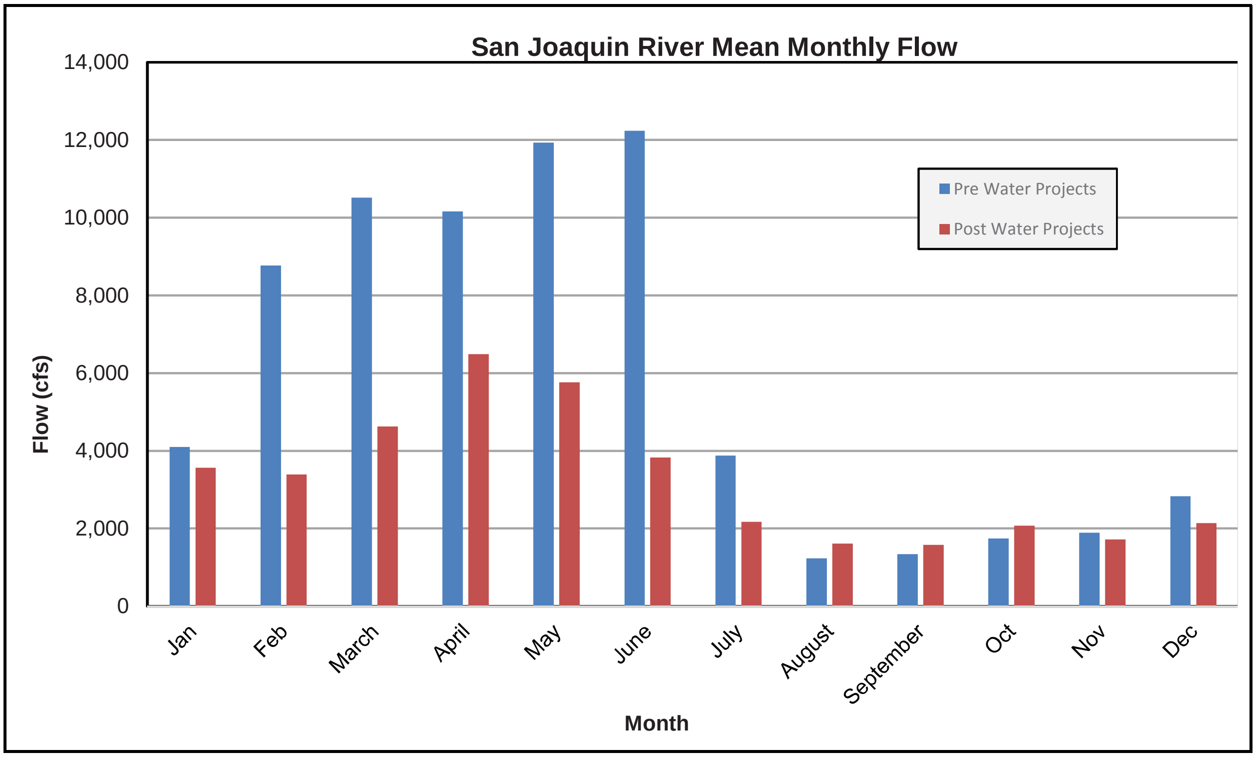

Figure 2-9 San Joaquin River Pre-, and Post-Water Project Mean Monthly Flow

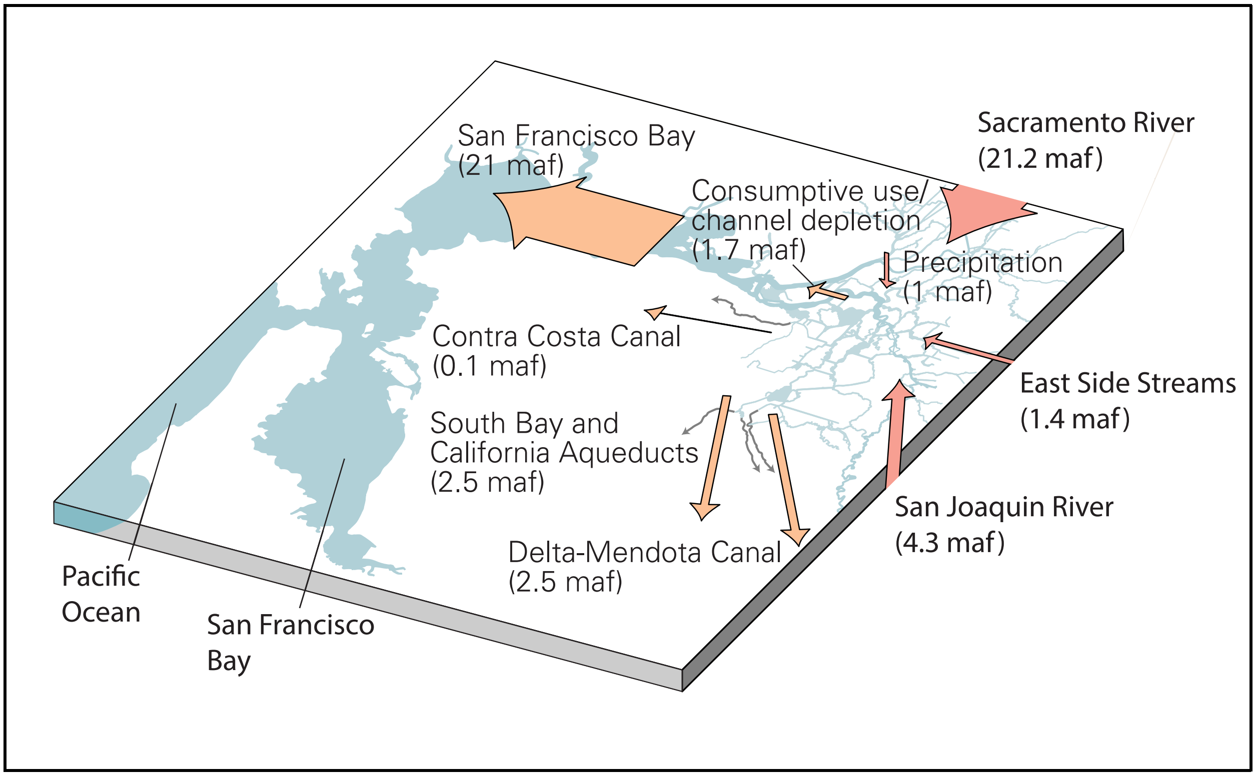

Figure 2-10 Delta Water Budget. (From USGS 2000)

2.4 Hydraulics

Flow within the Delta generally moves from an east to west direction. This is especially true during the fall and spring periods, when runoff from the tributary rivers draining to the Delta is high. This winter and spring runoff drives water through the Delta and into San Pablo Ba and San Francisco Bay. This overall direction is primarily driven by inflow to the Delta from the Sacramento and San Joaquin Rivers, as well as other smaller rivers and creeks draining to the Delta. As the summer progresses and tributary inflow decreases, the tidal inflow and outflow from the Delta becomes more pronounced.

The interconnected network of channels that make up the Delta are below sea level. This results in the tidal response extending throughout all of the Delta channels. During the summer there is an average of 170,000 ac-ft of water entering the Delta tidal flow at Martinez during each tidal cycle. This inflow is distributed throughout the channel network within the Delta resulting in a minimum water level that is maintained in both wet and dry years.

The natural ebb and flow of the Delta is complicated by modifications to the system imposed by the State and Federal Water Projects. These projects store winter runoff and spring snow melt for release later in the year when natural flows have decreased. Much of this release is conveyed through the Delta from the Sacramento River at the northern end of the Delta to Banks and Jones export pumps located at the southern end of the Delta. These pumping plants can pump thousands of cfs for deliveries to users south of the Delta.

The mean tidal range at the downstream end of the Delta as recorded at the Martinez is approximately 6 feet. This results in tidal flow from the west of Martinez entering and leaving the Delta with each diurnal tide.

Within the Delta there are irrigation withdrawals and drainage return flow, municipal water supply withdrawals, and as described above, exports to users outside the Delta. This creates a complex flow pattern that is developed within the network of channels that comprise the system.

The DSM2 model, developed by the California Department of Water Resources (DWR 2013) is a hydrodynamic and water quality model that was developed to evaluate flow conditions within the delta. It is an one-dimensional unsteady flow model that can evaluate flow and water quality transport throughout the Delta over multiple year time frames. Figure 2-12 shows the extent of the Delta Channels that are contained within the model network.

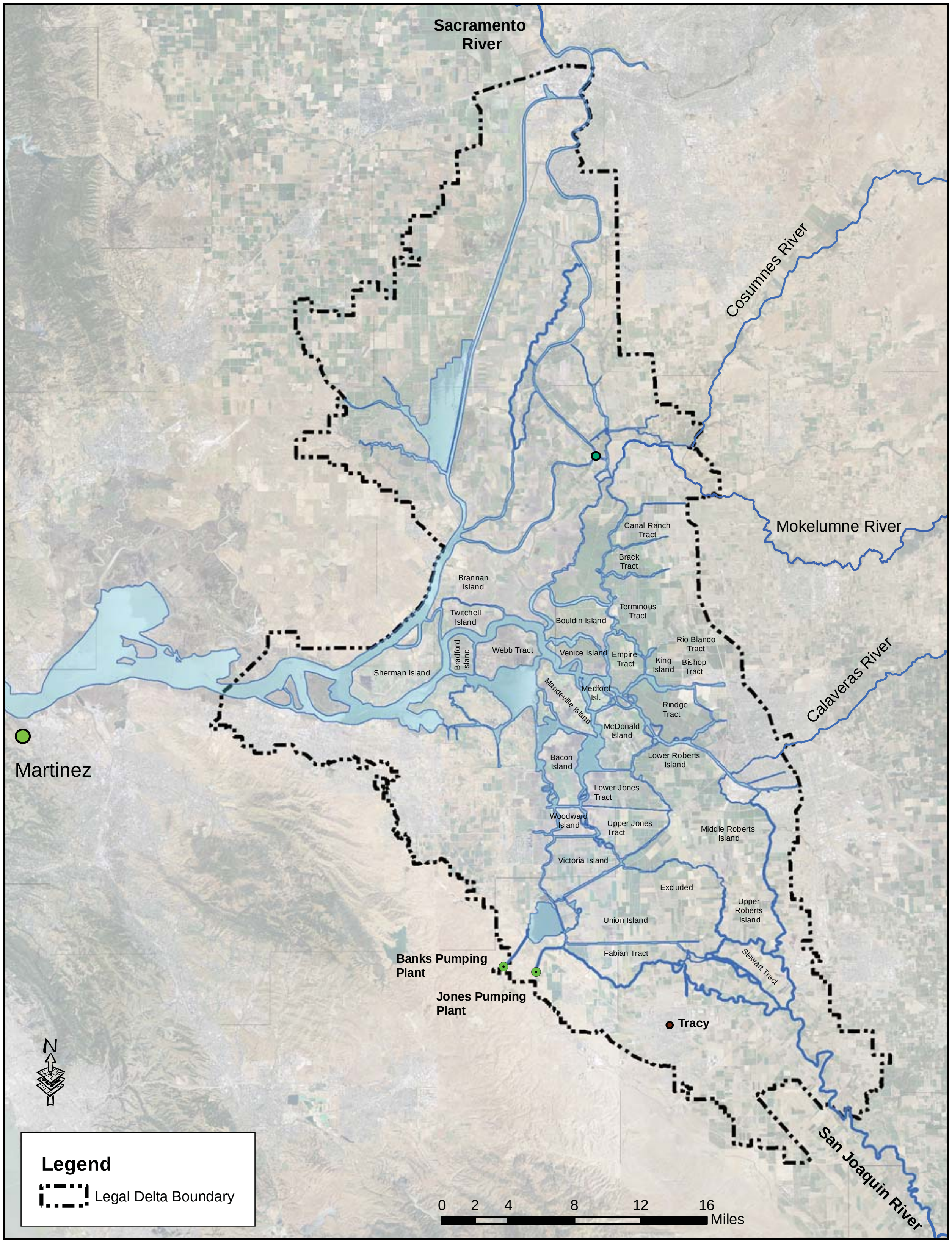

Figure 2-11 Delta Channel Map

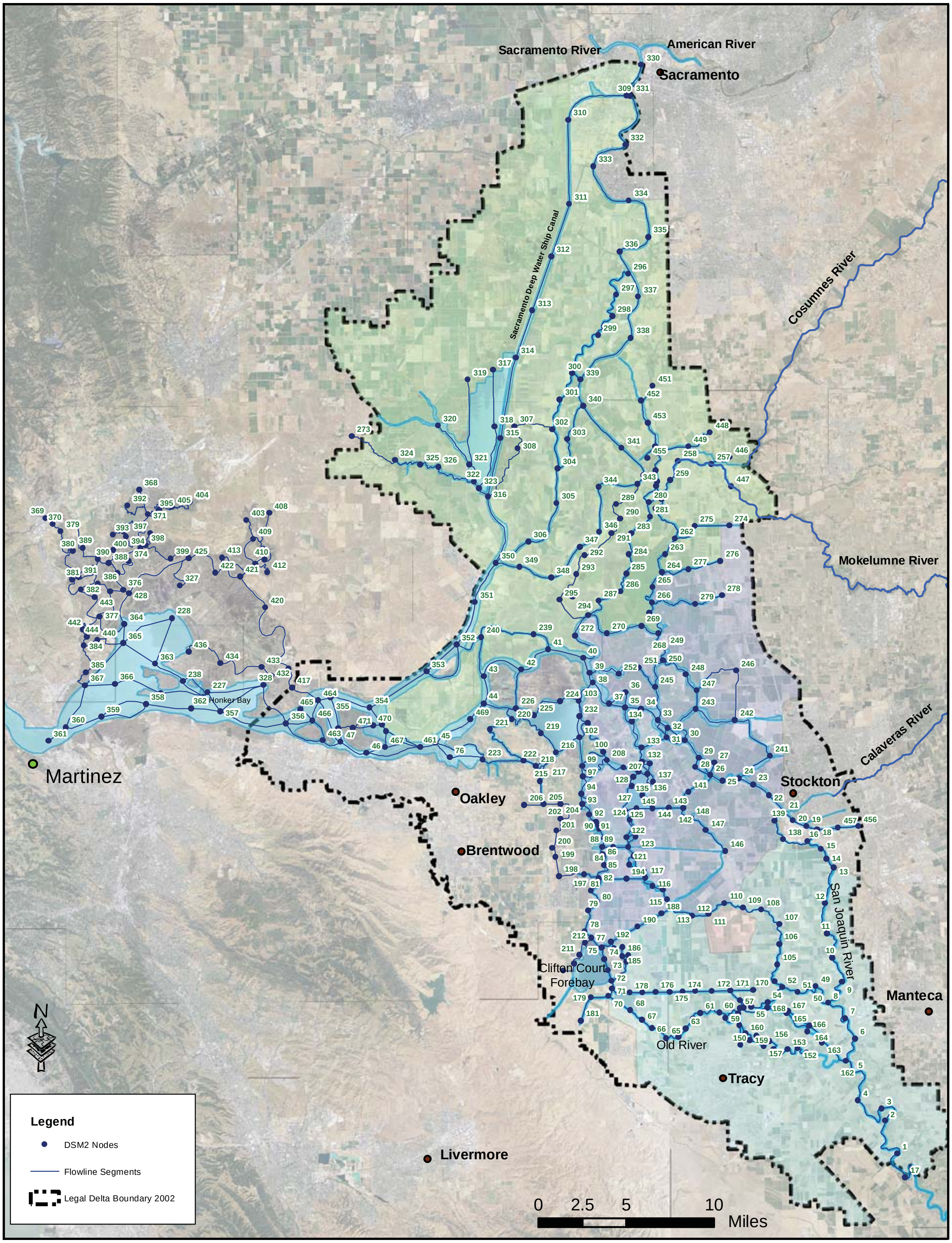

Figure 2-12 DSM2 Hydrodynamic Model Flow Network Map.

2.5 Water Quality

Water quality within the Delta is primarily driven by the water quality of the inflow to the Delta from tributary rivers, and tidal inflow from San Pablo Bay. During the later portion of the summer period, an increase in tidal inflow and drainage from water-users upstream on the San Joaquin River have a significant effect on Southern Delta water quality.

There are several water quality issues within the Delta, but the primary water quality constituent of concern is salinity. Elevated salinity levels can impact the beneficial use of water for municipal use as well as irrigation. Typically salinity levels are at their lowest during the winter rainy season, when freshwater inflow to the Delta dilutes the salinity in the existing Delta channels. As the summer progresses, reduced inflow to the Delta and an increase in irrigation return from tributaries tends to increase salinity in the Delta. Historically the salt loading Figures 2-14 and 2-15 are plots of the salinity level in the San Joaquin River at Vernalis for 2014 and 2015.

From a mass balance perspective, given a fixed water volume that generally exists over the summer period, an increase in salinity must be from salt entering the Delta from outside sources. The salinity within the irrigation return flow, from in-Delta irrigators, is the salinity that was withdrawn from the Delta, when the irrigation diversion took place. Figure 2-13 is a salt mass balance schematic for the salt entering the Delta. The salinity of the Sacramento River and east side tributaries is minimal. The primary external loading is from the San Joaquin River. Figures 2-14 and 2-15 are plots of the salinity level in the San Joaquin River at Vernalis for 2014 and 2015.

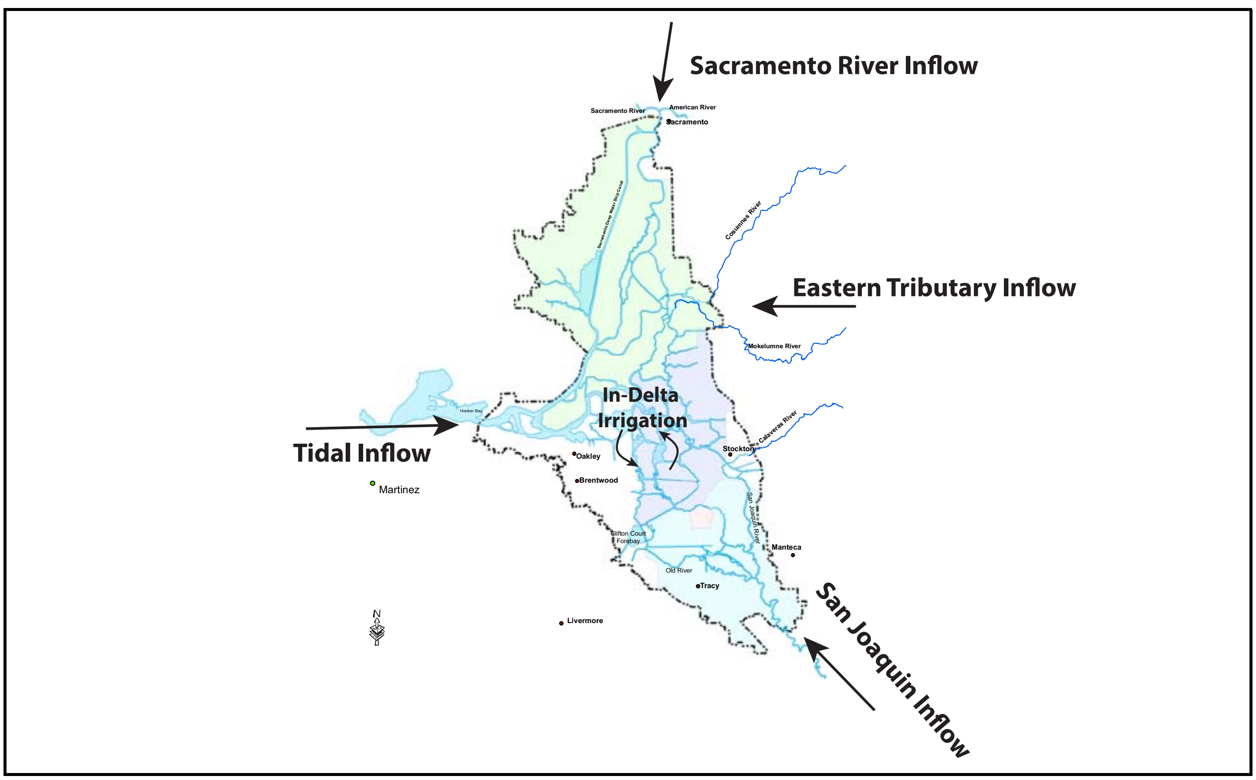

Figure 2-13 Delta Salinity Mass Balance Schematic

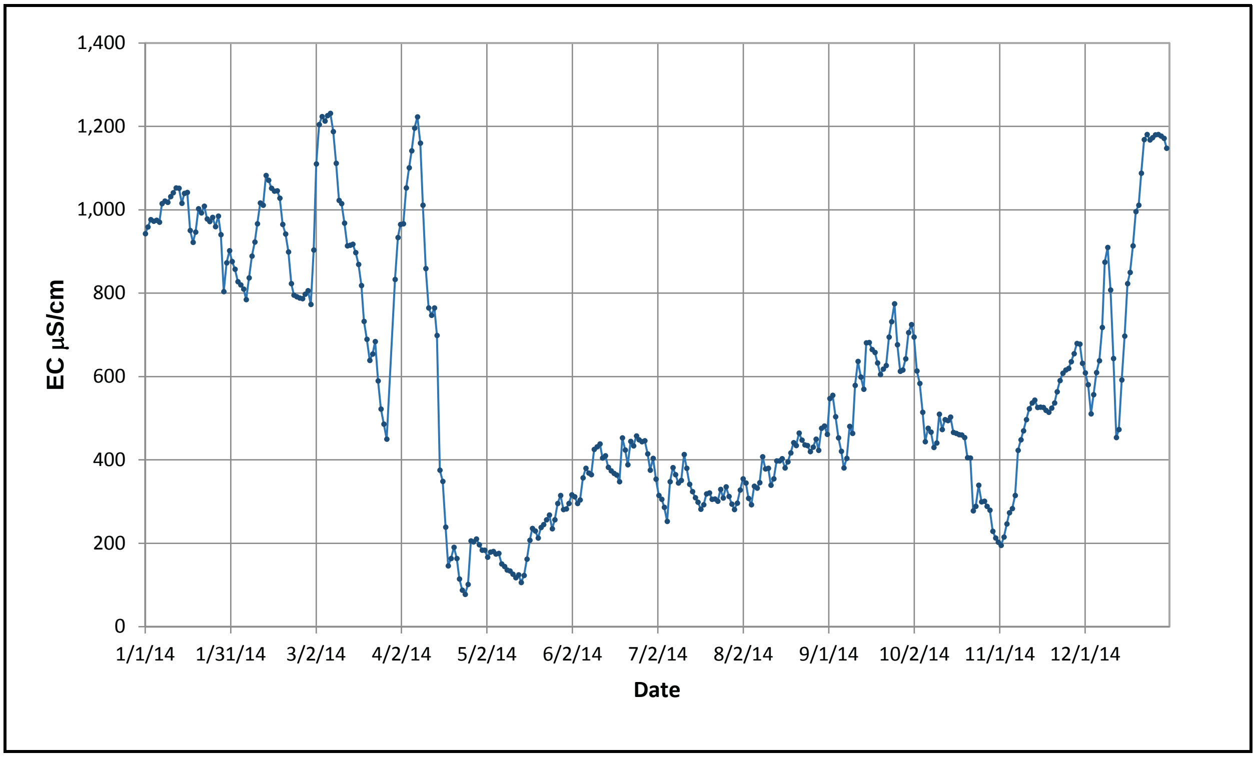

Figure 2-14 Vernalis Salinity Level, 2014

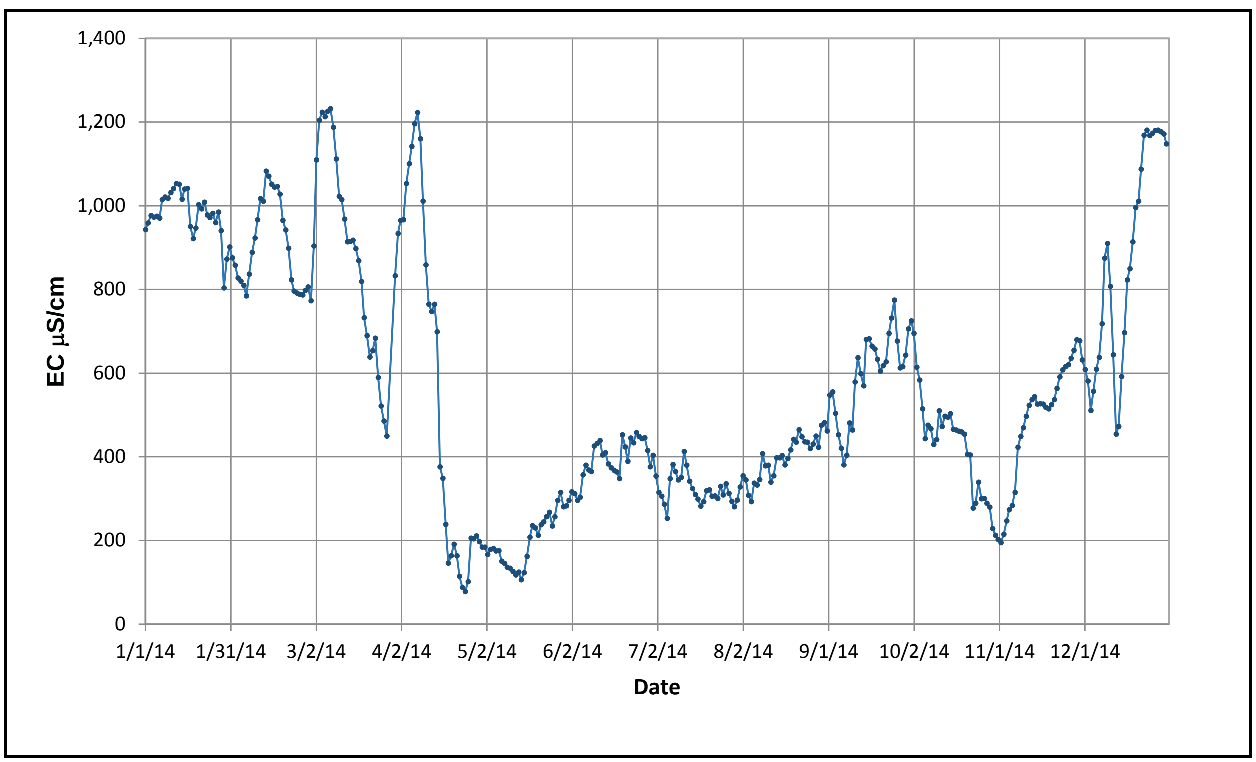

Figure 2-15 Vernalis Salinity Level, 2015

Salinity levels gradually rise over the late summer period. The California DWR evaluated the salinity conditions that existed in the 1930s and 1940s (DWR 1962). They looked at the timing and extent of the 1,000 ppm Chloride concentration incursion into the Delta. One Thousand ppm Chloride is equal to 4,360 µS/cm (4.3 mS/cm) using the low-flow relationship for EC vs Chloride that was developed from data collected at Bordon Highway Bridge. A plot of that relationship is shown in Figure 2-16.

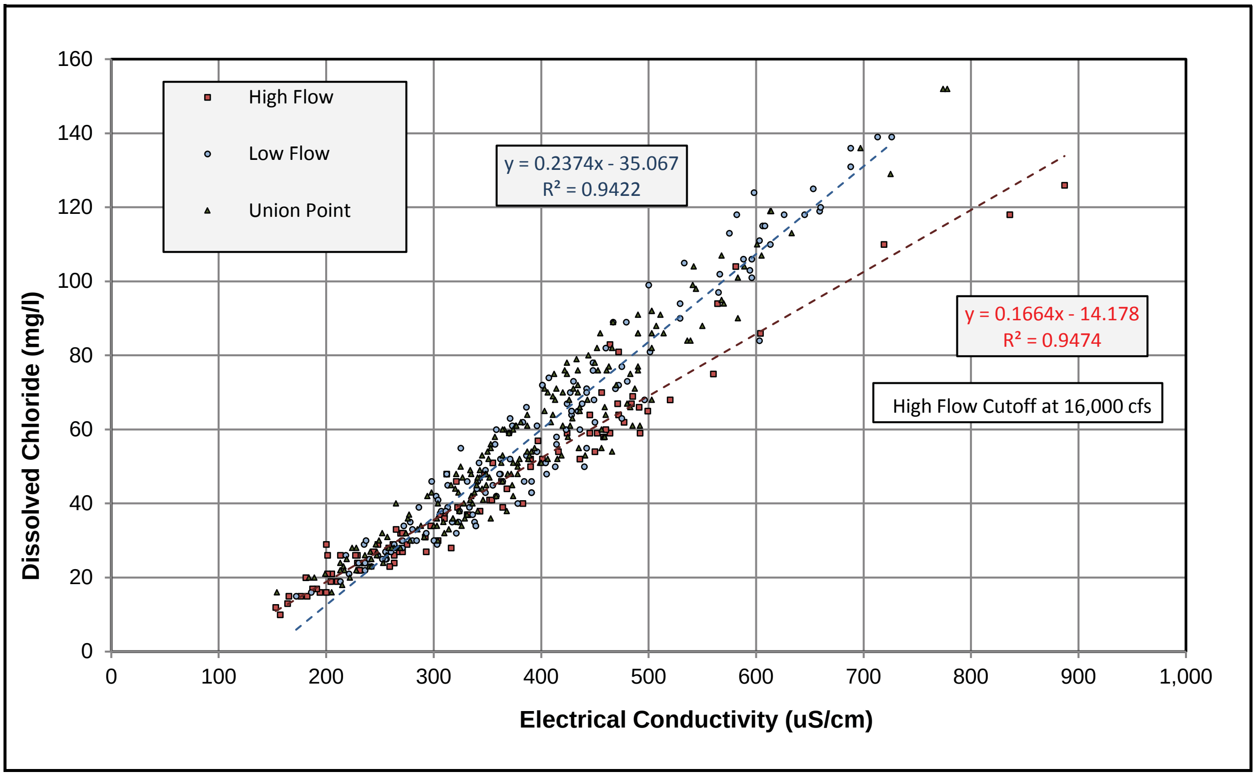

Figure 2-16 Electrical Conductivity vs Dissolved Chloride at Bordon Highway Bridge, Gage B9D75351293

A plot of the maximum extent of the 1,000 ppm Chloride concentration incursion into the Delta from data collected during the 1920's and 1930's is provided in Figure 2-17. As can be seen in the figure, the dates of the maximum salinity extent into the Delta for each year occur very late in the year, past the primary growing season.

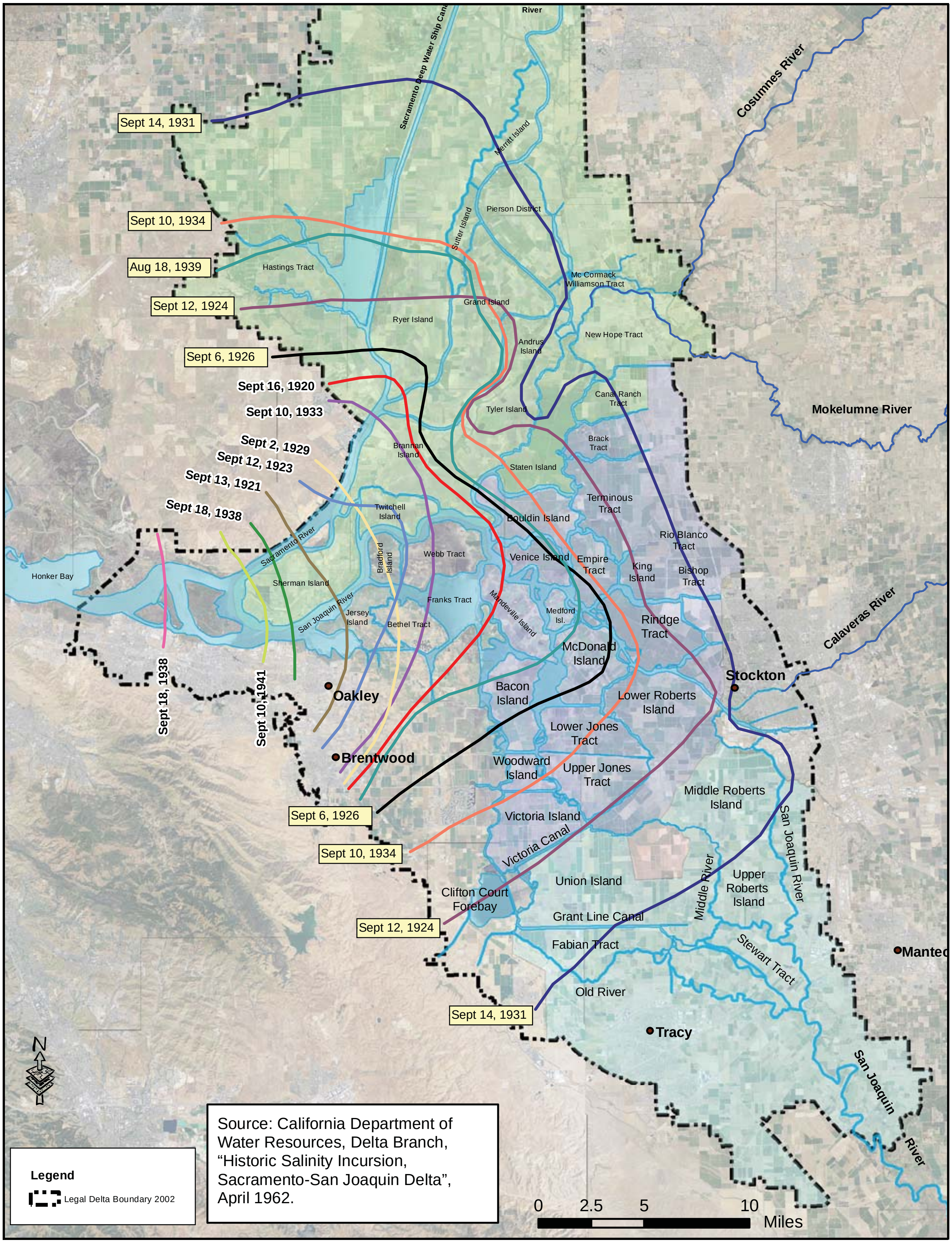

Figure 2-17 Historic Lines of Maximum Extent of the 1,000 ppm Chloride Concentration.

3 Water Availability

3.1 Introduction

The Delta is connected to San Pablo Bay and San Francisco Bay through the Carquinez Straights. San Francisco Bay is connected to the Pacific Ocean. This connection allows the ocean tide to push the water that is west of the Delta, into the Delta, during an incoming tide. The connection also allows water to drain out of the Delta during an outgoing tide. Consequently, the Delta is tidally influenced which results in a constant resupply of water to the Delta each day. The water entering the Delta from the west mixes with the water that is entering the Delta from the San Joaquin River, Sacramento River, and other smaller tributaries along the east side of the Delta.

3.2 Water Flow Conditions In The Delta

The city of Martinez lies along the Carquinez Straights at the outlet of the Delta, see Figure 3-2. The tidal range at Martinez is approximately 6 feet from mean higher high tide to mean lower low tide. The range can be seen graphically in Figure 3-1. The tide moving into the Delta essentially equates to a 6 foot slow moving wave entering the Delta each day. The area between the high and low tide lines is called the tidal prism. It defines the volume of water that is moved into and out of the Delta with each tidal cycle. The area below the tidal prism never drys out. In addition to the volume of water within the tidal prism, there is water in the channel below the tidal prism which is also flowing into and out the Delta with each tidal cycle. Over a typical tidal cycle during the summer months approximately 170,000 ac-ft of water moves into the Delta twice each day (DSM2 Model Run, May-July 2013).

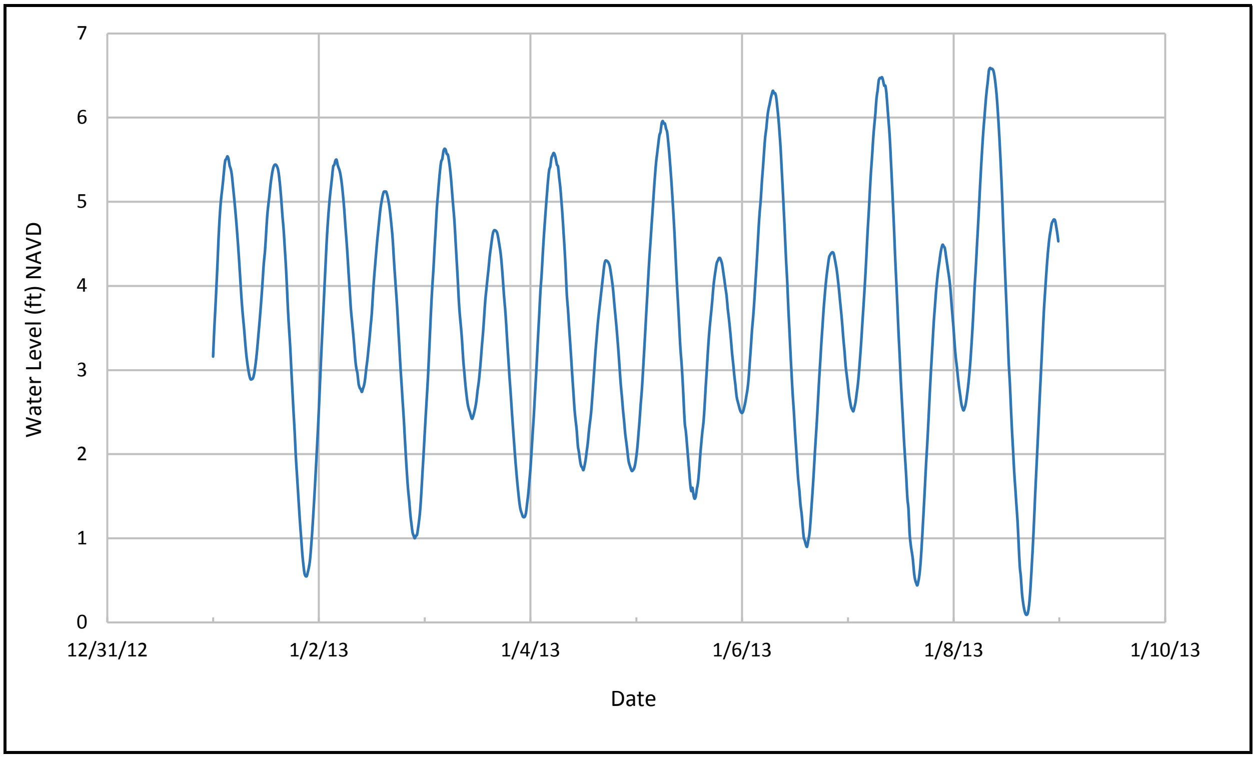

Figure 3-1 Representative Tidal Range at Martinez.

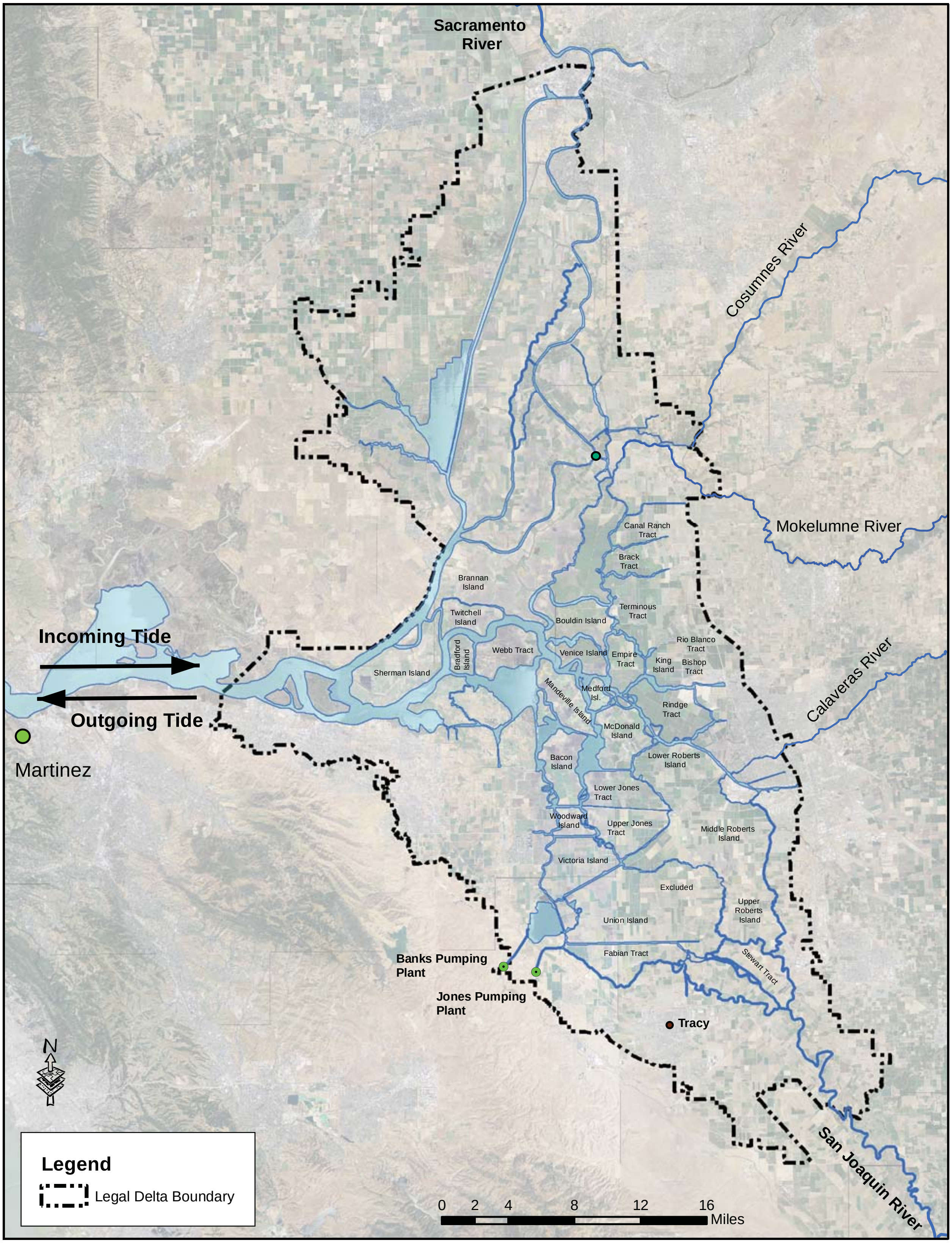

Figure 3-2 California Delta and Tidal Influence.

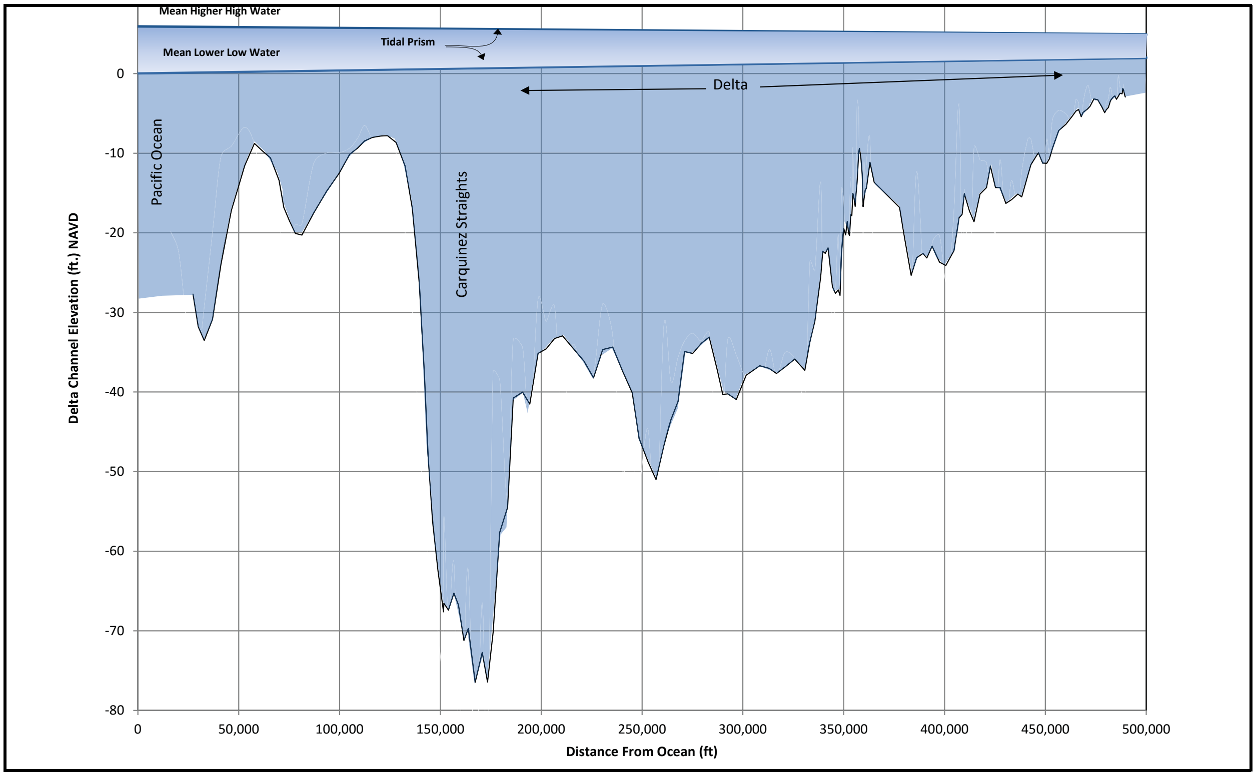

Figure 3-3 Profile Through The Delta.

There are two tidal cycles each day. Typically one cycle is higher than the other, as can be seen in Figure 3-1. As such, there are two high tides and two low tides. The highest of the two high tides is called the high high tide. The lower of the two high tides is called the low high tide. The low tides are named in a similar fashion. Figure 3-5 through 3-9 show cross-sections of typical Delta channels from Martinez, upstream to the city of Lathrop, which is close to the eastern boundary of the Delta. Moving downstream to upstream through the Delta, there is 1 cross-section at Martinez, 3 cross sections along the Old River, and 1 cross section at Mossdale Bridge on the San Joaquin River. Each of the channel cross-sections shows the area below the tidal prism, which is always full of water, and the range of the tidal prism for that location on the channel. As can be seen, at each location from the downstream most part of the Delta to the most upstream end of the Delta, the internal Delta channels always contain water and never go dry. Figure 3-4 shows the location of each of the cross-sections.

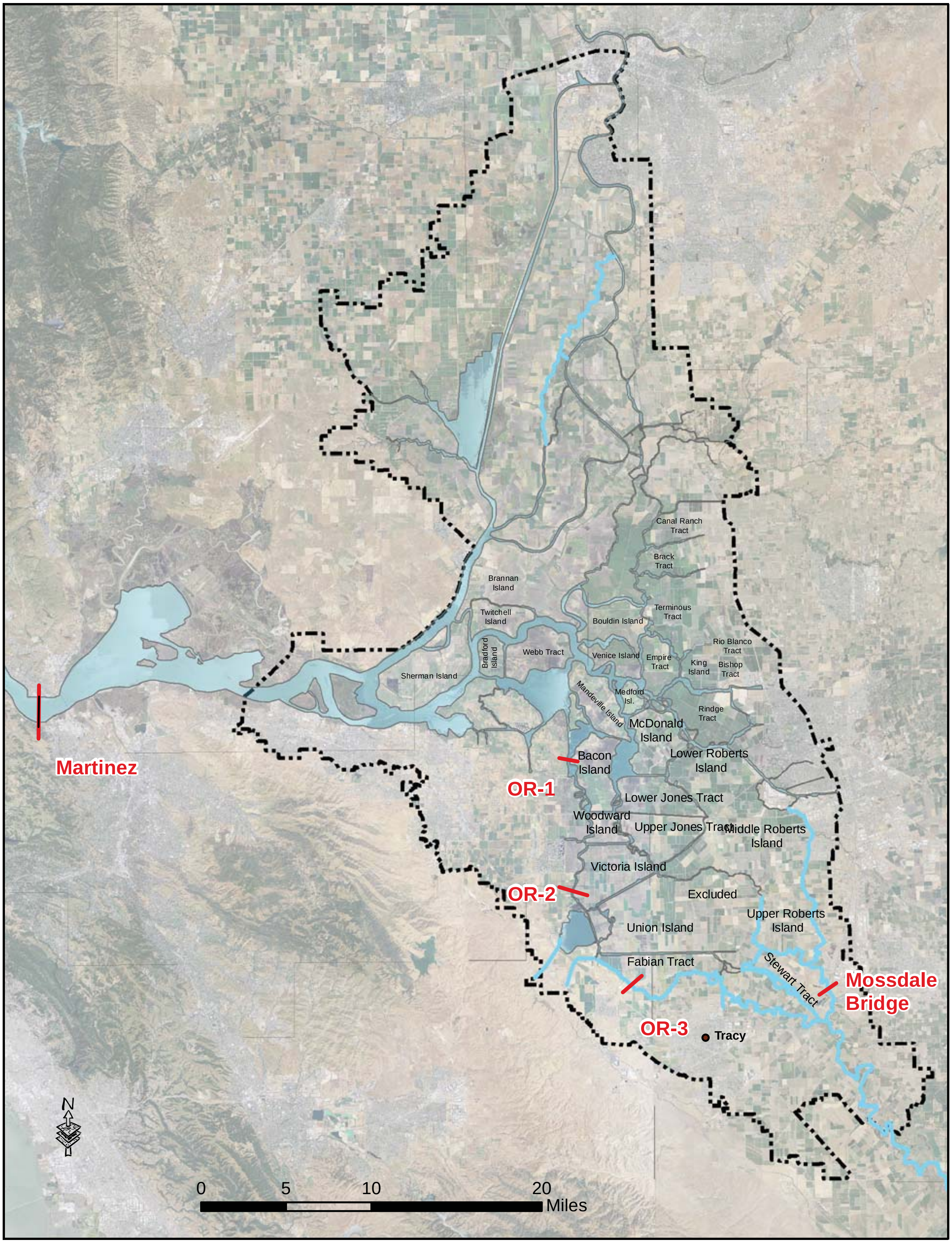

Figure 3-4 Cross-Section Location Map For Old River and San Joaquin River Cross-Sections.

The Delta channels do not act like a typical stream channels. Although it may appear counter-intuitive to some, water does not flow downhill. However, a basic law of physics is that water flows from a high-head location to a low-head location. In a typical stream, the slope of the stream is the dominant factor that creates a high head to low head direction. In that typical stream, once water passes by a specified point, it is hard to get water to flow in the opposite direction (uphill!). But in a flat channel with little to no slope, the high-head to low head condition can be created by pumping water out of the channel. If water is pumped from one end of the channel, you slightly lower the water surface at that location (create a low-head condition) and, water will flow towards that direction. If water is pumped from the other end of the channel, water will flow in that direction. In the Delta, there is a network of interconnected relatively flat channels. The complete network of channels will respond by moving directly toward the direction where a withdrawal has occurred. Given the numerous withdrawals in the Delta, and the effect of the tides, water is always moving back and forth in the channels but the elevations of the water in the channels experiences very little change.

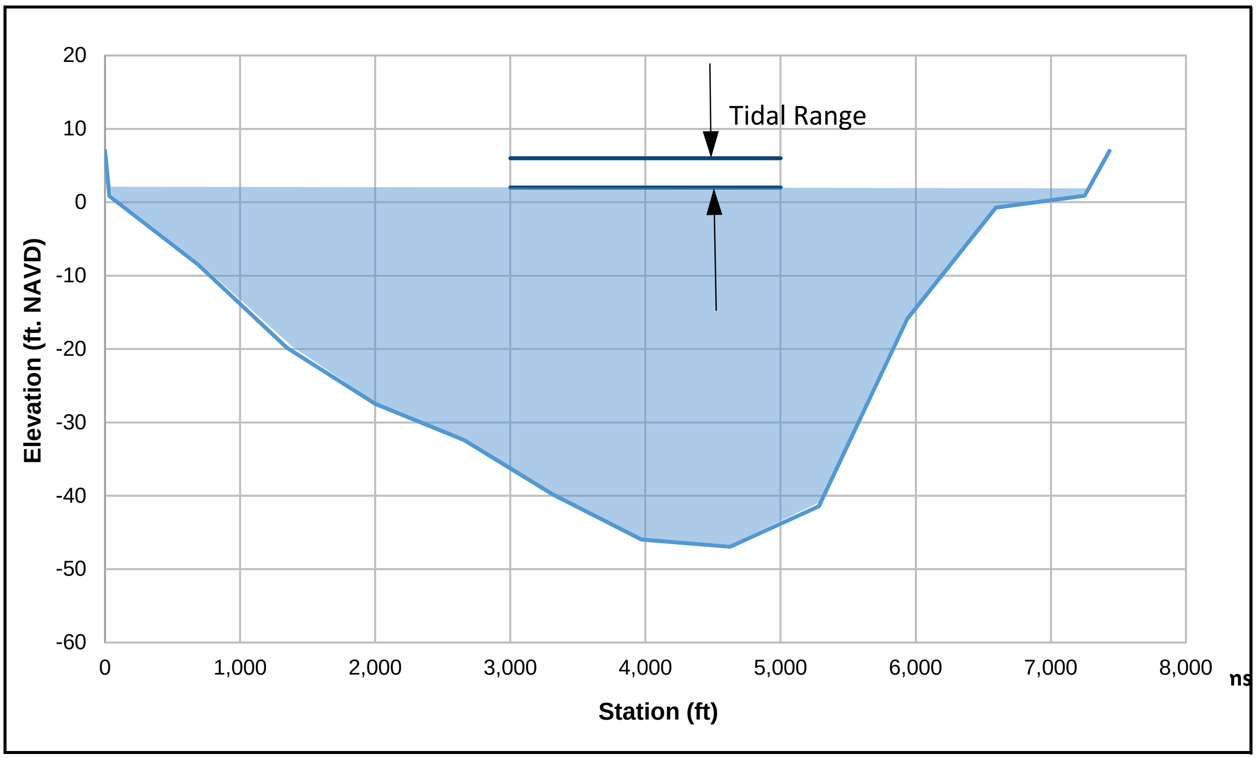

Figure 3-5 Channel Cross-Section at Martinez.

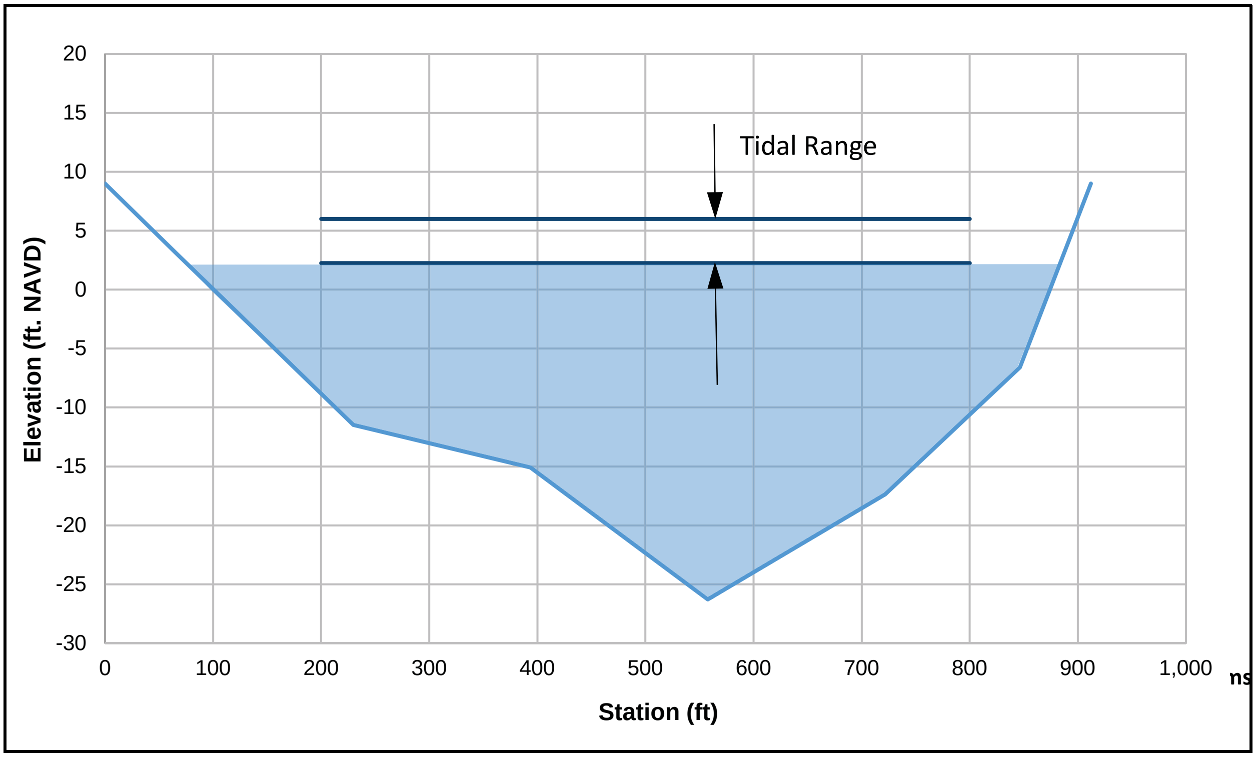

Figure 3-6 Old River Cross-Section, OR-1.

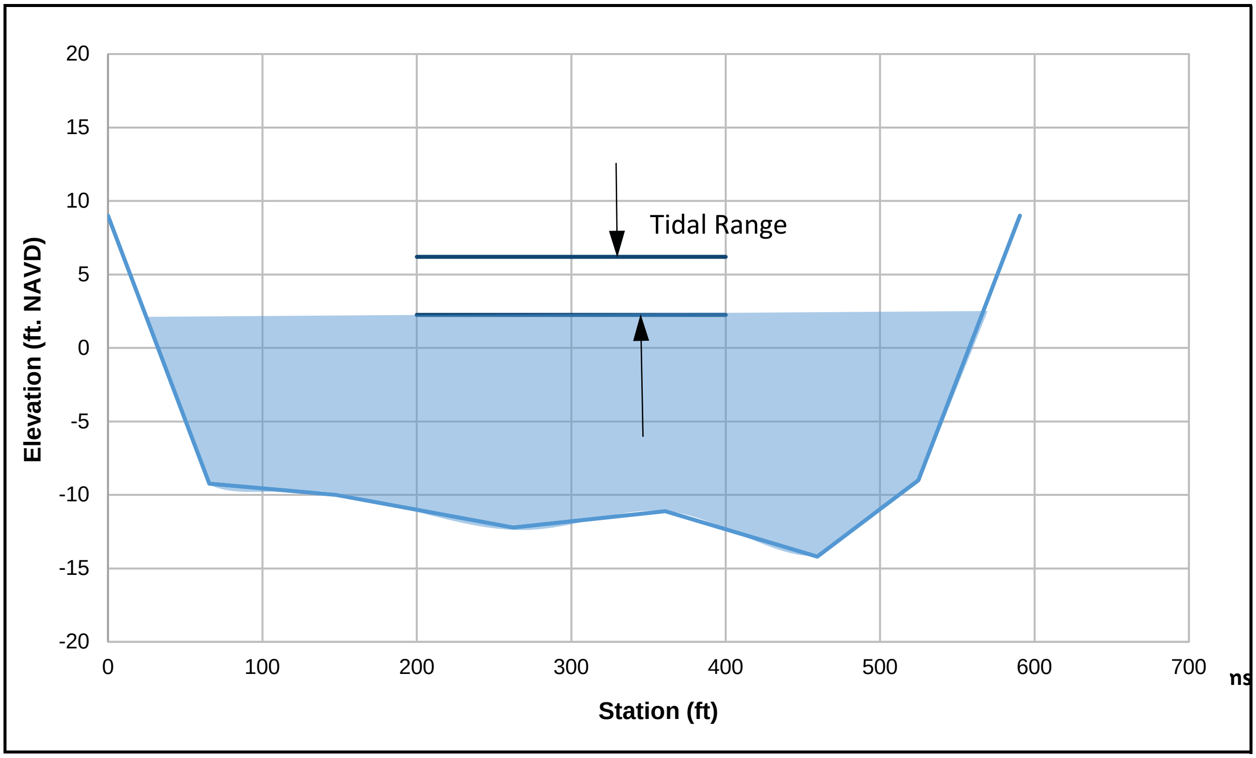

Figure 3-7 Old River Cross-Section, OR-2.

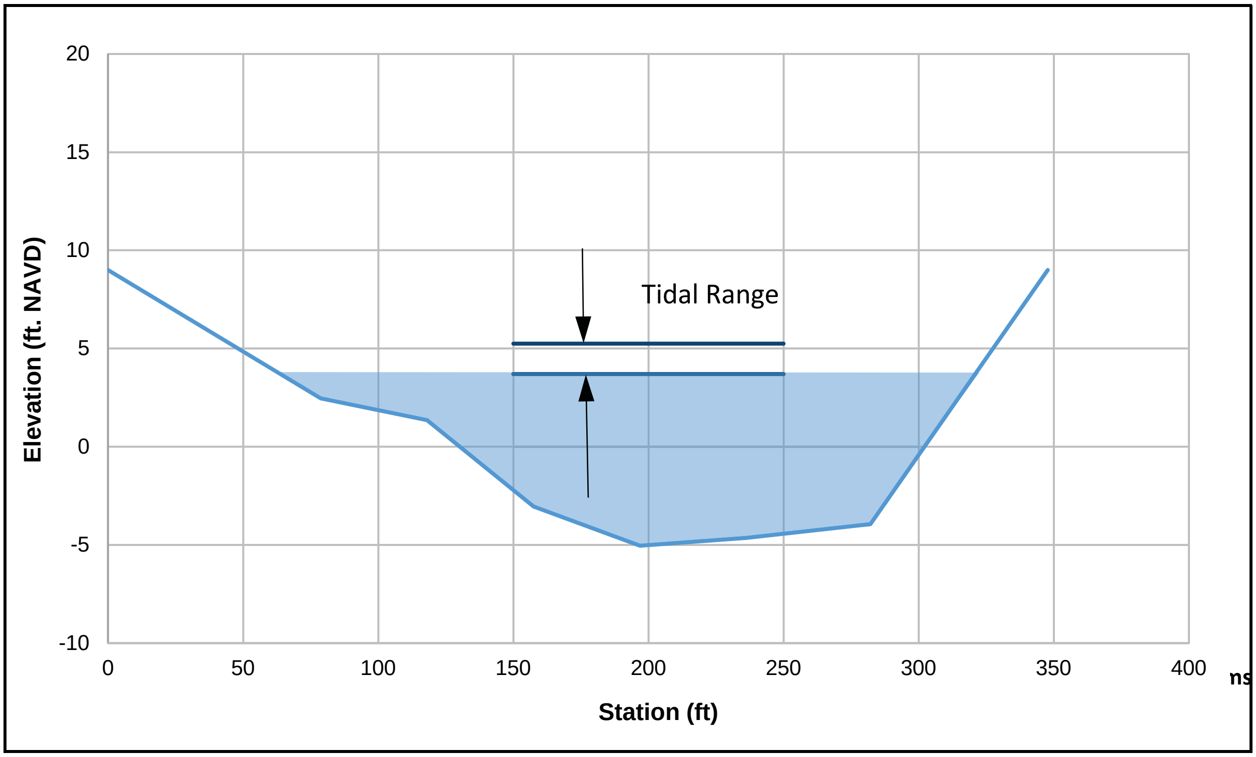

Figure 3-8 Old River Cross-Section, OR-3.

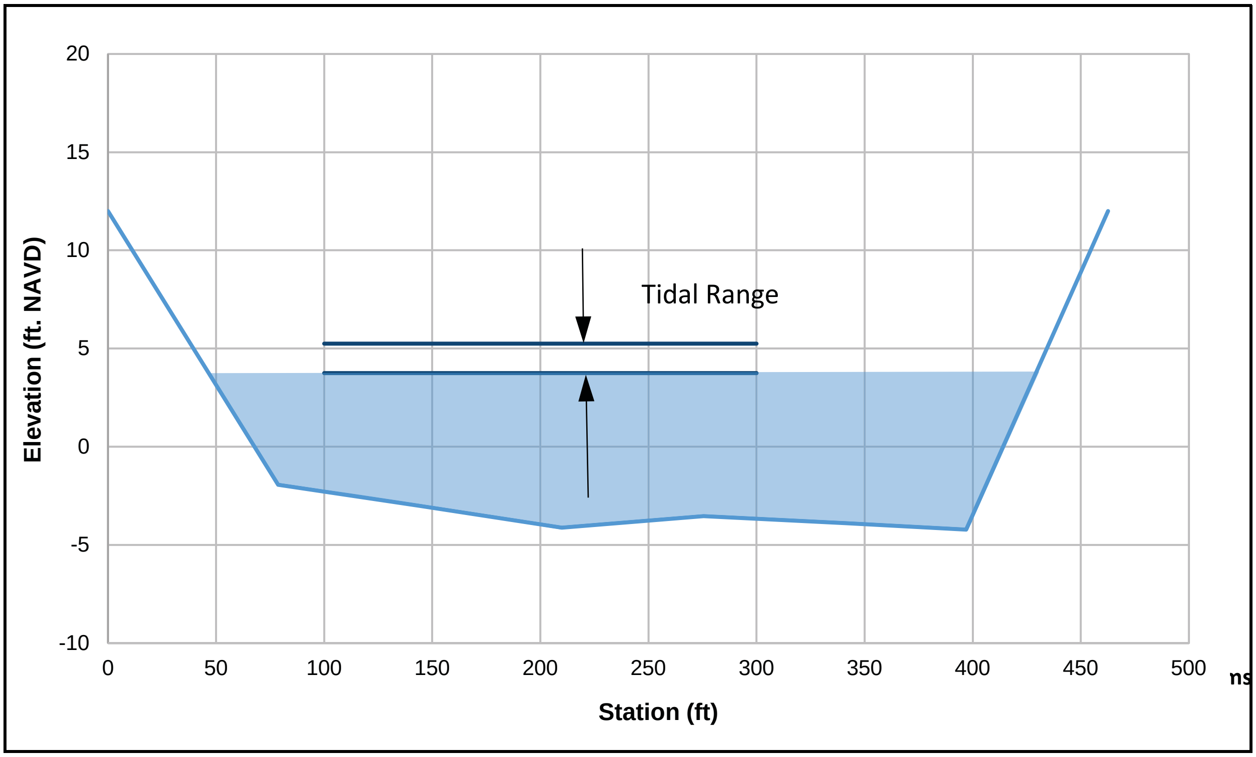

Figure 3-9 San Joaquin River Cross-Section, Mossdale Bridge.

Since the Delta is connected to San Pablo Bay, just as the internal Delta channels can respond to pumping, if enough pumping were to occur to lower the water level in the Delta, water would flow into the Delta from the west to fill in the low head condition. The tidal cycle augments this process, insuring that the Delta channels will be refilled approximately every 6 hours.

Given the constant refilling of the Delta by tidal inflow, and the ability for the integrated network of Delta channels to respond as a unified system, an extraordinary event would need to occur in order for any of the channels to dry out. During the drought of 2014 and 2015 there was virtually no change in the water level at the BBID and WSID points of diversion as compared to the summer water level during wet years. Figure 3-10 is a plot of the water level at the Old River at Tracy river gage. As can be seen in the figure the August river stage is very consistent between wet and dry years. The high water level will change between wet and dry years, but there is a minimum level that is always maintained due to the fact that the channels are below sea level and supplied by tidal inflow, regardless of what the tributary inflow to the Delta may be.

Therefore, I conclude that there was water available at the WSID and BBID points of diversion during the subject time frames relative to the draft CDO and ACL Complaint.

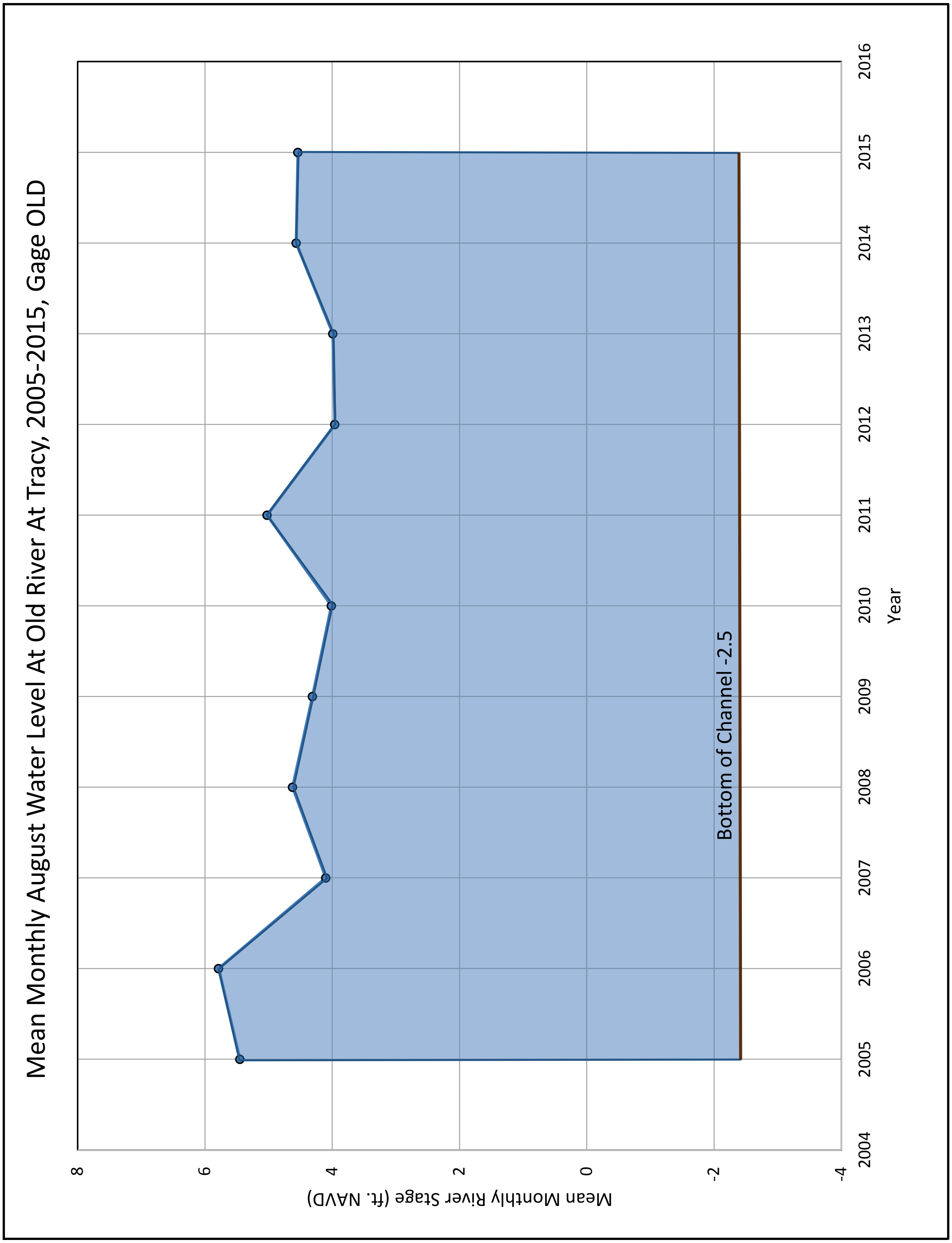

Figure 3-10 Mean Monthly August Water Level At Old River at Tracy, 2014-2016.

3.3 Effect of Withdrawal At The WSID Point of Diversion

3.3.1 Method of Analysis

Using the DSM2 model developed by DWR (DWR 2013), we analyzed what the impact is on Old River as a result of diversions at the West Side Irrigation District's (WSID) Point of Diversion (POD) of 8 cubic feet per second (cfs) or 14 cfs. The location of the WSID POD is shown in Figure 3-11.

The diversion was analyzed by developing 3 separate DSM2 model scenarios. The first represented a condition where no diversion existed at the WSID POD. The second and third scenarios were DSM2 model runs with an applied 8 cfs and 14 cfs diversion at the POD respectively. The difference in water surface elevation between the no-diversion scenario and the 8 and 14 cfs diversion scenarios was evaluated to determine the effect that each diversion had on the water in the river.

The DSM2 model was run from January 2012 through the end of the 2015 water year. The water surface elevation comparison was conducted for the June 1 through June 15 period. The Old River at Tracy (ORT) Barrier was in place during this period. The location of the ORT Barrier to the WSID diversion point is shown in Figure 3-11.

The Old River Barrier is part of the South Delta Barriers Project, which was initiated to evaluate the effects that flow barriers may have on mitigating the water level and quality impacts that result from the SWP and CVP export pumping operations. The purpose of the barriers is to increase the "irrigation season" water levels and hopefully water quality, in areas of the Delta that have been impacted by pumping from the State and Federal water projects. The ORT barrier is typically installed in the spring and removed in the fall when water flow in the Delta is at its lowest.

Figure 3-12 is a plot of the Sacramento River Unimpaired Runoff. This index is a good indicator for evaluating historic wet and dry conditions in the Delta. As can be seen in the figure the 2014 and 2015 water years, although not the driest years, were among the driest over the 94 year period of record.

3.3.2 Stage Response To The Diversion

For the 2015 period, based on the results of the DSM2 model, the 14 cfs diversion reduced the water level in the channel at the diversion point by an average of average of 0.005 ft, with a maximum difference of 0.008 ft. The 8 cfs diversion reduced the water level in the channel by an average of 0.003 ft. and a maximum of 0.005 ft. A reduction in the water surface elevation for anything less than 0.01 ft. is essentially zero. This is below the accuracy level for the model to accurately compute, and impossible to accurately measure in the field without taking extraordinary measures.

Figure 3-13 is a close-up plot of the river stage at the WSID POD comparing the no-diversion scenario to the 14 cfs diversion scenario in early June 2015. The no-diversion scenario is plotted beneath the 14 cfs-diversion scenario so that both lines can be seen. As can be seen in the figure, the water levels are basically indistinguishable.

Figure 3-14 shows the water surface at the WSID POD for the no-diversion and the 14 cfs diversion scenario. This plot shows the full depth of the4 channel. The channel bottom in this reach is approximately -6.5, providing for a rough depth of 10 feet. Given a depth of 10 feet, the reduction in water surface due to the two diversion scenarios of less than one hundredth of a foot is insignificant.

As can be seen from the results, the diversion of 14 cfs and 8 cfs had no impact to the available water in the channel. Therefore, I conclude that, for these diversion rates, there would have been no impact to the available water in the channel during 2015 and the subject time frame relative to the draft CDO.

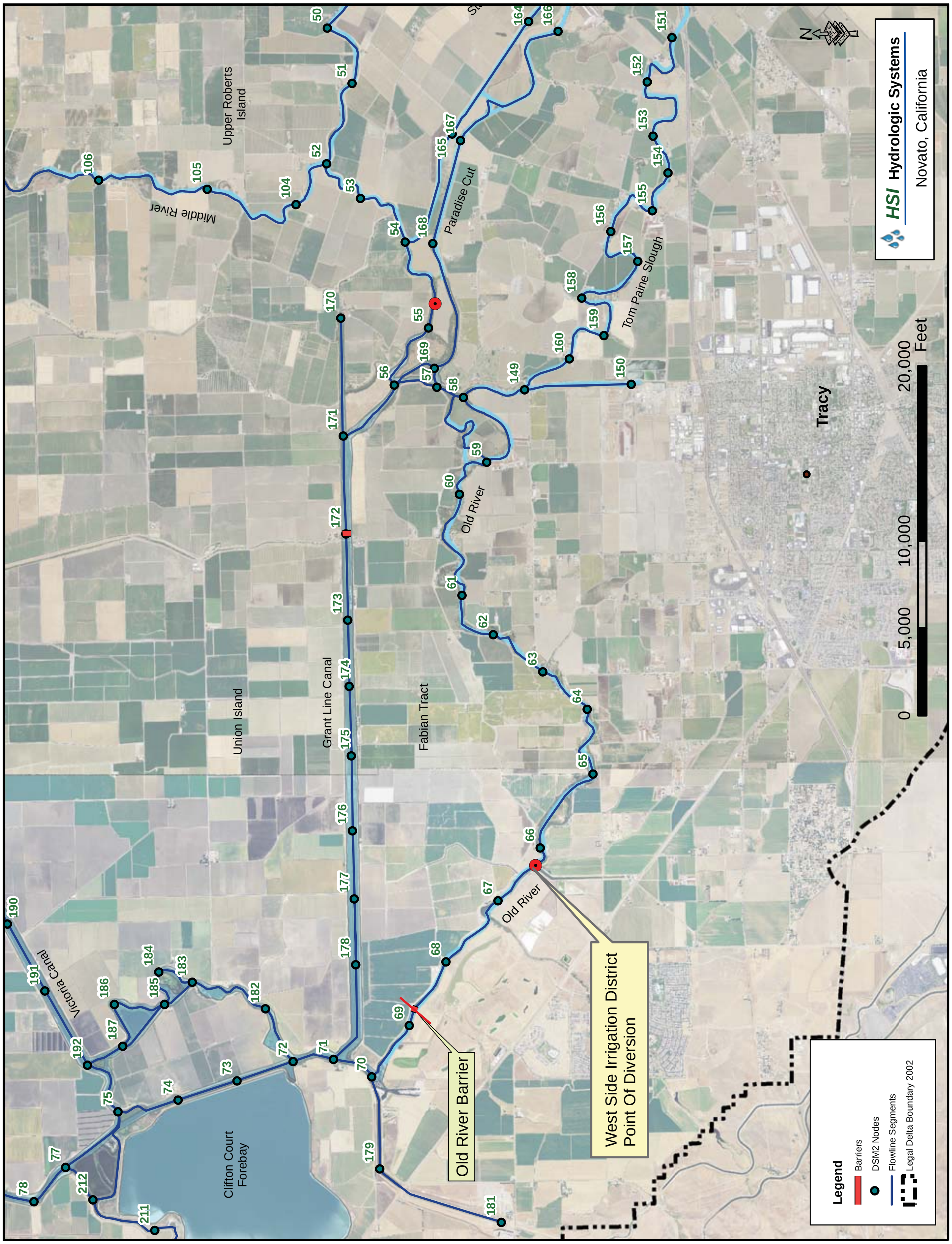

Figure 3-11 Location of WSID Diversion Point With DMS2 Model Node Locations

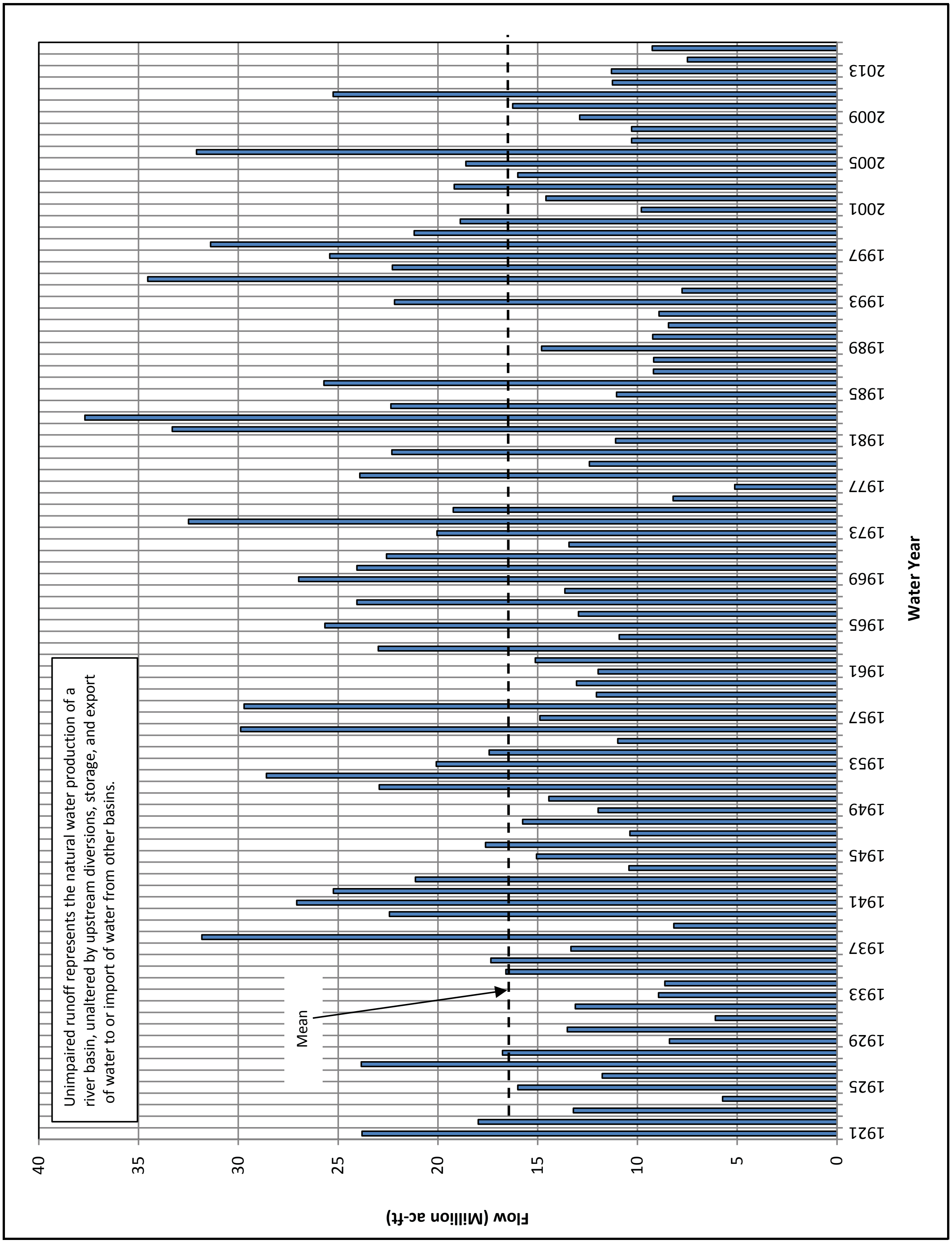

Figure 3-12 Sacramento River Unimpaired Runoff.

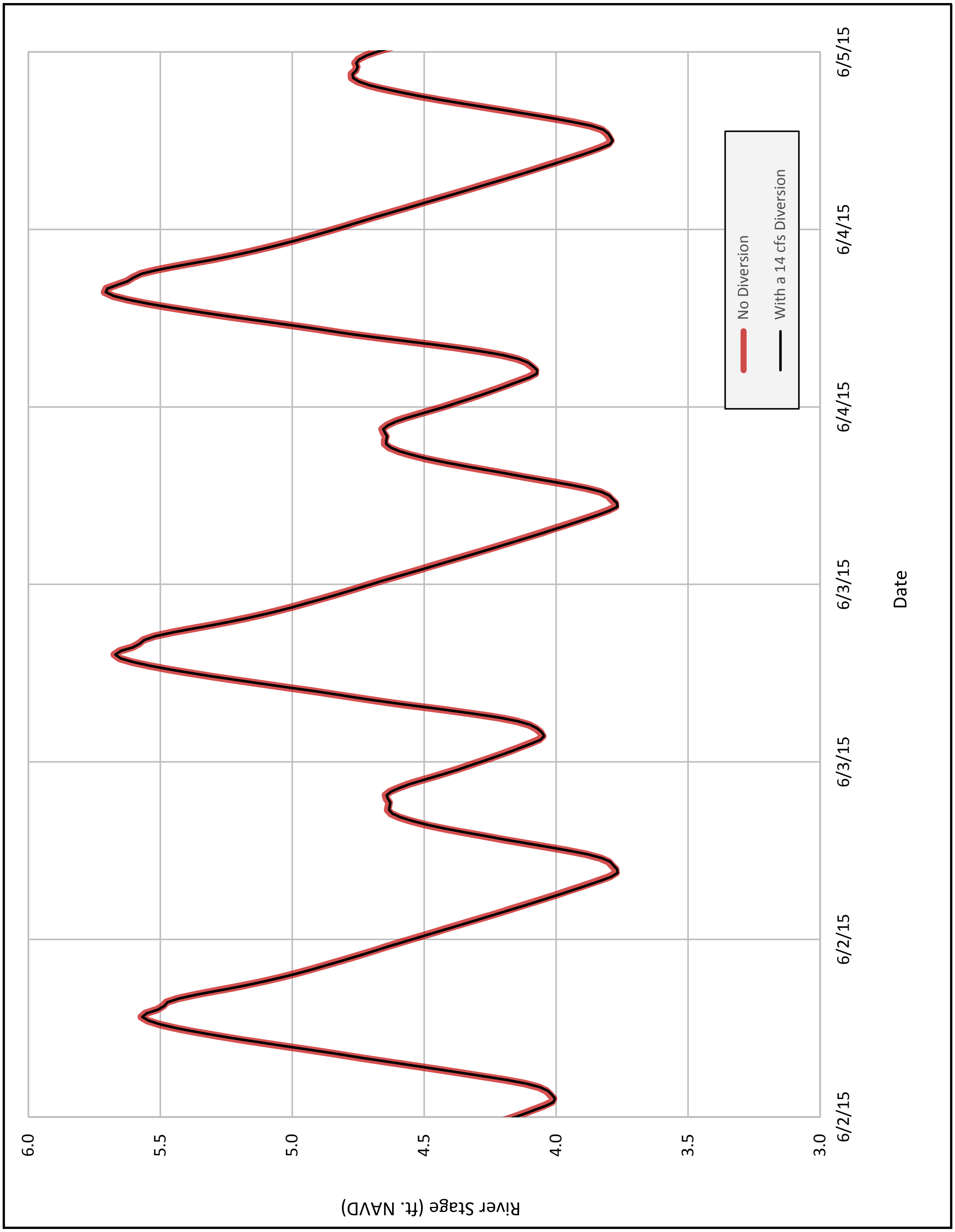

Figure 3-13 Detail of the River Stage at the WSID Diversion Point With and Without the 14 cfs Diversion.

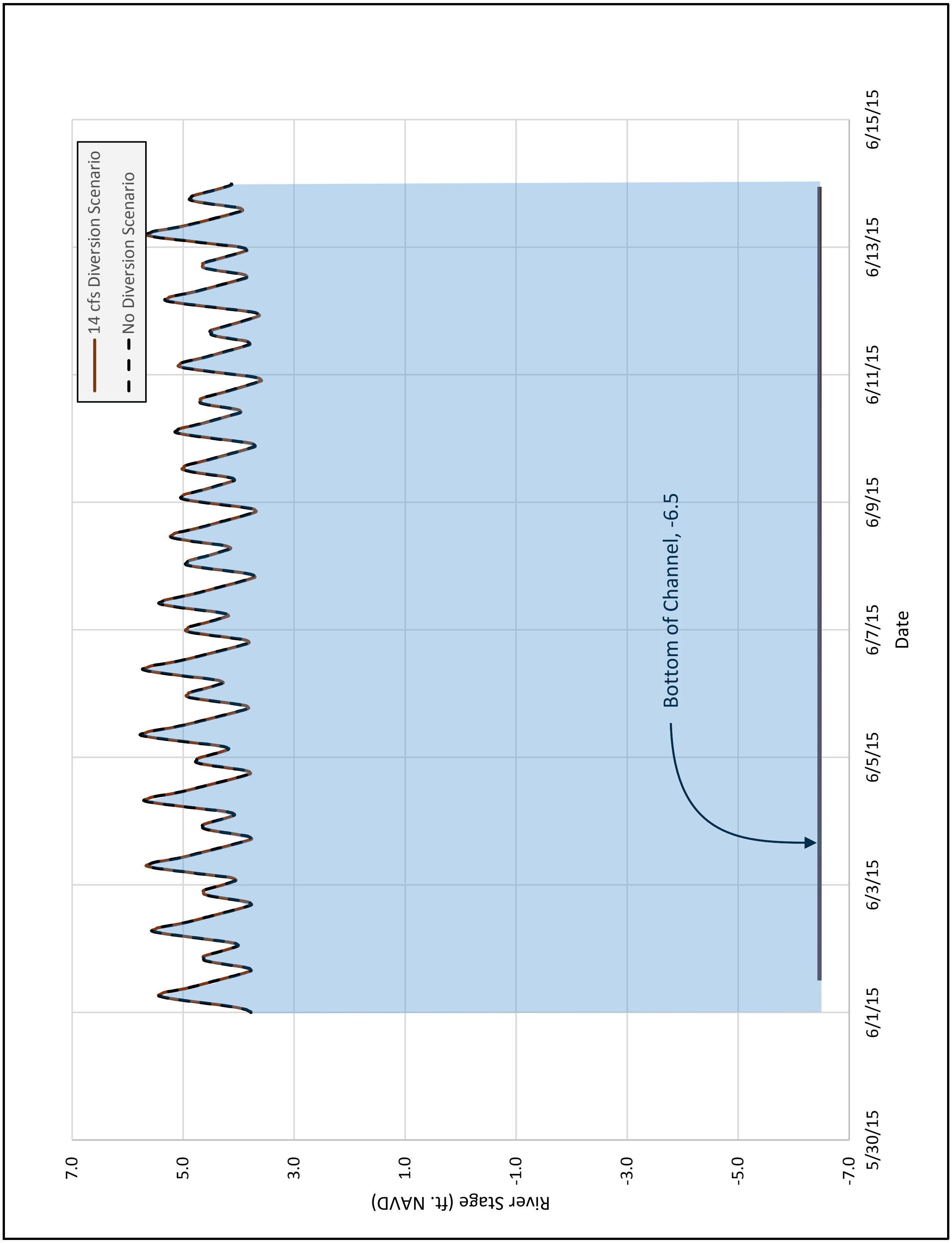

Figure 3-14 Comparison of the No-Diversion Water Surface at the WSID POD with the Water Surface Resulting From a 14 cfs Diversion.

3.3.3 Flow Response To The Diversion

It is important and necessary to emphasize how the Delta conditions are unique and so very different than the normal conditions evaluated in other streams. In those streams and rivers upstream of the Delta, diversions will necessarily result in a decrease in the flow of the stream which decreases the flow of water and the water level downstream of the diversion point. Absent any sort of substantial accretions to the stream not associated with the diversion, the effect of the diversion is to impact the supply of and perhaps the ability to divert by down stream interests.

In the Delta that is not the case. Because the Delta is an interconnected network of channels, a diversion from one point creates a small depression in the immediate area of the diversion. This depression is then replenished by water flowing towards that depression. The diversion simply, but slightly alters the direction or rate at which the ever-present supply refills the depression. As described above, given the vast quantity of water in the Delta itself, and the effect of the tides reversing the normal concept of upstream and downstream four times a day, small local diversions have no meaningful, and often no measurable effect on the supply of any neighboring diverter or the ability to divert from nearby locations.

4 Delta Water Quality

4.1 Introduction

The SWQCB has indicated that during this recent drought, that water quality would have degraded to such an extent that diverters could not use the water for irrigation. With that premise, diversion curtailments of BBID and WSID were put into effect. The SWQCB has also stated that it was only due to releases from the State and Federal Water Projects, that water quality was sufficient to be used for irrigation.

To evaluate that assertion, an analysis was conducted to evaluate the water quality that would exist at the BBID and WSID points of diversion without the State and Federal Water Projects. The location of the POD's is shown in Figure 1-1. As part of that analysis, the present conditions as well as the historic flow and salinity conditions were evaluated. The analysis was focused on the conditions at the WSID and BBID points of diversion. In Section three of this report it was shown that water is always available at the two points of diversion. This section evaluates the water quality conditions that exist throughout the year in dry water years.

The flow conditions in the Delta have changed significantly since the construction of the State Water Project (SWP) and the Federal Central Calley Project (CVP). As such, the analysis was focused on evaluating the conditions that existed during the 1930's prior to the development of the Projects. A hydrodynamic model DSM2, developed by the California Department of Water Resources (DWR, 2013), was used to augment the measured data, which can be sparse at some locations in the Delta.

4.2 Historic Data

Most of the historic data that was collected for this analysis were taken from a series of Water Supervisors Reports, titled Bulletin 23, that were produced by State of California Department of Public Works. These reports, which covered the period of 1924 through 1962, provide a significant amount of water quality data throughout the Delta. Figure 4-1 is a map of the Delta showing the location of those gages that had sufficient data to be used in this analysis. To evaluate the water quality conditions during a drought period, the salinity levels recorded at those gages were analyzed with regard to the magnitude and timing of the water quality changes through the year.

The Sacramento River Index was used as a gage to identify wet and dry years from the historic record. The Sacramento River Index is the sum of unimpaired flow in million acre-feet from 4 major rivers in the Sacramento River Basin:

- Sacramento River above Bend Bridge;
- Feather River at Oroville (inflow to Lake Oroville);
- Yuba River near Smartville;
- American River below Folsom Lake.

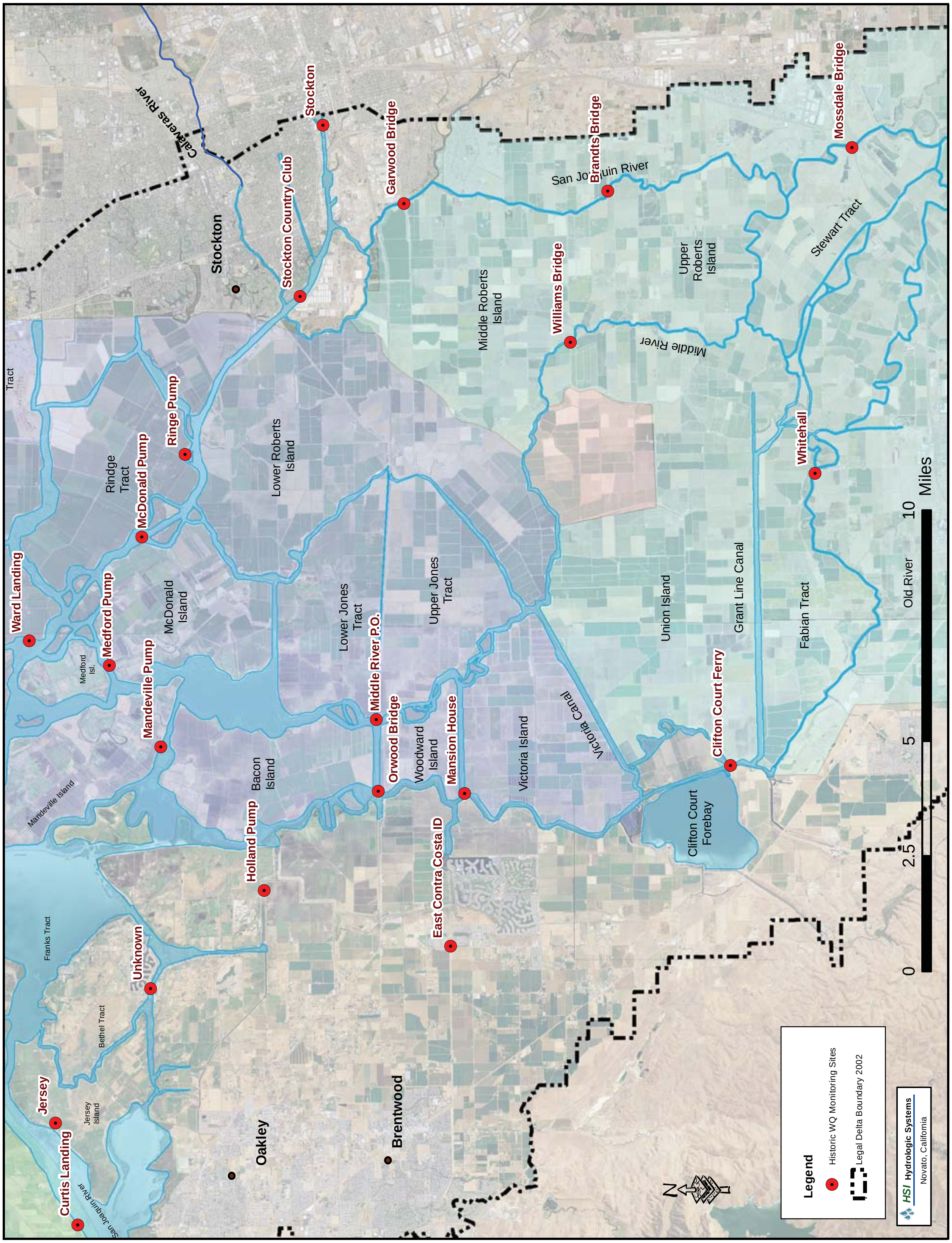

Figure 4-1 Location of Historic Water Quality Monitoring Points In The Delta.

This index has previously been called the four river index or the four basin index. A plot of that index from 1920 through 2015 is shown in Figure 3-12.

The Sacramento River Index is used to determine the type of water year for the valley. The different classifications and their index criteria are shown below (DWR 2013b):

- Year Type Water Year Index
- Wet Equal to or greater than 9.2
- Above Normal Greater than 7.8, and less than 9.2
- Below Normal Greater than 6.5, and equal to or less than 7.8
- Dry Greater than 5.4, and equal to or less than 6.5
- Critical Equal to or less than 5.4

There is also an eight river index that includes the four rivers of the Sacramento River Index, plus four additional rivers in the San Joaquin River Basin.

The Sacramento River Index was used to compare water year types from the early 1930's where we have historic water quality data to the most recent drought periods of 2014 and 2015. As can be seen in the figure, the 1931 and 1939 water years were drought years on the same order of magnitude as the 2014 and 2015 water years. The 1931 water year index is slightly less than water year 2014, and the 1939 water year was slightly dryer than 2015.

To analyze the salinity conditions during drought periods that existed prior to the State and Federal Water Projects ("Projects"), the salinity data that was collected at the historic gaging stations was plotted for the 1931 and 1939 years. Figures 4-3 through 4-18 are plots of the Chloride levels that were measured at representative historic stations that are shown in Figure 4-1. The stations that are plotted and their respective rivers are shown below

DS End of Delta	Antioch
Old River	Holland Pump
	Orwood Bridge
	Mansion House
	Clifton Court Ferry
	Whitehall
Middle River	Middle River Post Office
	Williams Bridge
San Joaquin River	Ringe Pump

Mossdale Bridge

The graphs have plotted the measured Chloride level in ppm over the year. Many modern salinity measurements are collected by measuring electrical conductivity (EC). EC measures the conductivity based on many ions in the water, not just Chloride. A relationship was developed between Chloride concentration in the water and measured EC at the Bordon Highway Bridge, located at the junction of Middle River and Victoria Canal. A conversion from ppm of Chloride to EC in μS/cm is provided in the equation below.

$$Chloride = 0.1664 \times EC - 14.178$$

Where:

Chloride is in ppm (mg/l)

EC is in μS/cm

A plot of the data used to develop this relationship is shown in Figure 2-16. The relationship between Chloride and measured EC varies across the Delta due to the change in the percentage of the different sources of water that are present at each location. The location of the Bordon Highway Bridge gage makes it a good location for an average conversion for the south Delta.

Given this relationship, a general guide for converting between Chloride and EC is shown below:

2,000 ppm Chloride = 8,570 μS/cm = 8.6 dS/m

1,000 ppm Chloride = 4,360 μS/cm = 4.4 dS/m

500 ppm Chloride = 2,250 μS/cm = 2.2 dS/m

200 ppm Chloride = 990 μS/cm = 1.0 dS/m

As can be seen in the plots, in 1931, a dryer year than either 2014 or 2015, the Chloride levels in the streams did not start to rise until well into August, and did not peak until the middle of September to the beginning of October, well past the normal growing season.

Figure 4-19 is a plot of the measured Chloride level on the San Joaquin River at Mossdale Bridge. This plot shows a comparison of the measured salinity levels in 1931 and 2014. Even though 1931 was a more intense drought than 2014, the salinity levels are still lower in 1931. It is likely that increased agricultural runoff that is discharged to the San Joaquin River is accounting for the increase in salinity levels, and subsequent loading to the Delta.

4.3 Historic Irrigation Diversion Data

A review of the areas that were irrigated during the 1930's did not show a marked reduction in irrigated acreage between the dry years of 1931 and 1938 and the wetter years of 1938 and 1941. Figures 4-20 and 4-21 are plots of the WSID irrigation diversions and irrigated acreages for the 1929 through 1943 period (DWR Water Supervisor Reports 1929-1943). These plots show that farmers continued to irrigate and grow crops in years drier than 2014 or 2015, and prior to the modifications to the Delta by the Projects. A review of the Water Supervisors Reports for the 1931 and 1939 years did not indicate that there was any cessation of diversions for either WSID or BBID (Division of Water Resources 1930, 1939).

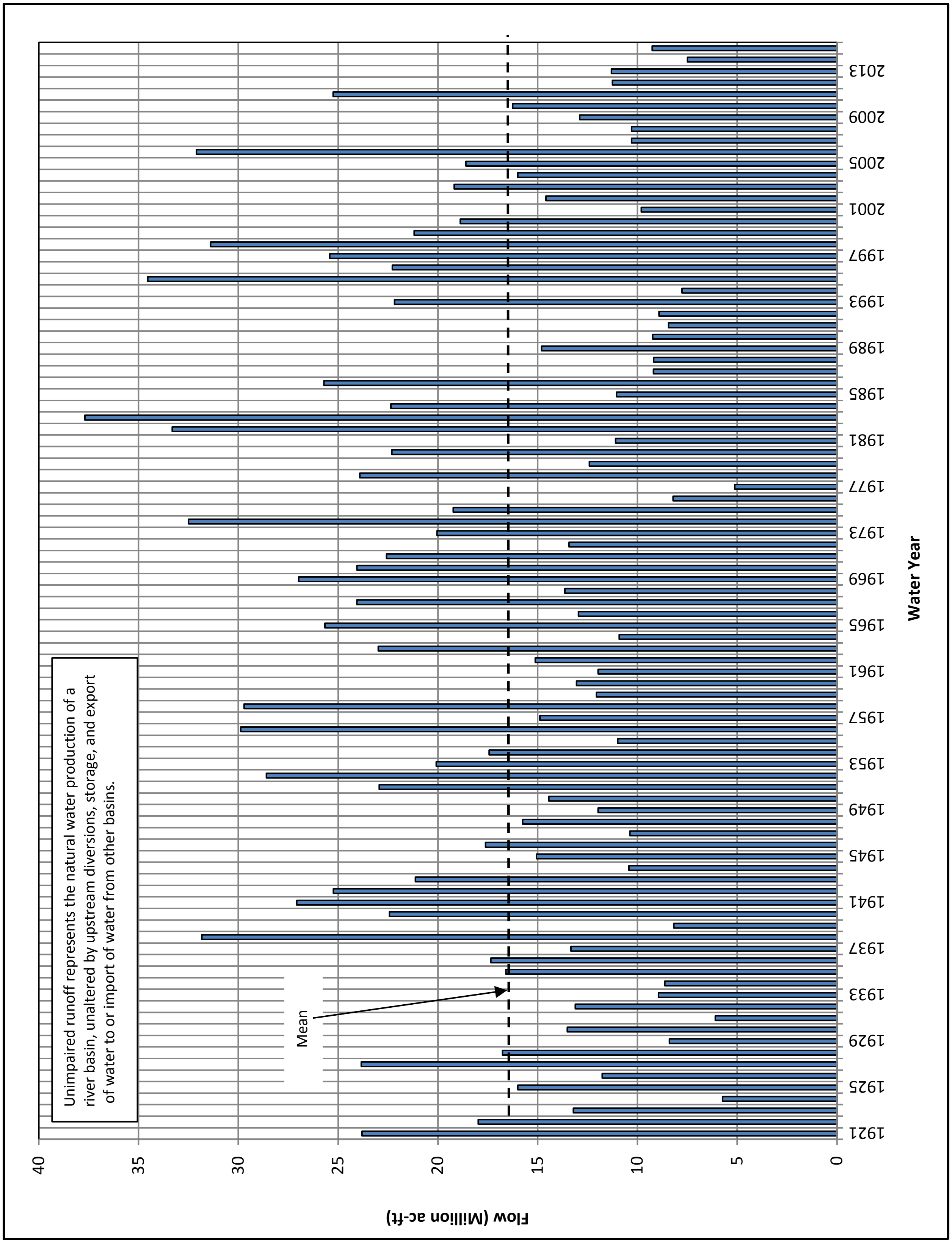

Figure 4-2 Sacramento River Index, 1921 - 2015

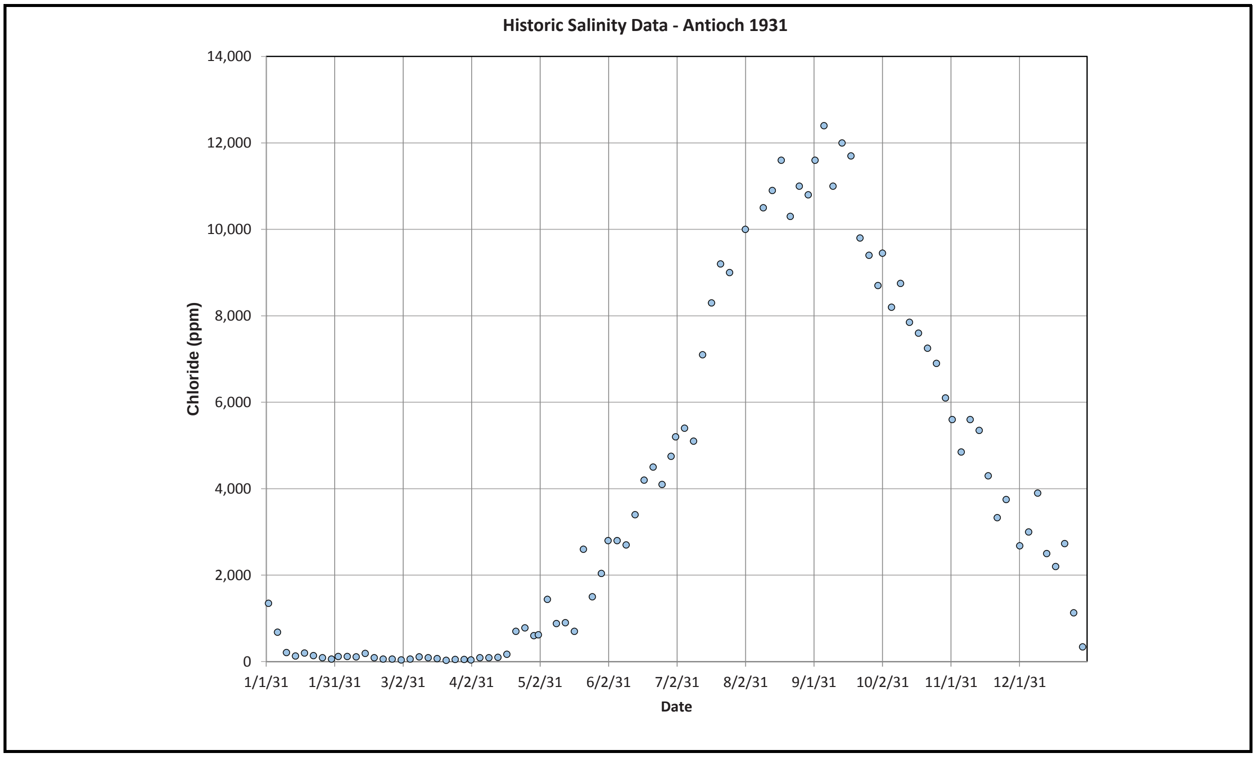

Figure 4-3 Antioch Chloride Levels, 1931

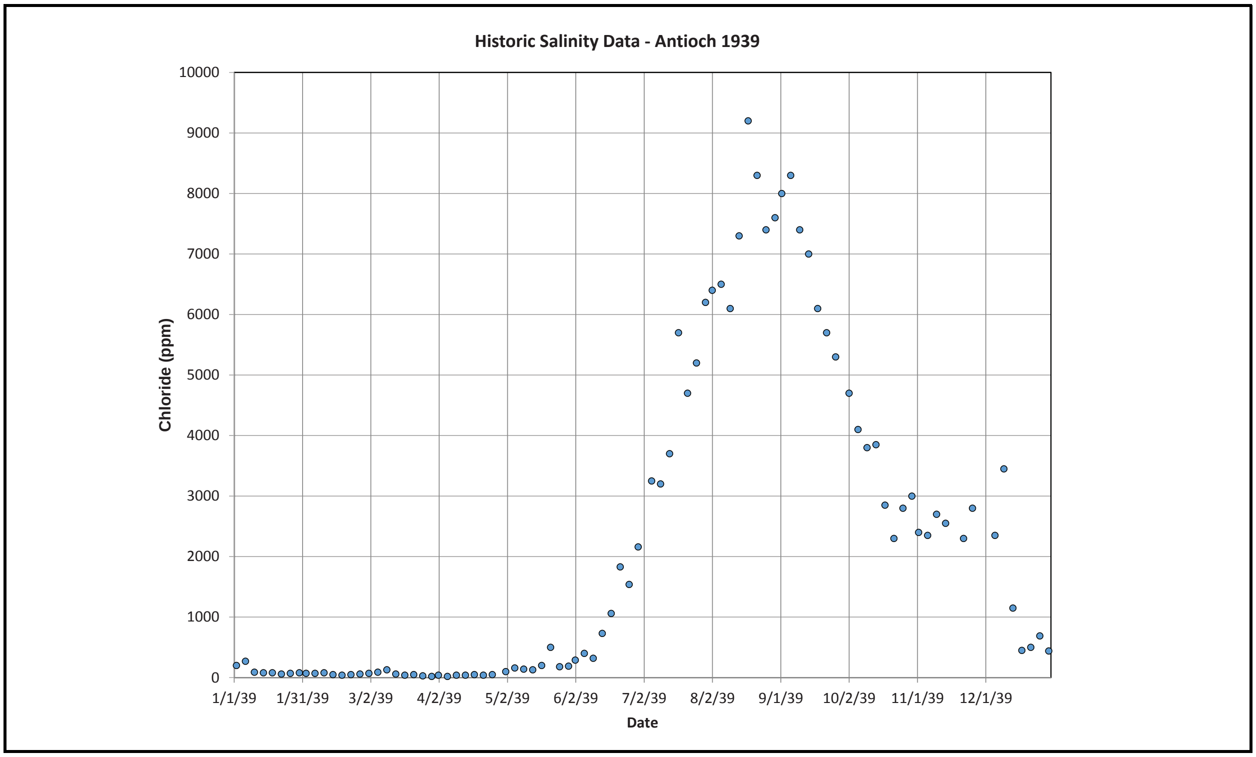

Figure 4-4 Antioch Chloride Levels, 1939

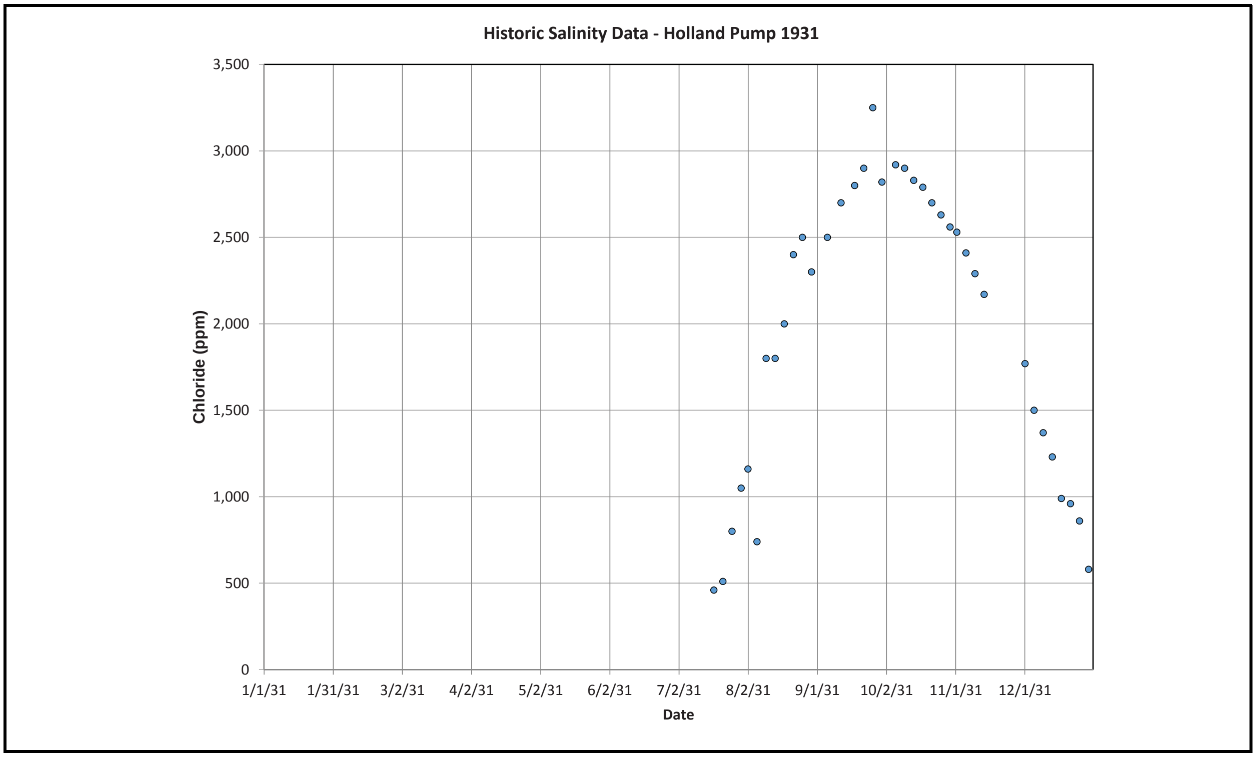

Figure 4-5 Holland Pump Salinity Levels, 1931

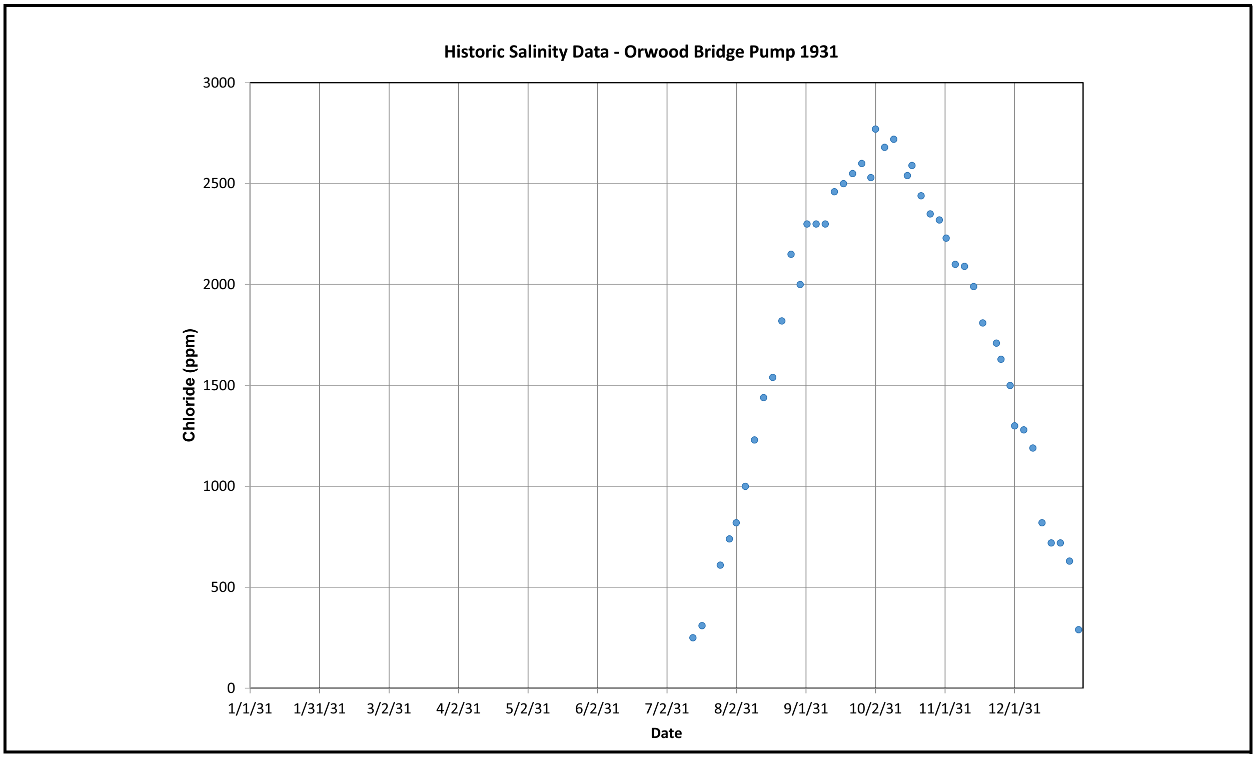

Figure 4-6 Orwood Bridge Salinity Levels, 1931

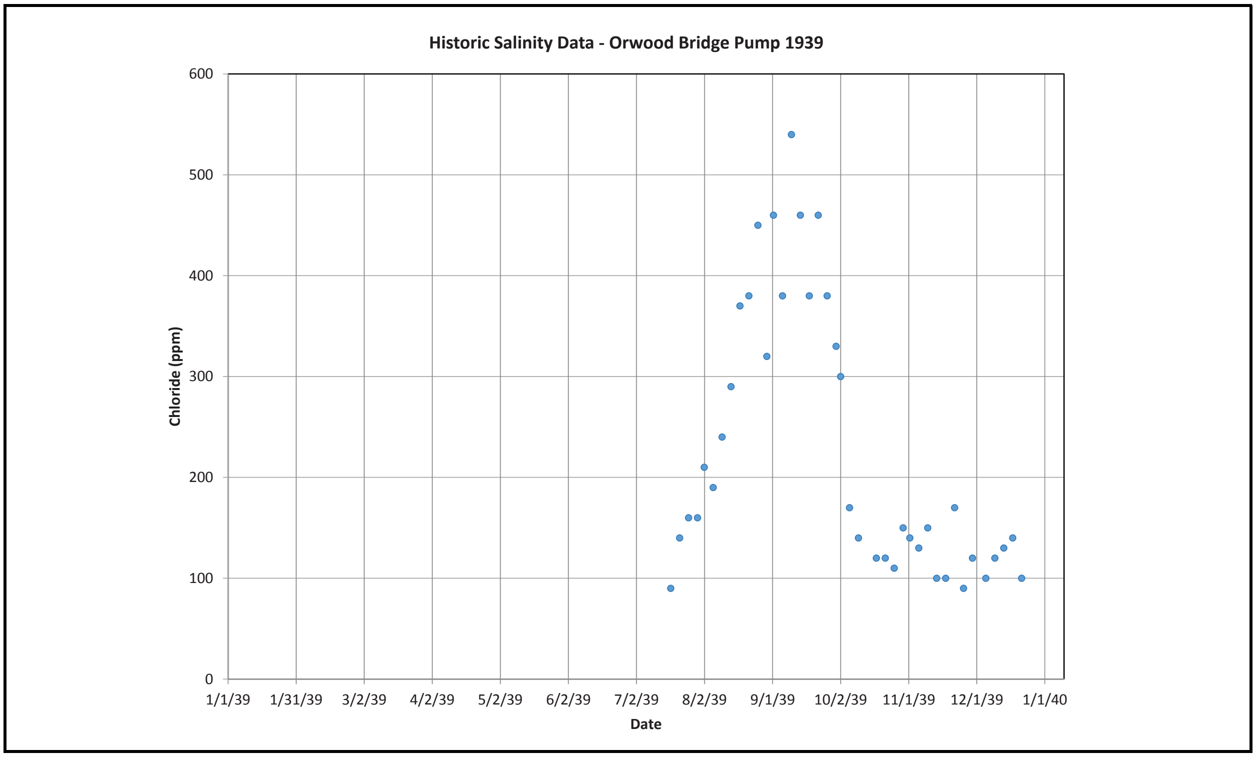

Figure 4-7 Orwood Bridge Salinity Levels, 1939

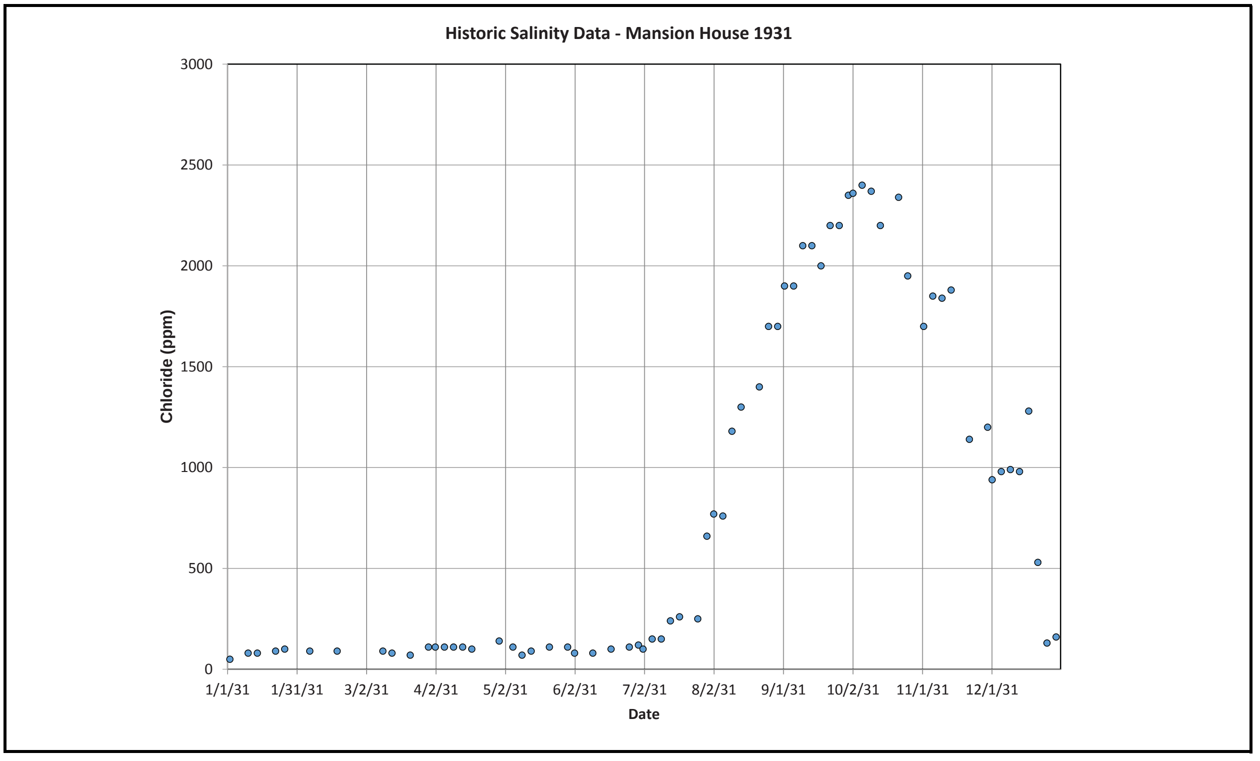

Figure 4-8 Mansion House Salinity Levels, 1931

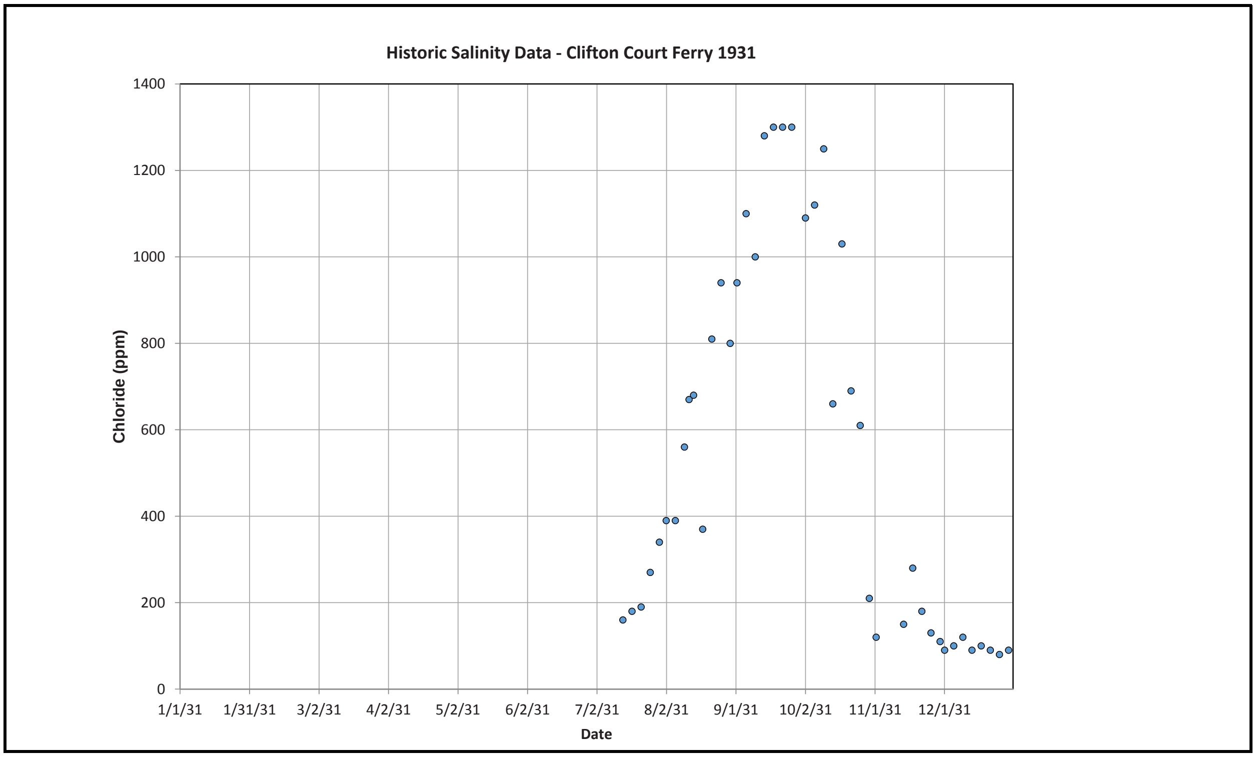

Figure 4-9 Clifton Court Ferry Salinity Levels, 1931

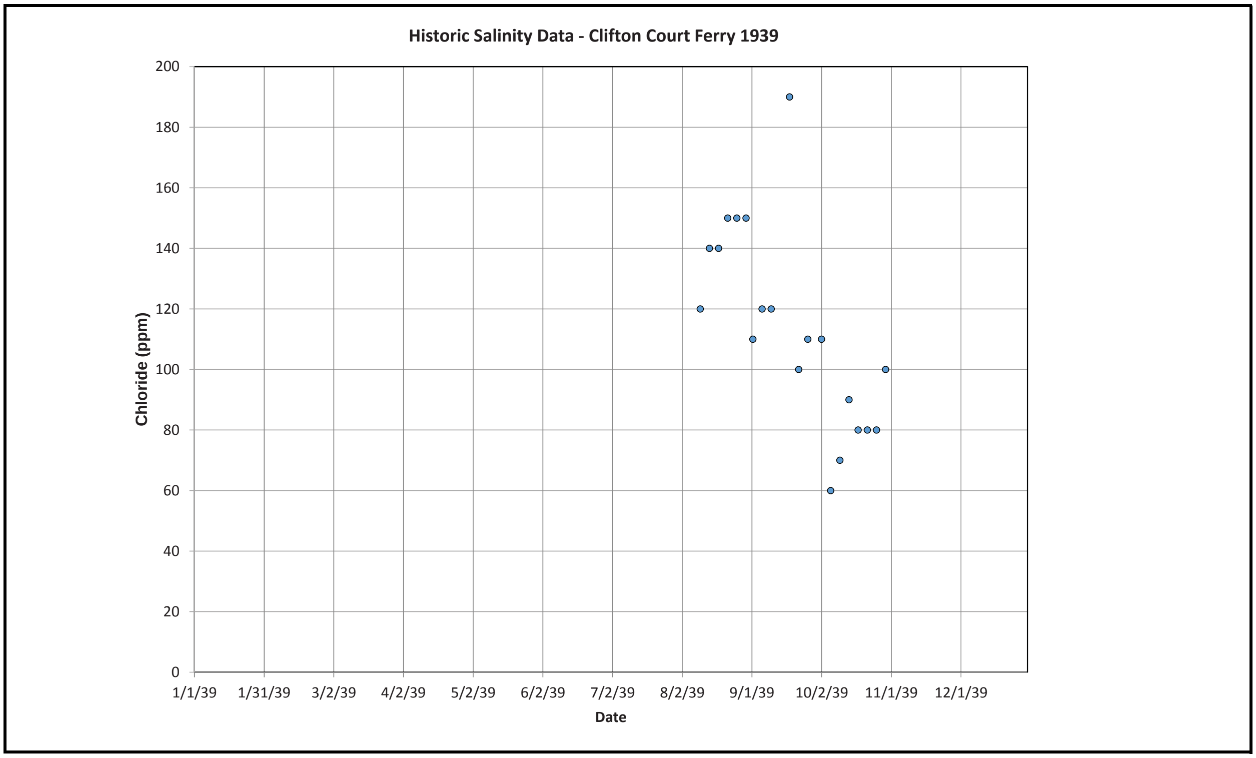

Figure 4-10 Clifton Court Salinity Levels, 1939

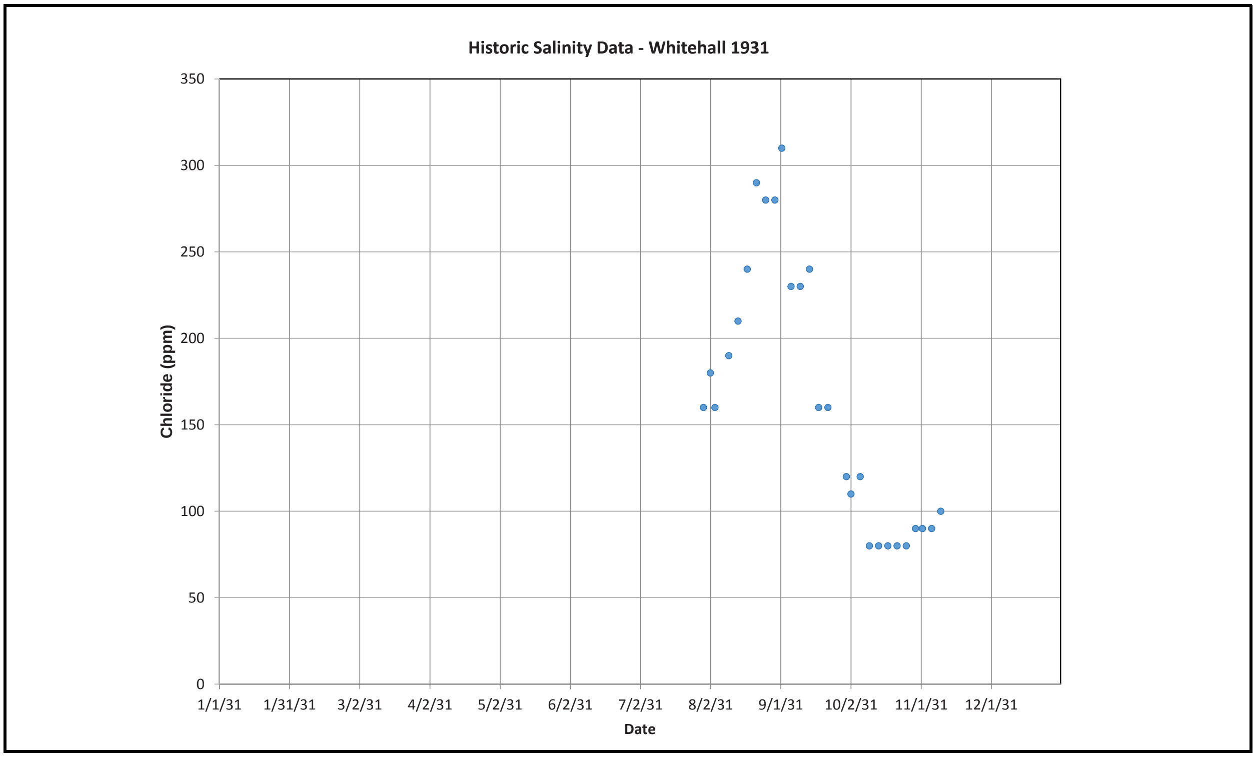

Figure 4-11 Whitehall Salinity Levels, 1931

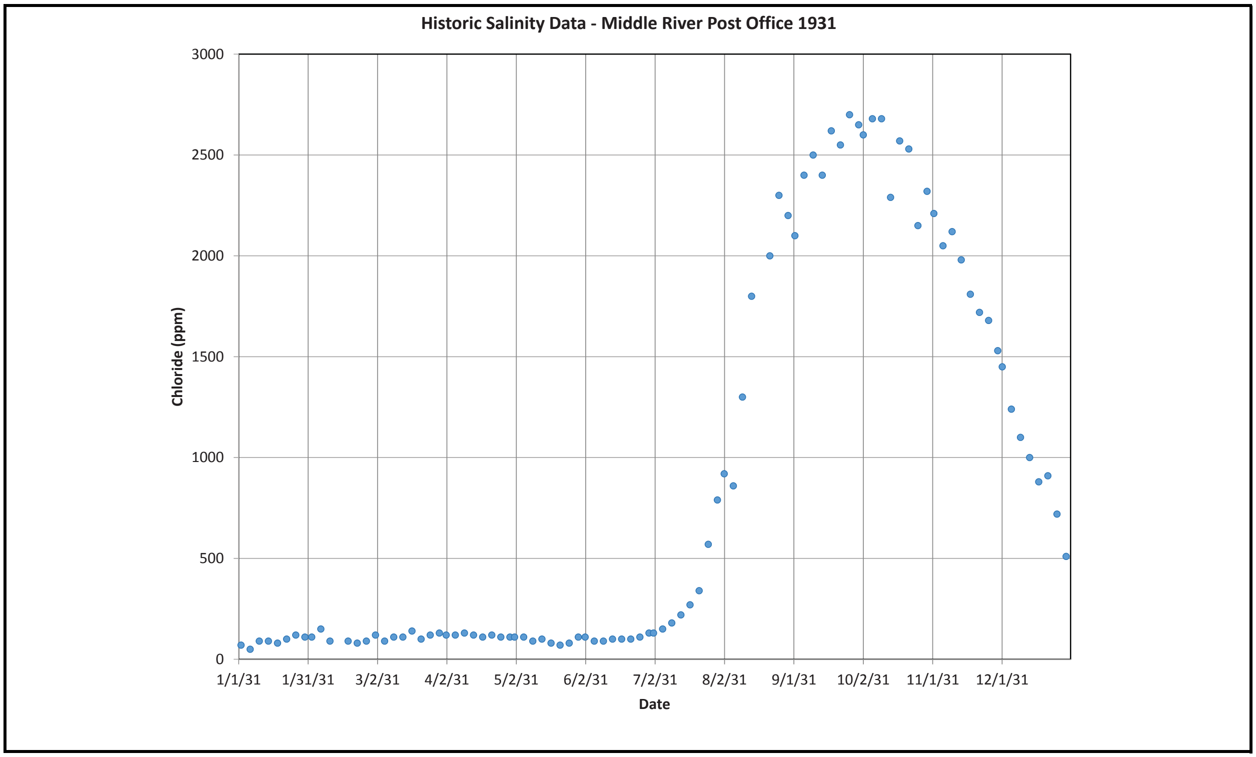

Figure 4-12 Middle River Post Office Salinity Levels, 1931

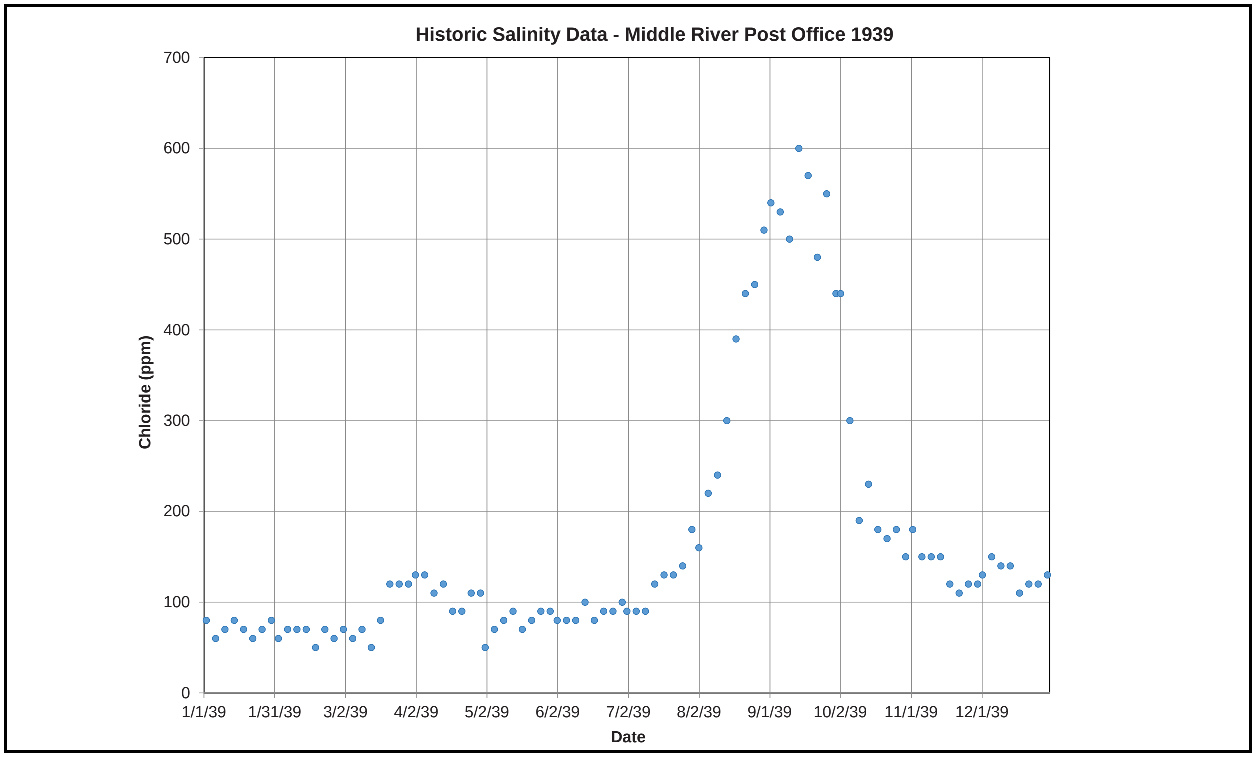

Figure 4-13 Middle River Post Office Salinity Levels, 1939

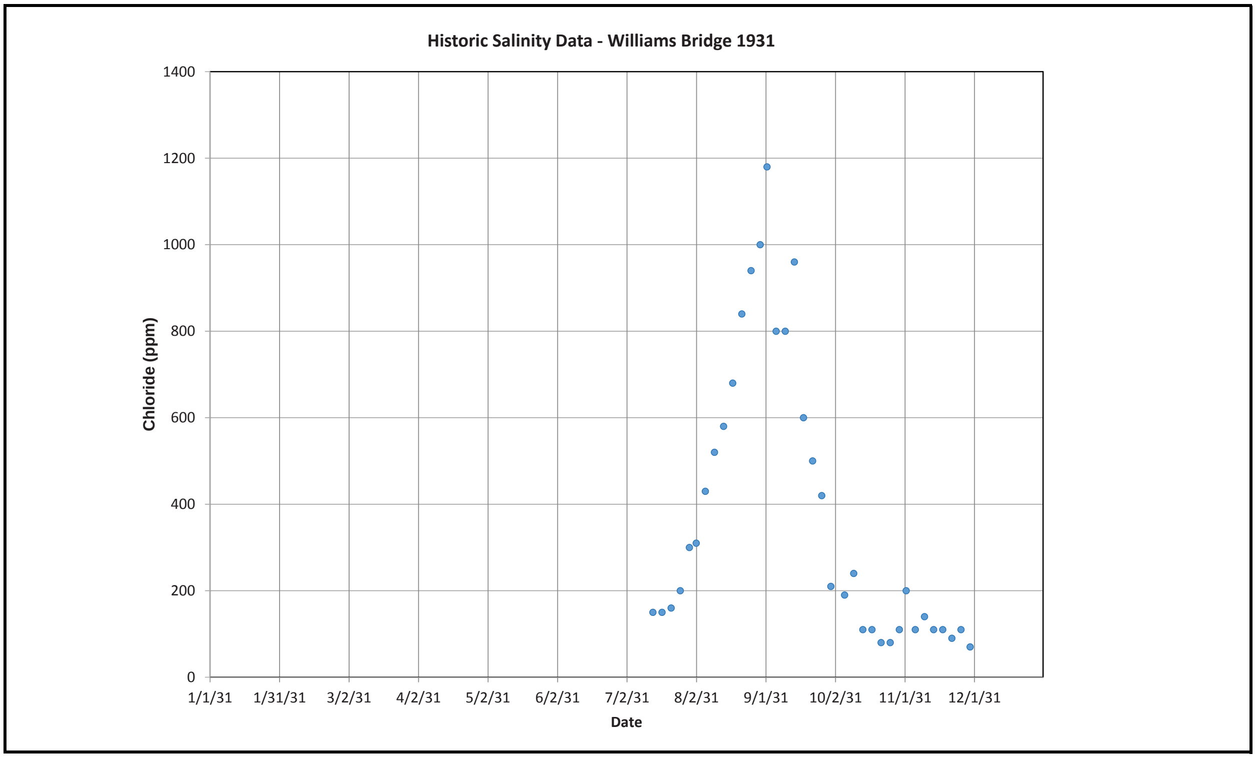

Figure 4-14 Williams Bridge Salinity Levels, 1931

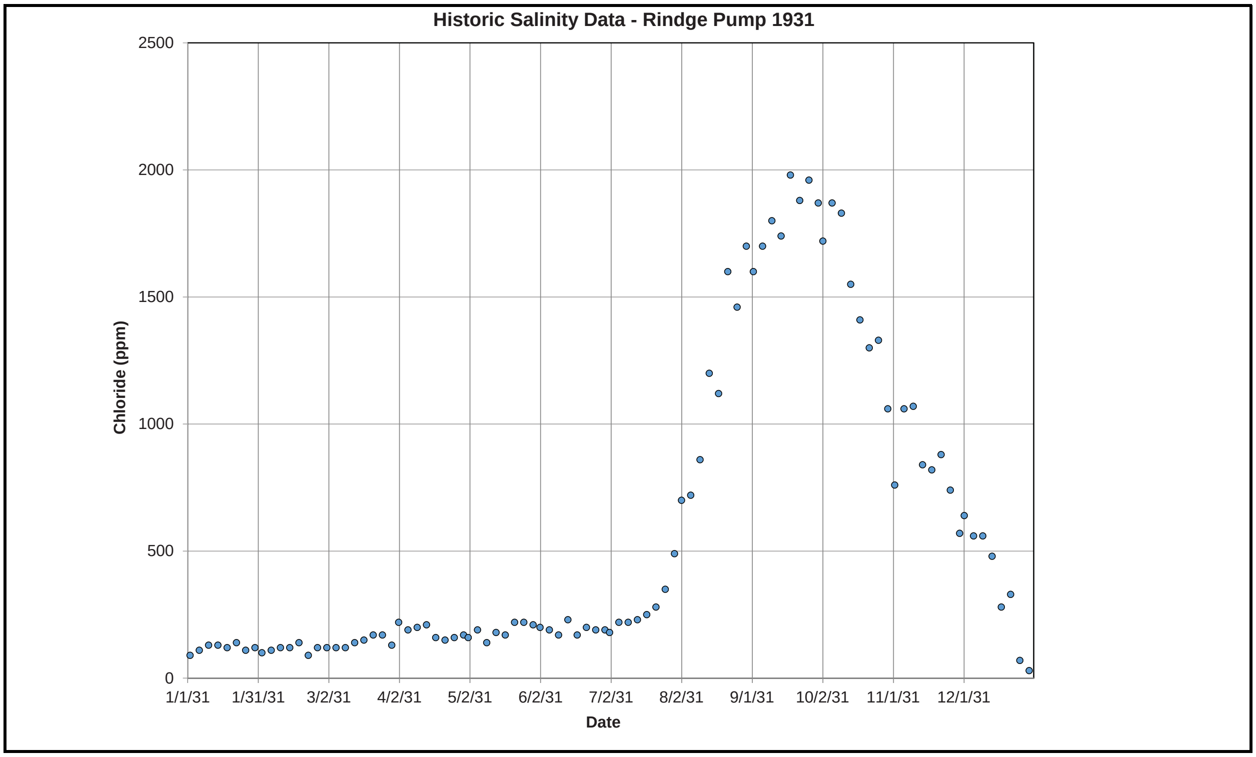

Figure 4-15 Ringe Pump Salinity Levels, 1931

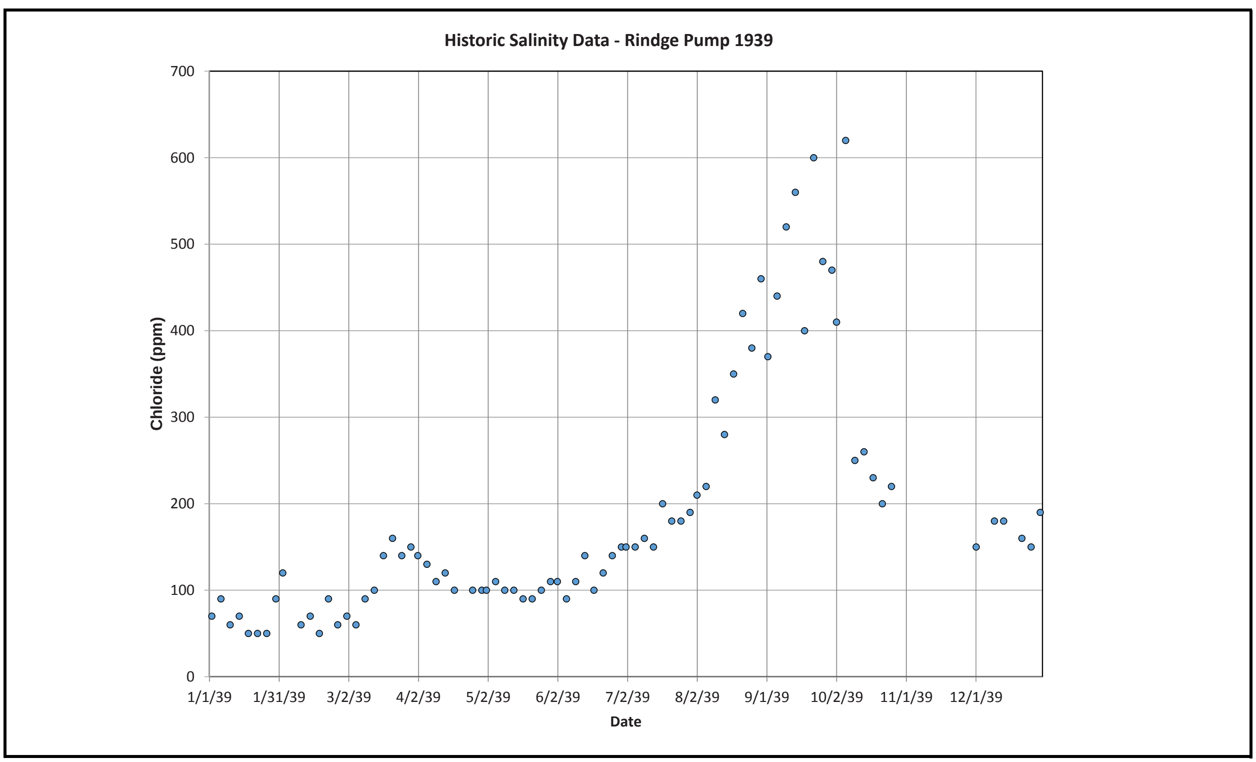

Figure 4-16 Ringe Pump Salinity Levels, 1939

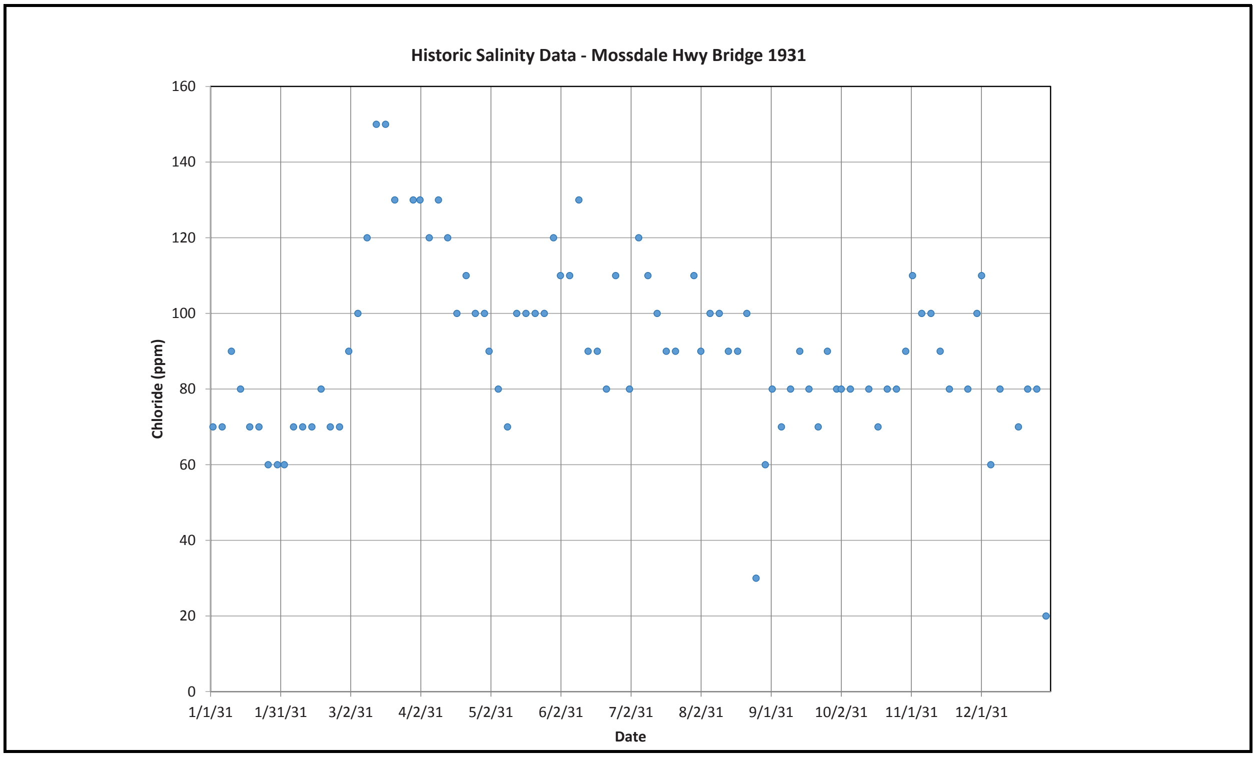

Figure 4-17 Mossdale Bridge Salinity Levels, 1931

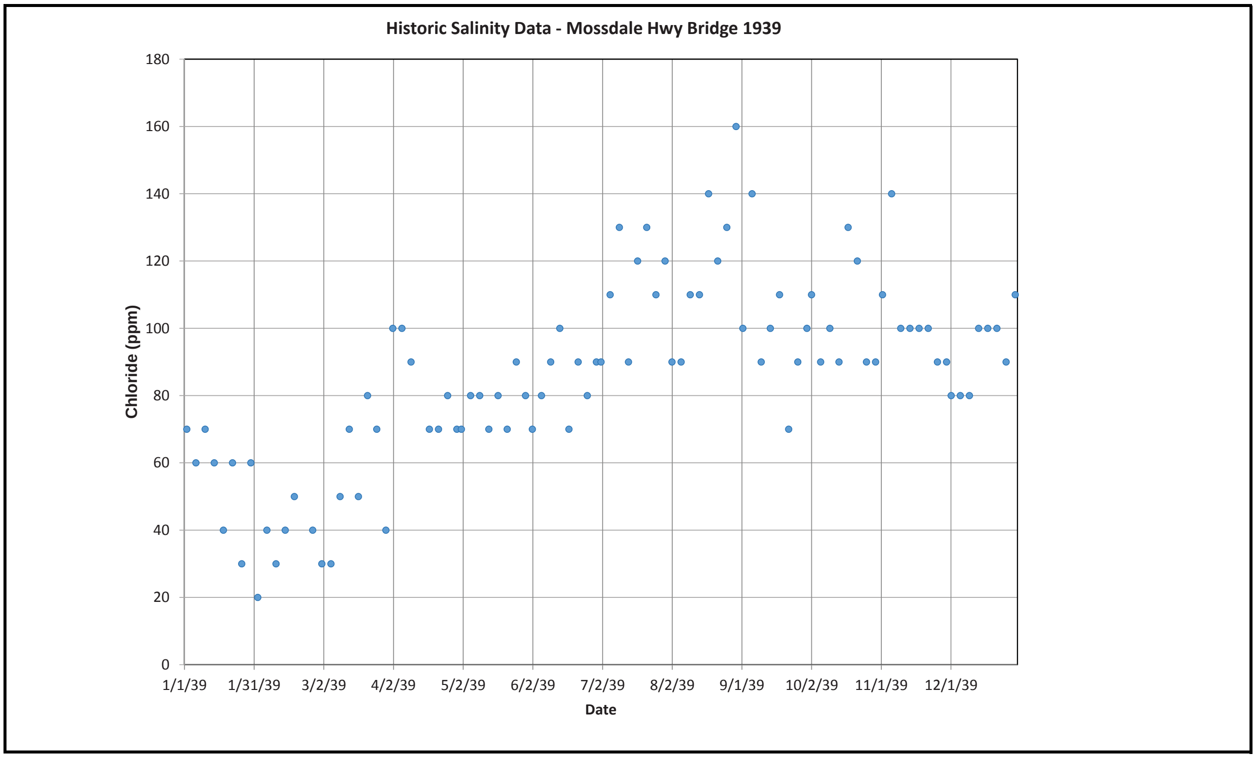

Figure 4-18 Mossdale Bridge Salinity Levels, 1939

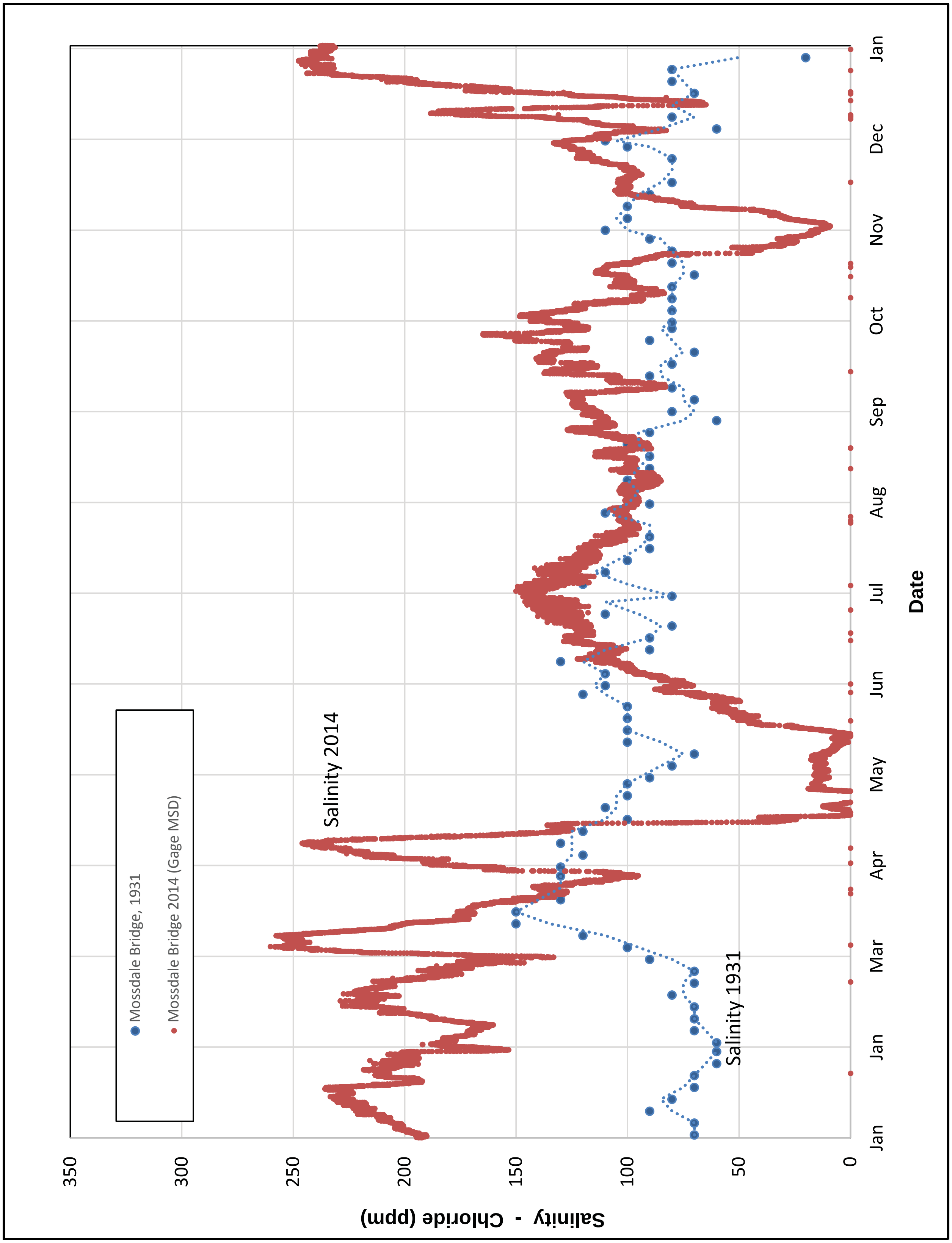

Figure 4-19 Measured Salinity Data At Mossdale Bridge, 1931 and 2014

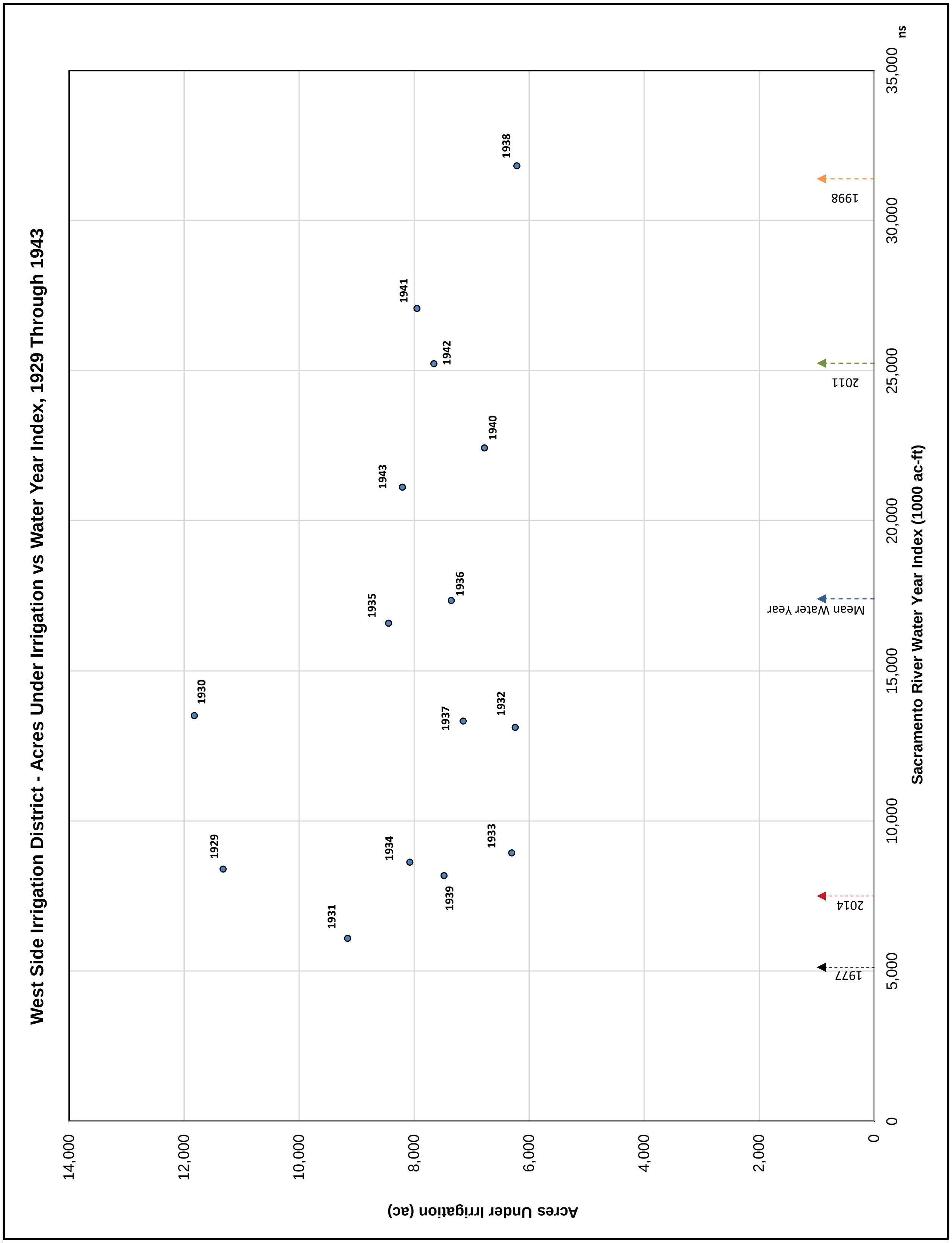

Figure 4-20 WSID Acres Under Irrigation vs Water Year Index Between 1929 and 1943.

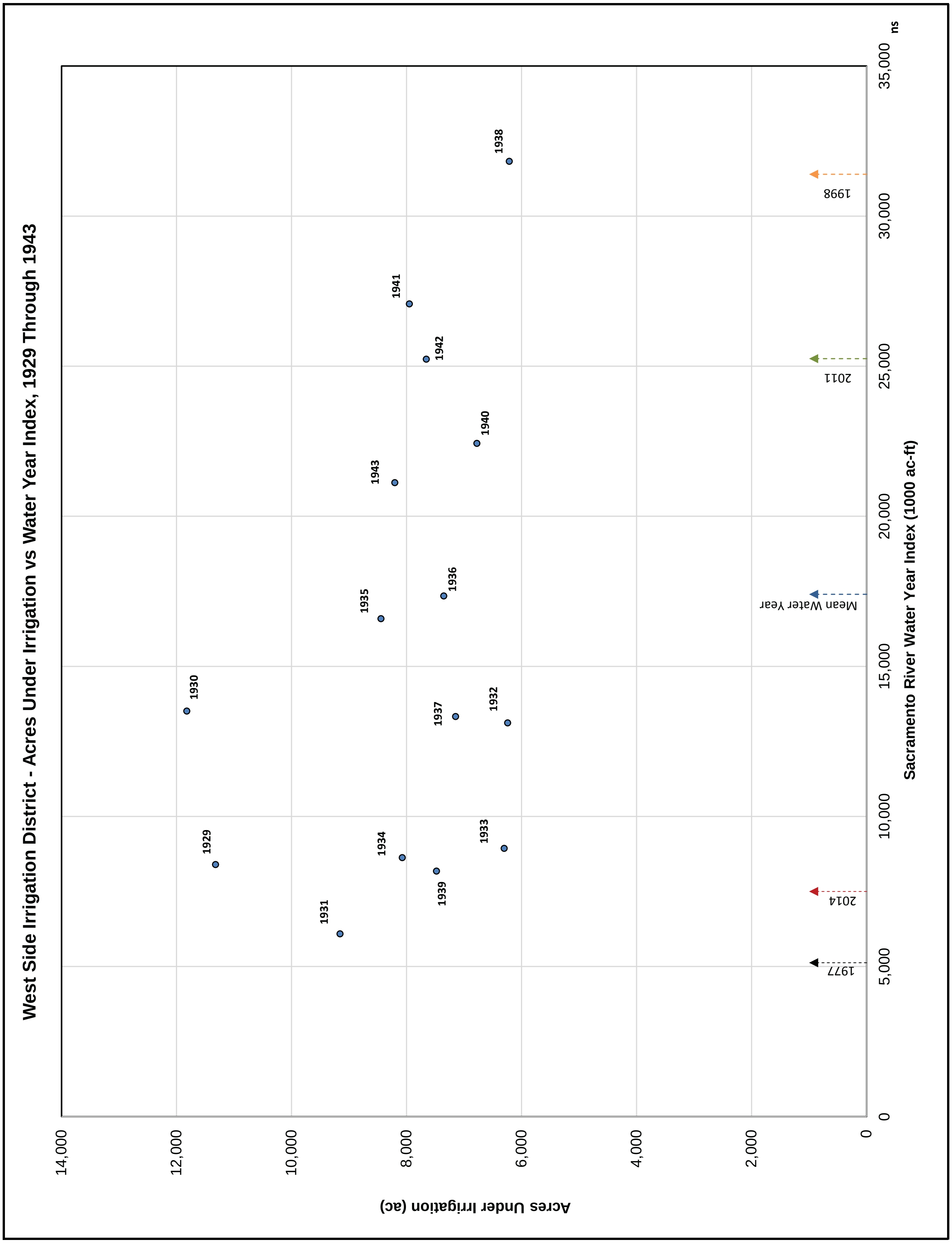

Figure 4-21 WSID Irrigation Diversion vs Water Year Index Between 1929 and 1943.

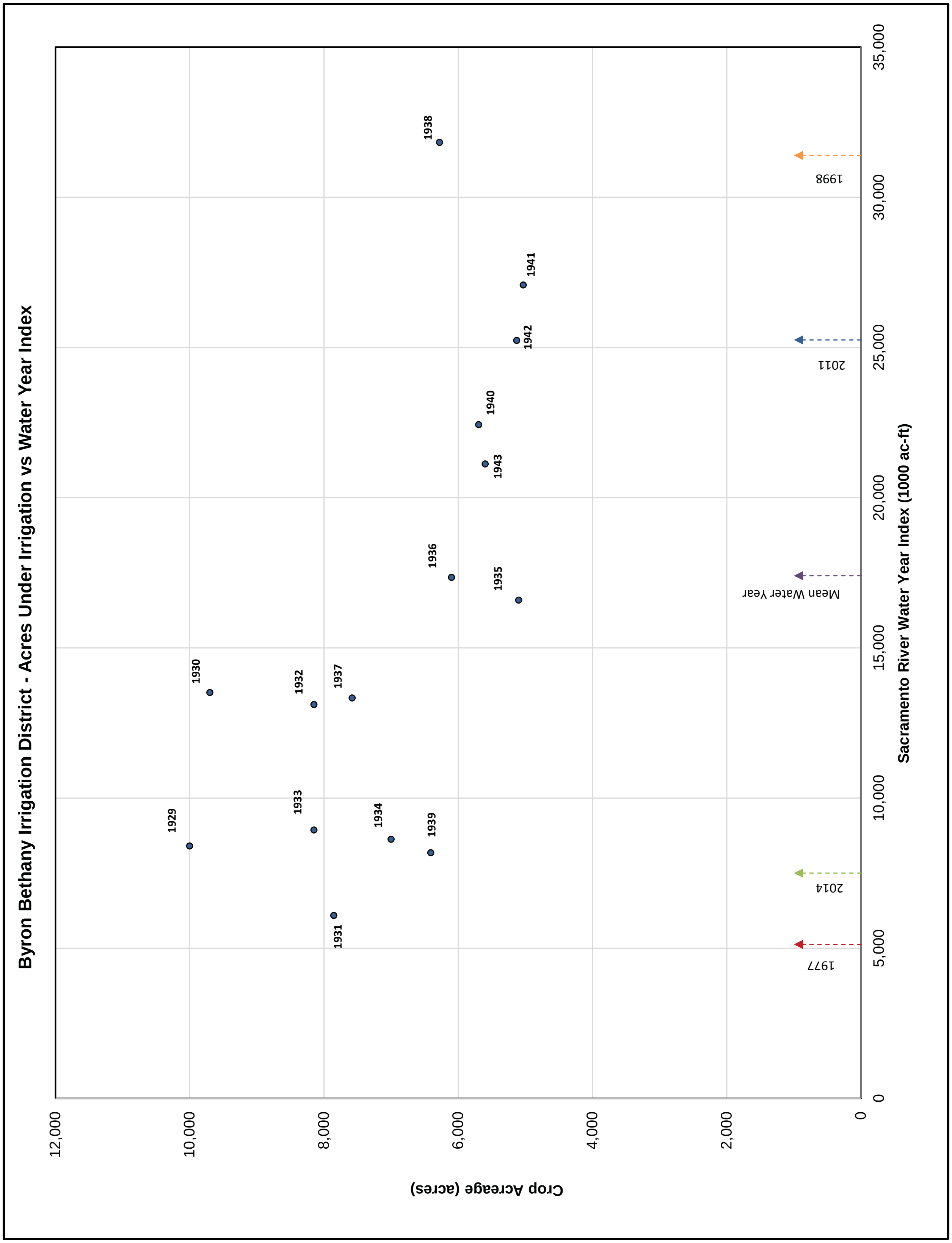

Figure 4-22 BBID Acres Under Irrigation vs Water Year Index Between 1929 and 1943.

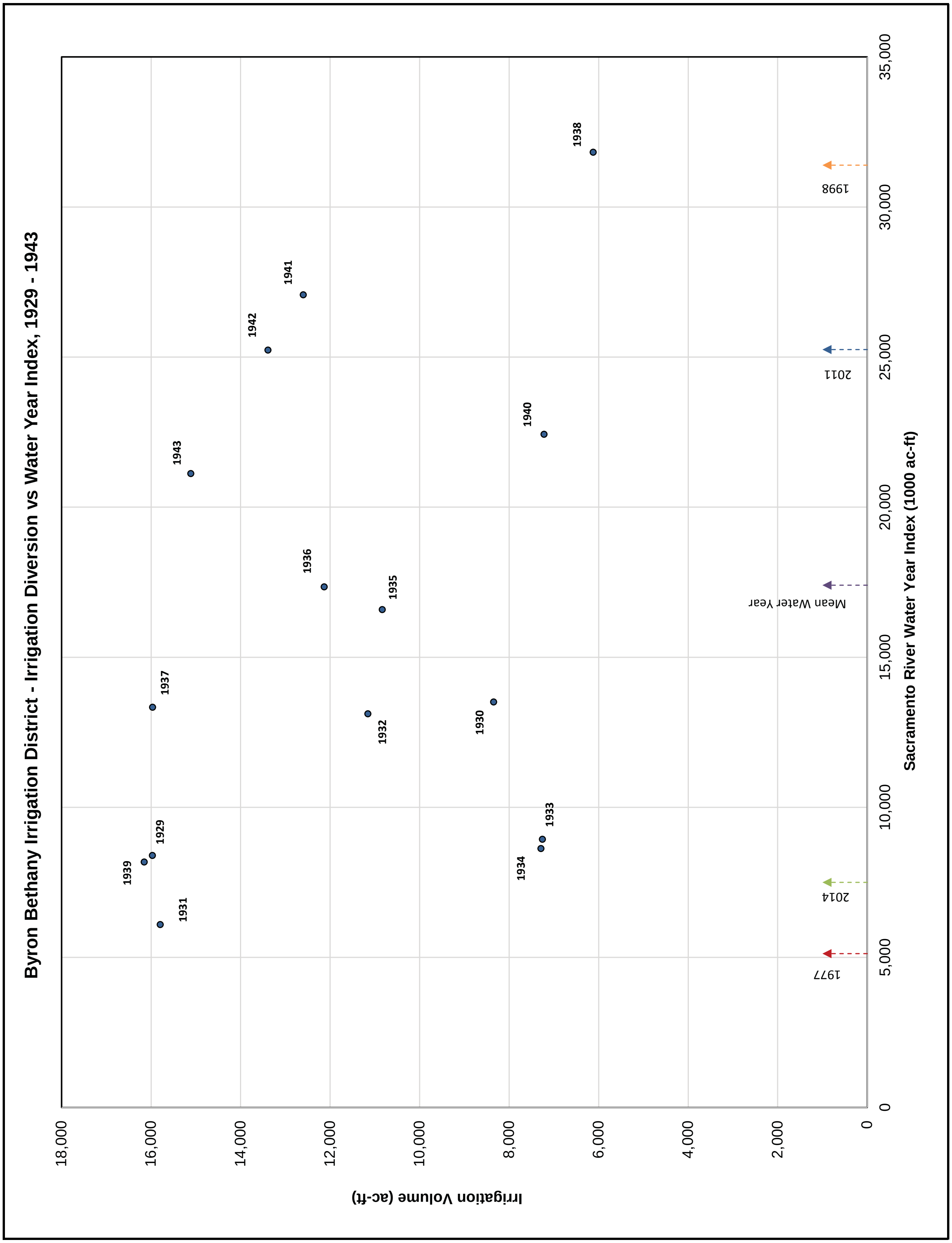

Figure 4-23 BBID Irrigation Diversion vs Water Year Index Between 1929 and 1943.

4.4 Source Water Analysis

The flow patterns and transport of salinity through the Delta was evaluated using the Department of Water Resources DSM2 hydrodynamic model (DWR 2013). This is a one-dimensional unsteady flow model that is based on the FourPt model for simulating unsteady one-dimensional flow in networks of open channels (USGS 1997). The model was used to evaluate the flow and water quality conditions in the Delta for the period 1931-1943.

The DSM2 model has the capability to track the different sources of water that enter the model to a specific location in the Delta. This volumetric fingerprinting feature of the model was used to evaluate the different sources of water that contribute flow to the BBID and WSID POD's at different times of the year for the 1931 and 1939 drought years.

The source volumetric fingerprinting process allowed for the tracking of flow from each tributary that discharges into the Delta as well as tidal flow entering from the west. This feature was also used to disaggregate the Sacramento River flows into 7 different time periods. Each of the 7 different periods could be tracked separately as if each were a different river. The flow from the Sacramento River was separated into individual months for January through June. The July through December period was lumped together for the 7th period. The DSM2 model was then run for the 1929 through 1943 period. The fingerprinting results for the 1931 and 1939 dry years were then evaluated to see how the Sacramento River flow moved through the Delta during a drought. Table 4-1 provides a list of the different source waters that were tracked in the model.

TABLE 4-1 Components of the Source Fingerprinting Analysis

No	Component	Abbreviation
1	Sacramento River - January	Sac-Jan
2	Sacramento River - February	Sac-Feb
3	Sacramento River - March	Sac-March
4	Sacramento River - April	Sac-April
5	Sacramento River - May	Sac-May
6	Sacramento River - June	Sac-June
7	Sacramento River - July-December	Sac-July-Dec
8	Agricultural Return Flow	AG
9	East Side Streams	East
10	Martinez	MTZ
11	Yolo Bypass	Yolo
12	San Joaquin River	San Joaquin

Figures 4-23 through 4-30 are plots showing the contribution of the different tracked sources of flow to the locations at and around the BBID and WSID POD’s during 1931 and 1939.

Figure 4-23 is a plot of the volumetric fingerprinting at the Head of Indian Slough at Old River for 1931. This is the BBID historic POD accessed Old River. An examination of the results shows that during the 1931 drought year, which was dryer than 2014 or 2015, at the beginning of August, up to 58 percent of the flow in Old River at the head of Indian Slough originated from the Sacramento River. The flow did not originate in that particular month, but was composed of Sacramento River flow that gradually entered the Delta from February through May. Based on the fingerprinting results, it takes approximately 4 months for the water from the Sacramento River to reach the Head of Indian Slough. As the San Joaquin River flows decrease during the year, the tidal action flowing into the Delta gradually pushes the Sacramento River water south into the Delta. Its this slow daily pushing that results in the four month lag in the Sacramento River water getting into the south Delta.

Figure 4-24 is a plot of Head of Indian Slough at Old River for 1939. As can be seen in the figure, due to the difference in flow and runoff patterns that occur in different years, the shape of the source components at the mouth of Indian Head Slough is different from 1931. But, the Sacramento River water still made it down to this point in the Delta, peaking around the beginning of September.

The remainder of the fingerprint plots show a similar flow pattern that is typical of the Delta in all years, even extreme drought years. Even in drought years the Sacramento River water enters the South Delta and can make up a sizable component of the flow in mid to late summer.

4.5 Summary of Water Quality Analysis

The water quality analysis evaluated the historic water quality conditions that occurred during the 1930’s, specifically the 1931 and 1939 drought years. Those two years, due to their similarity to the 2014 and 2015 drought years, provide a very good view into how the Delta responds in drought years with respect to water quality without the influence of the Projects. The historic data collected at Clifton Court Ferry and Whitehall are representative of what the water quality would be at the POD’s for the BBID and WSID. The data clearly show that the salinity, during these drought years, did not start to rise until the beginning of August, and didn't peak until late September and early October. This is well beyond the primary growing season. The BBID and WSID diversion data for the 1930’s and the amount of acreage that was being irrigated during those drought years was on par with the acreage and irrigation diversions during wet years during the 1931 to 1943 period.

The source flow fingerprint analysis for 1931 and 1939 showed that a significant amount of Sacramento River water entered into Old River over the summer. It seems to roughly have a 4 month delay prior to reaching the BBID and WSID POD’s. The March, April, and May inflow from the Sacramento River can amount to a significant portion of the volume of water at the diversion points.

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.

From the results of a source flow fingerprint analysis, a significant amount of Sacramento River water flows into Old River over the course of a summer, helping to keep the salinity levels down.

Given that the 1931 and 1939 water years were dryer than the 2014 and 2015 water years, they provide a good comparison of how the water quality would have been at the POD's during 2014 and 2015. Given that no noticeable reduction in irrigation diversions were observed in 1931 or 1939, I would expect that the water quality in 2014 and 2015 would have been acceptable for irrigation as well, especially since they were not as dry as 1931 and 1939.

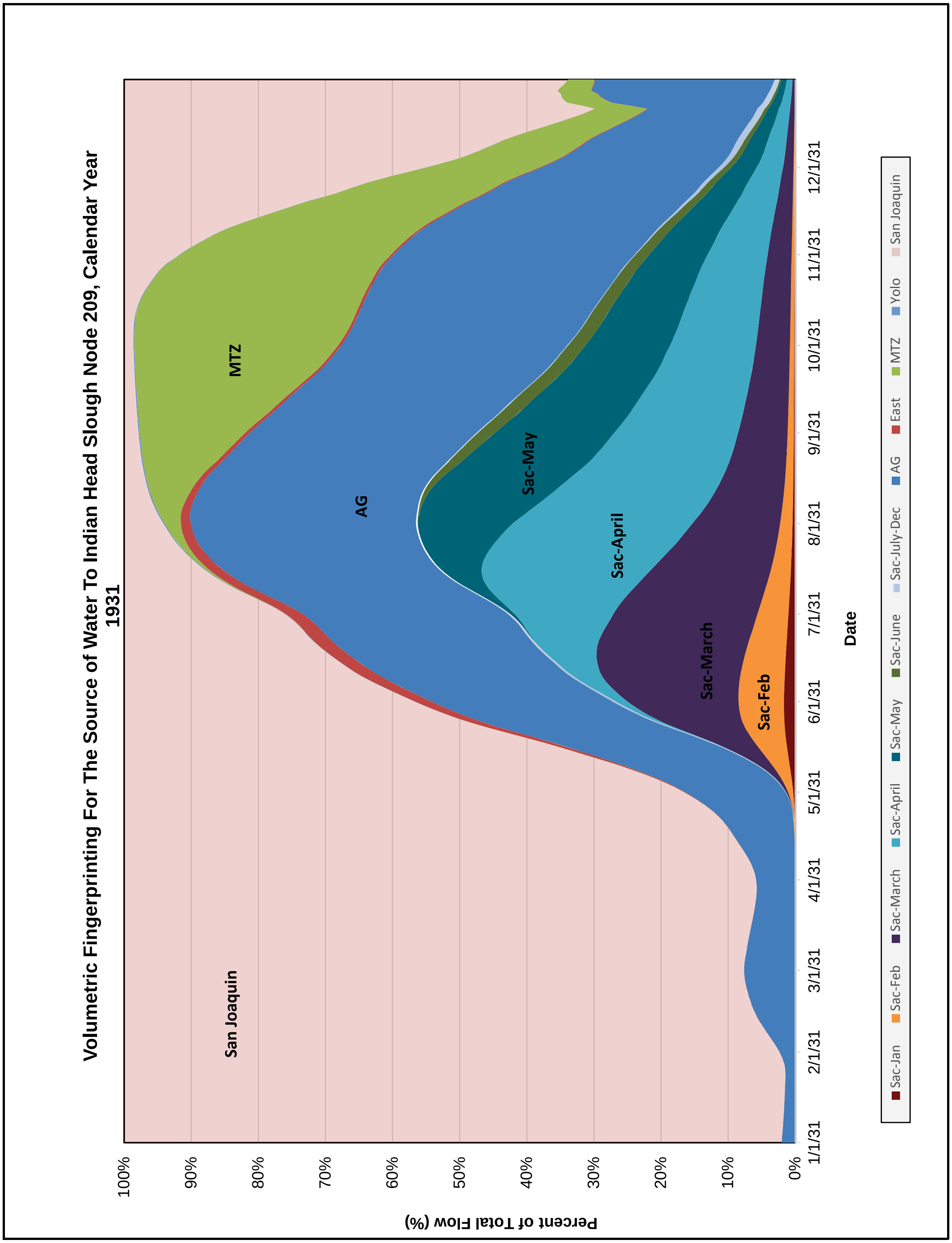

Figure 4-24 Volumetric Fingerprint of Contributing Flows To BBID Historic POD, Indian Head Slough at Old River, 1931

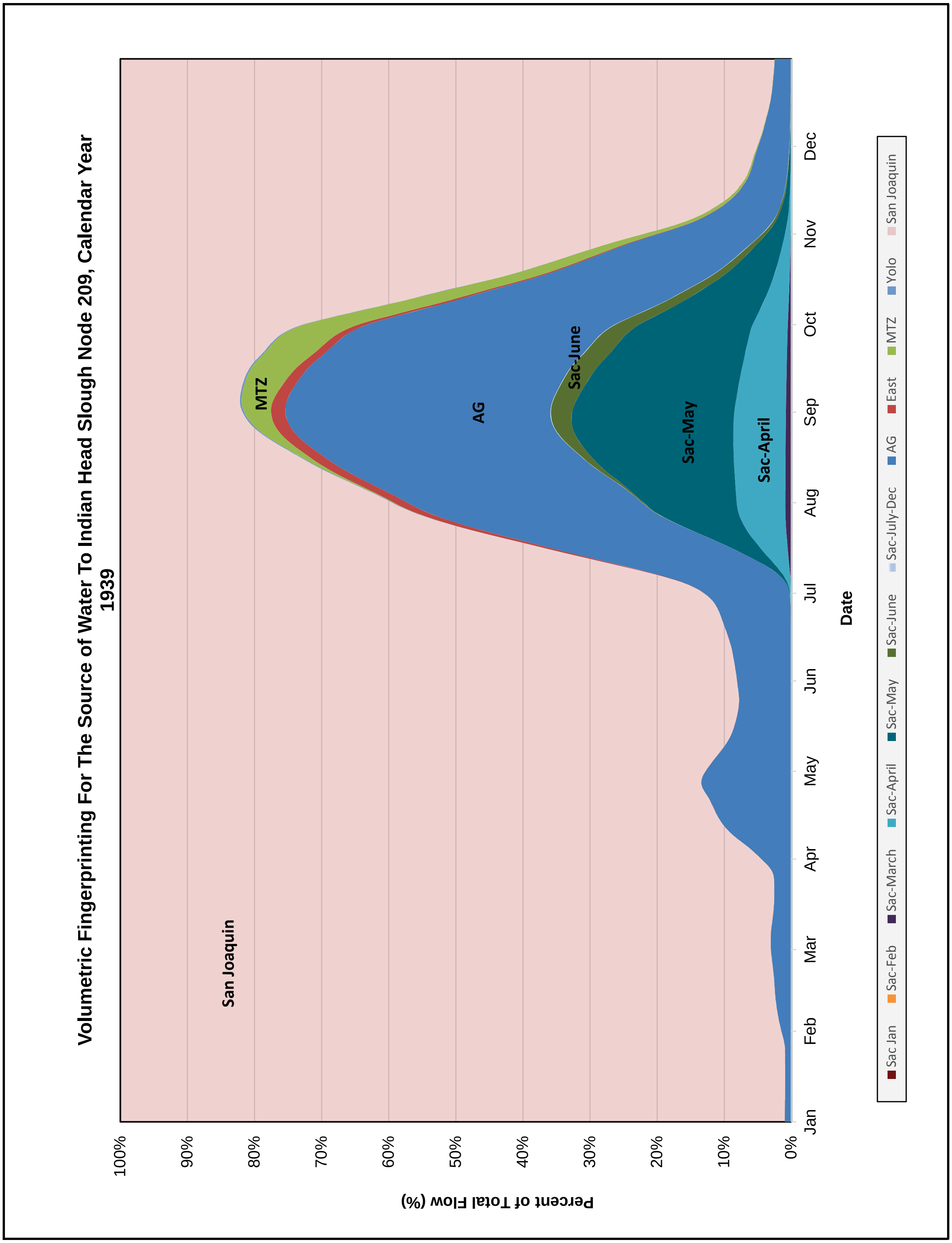

Figure 4-25 Volumetric Fingerprint of Contributing Flows To BBID Historic POD, Indian Head Slough at Old River, 1939

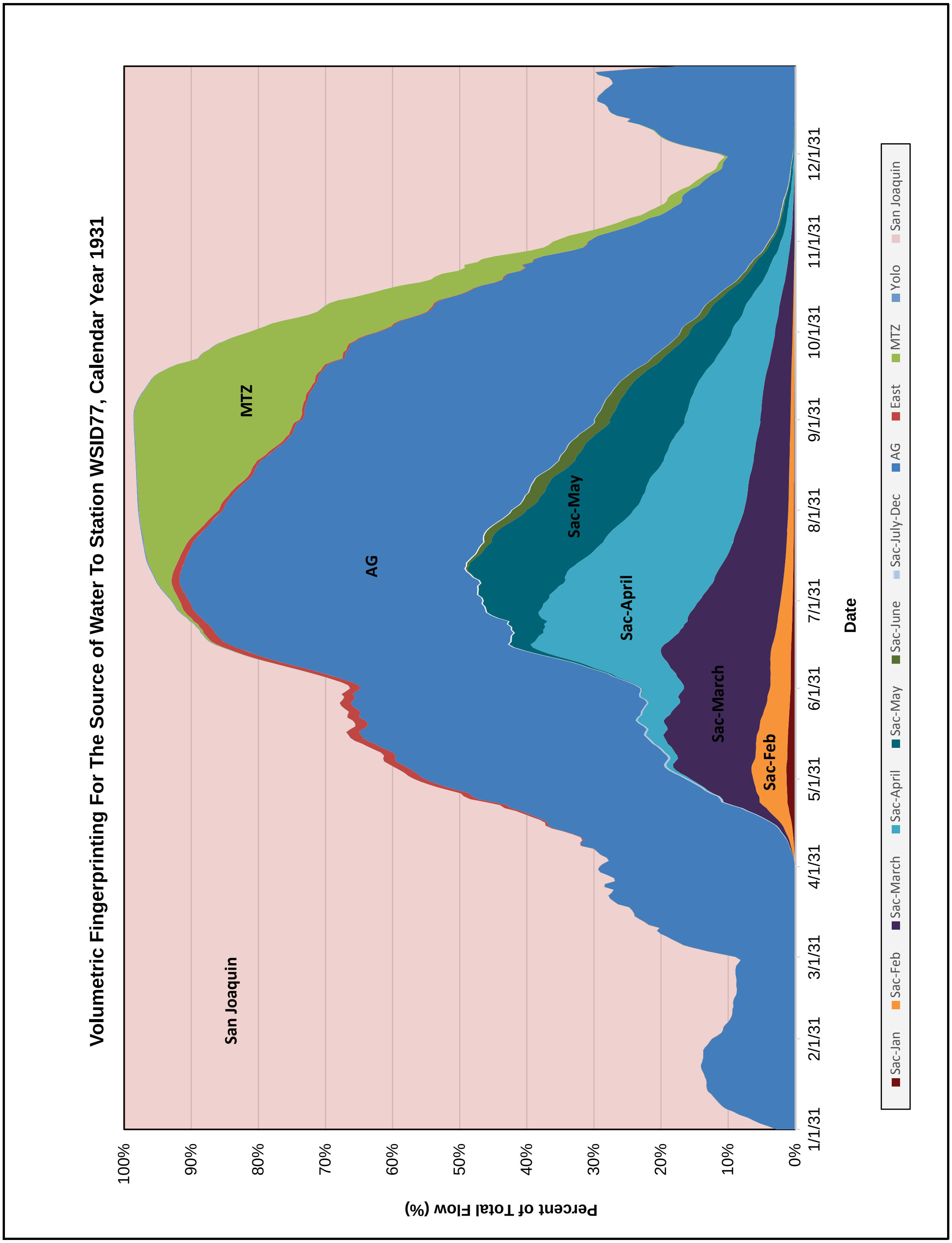

Figure 4-26 Volumetric Fingerprint of Contributing Flows To The WSID POD, Old River, 1931

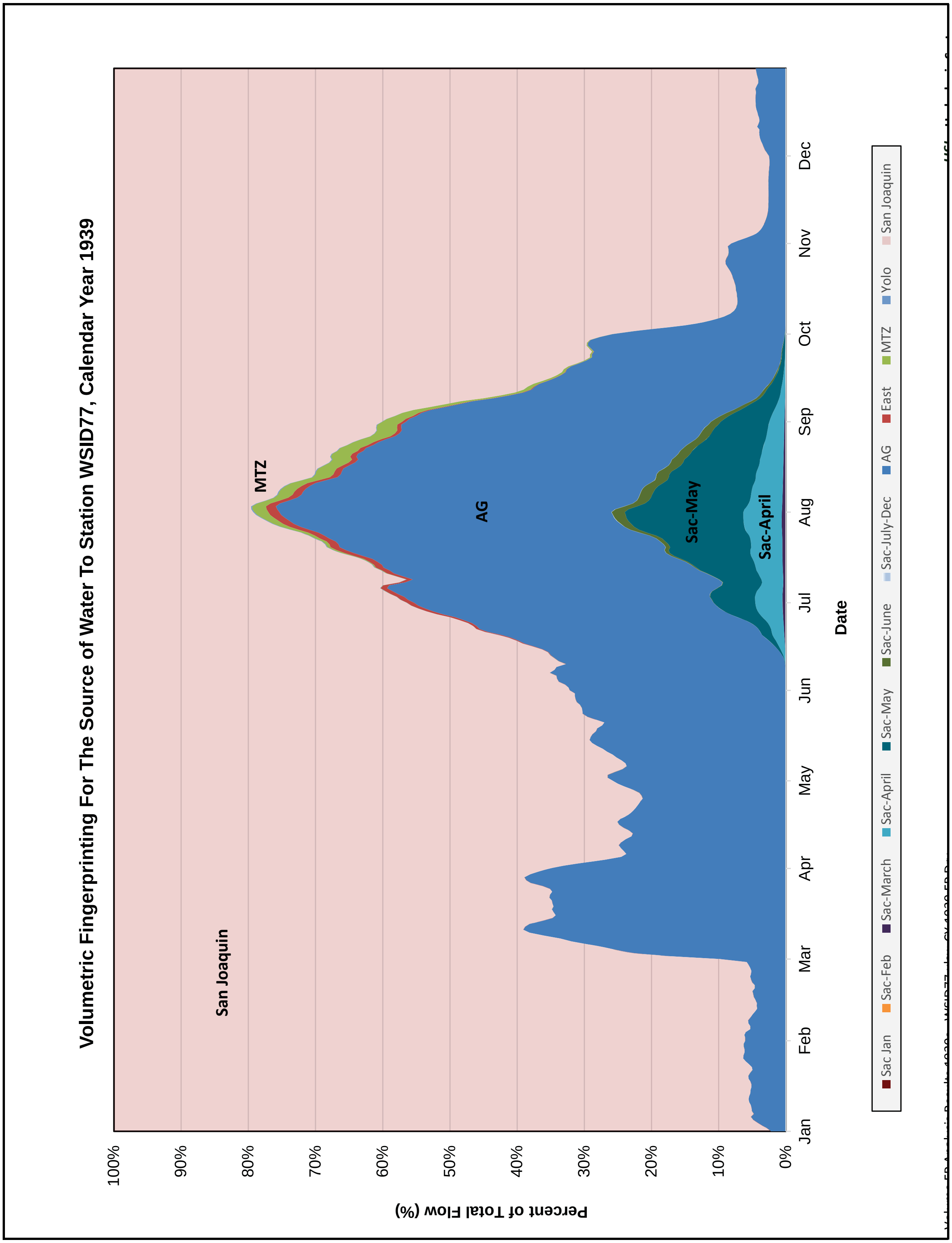

Figure 4-27 Volumetric Fingerprint of Contributing Flows to WSID POD, Old River, 1939

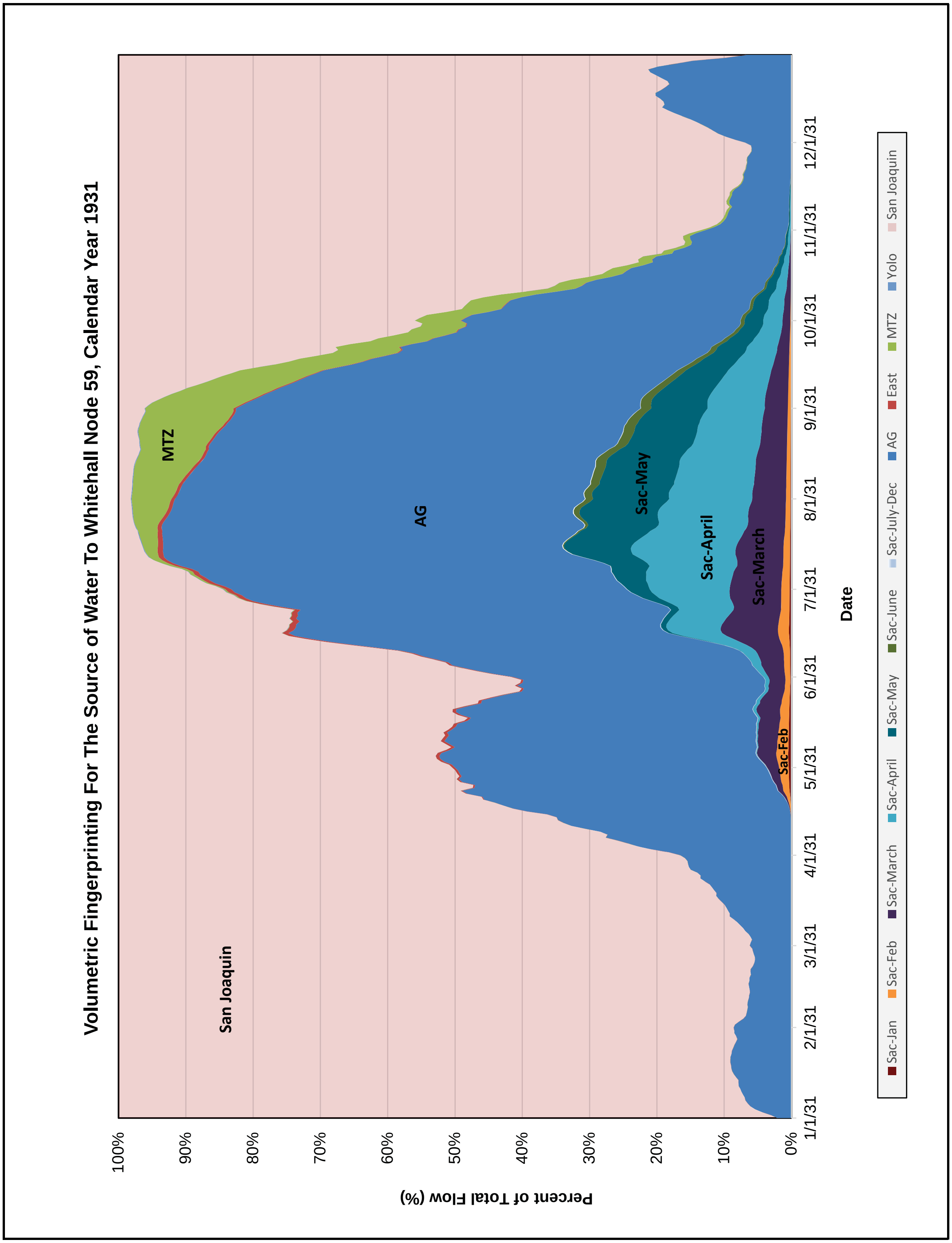

Figure 4-28 Volumetric Fingerprint of Contributing Flows to Whitehall on Old River, 1931

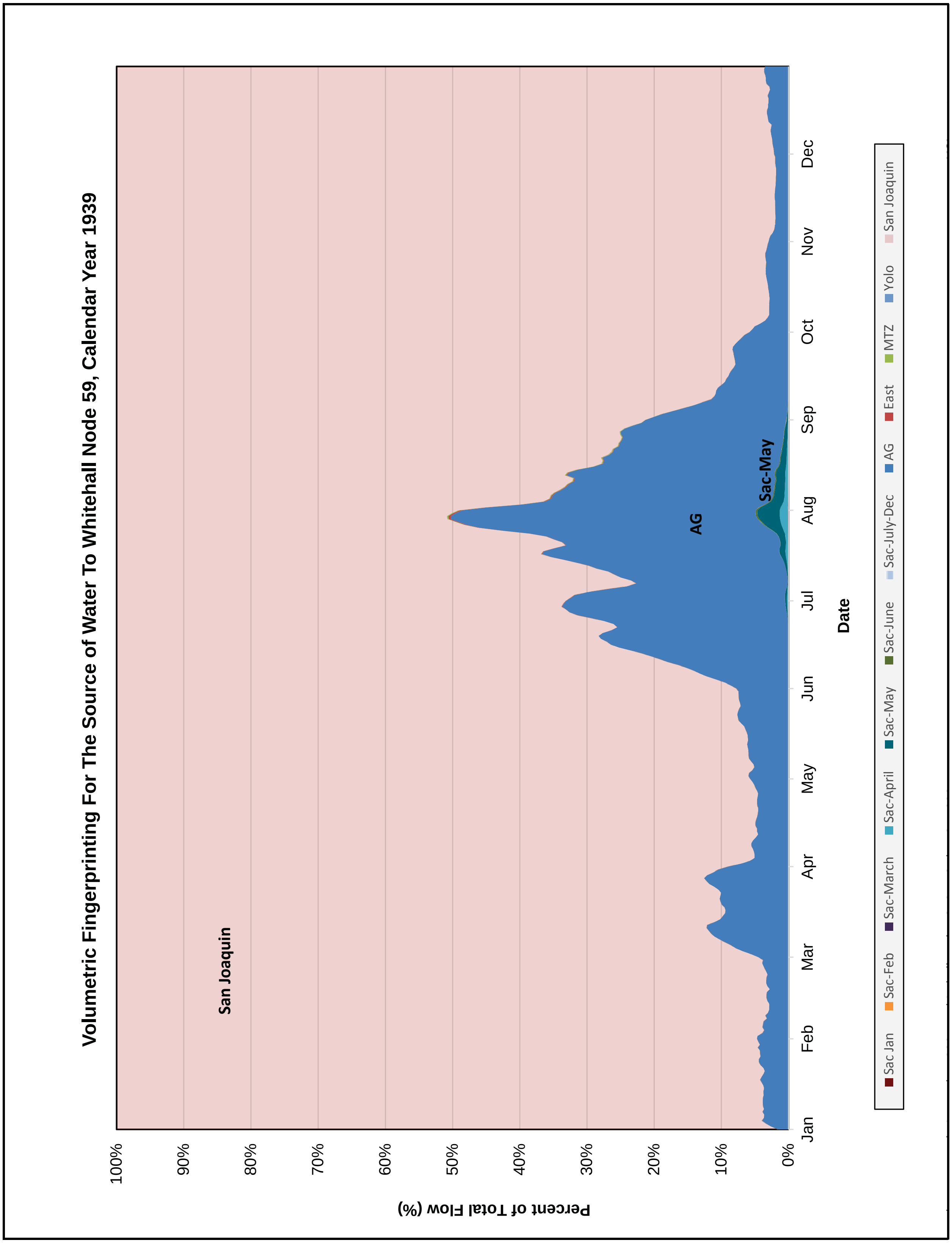

Figure 4-29 Volumetric Fingerprint of Contributing Flows to Whitehall, Old River, 1939

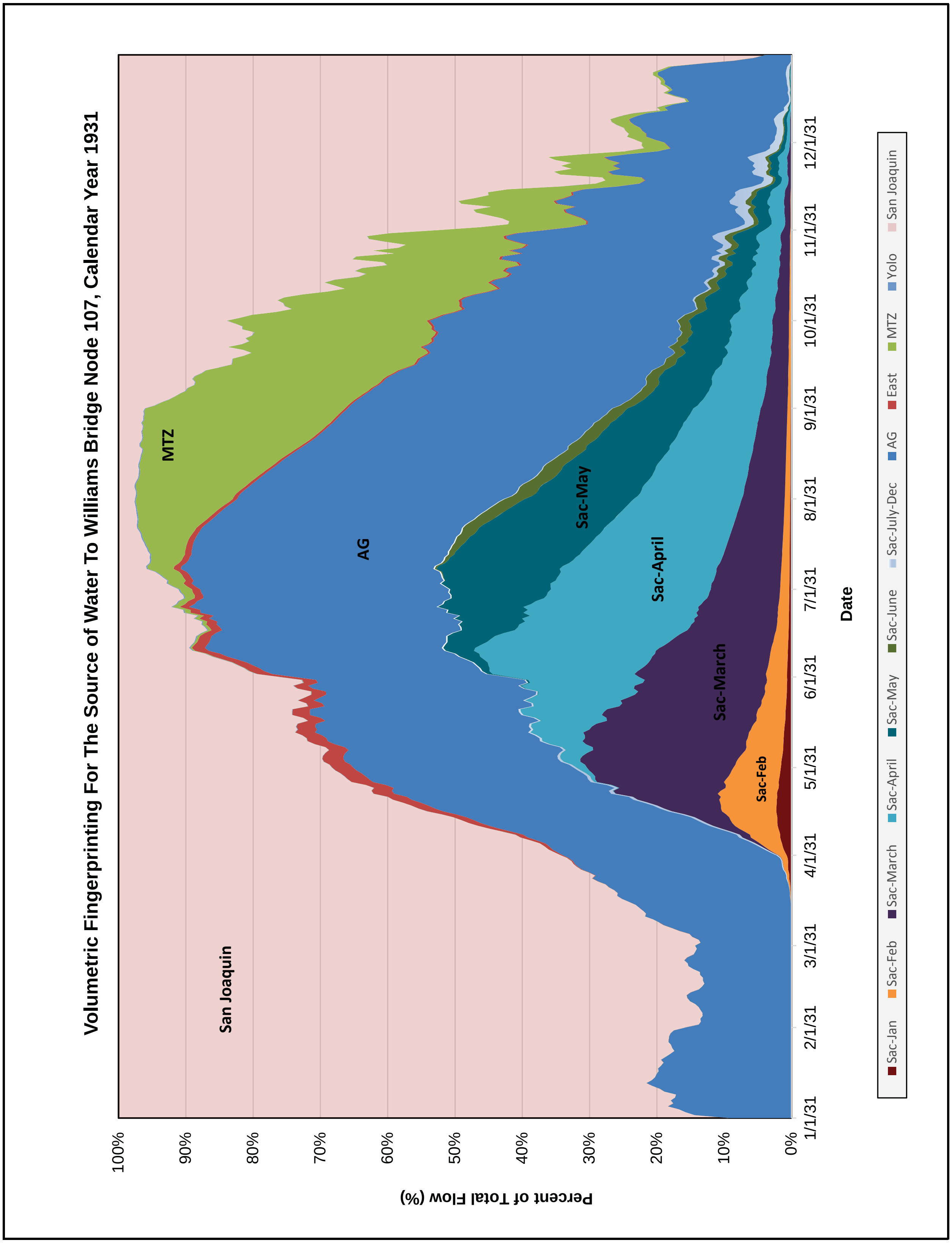

Figure 4-30 Volumetric Fingerprint of Contributing Flows to Williams Bridge, Middle River 1931

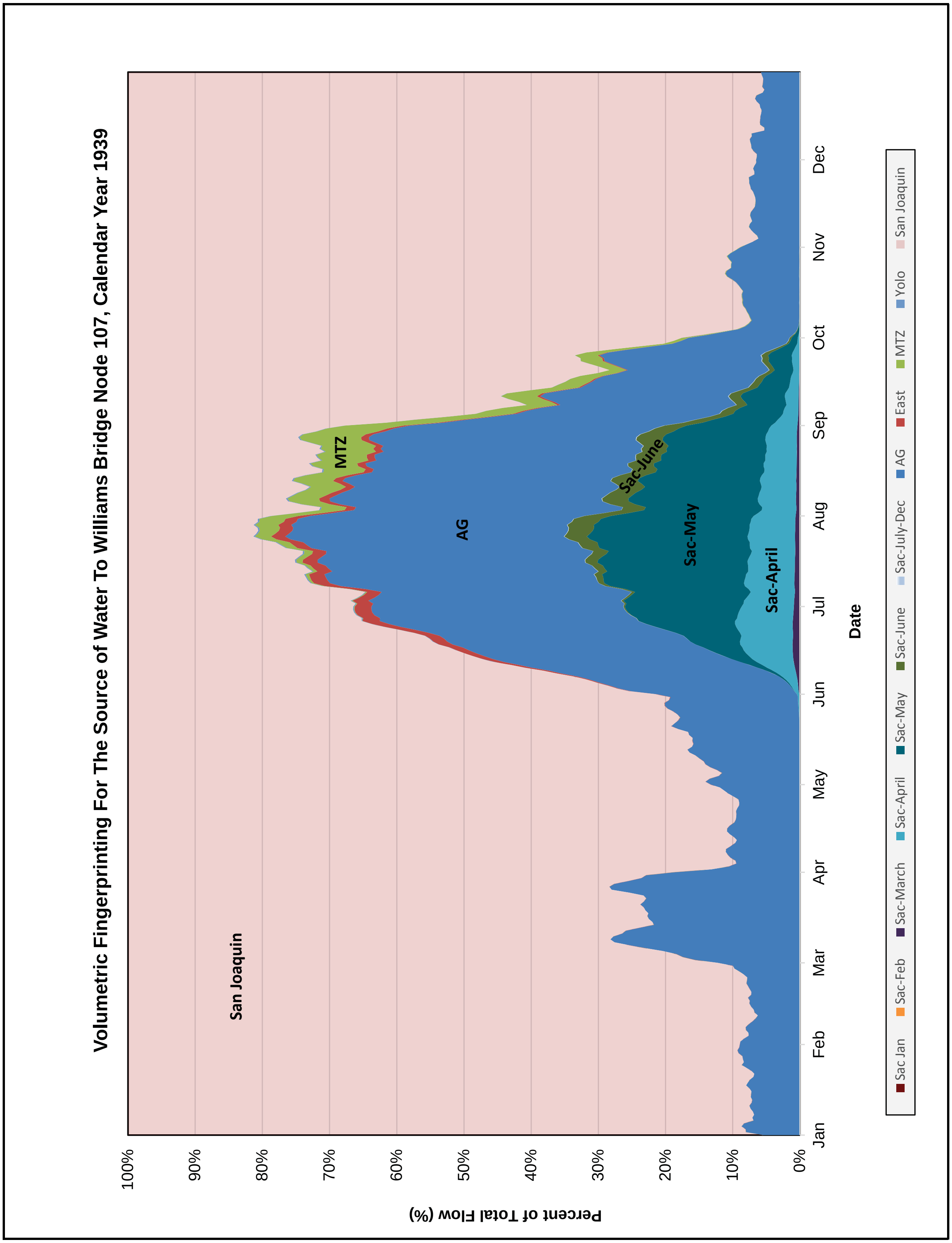

Figure 4-31 Volumetric Fingerprint of Contributing Flows to Williams Bridge, Middle River, 1939.

5 Summary

5.1 Introduction

This study was conducted to analyze the water availability and water quality conditions at the BBID and WSID Points of Diversion on Old River in the California Delta. To perform that analysis the hydraulics of the Delta were evaluated using collected flow, channel geometry, and water quality data at recent and historic gaging stations. The hydrodynamic model DSM2 (DWR 2013), developed by the California Department of Water Resources (DWR) was also used to investigate more detailed hydraulic characteristics of the Delta channel system.

Water Availability

The Delta receives water from tributary rivers that drain into the network of channels as well as tidally driven inflow from the west. As tributary inflow decreases over the summer months, the tidally driven flow dominates the hydraulics of the system pushing the existing water in the system back up into the delta channels as well as adding new water to the system. Given that all of the Delta channels are below sea level this tidal action insures that the interconnected network of channels are refilled with each diurnal tidal cycle, replacing any water that was lost to the system such as through diversions, evaporation, or seepage.

Given the constant refilling of the Delta by tidal inflow, and the ability for the integrated network of Delta channels to respond as a unified system, an extraordinary event would need to occur in order for any of the channels to dry out. During the drought of 2014 and 2015 there was virtually no change in the water level at the BBID and WSID points of diversion as compared to the summer water level during wet years. Figure 5-1 is a plot of the water level at the Old River at Tracy river gage. As can be seen in the figure the August river stage is very consistent between wet and dry years. The high water level will change between wet and dry years, but there is a minimum level that is always maintained due to the fact that the channels are below sea level and supplied by tidal inflow, regardless of what the tributary inflow to the Delta may be.

Therefore, there was water available at the WSID and BBID points of diversion during the subject time frames relative to the draft CDO and ACL Complaint.

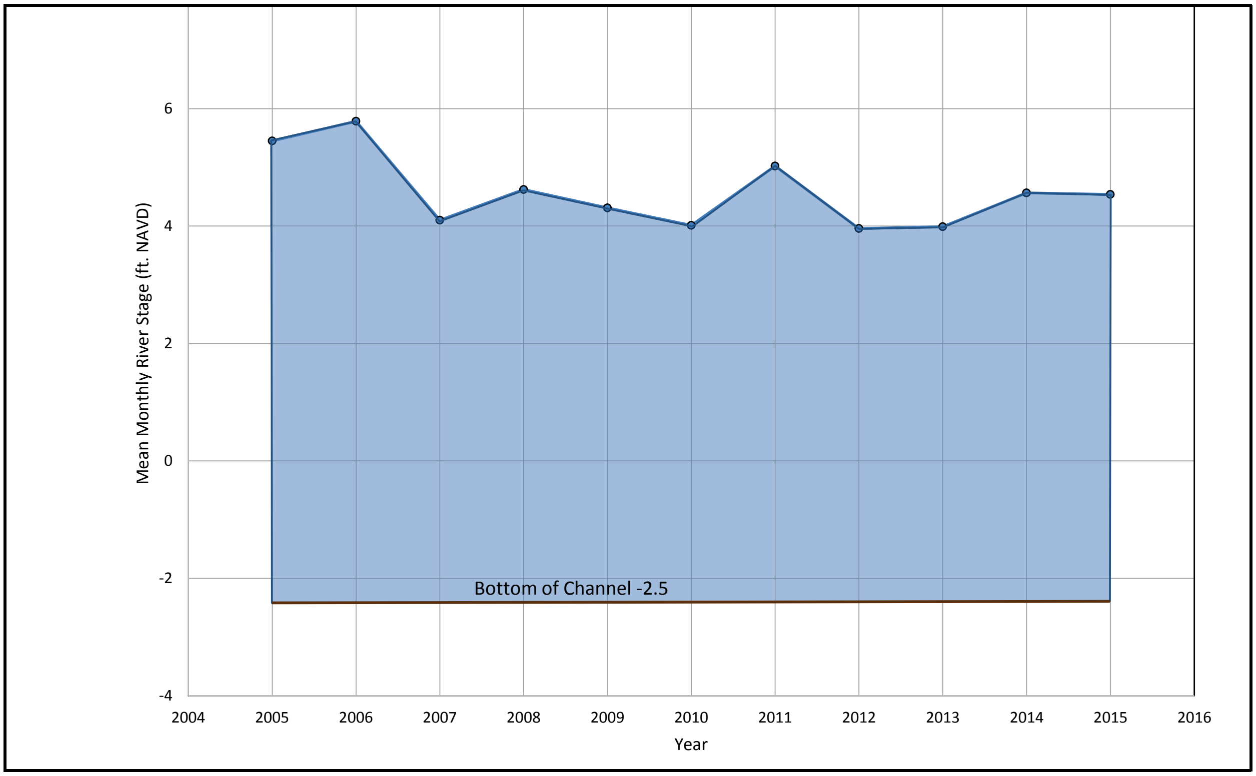

Figure 5-1 Mean Monthly August Water Level At Old River at Tracy, 2014-2016.

WSID Diversion Analysis

Using the DSM2 model, an analysis was conducted to evaluate the impact on Old River from a withdrawal at the West Side Irrigation District's (WSID) Point of Diversion (POD) of 8 cubic feet per second (cfs) or 14 cfs. The results from that analysis, showed that for both diversion dates, the maximum reduction in water level in the channel was less than 0.008 ft.

Figure 5-2 shows the water surface at the WSID POD for the no-diversion and the 14 cfs diversion scenario. As can be seen in the figure, the two water surface elevations are indistinguishable. Additionally, given an existing channel depth of around 10 feet, the reduction in water surface due to the two diversion scenarios of less than one hundredth of a foot is insignificant.

As can be seen from the results, the diversion of 14 cfs and 8 cfs had no impact to the available water in the channel. Therefore, for these diversion rates, there would have been no impact to the available water in the channel during 2015 and the subject time frame relative to the draft CDO.

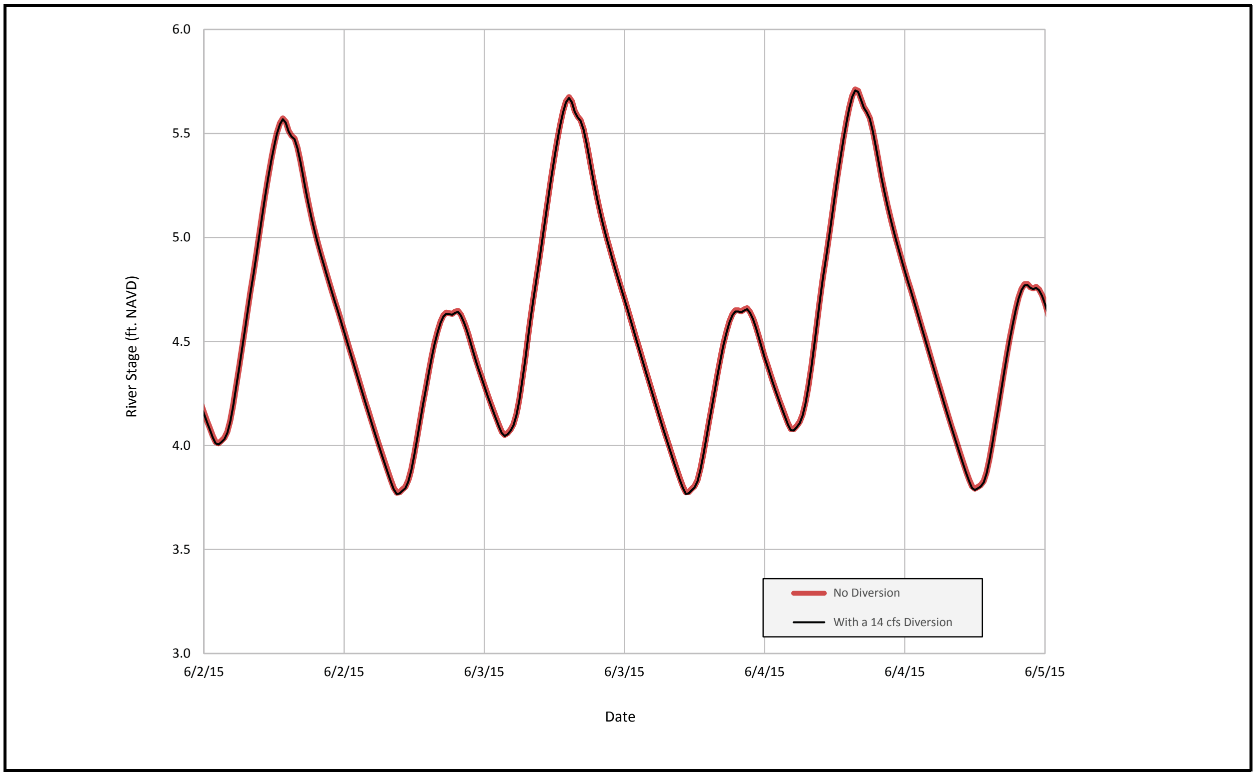

Figure 5-2 Detail of the River Stage at the WSID Diversion Point With and Without the 14 cfs Diversion.

Water Quality

The water quality analysis evaluated the historic water quality conditions that occurred during the 1930's, specifically the 1931 and 1939 drought years. Those two years, due to their similarity to the 2014 and 2015 drought years, provide a very good view into how the Delta responds in drought years with respect to water quality without the influence of the State and Federal Water Projects ("Projects").

The historic data collected at Clifton Court Ferry, and Whitehall are representative of what the water quality would be at the POD's for the BBID and WSID. The data clearly show that the salinity, during these drought years, did not start to rise until the beginning of August, and didn't peak until late September and early October. This is well beyond the primary growing season. The BBID and WSID diversion data for the 1930's and the amount of acreage that was being irrigated during those drought years was on par with the irrigated acreage and irrigation diversions during wet years during the 1931 to 1943 period.

The source flow fingerprint analysis for 1931 and 1939 showed that a significant amount of Sacramento River water entered into Old River over the summer. It seems to roughly have a 4 month delay prior to reaching the BBID and WSID POD's. The March, April, and May inflow from the Sacramento River can amount to a significant portion of the volume of water at the diversion points. Figure 5-3 is a plot of the source fingerprint analysis at the WSID POD for the 1931 drought year.

The flow of Sacramento River water into Old River over the course of a summer, helps to keep the salinity levels down. 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) the water quality during these two drought years did not hinder irrigation diversions.

Given that no noticeable reduction in irrigation diversions were observed in 1931 or 1939, I would expect that the water quality in 2014 and 2015 would have been acceptable for irrigation as well, especially since they were not as dry as 1931 and 1939.

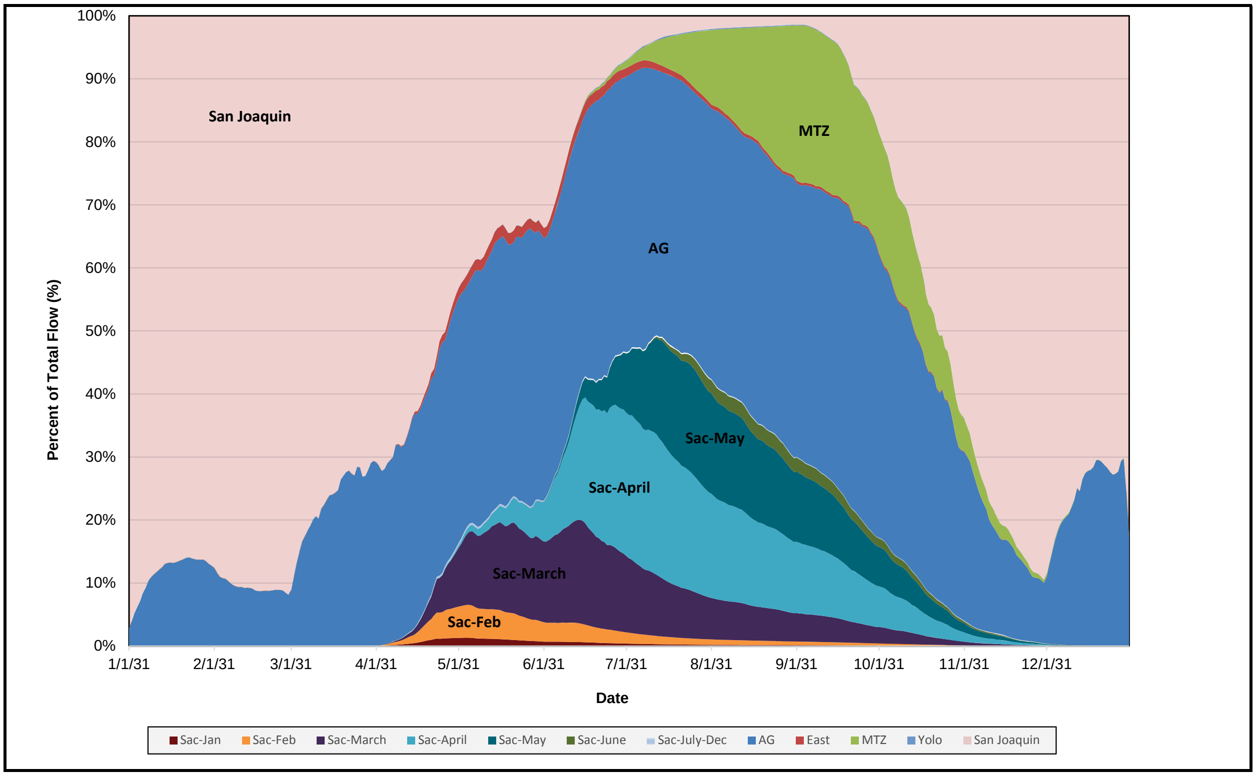

Figure 5-3 Volumetric Fingerprint of Contributing Flows To The WSID POD, Old River, 1931

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Appendices

A. NDWA Contract

B. Historic Water Quality Data

Appendix A -

CONTRACT BETWEEN STATE OF CALIFORNIA

DEPARTMENT OF WATER RESOURCES

AND

NORTH DELTA WATER AGENCY

FOR THE ASSURANCE OF A DEPENDABLE WATER SUPPLY OF SUITABLE QUALITY

CONTRACT
BETWEEN
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
AND
NORTH DELTA WATER AGENCY

FOR THE ASSURANCE
OF A DEPENDABLE WATER SUPPLY OF SUITABLE QUALITY

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CONTRACT BETWEEN THE STATE OF CALIFORNIA DEPARTMENT OF WATER RESOURCES AND THE NORTH DELTA WATER AGENCY FOR THE ASSURANCE OF A DEPENDABLE WATER SUPPLY OF SUITABLE QUALITY

THIS CONTRACT, made this 28th day of Jan, 1981, between the STATE OF CALIFORNIA, acting by and through its DEPARTMENT OF WATER RESOURCES (State), and the NORTH DELTA WATER AGENCY (Agency), a political subdivision of the State of California, duly organized and existing pursuant to the laws thereof, with its principal place of business in Sacramento, California.

RECITALS

(a) The purpose of this contract is to assure that the State will maintain within the Agency a dependable water supply of adequate quantity and quality for agricultural uses and, consistent with the water quality standards of Attachment A, for municipal and industrial uses, that the State will recognize the right to the use of water for agricultural, municipal, and industrial uses within the Agency, and that the Agency will pay compensation for any reimbursable benefits allocated to water users within the Agency resulting from the Federal Central Valley Project and the State Water Project, and offset by any detriments caused thereby.

(b) The United States, acting through its Department of the Interior, has under construction and is operating the Federal Central Valley Project (FCVP).

(c) The State has under construction and is operating the State Water Project (SWP).

(d) The construction and operation of the FCVP and SWP at times have changed and will further change the regimen of rivers tributary to the Sacramento-San Joaquin Delta (Delta) and the regimen of the Delta channels from unregulated flow to regulated flow. This regulation at times improves the quality of water in the Delta and at times diminishes the quality from that which would exist in the absence of the FCVP and SWP. The regulation at times also alters the elevation of water in some Delta channels.

(e) Water problems within the Delta are unique within the State of California. As a result of the geographical location of the lands of the Delta and tidal influences, there is no physical shortage of water. Intrusion of saline ocean water and municipal, industrial and agricultural discharges and return flows, tend, however, to deteriorate the quality.

(f) The general welfare, as well as the rights and requirements of the water users in the Delta, require that there be maintained in the Delta an adequate supply of good quality water for agricultural, municipal and industrial uses.

(g) The law of the State of California requires protection of the areas within which water originates and the watersheds in which water is developed. The Delta is such an area and within such a watershed. Part 4.5 of Division 6 of the California Water Code affords a first priority to provision of salinity control and maintenance of an adequate water supply in the Delta for reasonable and beneficial uses of water and relegates to lesser priority all exports of water from the Delta to other areas for any purpose.

(h) The Agency asserts that water users within the Agency have the right to divert, are diverting, and will continue to divert, for reasonable beneficial use, water from the Delta that would have been available therein if the FCVP and SWP were not in existence, together with the right to enjoy or acquire such benefits to which the water users may be entitled as a result of the FCVP and SWP.

(i) Section 4.4 of the North Delta Water Agency Act, Chapter 283, Statutes of 1973, as amended, provides that the Agency has no authority or power to affect, bind, prejudice, impair, restrict, or limit vested water rights within the Agency.

(j) The State asserts that it has the right to divert, is diverting, and will continue to divert water from the Delta in connection with the operation of the SWP.

(k) Operation of SWP to provide the water quality and quantity described in this contract constitutes a reasonable and beneficial use of water.

(l) The Delta has an existing gradient or relationship in quality between the westerly portion most seriously affected by ocean salinity intrusion and the interior portions of the Delta where the effect of ocean salinity intrusion is diminished. The water quality criteria set forth in this contract establishes minimum water qualities at various monitoring locations. Although the water quality criteria at upstream locations is shown as equal in some periods of some years to the water quality at the downstream locations, a better quality will in fact exist at the upstream locations at almost all times. Similarly, a better water quality than that shown for any given monitoring location will also exist at interior points upstream from that location at almost all times.

(m) It is not the intention of the State to acquire by purchase or by proceeding in eminent domain or by any other manner the water rights of water users within the Agency, including rights acquired under this contract.

(n) The parties desire that the United States become an additional party to this contract.

AGREEMENTS

1. **Definitions.** When used herein, the term:

(a) "Agency" shall mean the North Delta Water Agency and shall include all of the lands within the boundaries at the time the contract is executed as described in Section 9.1 of the North Delta Water Agency Act, Chapter 283, Statutes of 1973, as amended.

(b) "Calendar year" shall mean the period January 1 through December 31.

(c) "Delta" shall mean the Sacramento-San Joaquin Delta as defined in Section 12220 of the California Water Code as of the date of the execution of the contract.

(d) "Electrical Conductivity" (EC) shall mean the electrical conductivity of a water sample measured in millimhos per centimeter per square centimeter corrected to a standard temperature of 25° Celsius determined in accordance with procedures set forth in the publication entitled "Standard Methods of Examination of Water and Waste Water", published jointly by the American Public Health Association, the American Water Works Association, and the Water Pollution Control Federation, 13th Edition, 1971, including such revisions thereof as may be made subsequent to the date of this contract which are approved in writing by the State and the Agency.

(e) "Federal Central Valley Project" (FCVP) shall mean the Central Valley Project of the United States.

(f) "Four-River Basin Index" shall mean the most current forecast of Sacramento Valley unimpaired runoff as presently published in the California Department of Water Resources Bulletin 120 for the sum of the flows of the following: Sacramento River above Bend Bridge near Red Bluff; Feather River, total inflow to Oroville Reservoir; Yuba River at Smartville; American River, total inflow to Folsom Reservoir. The May 1 forecast shall continue in effect until the February 1 forecast of the next succeeding year.

(g) "State Water Project" (SWP) shall mean the State Water Resources Development System as defined in Section 12931 of the Water Code of the State of California.

(h) "SWRCB" shall mean the State Water Resources Control Board.

(i) "Water year" shall mean the period October 1 of any year through September 30 of the following year.

2. **Water Quality.**

(a) (i) The State will operate the SWP to provide water qualities at least equal to the better of: (1) the standards adopted by the SWRCB as they may be established from time to time; or (2) the criteria established in this contract as identified on the graphs included as Attachment A.

(ii) The 14-day running average of the mean daily EC at the identified location shall not exceed the values determined from the Attachment A graphs using the Four-River Basin Index except for the period February through March of each year at the location in the Sacramento River at Emmaton for which the lower value of the 80 percent probability range shall be used.

(iii) The quality criteria described herein shall be met at all times except for a transition period beginning one week before and extending one week after the date of change in periods as shown on the graphs of Attachment A. During this transition period, the SWP will be operated to provide as uniform a transition as possible over the two-week period from one set of criteria to the next so as to arrive at the new criteria one week after the date of change in period as shown on the graphs of Attachment A.

(b) While not committed affirmatively to achieving a better water quality at interior points upstream from Emmaton than those set forth on Attachment A, the State agrees not to alter the Delta hydraulics in such manner as to cause a measurable adverse change in the ocean salinity gradient or relationship among the various monitoring locations shown on Attachment B and interior points upstream from those locations, with any particular flow past Emmaton.

(c) Whenever the recorded 14-day running average of mean daily EC of water in the Sacramento River at Sacramento exceeds 0.25 mmhos, the quality criteria indicated on the graphs of Attachment A may be adjusted by adding to the value taken therefrom the product of 1.5 times the amount that the recorded EC of the Sacramento River at Sacramento exceeds 0.25 mmhos.

3. **Monitoring.** The quality of water shall be measured by the State as needed to monitor performance pursuant to Article 2 hereof with equipment installed, operated, and maintained by the State, at locations indicated on "Attachment B". Records of such measurements shall at regular intervals be furnished to the Agency. All monitoring costs at North Fork Mokelumne River near Walnut Grove, Sacramento River at Walnut Grove, and Steamboat Slough at Sutter Slough incurred by the State solely for this contract shall be shared equally by the Agency and the State. All monitoring costs to be borne by the Agency for monitoring at the above locations are included in the payment under Article 10.

4. **Emergency Provisions.**

(a) If a structural emergency occurs such as a levee failure or a failure of an SWP facility, which results in the State's failure to meet the water quality criteria, the State shall not be in breach of this contract if it makes all reasonable efforts to operate SWP facilities so that the water quality criteria will be met again as soon as possible. For any period in which SWP failure results in failure of the State to meet the water quality criteria, the State shall waive payment under Article 10, prorated for that period, and the amount shall be deducted from the next payment due.

(b) (i) A drought emergency shall exist when all of the following occur:

(1) The Four-River Basin Index is less than an average of 9,000,000 acre feet in two consecutive years (which occurred in 1933-4 and 1976-7); and

(2) An SWRCB emergency regulation is in effect providing for the operation of the SWP to maintain water quality different from that provided in this contract; and

(3) The water supplied to meet annual entitlements of SWP agricultural contractors in the San Joaquin Valley is being reduced by at least 50 percent of these agricultural entitlements (it being the objective of the SWP to avoid agricultural deficiencies in excess of 25 percent) or the total of water supplied to meet annual entitlements of all SWP contractors is being reduced by at least 15 percent of all entitlements, whichever results in the greater reduction in acre feet delivered.

(ii) A drought emergency shall terminate if any of the conditions in (b) (i) of this Article ceases to exist or if the flow past Sacramento after October 1 exceeds 20,000 cubic feet per second each day for a period of 30 days.

(iii) Notwithstanding the provisions of Article 2 (a), when a drought emergency exists, the emergency water quality criteria of the SWRCB shall supersede the water quality requirements of this contract to the extent of any inconsistency; provided, however, that the State shall use all reasonable efforts to preserve Delta water quality, taking into consideration both the limited water supply available for that purpose and recognizing the priority established for Delta protection referred to in Recital (g).

(iv) When a drought emergency exists, and an overland supply is not available to an individual water user comparable in quality and quantity to the water which would have been available to the user under Attachment A, the State shall compensate the user for loss of net income for each acre either (A) planted to a more salt-tolerant crop in the current year, (B) not planted to any crop in the current year provided such determination not to plant was reasonable based on the drought emergency, or (C) which had a reduced yield due to the drought emergency, calculated on the basis of the user's average net income for any three of the prior five years for each such acre. A special contract claims procedure shall be estalished by the State to expedite and facilitate the payment of such compensation.

5. **Overland Water Supply Facilities.**

(a) Within the general objectives of protecting the western Delta areas against the destruction of agricultural productivity as a result of the increased salinity of waters in the Delta channels resulting in part from SWP operation, the State may provide diversion and overland facilities to supply and distribute water to Sherman Island as described in the report entitled "Overland Agricultural Water Facilities Sherman Island" dated January 1980. Final design and operating specifications shall be subject to approval of the Agency and Reclamation District No. 341. The Agency or its transferee will assume full ownership, operation, and maintenance responsibility for such facilities after successful operation as specified. After the facilities are constructed and operating, the water qualitry criteria for the Sacramento River at Emmaton shall apply at the intake of the facilities in Three Mile Slough.

(b) The State and the Agency may agree to the construction and operation of additional overland water supply facilities within the Agency, so long as each landowner served by the overland facilities receives a quality of water not less than that specified in Attachment A for the upstream location nearest to his original point of diversion. The design and operation of such facilities and the cost sharing thereof are subject to approval of any reclamation district which includes within its boundaries the area to be served. The ownership, operation, and maintenance of diversion works and overland facilities shall be the subject of a separate agreement between the Agency or its transferees and the State.

6. **Flow Impact.** The State shall not convey SWP water so as to cause a decrease or increase in the natural flow, or reversal of the natural flow direction, or to cause the water surface elevation in Delta channels to be altered, to the detriment of Delta channels or water users within the Agency. If lands, levees, embankments, or revetments adjacent to Delta channels within the Agency incur seepage or erosion damage or if diversion facilities must be modi-

fied as a result of altered water surface elevations as a result of the conveyance of water from the SWP to lands outside the Agency after the date of this contract, the State shall repair or alleviate the damage, shall improve the channels as necessary, and shall be responsible for all diversion facility modifications required.

7. **Place of Use of Water.**

(a) Any subcontract entered into pursuant to Article 18 shall provide that water diverted under this contract for use within the Agency shall not be used or otherwise disposed of outside the boundaries of the Agency by the subcontractor.

(b) Any subcontract shall provide that all return flow water from water diverted within the Agency under this contract shall be returned to the Delta channels. Subject to the provisions of this contract concerning the quality and quantity of water to be made available to water users within the Agency, and to any reuse or recapture by water users within the Agency, the subcontractor relinquishes any right to such return flow, and as to any portion thereof which may be attributable to the SWP, the subcontractor recognizes that the State has not abandoned such water.

(c) If water is attempted to be used or otherwise disposed of outside the boundaries of the Agency so that the State's rights to return flow are interfered with, the State may seek appropriate administrative or judicial action against such use or disposal.

(d) This article shall not relieve any water user of the responsibility to meet discharge regulations legally imposed.

8. **Scope of Contract.**

(a) During the term of this contract:

(i) This contract shall constitute the full and sole agreement between the State and the Agency as to (1) the quality of water which shall be in the Delta channels, and (2) the payment for the assurance given that water of such quality shall be in the Delta channels for reasonable and beneficial uses on lands within the Agency, and said diversions and uses shall not be disturbed or challenged by the State so long as this contract is in full force and effect.

(ii) The State recognizes the right of the water users of the Agency to divert from the Delta channels for reasonable and beneficial uses for agricultural, municipal and industrial purposes on lands within the Agency, and said diversions and uses shall not be disturbed or challenged by the State so long as this contract is in full force and effect, and the State shall furnish such water as may be required within the Agency to the extent not otherwise available under the water rights of water users.

(iii) The Agency shall not claim any right against the State in conflict with the provisions hereof so long as this contract remains in full force and effect.

(b) Nothing herein contained is intended to or does limit rights of the Agency against others than the State, or the State against any person other than the Agency and water users within the Agency.

(c) This contract shall not affect, bind, prejudice, impair, restrict, or limit vested water rights within the Agency.

(d) The Agency agrees to defend affirmatively as reasonable and beneficial the water qualities established in this contract. The State agrees to defend affirmatively as reasonable and beneficial the use of water required to provide and sustain the qualities established in this contract. The State agrees that such use should be examined only after determination by a court of competent jurisdiction that all uses of water exported from the Delta by the State and by the United States, for agricultural, municipal, and industrial purposes are reasonable and beneficial, and that irrigation practices, conservation efforts, and groundwater management within areas served by such exported water should be examined in particular.

(e) The Agency consents to the State's export of water from the Delta so long as this contract remains in full force and effect and the State is in compliance herewith.

9. **Term of Contract.**

(a) This contract shall continue in full force and effect until such time as it may be terminated by the written consent and agreement of the parties hereto, provided that 40 years after execution of this contract and every 40 years thereafter, there shall be a six-month period of adjustment during which any party to this contract can negotiate with the other parties to revise the contract as to the provisions set out in Article 10. If, during this period, agreement as to a requested revision cannot be achieved, the parties shall petition a court of competent jurisdiction to resolve the issue as to the appropriate payment to be made under Article 10. In revising Article 10, the court shall review water quality and supply conditions within the Agency under operation of the FCVP and SWP, and identify any reimbursable benefits allocated to water users within the Agency resulting from operation of the FCVP and SWP, offset by any detriments caused thereby. Until such time as any revision is final, including appeal from any ruling of the court, the contract shall remain in effect as without such revision.

(b) In the event this contract terminates, the parties' water rights to quality and quantity shall exist as if this contract had not been entered into.

10. **Amount and Method of Payment for Water.**

(a) The Agency shall pay each year as consideration for the assurance that an adequate water supply and the specific water quality set forth in this contract will be maintained and monitored, the sum of one hundred seventy thousand dollars ($170,000.00). The annual payments shall be made to the State one-half on or before January 1 and one-half on or before July 1 of each year commencing with January 1, 1982.

(b) The payment established in (a) above shall be subject to adjustment as of January 1, 1987, and every fifth year thereafter. The adjusted payment shall bear the same relation to the payment specified in (a) above that the mean of the State's latest projected Delta Water Rate for the five years beginning with the year of adjustment bears to $10.00 per acre foot; provided that, no adjusted payment shall exceed the previous payment by more than 25 percent.

(c) The payments provided for in this article shall be deposited by the State in trust in the California Water Resources Development System Revenue Account in the California Water Resources Development Bond Fund. The trust shall continue for five years (or such longer period as the State may determine) but shall be terminated when the United States executes a contract as provided in Article 11 with the State and the Agency at which time the proportion of the trust fund that reflects the degree to which the operation of the FCVP has contributed to meeting the water quality standard under this contract as determined solely by the State shall be paid to the United States (with a pro rata share of interest). In the event that the United States has not entered into such a contract before the termination of the trust, the trust fund shall become the sole property of the State.

11. **Participation of the United States.** The Agency will exercice its best efforts to secure United States joinder and concurrence with the terms of this contract and the State will diligently attempt to obtain the joinder and concurrence of the United States with the terms of this contract and its participation as a party hereto. Such concurrence and participation by the United States in this contract shall include a recognition ratified by the Congress that the excess land provisions of Federal reclamation law shall not apply to this contract.

12. **Remedies.**

(a) The Agency shall be entitled to obtain specific performance of the provisions of this contract by a decree of the Superior Court in Sacramento County requiring the State to meet the standards set forth in this contract. If the water quality in Delta channels falls below that provided in this contract, then, at the request of the Agency, the State shall cease all diversions to storage in SWP reservoirs or release stored water from SWP reservoirs or cease all export by the SWP from Delta channels, or any combination of these, to the extent that such action will further State compliance with the water quality standards set forth in this contract, except that the State may continue to export from Delta channels to the extent required to meet water quality requirements in contracts with the Delta agencies specified in Section 11456 of the California Water code.

(b) To the extent permitted by law, the State agrees to forego the use of eminent domain proceedings to acquire water rights of water users within the Agency or any rights acquired under this contract for water or water quality maintenance for the purpose of exporting such water from the Delta. This provision shall not be construed to prohibit the utilization of eminent domain proceedings for the purpose of acquiring land or any other rights necessary for the construction of water facilities.

(c) Except as provided in the water quality assurances in Article 2 and the provisions of Article 6 and Article 8, neither the State nor its officers, agents, or employees shall be liable for or on account of:

(i) The control, carriage, handling, use, disposal, or distribution of any water outside the facilities constructed, operated and maintained by the State.

(ii) Claims of damage of any nature whatsoever, including but not limited to property loss or damage, personal injury or death arising out of or connected with the control, carriage, handling, use, disposal or distribution of any water outside of the facilities constructed, operated and maintained by the State.

(d) The use by the Agency or the State of any remedy specified herein for the enforcement of this contract is not exclusive and shall not deprive either from using any other remedy provided by law.

13. **Comparable Treatment.** In the event that the State gives on the whole substantially more favorable treatment to any other Delta entity under similar circumstances than that accorded under this contract to the Agency, the State agrees to renegotiate this contract to provide comparable treatment to the Agency under this contract.

GENERAL PROVISIONS

14. **Amendments.** This contract may be amended or terminated at any time by mutual agreement of the State and the Agency.

15. **Reservation With Respect to State Laws.** Nothing herein contained shall be construed as estopping or otherwise preventing the Agency, or any person, firm, association, corporation, or public body claiming by, through, or under the Agency, from contesting by litigation or other lawful means, the validity, constitutionality, construction or application of any law of the State of California.

16. **Opinions and Determinations.** Where the terms of this contract provide for action to be based upon the opinion, judgment, approval, review, or determination of either party hereto, such terms are not intended to be and shall never be construed as permitting such opinion, judgment, approval, review, or determination to be arbitrary, capricious, or unreasonable.

17. **Successors and Assigns Obligated.** This contract and all of its provisions shall apply to and bind the successors and assigns of the parties hereto.

18. **Assignment and Subcontract.** The Agency may enter into subcontracts with water users within the Agency boundaries in which the assurances and obligations provided in this contract as to such water user or users are assigned to the area covered by the subcontract. The Agency shall remain primarily liable and shall make all payments required under this contract. No assignment or transfer of this contract, or any part hereof, rights hereunder, or interest herein by the Agency, other than a subcontract containing the same terms and conditions, shall be valid unless and until it is approved by the State and made subject to such reasonable terms and conditions as the State may impose. No assignment or transfer of this contract or any part hereof, rights hereunder, or interest herein by the State shall be valid except as such assignment or transfer is made pursuant to and in conformity with applicable law.

19. **Books, Records, Reports, and Inspections Thereof.** Subject to applicable State laws and regulations, the Agency shall have full and free access at all reasonable times to the SWP account books and official records of the State insofar as the same pertain to the matters and things provided for in this contract, with the right at any time during office hours to make copies thereof, and the proper representatives of the State shall have similar rights with respect to the account books and records of the Agency.

20. **Waiver of Rights.** Any waiver at any time by either party hereto of its rights with respect to a default, or any other matter arising in connection with this contract, shall not be deemed to be a waiver with respect to any other default or matter.

21. **Assurance Relating to Validity of Contract.** This contract shall be effective after its execution by the Agency and the State. Promptly after the execution and delivery of this contract, the Agency shall file and prosecute to a final decree, including any appeal therefrom to the highest court of the State of California, in a court of competent jurisdiction a special proceeding for the judicial examination, approval, and confirmation of the proceedings of the Agency's Board of Directors and of the Agency leading up to and including the making of this contract and the validity of the provisions thereof as a binding and enforceable obligation upon the State and the Agency. If, in this proceeding or other proceeding before a court of competent jurisdiction, any portion of this contract should be determined to be constitutionally invalid, then the remaining portions of this contract shall remain in full force and effect unless modified by mutual consent of the parties.

22. **Notices.** All notices that are required either expressly or by implication to be given by one party to the other shall be deemed to have been given if delivered personally or if enclosed in a properly addressed, postage prepaid, envelope and deposited in a United States Post Office. Unless or until formally notified otherwise, the Agency shall address all notices to the State as follows:

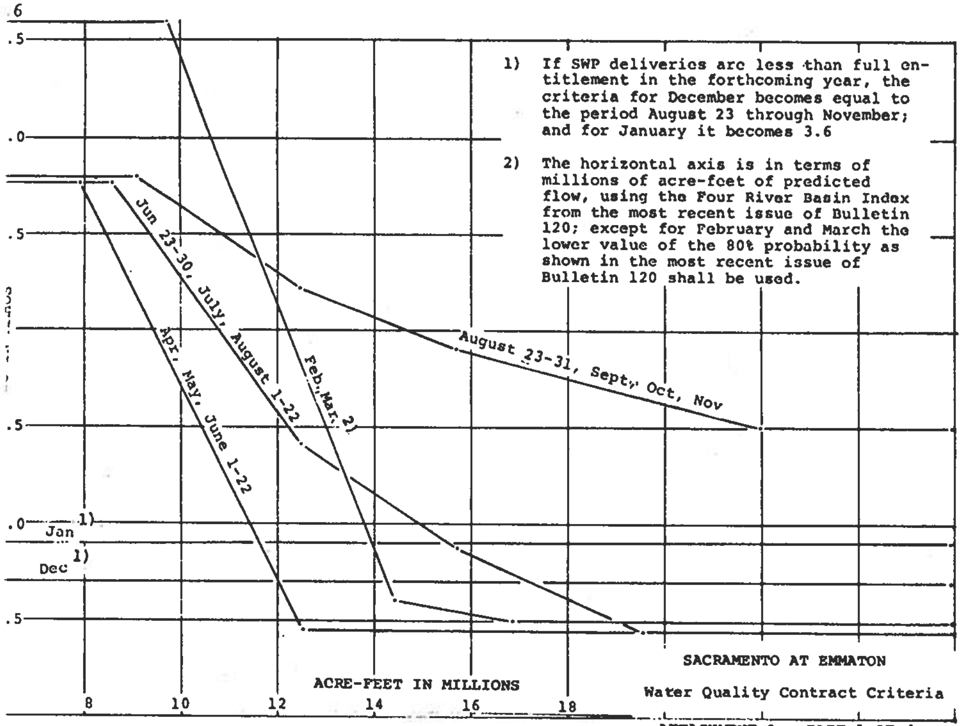
Director, Department of Water Resources
P.O. Box 388
Sacramento, California 95802

and the State shall address all notices to the Agency as follows:

North Delta Water Agency
333 Forum Building, 1107 - 9th Street
Sacramento, California 95814

IN WITNESS WHEREOF, the parties hereto have executed this contract on the date first above written.

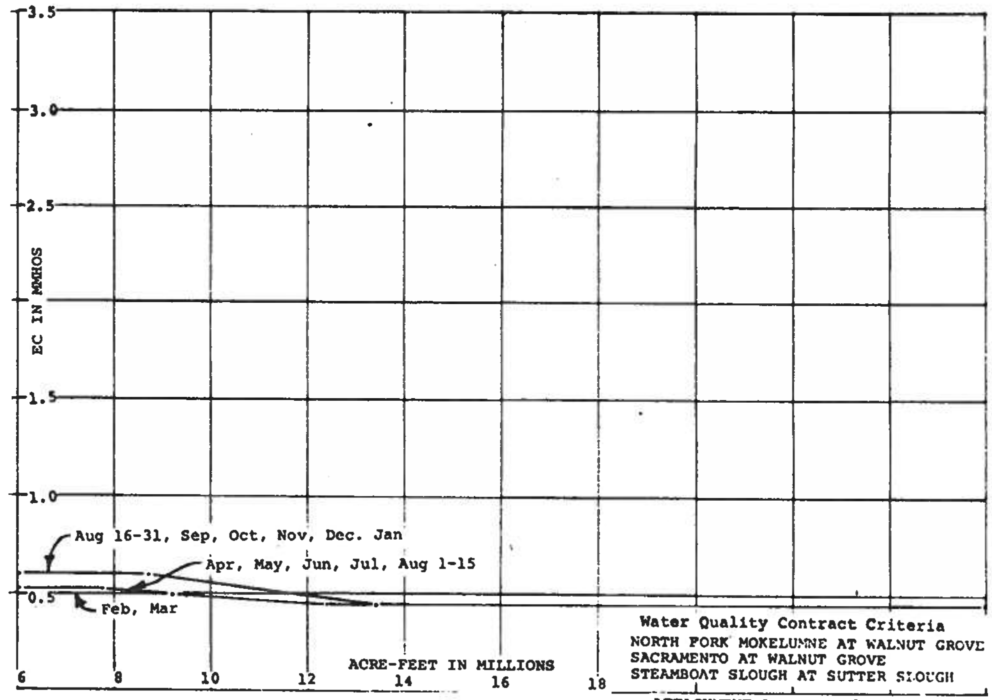
Approved as to legal form and sufficiency:	STATE OF CALIFORNIA
By /s/ P. A. TOWNER Chief Counsel Dept. of Water Resources	By /s/ RONALD B. ROBIE Dept. of Water Resources
Approved as to legal form and sufficiency:	NORTH DELTA WATER AGENCY
By /s/ GEORGE BASYE General Counsel North Delta Water Agency	By /s/ W. R. DARSIE Chairman Board of Directors



SACRAMENTO AT EMMATON

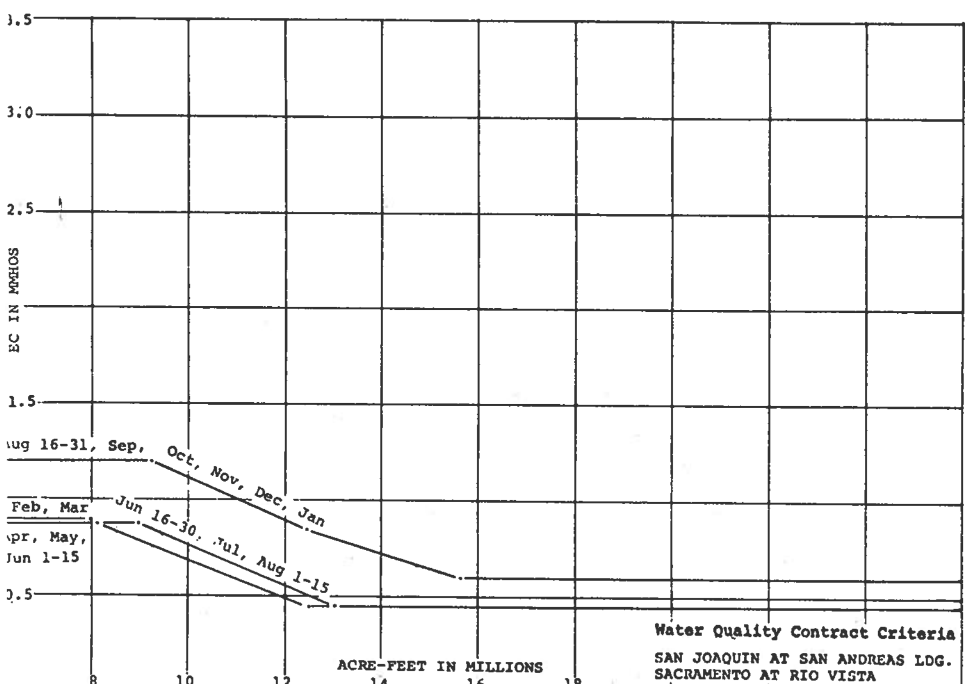
Water Quality Contract Criteria

ATTACHMENT A - PART 1 OF 4



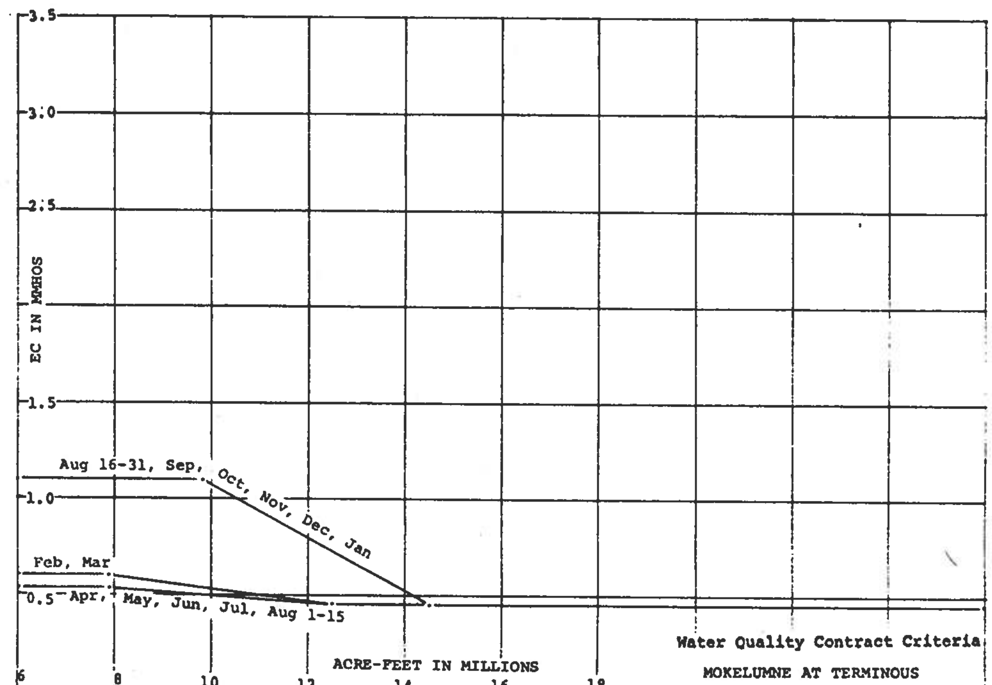
Water Quality Contract Criteria
NORTH FORK MOKELUMNE AT WALNUT GROVE
SACRAMENTO AT WALNUT GROVE
STEAMBOAT SLOUGH AT SUTTER SLOUGH

ATTACHMENT A - PART 2 OF 4



Water Quality Contract Criteria
SAN JOAQUIN AT SAN ANDREAS LDG.
SACRAMENTO AT RIO VISTA

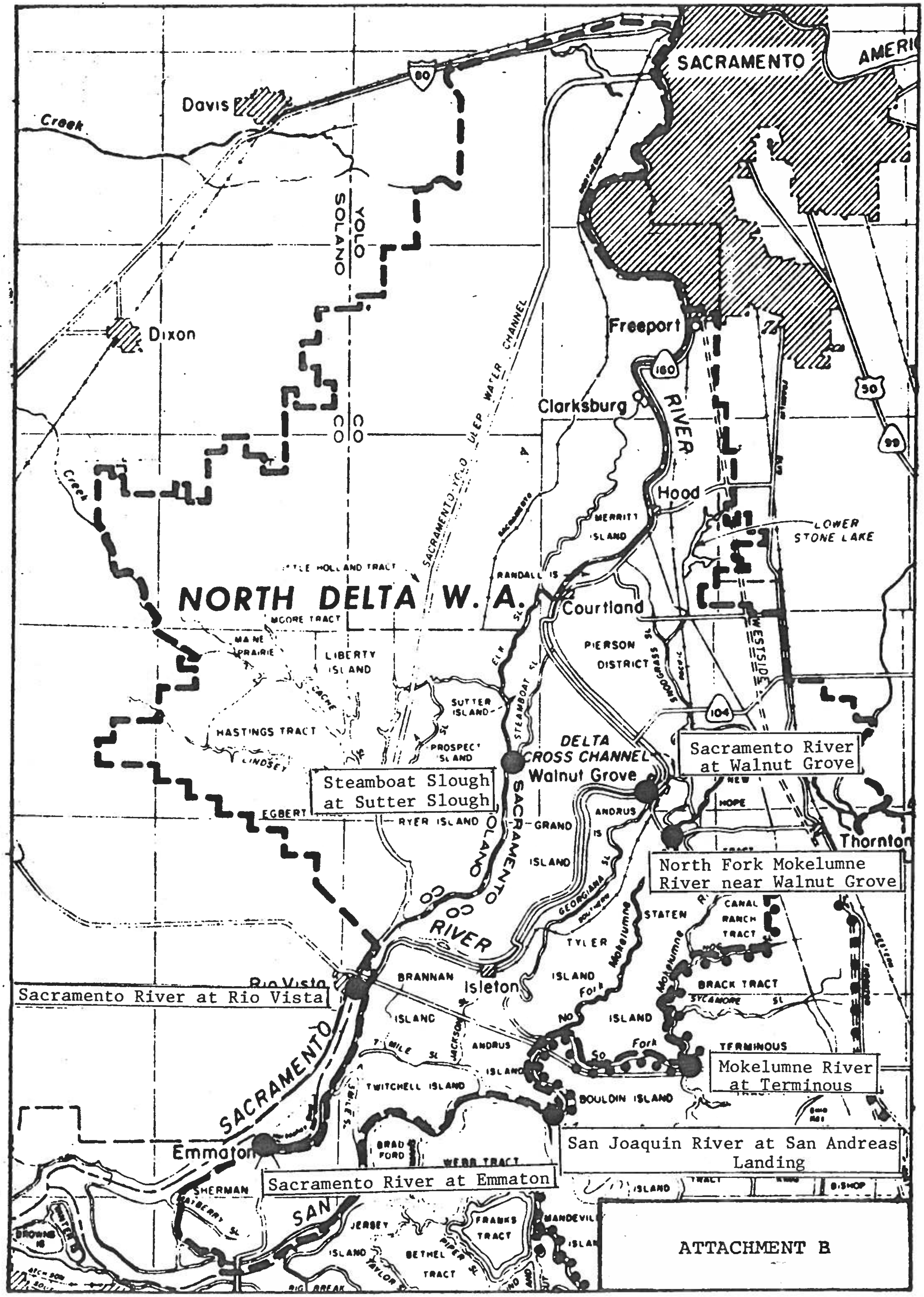
ATTACHMENT A - PART 3 OF 4



Water Quality Contract Criteria

MOKELUMNE AT TERMINOUS

ATTACHMENT A - PART 4 OF 4



ATTACHMENT B

Appendix B - Historic Water Quality Data

Chloride Data Collected In The Delta

Historic Delta Water Quality Data

Point Orient		Point Davis		Clifton Court Ferry		Williams Bridge		Whitehall		Mossdale (Hwy) Bridge	
Date	ppm	Date	ppm	Date	ppm	Date	ppm	Date	ppm	Date	ppm
1/2/31	15400	1/2/31	12500	7/14/31	160	7/14/31	150	7/30/31	160	1/2/31	70
1/6/31	16400	1/6/31	11500	7/18/31	180	7/18/31	150	8/2/31	180	1/6/31	70
1/10/31	15200	1/10/31	10800	7/22/31	190	7/22/31	160	8/4/31	160	1/10/31	90
1/14/31	15400	1/14/31	9400	7/26/31	270	7/26/31	200	8/10/31	190	1/14/31	80
1/18/31	14200	1/18/31	11000	7/30/31	340	7/30/31	300	8/14/31	210	1/18/31	70
1/22/31	14000	1/22/31	10200	8/2/31	390	8/2/31	310	8/18/31	240	1/22/31	70
1/26/31	13800	1/26/31	8100	8/6/31	390	8/6/31	430	8/22/31	290	1/26/31	60
1/30/31	14100	1/30/31	10200	8/10/31	560	8/10/31	520	8/26/31	280	1/30/31	60
2/2/31	15500	2/2/31	10800	8/12/31	670	8/14/31	580	8/30/31	280	2/2/31	60
2/6/31	14700	2/6/31	10200	8/14/31	680	8/18/31	680	9/2/31	310	2/6/31	70
2/10/31	15400	2/10/31	9400	8/18/31	370	8/22/31	840	9/6/31	230	2/10/31	70
2/18/31	13300	2/14/31	9900	8/22/31	810	8/26/31	940	9/10/31	230	2/14/31	70
2/22/31	13200	2/18/31	7600	8/26/31	940	8/30/31	1000	9/14/31	240	2/18/31	80
2/26/31	13600	2/22/31	8100	8/30/31	800	9/2/31	1180	9/18/31	160	2/22/31	70
3/2/31	14900	2/26/31	7800	9/2/31	940	9/6/31	800	9/22/31	160	2/26/31	70
3/6/31	14600	3/2/31	9600	9/6/31	1100	9/10/31	800	9/30/31	120	3/2/31	90
3/10/31	14200	3/6/31	9600	9/10/31	1000	9/14/31	960	10/2/31	110	3/6/31	100
3/14/31	13400	3/10/31	8600	9/14/31	1280	9/18/31	600	10/6/31	120	3/10/31	120
3/18/31	14400	3/14/31	9200	9/18/31	1300	9/22/31	500	10/10/31	80	3/14/31	150
3/22/31	12300	3/18/31	9100	9/22/31	1300	9/26/31	420	10/14/31	80	3/18/31	150
3/26/31	12400	3/26/31	5800	9/26/31	1300	9/30/31	210	10/18/31	80	3/22/31	130
3/30/31	12100	3/30/31	9200	10/2/31	1090	10/6/31	190	10/22/31	80	3/30/31	130
4/2/31	15200	4/2/31	10200	10/6/31	1120	10/10/31	240	10/26/31	80	4/2/31	130
4/6/31	15800	4/6/31	9700	10/10/31	1250	10/14/31	110	10/30/31	90	4/6/31	120
4/10/31	14200	4/10/31	9200	10/14/31	660	10/18/31	110	11/2/31	90	4/10/31	130
4/14/31	14500	4/14/31	9400	10/18/31	1030	10/22/31	80	11/6/31	90	4/14/31	120
4/18/31	15100	4/18/31	10400	10/22/31	690	10/26/31	80	11/10/31	100	4/18/31	100
4/22/31	16000	4/22/31	13100	10/26/31	610	10/30/31	110			4/22/31	110
4/26/31	15500	4/26/31	12500	10/30/31	210	11/2/31	200			4/26/31	100
4/30/31	15800	4/30/31	12700	11/2/31	120	11/6/31	110			4/30/31	100
5/2/31	15400	5/2/31	13200	11/14/31	150	11/10/31	140			5/2/31	90
5/6/31	16100	5/6/31	13200	11/18/31	280	11/14/31	110			5/6/31	80
5/10/31	16000	5/10/31	12800	11/22/31	180	11/18/31	110			5/10/31	70

Historic Delta Water Quality Data

Point Orient	
Date	ppm
5/14/31	15200
5/18/31	16400
5/22/31	16400
5/26/31	16700
5/30/31	16000
6/2/31	17400
6/6/31	16800
6/10/31	16400
6/14/31	17400
6/18/31	17100
6/22/31	17200
6/26/31	17400
6/30/31	17400
7/6/31	17700
7/10/31	17800
7/14/31	17800
7/18/31	17700
7/22/31	18200
7/26/31	18300
7/30/31	18400
8/2/31	18200
8/6/31	18100
8/10/31	18600
8/14/31	18600
8/18/31	18400
8/22/31	18700
8/26/31	18400
8/30/31	18200
9/2/31	18000
9/6/31	18200
9/10/31	17800
9/14/31	18000
9/18/31	17600
9/22/31	18000
9/30/31	17900
10/2/31	18000
10/6/31	18000
10/10/31	18000
10/14/31	17950
10/18/31	17800

Point Davis	
Date	ppm
5/14/31	12500
5/18/31	12800
5/22/31	14000
5/26/31	14100
5/30/31	14900
6/2/31	14400
6/10/31	13800
6/14/31	15000
6/18/31	15000
6/22/31	14600
6/26/31	15100
6/30/31	15400
7/2/31	14800
7/6/31	16400
7/10/31	16600
7/14/31	16200
7/18/31	16800
7/22/31	16800
7/26/31	17000
7/30/31	17400
8/2/31	17600
8/6/31	17700
8/10/31	17700
8/14/31	18100
8/18/31	16900
8/22/31	17800
8/26/31	18100
8/30/31	17400
9/22/31	17500
9/30/31	17300
10/6/31	17600
10/10/31	17900
10/14/31	16900
10/18/31	17050
10/22/31	17000
10/26/31	16650
11/6/31	14900
11/10/31	15900
11/14/31	15100
11/18/31	15150

Clifton Court Ferry	
Date	ppm
11/26/31	130
11/30/31	110
12/2/31	90
12/6/31	100
12/10/31	120
12/14/31	90
12/18/31	100
12/22/31	90
12/26/31	80
12/30/31	90
8/10/39	120
8/14/39	140
8/18/39	140
8/22/39	150
8/26/39	150
8/30/39	150
9/2/39	110
9/6/39	120
9/10/39	120
9/18/39	190
9/22/39	100
9/26/39	110
10/2/39	110
10/6/39	60
10/10/39	70
10/14/39	90
10/18/39	80
10/22/39	80
10/26/39	80
10/30/39	100

Williams Bridge	
Date	ppm
11/22/31	90
11/26/31	110
11/30/31	70

Whitehall	
Date	ppm

Mossdale (Hwy) Bridge	
Date	ppm
5/14/31	100
5/18/31	100
5/22/31	100
5/26/31	100
5/30/31	120
6/2/31	110
6/6/31	110
6/10/31	130
6/14/31	90
6/18/31	90
6/22/31	80
6/26/31	110
7/2/31	80
7/6/31	120
7/10/31	110
7/14/31	100
7/18/31	90
7/22/31	90
7/30/31	110
8/2/31	90
8/6/31	100
8/10/31	100
8/14/31	90
8/18/31	90
8/22/31	100
8/26/31	30
8/30/31	60
9/2/31	80
9/6/31	70
9/10/31	80
9/14/31	90
9/18/31	80
9/22/31	70
9/26/31	90
9/30/31	80
10/2/31	80
10/6/31	80
10/14/31	80
10/18/31	70
10/22/31	80

Historic Delta Water Quality Data

Point Orient		Point Davis		Clifton Court Ferry		Williams Bridge		Whitehall		Mossdale (Hwy) Bridge	
Date	ppm	Date	ppm	Date	ppm	Date	ppm	Date	ppm	Date	ppm
10/22/31	17700	11/22/31	14550							10/26/31	80
10/26/31	17650	11/26/31	14700							10/30/31	90
10/30/31	10000	11/30/31	13700							11/2/31	110
11/2/31	17550	12/2/31	13900							11/6/31	100
11/10/31	17850	12/6/31	14000							11/10/31	100
11/14/31	17610	12/10/31	15000							11/14/31	90
11/18/31	17350	12/14/31	13200							11/18/31	80
11/22/31	17800	12/18/31	13100							11/26/31	80
11/26/31	17200	12/22/31	14150							11/30/31	100
11/30/31	17700	12/30/31	3850							12/2/31	110
12/2/31	17500									12/6/31	60
12/6/31	16600	1/10/39	9200							12/10/31	80
12/10/31	18200	1/18/39	10200							12/18/31	70
12/14/31	16800	1/26/39	9600							12/22/31	80
12/18/31	16600	2/2/39	11200							12/26/31	80
12/22/31	16500	2/10/39	6600							12/30/31	20
12/26/31	16800	2/22/39	8800								
12/30/31	13500	2/26/39	8200							1/2/39	70
		3/2/39	9000							1/6/39	60
1/2/39	14400	3/10/39	11200							1/10/39	70
1/6/39	15200	3/22/39	7400							1/14/39	60
1/10/39	14600	3/26/39	6000							1/18/39	40
1/14/39	15000	4/10/39	5600							1/22/39	60
1/18/39	14600	5/2/39	11200							1/26/39	30
1/22/39	13200	5/10/39	10400							1/30/39	60
1/26/39	14000	5/14/39	12000							2/2/39	20
1/30/39	12000	5/18/39	13600							2/6/39	40
2/2/39	15200	5/22/39	12600							2/10/39	30
2/6/39	15000	5/26/39	11600							2/14/39	40
2/10/39	13200	5/30/39	10800							2/18/39	50
2/14/39	11400	6/2/39	12600							2/26/39	40
2/18/39	13800	6/6/39	11600							3/2/39	30
2/22/39	12800	6/10/39	14000							3/6/39	30
2/26/39	13400	6/14/39	14000							3/10/39	50
3/2/39	14000	6/18/39	13800							3/14/39	70
3/6/39	16000	6/22/39	14600							3/18/39	50
3/10/39	15800	6/26/39	13400							3/22/39	80
3/14/39	12000	6/30/39	14000							3/26/39	70
3/18/39	12000	7/2/39	14600							3/30/39	40
3/22/39	12200	7/6/39	14400							4/2/39	100

Historic Delta Water Quality Data

Point Orient		Point Davis		Clifton Court Ferry		Williams Bridge		Whitehall		Mossdale (Hwy) Bridge	
Date	ppm	Date	ppm	Date	ppm	Date	ppm	Date	ppm	Date	ppm
3/26/39	12200	7/10/39	15000							4/6/39	100
3/30/39	13400	7/14/39	15600							4/10/39	90
4/2/39	14800	7/18/39	16600							4/18/39	70
4/6/39	13800	7/22/39	16200							4/22/39	70
4/10/39	12800	7/26/39	16600							4/26/39	80
4/14/39	12000	7/30/39	17200							4/30/39	70
4/18/39	13400	8/2/39	16400							5/2/39	70
4/22/39	12600	8/6/39	16600							5/6/39	80
4/26/39	13600	8/10/39	16200							5/10/39	80
4/30/39	14800	8/14/39	17800							5/14/39	70
5/2/39	16200	8/18/39	17000							5/18/39	80
5/6/39	14800	8/22/39	17400							5/22/39	70
5/10/39	14800	8/30/39	17400							5/26/39	90
5/14/39	15000	9/2/39	17400							5/30/39	80
5/18/39	17000	9/6/39	17600							6/2/39	70
5/22/39	16000	9/10/39	17800							6/6/39	80
5/26/39	17800	9/14/39	17000							6/10/39	90
5/30/39	16200	9/18/39	17000							6/14/39	100
6/2/39	16000	9/26/39	17000							6/18/39	70
6/6/39	16400	10/2/39	17000							6/22/39	90
6/10/39	16000	10/6/39	16400							6/26/39	80
6/14/39	16800	10/10/39	15800							6/30/39	90
6/18/39	17000	10/14/39	18400							7/2/39	90
6/26/39	17000	10/18/39	15200							7/6/39	110
6/30/39	17600	10/22/39	14600							7/10/39	130
7/2/39	17800	10/26/39	15000							7/14/39	90
7/6/39	17600	10/30/39	15000							7/18/39	120
7/10/39	18000	11/2/39	17000							7/22/39	130
7/14/39	17400	11/6/39	14800							7/26/39	110
7/18/39	18000	11/10/39	14800							7/30/39	120
7/22/39	17600	11/14/39	14800							8/2/39	90
7/26/39	18400	11/18/39	13600							8/6/39	90
7/30/39	18600	11/22/39	15800							8/10/39	110
8/2/39	18000	11/26/39	14800							8/14/39	110
8/6/39	18000	11/30/39	14800							8/18/39	140
8/10/39	18400	12/2/39	12800							8/22/39	120
8/14/39	19200	12/6/39	14600							8/26/39	130
8/18/39	18600	12/10/39	15200							8/30/39	160
8/22/39	18600	12/18/39	12200							9/2/39	100
8/26/39	18400	12/22/39	13000							9/6/39	140

Historic Delta Water Quality Data

Point Orient	
Date	ppm
8/30/39	18200
9/2/39	18600
9/6/39	18600
9/10/39	18400
9/14/39	18600
9/18/39	17800
9/22/39	18000
9/26/39	18400
9/30/39	17800
10/2/39	18400
10/6/39	18000
10/10/39	18400
10/14/39	17800
10/18/39	17800
10/22/39	17400
10/26/39	17800
10/30/39	18000
11/2/39	17800
11/6/39	17800
11/10/39	17200
11/14/39	17200
11/18/39	17200
11/22/39	17400
11/26/39	17600
11/30/39	16200
12/2/39	17800
12/6/39	17600
12/10/39	17600
12/14/39	17500
12/18/39	16200
12/22/39	16800
12/26/39	17200
12/30/39	15800

Point Davis	
Date	ppm
12/26/39	12800
12/30/39	12600

Clifton Court Ferry	
Date	ppm

Williams Bridge	
Date	ppm

Whitehall	
Date	ppm

Mossdale (Hwy) Bridge	
Date	ppm
9/10/39	90
9/14/39	100
9/18/39	110
9/22/39	70
9/26/39	90
9/30/39	100
10/2/39	110
10/6/39	90
10/10/39	100
10/14/39	90
10/18/39	130
10/22/39	120
10/26/39	90
10/30/39	90
11/2/39	110
11/6/39	140
11/10/39	100
11/14/39	100
11/18/39	100
11/22/39	100
11/26/39	90
11/30/39	90
12/2/39	80
12/6/39	80
12/10/39	80
12/14/39	100
12/18/39	100
12/22/39	100
12/26/39	90
12/30/39	110

Durham Ferry Bridge	
Date	ppm
5/2/31	60
5/6/31	80
5/10/31	60
5/16/31	110
5/22/31	90
5/26/31	100
5/30/31	110
6/2/31	90
6/6/31	80
6/10/31	100
6/14/31	110
6/18/31	90
6/22/31	90
6/26/31	100
6/30/31	80
7/2/31	80
7/6/31	70
7/10/31	100
7/14/31	80
7/22/31	80
7/26/31	80
7/30/31	80
8/2/31	70
8/6/31	80
8/10/31	80
8/14/31	80
8/18/31	90
8/22/31	90
8/26/31	70
8/30/31	60
9/2/31	70
9/6/31	60
9/10/31	70

Orwood Bridge Pump	
Date	ppm
7/14/31	250
7/18/31	310
7/26/31	610
7/30/31	740
8/2/31	820
8/6/31	1000
8/10/31	1230
8/14/31	1440
8/18/31	1540
8/22/31	1820
8/26/31	2150
8/30/31	2000
9/2/31	2300
9/6/31	2300
9/10/31	2300
9/14/31	2460
9/18/31	2500
9/22/31	2550
9/26/31	2600
9/30/31	2530
10/2/31	2770
10/6/31	2680
10/10/31	2720
10/16/31	2540
10/18/31	2590
10/22/31	2440
10/26/31	2350
10/30/31	2320
11/2/31	2230
11/6/31	2100
11/10/31	2090
11/14/31	1990
11/18/31	1810

Middle River Post Office	
Date	ppm
1/2/31	70
1/6/31	50
1/10/31	90
1/14/31	90
1/18/31	80
1/22/31	100
1/26/31	120
1/30/31	110
2/2/31	110
2/6/31	150
2/10/31	90
2/18/31	90
2/22/31	80
2/26/31	90
3/2/31	120
3/6/31	90
3/10/31	110
3/14/31	110
3/18/31	140
3/22/31	100
3/26/31	120
3/30/31	130
4/2/31	120
4/6/31	120
4/10/31	130
4/14/31	120
4/18/31	110
4/22/31	120
4/26/31	110
4/30/31	110
5/2/31	110
5/6/31	110
5/10/31	90

Rindge (Ringe) Pump	
Date	ppm
1/2/31	90
1/6/31	110
1/10/31	130
1/14/31	130
1/18/31	120
1/22/31	140
1/26/31	110
1/30/31	120
2/2/31	100
2/6/31	110
2/10/31	120
2/14/31	120
2/18/31	140
2/22/31	90
2/26/31	120
3/2/31	120
3/6/31	120
3/10/31	120
3/14/31	140
3/18/31	150
3/22/31	170
3/26/31	170
3/30/31	130
4/2/31	220
4/6/31	190
4/10/31	200
4/14/31	210
4/18/31	160
4/22/31	150
4/26/31	160
4/30/31	170
5/2/31	160
5/6/31	190

Antioch	
Date	ppm
1/2/31	1350
1/6/31	680
1/10/31	210
1/14/31	130
1/18/31	200
1/22/31	140
1/26/31	90
1/30/31	60
2/2/31	120
2/6/31	120
2/10/31	110
2/14/31	190
2/18/31	90
2/22/31	60
2/26/31	60
3/2/31	40
3/6/31	60
3/10/31	110
3/14/31	90
3/18/31	70
3/22/31	30
3/26/31	50
3/30/31	50
4/2/31	40
4/6/31	90
4/10/31	90
4/14/31	100
4/18/31	170
4/22/31	700
4/26/31	780
4/30/31	600
5/2/31	620
5/6/31	1440

Central Landing, Bouldin Island	
Date	ppm
5/2/31	40
5/6/31	30
5/10/31	30
5/14/31	30
5/18/31	40
5/22/31	50
5/26/31	50
5/30/31	60
6/6/31	70
6/10/31	70
6/14/31	80
6/18/31	120
6/22/31	130
6/26/31	130
6/30/31	240
7/2/31	280
7/6/31	350
7/10/31	400
7/14/31	600
7/18/31	1040
7/22/31	1220
7/26/31	1800
7/28/31	2650
7/30/31	2600
8/2/31	2800
8/4/31	2400
8/6/31	2700
8/8/31	3500
8/10/31	3900
8/12/31	3800
8/14/31	3000
8/18/31	3400
8/20/31	3450

Holland Pump	
Date	ppm
1/2/31	70
1/6/31	90
1/10/31	100
1/14/31	110
1/18/31	100
1/22/31	100
1/26/31	110
1/30/31	80
2/2/31	100
2/6/31	100
2/10/31	100
2/14/31	100
2/18/31	100
2/22/31	120
2/26/31	120
3/2/31	100
3/6/31	90
3/10/31	110
3/14/31	100
3/18/31	100
3/22/31	90
3/26/31	110
3/30/31	100
4/2/31	90
4/6/31	70
4/10/31	90
4/14/31	70
4/18/31	70
4/22/31	70
4/26/31	100
4/30/31	90
5/2/31	70
5/6/31	70

Durham Ferry Bridge	
Date	ppm
9/14/31	70
9/18/31	60
9/22/31	60
9/26/31	60
9/30/31	60
10/2/31	70
10/6/31	70
10/10/31	50
10/14/31	60
10/16/31	60
10/26/31	80
10/30/31	90

Orwood Bridge Pump	
Date	ppm
11/24/31	1710
11/26/31	1630
11/30/31	1500
12/2/31	1300
12/6/31	1280
12/10/31	1190
12/14/31	820
12/18/31	720
12/22/31	720
12/26/31	630
12/30/31	290
7/18/39	90
7/22/39	140
7/26/39	160
7/30/39	160
8/2/39	210
8/6/39	190
8/10/39	240
8/14/39	290
8/18/39	370
8/22/39	380
8/26/39	450
8/30/39	320
9/2/39	460
9/6/39	380
9/10/39	540
9/14/39	460
9/18/39	380
9/22/39	460
9/26/39	380
9/30/39	330
10/2/39	300
10/6/39	170
10/10/39	140
10/18/39	120
10/22/39	120
10/26/39	110
10/30/39	150
11/2/39	140

Middle River Post Office	
Date	ppm
5/14/31	100
5/18/31	80
5/22/31	70
5/26/31	80
5/30/31	110
6/2/31	110
6/6/31	90
6/10/31	90
6/14/31	100
6/18/31	100
6/22/31	100
6/26/31	110
6/30/31	130
7/2/31	130
7/6/31	150
7/10/31	180
7/14/31	220
7/18/31	270
7/22/31	340
7/26/31	570
7/30/31	790
8/2/31	920
8/6/31	860
8/10/31	1300
8/14/31	1800
8/22/31	2000
8/26/31	2300
8/30/31	2200
9/2/31	2100
9/6/31	2400
9/10/31	2500
9/14/31	2400
9/18/31	2620
9/22/31	2550
9/26/31	2700
9/30/31	2650
10/2/31	2600
10/6/31	2680
10/10/31	2680
10/14/31	2290

Rindge (Ringe) Pump	
Date	ppm
5/10/31	140
5/14/31	180
5/18/31	170
5/22/31	220
5/26/31	220
5/30/31	210
6/2/31	200
6/6/31	190
6/10/31	170
6/14/31	230
6/18/31	170
6/22/31	200
6/26/31	190
6/30/31	190
7/2/31	180
7/6/31	220
7/10/31	220
7/14/31	230
7/18/31	250
7/22/31	280
7/26/31	350
7/30/31	490
8/2/31	700
8/6/31	720
8/10/31	860
8/14/31	1200
8/18/31	1120
8/22/31	1600
8/26/31	1460
8/30/31	1700
9/2/31	1600
9/6/31	1700
9/10/31	1800
9/14/31	1740
9/18/31	1980
9/22/31	1880
9/26/31	1960
9/30/31	1870
10/2/31	1720
10/6/31	1870

Antioch	
Date	ppm
5/10/31	880
5/14/31	900
5/18/31	700
5/22/31	2600
5/26/31	1500
5/30/31	2040
6/2/31	2800
6/6/31	2800
6/10/31	2700
6/14/31	3400
6/18/31	4200
6/22/31	4500
6/26/31	4100
6/30/31	4750
7/2/31	5200
7/6/31	5400
7/10/31	5100
7/14/31	7100
7/18/31	8300
7/22/31	9200
7/26/31	9000
8/2/31	10000
8/10/31	10500
8/14/31	10900
8/18/31	11600
8/22/31	10300
8/26/31	11000
8/30/31	10800
9/2/31	11600
9/6/31	12400
9/10/31	11000
9/14/31	12000
9/18/31	11700
9/22/31	9800
9/26/31	9400
9/30/31	8700
10/2/31	9450
10/6/31	8200
10/10/31	8750
10/14/31	7850

Central Landing, Bouldin Island	
Date	ppm
8/22/31	4250
8/24/31	4300
8/26/31	4150
8/30/31	3500
9/2/31	3100
9/6/31	3200
9/10/31	2500
9/14/31	2120
9/18/31	1800
9/22/31	2950
9/26/31	1780
9/30/31	1100
10/2/31	1880
10/10/31	1510
10/14/31	990
10/18/31	1720
10/22/31	980
10/26/31	930
10/30/31	620
11/2/31	760
11/6/31	710
11/10/31	450
11/14/31	730
11/18/31	150
11/22/31	720
11/26/31	740
11/30/31	180
12/2/31	200
12/6/31	340
12/10/31	340
12/14/31	310
12/18/31	560
12/22/31	260
12/26/31	110
12/30/31	130

No 1939 data

Holland Pump	
Date	ppm
5/10/31	70
5/14/31	80
5/18/31	100
5/22/31	100
5/26/31	90
5/30/31	80
6/2/31	70
6/6/31	80
6/10/31	80
6/14/31	100
6/20/31	100
6/22/31	140
6/26/31	120
6/30/31	170
7/2/31	190
7/6/31	220
7/10/31	240
7/14/31	380
7/18/31	460
7/22/31	510
7/26/31	800
7/30/31	1050
8/2/31	1160
8/6/31	740
8/10/31	1800
8/14/31	1800
8/18/31	2000
8/22/31	2400
8/26/31	2500
8/30/31	2300
9/6/31	2500
9/12/31	2700
9/18/31	2800
9/22/31	2900
9/26/31	3250
9/30/31	2820
10/6/31	2920
10/10/31	2900
10/14/31	2830
10/18/31	2790

Durham Ferry Bridge	
Date	ppm

Orwood Bridge Pump	
Date	ppm
11/6/39	130
11/10/39	150
11/14/39	100
11/18/39	100
11/22/39	170
11/26/39	90
11/30/39	120
12/6/39	100
12/10/39	120
12/14/39	130
12/18/39	140
12/22/39	100

Middle River Post Office	
Date	ppm
10/18/31	2570
10/22/31	2530
10/26/31	2150
10/30/31	2320
11/2/31	2210
11/6/31	2050
11/10/31	2120
11/14/31	1980
11/18/31	1810
11/22/31	1720
11/26/31	1680
11/30/31	1530
12/2/31	1450
12/6/31	1240
12/10/31	1100
12/14/31	1000
12/18/31	880
12/22/31	910
12/26/31	720
12/30/31	510
1/2/39	80
1/6/39	60
1/10/39	70
1/14/39	80
1/18/39	70
1/22/39	60
1/26/39	70
1/30/39	80
2/2/39	60
2/6/39	70
2/10/39	70
2/14/39	70
2/18/39	50
2/22/39	70
2/26/39	60
3/2/39	70
3/6/39	60
3/10/39	70
3/14/39	50

Rindge (Ringe) Pump	
Date	ppm
10/10/31	1830
10/14/31	1550
10/18/31	1410
10/22/31	1300
10/26/31	1330
10/30/31	1060
11/2/31	760
11/6/31	1060
11/10/31	1070
11/14/31	840
11/18/31	820
11/22/31	880
11/26/31	740
11/30/31	570
12/2/31	640
12/6/31	560
12/10/31	560
12/14/31	480
12/18/31	280
12/22/31	330
12/26/31	70
12/30/31	30
1/2/39	70
1/6/39	90
1/10/39	60
1/14/39	70
1/18/39	50
1/22/39	50
1/26/39	50
1/30/39	90
2/2/39	120
2/10/39	60
2/14/39	70
2/18/39	50
2/22/39	90
2/26/39	60
3/2/39	70
3/6/39	60
3/10/39	90

Antioch	
Date	ppm
10/18/31	7600
10/22/31	7250
10/26/31	6900
10/30/31	6100
11/2/31	5600
11/6/31	4850
11/10/31	5600
11/14/31	5350
11/18/31	4300
11/22/31	3330
11/26/31	3750
12/2/31	2680
12/6/31	3000
12/10/31	3900
12/14/31	2500
12/18/31	2200
12/22/31	2730
12/26/31	1130
12/30/31	340
1/2/39	200
1/6/39	270
1/10/39	90
1/14/39	80
1/18/39	80
1/22/39	60
1/26/39	70
1/30/39	80
2/2/39	70
2/6/39	70
2/10/39	80
2/14/39	50
2/18/39	40
2/22/39	50
2/26/39	60
3/2/39	70
3/6/39	90
3/10/39	130
3/14/39	60
3/18/39	40

Central Landing, Bouldin Island	
Date	ppm

Holland Pump	
Date	ppm
10/22/31	2700
10/26/31	2630
10/30/31	2560
11/2/31	2530
11/6/31	2410
11/10/31	2290
11/14/31	2170
12/2/31	1770
12/6/31	1500
12/10/31	1370
12/14/31	1230
12/18/31	990
12/22/31	960
12/26/31	860
12/30/31	580

No 1939 data

Durham Ferry Bridge		Orwood Bridge Pump		Middle River Post Office		Rindge (Ringe) Pump		Antioch		Central Landing, Bouldin Island		Holland Pump	
Date	ppm	Date	ppm	Date	ppm	Date	ppm	Date	ppm	Date	ppm	Date	ppm
				3/18/39	80	3/14/39	100	3/22/39	50				
				3/22/39	120	3/18/39	140	3/26/39	30				
				3/26/39	120	3/22/39	160	3/30/39	20				
				3/30/39	120	3/26/39	140	4/2/39	40				
				4/2/39	130	3/30/39	150	4/6/39	20				
				4/6/39	130	4/2/39	140	4/10/39	40				
				4/10/39	110	4/6/39	130	4/14/39	40				
				4/14/39	120	4/10/39	110	4/18/39	50				
				4/18/39	90	4/14/39	120	4/22/39	40				
				4/22/39	90	4/18/39	100	4/26/39	50				
				4/26/39	110	4/26/39	100	5/2/39	100				
				4/30/39	110	4/30/39	100	5/6/39	160				
				5/2/39	50	5/2/39	100	5/10/39	140				
				5/6/39	70	5/6/39	110	5/14/39	130				
				5/10/39	80	5/10/39	100	5/18/39	200				
				5/14/39	90	5/14/39	100	5/22/39	500				
				5/18/39	70	5/18/39	90	5/26/39	180				
				5/22/39	80	5/22/39	90	5/30/39	190				
				5/26/39	90	5/26/39	100	6/2/39	290				
				5/30/39	90	5/30/39	110	6/6/39	400				
				6/2/39	80	6/2/39	110	6/10/39	320				
				6/6/39	80	6/6/39	90	6/14/39	730				
				6/10/39	80	6/10/39	110	6/18/39	1060				
				6/14/39	100	6/14/39	140	6/22/39	1830				
				6/18/39	80	6/18/39	100	6/26/39	1540				
				6/22/39	90	6/22/39	120	6/30/39	2160				
				6/26/39	90	6/26/39	140	7/6/39	3250				
				6/30/39	100	6/30/39	150	7/10/39	3200				
				7/2/39	90	7/2/39	150	7/14/39	3700				
				7/6/39	90	7/6/39	150	7/18/39	5700				
				7/10/39	90	7/10/39	160	7/22/39	4700				
				7/14/39	120	7/14/39	150	7/26/39	5200				
				7/18/39	130	7/18/39	200	7/30/39	6200				
				7/22/39	130	7/22/39	180	8/2/39	6400				
				7/26/39	140	7/26/39	180	8/6/39	6500				
				7/30/39	180	7/30/39	190	8/10/39	6100				
				8/2/39	160	8/2/39	210	8/14/39	7300				
				8/6/39	220	8/6/39	220	8/18/39	9200				
				8/10/39	240	8/10/39	320	8/22/39	8300				
				8/14/39	300	8/14/39	280	8/26/39	7400				

Durham Ferry Bridge		Orwood Bridge Pump		Middle River Post Office		Rindge (Ringe) Pump		Antioch		Central Landing, Bouldin Island		Holland Pump	
Date	ppm	Date	ppm	Date	ppm	Date	ppm	Date	ppm	Date	ppm	Date	ppm
				8/18/39	390	8/18/39	350	8/30/39	7600				
				8/22/39	440	8/22/39	420	9/2/39	8000				
				8/26/39	450	8/26/39	380	9/6/39	8300				
				8/30/39	510	8/30/39	460	9/10/39	7400				
				9/2/39	540	9/2/39	370	9/14/39	7000				
				9/6/39	530	9/6/39	440	9/18/39	6100				
				9/10/39	500	9/10/39	520	9/22/39	5700				
				9/14/39	600	9/14/39	560	9/26/39	5300				
				9/18/39	570	9/18/39	400	10/2/39	4700				
				9/22/39	480	9/22/39	600	10/6/39	4100				
				9/26/39	550	9/26/39	480	10/10/39	3800				
				9/30/39	440	9/30/39	470	10/14/39	3850				
				10/2/39	440	10/2/39	410	10/18/39	2850				
				10/6/39	300	10/6/39	620	10/22/39	2300				
				10/10/39	190	10/10/39	250	10/26/39	2800				
				10/14/39	230	10/14/39	260	10/30/39	3000				
				10/18/39	180	10/18/39	230	11/2/39	2400				
				10/22/39	170	10/22/39	200	11/6/39	2350				
				10/26/39	180	10/26/39	220	11/10/39	2700				
				10/30/39	150	12/2/39	150	11/14/39	2550				
				11/2/39	180	12/10/39	180	11/22/39	2300				
				11/6/39	150	12/14/39	180	11/26/39	2800				
				11/10/39	150	12/22/39	160	12/6/39	2350				
				11/14/39	150	12/26/39	150	12/10/39	3450				
				11/18/39	120	12/30/39	190	12/14/39	1150				
				11/22/39	110			12/18/39	450				
				11/26/39	120			12/22/39	500				
				11/30/39	120			12/26/39	690				
				12/2/39	130			12/30/39	440				
				12/6/39	150								
				12/10/39	140								
				12/14/39	140								
				12/18/39	110								
				12/22/39	120								
				12/26/39	120								
				12/30/39	130								

Jersey		Mandeville Pump		Mansion House		Webb Pump		Bull's Head Point	
Date	ppm	Date	ppm	Date	ppm	Date	ppm	Date	ppm
1/2/31	190	1/2/31	70	1/2/31	50	1/2/31	60	1/2/31	11500
1/6/31	60	1/6/31	70	1/10/31	80	1/6/31	60	1/6/31	9100
1/10/31	60	1/10/31	80	1/14/31	80	1/10/31	50	1/10/31	7900
1/14/31	70	1/14/31	80	1/22/31	90	1/14/31	60	1/14/31	9000
1/18/31	80	1/18/31	90	1/26/31	100	1/18/31	60	1/18/31	6800
1/22/31	60	1/22/31	90	2/6/31	90	1/22/31	70	1/22/31	6600
1/26/31	70	1/26/31	100	2/18/31	90	1/26/31	60	1/26/31	7000
1/30/31	60	1/30/31	100	3/10/31	90	1/30/31	50	1/30/31	8500
2/2/31	60	2/2/31	100	3/14/31	80	2/2/31	60	2/2/31	4650
2/6/31	40	2/6/31	100	3/22/31	70	2/6/31	50	2/26/31	3000
2/10/31	50	2/10/31	100	3/30/31	110	2/10/31	60	3/2/31	7100
2/14/31	70	2/14/31	100	4/2/31	110	2/14/31	70	3/6/31	6400
2/18/31	70	2/18/31	110	4/6/31	110	2/18/31	60	3/10/31	6600
2/22/31	30	2/22/31	100	4/10/31	110	2/22/31	60	3/14/31	4500
2/26/31	50	2/26/31	100	4/14/31	110	2/26/31	80	3/18/31	4900
3/2/31	70	3/2/31	100	4/18/31	100	3/2/31	70	3/22/31	3700
3/6/31	40	3/6/31	110	4/30/31	140	3/6/31	60	3/26/31	2000
3/10/31	50	3/10/31	110	5/6/31	110	3/10/31	70	4/2/31	5500
3/14/31	50	3/14/31	100	5/10/31	70	3/14/31	60	4/6/31	5800
3/18/31	60	3/18/31	100	5/14/31	90	3/18/31	50	4/10/31	5000
3/22/31	40	3/22/31	100	5/22/31	110	3/22/31	40	4/14/31	6300
3/26/31	40	3/26/31	80	5/30/31	110	3/26/31	60	4/18/31	7300
3/30/31	50	3/30/31	100	6/2/31	80	3/30/31	40	4/22/31	10000
4/2/31	30	4/2/31	90	6/10/31	80	4/2/31	30	4/26/31	8300
4/6/31	30	4/6/31	90	6/18/31	100	4/6/31	20	4/30/31	9700
4/10/31	50	4/14/31	120	6/26/31	110	4/10/31	40	5/2/31	10300
4/14/31	40	4/18/31	70	6/30/31	120	4/14/31	50	5/6/31	10500
4/18/31	40	4/22/31	60	7/2/31	100	4/18/31	30	5/10/31	9000
4/22/31	180	4/26/31	70	7/6/31	150	4/22/31	140	5/14/31	8700
4/26/31	170	4/30/31	60	7/10/31	150	4/26/31	40	5/18/31	8700
4/30/31	200	5/2/31	80	7/14/31	240	4/30/31	50	5/22/31	12000
5/2/31	90	5/6/31	80	7/18/31	260	5/2/31	40	5/26/31	11100
5/6/31	380	5/14/31	70	7/26/31	250	5/6/31	80	5/30/31	12100

Jersey	
Date	ppm
5/10/31	60
5/14/31	120
5/18/31	150
5/22/31	950
5/26/31	440
5/30/31	430
6/2/31	1180
6/6/31	600
6/10/31	420
6/14/31	900
6/18/31	2480
6/22/31	1600
6/26/31	1550
6/30/31	2600
7/2/31	3650
7/6/31	3250
7/10/31	2700
7/14/31	4300
7/18/31	6000
7/22/31	5000
7/26/31	7900
7/30/31	7800
8/2/31	7200
8/10/31	7000
9/2/31	8000
9/10/31	8000
9/14/31	9100
9/26/31	6900
10/6/31	6000
10/18/31	4300
10/22/31	5320
10/26/31	4350
10/30/31	3900
11/2/31	3600
11/22/31	2450
12/2/31	1500
12/14/31	980
12/22/31	1340
12/26/31	820

Mandeville Pump	
Date	ppm
5/18/31	70
5/22/31	60
5/26/31	70
5/30/31	80
6/2/31	90
6/6/31	90
6/10/31	90
6/14/31	90
6/18/31	110
6/22/31	120
6/26/31	150
6/30/31	190
7/2/31	190
7/6/31	190
7/10/31	290
7/14/31	430
7/18/31	550
7/22/31	650
7/26/31	1110
7/30/31	1400
8/2/31	1580
8/6/31	1900
8/10/31	2200
8/14/31	2650
8/18/31	2300
8/22/31	2800
8/26/31	3200
8/30/31	3030
9/2/31	3250
9/6/31	3300
9/10/31	3500
9/14/31	3500
9/18/31	3400
9/22/31	3450
9/26/31	3400
9/30/31	3150
10/2/31	3200
10/6/31	3110
10/10/31	3040
10/14/31	2300

Mansion House	
Date	ppm
7/30/31	660
8/2/31	770
8/6/31	760
8/10/31	1180
8/14/31	1300
8/22/31	1400
8/26/31	1700
8/30/31	1700
9/2/31	1900
9/6/31	1900
9/10/31	2100
9/14/31	2100
9/18/31	2000
9/22/31	2200
9/26/31	2200
9/30/31	2350
10/2/31	2360
10/6/31	2400
10/10/31	2370
10/14/31	2200
10/22/31	2340
10/26/31	1950
11/2/31	1700
11/6/31	1850
11/10/31	1840
11/14/31	1880
11/22/31	1140
11/30/31	1200
12/2/31	940
12/6/31	980
12/10/31	990
12/14/31	980
12/18/31	1280
12/22/31	530
12/26/31	130
12/30/31	160

No 1939 data

Webb Pump	
Date	ppm
5/10/31	60
5/14/31	60
5/18/31	70
5/22/31	100
5/26/31	110
5/30/31	150
6/2/31	200
6/6/31	150
6/10/31	260
6/14/31	360
6/18/31	400
6/22/31	400
6/26/31	760
6/30/31	950
7/2/31	1020
7/6/31	1460
7/10/31	1680
7/14/31	2450
7/18/31	3100
7/22/31	3800
7/26/31	4600
7/30/31	4800
8/2/31	4600
8/6/31	5050
8/10/31	5200
8/14/31	6000
8/18/31	5400
8/22/31	6000
8/26/31	6700
8/30/31	5600
9/2/31	6800
9/6/31	6400
9/10/31	6200
9/14/31	6600
9/18/31	6000
9/22/31	5450
9/26/31	4900
9/30/31	4700
10/2/31	3900
10/6/31	4300

Bull's Head Point	
Date	ppm
6/2/31	12100
6/6/31	10800
6/10/31	10800
6/14/31	12800
6/18/31	13000
6/22/31	12000
6/26/31	13600
6/30/31	13600
7/2/31	13400
7/6/31	13700
7/10/31	13900
7/14/31	15000
7/18/31	13800
7/22/31	14800
7/26/31	16100
7/28/31	15700
7/30/31	15700
8/2/31	16600
8/6/31	16100
8/10/31	16100
8/14/31	15700
8/18/31	16000
8/22/31	16400
8/26/31	16900
8/30/31	15600
9/2/31	16200
9/6/31	16600
9/10/31	15800
9/14/31	16200
9/18/31	16400
9/22/31	16000
9/26/31	15000
9/30/31	15500
10/2/31	16150
10/6/31	16000
10/10/31	15500
10/14/31	15100
10/18/31	14850
10/22/31	14750
10/26/31	13900

Jersey	
Date	ppm
5/22/39	90
5/26/39	70
6/2/39	100
6/6/39	90
6/10/39	100
6/14/39	100
7/6/39	1120
7/10/39	700
7/14/39	920
7/18/39	3000
8/2/39	1500
8/14/39	4120
8/18/39	5000
8/30/39	4400
10/2/39	2040

Mandeville Pump	
Date	ppm
10/18/31	2830
10/22/31	2760
10/26/31	2870
10/30/31	2550
11/2/31	2370
11/6/31	2340
11/10/31	2250
11/14/31	2030
11/18/31	2010
11/22/31	2010
11/30/31	1680
12/2/31	1650
12/6/31	1500
12/10/31	1440
12/14/31	1340
12/18/31	1290
12/22/31	1160
12/26/31	970
12/30/31	610
7/18/39	180
7/22/39	170
7/26/39	250
7/30/39	230
8/2/39	310
8/6/39	380
8/10/39	450
8/14/39	550
8/22/39	760
8/26/39	800
8/30/39	890
9/2/39	910
9/6/39	940
9/10/39	1040
9/14/39	1000
9/18/39	1030
9/22/39	940
9/26/39	960
9/30/39	840
10/6/39	720

Mansion House	
Date	ppm

Webb Pump	
Date	ppm
10/10/31	4050
10/16/31	4000
10/18/31	3320
10/22/31	3270
10/26/31	2920
10/30/31	2600
11/2/31	2210
11/6/31	2160
11/10/31	2350
11/14/31	1850
11/18/31	1690
11/22/31	1320
11/26/31	1280
11/30/31	1090
12/2/31	1020
12/6/31	940
12/10/31	920
12/14/31	910
12/18/31	760
12/22/31	660
12/26/31	570
1/2/39	70
1/10/39	50
1/14/39	60
1/18/39	70
1/22/39	60
1/26/39	50
2/6/39	40
2/10/39	70
2/18/39	60
2/22/39	70
2/26/39	60
3/6/39	60
3/22/39	50
3/26/39	60
3/30/39	40
4/2/39	60
4/6/39	50
4/10/39	50

Bull's Head Point	
Date	ppm
10/30/31	14550
11/2/31	13450
11/6/31	13000
11/10/31	13600
11/14/31	13850
11/18/31	10400
11/22/31	10100
11/26/31	12300
11/30/31	10800
12/2/31	10200
12/6/31	12200
12/10/31	12350
12/14/31	9750
12/18/31	9650
12/22/31	12350
12/26/31	10200
12/30/31	950
1/2/39	9500
1/6/39	7200
1/10/39	3100
1/14/39	4100
1/22/39	6400
1/26/39	6800
1/30/39	4100
2/2/39	4000
2/6/39	6100
2/10/39	2000
2/14/39	3620
2/18/39	5000
2/22/39	4100
2/26/39	4200
3/2/39	4000
3/6/39	5240
3/10/39	5480
3/14/39	2100
3/18/39	2900
3/22/39	2900
3/26/39	4800
3/30/39	2300

Jersey		Mandeville Pump		Mansion House		Webb Pump		Bull's Head Point	
Date	**ppm**	**Date**	**ppm**	**Date**	**ppm**	**Date**	**ppm**	**Date**	**ppm**
		10/10/39	610			4/18/39	70	4/2/39	2100
		10/18/39	520			4/22/39	70	4/6/39	1900
		10/22/39	450			4/26/39	50	4/10/39	2020
		10/26/39	440			4/30/39	70	4/14/39	1460
		10/30/39	390			5/6/39	70	4/18/39	3700
		11/2/39	390			5/14/39	60	4/22/39	3400
		11/10/39	320			5/22/39	60	4/26/39	4400
		11/14/39	270			5/26/39	60	4/30/39	6850
		11/18/39	250			5/30/39	70	5/6/39	8000
		11/26/39	260			6/2/39	70	5/10/39	6800
		11/30/39	220			6/6/39	70	5/14/39	6900
		12/2/39	230			6/10/39	70	5/18/39	8300
		12/10/39	180			6/14/39	70	5/22/39	8800
		12/14/39	170			6/18/39	80	5/26/39	7800
		12/18/39	170			6/22/39	100	5/30/39	7900
		12/22/39	150			6/26/39	120	6/2/39	9600
		12/26/39	160			6/30/39	180	6/6/39	8200
		12/30/39	140			7/2/39	210	6/10/39	10200
						7/10/39	200	6/14/39	11000
						7/14/39	430	6/18/39	10600
						7/18/39	1160	6/22/39	10800
						7/22/39	810	7/2/39	12000
						7/26/39	1110	7/6/39	11200
						7/30/39	1390	7/10/39	11400
						8/2/39	1620	7/14/39	13800
						8/6/39	1420	7/18/39	13800
						8/10/39	1570	7/22/39	14400
						8/14/39	1600	7/26/39	14000
						8/18/39	2000	7/30/39	14400
						8/22/39	2150	8/6/39	14200
						8/26/39	2650	8/10/39	15200
						8/30/39	2600	8/14/39	16400
						9/6/39	2200	8/18/39	14200
						9/10/39	2050	8/22/39	15200
						9/14/39	1850	8/26/39	15600
						9/22/39	1480	8/30/39	14600
						9/26/39	1580	9/2/39	14100
						9/30/39	1520	9/10/39	14400
						10/2/39	1460	9/14/39	14800
						10/22/39	680	9/18/39	14400

Jersey		Mandeville Pump		Mansion House		Webb Pump		Bull's Head Point	
Date	ppm	Date	ppm	Date	ppm	Date	ppm	Date	ppm
						10/26/39	650	9/22/39	14400
						10/30/39	600	9/30/39	14000
						11/6/39	520	10/2/39	13400
						11/10/39	440	10/10/39	12800
						11/18/39	360	10/14/39	10800
						11/26/39	300	10/18/39	12800
						11/30/39	310	10/22/39	10600
						12/2/39	260	10/26/39	14600
						12/10/39	270	10/30/39	11400
						12/22/39	170	11/2/39	12800
						12/26/39	170	11/6/39	13400
						12/30/39	170	11/10/39	10000
								11/14/39	11400
								11/22/39	11200
								11/26/39	12000
								11/30/39	11800
								12/2/39	11200
								12/10/39	13600
								12/14/39	9800
								12/18/39	6600
								12/26/39	6800
								12/30/39	8600