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

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Chapter 4
South Delta Temporary Barriers Hydrodynamic Modeling

Authors: Lan Liang, Siqing Liu, Robert Suits,
Delta Modeling Section,
Bay-Delta Office,
California Department of Water Resources

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4.1 Summary

This chapter presents an abbreviated sample of the simulation of historical 2008 Delta hydrodynamic conditions and the effect of the installation and operation of the south Delta temporary barriers. For this analysis, historical Delta inflows, consumptive use, and exports were simulated under 2 barrier conditions: (1) historical 2008 installation and operation of the temporary barriers, and (2) no installation of south Delta temporary barriers. Delta Simulation Model II hydrodynamic module (DSM2-Hydro) was used to simulate the Delta hydrodynamics.

4.2 2008 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 was 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 2008 simulation are shown in Figure 4-1 through Figure 4-4.

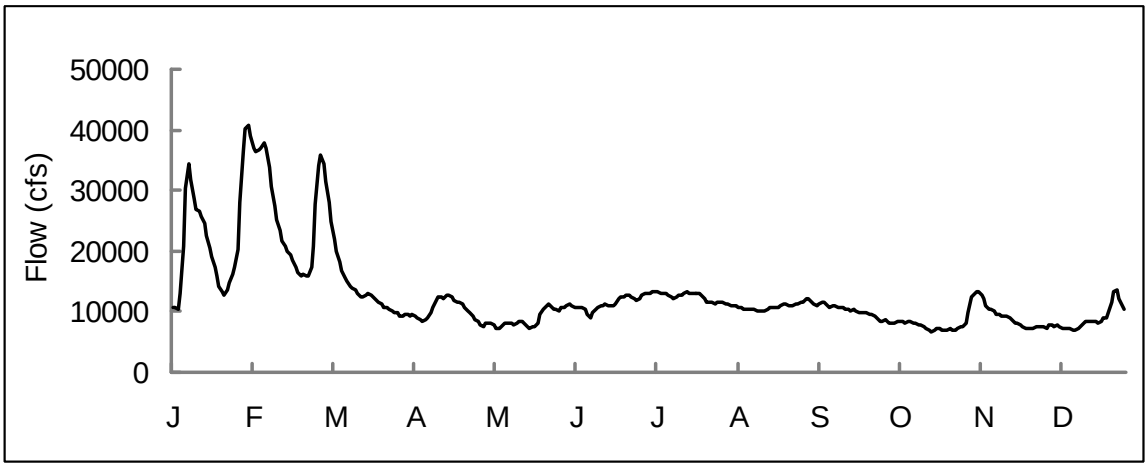

Figure 4-1 Daily average historical inflow from the Sacramento River, 2008

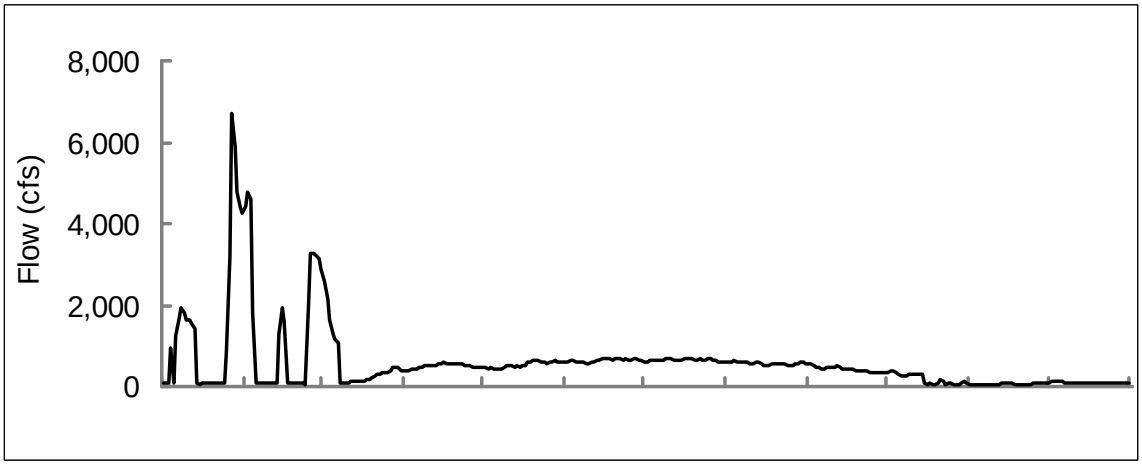

Figure 4-2 Daily average historical inflow from the Yolo Bypass, 2008

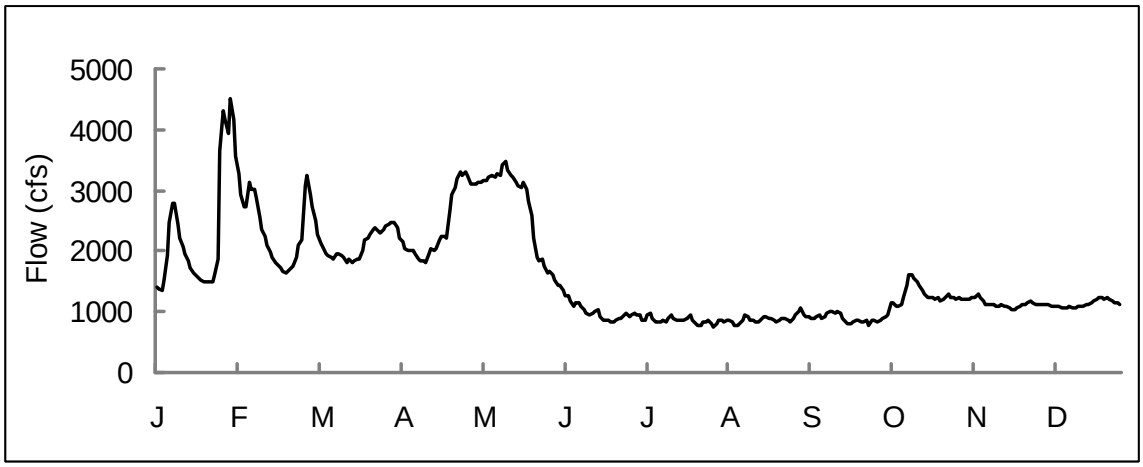

Figure 4-3 Daily average historical inflow from the San Joaquin River, 2008

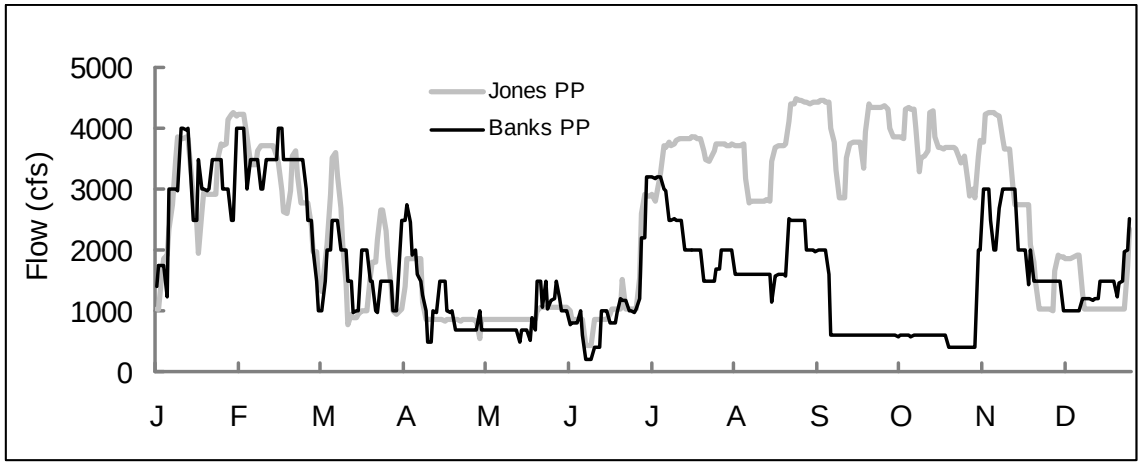

Figure 4-4 Daily average historical pumping at Banks and Jones pumping plants, 2008

4.3 2008 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 the DICU model includes precipitation, pan evaporation data, and water year type. The water year type determines which of 2 possible cropping patterns in the Delta is assumed. Delta land use in turn contributes to the estimation of agricultural water needs.

4.4 South Delta Structures

All 3 temporary agricultural barriers were installed in 2008. The head of Old River barrier was only installed in the fall. 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 4-1 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 4-1 for Grant Line Canal refers to the second phase installation because this is the time significant changes in stage upstream due to this barrier are first evident. 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 4-1.

Table 4-1 Historical South Delta Temporary Barriers installation and removal, 2008

	Installation			Removal		
Barrier	Started[1]	Ended[1]	DSM2 simulation	Started[1]	Ended[1]	DSM2 simulation
Middle River	5/21/08	5/21/08	5/25/08 1700 hrs	11/11/08	11/11/08	11/05/08 1600 hrs
Old River nr Delta Mendota Canal	6/04/08	6/04/08	6/04/08 1500 hrs	11/4/08	11/4/08	11/03/08 1200 hrs
Grant Line Canal	6/26/08	6/26/08	6/26/08 0800 hrs	11/11/08	11/11/08	11/10/08 1100 hrs
Old River @ Head (spring)	---	---	---	---	---	---
Old River @ Head (fall)	10/16/08	10/16/08	10/16/08 0800 hrs	11/03/08	11/03/08	11/03/08

[1] As reported by Temporary Barriers Program, DWR

4.5 Delta Downstream Stage at Martinez

The downstream boundary of DSM2 is Martinez where a time series of observed historical 15-minute data from 2008 were used for the simulation.

4.6 Delta Cross Channel Operation

The Delta Cross Channel gates were operated in 2008 and modeled in the historical DSM2 simulation from historical operation data.

4.7 Validation of DSM2 Simulation of Historical 2008 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 in Figure 4-5. Figure 4-6 presents observed and simulated daily minimum and maximum stage, and Figure 4-7 presents observed and simulated daily minimum, maximum, and average flow.

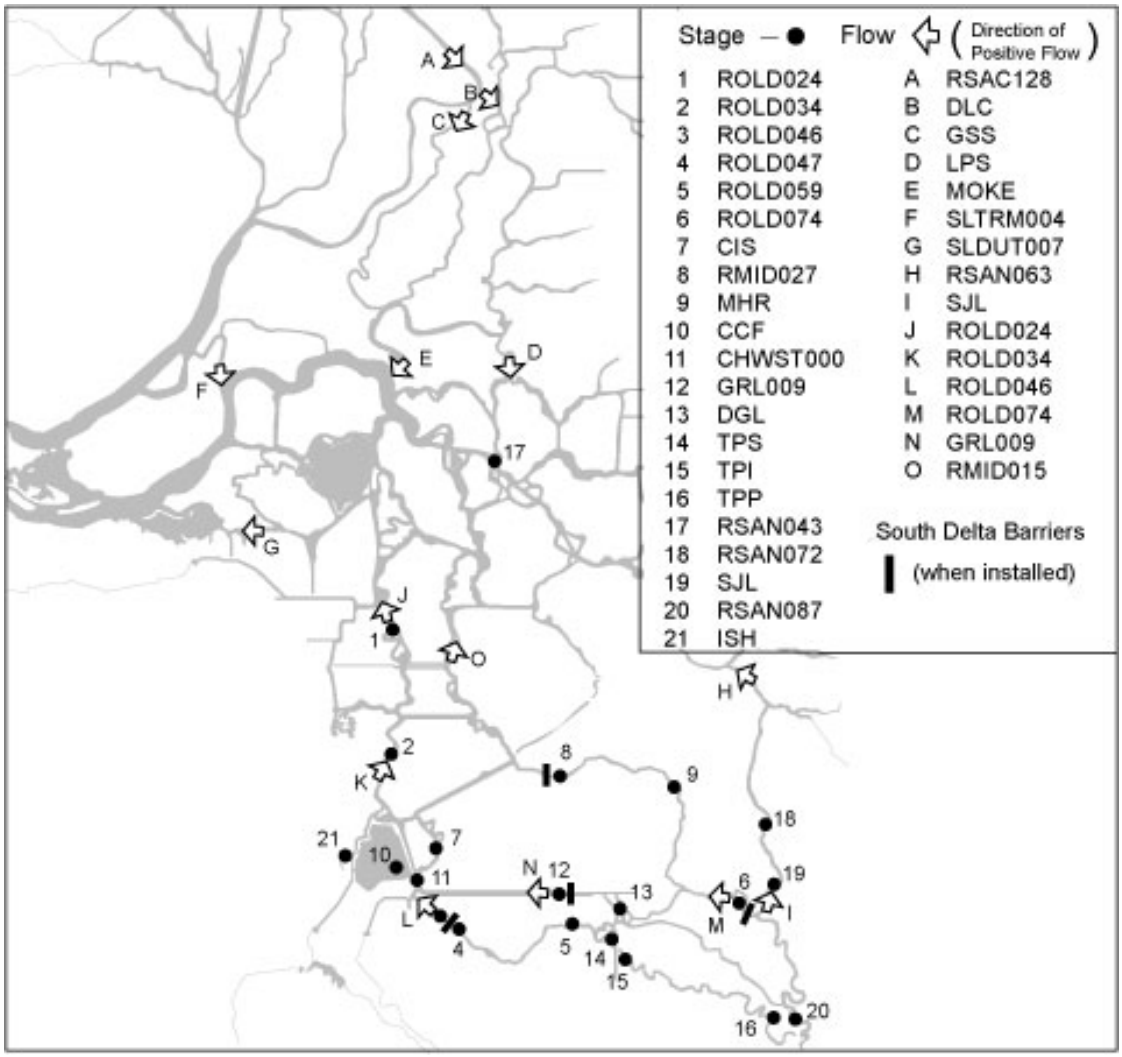

Figure 4-5 Locations where DSM2-simulated and measured stages and flows are presented, 2008

Figure 4-6 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 all DSM2 historical simulations.

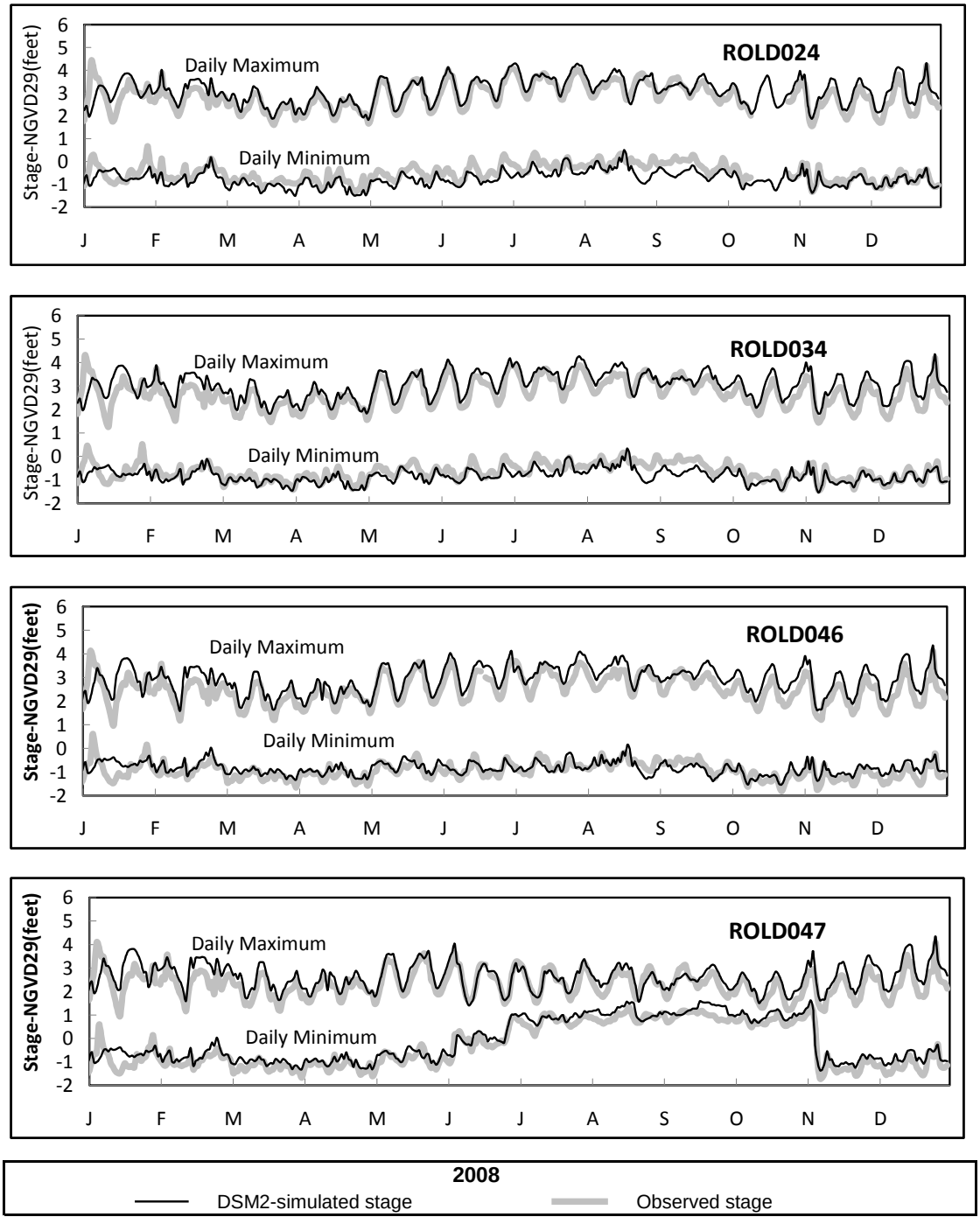

Figure 4-6 Comparison of DSM2-simulated and observed daily stage, 2008

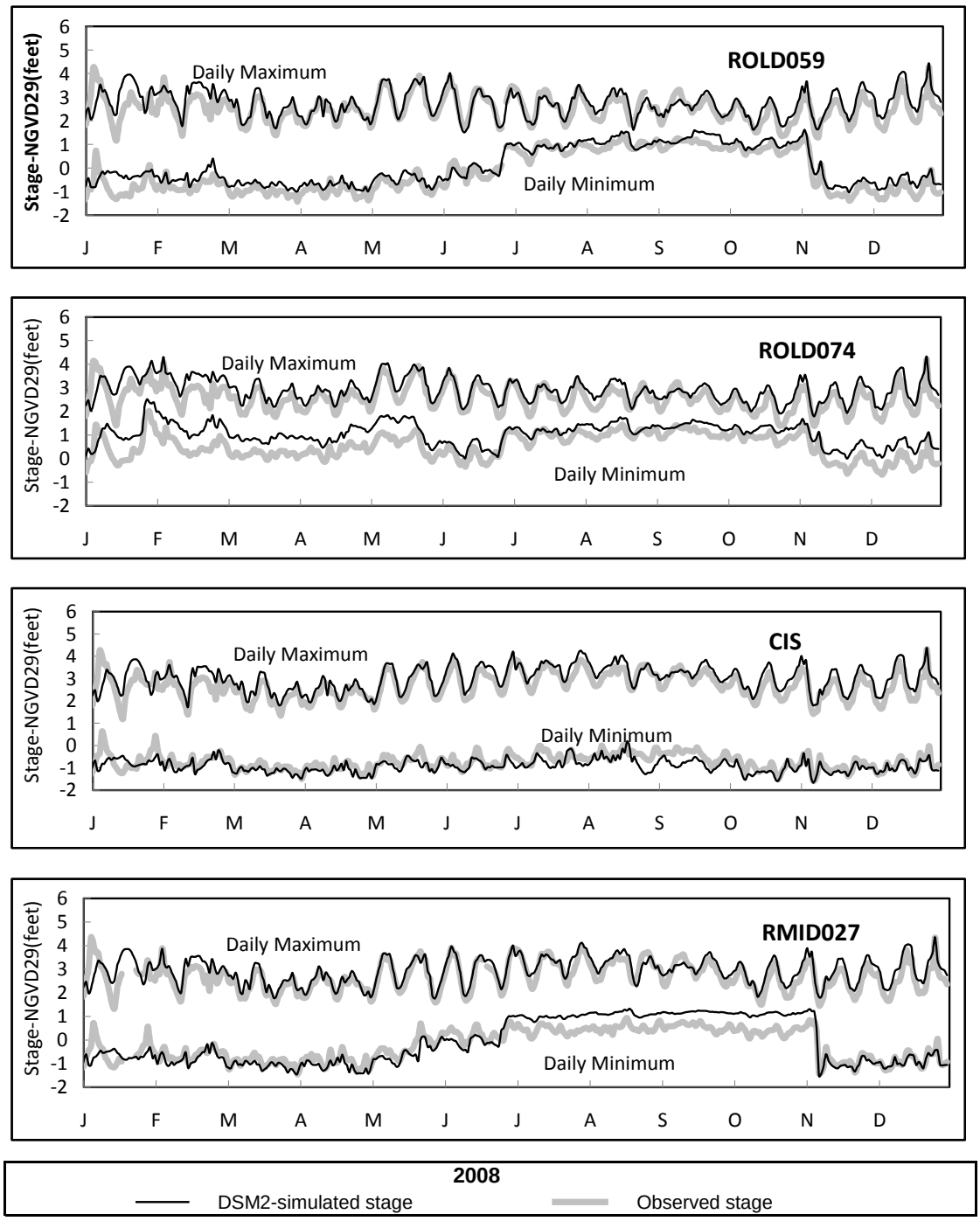

Figure 4-6 (cont.) Comparison of DSM2-simulated and observed daily stage, 2008

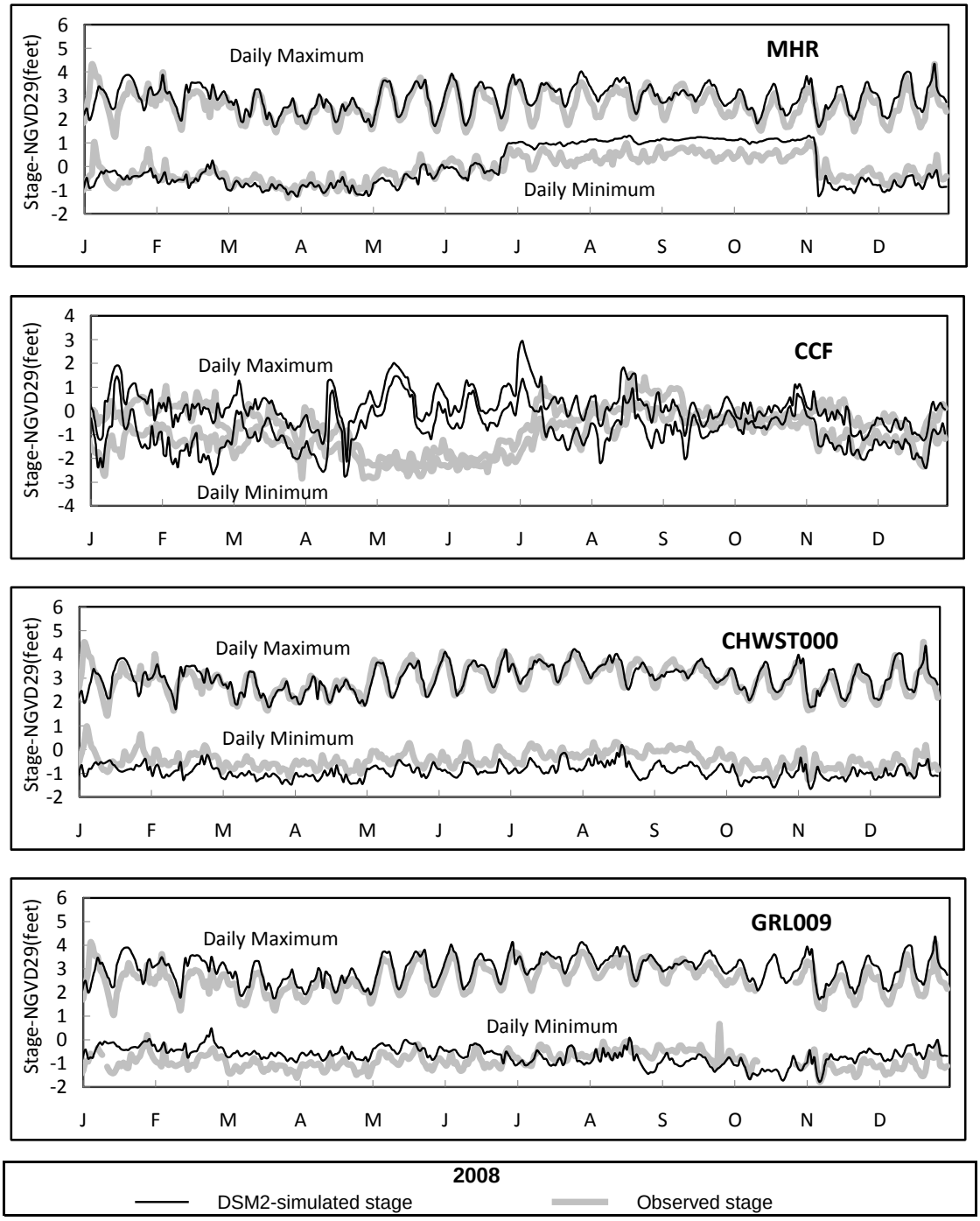

Figure 4-6 (cont.) Comparison of DSM2-simulated and observed daily stage, 2008

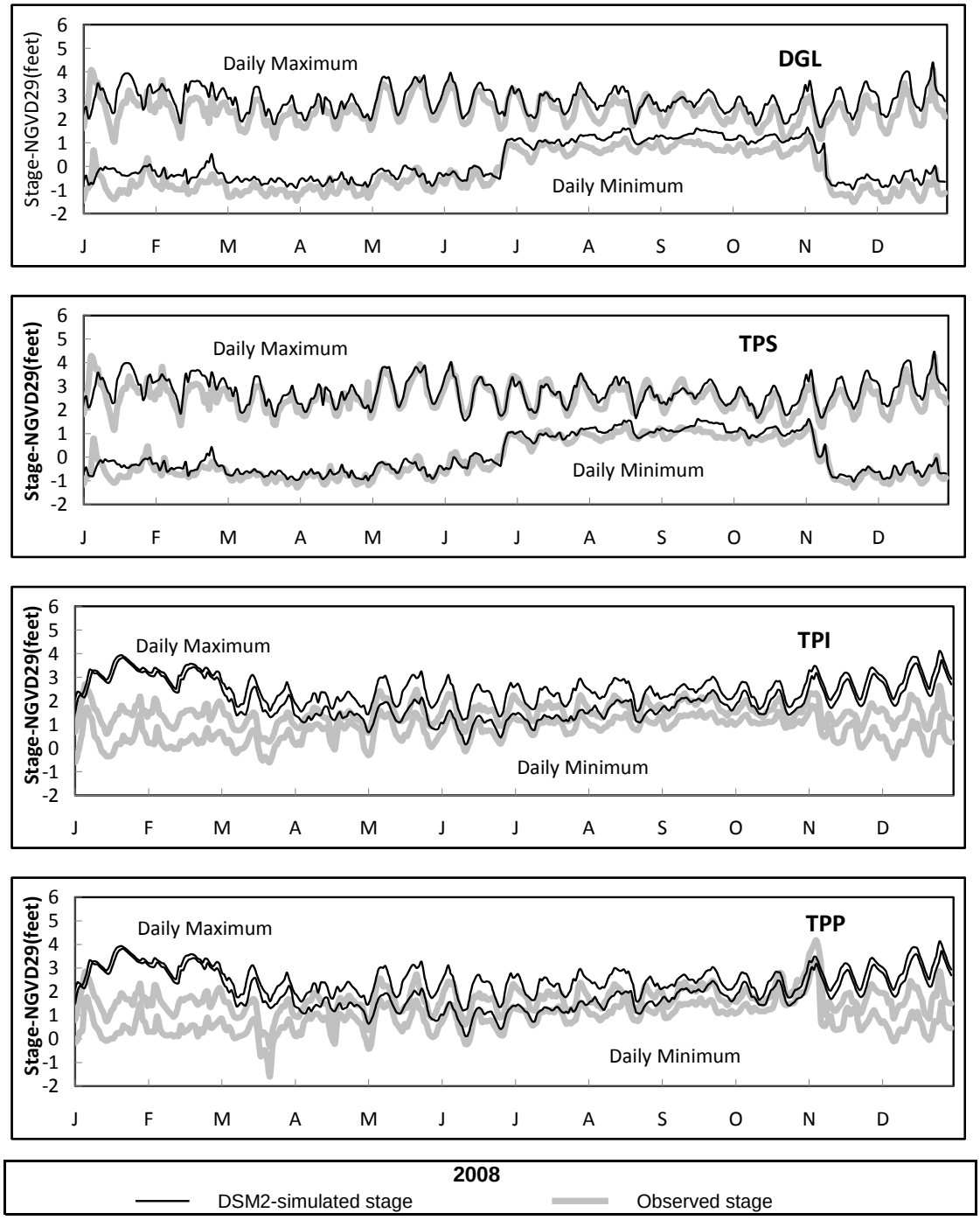

Figure 4-6 (cont.) Comparison of DSM2-simulated and observed daily stage, 2008

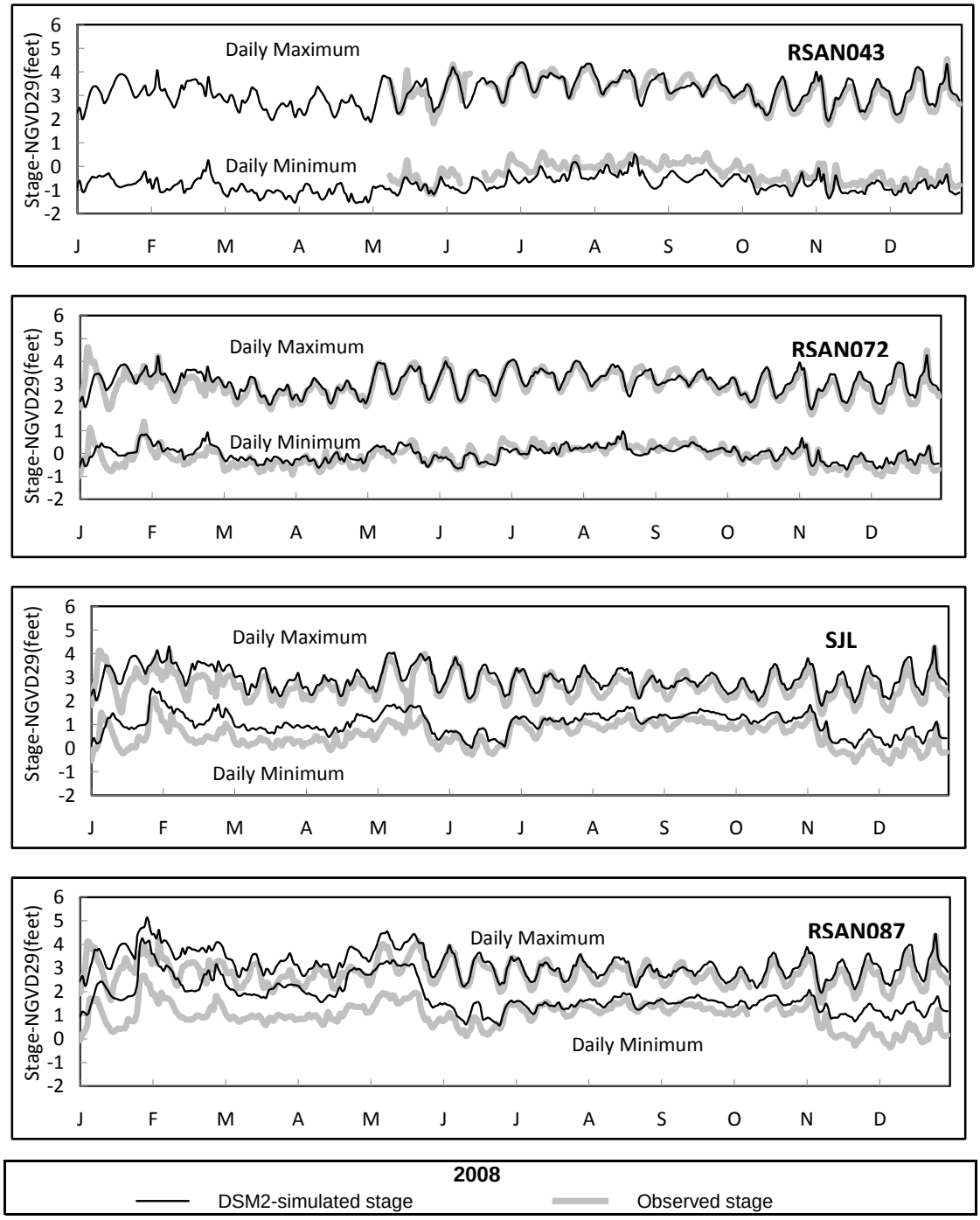

Figure 4-6 (cont.) Comparison of DSM2-simulated and observed daily stage, 2008

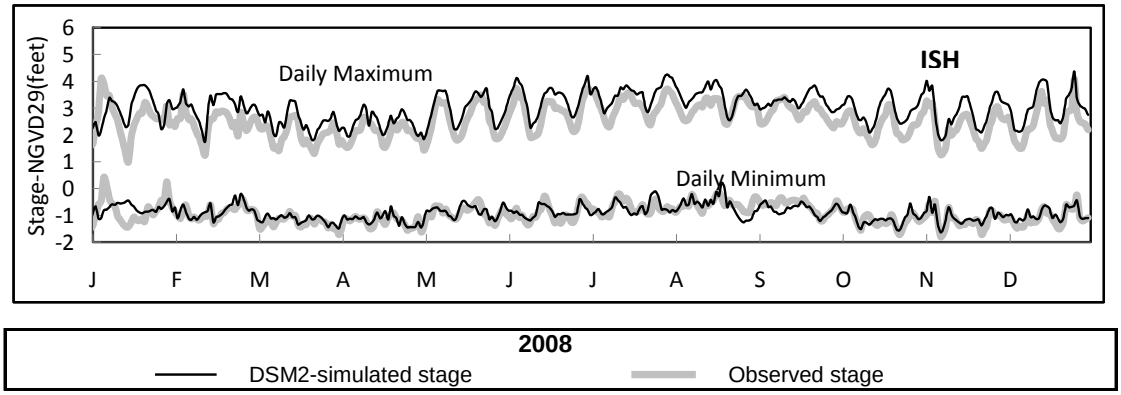

Figure 4-6 (cont.) Comparison of DSM2-simulated and observed daily stage, 2008

Figure 4-7 shows DSM2-simulated and observed daily maximum, average, and minimum flow wherever measured flow data are available in the Delta for 2008. The DSM2 simulation matched observed peak and average flows well at almost all locations in the Delta outside of the area affected by the temporary barriers in the south Delta. Locations where flow was measured and are within the influence of the barriers are Old River downstream of barrier near Delta Mendota Canal (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, ROLD074, 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. Peak downstream flows matched better once the Grant Line Canal was installed; otherwise, the DSM2 simulation showed peak downstream flows that were less than those observed. At ROLD074, simulated peak upstream and downstream flows matched observed flows well. 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, although the observed and simulated daily average flows match well, the observed daily peak upstream and downstream flows can significantly exceed simulated flows. This pattern has been noted in other years and may reflect the currently assumed Grant Line Canal bathymetry used in DSM2.

Taken together, Figure 4-6 and Figure 4-7 indicate that the DSM2 simulations of historical 2008 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.

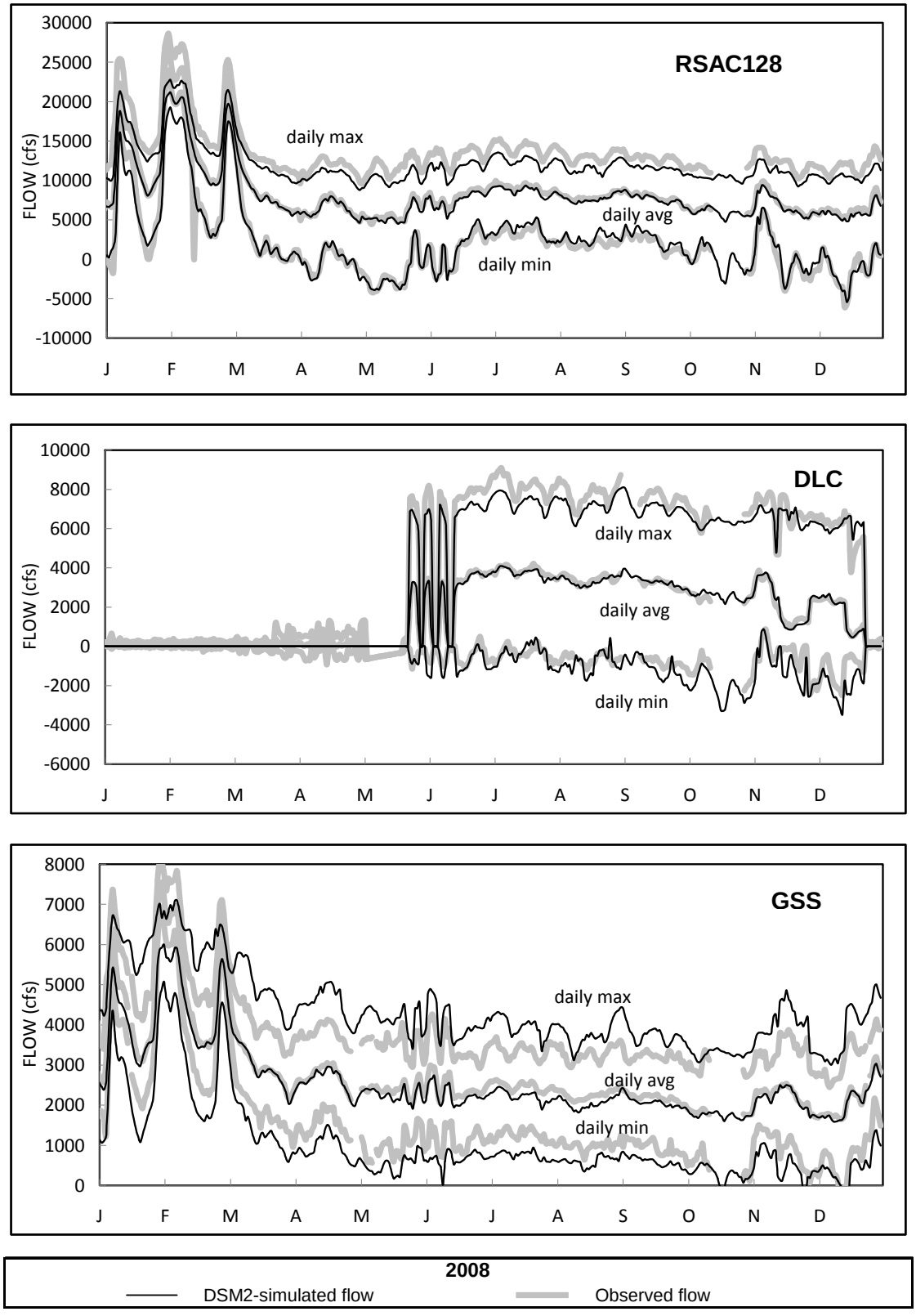

Figure 4-7 Comparison of DSM2-simulated and measured daily flow, 2008

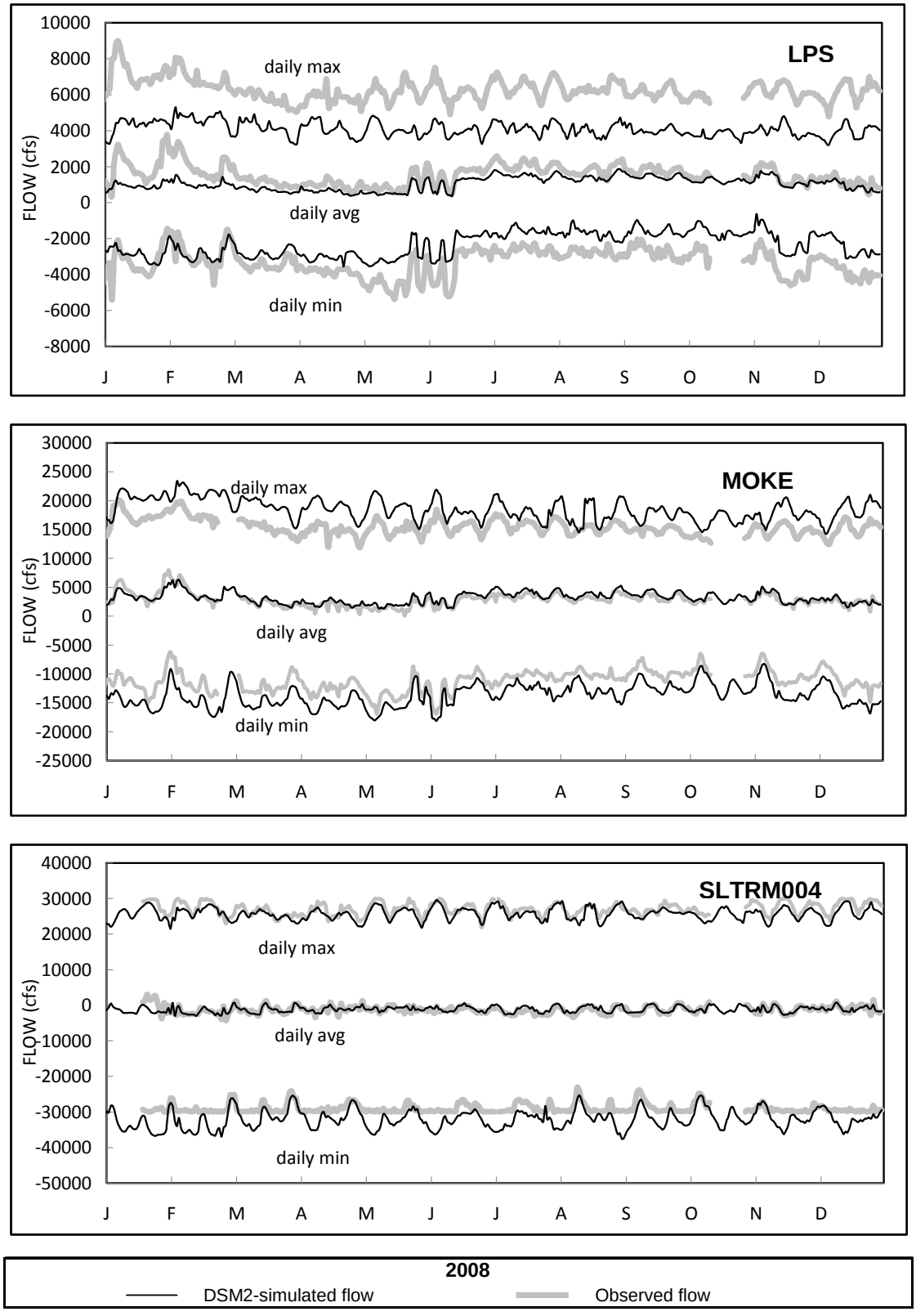

Figure 4-7 (cont.) Comparison of DSM2-simulated and measured daily flow, 2008

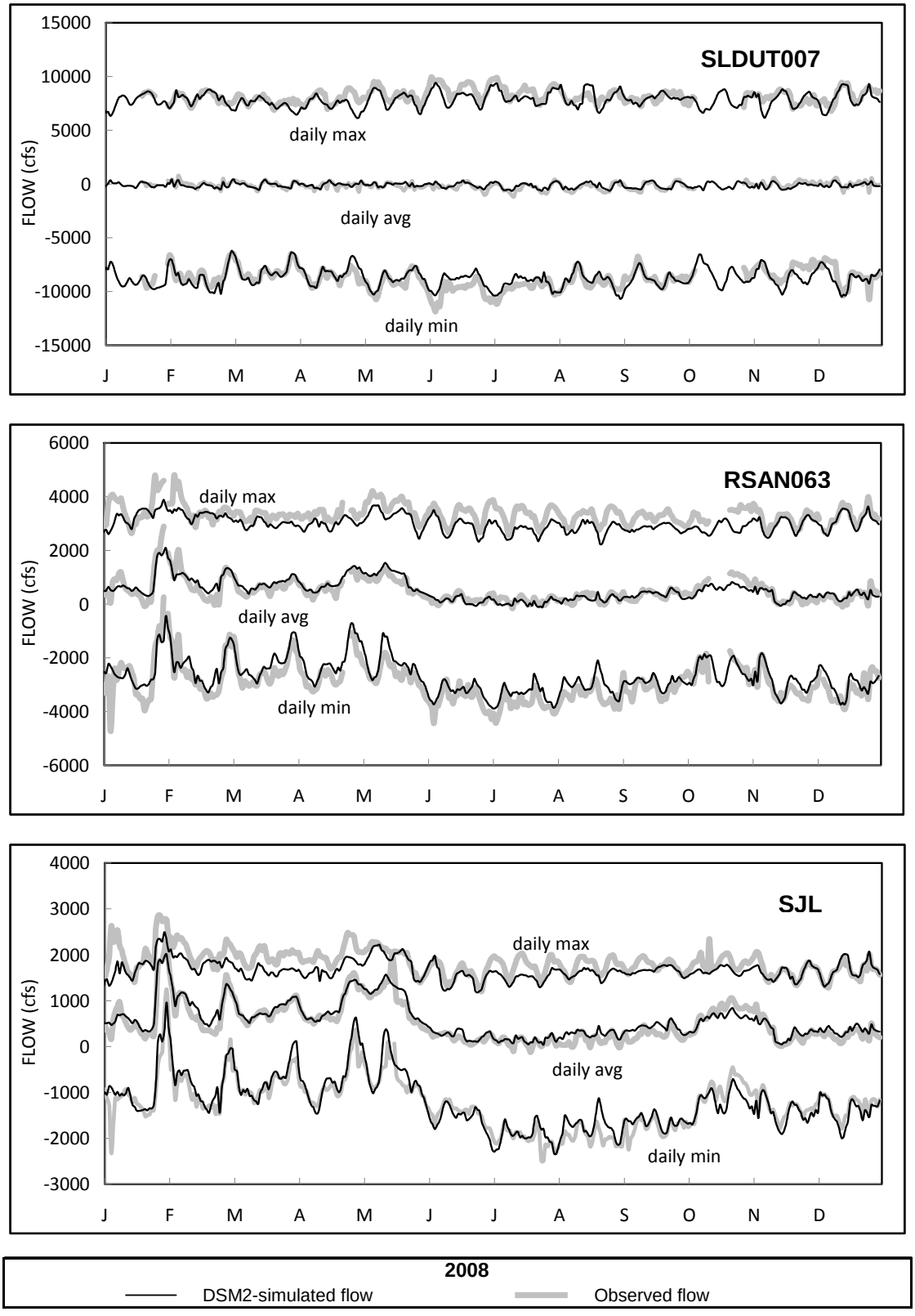

Figure 4-7 (cont.) Comparison of DSM2-simulated and measured daily flow, 2008

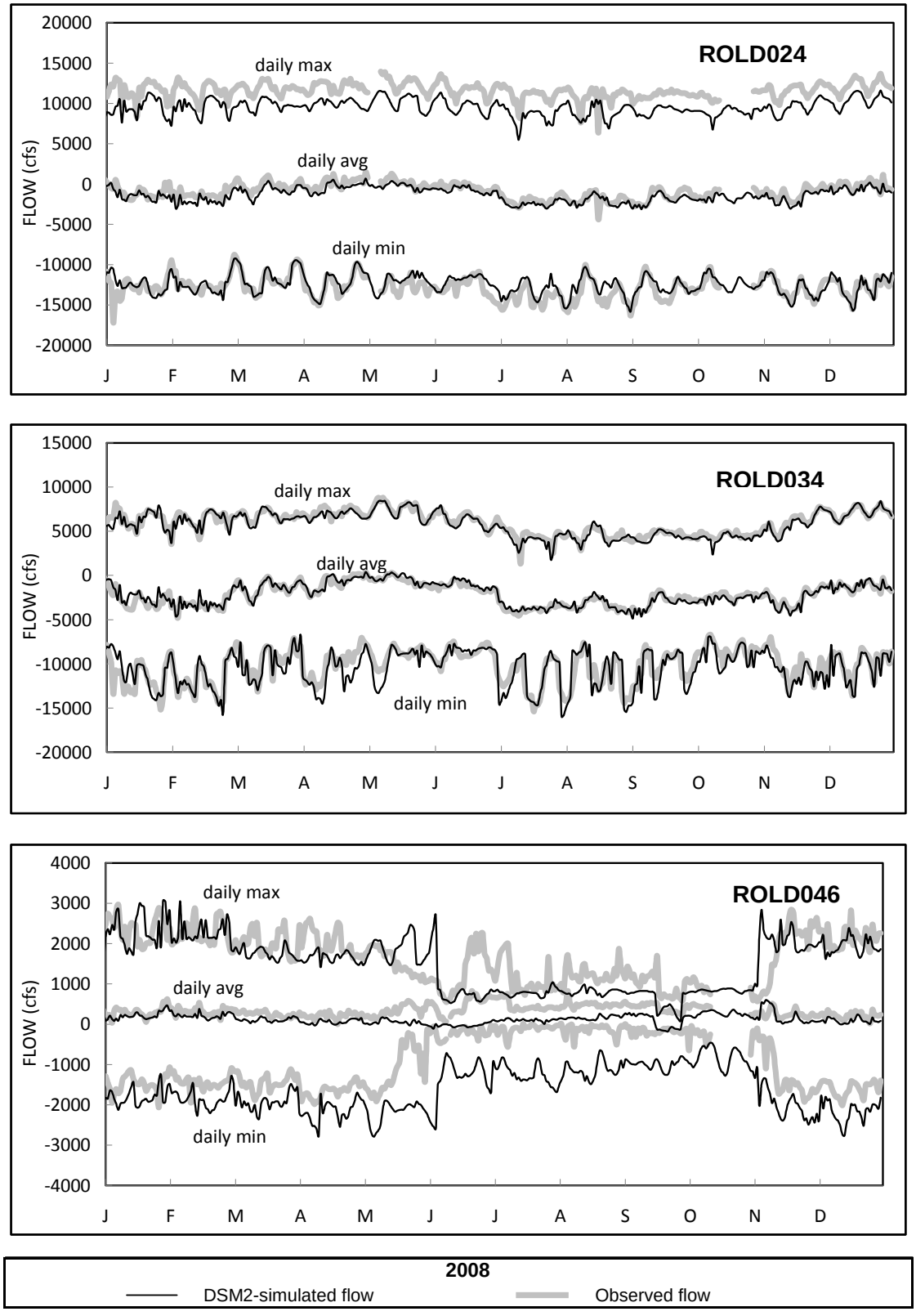

Figure 4-7 (cont.) Comparison of DSM2-simulated and measured daily flow, 2008

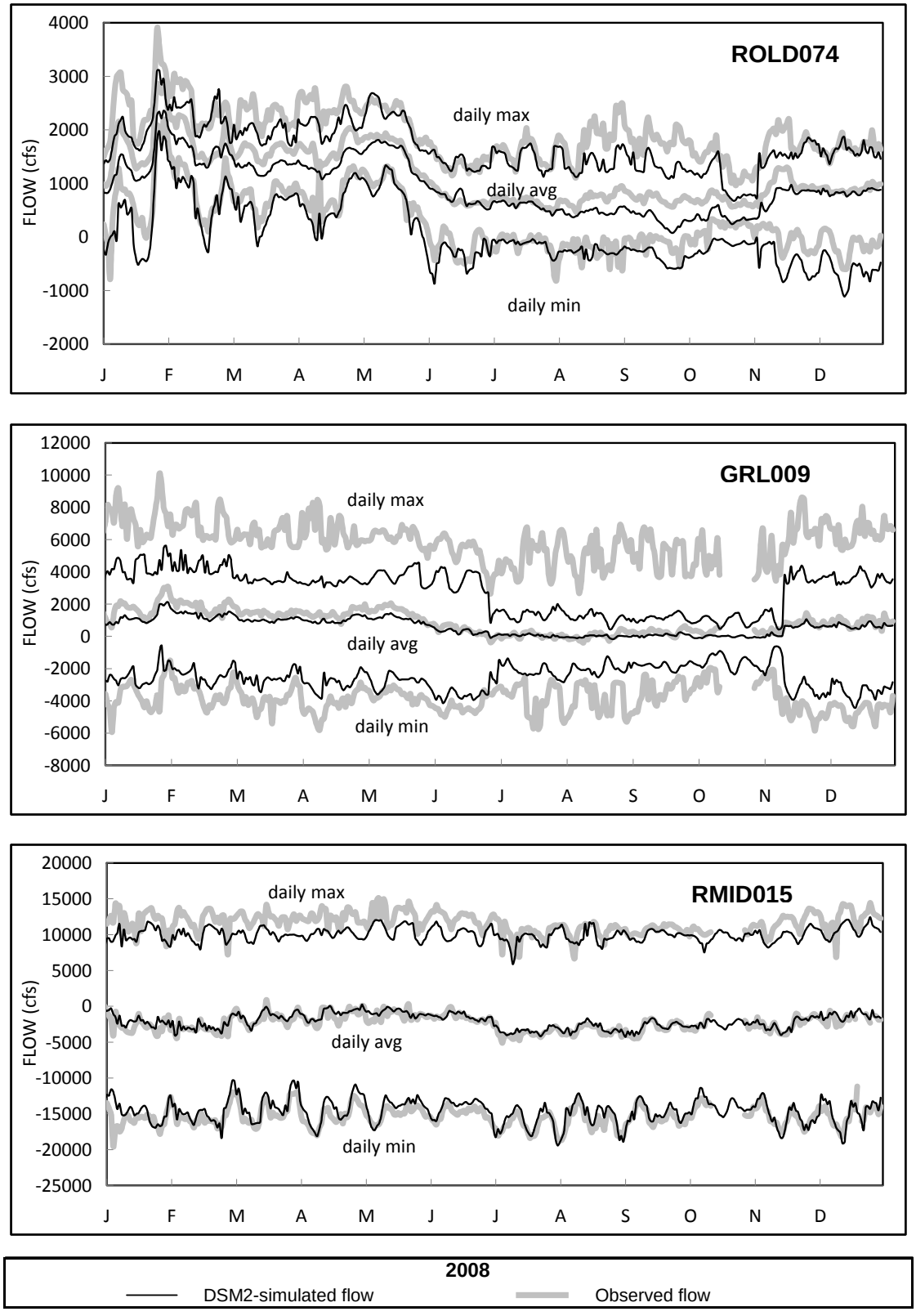

Figure 4-7 (cont.) Comparison of DSM2-simulated and measured daily flow, 2008

4.8 Effect of Temporary Barriers Installation and Operation on South Delta Hydrodynamics

In order to better process the 2008 Delta hydrodynamics, DSM2 simulation results were separated into 19 periods for which significant Delta inflows and exports were fairly constant and basic south Delta barrier configurations were unchanging. The 19 periods and their characteristics are shown in Table 4-2 below. The Delta hydrodynamics, as modeled by DSM2, are presented for each of the periods, excluding these periods when barriers were in the process of installation or removal: June 1-4, June 27-30, October 16, and November 1-11. 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. Therefore, the period of June 5 to 26 is presented as only Old River and Middle River barriers being installed.

Table 4-2 Characteristics of time intervals for presentation of simulation results, 2008

Period in 2008		Period Average Flows				Period Barrier Status			
		Sac R. + Yolo Bypass (cfs)	SJR (cfs)	DMC Pumping (cfs)	SWP Pumping (cfs)	MR	OR	GLC	ORH
JAN	1 - 5	11,159	1,351	1,302	1,441	--	--	--	--
	6 - 21	23,556	1,772	2,835	2,190	--	--	--	--
	22 - 31	25,604	3,138	3,235	2,906	--	--	--	--
FEB	1 - 4	47,854	3,176	4,174	3,971	--	--	--	--
	5 - 13	31,263	2,773	3,575	3,325	--	--	--	--
	14 - 29	22,263	2,274	2,827	3,448	--	--	--	--
MAR	1 - 31	14,710	2,179	1,813	1,594	--	--	--	--
APR	1 - 30	10,733	2,356	1,080	1,237	--	--	--	--
MAY	1 - 20	8,688	3,167	825	632	--	--	--	--
	21 - 31	11,088	2,023	999	1,073	IN	--	--	--
JUN	5 - 26	11812	984	884	756	IN	IN	--	--
JUL	1 - 31	13,216	903	3,406	2,127	IN	IN	IN	--
AUG	1 - 31	11,457	860	3,428	1,733	IN	IN	IN	--
SEP	1 - 30	10,976	812	3,942	1,052	IN	IN	IN	--
OCT	1 - 15	8,445	935	3,950	571	IN	IN	IN	--
	17 - 31	7,442	1,034	3,686	485	IN	IN	IN	IN
NOV	12 - 19	9,917	1,037	3,572	2,805	--	--	--	--
	20 - 30	8,028	1,173	1,992	1,777	--	--	--	--
DEC	1 - 31	8,785	1,193	1,314	1,315	--	--	--	--

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 4-8 with arrows indicating assumed positive flow direction.

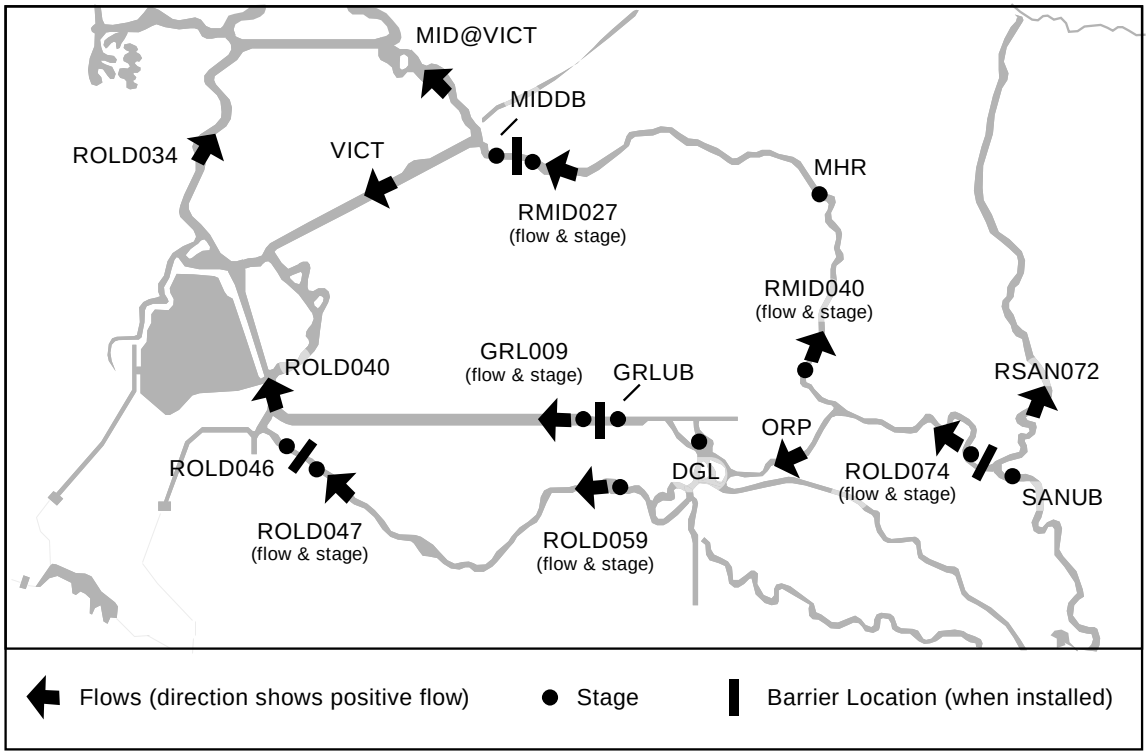

Figure 4-8 Locations where simulated Delta stages and flows for analysis of 2008 conditions are presented

Shown in Figures 4-9 and 4-10 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 analyze the effect of the installation of the barriers.

Figure 4-11 graphically presents the effects of the temporary barriers in 2008 on flow circulation and minimum water levels in the south Delta under the same time periods presented in Figures 4-9 and 4-10.

4.9 Discussion

The installation of the temporary barriers in 2008 significantly altered stages and flows in the south Delta. When the barrier in Middle River was installed in May, minimum water levels immediately upstream of the barrier were raised approximately a half-foot. This improvement decreased moving upstream until it essentially was eliminated at the junction of Old River. Thus, the effects on water levels due to the installation of the Middle River barrier alone were essentially limited to Middle River. The installation of the Old River barrier at the beginning of June in 2008 raised minimum water levels immediately upstream of the barrier approximately a half-foot, an effect which decreased farther upstream. The Old River barrier had little effect on water levels in Middle River or Grant Line Canal. For the period of June 5 to June 26, 2008, only the barriers at Middle River and Old River were fully 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 modestly altered by the

2 barriers since the flow split from the San Joaquin River down the head of Old River and the subsequent flow down Grant Line Canal weren't strongly affected.

The complete installation of the Grant Line Canal barrier in the beginning of July raised the minimum water level in Grant Line Canal upstream of the barrier approximately 1-½ feet and levels in Middle River and Old River an additional 1 foot and a half-foot, respectively. Also, circulation patterns were 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 more going down Old River. Thus, the full impact on minimum water levels and changed flow patterns 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.

The installation of the notched barrier at the head of Old River in October significantly further reduced the amount of San Joaquin River flowing down Old River and Grant Line Canal.

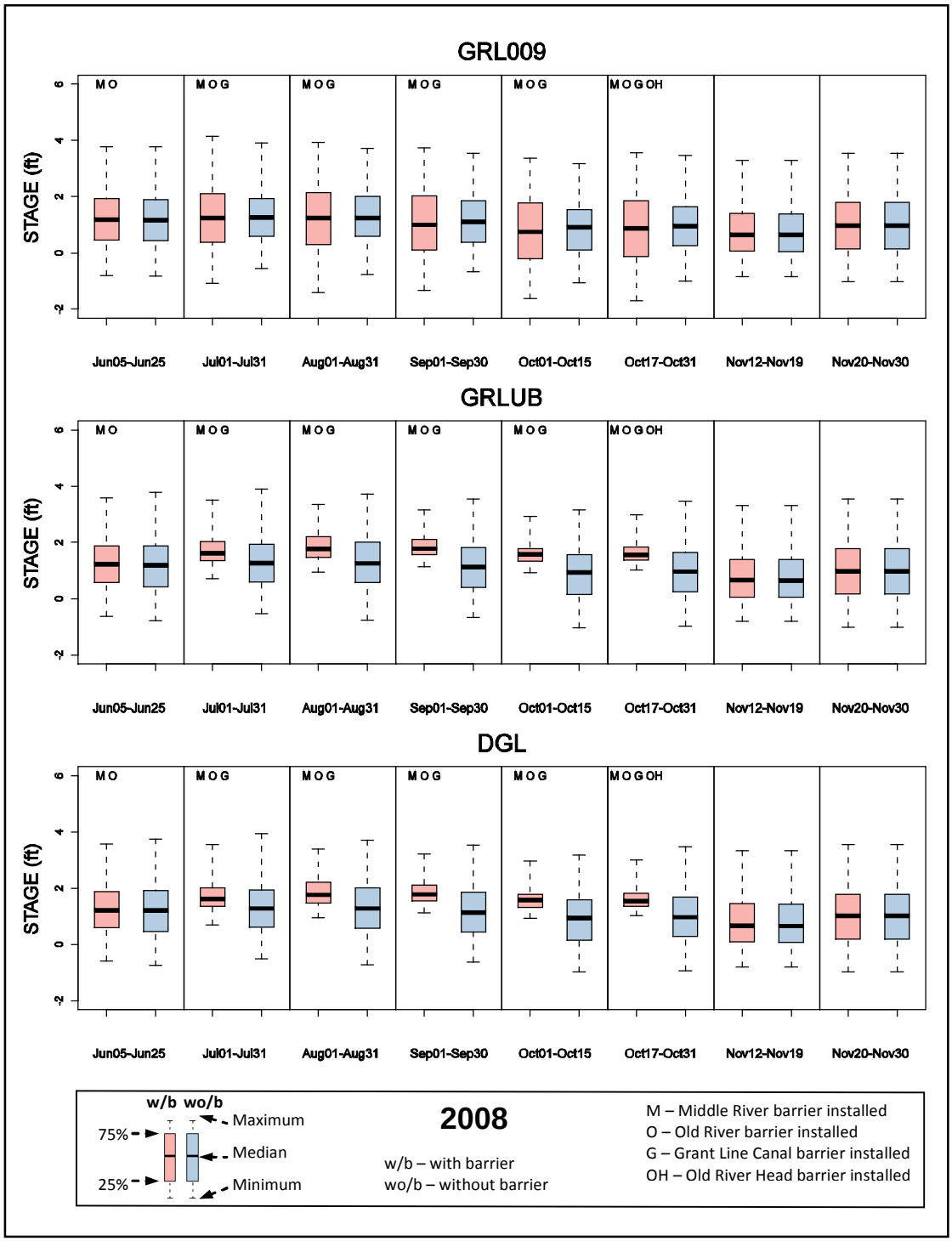

Figure 4-9 Distribution of DSM2-simulated stages for historical 2008 with and without temporary barriers installed

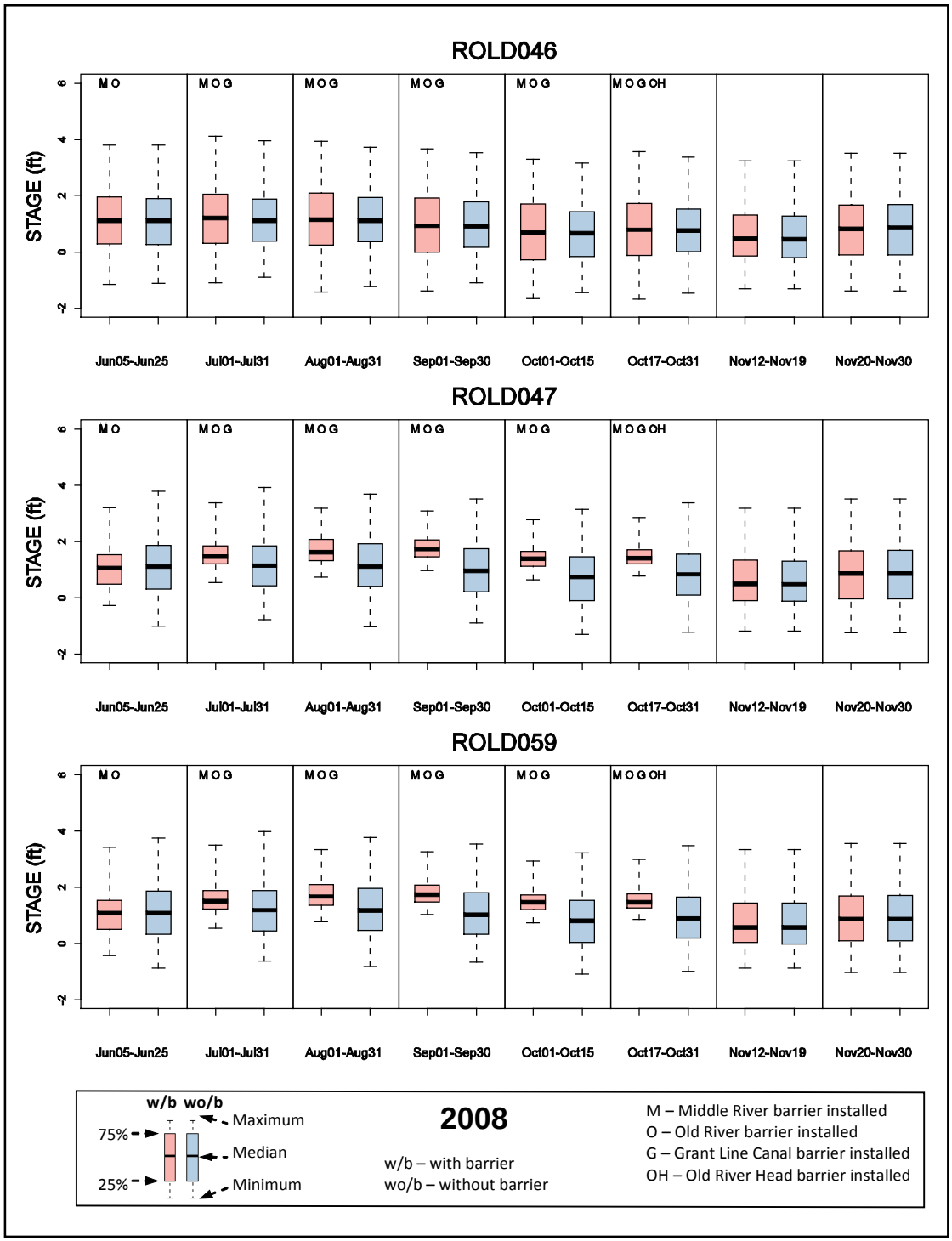

Figure 4-9 (cont.) Distribution of DSM2-simulated stages for historical 2008 conditions with and without temporary barriers installed

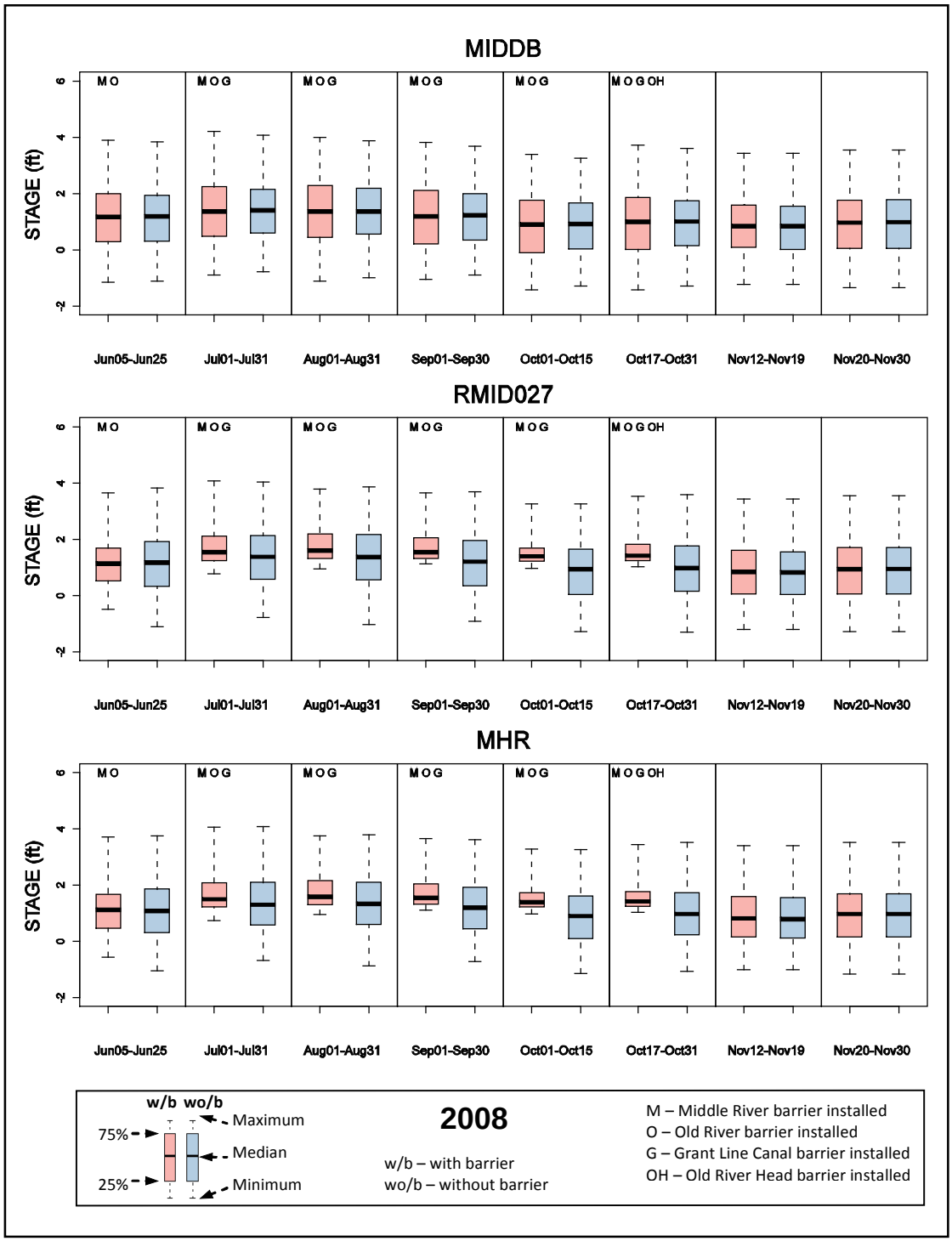

Figure 4-9 (cont.) Distribution of DSM2-simulated stages for historical 2008 conditions with and without temporary barriers installed

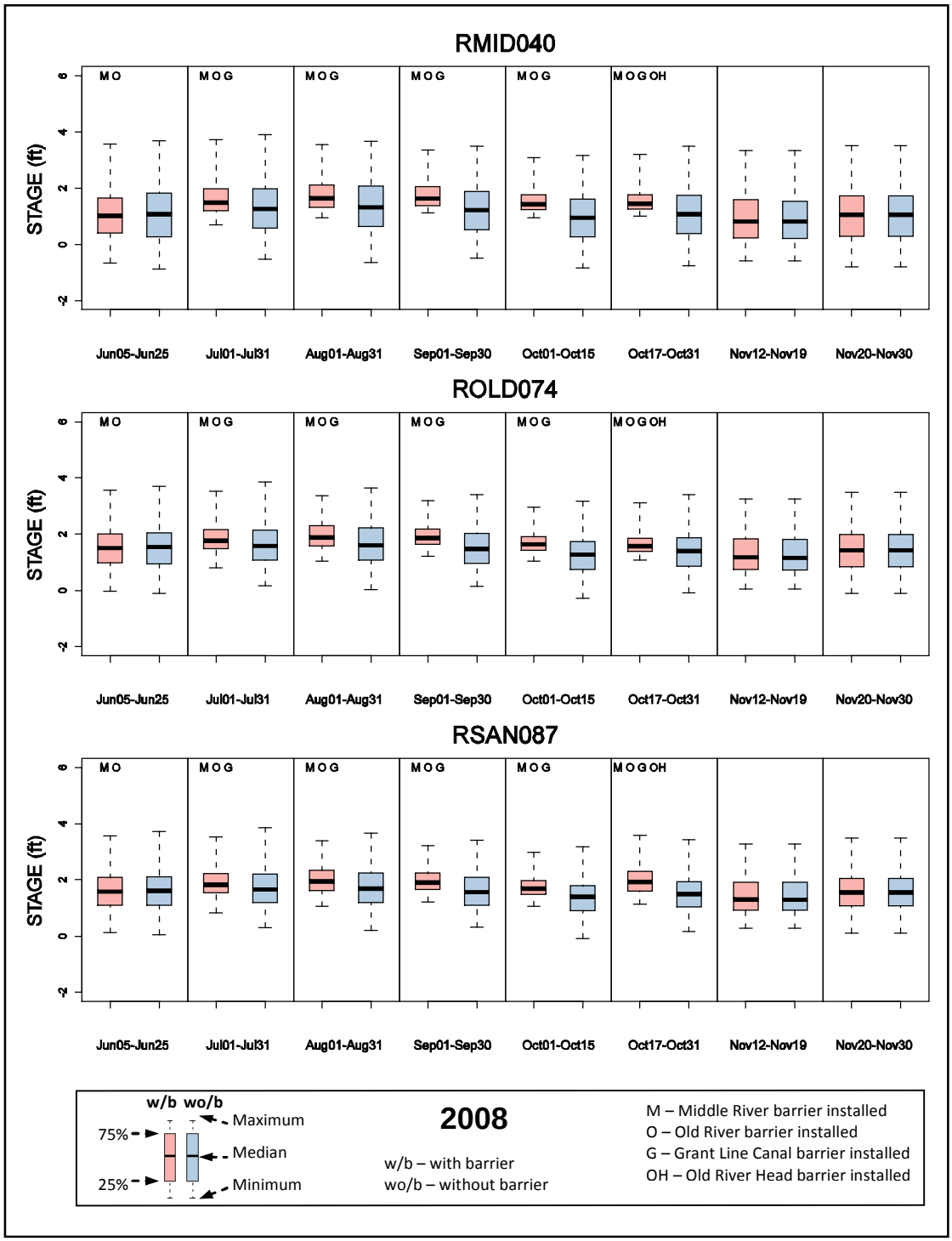

Figure 4-9 (cont.) Distribution of DSM2-simulated stages for historical 2008 conditions with and without temporary barriers installed

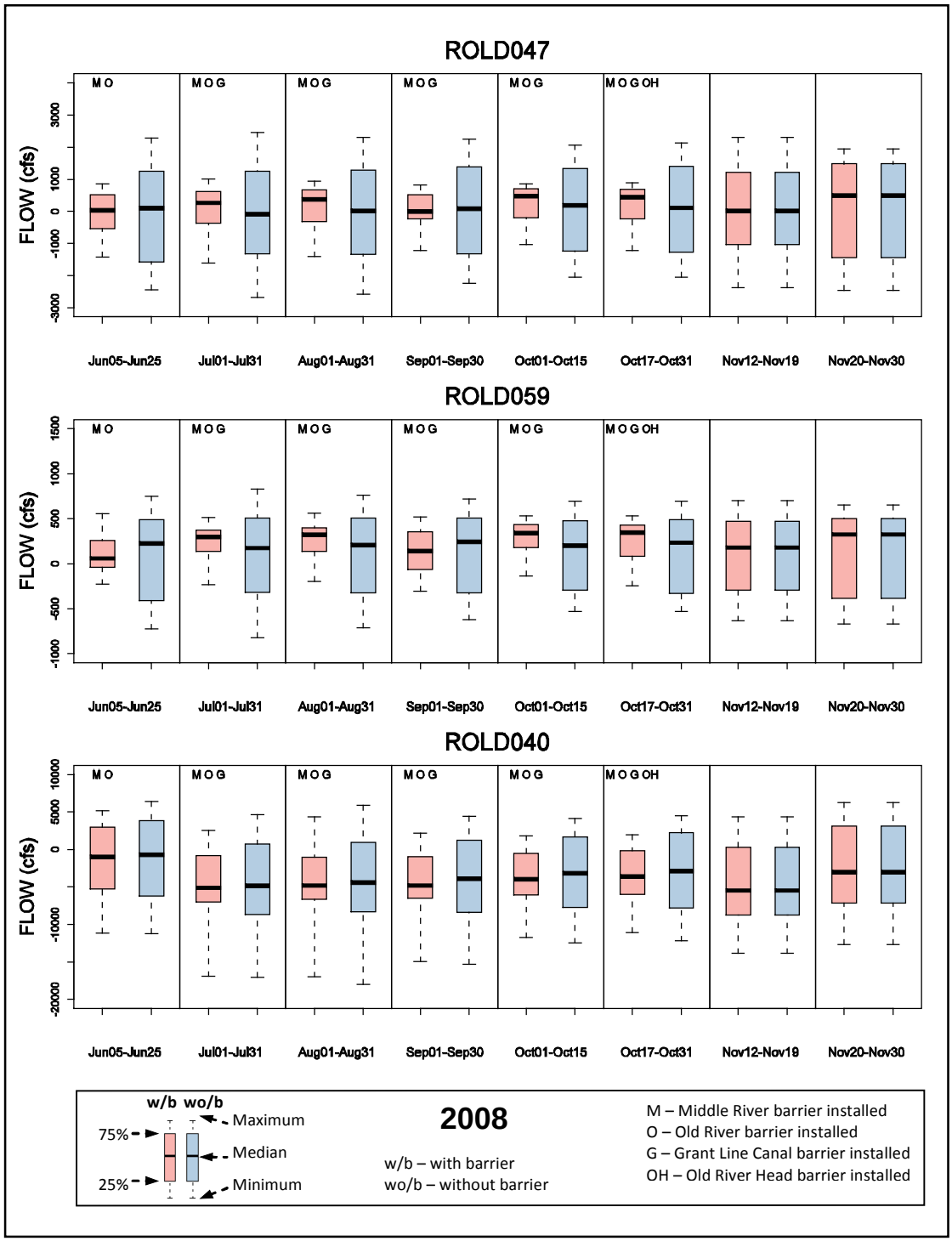

Figure 4-10 Distribution of DSM2-simulated flows for historical 2008 conditions with and without temporary barriers installed

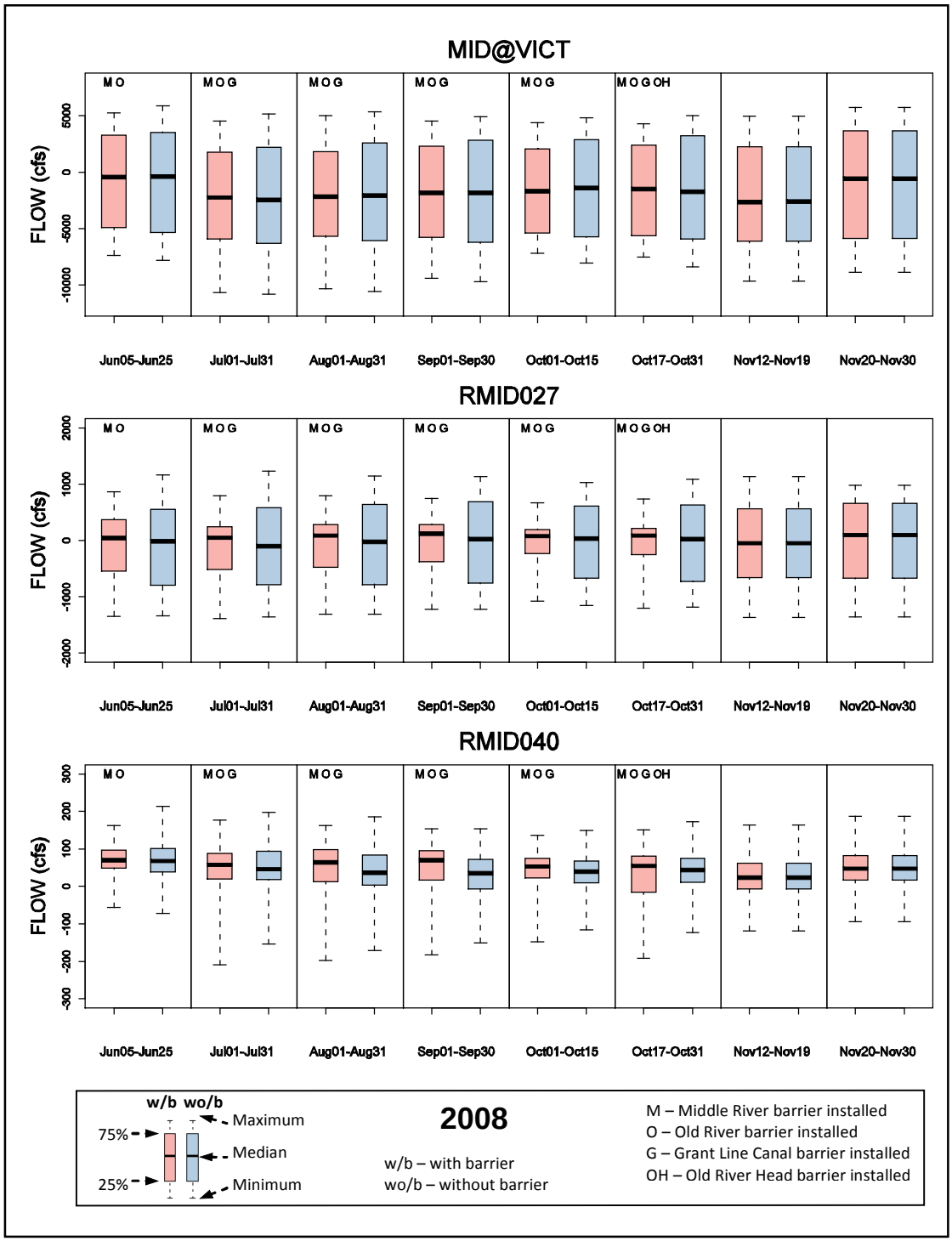

Figure 4-10 (cont.) Distribution of DSM2-simulated flows for historical 2008 conditions with and without temporary barriers installed

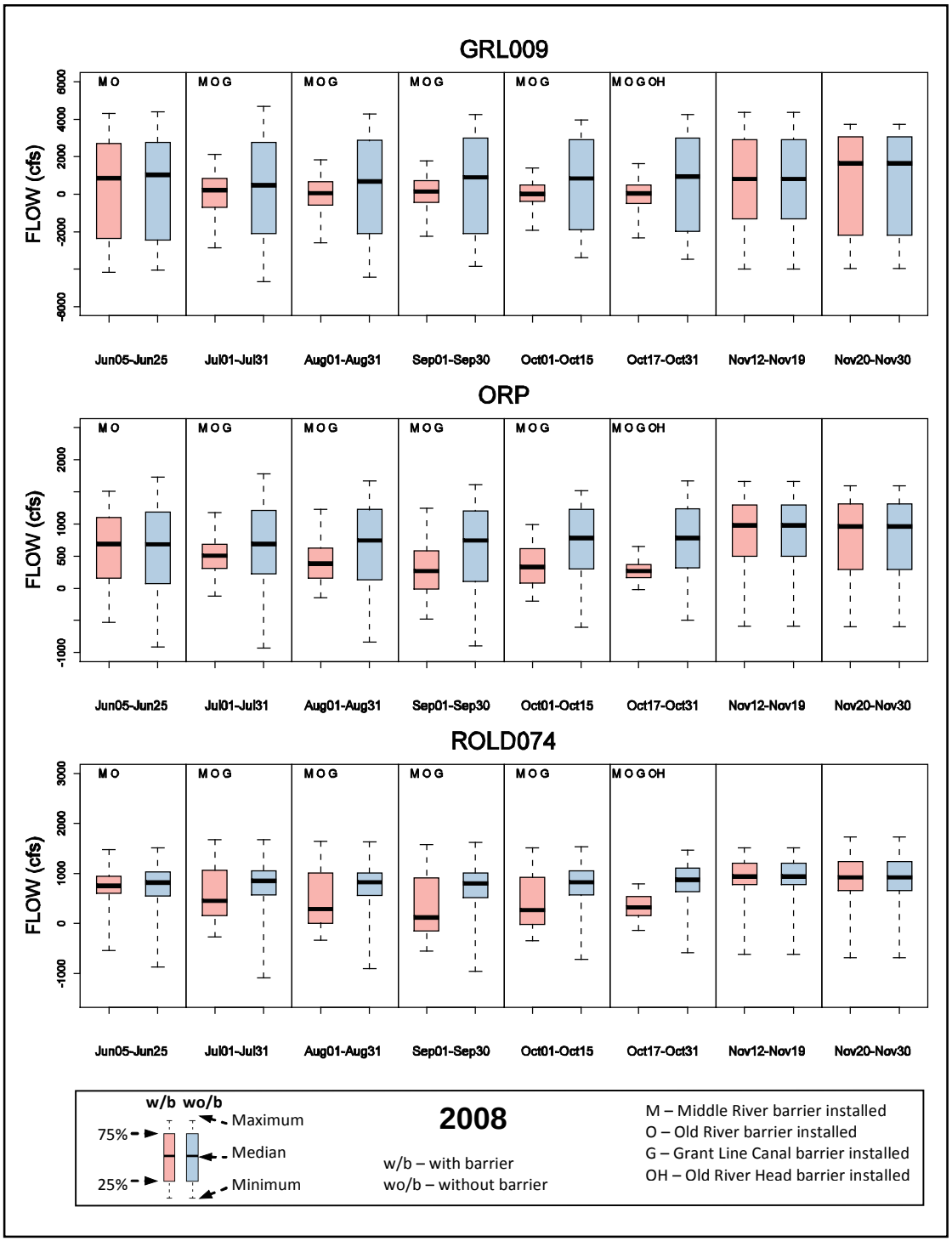

Figure 4-10 (cont.) Distribution of DSM2-simulated flows for historical 2008 conditions with and without temporary barriers installed

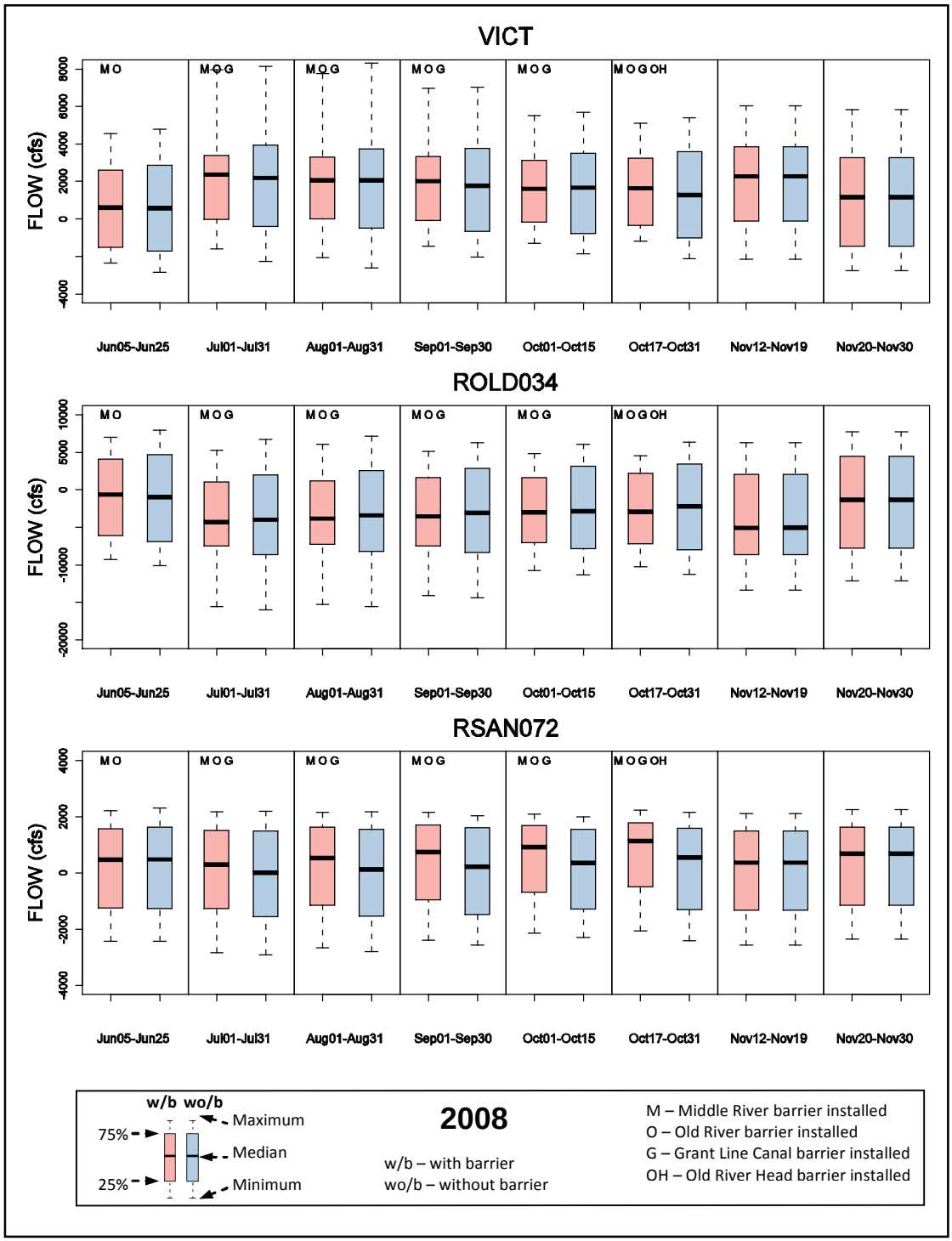

Figure 4-10 (cont.) Distribution of DSM2-simulated flows for historical 2008 conditions with and without temporary barriers installed

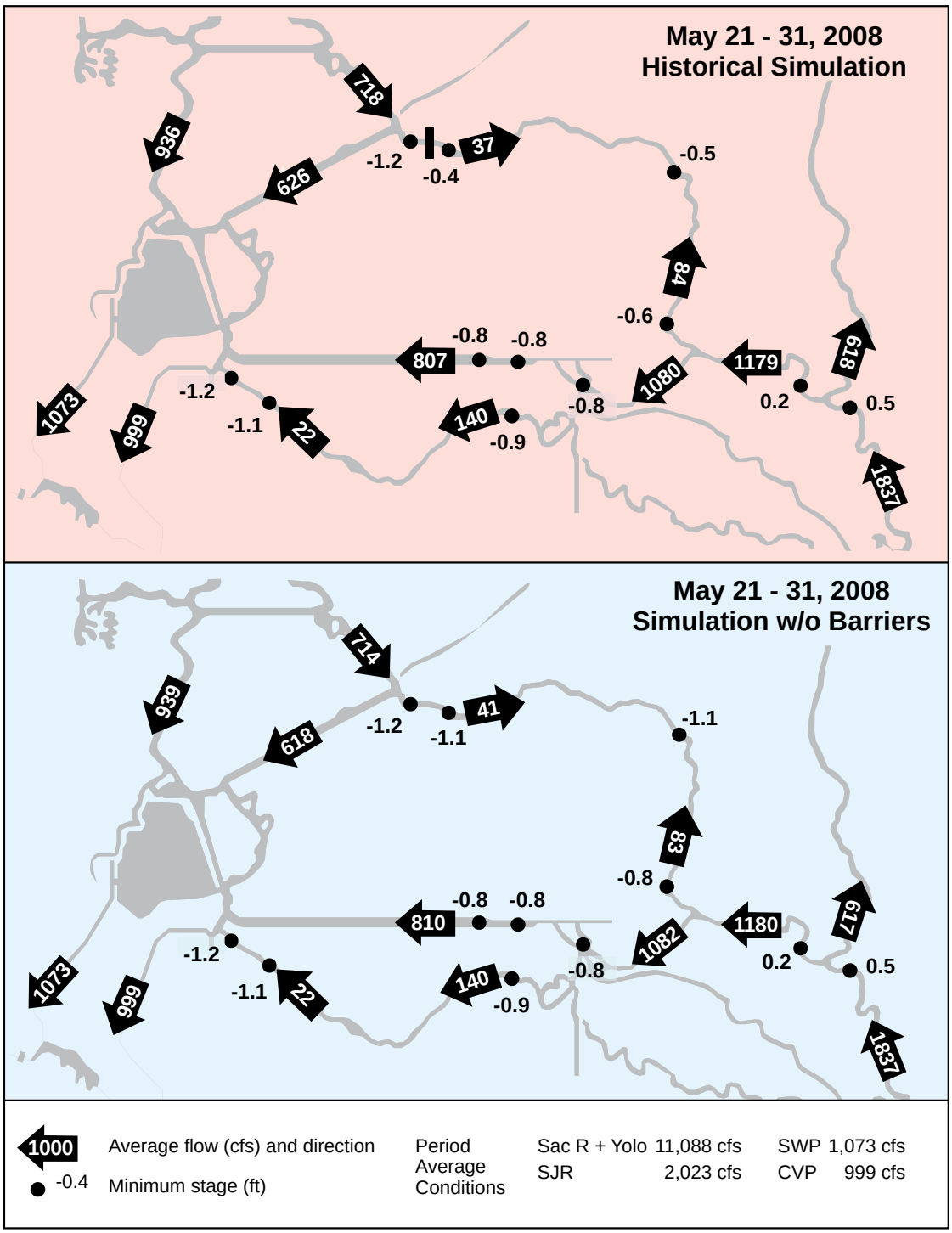

Figure 4-11 Simulated period-average flow and minimum stage for 2008 conditions with historical barrier configuration and no-barriers condition

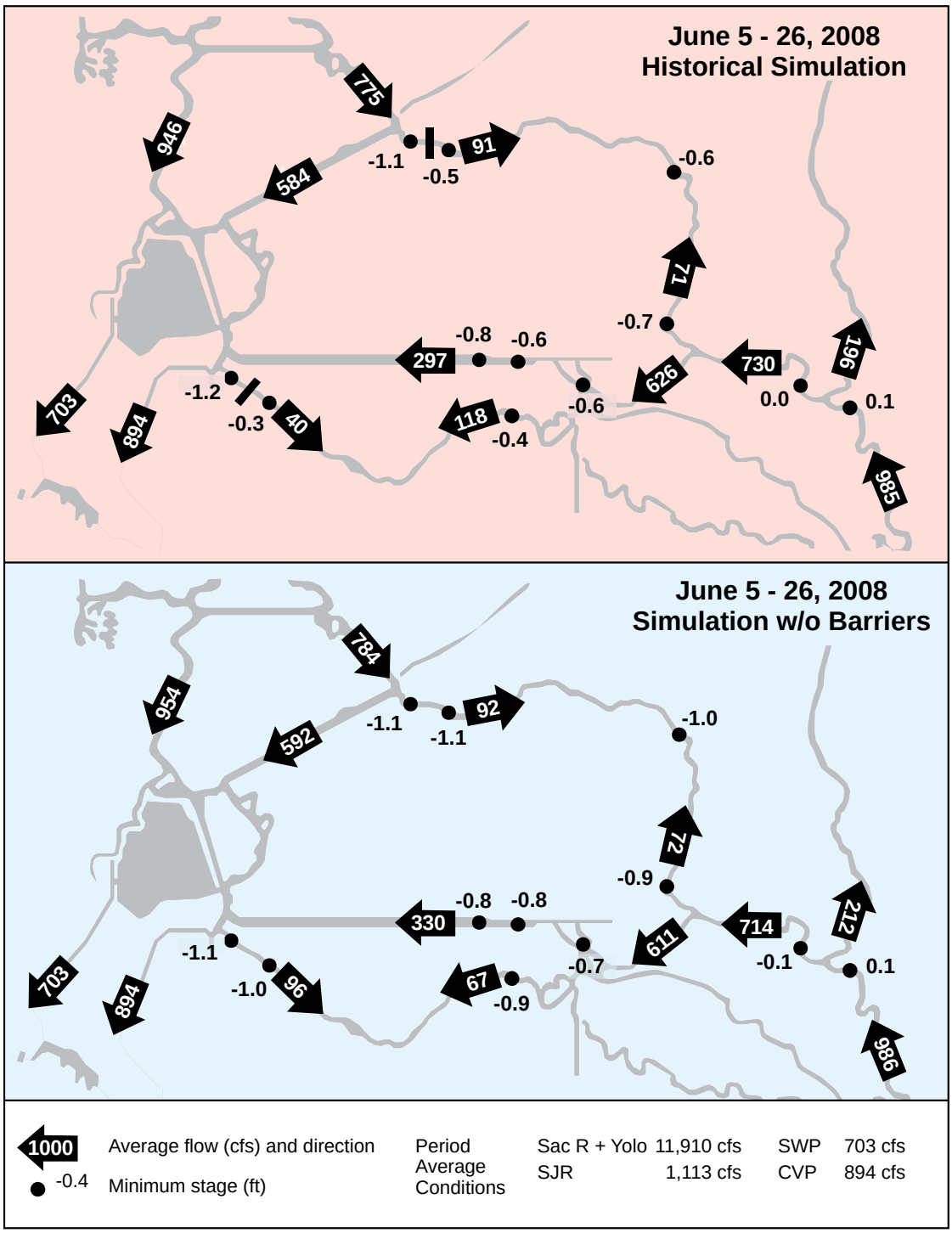

Figure 4-11 (cont.) Simulated period-average flow and minimum stage for 2008 conditions with historical barrier configuration and no-barriers condition

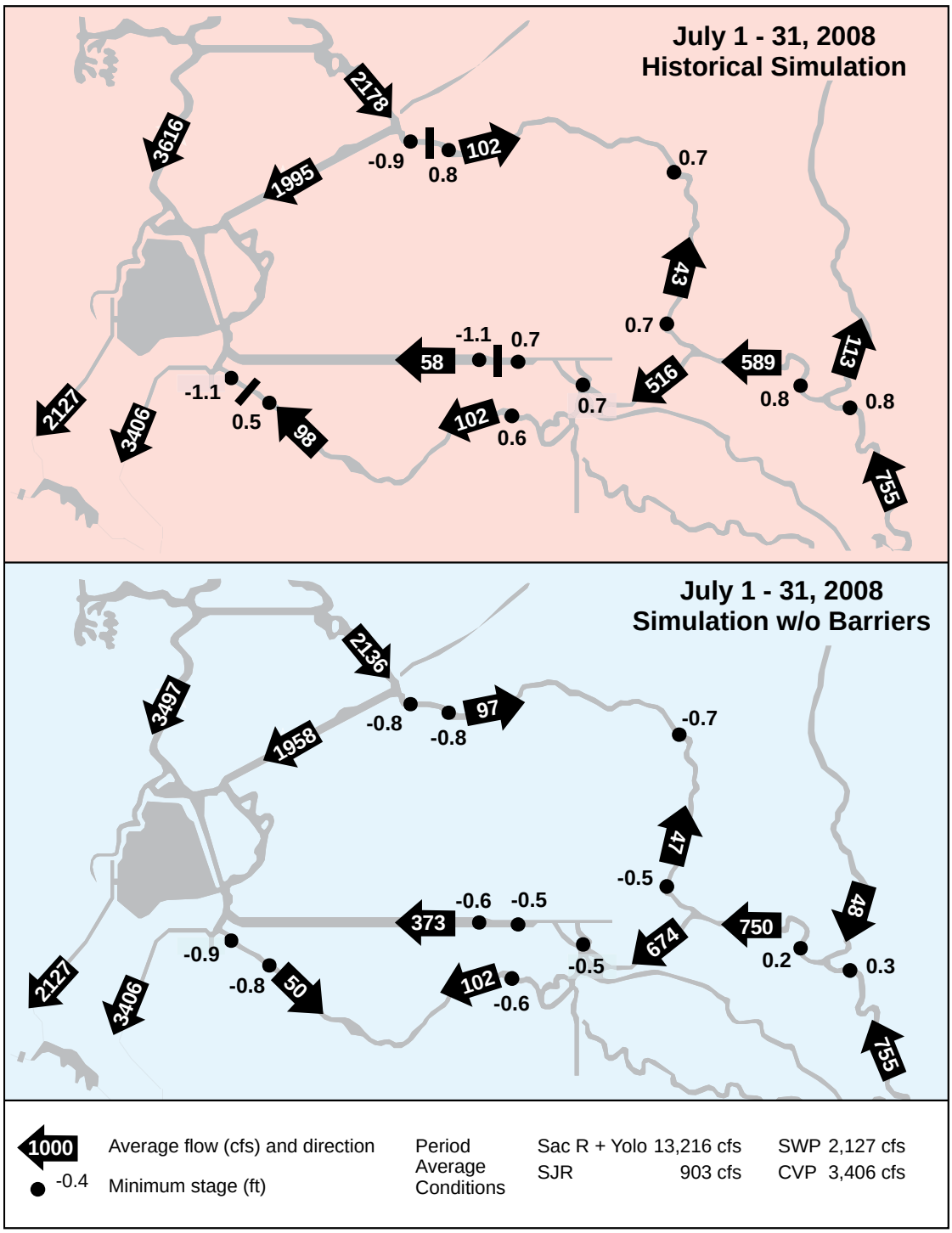

Figure 4-11 (cont.) Simulated period-average flow and minimum stage for 2008 conditions with historical barrier configuration and no-barriers condition

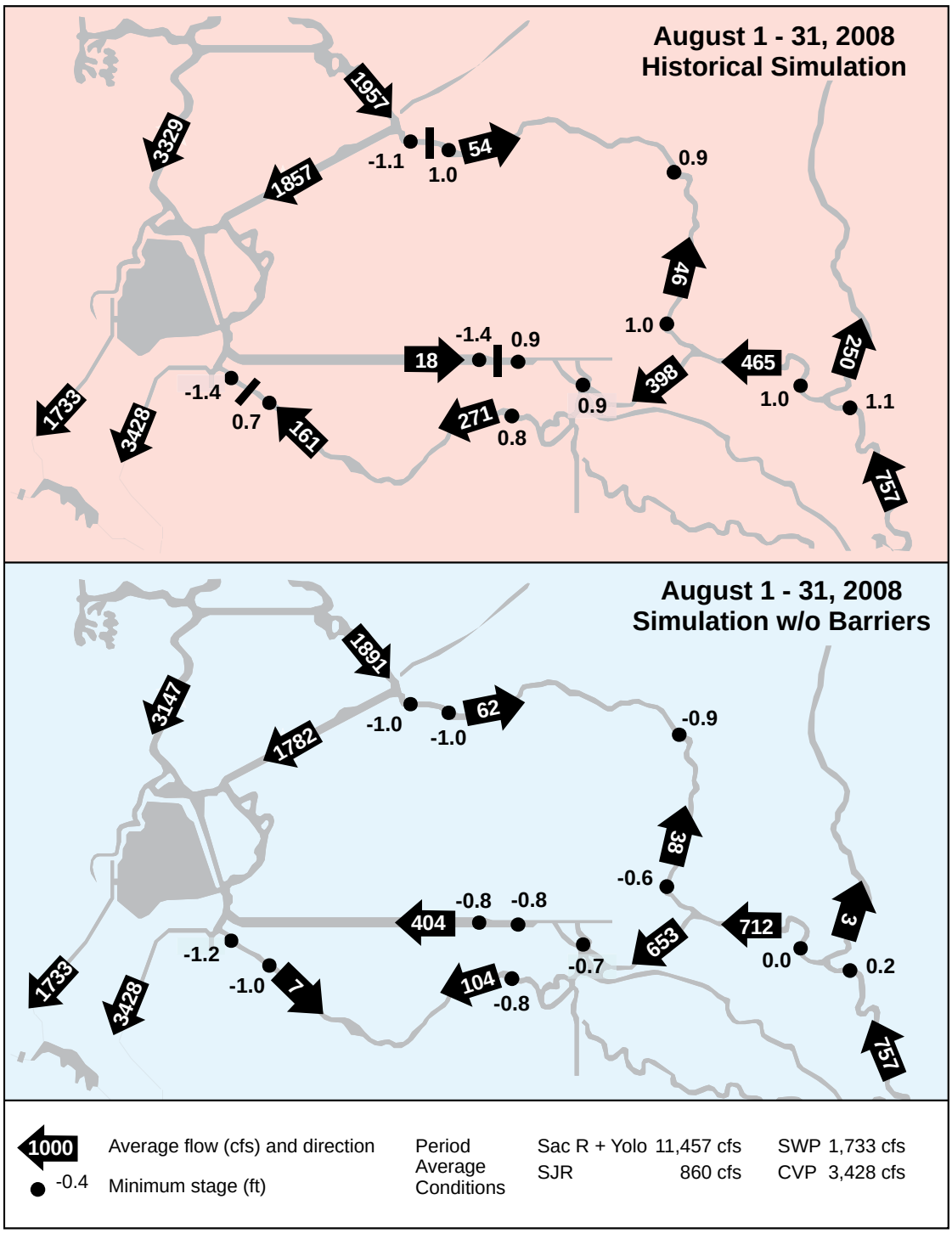

Figure 4-11 (cont.) Simulated period-average flow and minimum stage for 2008 conditions with historical barrier configuration and no-barriers condition

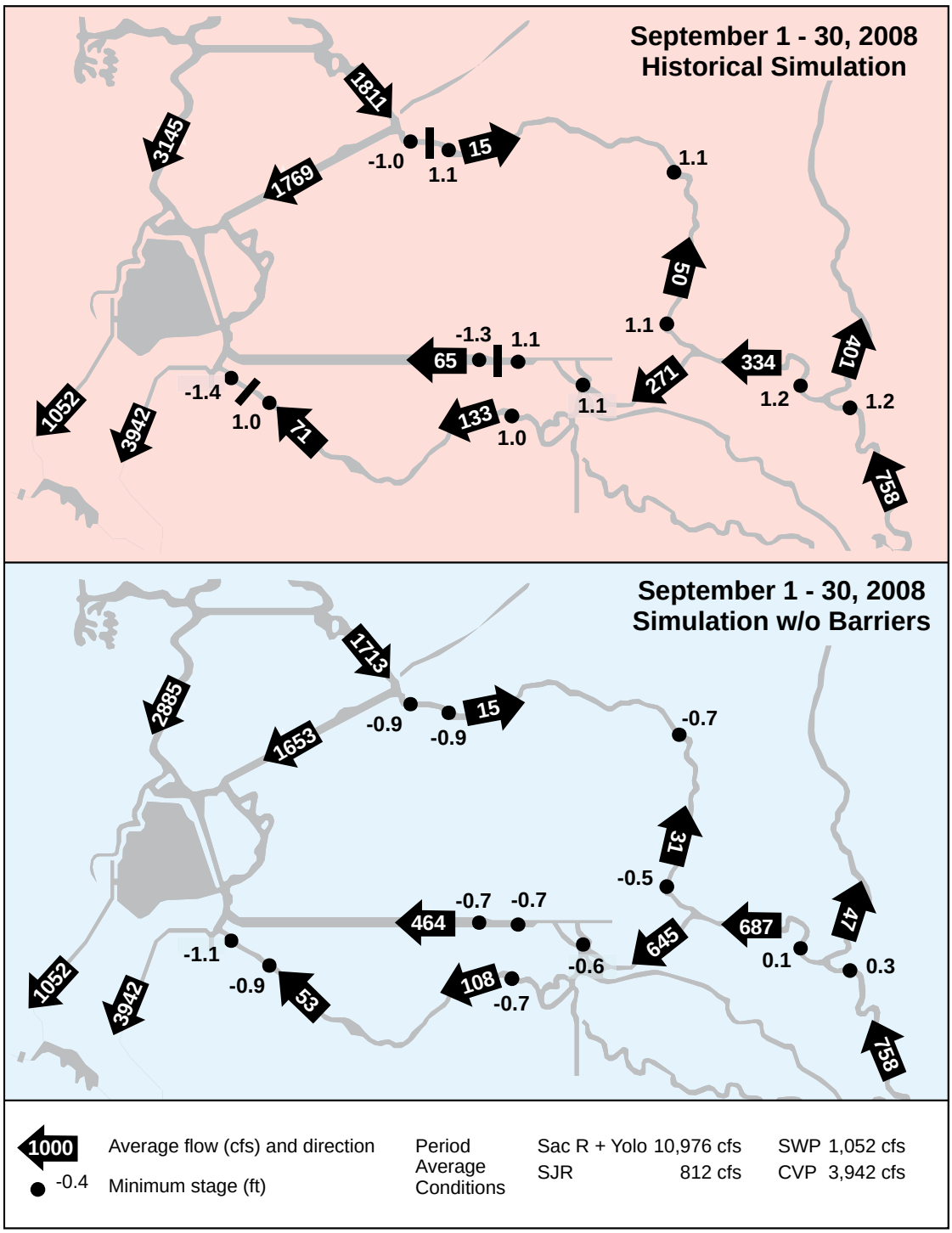

Figure 4-11 (cont.) Simulated period-average flow and minimum stage for 2008 conditions with historical barrier configuration and no-barriers condition

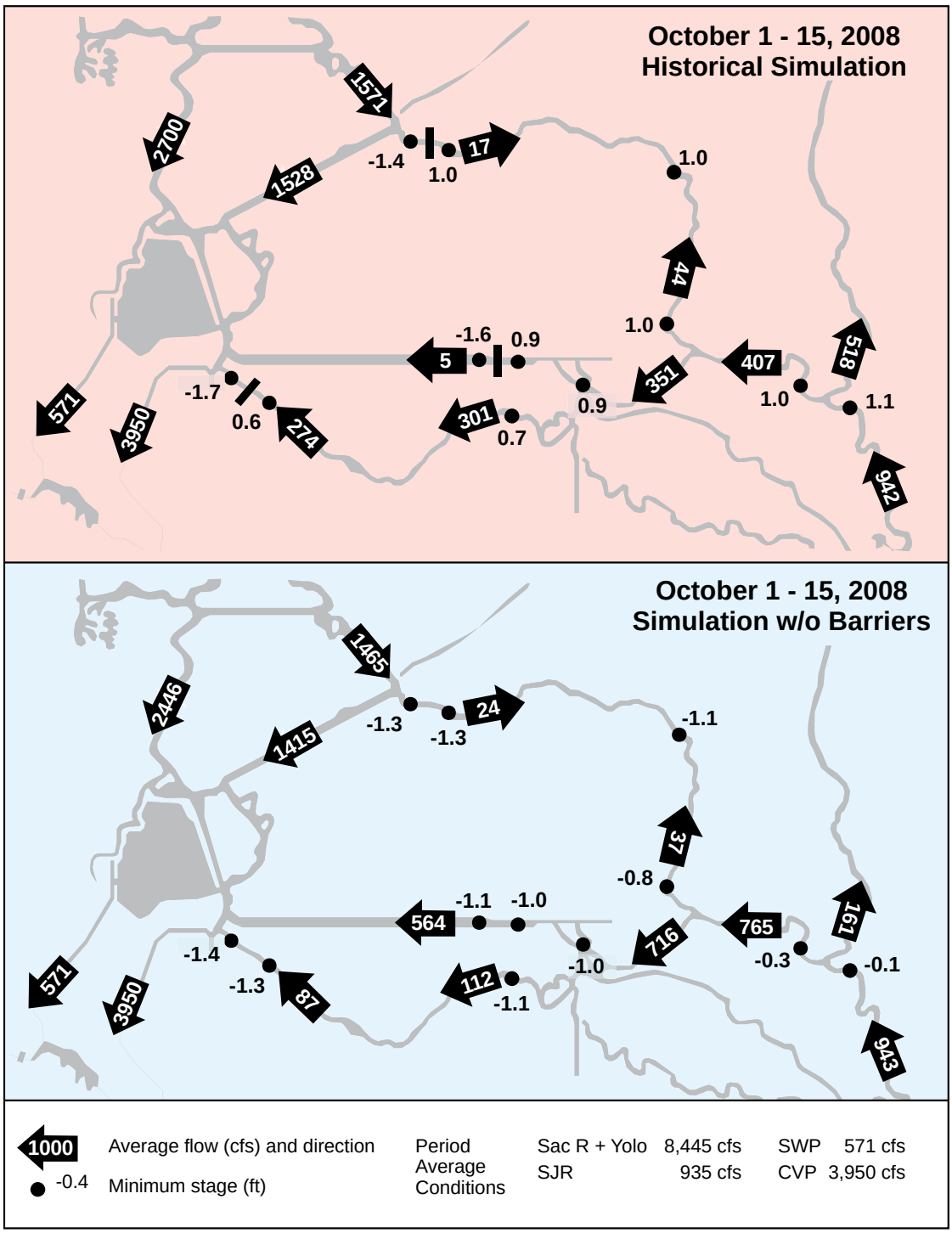

Figure 4-11 (cont.) Simulated period-average flow and minimum stage for 2008 conditions with historical barrier configuration and no-barriers condition

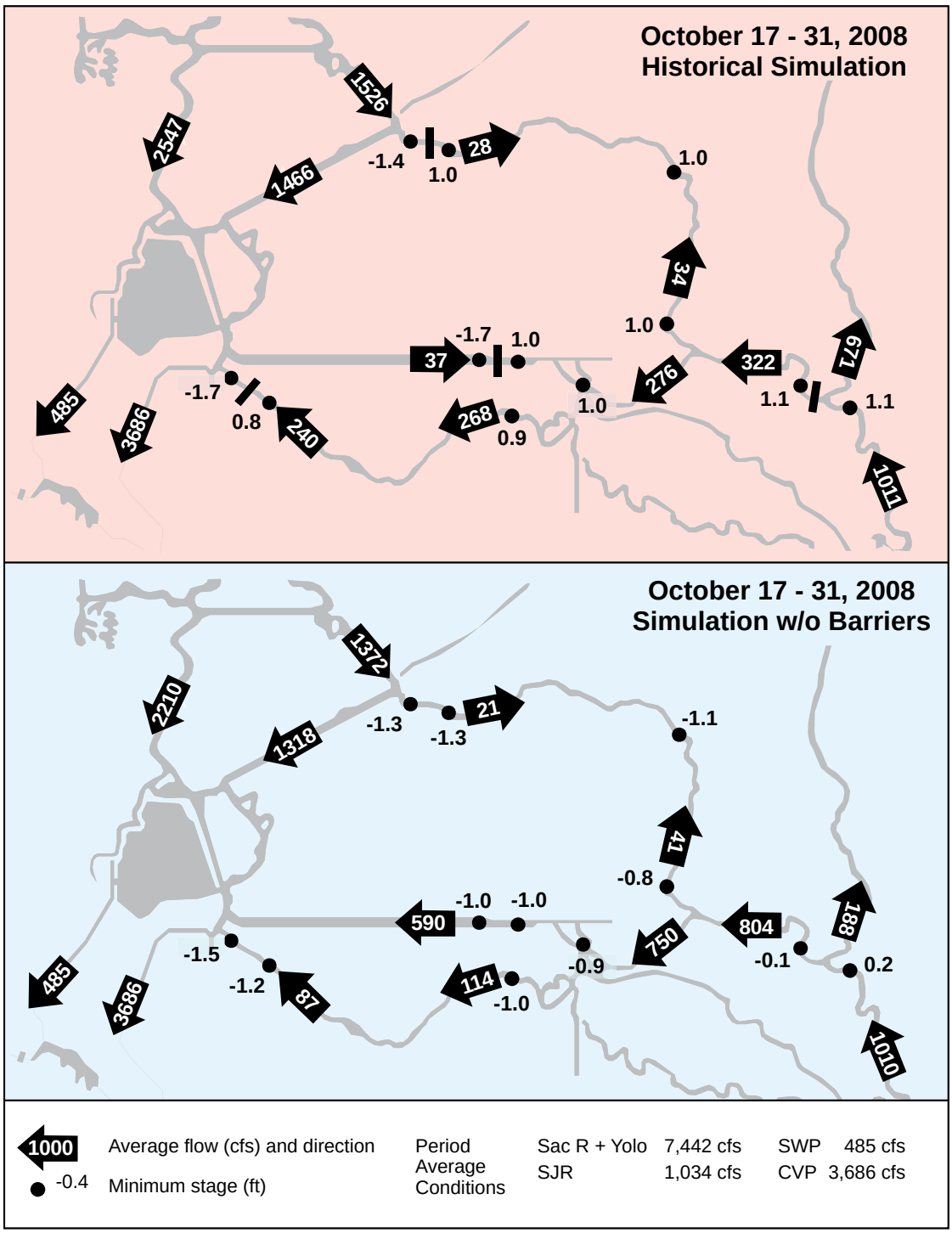

Figure 4-11 (cont.) Simulated period-average flow and minimum stage for 2008 conditions with historical barrier configuration and no-barriers condition