Element 6 - Hydrodynamic Modeling (2010)

This chapter details the simulation of historical 2010 Delta hydrodynamic conditions and the impacts due to the installation and operation of the South Delta temporary barriers. To enable this analysis, 2 conditions were simulated with historical Delta inflows, consumptive use, and exports: (1) historical 2010 installation and operation of the temporary barriers, and (2) no installation of South Delta temporary barriers.

DSM2-Hydro was used to simulate the Delta hydrodynamics. This model is a one-dimensional open channel unsteady flow model based on a 4-point finite difference solution of equations of momentum and continuity. The model network extends north to Sacramento River at I street, south to San Joaquin River at Vernalis, and west to Martinez where the observed 15-minute time series governs how the tide signal propagates into the Delta.

2010 Delta Boundary Conditions

Flow and stage information required at model boundaries were downloaded from the California Data Exchange Center Web site (cdec.water.ca.gov/). Input data were visually examined before any simulation. Any gaps or errors in data were of short duration, and values were estimated via simple interpolation. The resulting boundary conditions for the 2010 simulation are shown in Figures 7-1 through 7-4.

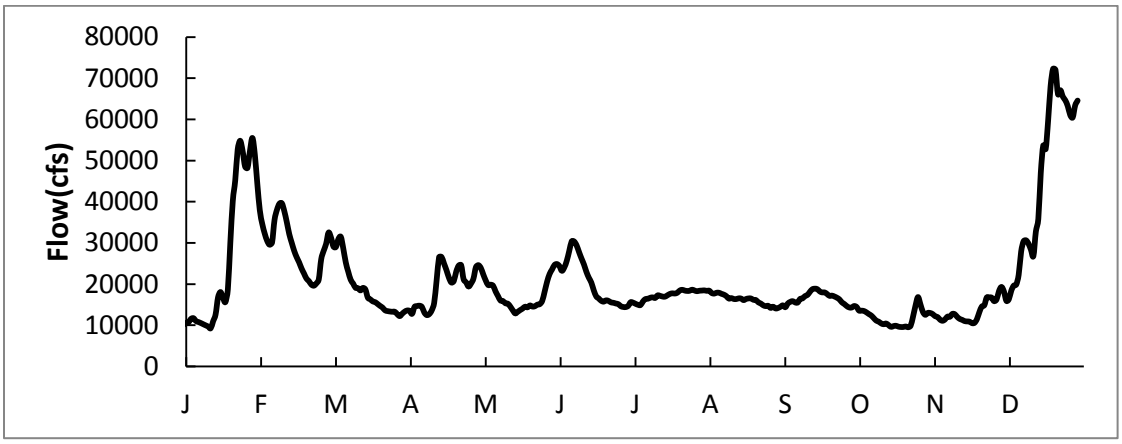

Figure 7-1. Daily Average Historical Inflow from the Sacramento River, 2010

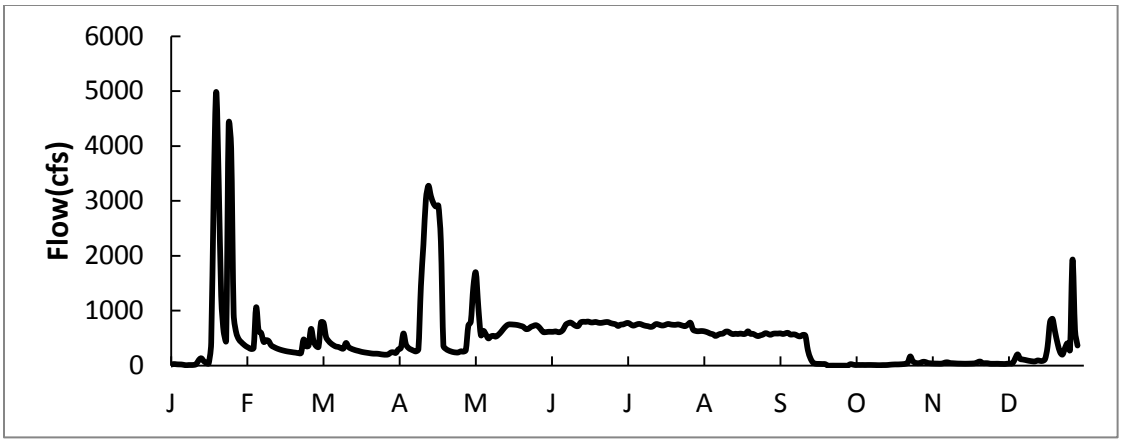

Figure 7-2. Daily Average Historical Inflow from the Yolo Bypass, 2010

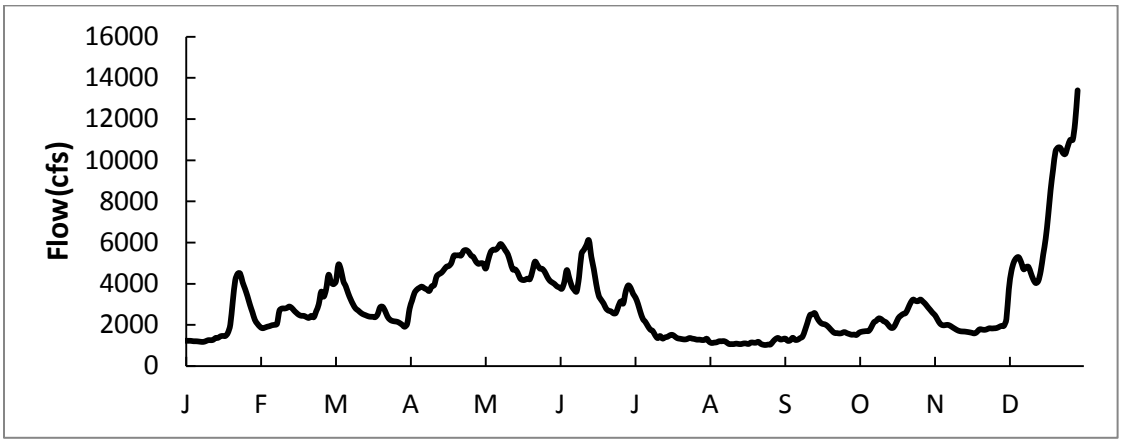

Figure 7-3. Daily Average Historical Inflow from the San Joaquin River, 2010

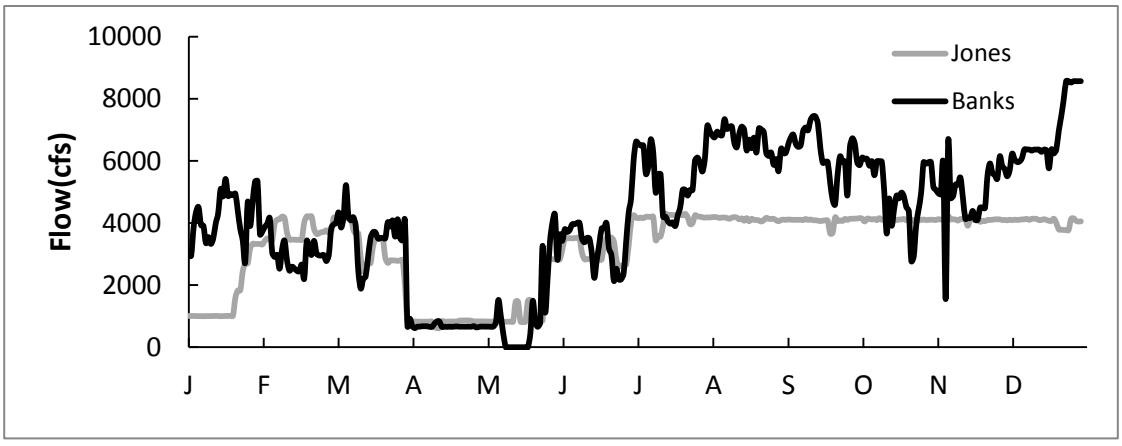

Figure 7-4. Daily Average Historical Pumping at Banks and Jones Pumping Plants, 2010

2010 Delta Consumptive Use

The Delta Island Consumptive Use (DICU) model provided an estimate of the amount of water diverted from and returned to Delta channels due to agricultural activities. Input to DICU model includes precipitation, pan evaporation data, and water year types. The water year type determines which of 2 possible cropping patterns in the Delta is assumed, which in turn contributes to the estimation of agricultural water needs.

South Delta Structures

All 3 temporary agricultural barriers were installed in 2010. The head of Old River barrier was not installed. The DSM2 simulation timed the installation and removal of the barriers to the changes in actual observed stages, which indicated effective closure or opening of the channel. Table 7-1 lists the historical installation and removal of the South Delta barriers. The Grant Line Canal barrier is typically installed in 2 stages. The first stage installs the boat ramp, but leaves the center of the channel open. The second stage closes the channel. The date and time shown in Table 7-1 for Grant Line Canal refers to the second phase installation because this is the time that significant changes in stage upstream are first evident due to this barrier. Flap gates in the barrier culverts were at times tied open or allowed to tidally operate. This level of detail of operation, while incorporated in the historical simulation, is not shown in Table 7-1.

Table 7-1. Historical South Delta Temporary Barriers Installation and Removal, 2010

	Installation			Removal		
Barrier	**Started***	**Ended***	**DSM2**	**Started***	**Ended***	**DSM2**
Middle River	5/18/10	5/24/10	5/21/10	10/28/10	10/28/10	10/28/10
			12:00			12:00
Old River near DMC	5/10/10	6/3/10	6/2/10	10/19/10	10/20/10	10/20/10
			07:00			12:00
Grant Line Canal	5/16/10	7/7/10	7/6/10	10/11/10	10/14/10	10/14/10
			20:00			02:00
Old River @ Head (spring)	--	--	--	--	--	--
Old River @ Head (fall)	--	--	--	--	--	--

*As reported by Temporary Barriers Program, DWR

Delta Downstream Stage at Martinez

The downstream boundary of DSM2 is Martinez where a time series of observed historical 15-minute data from 2010 was used for the simulation.

Delta Cross Channel Operation

The Delta Cross Channel gates were operated in 2010 and modeled in the historical DSM2-simulation as shown in Table 7-2.

Table 7-2. Historical Delta Cross Channel Operation for 2010

Date	Time	Operation
12/15/09	10:00	close
5/28/10	10:00	open
6/1/10	10:00	close
6/4/10	10:00	open
6/7/10	10:00	close
6/18/10	10:00	open
10/13/20	11:00	close
10/15/10	11:00	open
11/1/10	09:00	close
11/4/10	09:00	open
12/1/10	10:00	close

Validation of DSM2 Simulation of Historical 2010 Delta Hydrodynamics

Delta hydrodynamics were simulated according to the conditions presented above. Stage and flow results of the DSM2 simulation of historical Delta hydrodynamics were compared to available observed data from locations shown in Figure 7-5. Figure 7-6 presents observed and simulated daily minimum and maximum stage, and Figure 7-7 presents observed and simulated daily minimum, maximum, and average flow.

Figure 7-6 indicates that the DSM2 simulation reproduces the observed effect the temporary agriculture barriers have on upstream minimum (see stations RMID027, MHR, DGL, ROLD047, ROLD059, and TPS). Simulated daily levels generally match observed values well, with the exceptions of stages in Clifton Court Forebay and Tom Paine Slough. Model errors at these locations have been noted before and appear to occur for most DSM2 historical simulations.

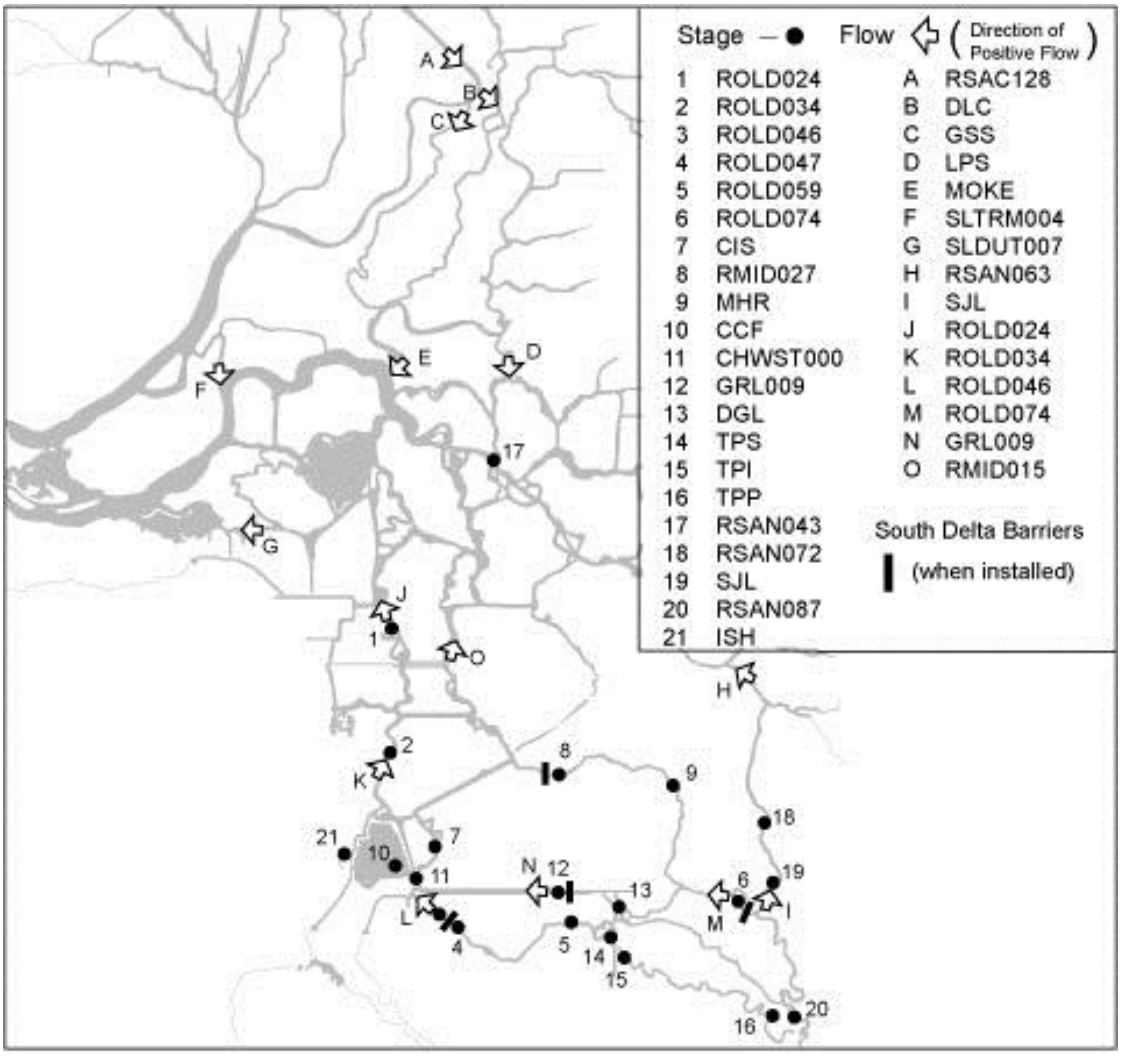

Figure 7-5. Locations where DSM2-simulated and Measured Stages and Flows are Presented, 2010

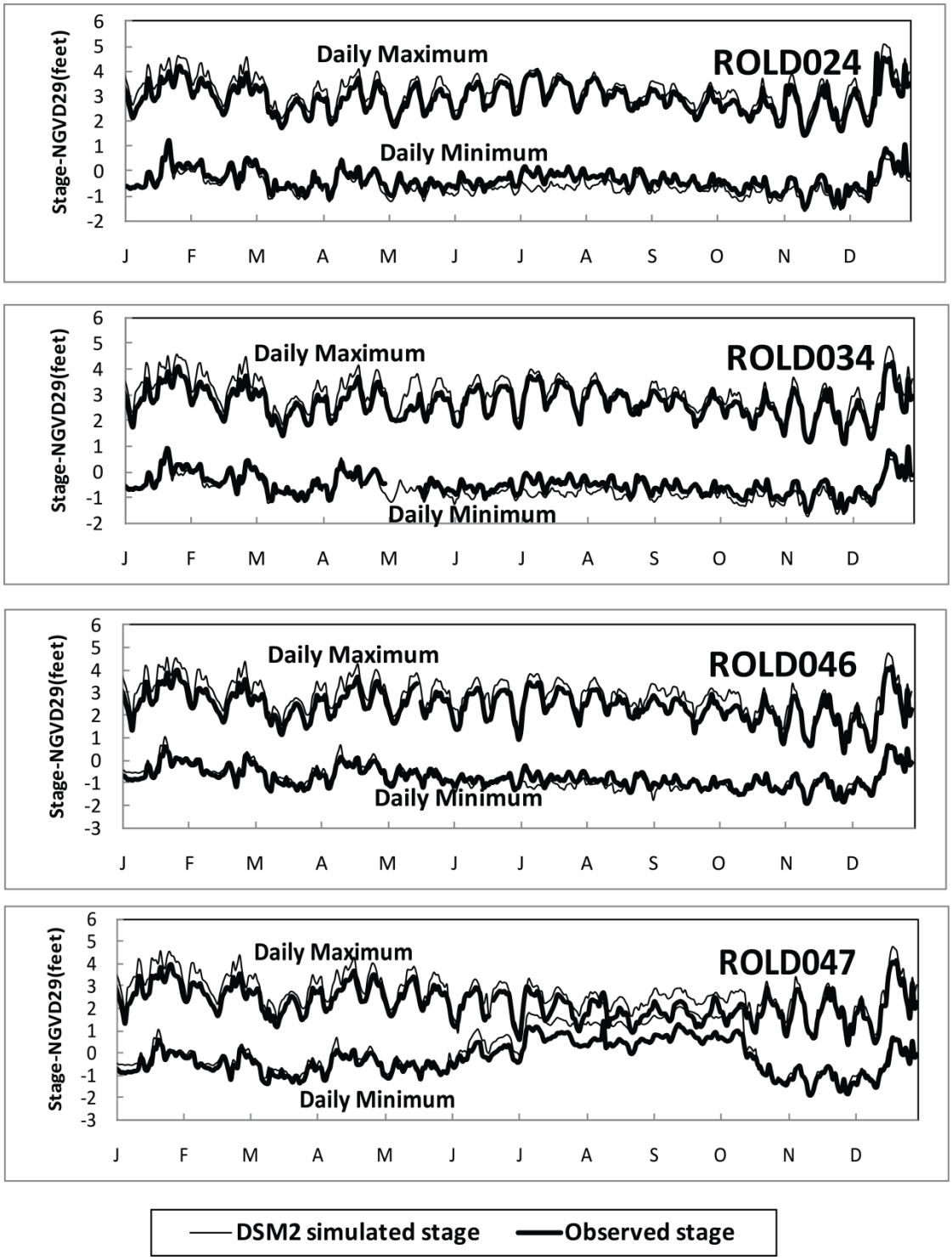

Figure 7-6. Comparison of DSM2-simulated and Observed Daily Stage, 2010

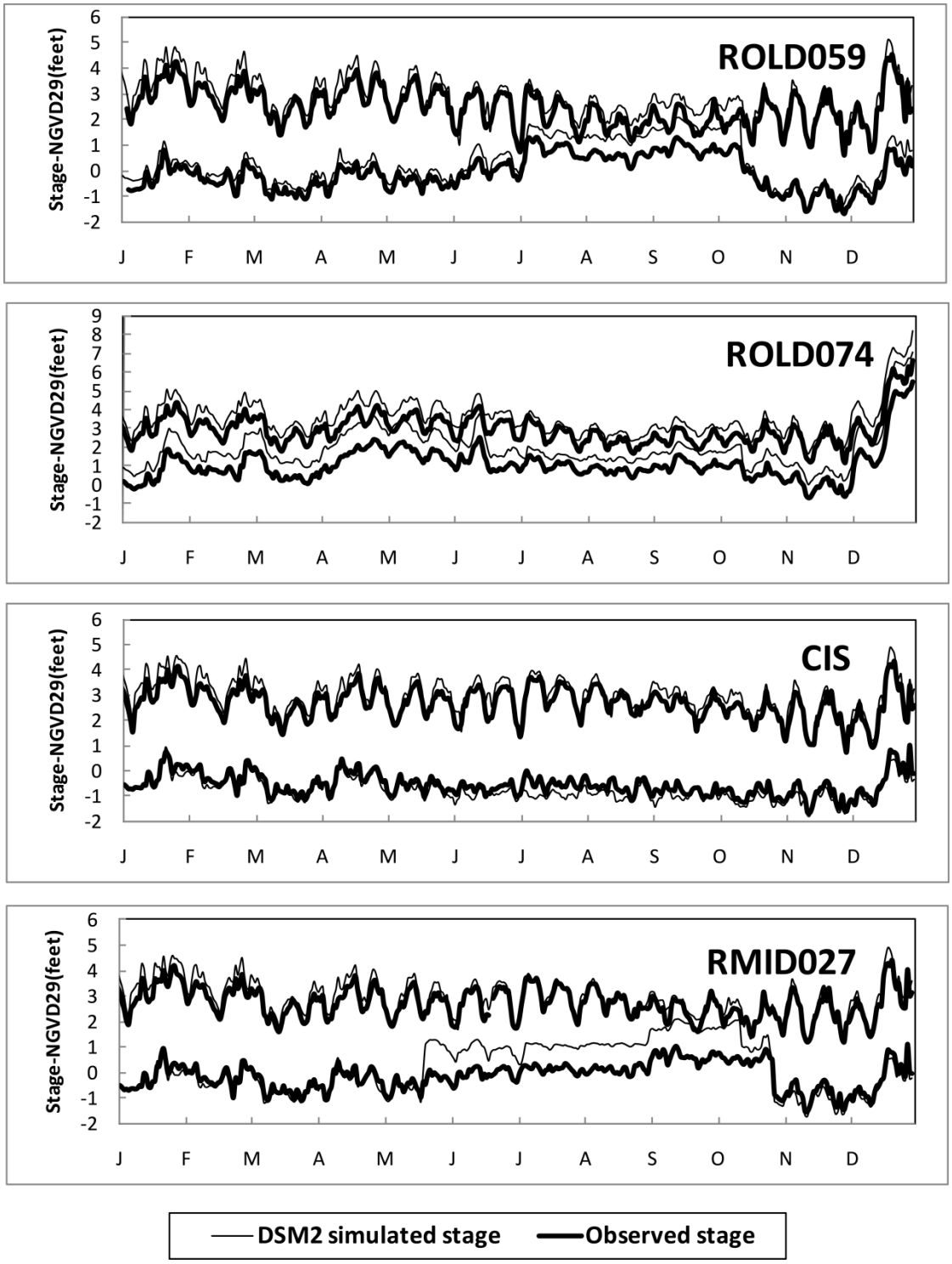

Figure 7-6 (cont.). Comparison of DSM2-simulated and Observed Daily Stage, 2010

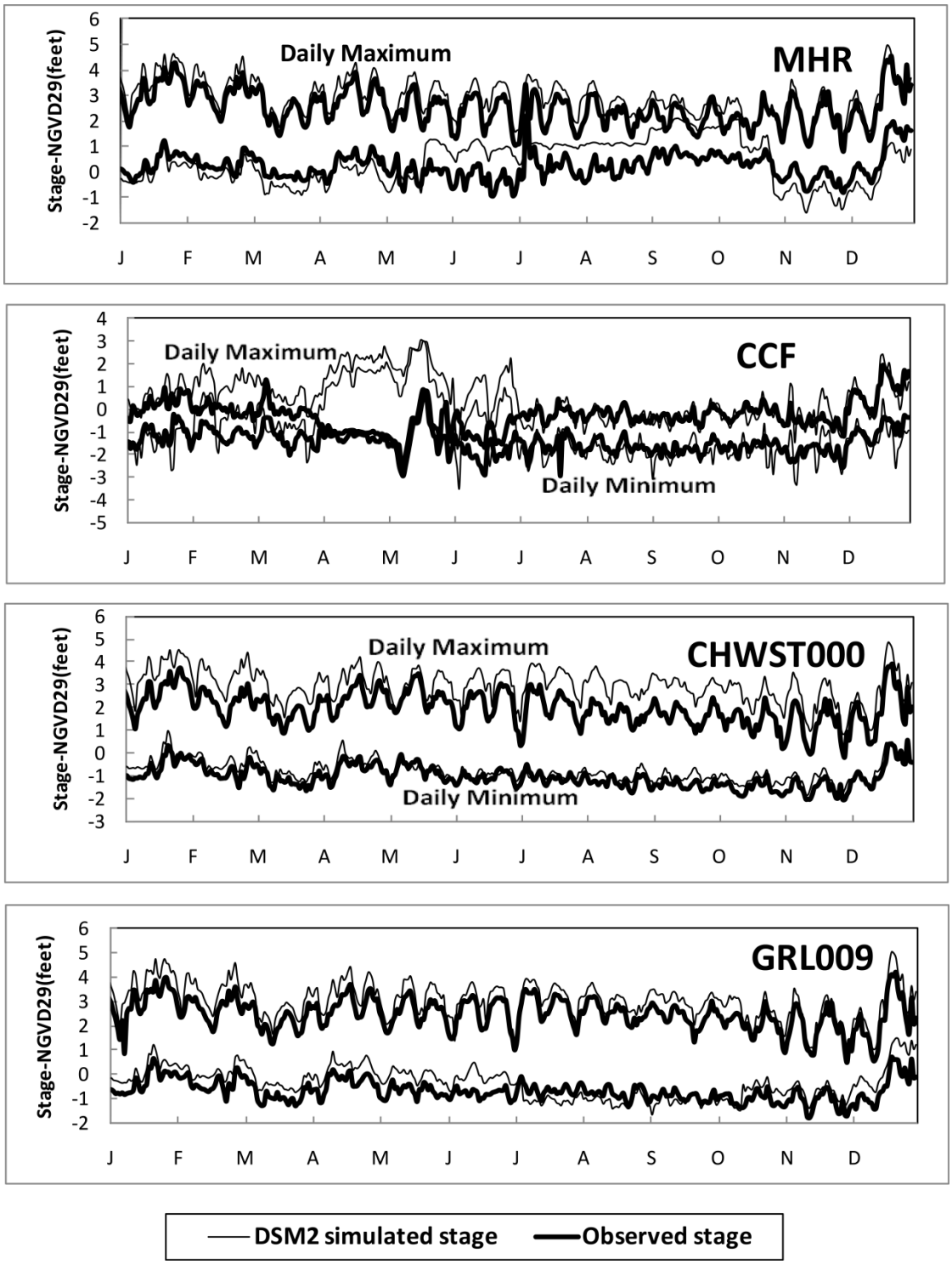

Figure 7-6 (cont.). Comparison of DSM2-simulated and Observed Daily Stage, 2010

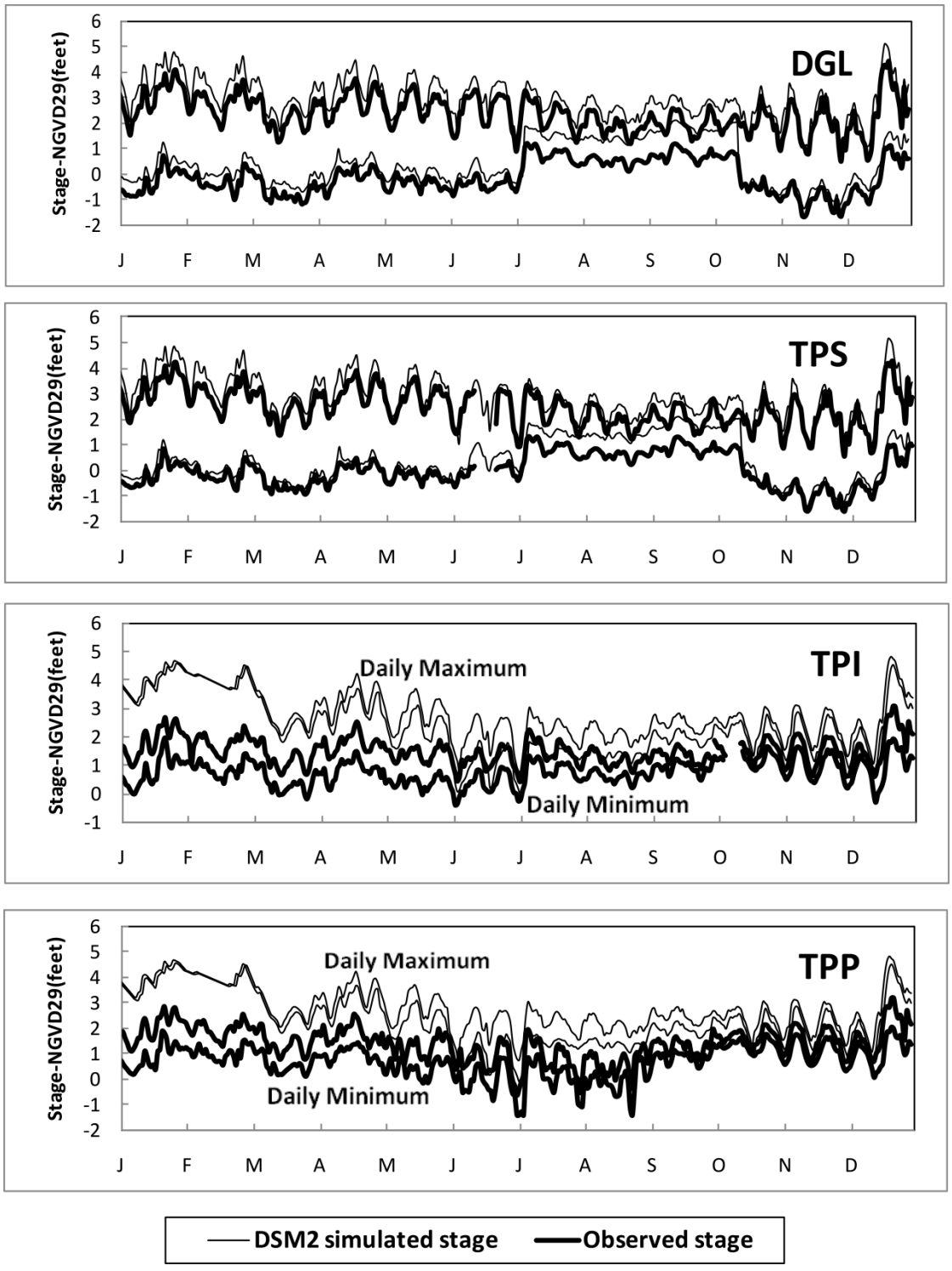

Figure 7-6 (cont.). Comparison of DSM2-simulated and Measured Daily Stage, 2010

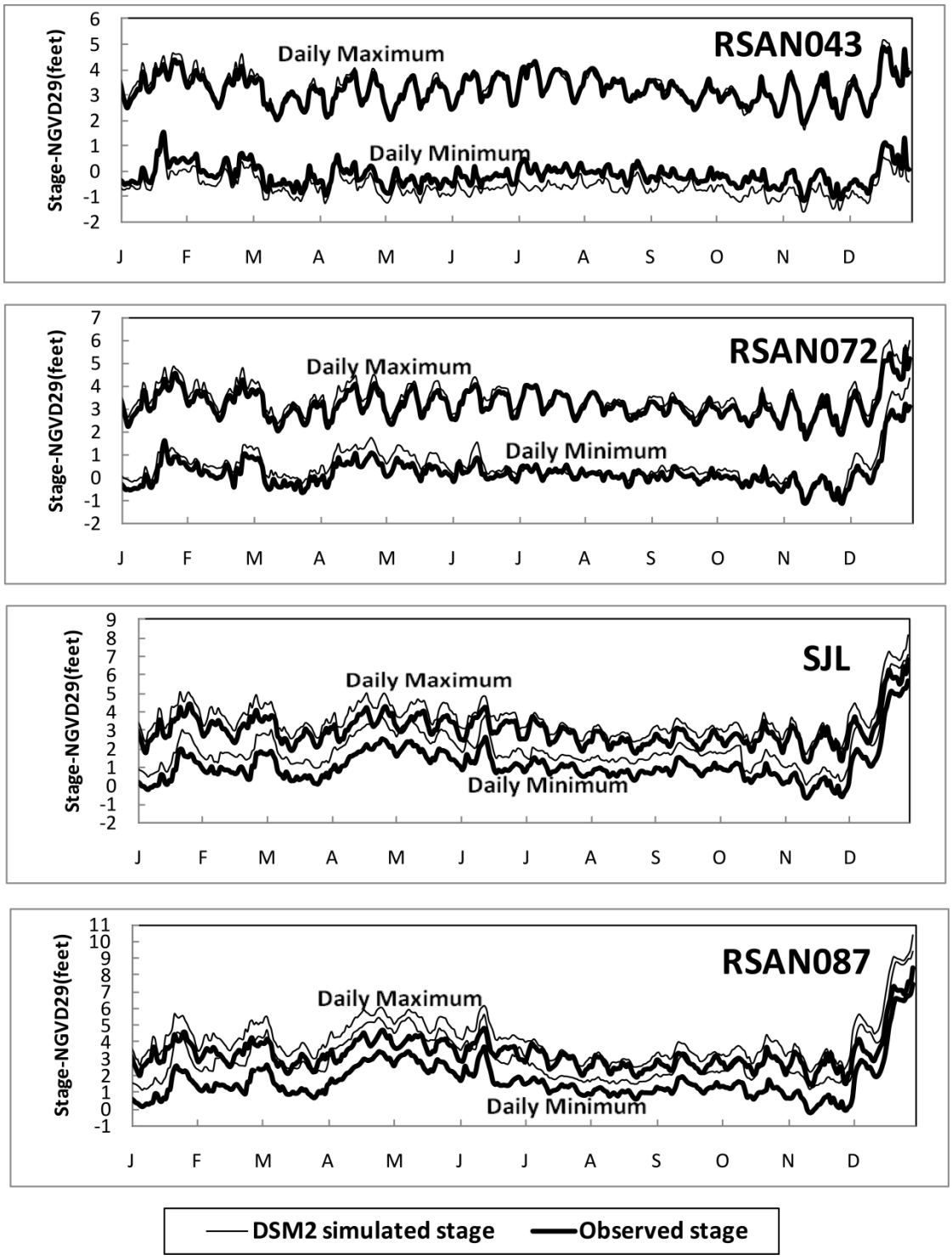

Figure 7-6 (cont.). Comparison of DSM2-simulated and Measured Daily Stage, 2010

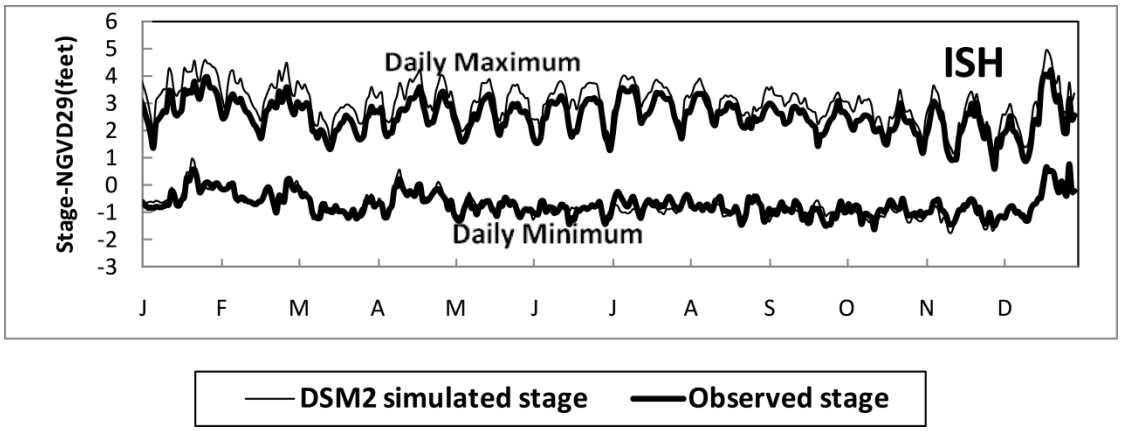

Figure 7-6 (cont.). Comparison of DSM2-simulated and Measured Daily Stage, 2010

Figure 7-7 shows DSM2-simulated and observed daily maximum, average, and minimum flow wherever measured flow data are available in the Delta for 2010. The DSM2 simulation matched observed peak and average flows well at most locations in the Delta outside of the area affected by the temporary barriers in the South Delta. Flow was measured at several locations within the influence of the barriers: Old River downstream of barrier near DMC intake (ROLD046), Old River at Head (ROLD074), and Grant Line Canal downstream of barrier site (GRL009). All 3 of these locations are actually downstream of the temporary barrier site, but flow at OLD074 can be assumed influenced by the installation of the temporary barriers in Old River near DMC intake and Grant Line Canal.

At ROLD046 and GRL009, the simulated daily average flow matches the observed daily average flow well. At ROLD046, observed peak upstream flows were near zero while DSM2 simulated peak upstream flows of approximately 1,000 cfs. At ROLD074, simulated average flow was about 500 cfs lower than the observed flow when the Grant Line Canal barrier was completely installed. Changes in tidal flow here in response to temporary barrier installation in Old River and Grant Line Canal are evident in both observed and simulated flows. At GRL009, while the observed and simulated daily average flows match well, the observed daily peak upstream and downstream flows can significantly exceed simulated flows. As a result, the DSM2-simulated flow at GRL shows significantly less tidal variation than what is observed. This pattern has been noted in other years and may reflect the currently assumed Grant Line Canal bathymetry and barrier description used in DSM2.

Taken as a whole, Figures 7-6 and 7-7 indicate that the DSM2 simulations of historical 2010 Delta conditions with and without barrier installation should provide meaningful results with which to evaluate how the barriers affected water levels and circulation in the South Delta.

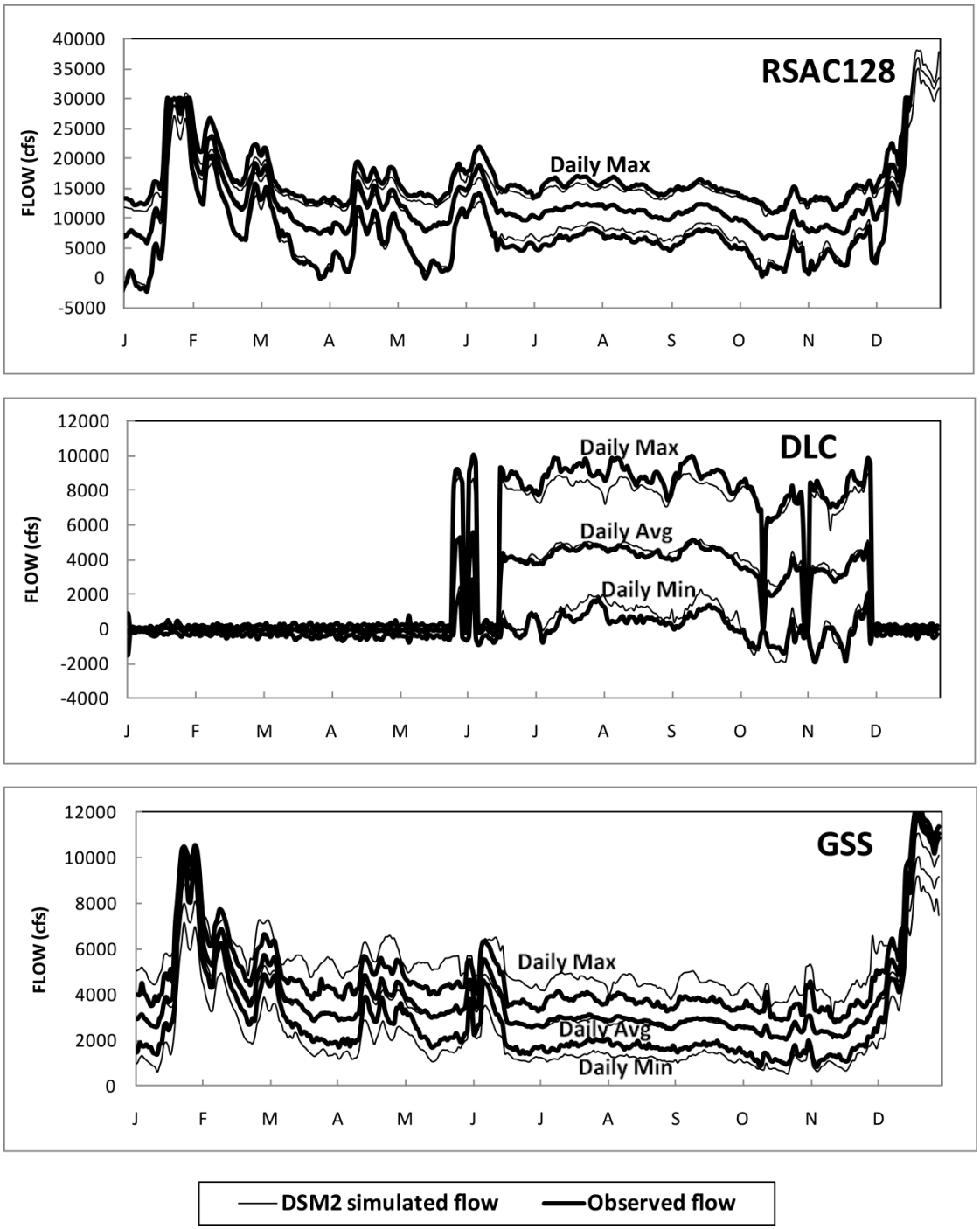

Figure 7-7. Comparison of DSM2-simulated and Measured Daily Flow, 2010

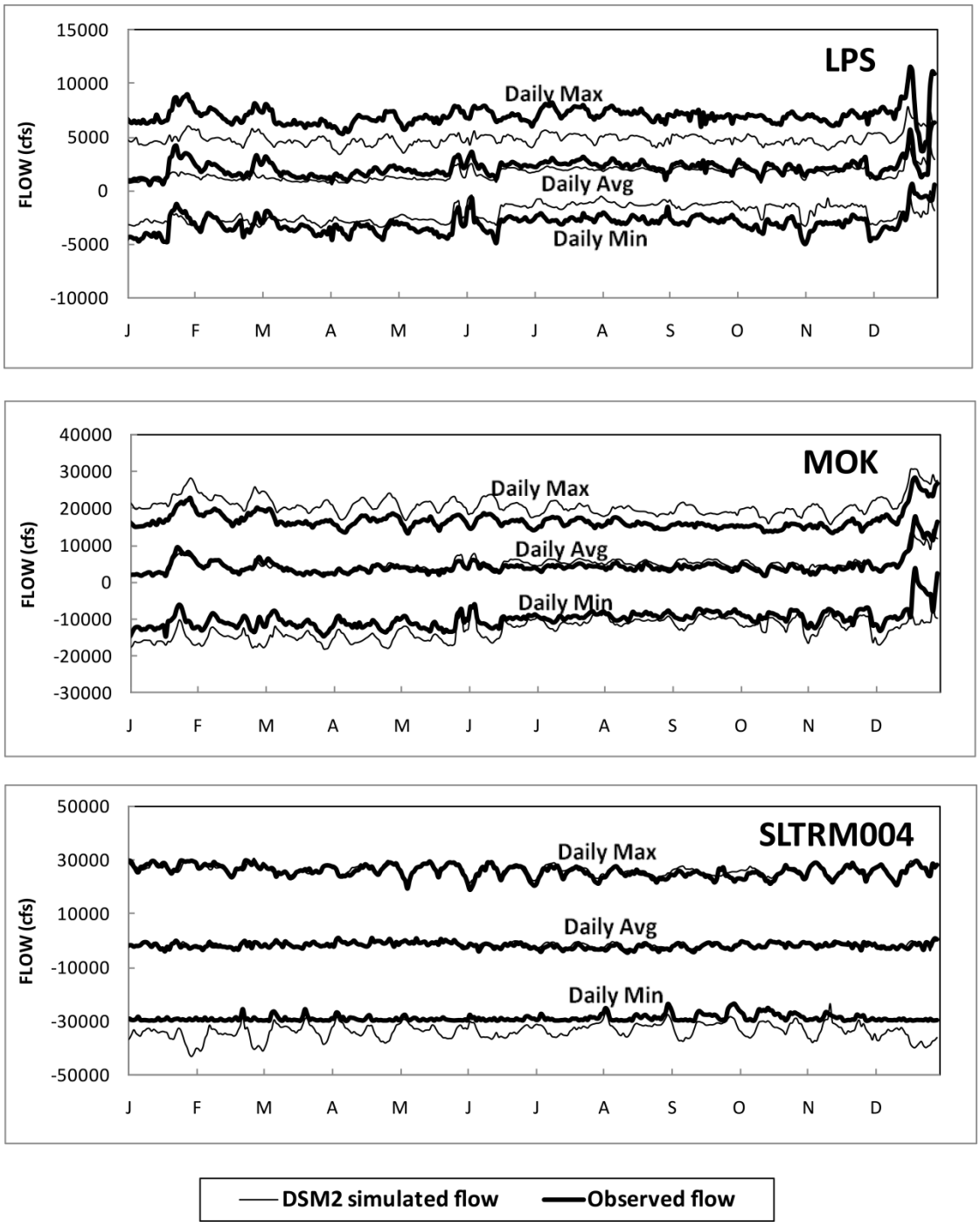

Figure 7-7 (cont.). Comparison of DSM2-simulated and Measured Daily Flow, 2010

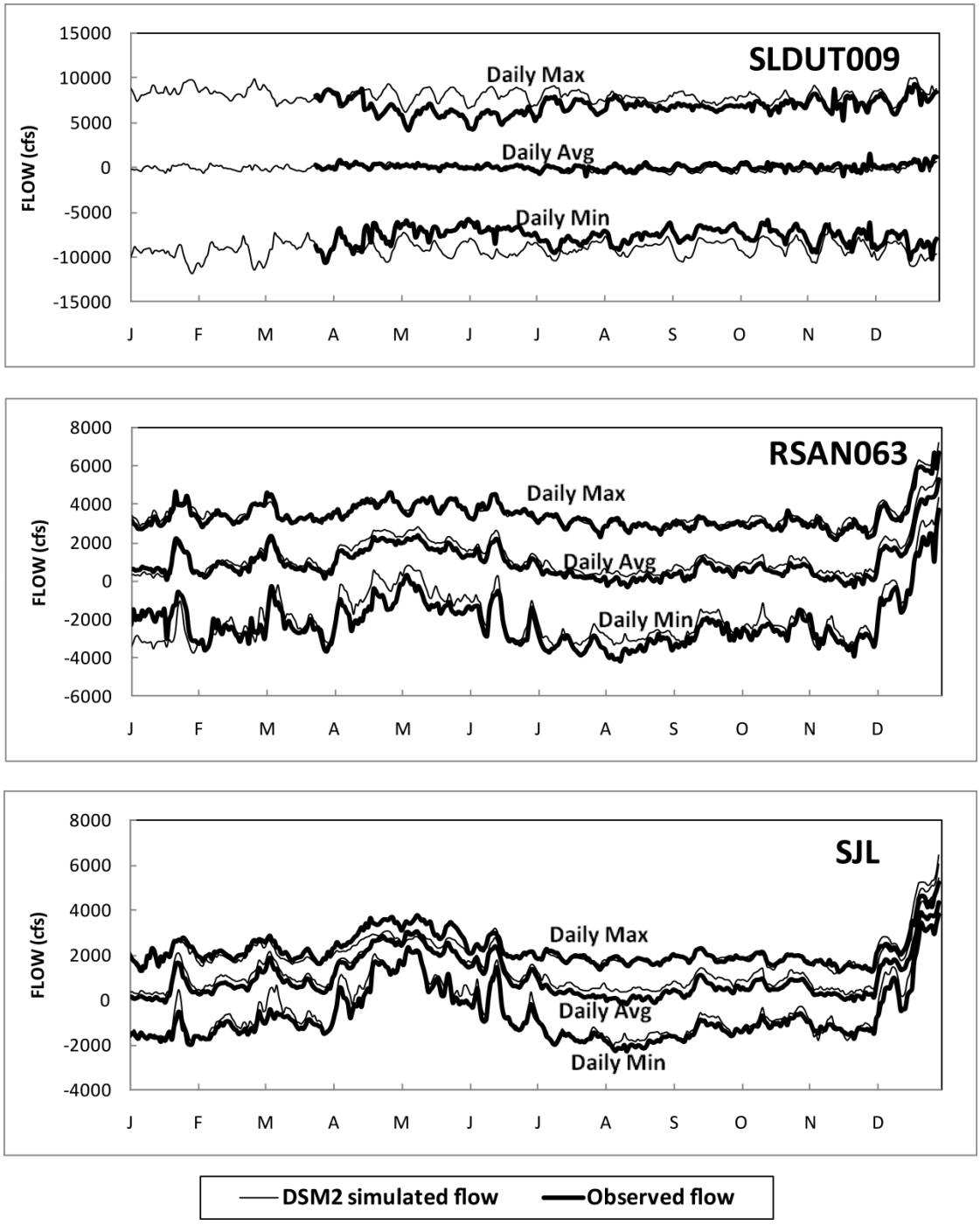

Figure 7-7 (cont.). Comparison of DSM2-simulated and Measured Daily Flow, 2010

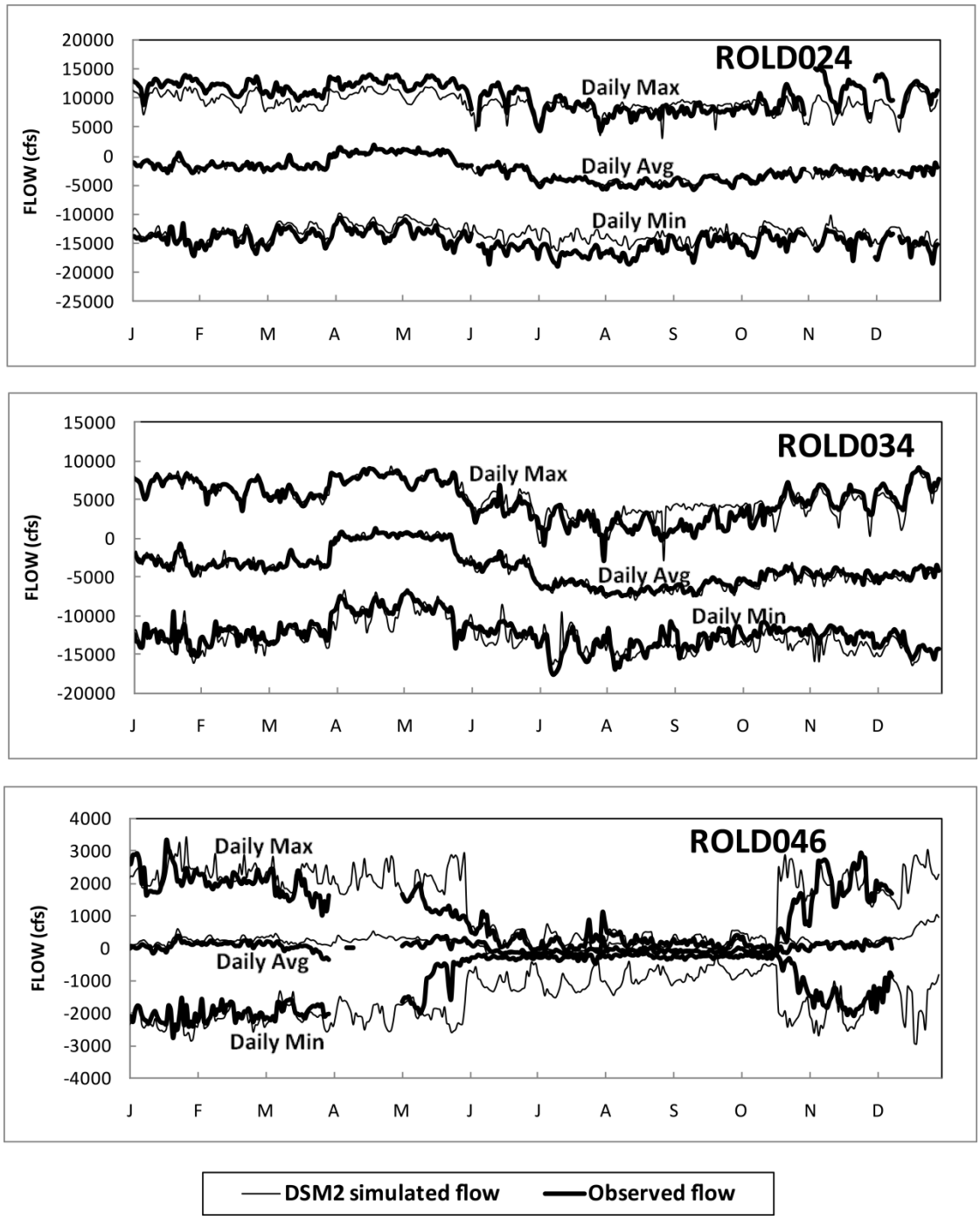

Figure 7-7 (cont.). Comparison of DSM2-simulated and Measured Daily Flow, 2010

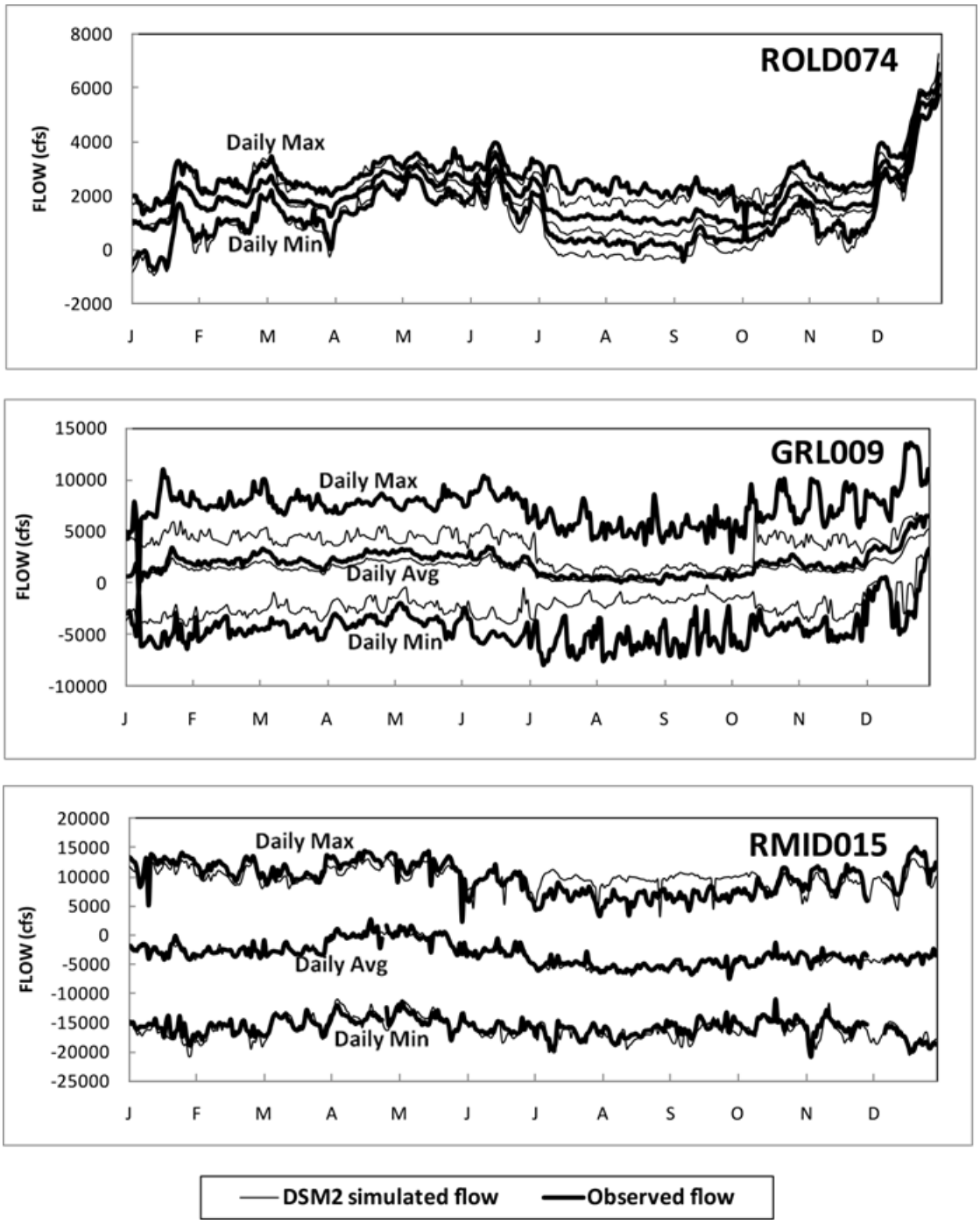

Figure 7-7 (cont.). Comparison of DSM2-simulated and Measured Daily Flow, 2010

Effect of Temporary Barriers Installation and Operation on South Delta Hydrodynamics

In order to better process the 2010 Delta hydrodynamics, DSM2 simulation results were separated into 24 periods for which significant Delta inflows and exports were fairly constant and basic South Delta barrier configurations were unchanging. The 24 periods and their characteristics are shown in Table 7-3. The Delta hydrodynamics, as modeled by DSM2, are presented for each period, excluding those periods when barriers were in the process of installation or removal: May 21, May 26, June 1-2, July 6, Oct 13, Oct 19 and Oct 27. Operational changes to the temporary barriers of having flap gates tied open or operated tidally were not factored into the processing of the simulation results. The Grant Line Canal barrier was not considered installed until the middle of the channel was closed.

Table 7-3. Characteristics of Time Intervals for Presentation of Simulation Results, 2010

Period in 2010		Period Average Flows (cfs)				Period Barrier Status			
		SAC R +YOLO	SJR	DMC pumping	SWP pumping	MR	OR	GLC	ORH
Jan	1-18	12,108	1,279	1,005	3,984	-	-	-	-
Jan	19-31	47,630	3,156	2,433	4,361	-	-	-	-
Feb	1-28	29,519	2,533	3,747	3,022	-	-	-	-
Mar	1-11	27,957	4,002	4,037	4,162	-	-	-	-
Mar	12-31	15,630	2,447	2,931	3,373	-	-	-	-
Apr	1-13	14,301	3,372	791	703	-	-	-	-
Apr	14-30	23,939	5,105	828	670	-	-	-	-
May	1-10	21,077	5,337	826	774	-	-	-	-
May	11-20	14,962	4,849	1,019	0	-	-	-	-
May	22-25	15,436	4,707	842	937	IN	-	-	-
May	27-31	20,828	4,377	2,829	3,001	IN	-	-	-
Jun	3-16	26,344	4,612	3,212	3,559	IN	IN	-	-
Jun	17-30	16,530	3,171	3,028	3,075	IN	IN	-	-
Jul	1-5	15,954	3,513	4,161	6,092	IN	IN	-	-
Jul	7-31	18,315	1,490	4,118	5,144	IN	IN	IN	-
Aug	1-31	16,949	1,143	4,137	6,679	IN	IN	IN	-
Sep	1-30	16,718	1,713	4,076	6,328	IN	IN	IN	-
Oct	1-12	12,687	1,854	4,125	5,866	IN	IN	IN	-
Oct	14-18	9,962	1,985	4,122	4,567	IN	IN	-	-
Oct	20-26	10,793	2,837	4,104	3,973	IN	-	-	-
Oct	28-31	13,523	3,064	4,106	5,948	-	-	-	-
Nov	1-30	13,246	1,901	4,106	4,966	-	-	-	-
Dec	1-7	18,728	4,019	4,104	5,932	-	-	-	-
Dec	8-31	52,182	7,836	4,035	7,109	-	-	-	-

Hourly simulated stage and flow data for each period were used to generate data for box plots, which graphically show period minimum, maximum, 25% quartile, 75% quartile, and median values. By the usual sign convention, negative flow values correspond to upstream flow. The locations where box plots of stage and flow are presented are shown in Figure 7-8 with arrows indicating assumed positive flow direction. Tables containing the numerical values associated with the box plots are presented in Appendix D at the end of this report.

Shown in Figures 7-9 and 7-10 are the box plots of simulated stages and flow for time periods when at least one barrier was historically installed. Stages are presented upstream and downstream of each barrier location and flows are presented throughout the South Delta in order to convey the general circulation patterns. Distributions of flow and stage from both the historical simulation and the condition of no barriers assumed installed are provided to help analysis of the effect of the installation of the barriers.

Figure 7-11 graphically presents the effect that the temporary barriers in 2010 had on flow circulation and minimum water levels in the South Delta under the same periods presented in Figures 7-9 and 7-10.

Discussion

The installation of the 3 temporary barriers in 2010 significantly altered stages and flows in the South Delta. When the barrier in Middle River alone was installed in May, increases in minimum levels caused by the barrier were limited to Middle River. Increase in minimum water levels ranged from 1½ feet immediately upstream of the Middle River to a half-foot at RMID040. The installation of the Old River barrier toward the beginning of June in 2010 raised minimum water levels immediately upstream of this barrier approximately one-half to one foot, a change which decreased farther upstream. The Old River barrier had little impact on water levels in Middle River or Grant Line Canal. For the period June 3 – July 5, 2010, only the barriers in Middle River and Old River were completely installed. During this time, these barriers' primary impact was significantly raising water levels immediately upstream, an effect which diminished farther upstream until becoming negligible in Grant Line Canal. The overall circulation pattern in the South Delta during this period was only moderately altered by the 2 barriers since the flow split from the San Joaquin River down the head of Old River and then the subsequent flow down Grant Line Canal were not strongly affected.

The complete installation of the Grant Line Canal barrier after July 6, 2010, raised minimum water levels in Grant Line Canal upstream of the barrier feet 1½ to 2 feet and levels in Middle River and Old River an additional one-half to one foot. Also, circulation patterns were significantly altered as shown by a reduced portion of San Joaquin River flow down the head of Old River and less of a portion of this water then passing down Grant Line Canal and Old River. Thus, the temporary barriers' full effect on minimum water levels and flow pattern was not realized until the Grant Line Canal barrier was completely installed. In general, the installation of the temporary barriers also resulted in reduced tidal variation in flows near the barriers, a trend once again made more pronounced in Old and Middle Rivers with the installation of the barrier in Grant Line Canal. Each of the barriers still allowed some downstream flow, while both upstream and downstream flow was suppressed in the channels upstream of each barrier site.

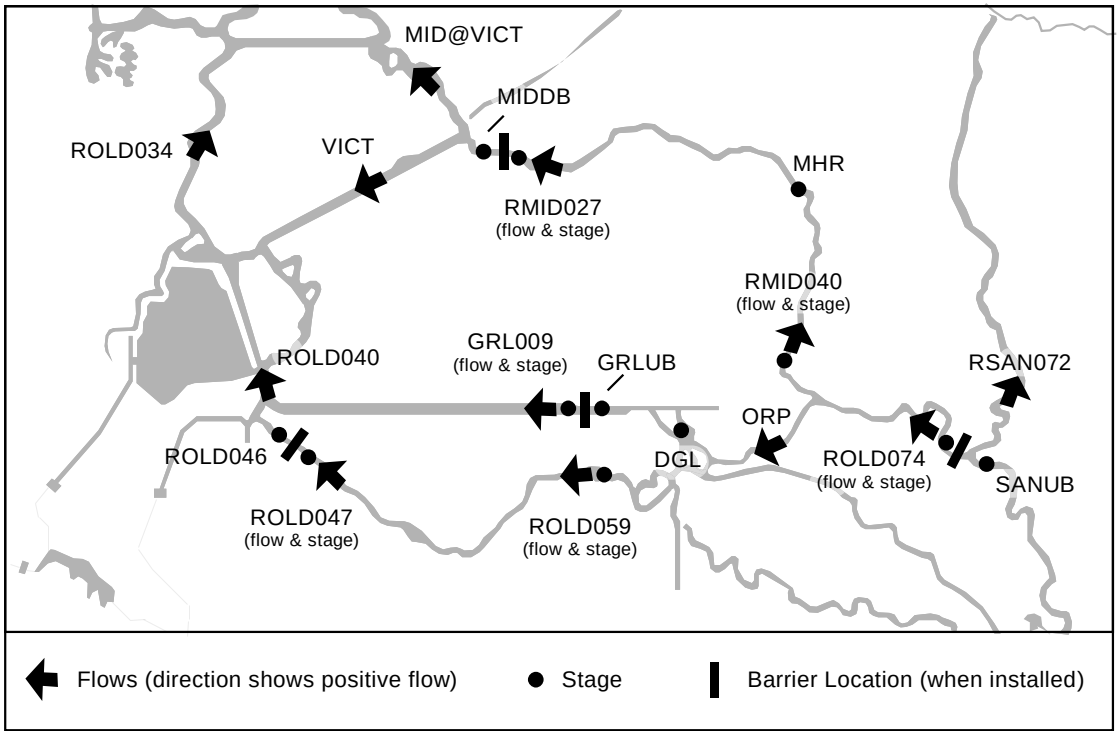

Figure 7-8. Locations where Simulated Delta Stages and Flows for Analysis of 2010 Conditions are Presented

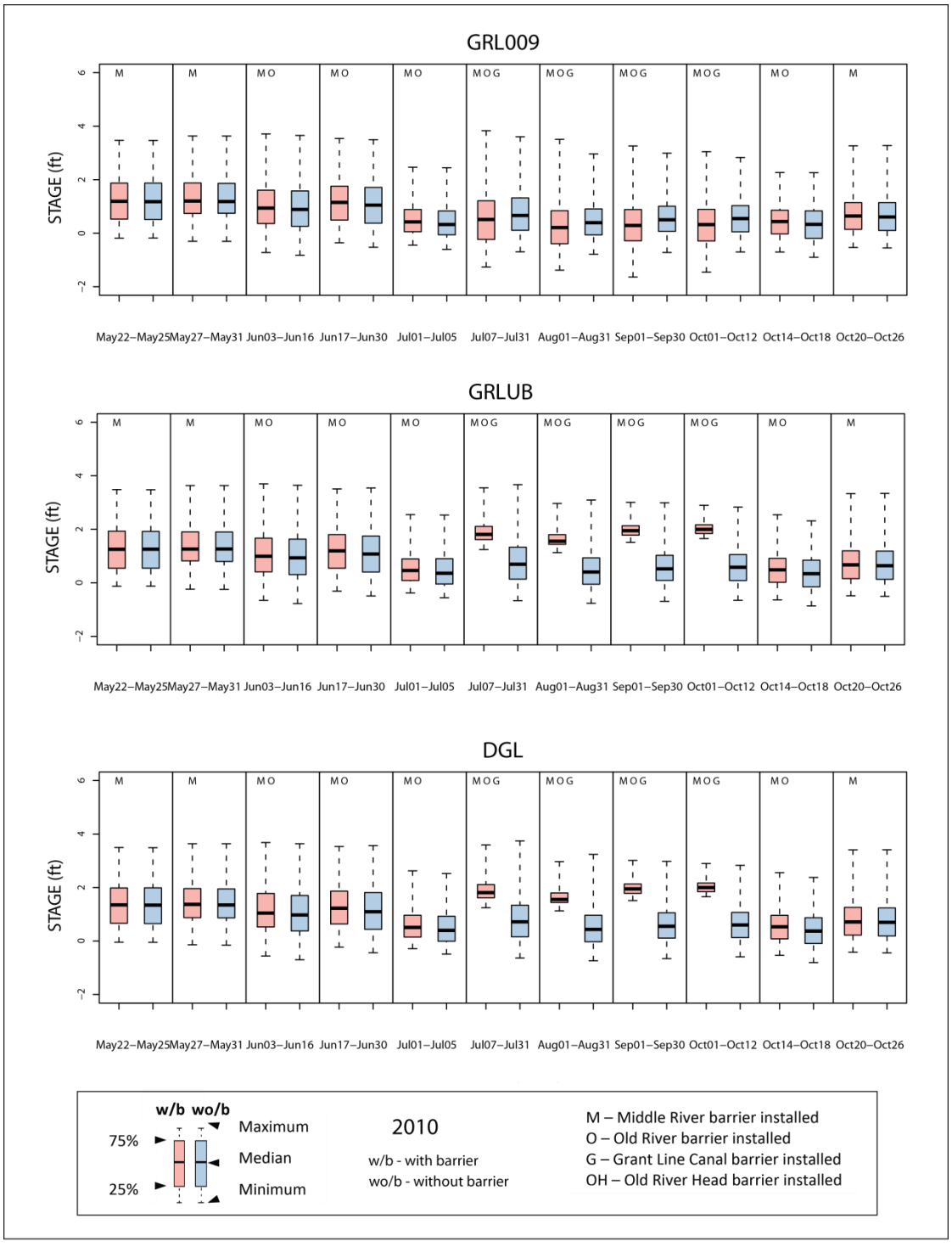

Figure 7-9. Distribution of DSM2-simulated Stages for Historical 2010 Conditions with and without Temporary Barriers Installed

Figure 7-9 (cont.). Distribution of DSM2-simulated Stages for Historical 2010 Conditions with and without Temporary Barriers Installed

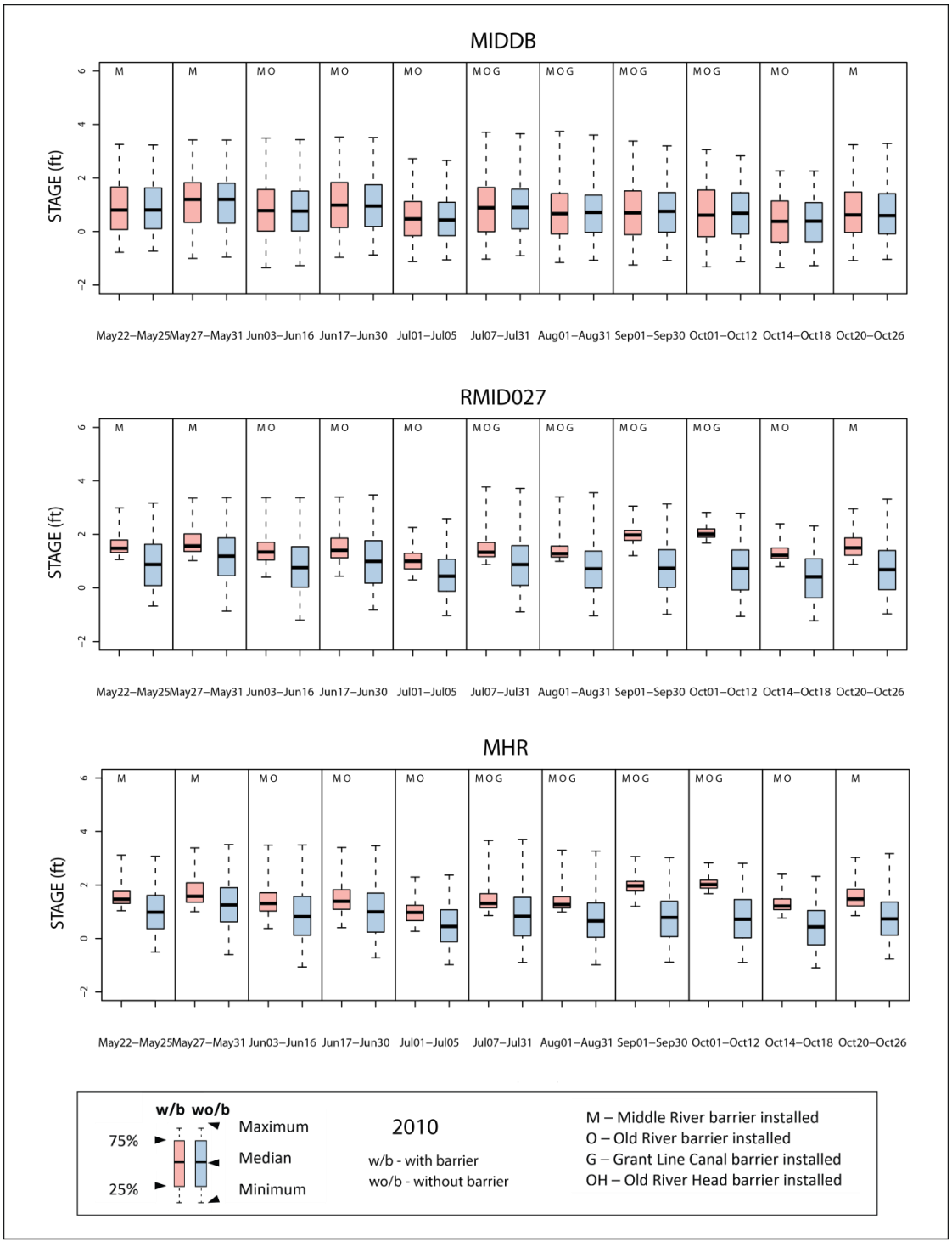

Figure 7-9 (cont.). Distribution of DSM2-simulated Stages for Historical 2010 Conditions with and without Temporary Barriers Installed

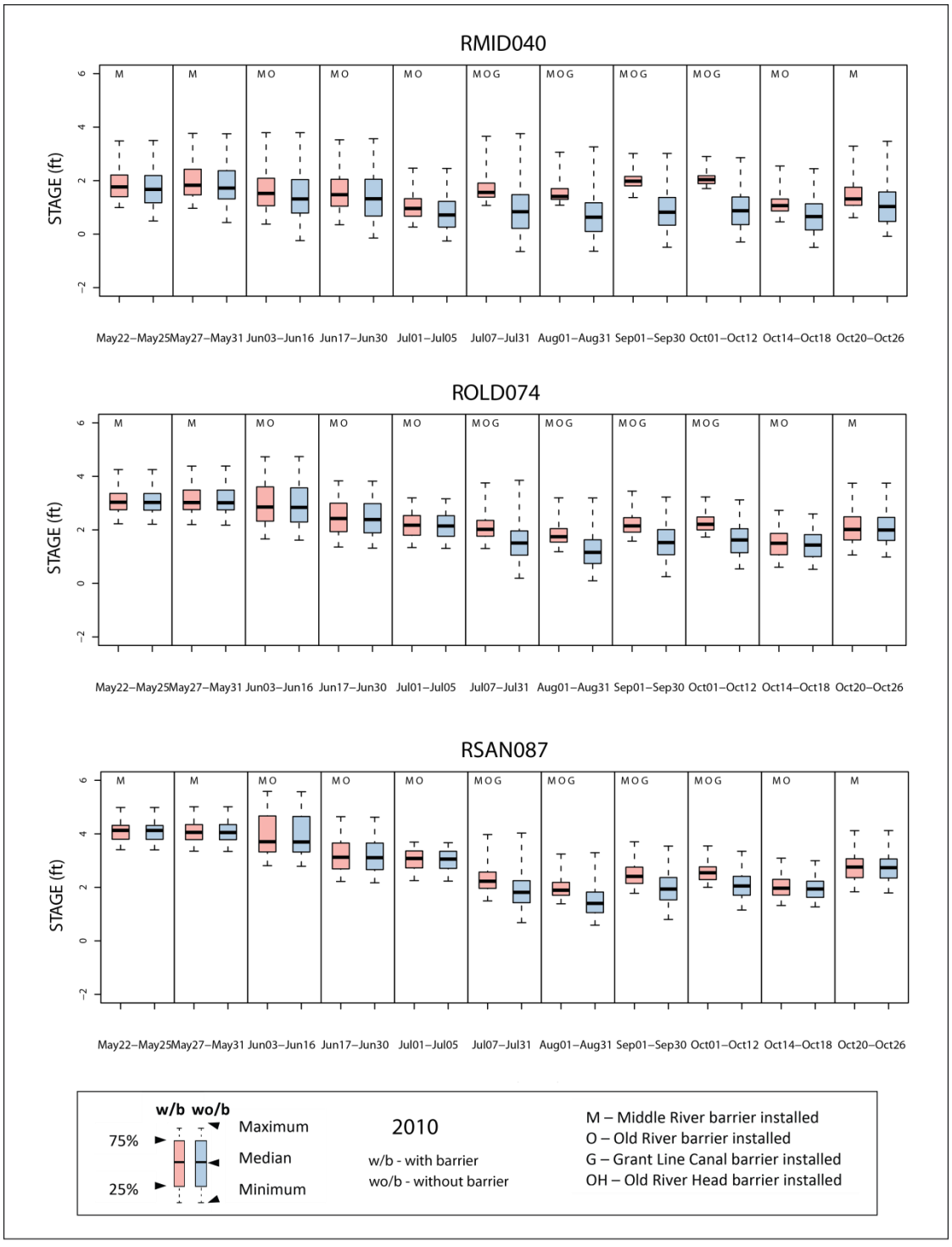

Figure 7-9 (cont.). Distribution of DSM2-simulated Stages for Historical 2010 Conditions with and without Temporary Barriers Installed

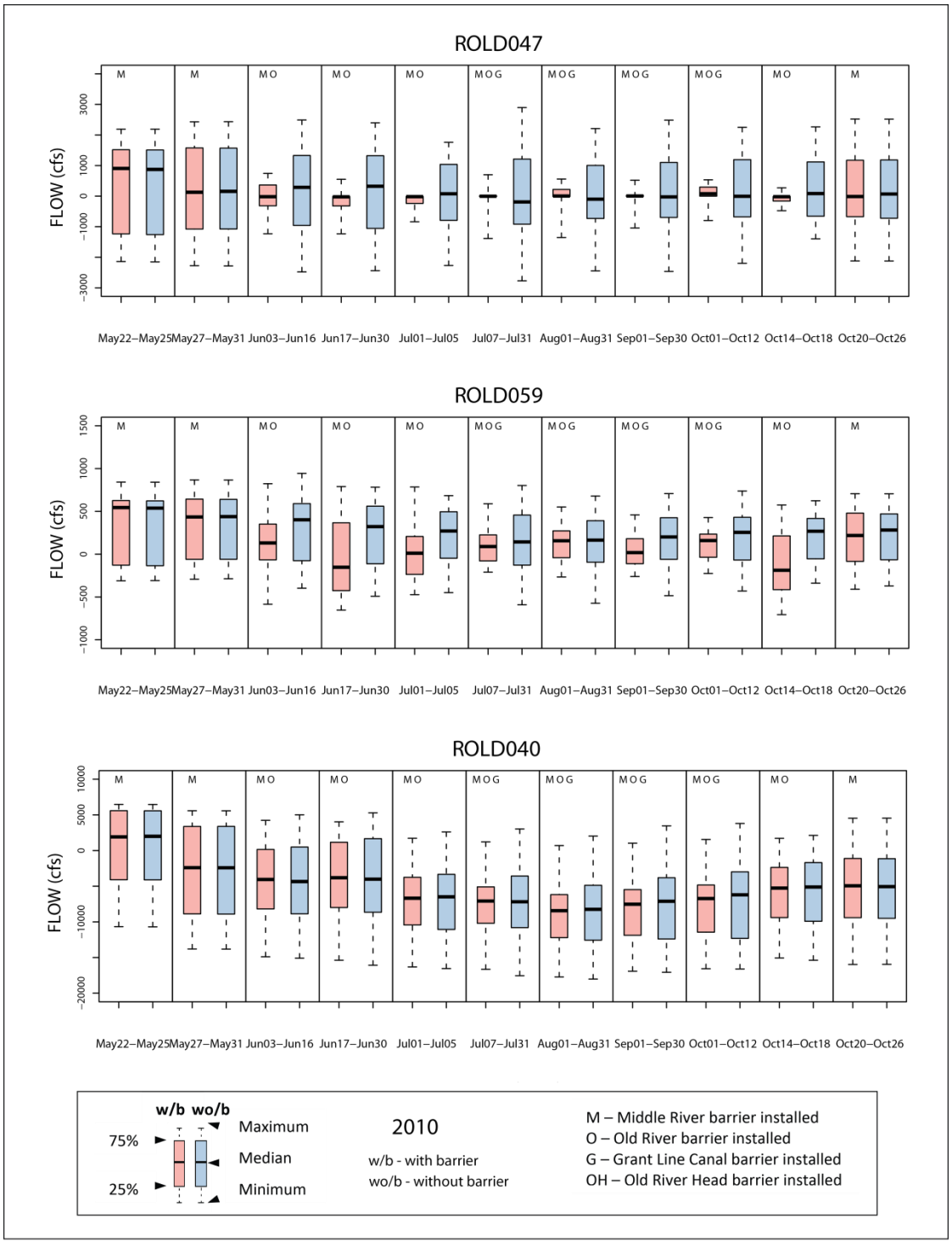

Figure 7-10. Distribution of DSM2-simulated Flows for Historical 2010 Conditions with and without Temporary Barriers Installed

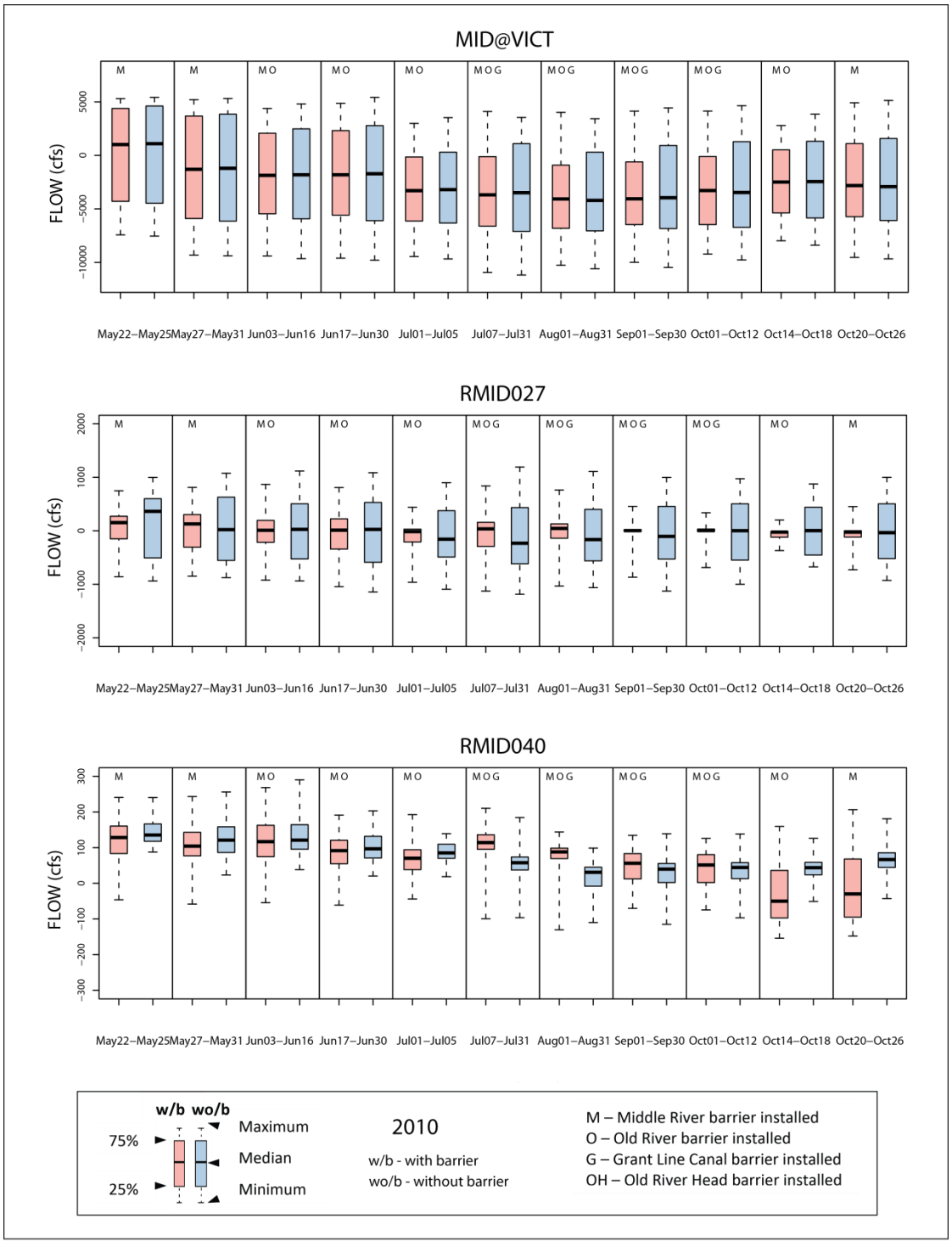

Figure 7-10 (cont.). Distribution of DSM2-simulated Flows for Historical 2010 Conditions with and without Temporary Barriers Installed

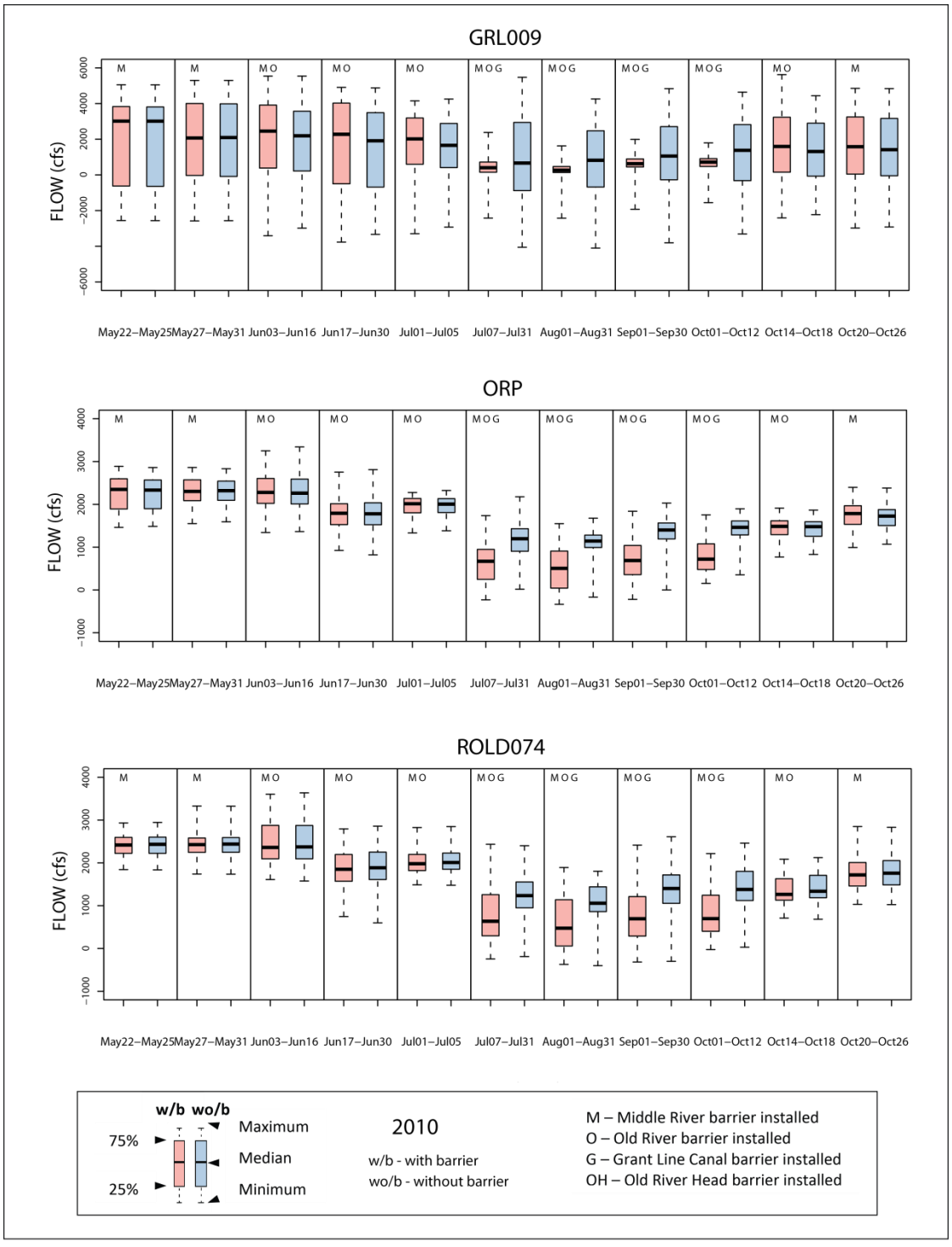

Figure 7-10 (cont.). Distribution of DSM2-simulated Flows for Historical 2010 Conditions with and without Temporary Barriers Installed

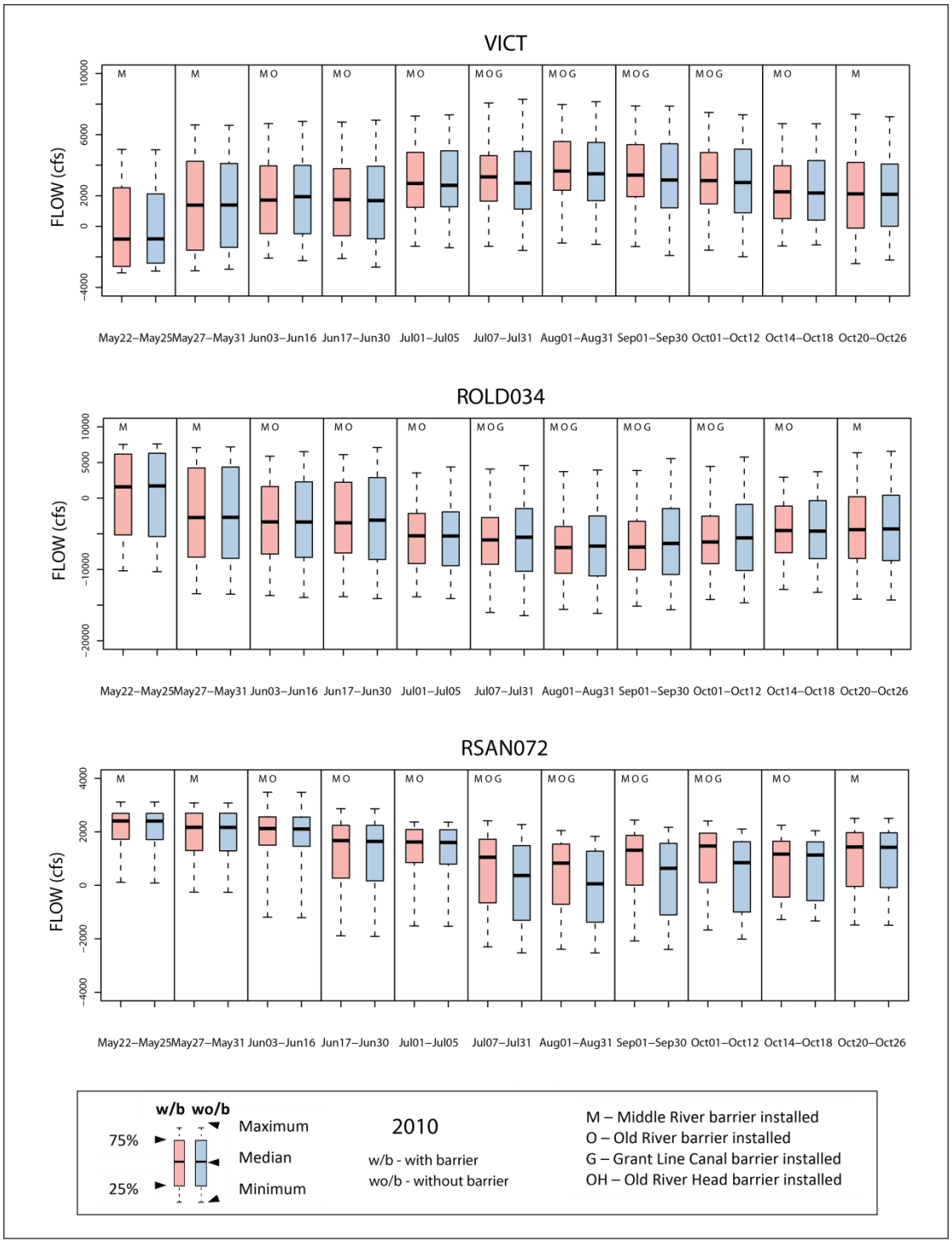

Figure 7-10 (cont.). Distribution of DSM2-simulated Flows for Historical 2010 Conditions with and without Temporary Barriers Installed

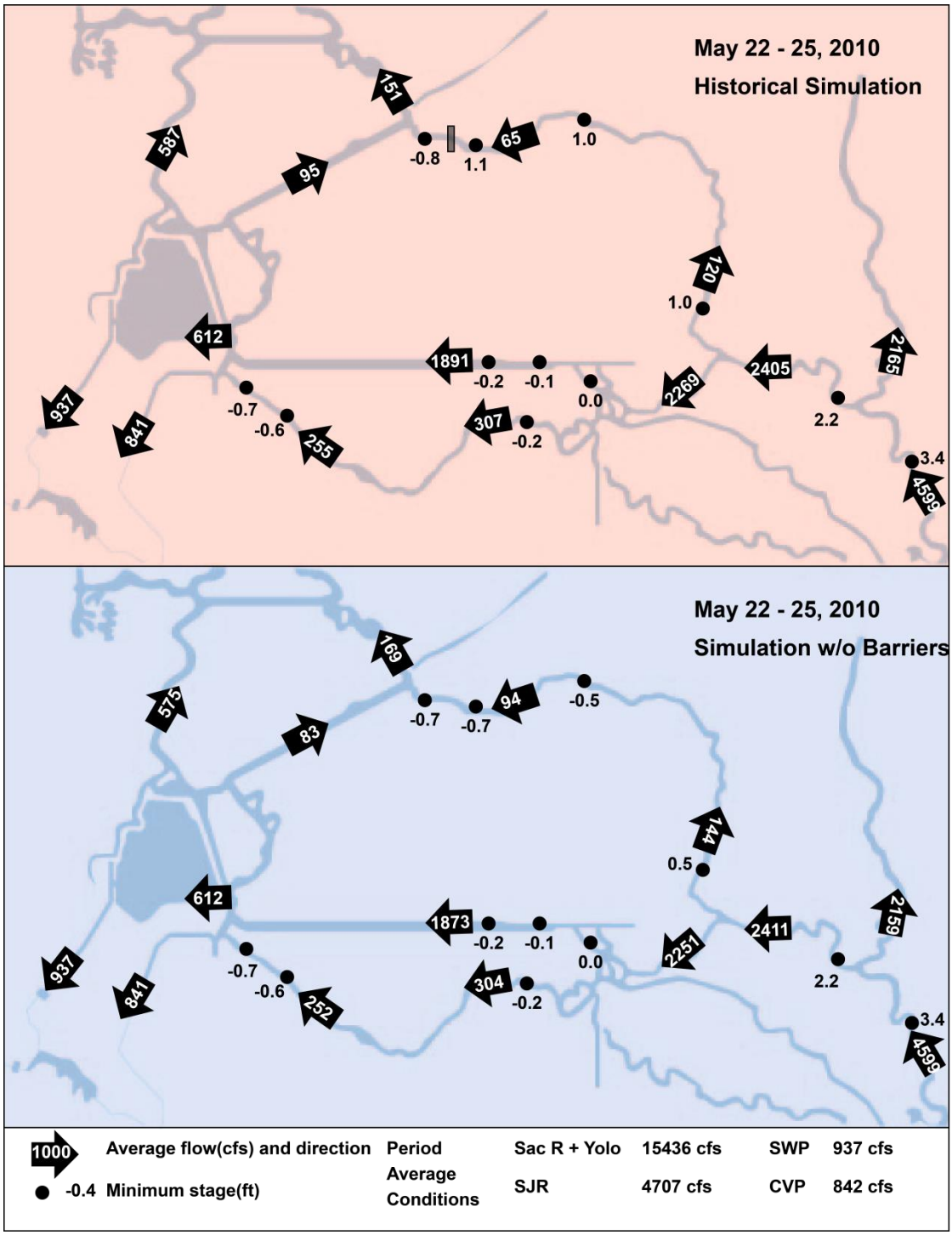

Figure 7-11. Simulated Period Average Flow and Minimum Stage under 2010 Conditions with Historical Barrier Configuration and No-barrier Condition

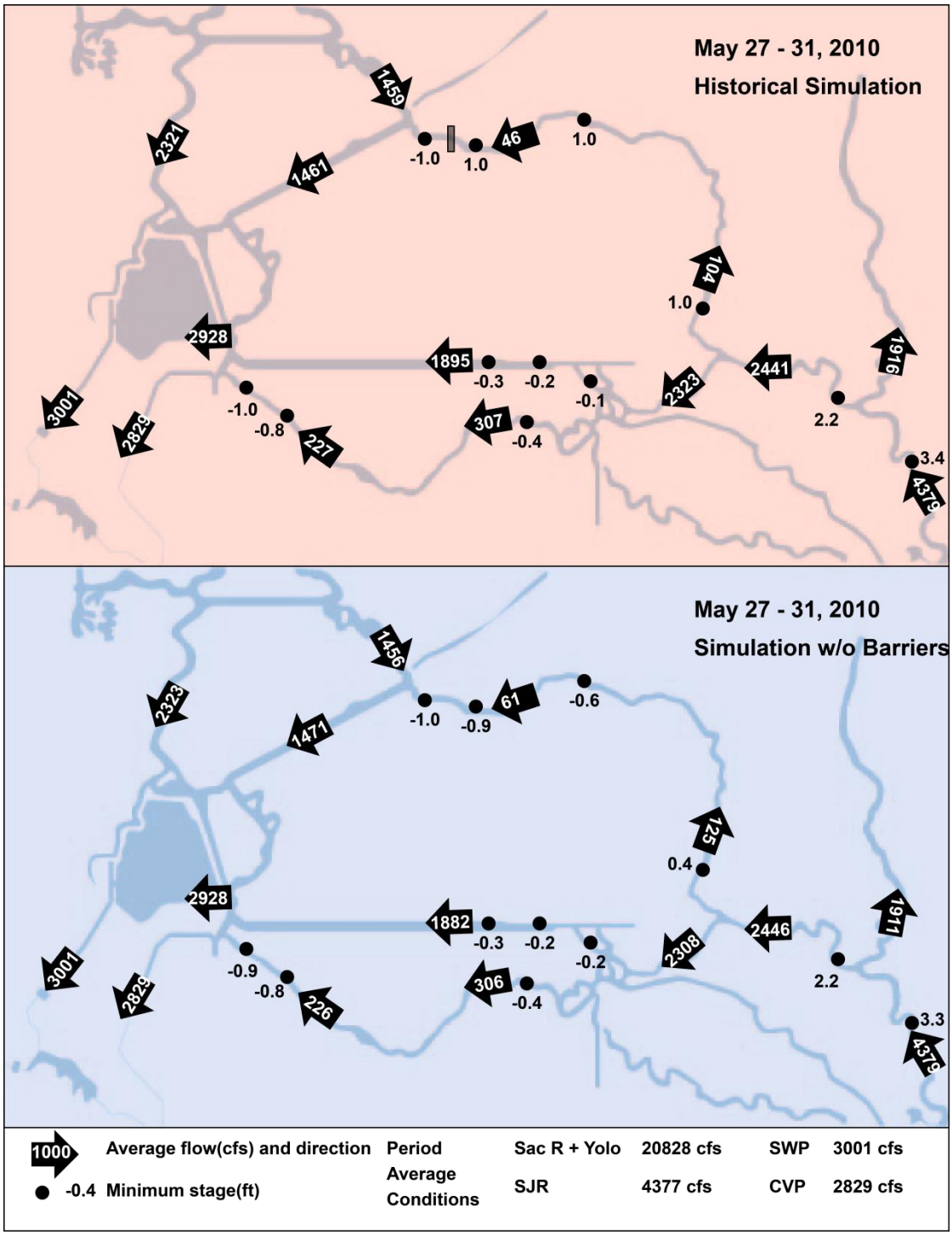

Figure 7-11 (cont.). Simulated Period Average Flow and Minimum Stage under 2010 Conditions with Historical Barrier Configuration and No-barrier Condition

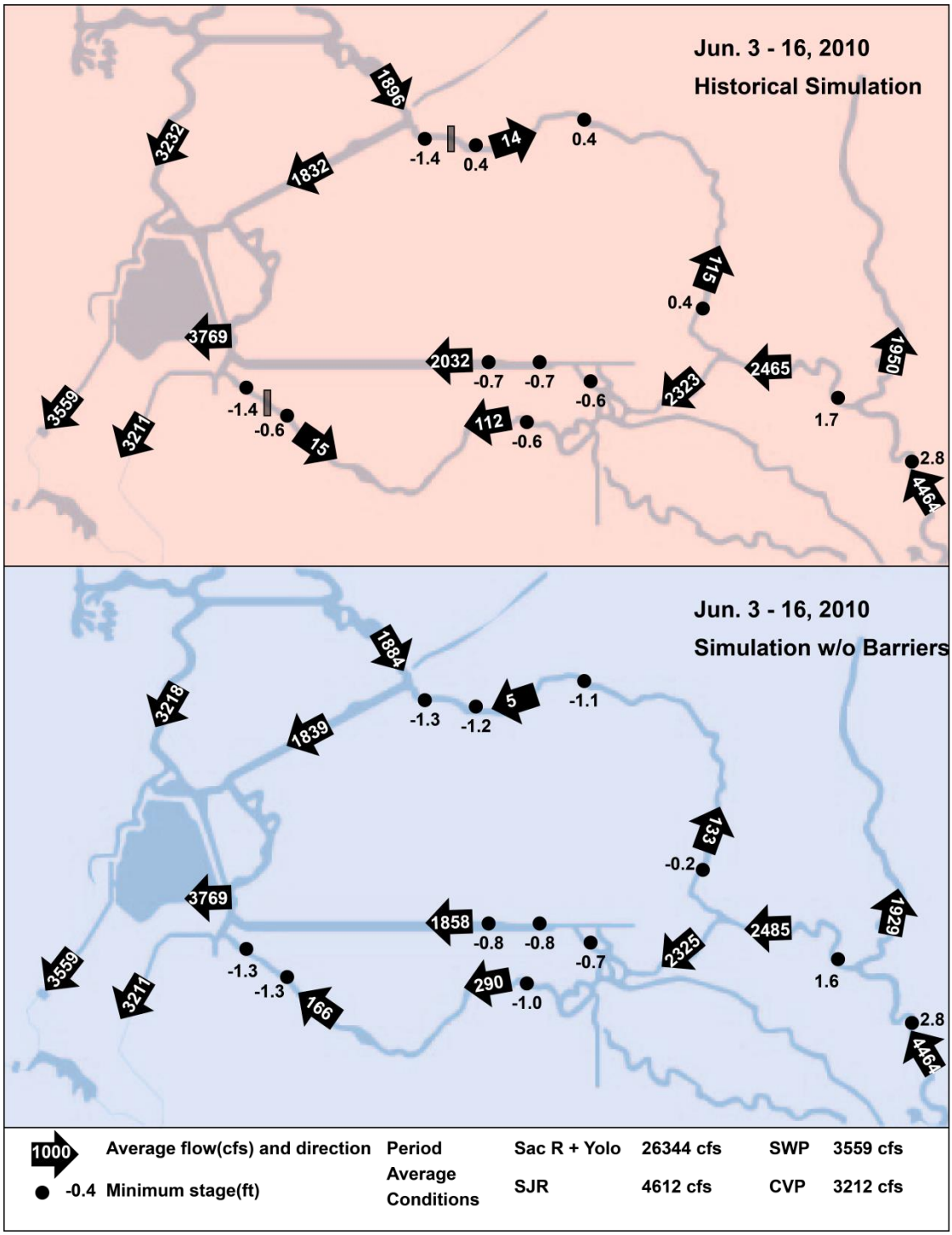

Figure 7-11 (cont.). Simulated Period Average Flow and Minimum Stage under 2010 Conditions with Historical Barrier Configuration and No-barrier Condition

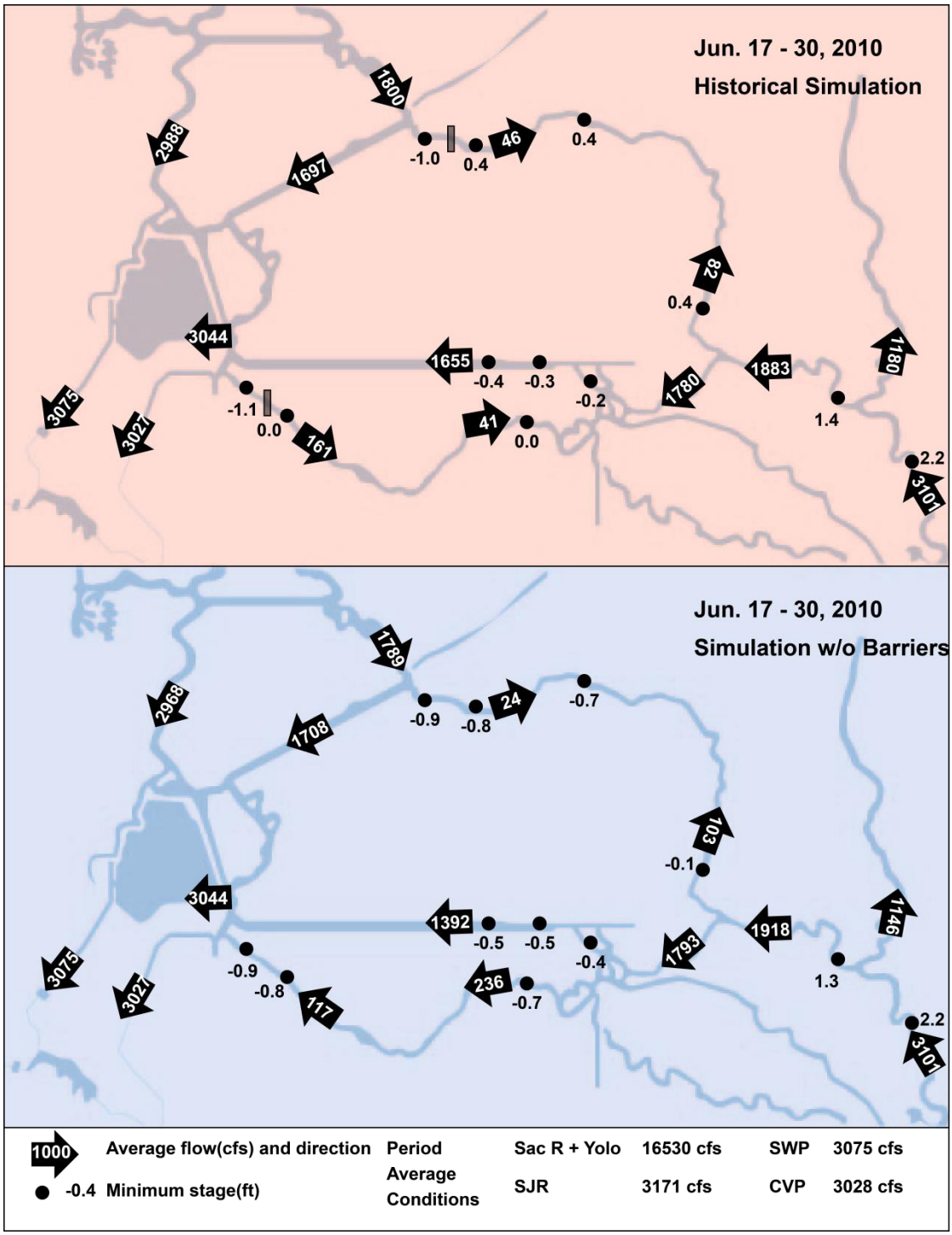

Figure 7-11 (cont.). Simulated Period Average Flow and Minimum Stage under 2010 Conditions with Historical Barrier Configuration and No-barrier Condition

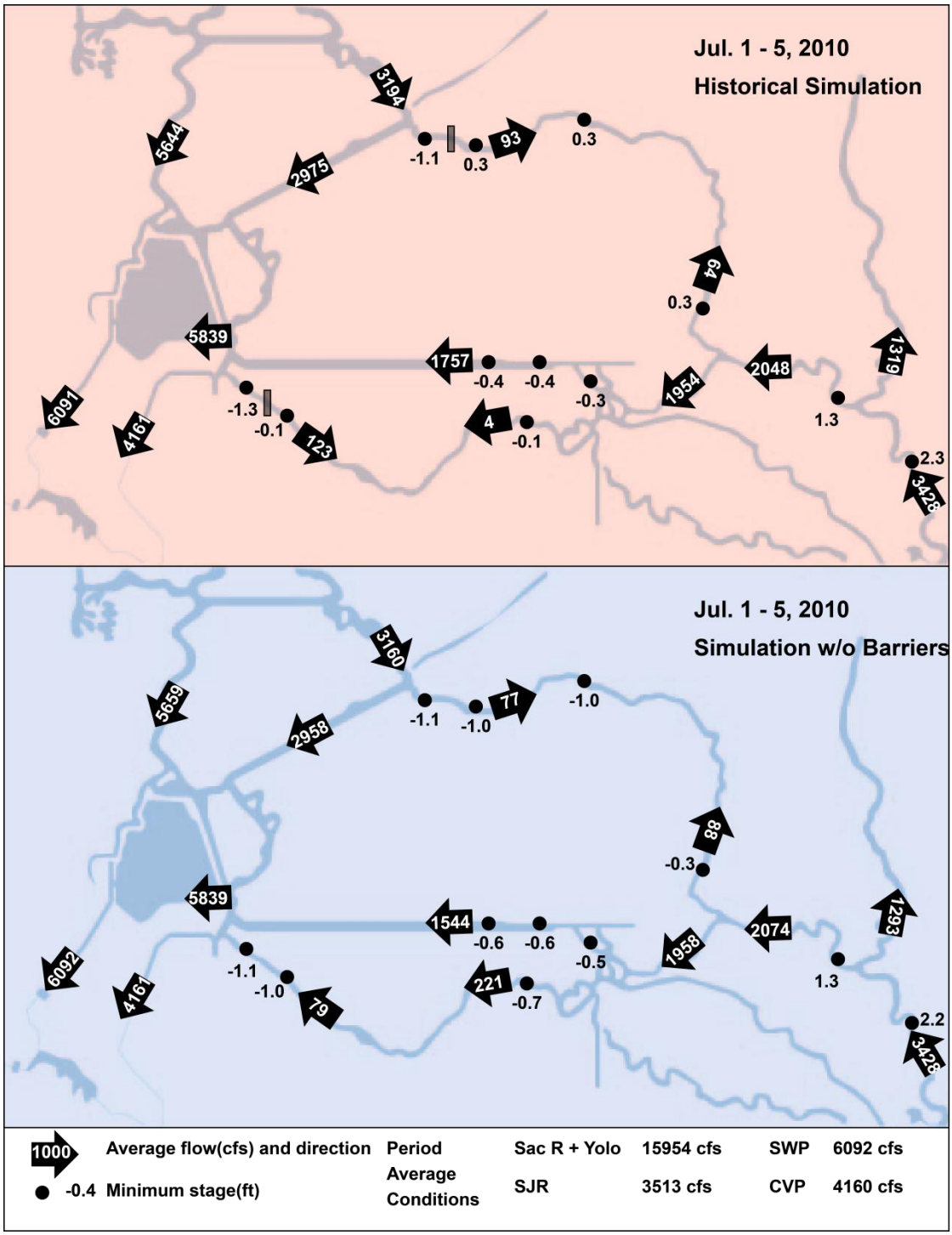

Figure 7-11 (cont.). Simulated Period Average Flow and Minimum Stage under 2010 Conditions with Historical Barrier Configuration and No-barrier Condition

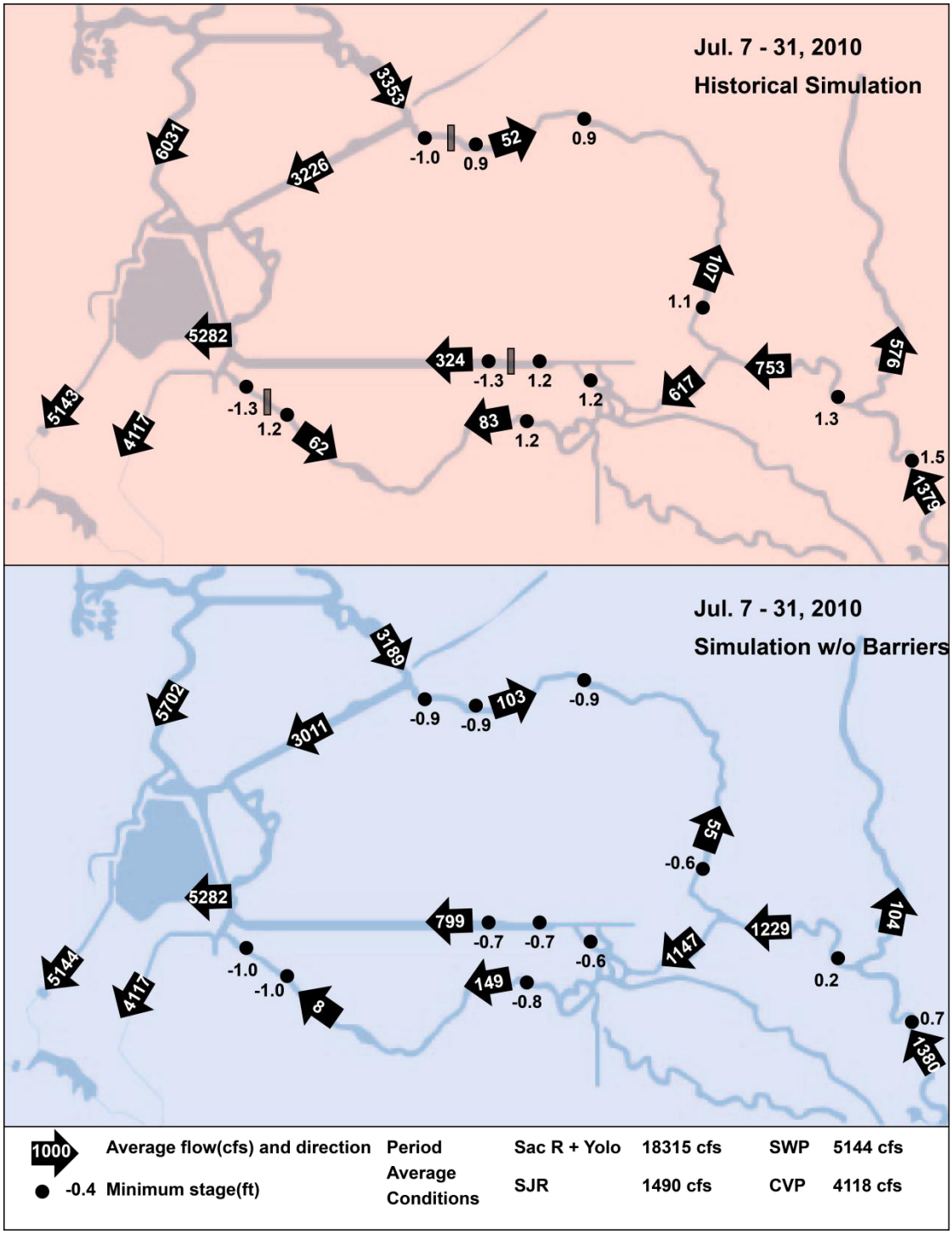

Figure 7-11 (cont.). Simulated Period Average Flow and Minimum Stage under 2010 Conditions with Historical Barrier Configuration and No-barrier Condition

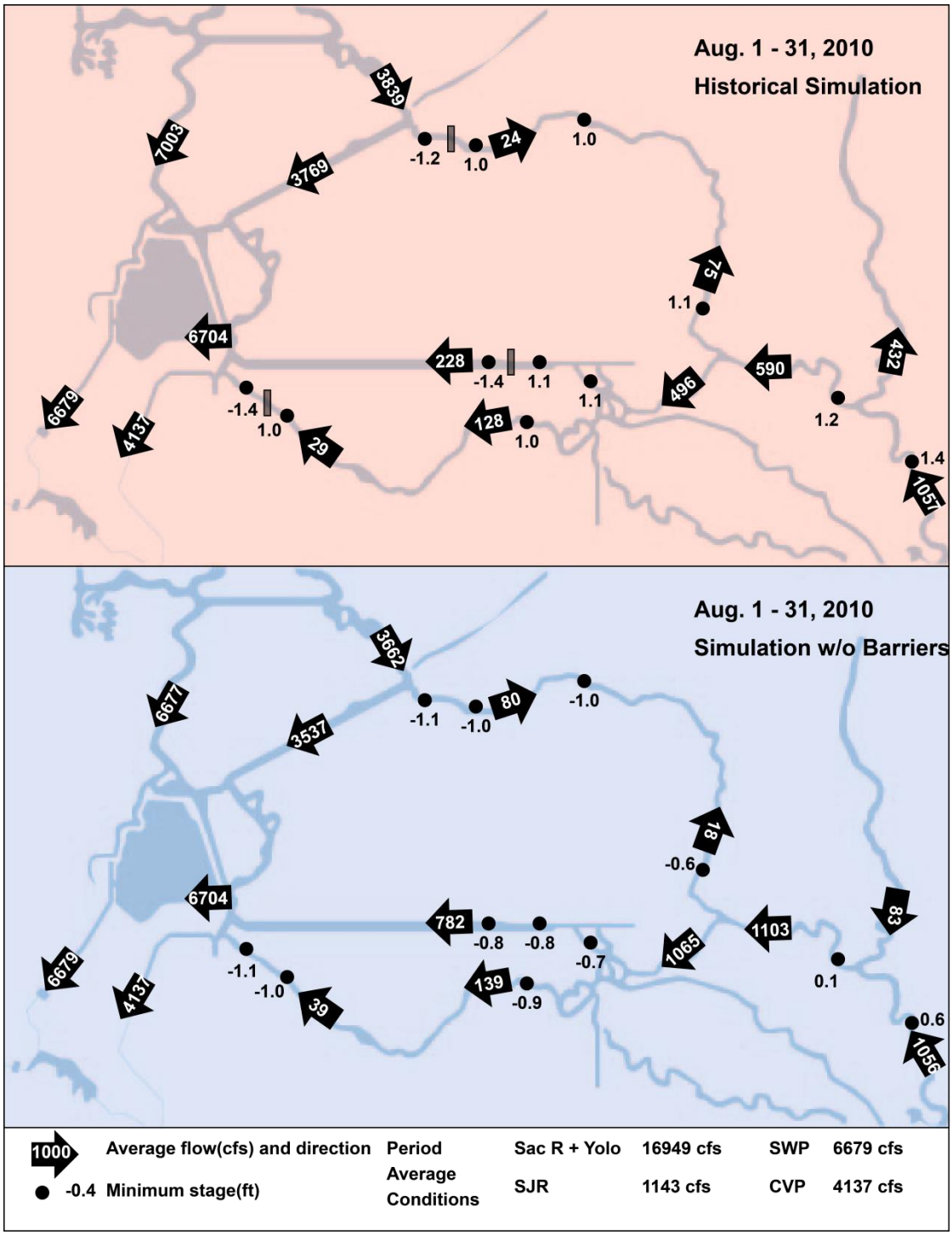

Figure 11 (cont.). Simulated Period Average Flow and Minimum Stage under 2010 Conditions with Historical Barrier Configuration and No-barrier Condition

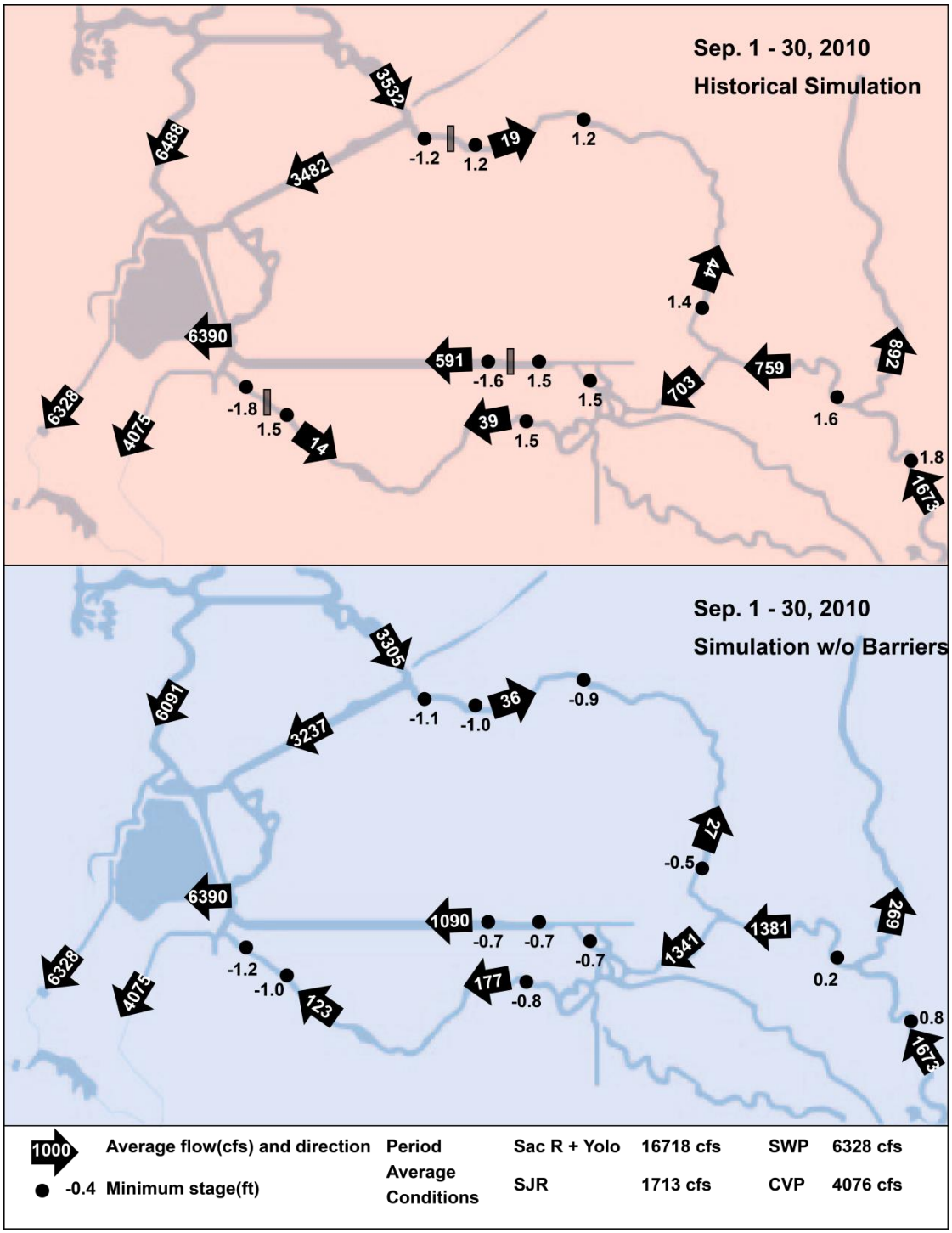

Figure 11 (cont.). Simulated Period Average Flow and Minimum Stage under 2010 Conditions with Historical Barrier Configuration and No-barrier Condition

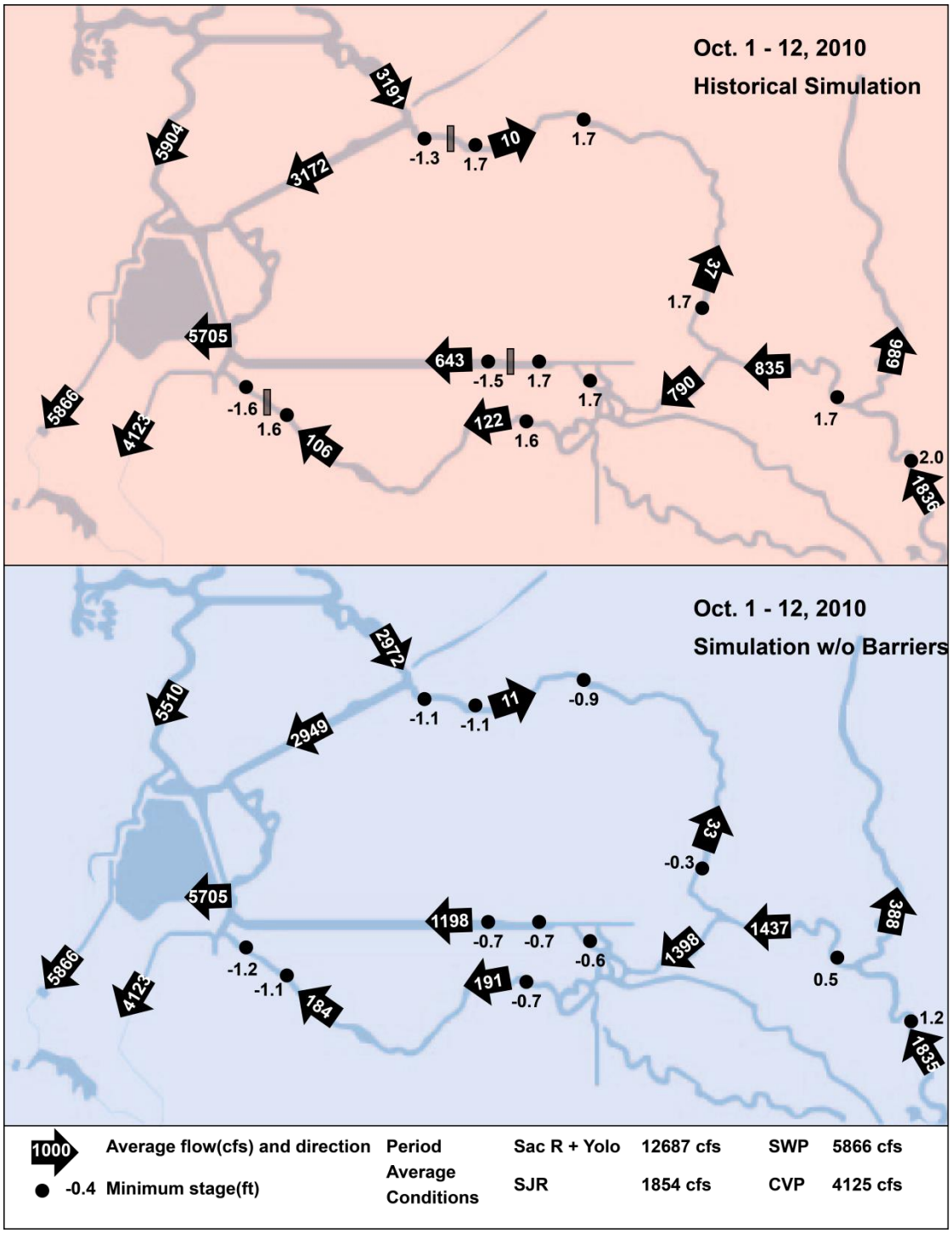

Figure 11 (cont.). Simulated Period Average Flow and Minimum Stage under 2010 Conditions with Historical Barrier Configuration and No-barrier Condition

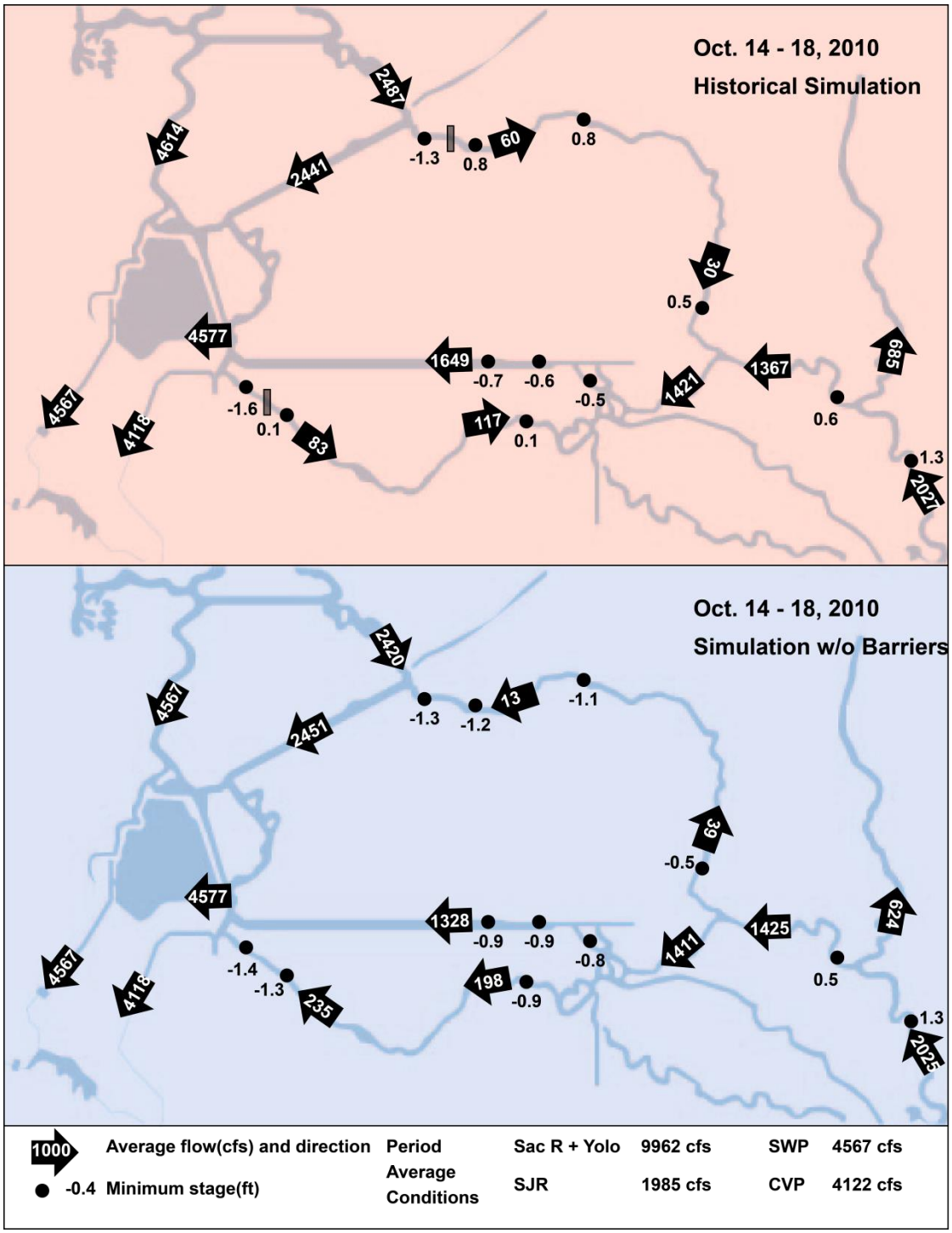

Figure 11 (cont.). Simulated Period Average Flow and Minimum Stage under 2010 Conditions with Historical Barrier Configuration and No-barrier Condition

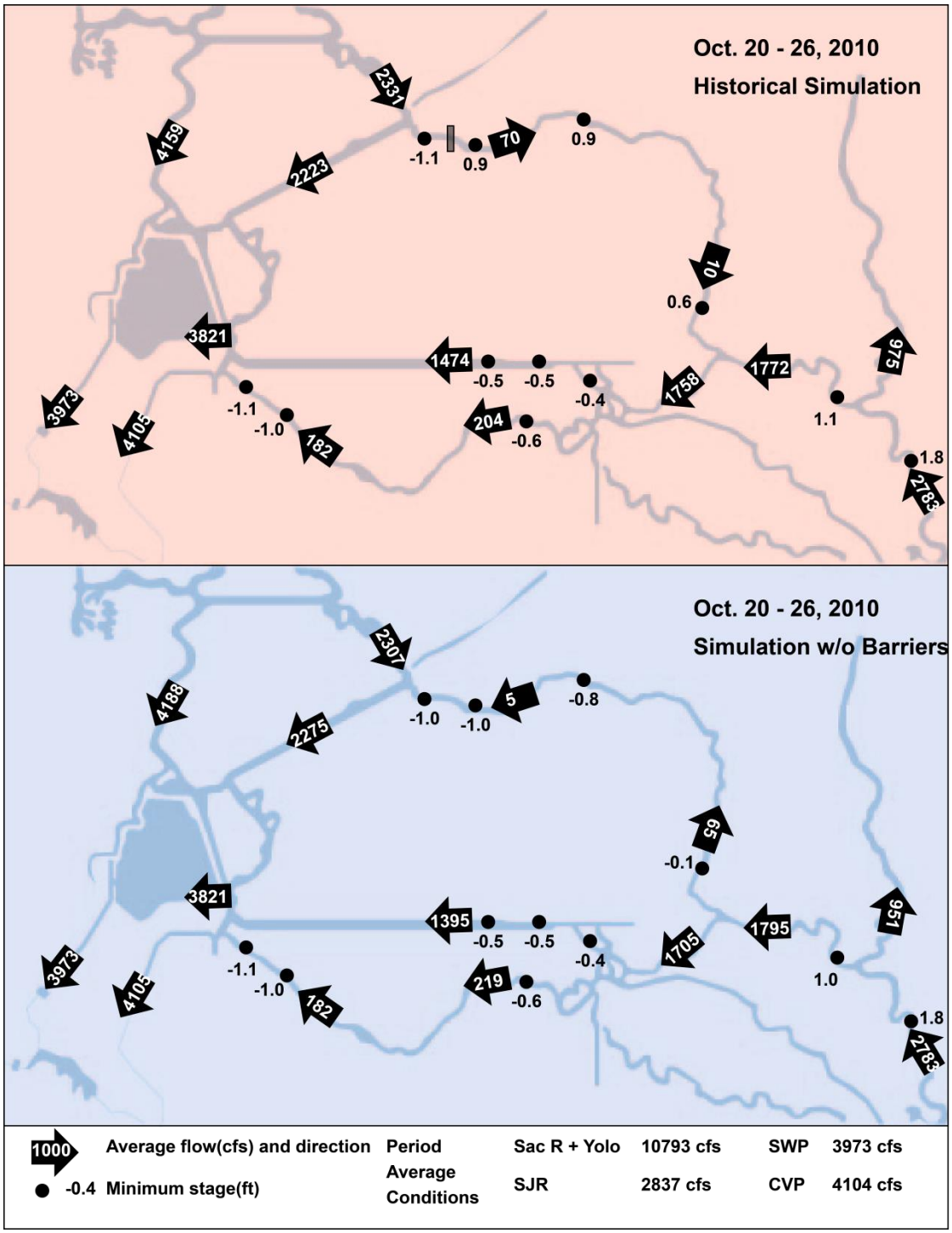

Figure 11 (cont.). Simulated Period Average Flow and Minimum Stage under 2010 Conditions with Historical Barrier Configuration and No-barrier Condition