Methodology for Flow and Salinity Estimates in the Sacramento-San Joaquin Delta and Suisun Marsh

26th Annual Progress Report
October 2005

Chapter 6:
Fingerprinting: Clarifications and Recent Applications

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6 Fingerprinting: Clarifications and Recent Applications

6.1 Introduction

Within the context of the modeling of the hydrodynamics and water quality of the Sacramento-San Joaquin Delta, *fingerprinting* refers to a methodology for running the Delta Simulation Model II to determine sources of water or constituents at specified locations. The DSM2 fingerprinting methodology is described in detail in Anderson (2002). The two main purposes of this chapter are to clarify the types of fingerprinting and to present recent fingerprinting applications.

6.2 Fingerprinting Overview

Fingerprinting provides an application of DSM2 that can improve understanding of circulation in the Delta by examining sources of water and/or constituents at specified locations. A fingerprinting analysis is analogous to collecting a bucket of water at a given location and determining how much water (or how much of a constituent) in the bucket came from each potential source. To conduct a fingerprinting study, the QUAL module of DSM2 is run with user-defined conservative constituents representing the source waters or source constituent concentrations (see Anderson, 2002 for additional details). For the Sacramento-San Joaquin Delta representation in DSM2, six major sources are typically considered:

Fingerprinting Source Locations

- ☐ Sacramento River at Sacramento
- ☐ San Joaquin River at Vernalis
- ☐ Martinez (ocean/bay water)
- ☐ Eastside streams (Calaveras, Mokelumne, and Cosumnes Rivers)
- ☐ Agricultural return flows
- ☐ Yolo Bypass

Fingerprinting analysis typically is conducted to determine either (a) how much of the water at a specified location and time came from each of the above sources or (b) how much of a constituent (for example, electrical conductivity or dissolved organic carbon) at a given location and time came from each of the above sources. A sample fingerprinting analysis for source water, EC and DOC at Clifton Court Forebay for historical conditions for January–April 2005 is presented in Figure 6.6 in the Recent Applications section of this chapter. The next section of this chapter further describes the types of fingerprinting analysis and provides illustrative examples.

6.3 Clarification on Types of Fingerprinting

Because the term *fingerprinting* can be used in various contexts related to DSM2 studies and analysis, this section aims to clarify what is meant by *fingerprinting* by providing descriptions of the different types of fingerprinting analysis including some illustrative examples.

6.3.1 Volumetric and Constituent Fingerprinting

There are two main types of fingerprinting analysis (Figure 6.1):

- ☐ Volumetric Fingerprinting
- ☐ Constituent Fingerprinting

Volumetric fingerprinting determines the portion of the volume of water contributed from each source at a specified location and time. Volumetric fingerprinting is analogous to collecting a bucket of water at a specified location in the Delta and determining how much of the water came from the Sacramento River, the San Joaquin River, Martinez, agricultural return flows, and other sources.

Constituent fingerprinting determines the portion of a constituent concentration that originates from each source at a specified location and time. Constituent fingerprinting is analogous to collecting a bucket of water at a specified location and time in the Delta and determining how much of the salinity (or other constituent) in the bucket came from the Sacramento River, the San Joaquin River, Martinez, agricultural return flows, and other sources. For the example in Figure 6.1, the majority of the water comes from the Sacramento River. However, Martinez contributes most of the EC.

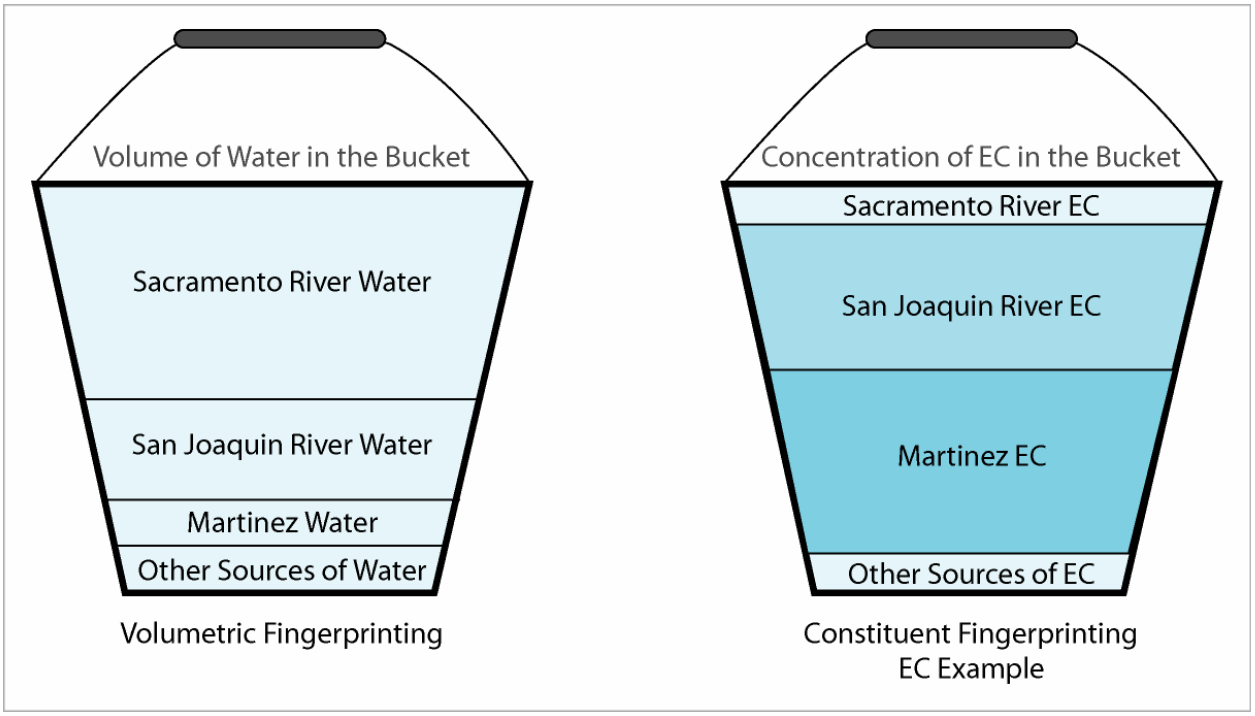

Figure 6.1: Volumetric and Constituent Fingerprinting Conceptualizations.

6.3.2 Timed Fingerprinting

Volumetric or constituent fingerprinting analyses provide information related to the source of the water or constituent. In a typical fingerprinting simulation, the source of the water or constituent is examined, but timing associated with that source is not considered. There are times when it may be of interest to have information related to the timing of the source. For example, after transition periods with large changes in flows or concentrations, it may be of interest to know how much of the water or constituent at a given location originated before or after the transition. A Delta example could be the VAMP (Vernalis Adaptive Management Plan) period from April 15 to May 15 when San Joaquin River flows are increased. To better understand changes in water quality after VAMP, it may be desired to know how much of the water at a given location was contributed before VAMP (prior to April 15), during VAMP (April 15–May 15), or after VAMP (after May 15).

If the timing associated with that source is also of interest, the fingerprinting analysis can be extended to consider both when and where the water or source contribution originated. For example, to better understand changes in water quality after VAMP, it may be desired to know how much of the water at a given location was contributed by the San Joaquin River before, during, and after VAMP compared to the Sacramento River. Similar to the basic fingerprinting analysis, there are two main types of timed fingerprinting analysis (Figure 6.2):

- ☐ Volumetric Timed Fingerprinting
- ☐ Constituent Timed Fingerprinting

For a timed fingerprint analysis, the source water or source constituent information is tracked by both origin location and timing. A timed fingerprinting analysis is analogous to collecting a bucket of water at a specified location and time and determining how much water (or how much of a constituent) originated from each source from each time interval of interest. For example, how much water in the bucket came from the Sacramento River this month, last month, and two months ago? The user defines the source timing period to be examined, for example, per month, per week, or during another specified time period. To conduct a timed fingerprint in the QUAL module of DSM2, the user specifies a conservative constituent to represent each source at each time interval. Thus a timed fingerprinting analysis is more labor intensive to set up and analyze than a basic fingerprinting analysis. A timed fingerprinting analysis is also more computationally expensive because each source at each analysis interval is represented by a separate conservative constituent.

A timed fingerprinting conceptualization is shown in Figure 6.2 considering two time periods for each source location, T_o and T_o-1. These time periods can represent any two consecutive periods such as this month and last month or this week and last week. The Sacramento River is the main source of water volume, with the majority of the contribution coming from the current time period (T_o) and less of the water originating from the previous time period (T_o-1). The main source of EC is Martinez. Similarly the majority of the EC is contributed during the current time period (T_o) with less EC originating from the previous time period (T_o-1).

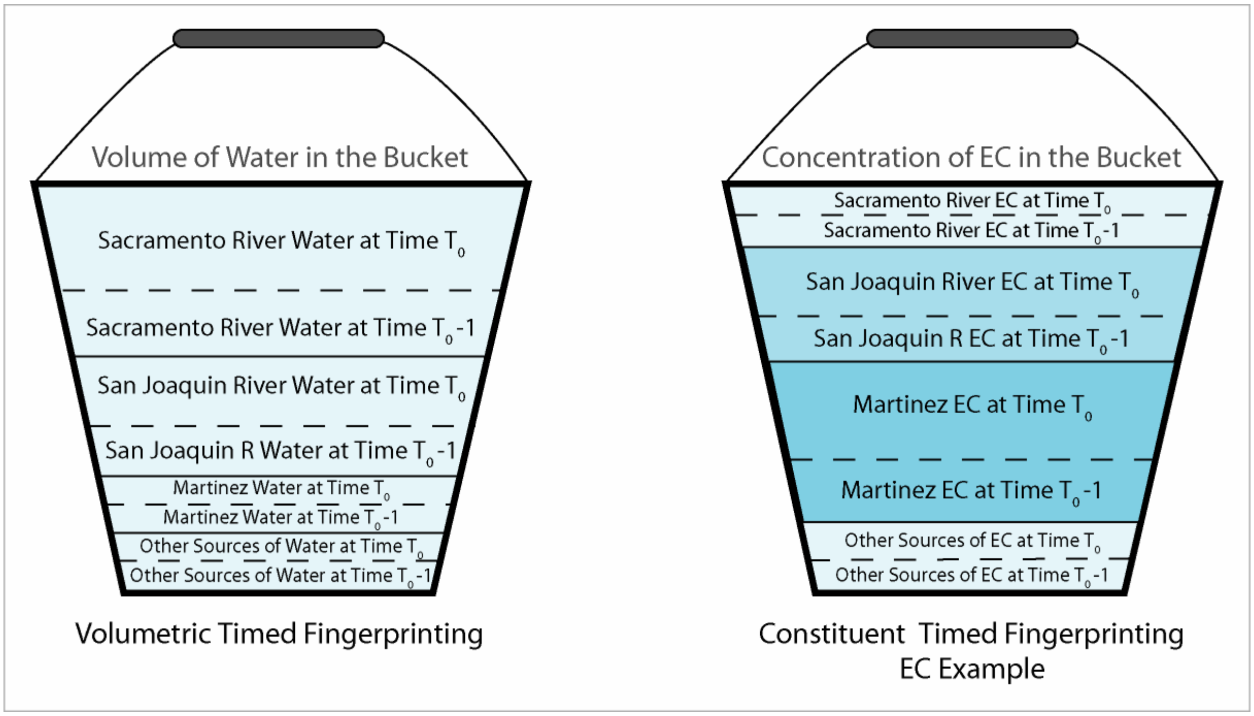

Figure 6.2: Timed Fingerprinting Conceptualizations.

6.3.3 Fingerprinting Example

Fingerprinting analyses for semi-steady state scenarios were conducted to illustrate volumetric and constituent fingerprinting. In a steady state scenario, the Delta inflows and exports do not change over time. These simulations are considered semi-steady state because the stage boundary condition at Martinez varies with time. A time varying tidal boundary condition is necessary at Martinez in order to produce bidirectional tidal flows. A constant stage at Martinez results in unidirectional flows, which are not reflective of Delta hydrodynamics.

Two semi-steady state scenarios were simulated to illustrate how fingerprinting can improve understanding of the effects of system operations on Delta hydrodynamics and water quality.

<u>Semi-Steady State Scenarios</u>

- ☐ Dry spring with the Delta Cross Channel closed
- ☐ Dry spring with the Delta Cross Channel open

For the semi-steady state simulations, the following constant Delta inflows, exports, and EC concentrations representative of drier spring conditions were used (Table 6.1). The Clifton Court Forebay gates were operated to allow inflow into the forebay whenever the water level in the channel was greater than the water level inside the forebay. Because this analysis is for illustrative purposes only, south Delta temporary barriers and minor inflows and exports were not considered. The only difference between the two scenarios is the operation of the Delta Cross Channel gates. The simulations were run for a one-year period to ensure that the effects of assumed initial conditions were removed and that steady state was reached.

Table 6.1: DSM2 Semi-Steady State Scenario Boundary Conditions.

Location	**Boundary Condition Value**	
Delta Inflows	***Flows***	***EC***
Sacramento River	10,000 cfs	175 uS/cm
San Joaquin River	1,000 cfs	500 uS/cm
Delta Exports	***Exports***	***EC***
State Water Project	2,000 cfs	N/A
Central Valley Project	2,000 cfs	N/A
Contra Costa Canal	200 cfs	N/A
Tidal Stage	***Stage***	***EC***
Martinez	Adjusted Astronomical Tide	20,000 uS/cm

To illustrate fingerprinting analyses, three sources were considered for inflows and EC:

<u>Fingerprinting Source Locations</u>

☐ Sacramento River
☐ San Joaquin River
☐ Carquinez Strait at Martinez (ocean/bay water)

In fingerprinting simulations, separate user-defined conservative constituents are defined for each source. For a volumetric fingerprinting simulation, the concentration of each user-defined conservative constituent can be set to a value of 100, so that at any location in the Delta, the value of that constituent represents the percent contribution from that source. For a constituent fingerprinting simulation, each user-defined conservative constituent is set to the same value as the water quality constituent of interest at that source (EC in this example). Values of the user-defined volumetric and constituent fingerprinting conservative constituents are presented in Table 6.2.

Table 6.2: Fingerprinting Boundary Conditions for Semi-Steady State Scenarios.

Location	**Volumetric Fingerprinting Boundary Values**	**Constituent Fingerprinting Boundary Values**
Sacramento River at Sacramento	100	175
San Joaquin River at Vernalis	100	500
Martinez	100	20,000

For each type of fingerprinting, an additional fingerprinting conservative constituent was defined to check for conservation of mass. For volumetric fingerprinting, the mass conservation constituent should have a value of 100 at all locations in the system; and for constituent fingerprinting, the mass conservation constituent should have the value of the water quality constituent being simulated (EC in this example). Thus for these examples, four user-defined conservative constituents (Sacramento River, San Joaquin River, Martinez, and mass conservation check) were defined for volumetric and constituent fingerprinting, resulting in eight total fingerprinting constituents.

For analysis of results, semi-steady state was assumed to be reached when the value of the volumetric mass balance conservative constituent equaled 100 (representing 100% of the flow sources) at all locations. For these scenarios, semi-steady state was reached in approximately 10 months when the Delta Cross Channel gates were closed and 6 months when they were open. Simulation results presented in this chapter are for one year after the start of the simulation to ensure that the simulation had reached semi-steady state and so that the Adjusted Astronomical Tide corresponded to drier spring conditions. Daily average semi-steady state fingerprinting results at the end of a one-year simulation are presented at three Delta urban intakes (Figure 6.3) for the scenarios with the Delta Cross Channel gates closed (Table 6.3 and Figure 6.4) and with the Delta Cross Channel gates open (Table 6.4 and Figure 6.5).

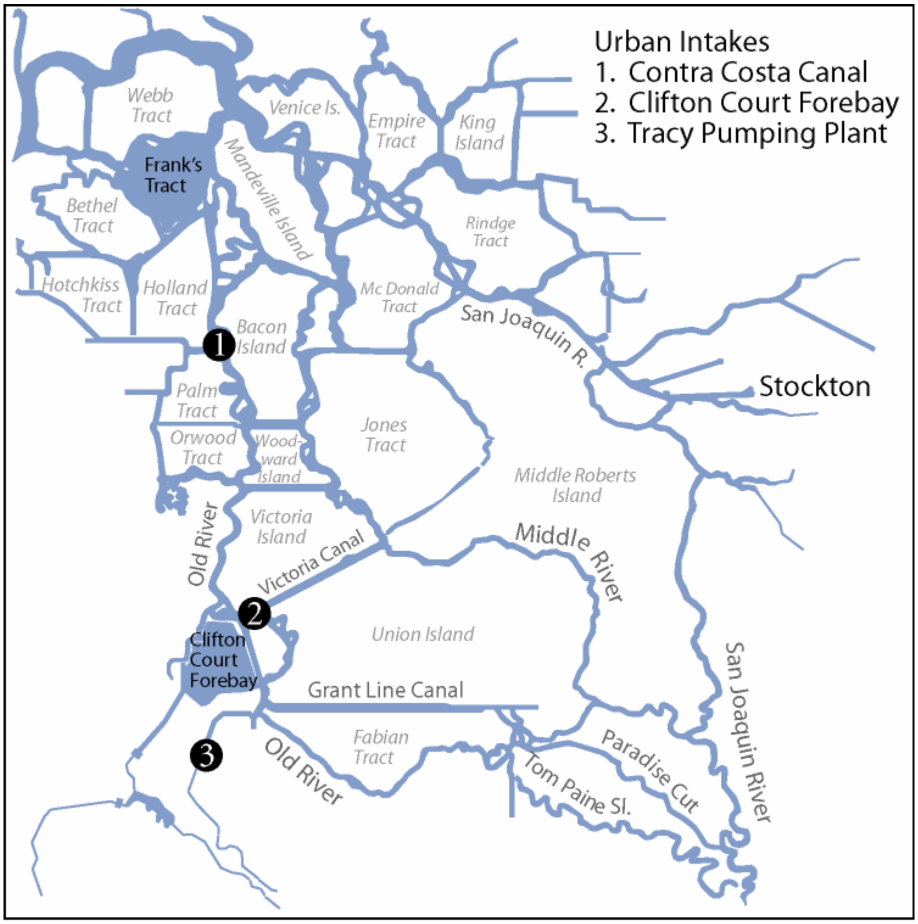

Figure 6.3: Delta Urban Intake Locations.

Table 6.3: Fingerprinting Results at Urban Intakes for a Dry Spring Semi-Steady State Scenario with the Delta Cross Channel Gates Closed.

Location	Volumetric Fingerprinting		Constituent Fingerprinting	
	Flow	% Contribution of Water	Total EC	EC Contribution
Contra Costa Canal	200 cfs	***Total = 99.8%***[1]	468 uS/cm	***Total = 468 uS/cm***
Sacramento River		97.9 %		171 uS/cm (36.6%)
San Joaquin River		0.5 %		2 uS/cm (0.5%)
Martinez		1.5 %		295 uS/cm (62.9%)
Clifton Court Forebay	1736 cfs[2]	***Total = 99.7%***	400 uS/cm	***Total = 400 uS/cm***
Sacramento River		91.8 %		161 uS/cm (40.2%)
San Joaquin River		6.9 %		34 uS/cm (8.6%)
Martinez		1.0 %		205 uS/cm (51.3%)
Tracy Pumping Plant	2000 cfs	***Total = 99.8%***	440 uS/cm	***Total = 440 uS/cm***
Sacramento River		54.6 %		96 uS/cm (21.7%)
San Joaquin River		44.6 %		223 uS/cm (50.7%)
Martinez		0.6 %		121 uS/cm (27.6%)

Table 6.4: Fingerprinting Results at Urban Intakes for a Dry Spring Semi-Steady State Scenario with the Delta Cross Channel Gates Open.

Location	Volumetric Fingerprinting		Constituent Fingerprinting	
	Flow	% Contribution of Water	Total EC	EC Contribution
Contra Costa Canal	200 cfs	***Total = 99.9%***[1]	299 uS/cm	***Total = 299 uS/cm***
Sacramento River		98.8 %		173 uS/cm (57.8%)
San Joaquin River		0.5 %		3 uS/cm (0.9%)
Martinez		0.6 %		124 uS/cm (41.4%)
Clifton Court Forebay	1732 cfs[2]	***Total = 99.9%***	267 uS/cm	***Total = 267 uS/cm***
Sacramento River		92.8 %		162 uS/cm (60.8%)
San Joaquin River		6.8 %		34 uS/cm (12.8%)
Martinez		0.4 %		70 uS/cm (26.4%)
Tracy Pumping Plant	2000 cfs	***Total = 100.0%***	361 uS/cm	***Total = 361 uS/cm***
Sacramento River		54.9 %		96 uS/cm (26.6%)
San Joaquin River		44.8 %		224 uS/cm (62.1%)
Martinez		0.2 %		41 uS/cm (11.3%)

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[1] Totals of slightly less than 100% reflect round-off errors.

[2] The target export at Clifton Court Forebay was 2,000 cfs. Because inflows into the forebay are tidal, the daily average inflow may be slightly greater or slightly less than the target. However the long-term average inflow into the forebay equals the target inflow.

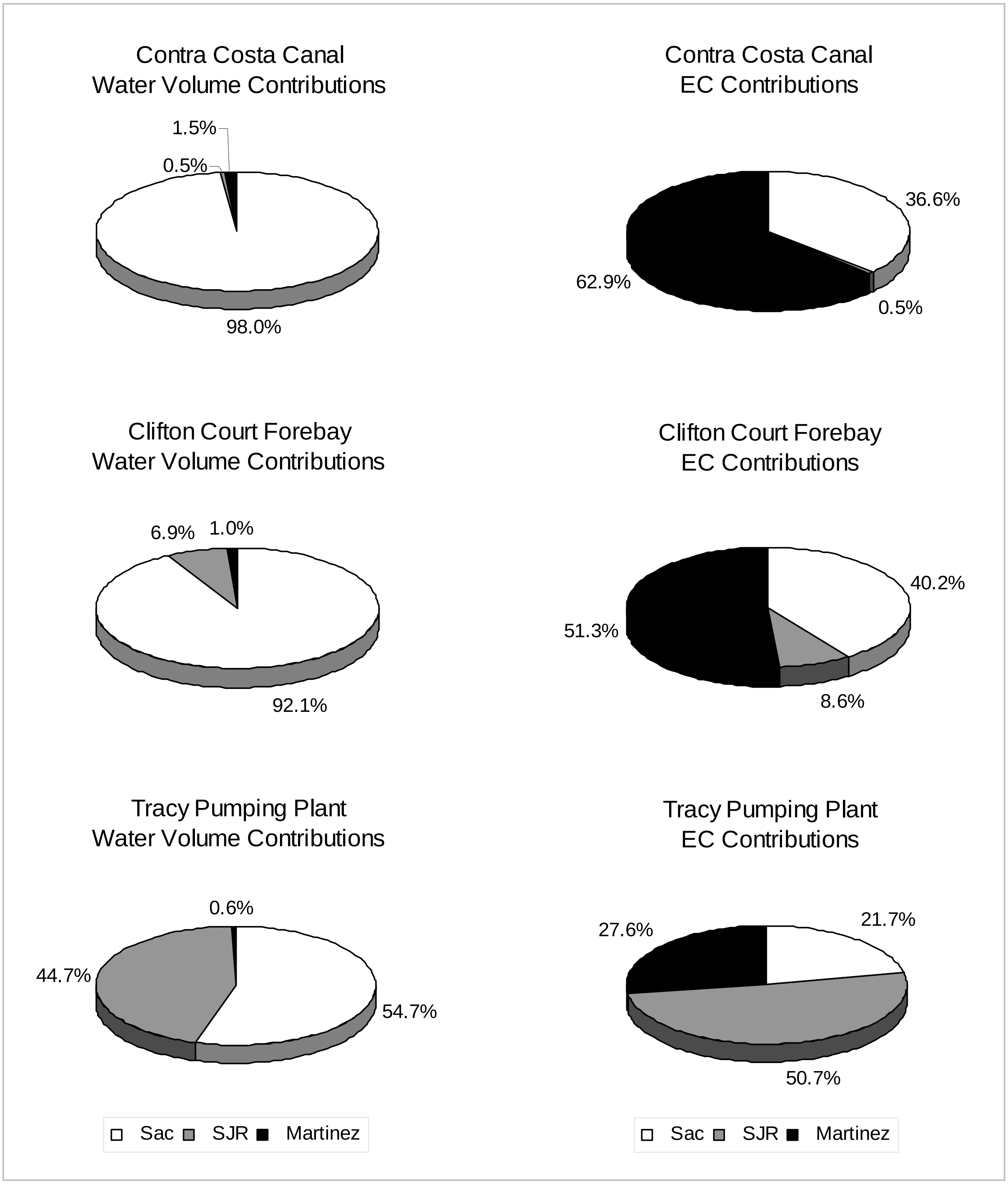

Figure 6.4: Water and EC Contributions at Urban Intakes with Delta Cross Channel Closed for a Semi-Steady State Dry Spring Conditions.

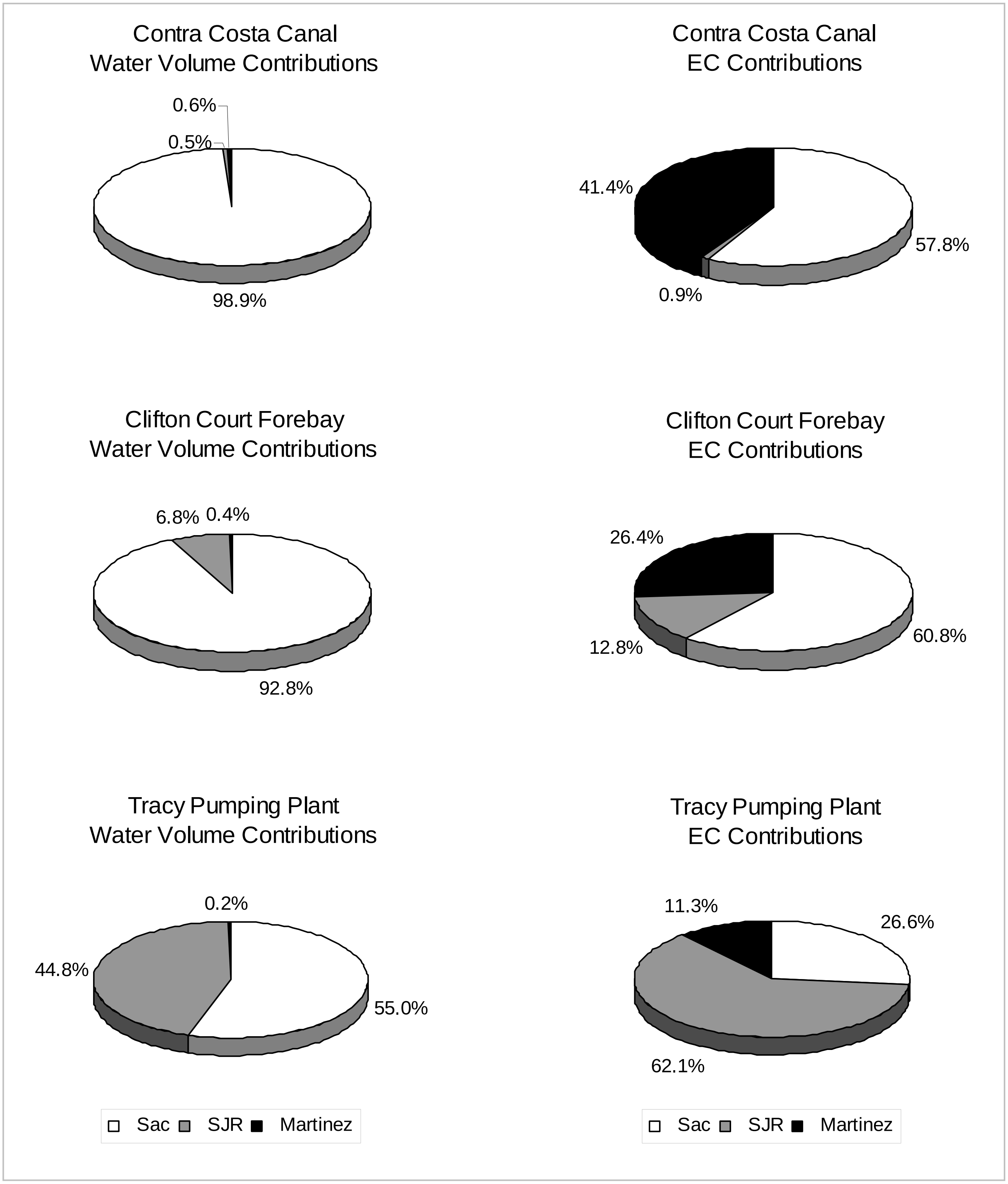

Figure 6.5: Water and EC Contributions at Urban Intakes with Delta Cross Channel Open for a Semi-Steady State Dry Spring Conditions.

In practice, the Delta Cross Channel gates are closed during certain periods in the spring to keep migrating juvenile salmon in the main stem of the Sacramento River and out of the interior Delta. When migrating salmon are not a concern, the Delta Cross Channel gates can be opened to allow relatively fresh Sacramento River water to flow into the interior Delta, thus improving Delta water quality.

An improvement in Delta water quality resulting from opening the Delta Cross Channel gates was shown by the simulation results for dry spring semi-steady state conditions (Table 6.3 and Table 6.4, Figure 6.4 and Figure 6.5). At the urban intakes, opening the Delta Cross Channel gates reduced EC concentrations by approximately 35% at Contra Costa Canal and Clifton Court Forebay and by nearly 20% at Tracy Pumping Plant. Fingerprinting simulation results can be used to gain further insight into how opening the Delta Cross Channel gates reduced EC concentrations at the urban intakes.

Effects of Delta Cross Channel operations on source contributions of water and EC at three urban intakes were examined using volumetric and constituent fingerprinting. For the dry spring conditions, volumetric fingerprinting results show that the Sacramento River was the major source of water at the three urban intakes regardless of the Delta Cross Channel gate position. The San Joaquin River was a significant source of water at the Tracy Pumping Plant, but provided only minor contributions of water at the other two urban intakes.

The constituent fingerprinting results illustrate that Martinez and the San Joaquin River provided the majority of the EC at all three urban intakes. For example, at Contra Costa Canal, Martinez provided only 1.5% of the flow when the Delta Cross Channel gates were closed (Table 6.3 and Figure 6.4). However, because of its high salinity, Martinez provided almost 63% of the EC. Opening the Delta Cross Channel gates resulted in an increase in flow from the Sacramento River of about 1%. Although the increase in freshwater source was relatively small, the corresponding 1% reduction in water from the high salinity source from Martinez reduced the EC contribution from Martinez from 63% to 41% (Table 6.4 and Figure 6.5).

The fingerprinting results can also provide insight into Delta dynamics that cannot be deduced from flow and EC simulations alone. For example, for the scenario with the Delta Cross Channel gates closed (Table 6.3 and Figure 6.4), the EC at Clifton Court Forebay and Tracy Pumping plant were similar (400 uS/cm and 440 uS/cm respectively). Although the EC concentrations were similar, the major source of the EC was different at each intake. For Clifton Court Forebay, the majority of the EC came from Martinez (~51%) and the Sacramento River (~40%). However, for the Tracy Pumping Plant, about half of the EC came from the San Joaquin River (~50%) with the Sacramento River and Martinez providing about a quarter of the EC each (~22% and 28% respectively).

6.4 Recent Applications

Recent applications of DSM2 fingerprinting by the Delta Modeling section fall into two main categories: (1) Understanding historical Delta conditions and (2) Understanding hypothetical Delta conditions for planning studies. The following recent fingerprinting applications are presented in this section:

Understanding Historical Delta Conditions

- ☐ Fingerprinting Reports for MWQI Real Time Data Forecasting Reports
- ☐ Fingerprint of the San Joaquin River at Vernalis
- ☐ Using DSM2 Fingerprints to Check Carbon Dating Studies

Understanding Hypothetical Delta Conditions for Planning Studies

- ☐ Improve Understanding of Delta Flows and Water Quality for SDIP Studies
- ☐ Using Volumetric Fingerprints to Develop DOC Constraints in CALSIM

6.4.1 Fingerprinting Reports for MWQI Real Time Data Forecasting Reports

Delta Modeling Section staff have been conducting DSM2 fingerprinting studies in support of the California Department of Water Resource's Municipal Water Quality Investigations Program's (MWQI) weekly Real Time Data Forecasting (RTDF) reports. The RTDF report conveys the current conditions of the Delta and provides the best estimates for future conditions in the short term, about two weeks into the future.

Some of the parameters included in the description of current conditions and in the forecasts included in the RTDF are EC and dissolved organic carbon (DOC) at Clifton Court Forebay. In order to better understand the historical conditions upon which those forecasts are based, the following fingerprinting studies are often conducted using a DSM2 simulation of historical conditions:

- ☐ Volumetric fingerprinting for source water
- ☐ Constituent fingerprinting for electro conductivity (EC)
- ☐ Constituent fingerprinting for dissolved organic carbon (DOC)

A sample fingerprinting report for historical percent source water, EC and DOC at Clifton Court Forebay from the May 10, 2005 RTDF report is shown in Figure 6.6 (DWR, 2005). The volumetric fingerprint indicates the historical source contributions of water in Clifton Court Forebay. For example, Figure 6.6 shows the shifting of the major water source from the Sacramento River in January 2005 to the San Joaquin River in April 2005. The individual sources of historical EC and DOC are shown in the constituent fingerprints. The total concentration of historical EC or DOC is indicated by the solid black line at the top of the figure and equals the sum of the constituent contributions from each source. For example, Figure 6.6 shows that by April 2005, the San Joaquin River was the major source of both EC and DOC in the water at Clifton Court. The drop in EC concentration in April 2005 (Figure 6.6) can be further explained by observing that during this time period San Joaquin River flows were relatively high and had relatively low EC concentrations. Such combining of fingerprinting results with knowledge of flows and exports in the system can further enhance understanding of how Delta conditions and operations affect export water quality.

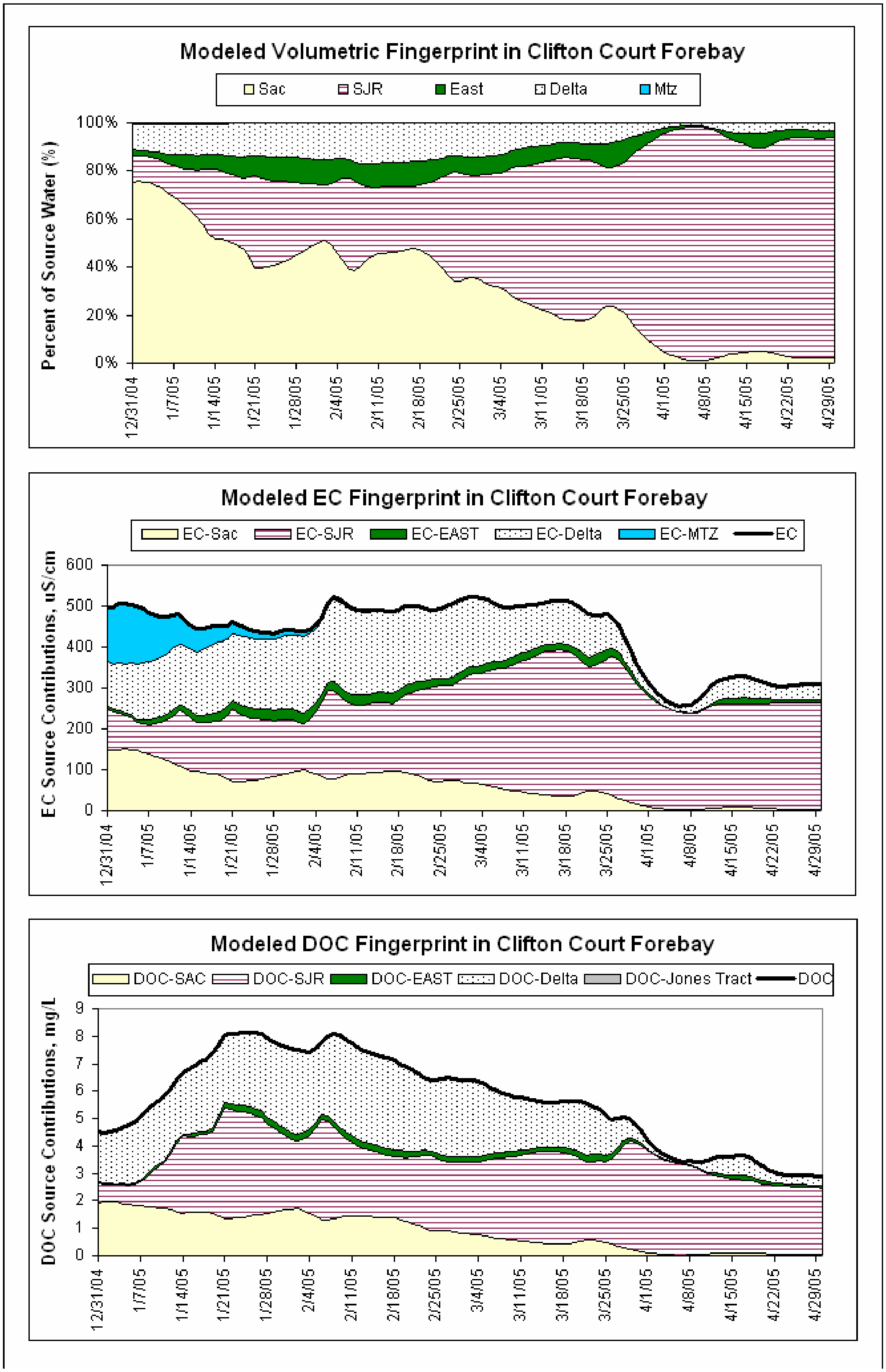

Figure 6.6: Fingerprinting Results for MWQI Real Time Data Forecasting Report May 2005.

6.4.2 Fingerprint of the San Joaquin River at Vernalis

Fingerprinting has been used to better understand how DSM2 with the San Joaquin River extension up to Bear Creek (DSM2-SJR) models flow and salinity in the San Joaquin River at Vernalis (Wilde and Suits, 2004). The major inflows to the reach of the San Joaquin River from Bear Creek to Vernalis are eastside tributaries (the Stanislaus, Tuolumne, and Merced rivers), westside creeks and sloughs (Salt and Mud sloughs, Orestimba, Del Puerto, and Hospital/Ingram creeks), unmonitored yet significant sources such as agricultural drainage, groundwater, and tile drains, as well as the additional water (add-water) needed to force a water balance during calibration as per Pate (2001).

Fingerprinting was used to address such questions as:

- ☐ How much of the Vernalis flow at a given time is from specific tributaries?
- ☐ At Vernalis how do the contributing flows vary seasonally?
- ☐ What are the major sources of salt and how do these vary with time?
- ☐ Which sources of water and salts in the system need better understanding in order to accurately simulate flow and salinity at Vernalis?

As shown in the historical daily volumetric fingerprint values in Figure 6.7, the eastside streams are the dominant source of water at Vernalis (35%-90%). Add-water, assumed a constant rate of 350 cfs all year (Pate, 2001), can also be a significant contributor, particularly in the drier years from 1990 to 1993. Averaging these values by month over the simulation period reveals the source water seasonal variation by volumetric percent (Figure 6.8). The eastside tributaries' relative contribution to total flow in the summer is only marginally less than in the winter due to the system's highly managed and substantial reservoir storage capacity. The unmonitored sources of return flow add more to the system in the summer than in the winter, and the westside creeks and sloughs contribute more in the winter and early spring.

The daily salinity fingerprint in Figure 6.9 shows a highly seasonal fluctuation in source contribution to salinity at Vernalis. Figure 6.9 also reveals the important dry period contribution to salinity at Vernalis of the add-water which is assumed to have an EC of twice that for Orestemba Creek as according to Pate (2001). From 1990 through 1993 add-water contributes 30%-60% of the San Joaquin River salt load at Vernalis. For monthly averaged values from 1990 to 1999, the add-water salt load contribution is 20%-40% (Figure 6.10). This large contribution of salt by unknown water source, as revealed by fingerprinting, is guiding the review of the assumptions in DSM2-SJR modeling of historical conditions and helps highlight the significance of the unknown sources of flow and salt to current modeling capabilities.

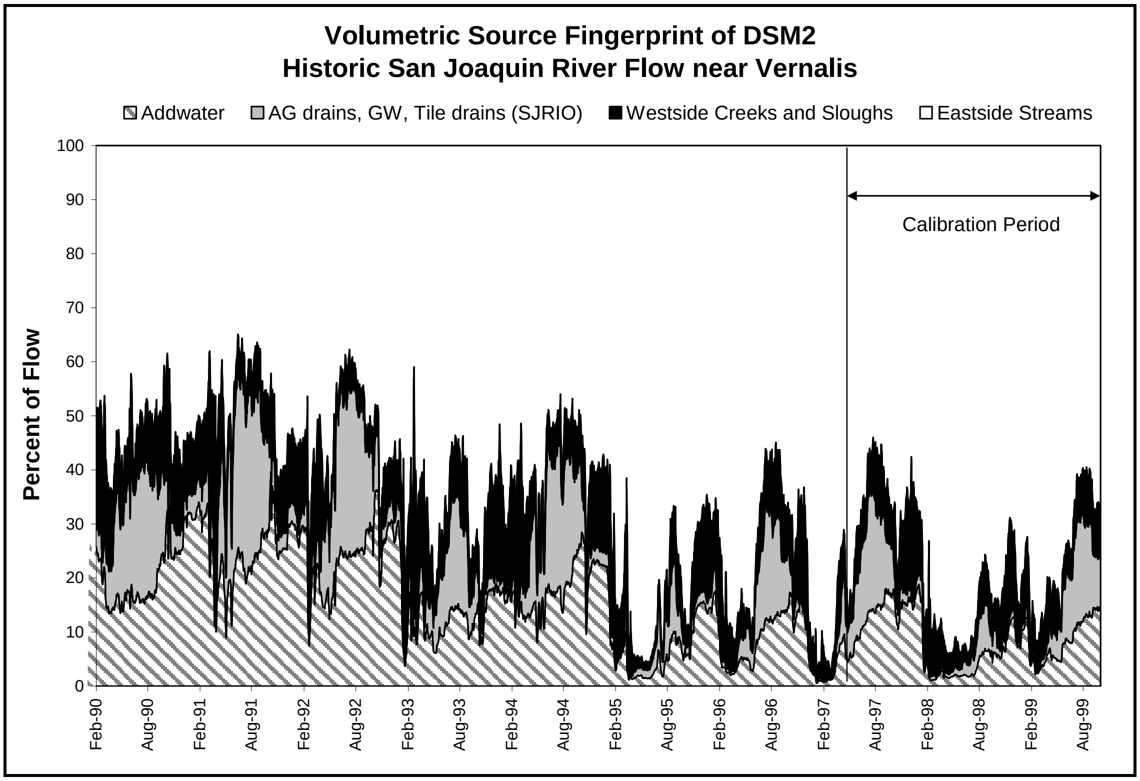

Figure 6.7: DSM2-SJR Generated Volumetric Fingerprint at Vernalis Indicating the Relative Flow Contribution from Grouped Sources.

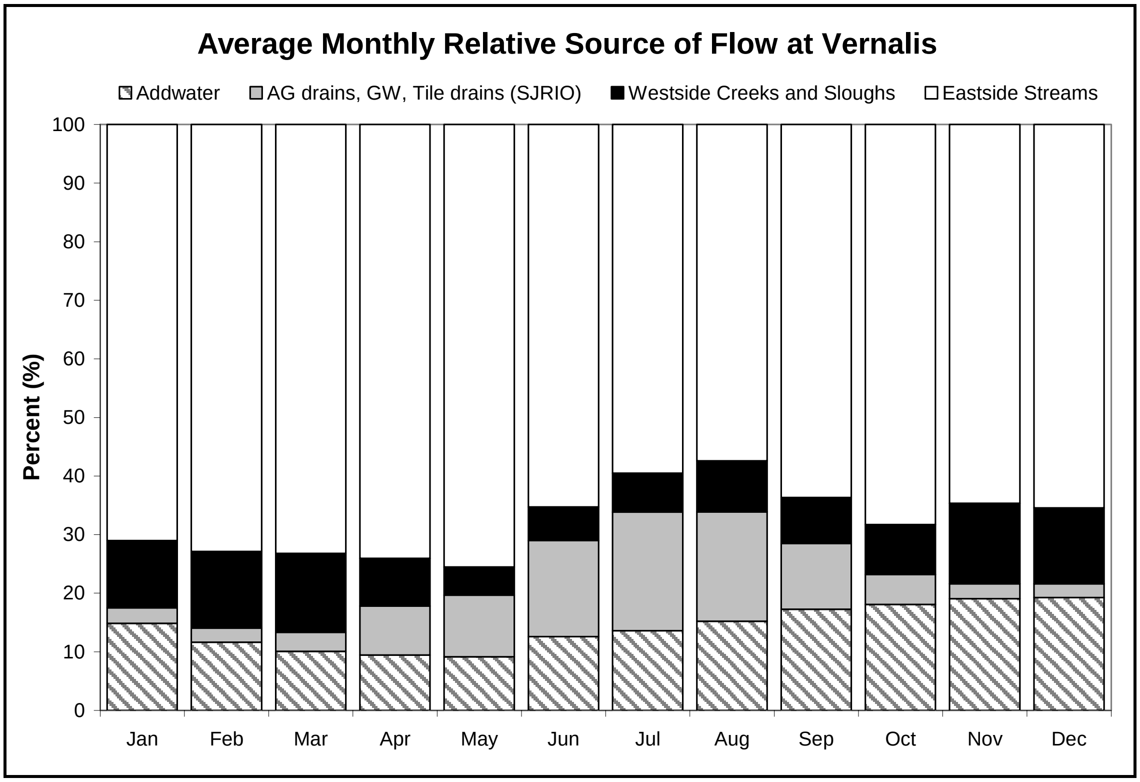

Figure 6.8: DSM2-SJR Generated Average Monthly Volumetric Source Contribution at Vernalis over the January 1990 – September 1999 Simulation Period.

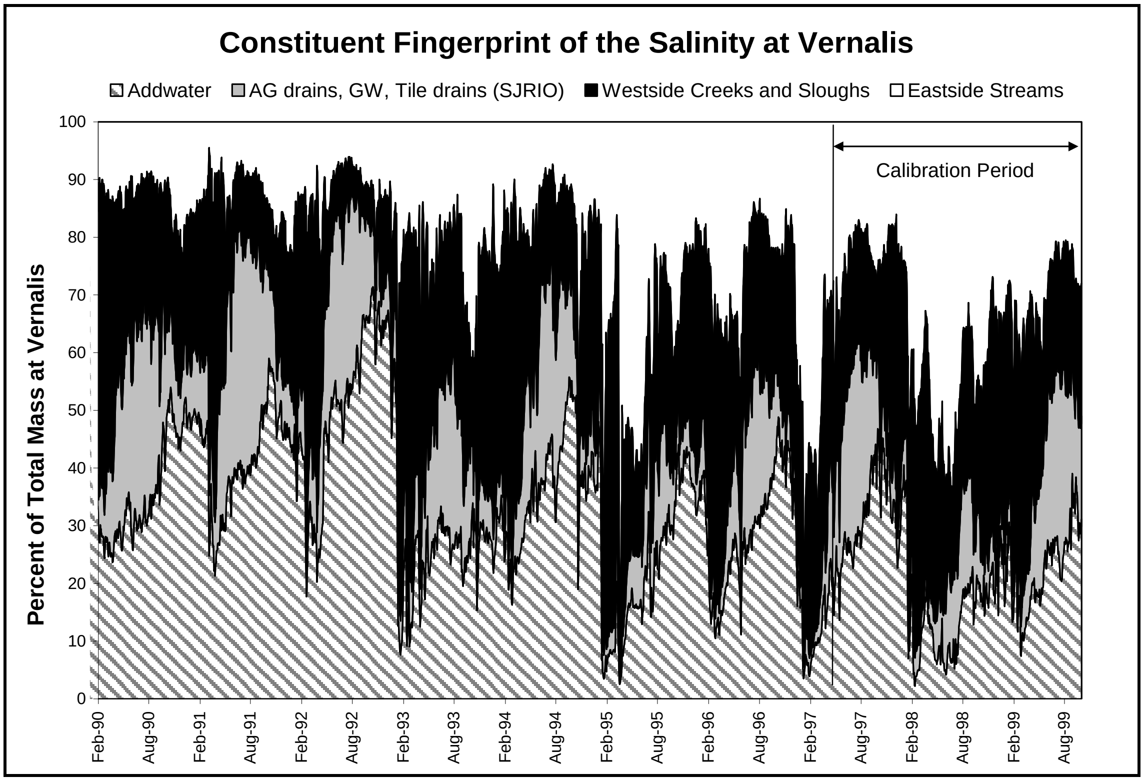

Figure 6.9: DSM2-SJR Generated Constituent Fingerprint at Vernalis Indicating the Relative Load Contribution from Grouped Sources.

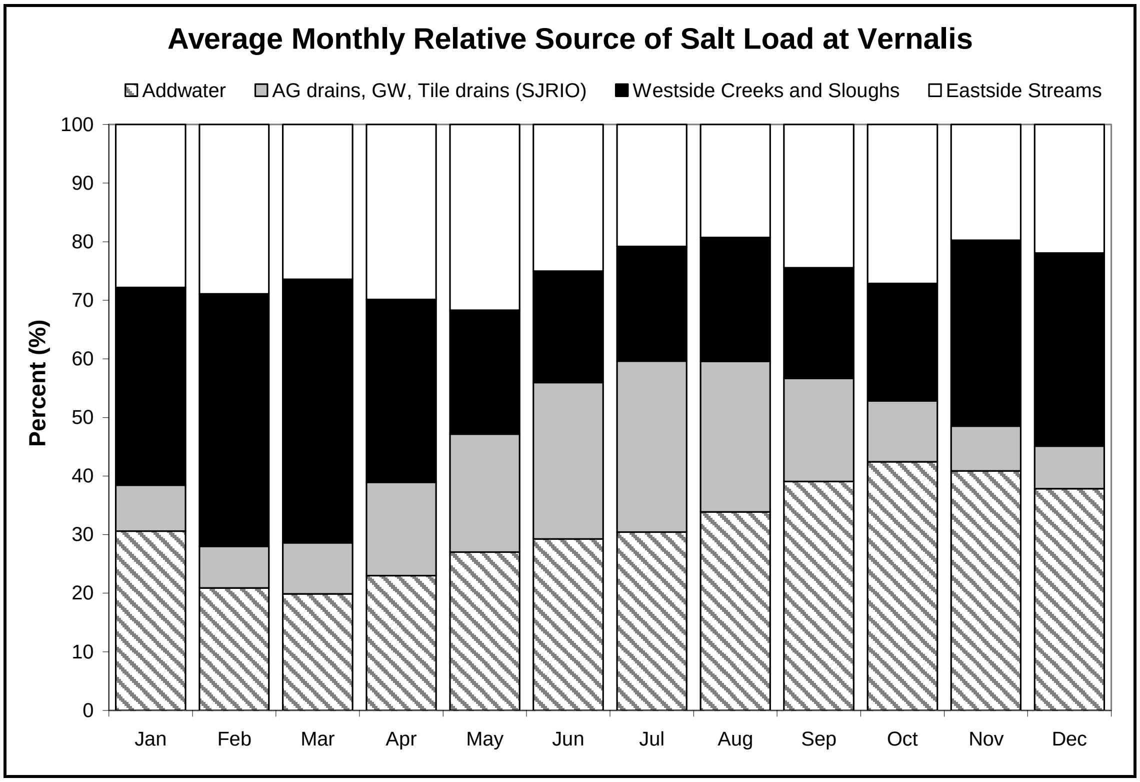

Figure 6.10: DSM2-SJR Generated Average Monthly Percent Contribution of Salinity at Vernalis over the January 1990 – September 1999 Simulation Period.

6.4.3 Using DSM2 Fingerprints to Check Carbon Dating Studies

Coupling the radiocarbon fingerprint for Delta peat-derived carbon with DSM2 volumetric fingerprints has allowed DWR, Lawrence Livermore National Laboratory, and University of Florida researchers to model both the quantity and quality of dissolved organic matter (DOM) exported from the Sacramento – San Joaquin Delta to the California State Water Project (DiGiorgio et al., 2004). The source of water and DOM at Banks Pumping Plant simulated in DSM2 was compared with the radiocarbon content of DOM samples to help validate changes in DOM as it moved through the Delta. Preliminary results from the radiocarbon study indicate that the DOM pool is buffered in terms of size, but it is in dynamic flux, turning over fairly rapidly as it is transported through the river system.

6.4.4 Improve Understanding of Delta Flows and Water Quality for SDIP Studies

Fingerprinting analyses have been used to improve impacts assessments of changes in Delta water quality as a result of implementation of elements of the South Delta Improvements Program (SDIP). This section briefly reviews two such fingerprinting applications:

- ☐ Investigate contributions of agricultural drainage to South Delta flows and EC (Nader and Shrestha, 2005)
- ☐ Improve understanding of potential impacts of proposed permanent barrier operations on Delta water quality (Anderson, 2005)

These fingerprinting applications are described in more detail below. Because the focus of this paper is to describe various fingerprinting applications, the study questions and approach are summarized. However, the results from the studies are not presented.

Agricultural Drainage Impacts on Delta EC

One set of fingerprinting studies conducted for SDIP examined contributions of agricultural drainage to South Delta flows and EC in Middle and Old rivers (Nader and Shrestha, 2005). Both volumetric and constituent fingerprinting analyses were conducted. Two main issues were investigated: (1) high agricultural drainage contributions when flows were nearly stagnant, and (2) sensitivity of Brandt Bridge EC to potential errors in agricultural drainage EC concentrations.

Volumetric fingerprinting analyses indicated that the highest agricultural drainage contributions to flows in the South Delta occurred at Old River at Tracy Road and Middle River at Mowery Bridge. Low net flows at these locations resulted in higher flow contributions from agricultural drainage.

Additional fingerprinting analyses determined the contribution of Brandt Bridge EC from agricultural drainage. These results were used to conduct a sensitivity analysis of how potential errors in estimating agricultural drainage EC may affect the estimate of Brandt Bridge EC.

Barrier Operation Impacts on Water Quality

Another fingerprinting analysis was conducted for SDIP to improve understanding of differences in modeled Delta water quality for various operational scenarios of planned tidal barriers (Anderson, 2005). Water quality simulations using DSM2-QUAL quantify differences in water quality constituent concentrations between alternatives. Because the results are time series of concentrations at a location, there is no direct indication of why the concentrations differed between alternatives. Fingerprinting analysis can provide additional understanding by indicating how the mix of water from various sources changes for each scenario. For example, a fingerprinting analysis may indicate that an improvement in water quality at a certain location is due to an increased flow contribution at that location from a better quality source or a reduced flow contribution from a high concentration source.

For SDIP impacts assessments, several DSM2 hydrodynamic and water quality simulations were conducted for various operational scenarios for South Delta fish and agricultural barriers (for example, no barriers, temporary barriers, proposed permanent barriers). For certain scenarios, reasons for changes in water quality were not readily evident, thus volumetric fingerprinting analyses were conducted to directly view how the various operational scenarios affected the source flow contributions at selected locations. For example, fingerprinting results indicated that an improvement in EC at Old River at Bacon Island for one scenario was due to a slight decrease in the source contribution from Martinez. Although the reduction in volume contributed by Martinez was small, the high source EC concentration for Martinez resulted in a noticeable reduction in EC at Old River at Bacon Island.

6.4.5 Using Volumetric Fingerprints to Develop DOC Constraints in CalSim

Although DWR’s statewide operations model (CalSim) uses an Artificial Neural Network (ANN) to estimate salinity in the Delta, CalSim does not have a method to predict DOC. Special flow-based DOC constraints were necessary for the CalSim and DSM2 In-Delta Storage studies in order to meet the specific DOC objectives that have been placed on the proposed IDS project. Although earlier IDS studies made use of DSM2 Particle Tracking Model island particle fate – flow relationships, the PTM-based approach was limited. Instead, new CalSim DOC constraints were developed by using a volumetric fingerprint at the urban drinking water intakes to establish a relationship between the volume of IDS releases and various flow parameters (Mierzwa and Wilde, 2004). These volumetric fingerprinting-based CalSim DOC constraints have been used in a number of joint CalSim and DSM2 IDS studies.

6.5 Summary

Volumetric, concentration and timed fingerprinting analyses provide insightful tools for improving understanding of how varying inflows with varying constituent concentrations affect water quality in the Delta. This paper describes the types of fingerprinting analysis and presents recent fingerprinting applications.

6.6 References

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