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

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Chapter 6:
Using DSM2 to Develop Operation Strategies for South Delta Improvements Program's Proposed Permanent Gates

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6 Using DSM2 to Develop Operation Strategies for South Delta Improvements Program's Proposed Permanent Gates

6.1 Introduction

The Department of Water Resources' (DWR) South Delta Improvements Program (SDIP) proposes the installation of four permanent operable gates in the south Delta. These gates are intended to replace the existing temporary barriers and have three primary objectives:

- minimize the number of in- and out-migrating salmon moving towards export pumps,
- maintain adequate water levels for South Delta farmers to prevent cavitation from occurring in their irrigation pumps, and
- improve water quality in the South Delta channels by providing better circulation.

One gate is proposed installed at the head of Old River (HOR) to minimize the impact of export pumps on the in- and out-migrating salmon. Periods of operation would be during the April 15 to May 15 Vernalis Adaptive Management Plan (VAMP) periods and in October and November. SDIP also proposes to install three permanent agricultural gates: in Middle River (MR) between the confluence of Victoria Canal and Tracy Road Bridge, in Old River (OR) near the confluence of Grant Line Canal and the Tracy Pumping Plant, and in Grant Line Canal (GLC) near the mouth of Grant Line Canal and toward the Clifton Court Forebay (CCF). Figure 6.1 shows the gate locations. All four South Delta permanent gates are assumed operable to provide significantly more flexibility than the existing temporary barriers. This chapter provides an overview of the problems with the water conditions in the South Delta channels and discusses using DWR's Delta Simulation Model II (DSM2) in driving the evolution of the plans for the operation of the permanent gates, plans which are included in the 2005 Draft SDIP EIR/EIS (DWR, 2005).

6.2 Overview of South Delta Channel Problems

For the last three decades, the farmers in the south Delta region have experienced problems operating the pumps and siphons used to irrigate their fields. The main problem was low water levels, but water quality has also been a concern. The South Delta Water Agency (SDWA) complained that the low water levels caused by tidal affects in the Delta had been exacerbated by the operation of the State Water Project (SWP) and Central Valley Project (CVP) pumps. After years of negotiations, the Department of Water Resources (DWR) agreed to install, when needed, seasonal temporary rock barriers in Middle River, Old River, and Grant Line Canal (referred to as agricultural barriers). It was also agreed that DWR would install a temporary rock barrier at the head of Old River during the spring and fall to help migrating salmon.

The current temporary agricultural barriers help capture water during flood tides by allowing flow through culverts with flap-gates, and then prevent flow downstream during the ebb tide once the water level drops below the weir crest elevation. When all three temporary agricultural barriers are installed, the water levels upstream of the barriers are typically adequate for the farmers to irrigate their farms. However, the water quality in the area bounded by the temporary south Delta barriers can be poor. This is because the water captured upstream of the agricultural barriers is predominantly from the San Joaquin River with some agricultural drainage added, and this drainage water is usually much saltier than the river water (see Chapter 4 for more information on sources of salinity in the South Delta). A possible exception to the poorer water quality upstream of the barriers is in the section of the rivers immediately upstream of the barriers. These regions receive a portion of the water that is moving upstream on the flood tide, water which at times is primarily of Sacramento River origin. This water is typically of better quality than that originating from San Joaquin River. Unfortunately under typical conditions the flood tide does not provide sufficient energy to transport the better quality water very far upstream of the barriers. When the San Joaquin River flow at Vernalis is below 1200 cfs, particularly during the summer irrigation season, the net tidal flows in Middle River, Old River, and Grant Line Canal upstream of the barriers are near zero. Under these conditions of little circulation, the concentration of salt in south Delta channels can significantly increase due to return flows from agricultural drainage.

The permanent operable gates proposed in the SDIP would provide much more operational flexibility than the current temporary agricultural barriers. In support of the SDIP, operating rules for the permanent gates were sought that use tides to provide improved circulation and transport more of the better quality of Sacramento River source to the channels upstream of the gates, while also improving water levels.

6.3 Development of Plan C Gate Operations

In 2003 SDIP management requested the Delta Modeling Section design an operation of South Delta gates that maintains specified minimum water levels at three locations: Middle River near Undine Road Bridge, Old River near Tracy Road Bridge, and Grant Line Canal near Tracy Road Bridge. The target minimum levels at the sites were originally 0.5 ft mean sea level (MSL), 0.0 ft MSL, and 0.0 ft MSL respectively. The more stringent 0.5 ft. MSL minimum water level at Middle River near Undine Road would be the controlling stage criteria since the three locations are hydraulically connected. That is, meeting the 0.5 ft. MSL minimum stage requirement at Middle River near Undine Road would ensure that the target minimum stages at the other two locations would be met. The Middle River location originally had higher target minimum water level due to Middle River reaches being more shallow compared to those of Grant Line Canal and Old River. SDIP negotiated with SDWA to lower the Middle River target minimum water level to 0.0 ft MSL provided DWR agreed to dredge a portion of Middle River to improve the conveyance in Middle River. Therefore, for the process of establishing strategies for permanent gate operation, the 0.0 ft. MSL minimum water level was assumed the criterion at all three locations.

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6.3.1 Plan A Operation

The first series of permanent operable gate operations developed by the Delta Modeling Section is labeled "plan A." This proposed gate operation focuses on achieving the minimum water level criteria. It was used in SDIP's 2005 Draft Environmental Impact Statement/Environment Impact Report (DWR, 2005).

The fish gate at the head of Old River (HOR) is assumed fully closed during the April 15 to May 15 VAMP period and partially closed during periods in October and November. During these fall periods, the gate is assumed to allow 10 to 15% of the flow from San Joaquin River to pass into Old River to improve water quality by reducing stagnation problems downstream of the fish gate. These gate operations are overridden anytime the San Joaquin River flow at Vernalis exceeds 18,500 cfs, at which times the gate is assumed fully opened to protect against flooding. At all other times outside these spring and fall operations, the fish gate is kept open.

When operating, the Middle River (MR) and Old River (OR) gates are assumed operated as full tidal gates. They are always open during flood tides and are simultaneously closed during the ebb tide when the minimum water level at any one of the three target locations falls below 0.0 ft MSL. When operating, the Grant Line Canal (GLC) gate is also always open during flood tides, but its closure during ebb tide is more complex. During ebb tides, the GLC gate is operated as a special weir with a 1 ft. MSL crest elevation if MR and OR gates fail to maintain the 0.0 ft MSL water level target. The GLC gate allows water to flow downstream as long as water levels at the three target locations are higher than 1ft. MSL.

The timing of the "plan A" gate operations was developed in an iterative process. The first iteration, which assumed no gates where operating (i.e. the gates were open), identified times when minimum water levels fell below 0.0 ft MSL at the target locations. In the second iteration, the MR and OR gates were simultaneously tidally operated during the times water levels in the first iteration fell below 0.0 ft MSL. A transitional period component was included for gradual opening to closing, and a buffer time was included to insure water levels do not fall below the 0.0 ft MSL threshold. In the third and final iteration, Grant Line Canal was operated when operating the other two gates failed to achieve or maintain the target minimum water levels.

6.3.2 Plan B Operation

The "plan A" gate operation strategy resulted in the gates being operated too often. Due to transitional and buffer times (in all three gates), as well as the higher weir crest elevation for the Grant Line Canal gate, the upstream water levels at the gates locations (eastward and away from project pumps) was higher than needed to achieve the target levels. While generating the higher water levels, the "plan A" gate operation failed to maintain adequate circulation, and as a result, significant improvement in water quality did not occur. The "plan A" gate operation was modified (also known as the "plan B" gate operation) by eliminating the transitional and buffer times and reducing the crest elevation for GLC weir to 0.0 ft MSL. The "plan B" gate operation showed slight improvement in circulation and water quality compared to the "plan A" gate operation.

6.3.3 Plan C Operation

"Plan C" and "modified plan C" gate operations evolved to achieve the objective of improving water quality with better flow circulation in south Delta channels in addition to maintaining adequate water levels. These gate operation strategies attempt to maintain unidirectional net flows in the Middle River, Old River, and Grant Line Canal reaches to avoid flow stagnation and subsequent increases in salt concentrations in south Delta channels. In addition to improving water quality and water levels in the south Delta, "modified plan C" improves flows and dissolved oxygen in the San Joaquin River downstream of Old River at Head.

Plan C and Modified Plan C Gate Operation Rules

Unlike the "plan A" and "plan B" operations, the "plan C" and "modified plan C" operation rules are dependent on the San Joaquin River (SJR) hydrology at Vernalis. Because the fish gate operation dictates the amount of flow into the South Delta region through Old River, the agricultural gate operation is also dependent on the operation of the fish gate. Tables 6.1 and 6.2 summarize the "plan C" gate operation rules.

Table 6.1: Operation of Head of Old River Gate (Fish Gate).

Condition	Head of Old River (HOR) Gate
SJR > 10000	Fully Open
Pre, VAMP and Post VAMP (APR- MAY)	Fully Closed
Fall (OCT – NOV)	Partial leakage of flow (about 10 to 15%, achieved in DSM2 by using flow coefficients of 0.02)
Summer (JUN – SEP) and 2500 cfs > SJR > 800 cfs	Limit flow through Head of Old River to 500 cfs.

Table 6.2: Operation of Agricultural Gates.

Condition		Middle River (MR)	Old River at Tracy (OR)	Grant Line Canal (GLC)
If HOR is operated (see Table 6.1)		Operated	Operated	Operated
If HOR is open AND Monthly Flow (cfs)	SJR < 2500	Operated	Operated	Operated
	2500 < SJR < 4000	Fully Open	Operated	Operated
	4000 < SJR < 8000	Fully Open	Fully Open	Operated
	SJR > 8000	Fully Open	Fully Open	Fully Open

When the MR and OR gates are operated, they are fully open during flood tides and fully closed during ebb tides. When the GLC gate is operated, it is fully open during flood tides and the early part of ebb tides. Once the water levels approach the target minimum water levels of 0.0 ft.

MSL, the GLC gate is partially closed to protect minimum water levels. In DSM2, during ebb tides, the GLC gate is modeled as a series of culverts with the crest elevation of -0.5 MSL.

The "modified plan C" gate operation differs from the "plan C" gate operation by limiting the flow down the head of Old River in the summer months (June – September) to 500 cfs the when San Joaquin River flow at Vernalis is between 800 and 2500 cfs. Studies have shown that for these conditions, a diversion of about 500 cfs of San Joaquin River flow down the head of Old River is sufficient to meet the minimum water level criteria at the three target locations. In addition, limiting the amount of San Joaquin River flow down Old River keeps more flow in the main stem of the San Joaquin River, which in turn improves water levels, water quality, and dissolved oxygen in the San Joaquin River. The magnitude of the tidal pumping through MR and OR gates also will increase slightly. The object-to-object feature of DSM2 was used to directly relocate water on one side of the HOR to the other, without having to change the way DSM2 simulates gate structures.

Figures 6.1 to 6.4 show the gates locations, gates operation rules, and the likely direction of net flows in South Delta channels. Figure 6.5 shows the additional rule that applies only to the "modified plan C" gate operation.

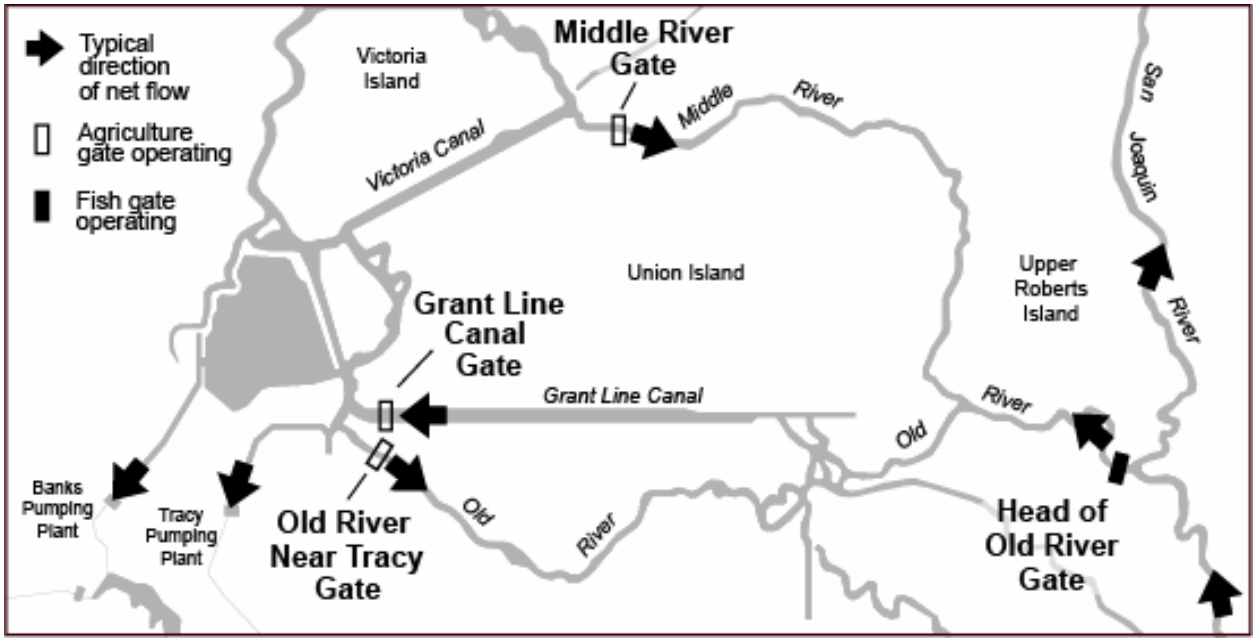

Figure 6.1: South Delta permanent gate operation for low San Joaquin River flows (SJR< 2500 cfs) or Old River at head gate closed.

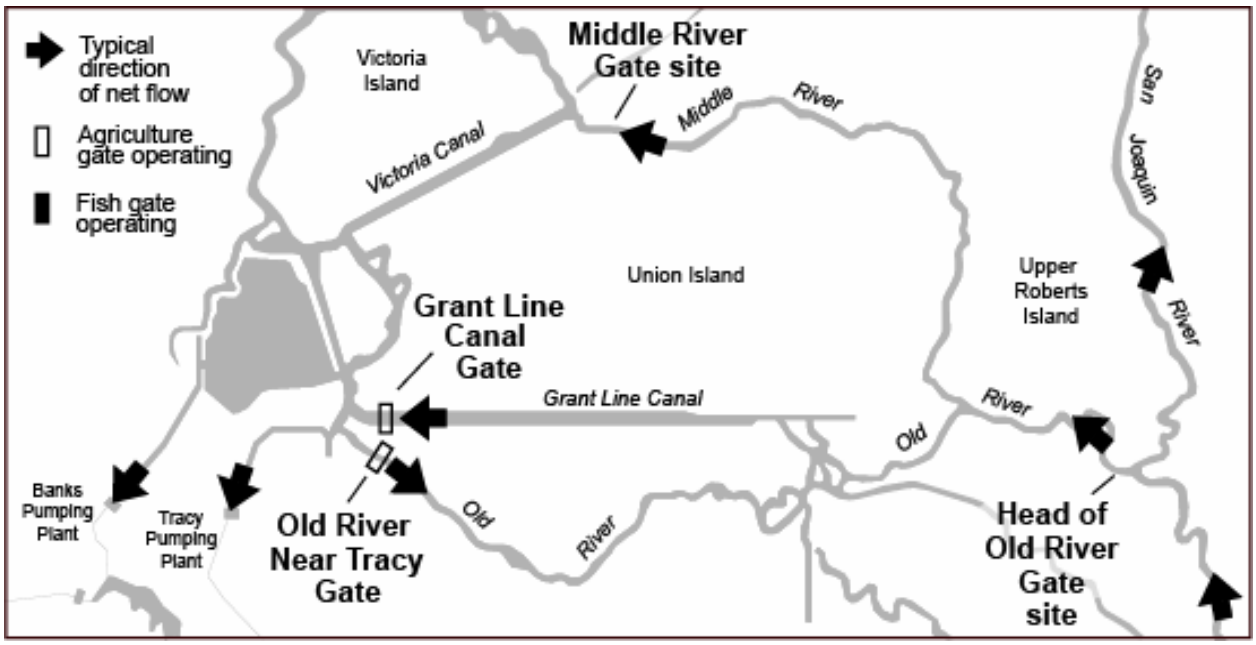

Figure 6.2: South Delta permanent gate operation for intermediate San Joaquin River flows (2500 < SJR < 4000 cfs) and head of Old River gate open.

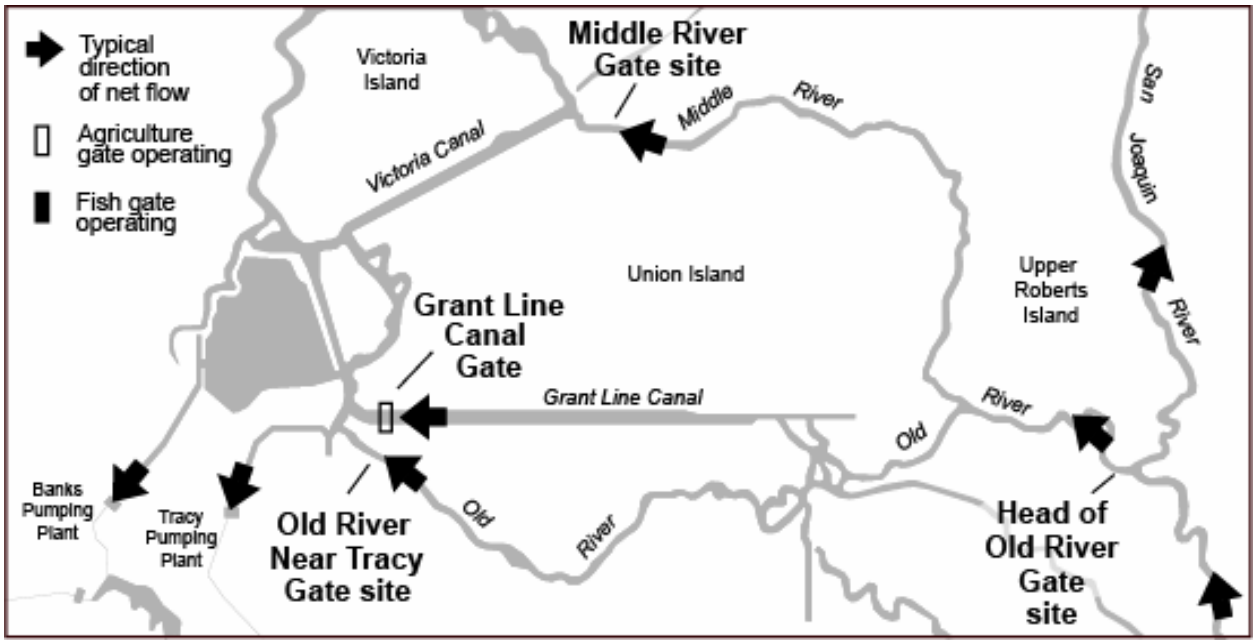

Figure 6.3: South Delta permanent gate operation for high San Joaquin River flows (4000 < SJR < 8000 cfs) and HOR open.

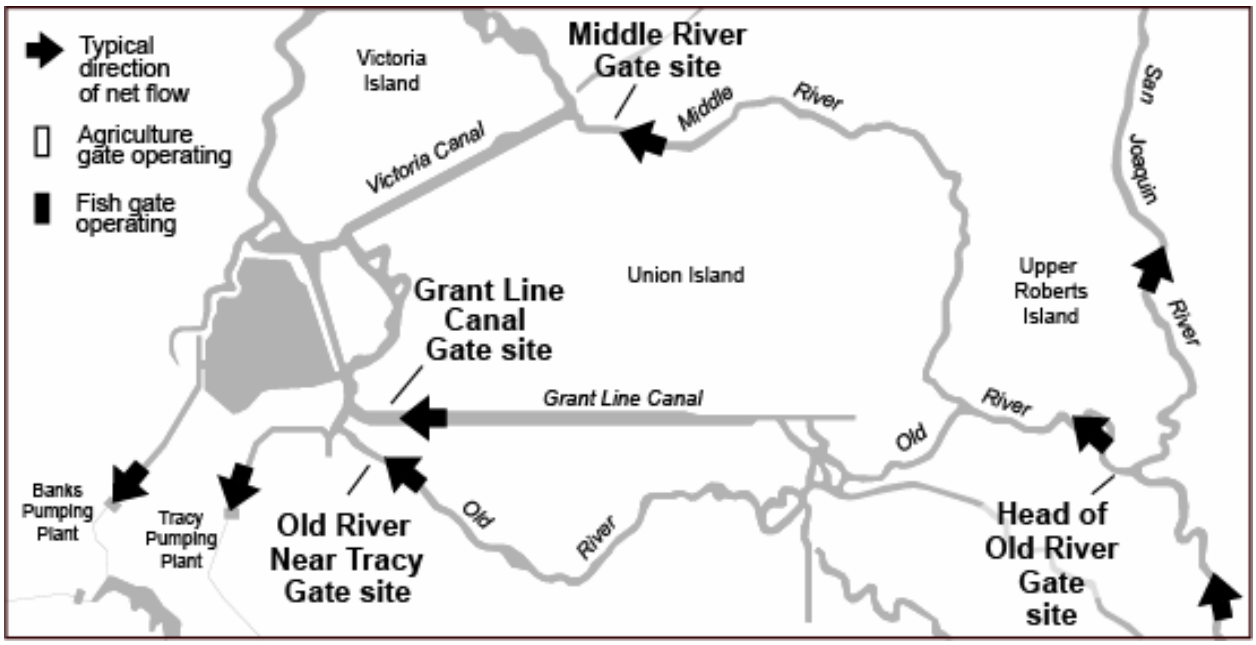

Figure 6.4: South Delta permanent gate operation for very high San Joaquin River flows (SJR > 8000 cfs).

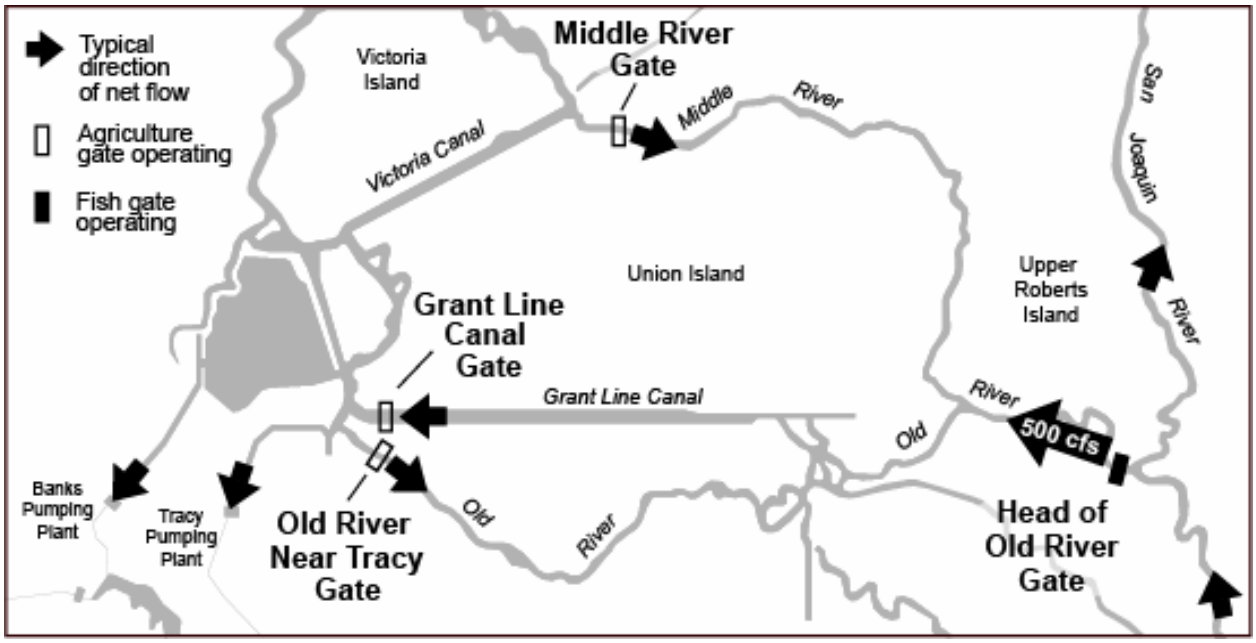

Figure 6.5: South Delta permanent gate operation for Modified Plan C (Jun-Sep) San Joaquin River (800 < SJR < 2500 cfs) and head of Old River gate closed.

6.4 Summary and Recommendations

The south Delta gate operation methodologies ("plan C" and "modified plan C") described here are general operation rules that are simple and easy to implement. The number of agricultural gates operated depends solely on the anticipated San Joaquin River flow at Vernalis and whether the fish gate at the head of Old River is operated. In general, the "modified plan C" (or "plan C") operation rule is sufficient to maintain adequate minimum water levels and water quality in the south Delta reaches most of the time. However, there are still a few times in the simulations when minimum water levels fall below 0.0 ft MSL at the target locations. These violations occur mostly during high San Joaquin flows when either the Middle River gate or both Middle and Old River gates are assumed not needed under the general rule; hence, these violations were artifacts of the simple operating rules. In reality, such violations can easily be prevented by more refined operating rules that call for either the Old River or both Middle and Old River gates operated during such conditions.

In the proposed general gate operation rules, the Grant Line Canal gate is usually operated differently from the Middle River and Old River gates. The Middle River and Old River gates, when operated, allow flow only in the upstream direction during flood tide. The Grant Line Canal gate serves as the main outlet for stored water, allowing water to leave south Delta channels during the ebb tide and inducing unidirectional flow in the three channels. As discussed earlier, unidirectional flow provides better circulation and helps to improve water quality. Under certain conditions, especially during neap tide, the flood tide lacks sufficient upstream energy to create unidirectional flow in Middle and Old rivers. This in turn may cause stagnation and an increase in salinity concentration. Studies have shown that during these times, which typically last about 3 to 4 days, changing the gate operations by having some combination of the Old River or Middle River gates act as outlets may induce the desired circulation. The flexibility of permanent operable gates allows such alternate operations which can resolve specific problems that are inadequately addressed with using standard operations.

6.5 Reference

California Department of Water Resources. (2005). *South Delta Improvements Program Draft Environmental Impact Statement/Environmental Impact Draft Report, 2005.* Sacramento, CA: California Department of Water Resources, Bay-Delta Office.

http://sdip.water.ca.gov/documents/draft_eis_eir.cfm