Appendix C

Validation of the DSM2 simulation of historical 2011 Delta hydrodynamics

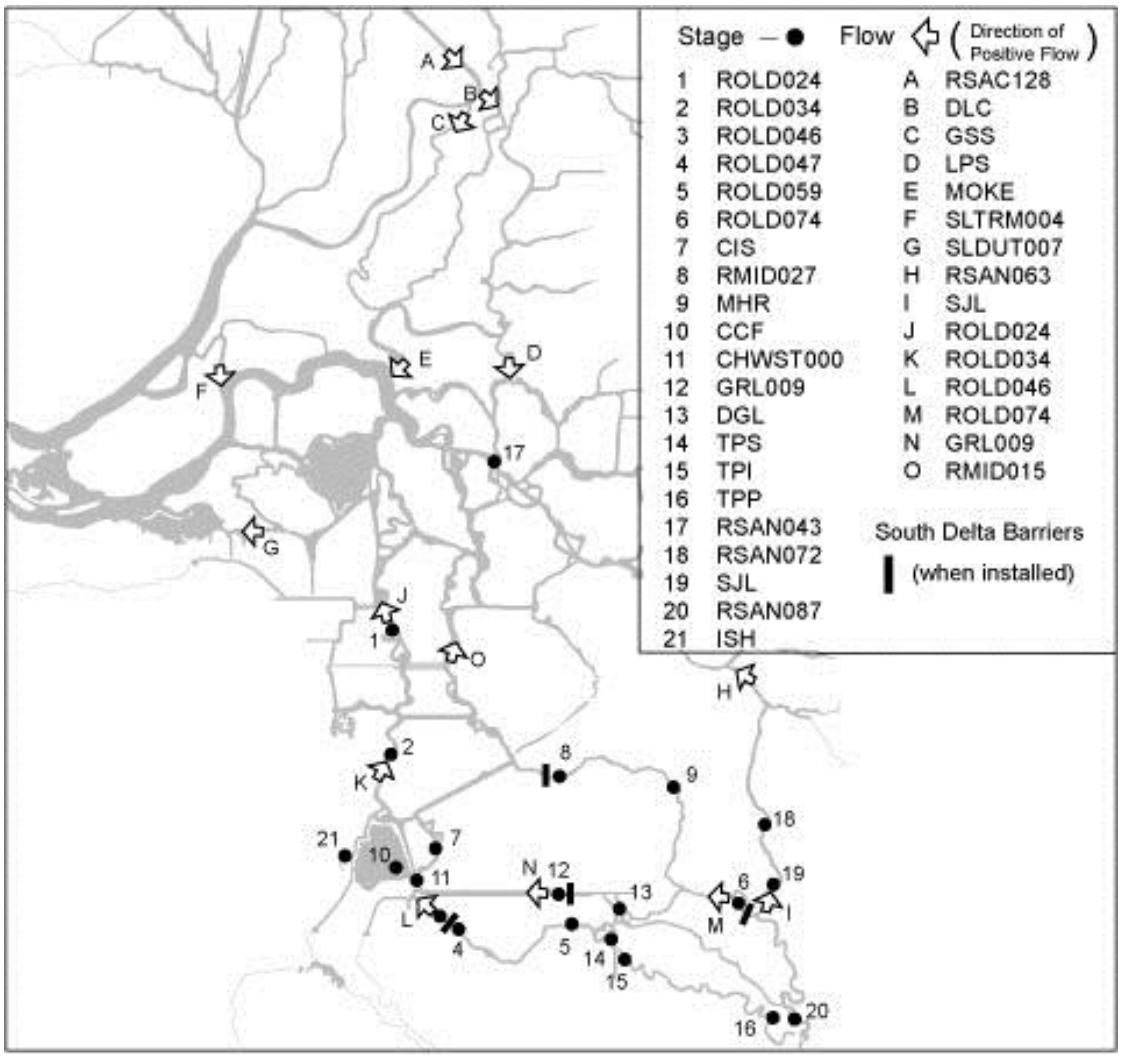
Validation of the DSM2 simulation of historical 2011 Delta hydrodynamics consists of two types of comparisons. First, simulated daily extremes in water level and flow and average flow are compared to observed values. Due to ocean tides, most locations in the Delta, including the south Delta, experience two intervals each day of upstream and downstream flow as well as two distinct high stages and low stages. Comparing the daily range in flow and water levels as well as the daily average flow provides a simple check on whether the model simulation captures the tide-driven movement of Delta waters.

A second way of validating the model simulation is to compare model results and observed data which have been processed in a manner consistent with the analysis in the study, which for this report consists of box and whisker plots of 15-minute flow and stage and schematics showing average flow and minimum stages for discrete periods of time.

Daily extremes in stage and flow and daily average flow

Stage and flow results of the DSM2 simulation of historical Delta hydrodynamics were compared to available observed data throughout the Delta while focusing on the south Delta (Figure C-1). Figure C-2 presents observed and simulated daily minimum and maximum stage and Figure C-3 presents observed and simulated daily minimum, maximum, and average flow.

Figure C-1. Locations where DSM2-simulated and measured stages and flows are presented, 2011.



As shown in Figure C-2, the DSM2 simulation reproduces the observed effect the temporary agriculture barriers have on upstream minimum water levels (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 variance from observed water levels at these locations has been noted before and appear to occur for most all DSM2 historical simulations.

Figure C-2. Comparison of DSM2-simulated and observed daily stage, 2011.

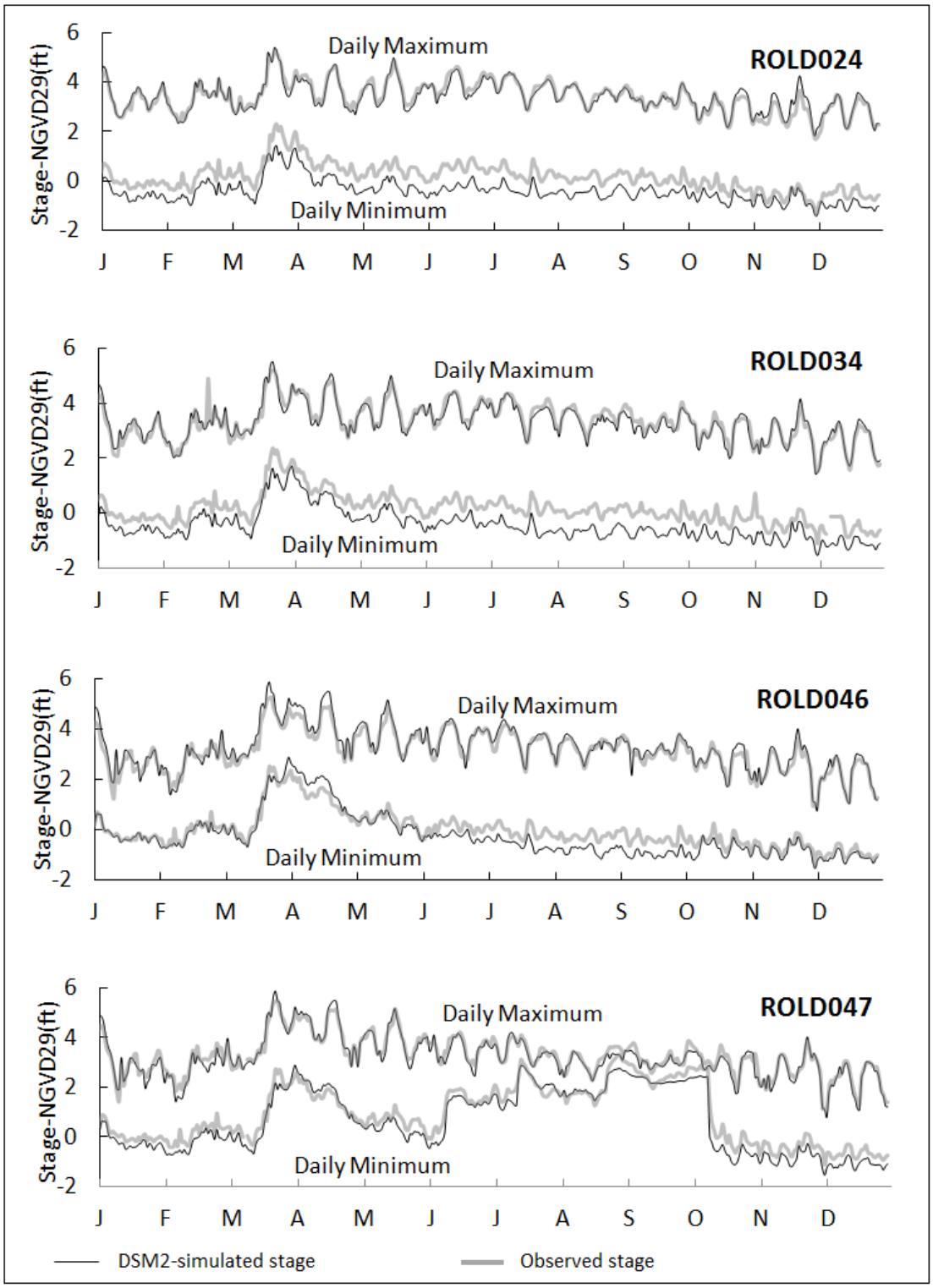


Figure C-2 (cont). Comparison of DSM2-simulated and observed daily stage, 2011.

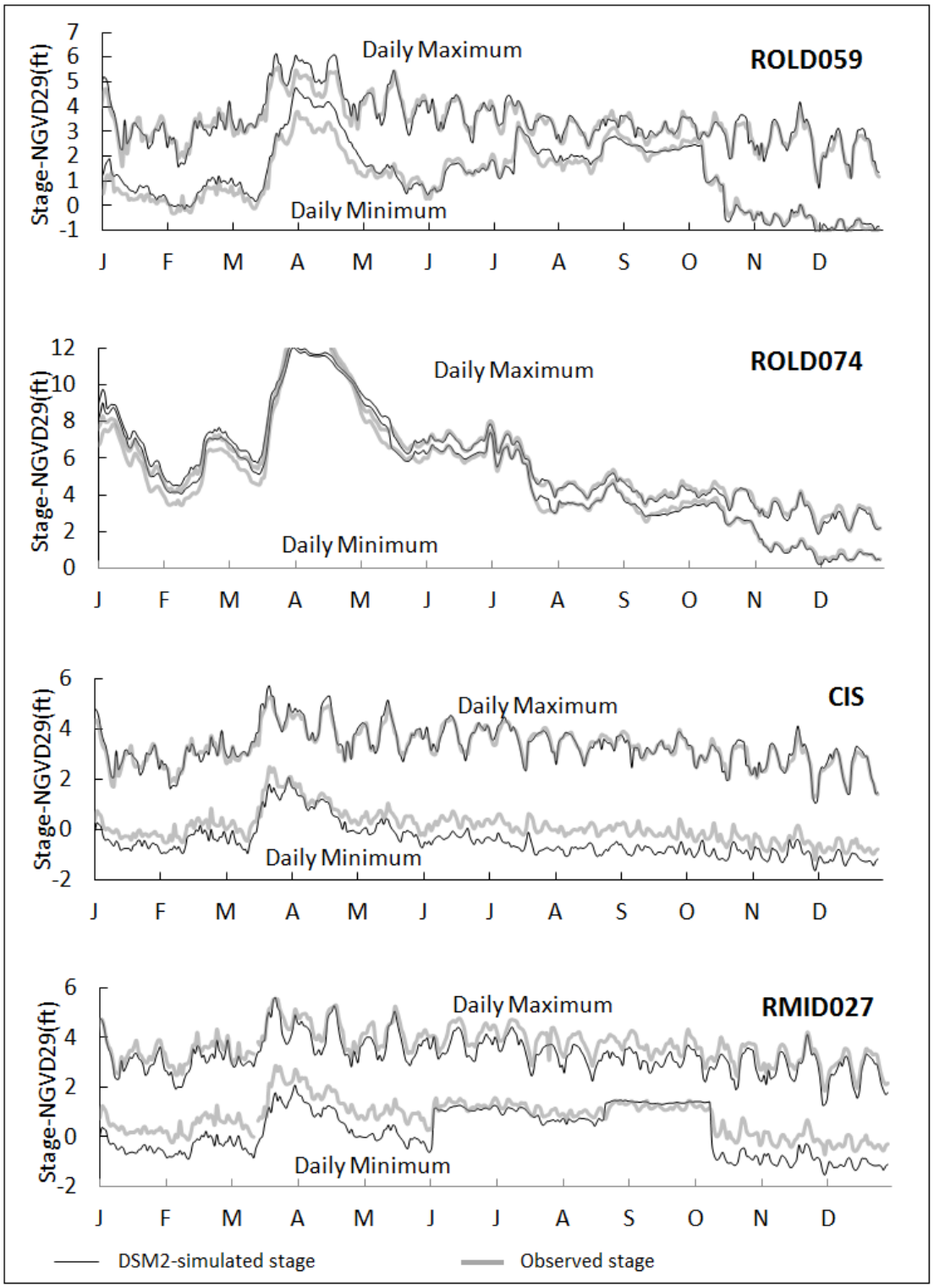


Figure C-2 (cont). Comparison of DSM2-simulated and observed daily stage, 2011.

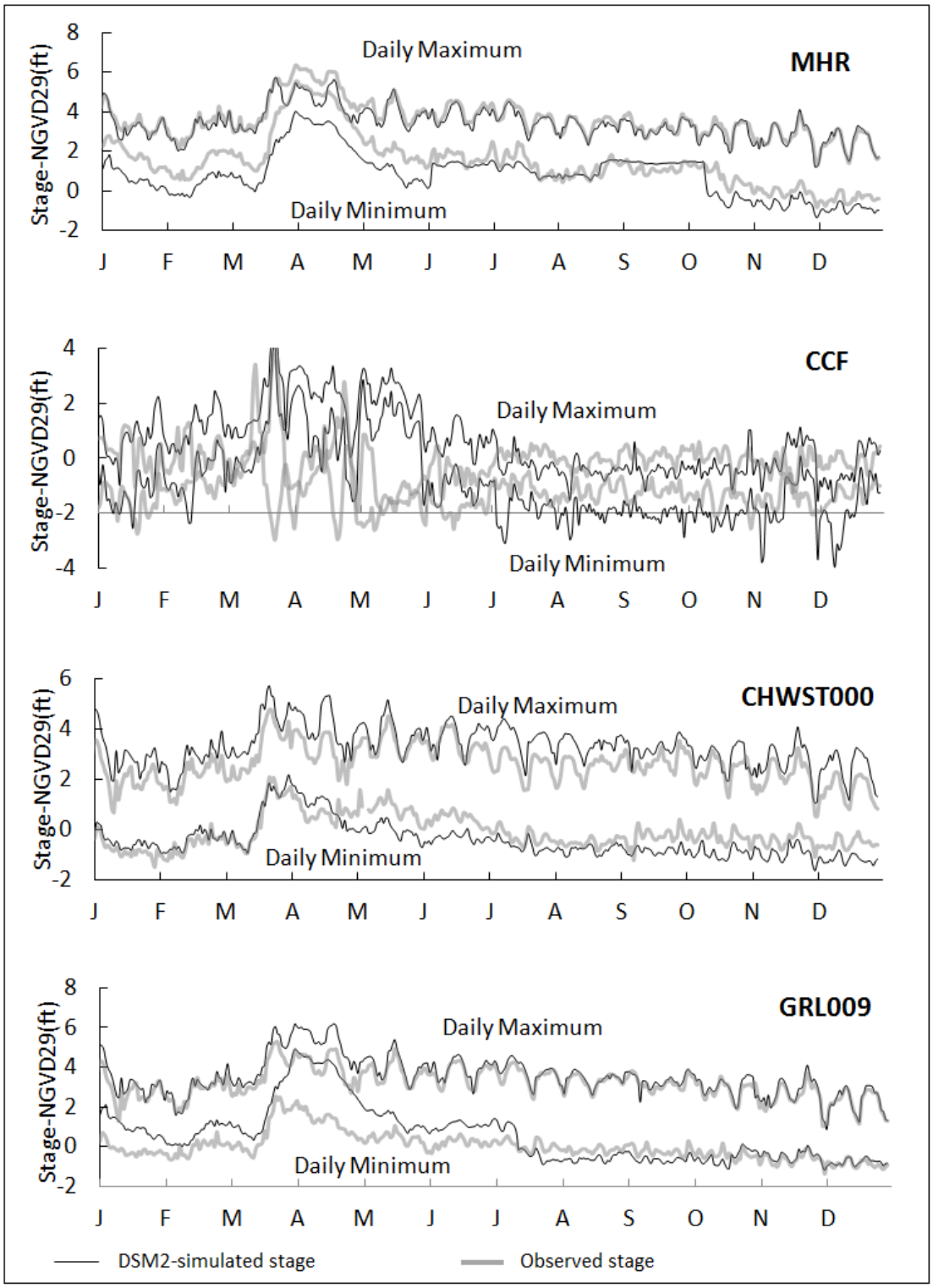


Figure C-2 (cont). Comparison of DSM2-simulated and measured daily stage, 2011.

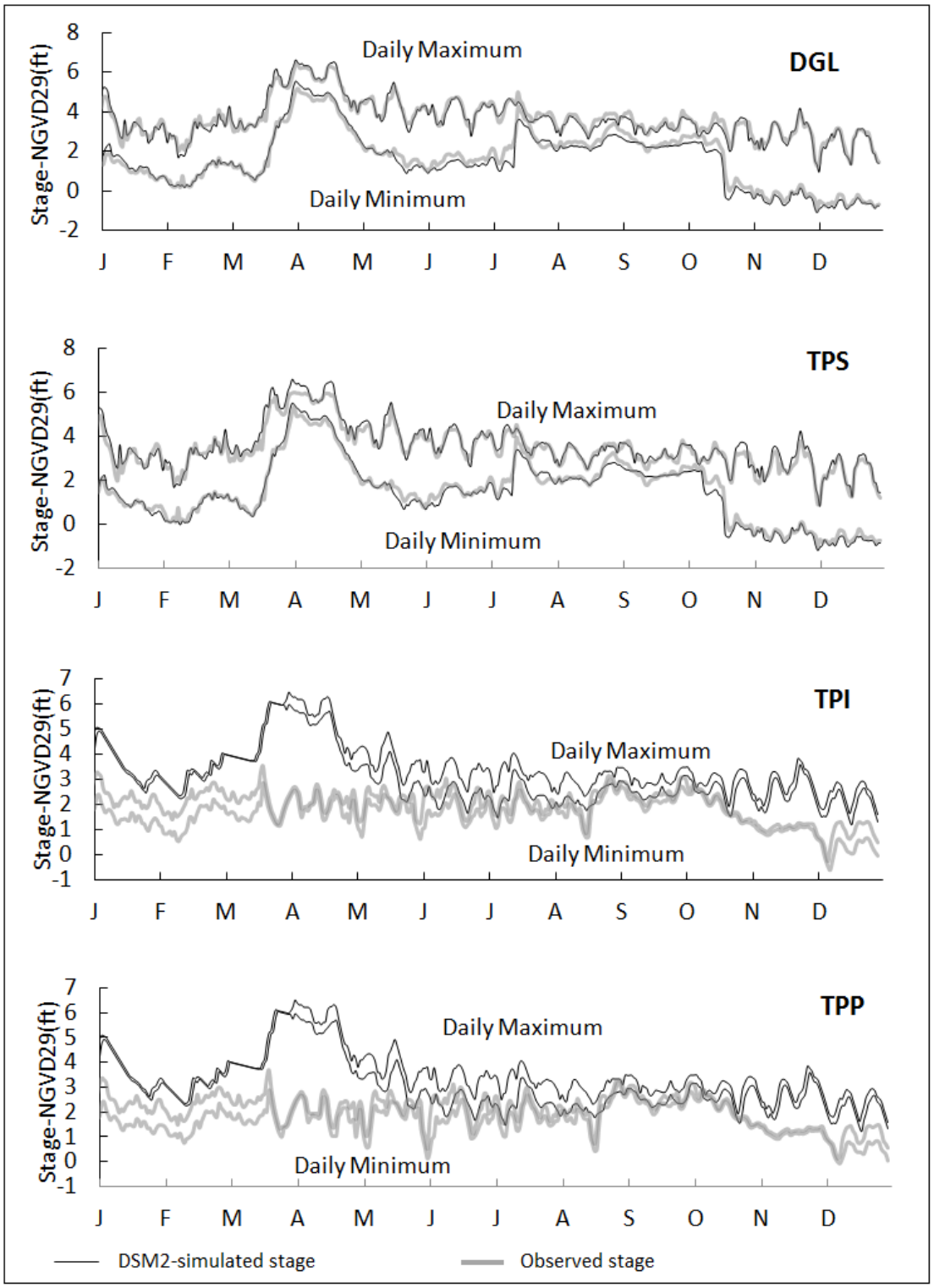


Figure C-2 (cont). Comparison of DSM2-simulated and measured daily stage, 2011.

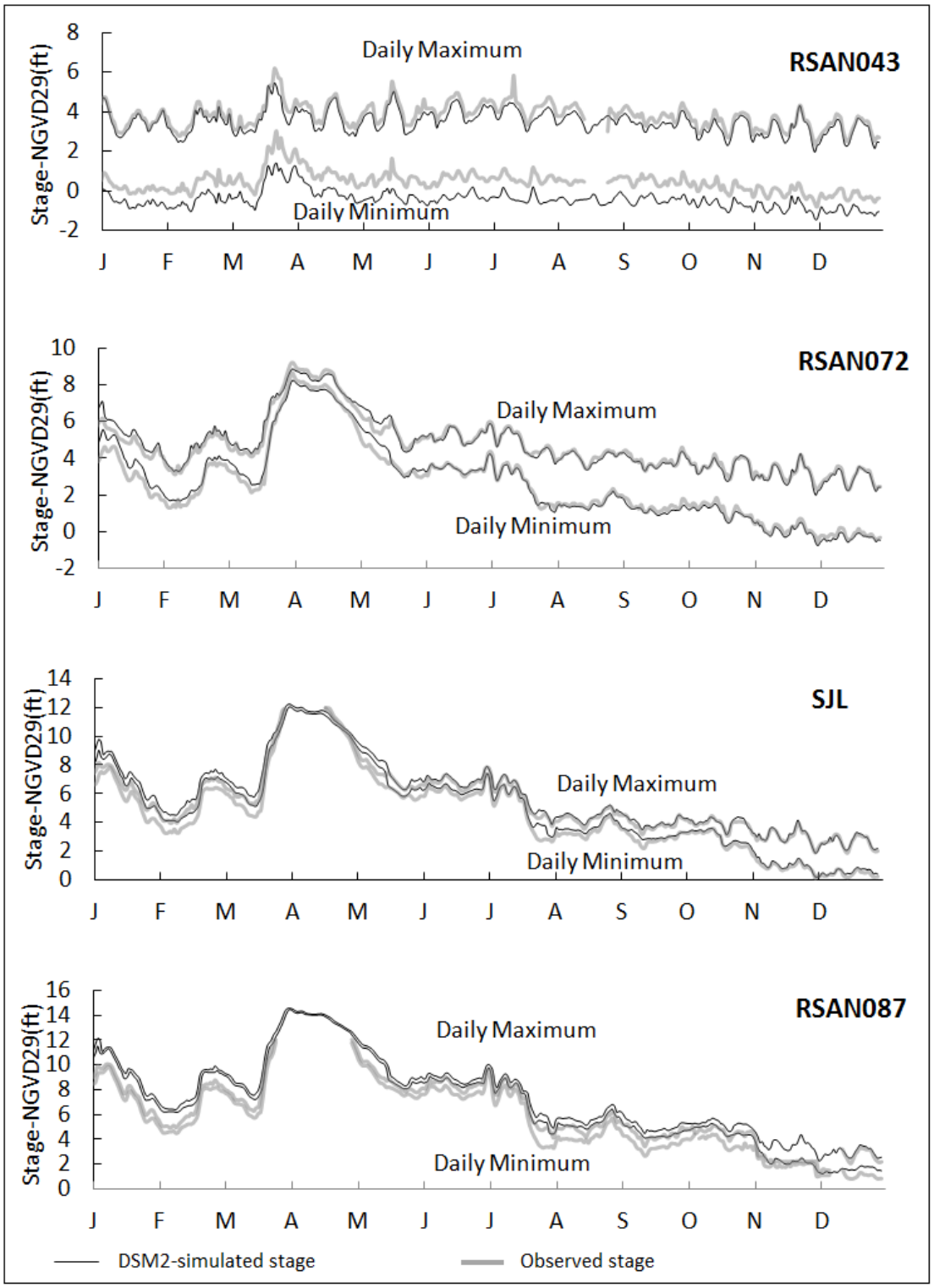


Figure C-2 (cont). Comparison of DSM2-simulated and measured daily stage, 2011.

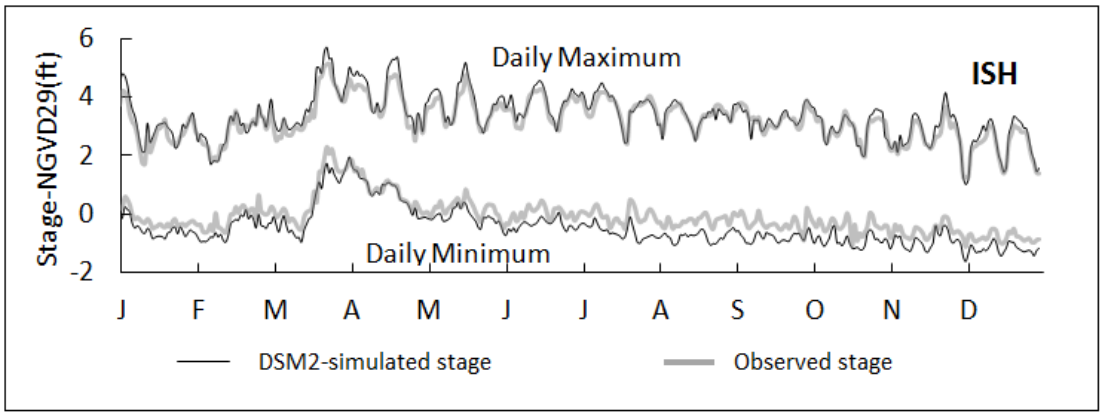


Figure C-3 shows DSM2-simulated and observed daily maximum, average and minimum flow in the Delta for 2011. The DSM2 simulation matched observed peak and average flows well at most all locations outside of the area affected by the temporary barriers in the south Delta. Flow was measured at several locations in the south Delta: Old River downstream of barrier near DMC intake (ROLD046), Old River at Head (ROLD074), and Grant Line Canal downstream of barrier site (GRL009).

At ROLD046, ROLD074, and GRL009, simulated daily average flows generally match observed daily average flows well. At times before the installation of the barriers, simulated daily average flow at ROLD074 was significantly less than observed flow: about 900 cfs less for January through March 28 and about 1200 cfs less for May. At GRL009, the observed and simulated daily average flows generally match well; however, as in past simulations, the observed daily peak upstream and downstream flows significantly exceed simulated flows. In other words, 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. At ROLD046, daily maximum, minimum, and average flows simulated by DSM2 matched observed well with the exception of daily maximum flow for the period of July 14, 2011 through August 23, 2011. During this time, daily maximum simulated flow was about 1,040 cfs less than observed daily maximum. Figure C-4 shows the 15-minute simulated and observed flow at ROLD046 for July and August, 2011. During the period when DSM2-simulated daily maximum flow is substantially less than observed daily maximum flow, the barriers at Grant Line Canal and Old River at DMC were installed and the flap gates on the Old River barrier were fixed open. When the flap gates on the barrier at Old River were allowed to operate tidally, DSM2-simulted and observed flows matched very well.

Taken as a whole, Figures C-2 and C-3 indicate that analysis of south Delta hydrodynamics based on distributions of DSM2-simulated 15-minute flow and stage is meaningful.

Figure C-3. Comparison of DSM2-simulated and measured daily flow, 2011.

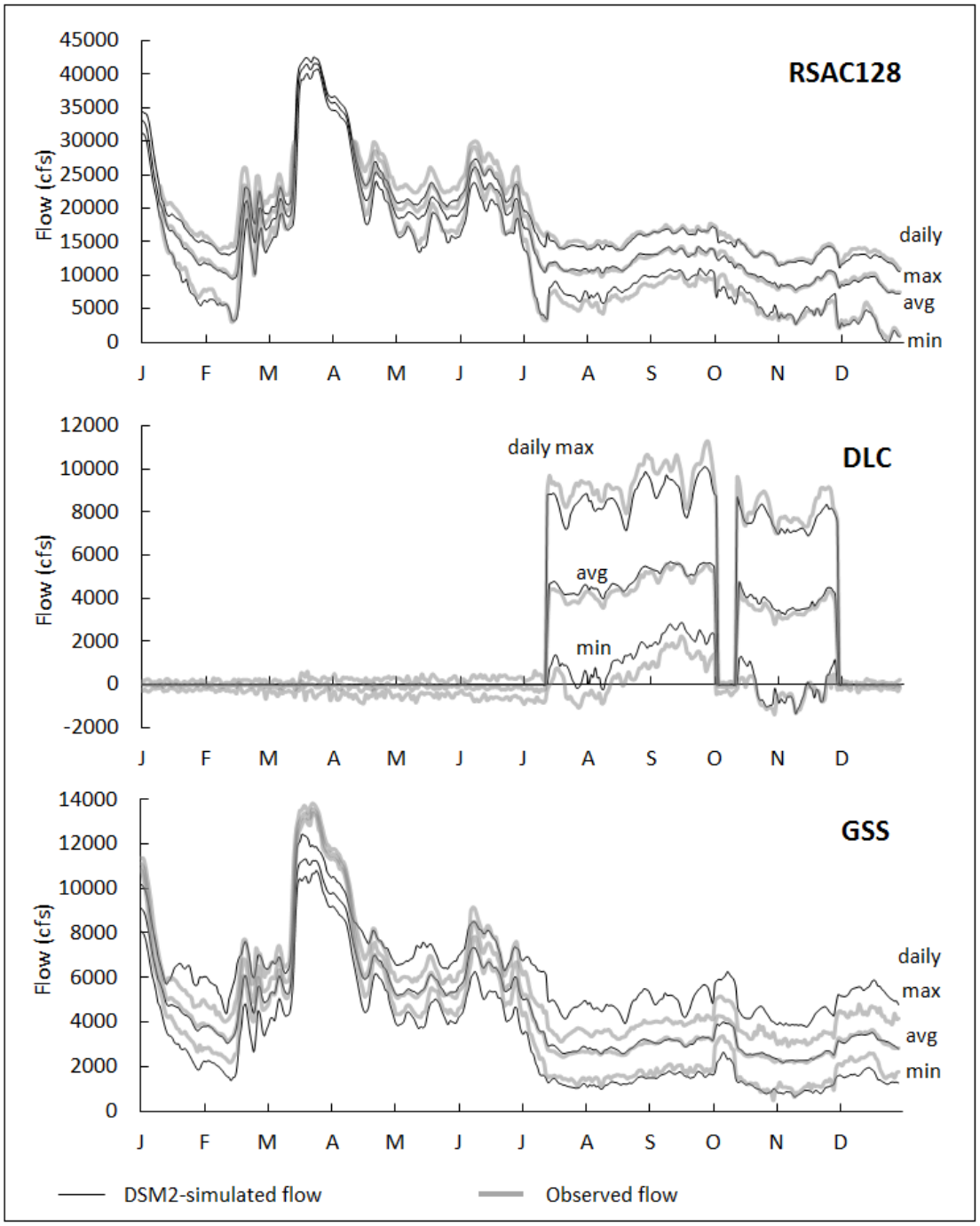


Figure C-3 (cont). Comparison of DSM2-simulated and measured daily flow, 2011.

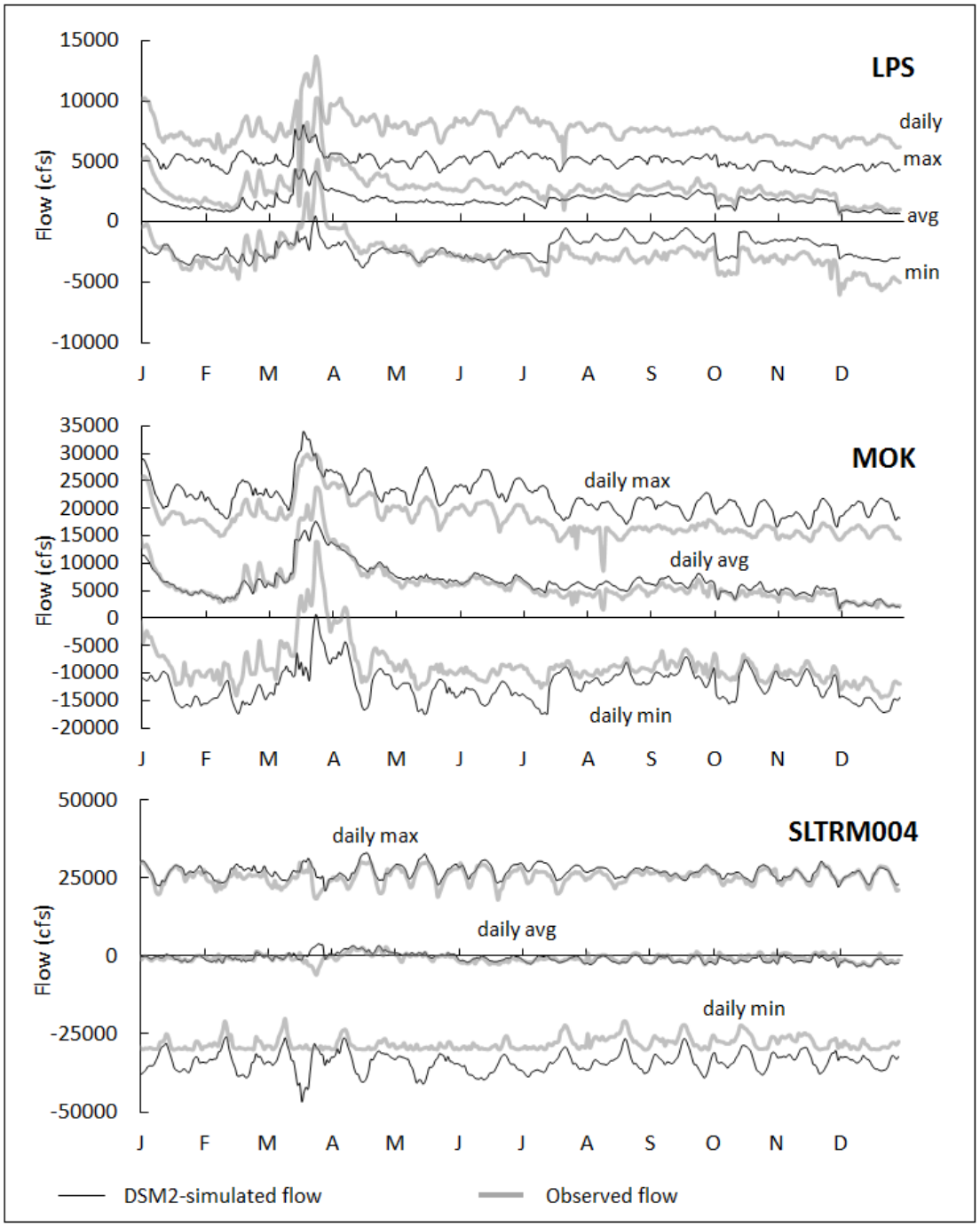


Figure C-3 (cont). Comparison of DSM2-simulated and measured daily flow, 2011.

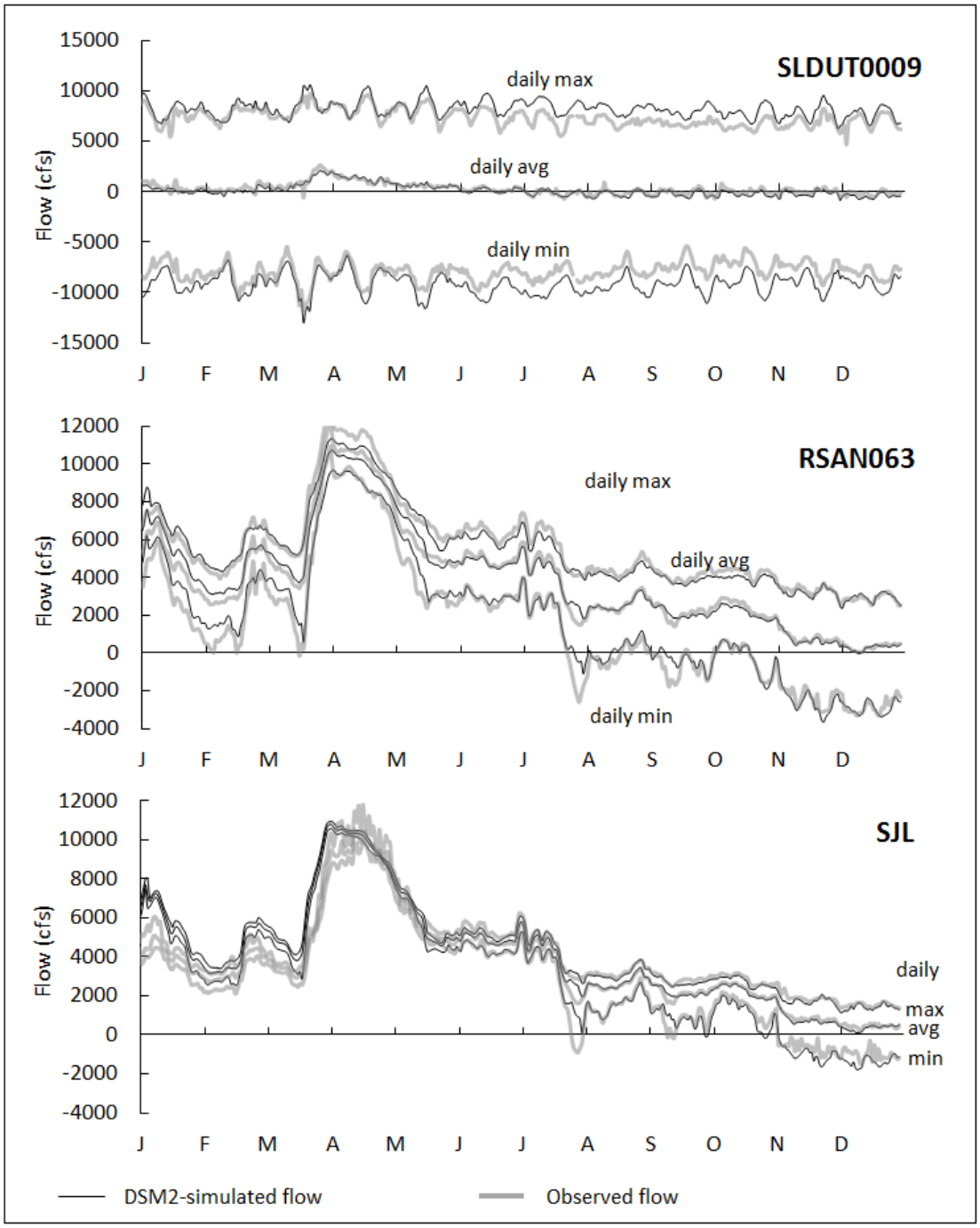


Figure C-3 (cont). Comparison of DSM2-simulated and measured daily flow, 2011.

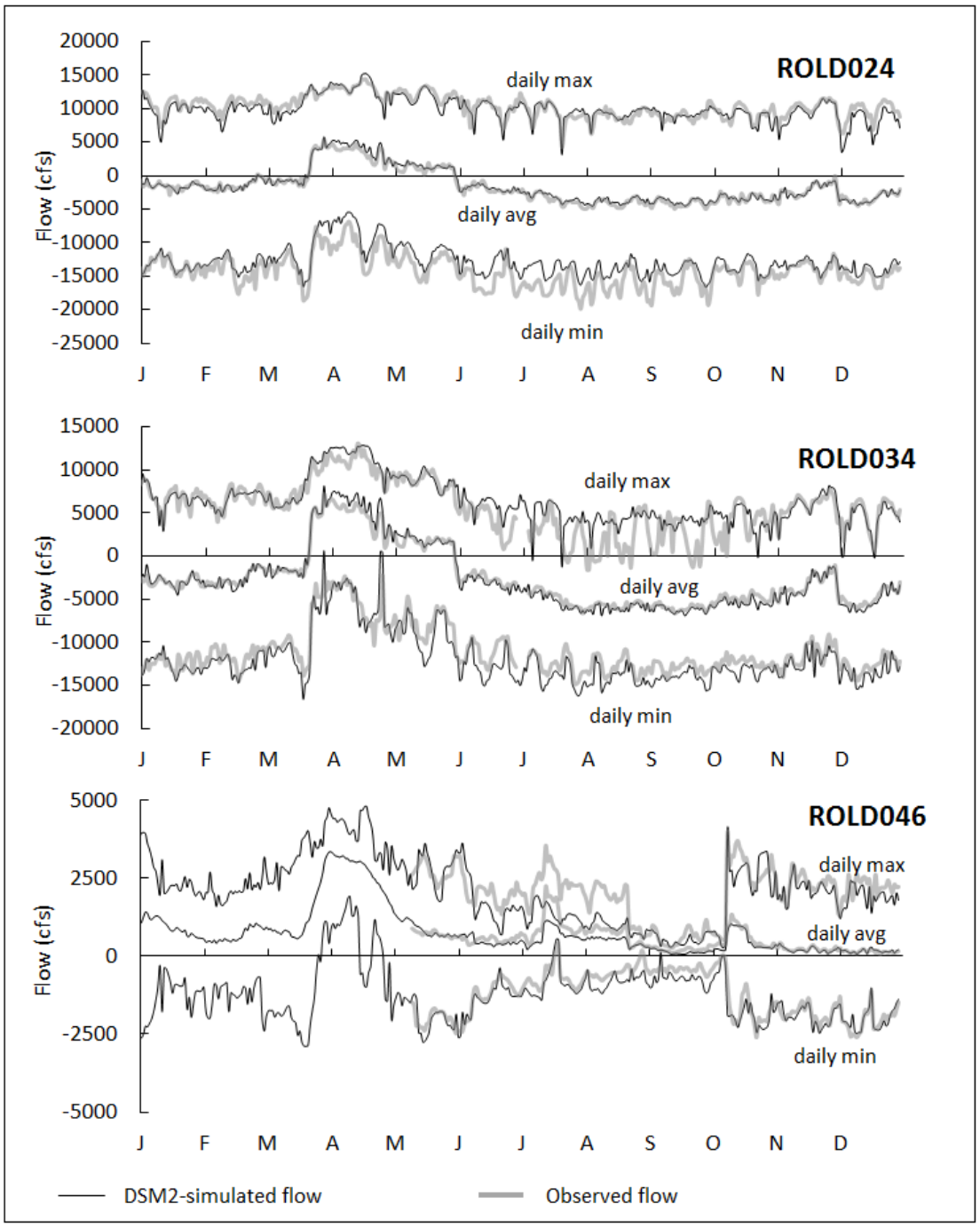


Figure C-3 (cont). Comparison of DSM2-simulated and measured daily flow, 2011.

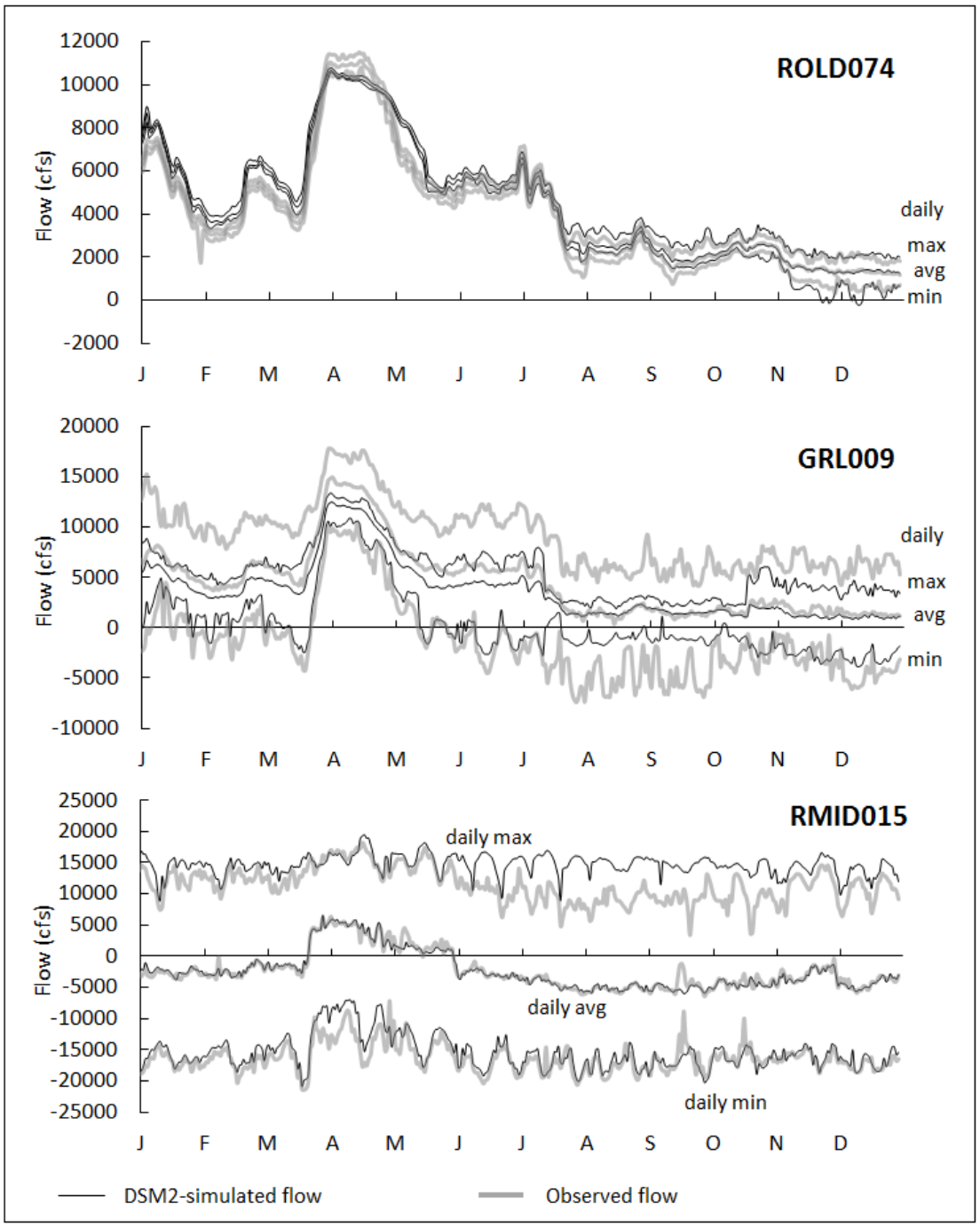
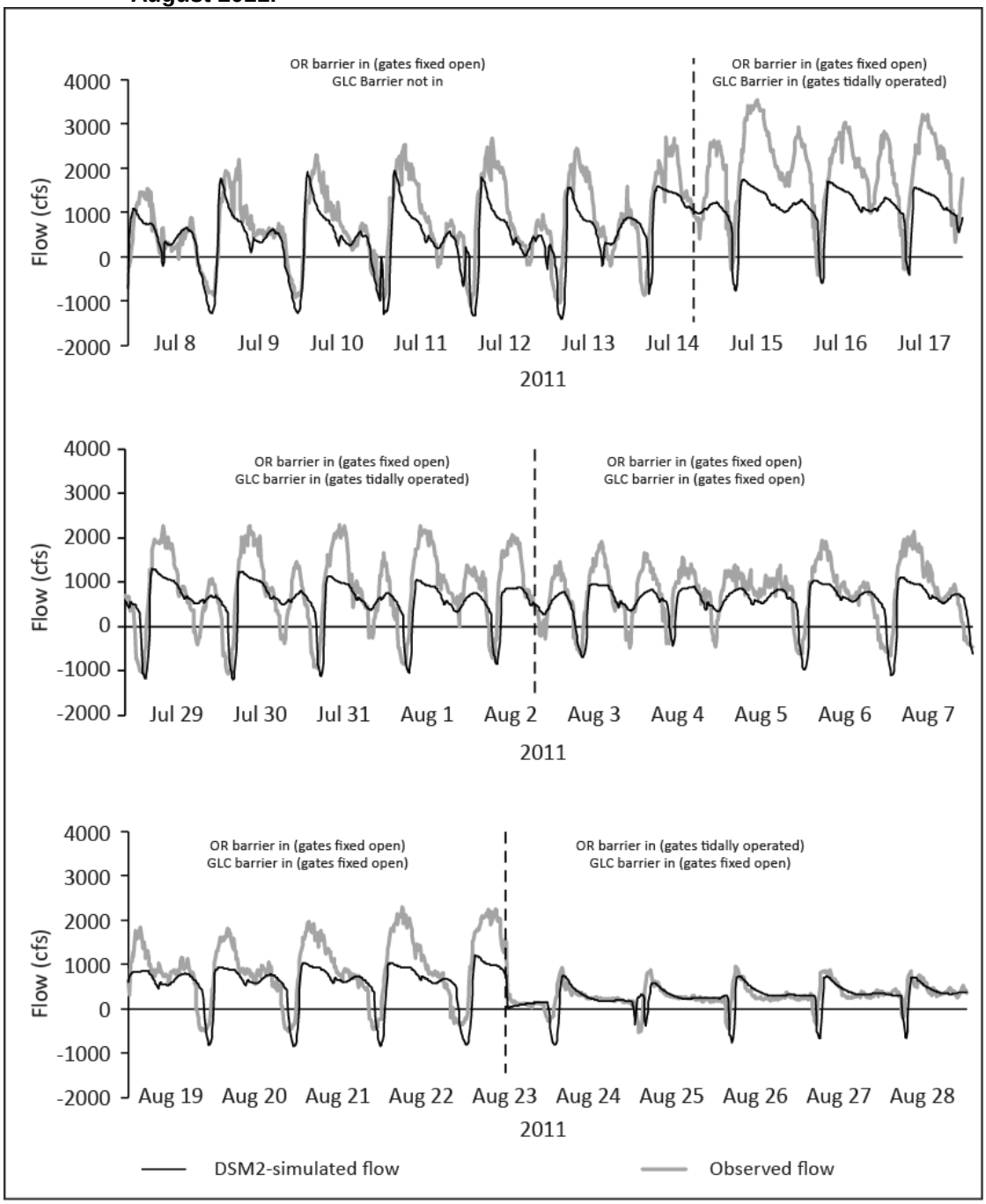


Figure C-4. DSM2-simulated and measured 15-minute flow at ROLD046, July and August 2011.



Characterizing south Delta hydrodynamics over discrete periods of time

The impacts upon flow and water levels caused by the temporary barriers depend in part on other factors: the inflow of San Joaquin River, agriculture diversions and returns, Banks and Jones Pumping Plant operations, and Clifton Court Forebay intake gates operation. To account for this, the results of the simulations of historical conditions and no-temporary barrier installation conditions were partitioned into periods of time for which flows and exports changed relatively little and any of the three temporary barriers were either fully installed or removed. Following this approach, the results of the 2011 simulation were processed according to 21 periods of time as shown in Table C-1. These intervals exclude periods when barriers were in the process of installation or removal or sharp changes in inflows or exports were occurring: June 5,10-13; August 1,2,22,23; and October 10,11,19.

Table C-1. Characteristics of time intervals for presentation of simulation results, 2011

Period in 2011		Period Average Flows (cfs)				Period Barrier Status			
		SAC R +YOLO	SJR	DMC pumping	SWP pumping	MR	OR	GLC	ORH
Jan	1-31	35376	12014	3955	6750				
Feb	1-28	24828	8698	3029	5919				
Mar	1-23	52202	10265	3805	3761				
Mar	24-31	93065	20757	609	2526				
Apr	1-21	73652	27211	2299	3523				
Apr	22-30	45295	22143	2004	4724				
May	1-31	36677	12942	1660	1630				
Jun	1-4	36208	10548	3568	5377				
Jun	6-9	44965	11080	3474	5936	IN			
Jun	14-30	41377	10265	3519	6576	IN	IN		
Jul	1-13	28531	10789	4179	7005	IN	IN		
Jul	15-31	17757	6959	4175	7046	IN	IN	IN	
Aug	3-21	16876	5116	4144	7150	IN	IN	IN	
Aug	24-31	19964	6332	4175	7093	IN	IN	IN	
Sep	1-30	21506	4331	4133	7104	IN	IN	IN	
Oct	1-9	22331	4659	4097	6407	IN	IN	IN	
Oct	12-18	18213	5057	4036	6727			IN	
Oct	20-31	13661	4419	3875	6619				
Nov	1-15	11770	2763	4090	4887				
Nov	16-30	13896	2050	2564	2042				
Dec	1-31	14592	1694	3895	5177				

For each time period, 15-minute stage and flow were used to generate box and whiskers 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. In addition to considering distributions of flow and water levels in the south

Delta, flow schematics showing period-average flow and minimum water levels were generated to visually show impact of temporary barriers on circulation and water levels.

With this type of impact analysis in mind, the DSM2 simulation of historical conditions was validated by comparing DSM2-simulated water levels and flows to observed values, where available, through box and whiskers plots (Figures C-5 and C-6 respectively) and flow schematics (Figure C-7). The record of observed 15-minute flow and water level data was complete or very nearly complete at all locations for 2011. Missing observed data was estimated in order to present period-average flows in Figure C-7.

As shown in Figures C-5, C-6, and C-7, the DSM2-simulation of historical hydrodynamics well recreates the distribution of flow and water levels as well as circulation patterns. The large changes in flows and water levels corresponding to barriers installation or removal are shown in the distributions of both the observed and simulated values and in the period-average flows and minimum water levels in the schematics. The before-mentioned issue of simulated water levels in Clifton Court Forebay and Tom Paine Slough not matching observed values and of the suspected errors in observed flow in Grant Line Canal are evident in Figure C-7.

Taken as a whole, Figures C-2, C-3, C-5, C-6, and C-7 validate the use of the DSM2 simulation of historical 2011 hydrodynamic conditions for the analysis of the impact of the temporary barriers on south Delta flows and water levels.

Figure C-5. Distribution of DSM2-simulated and observed 15-minute water levels for discrete periods of time, 2011.

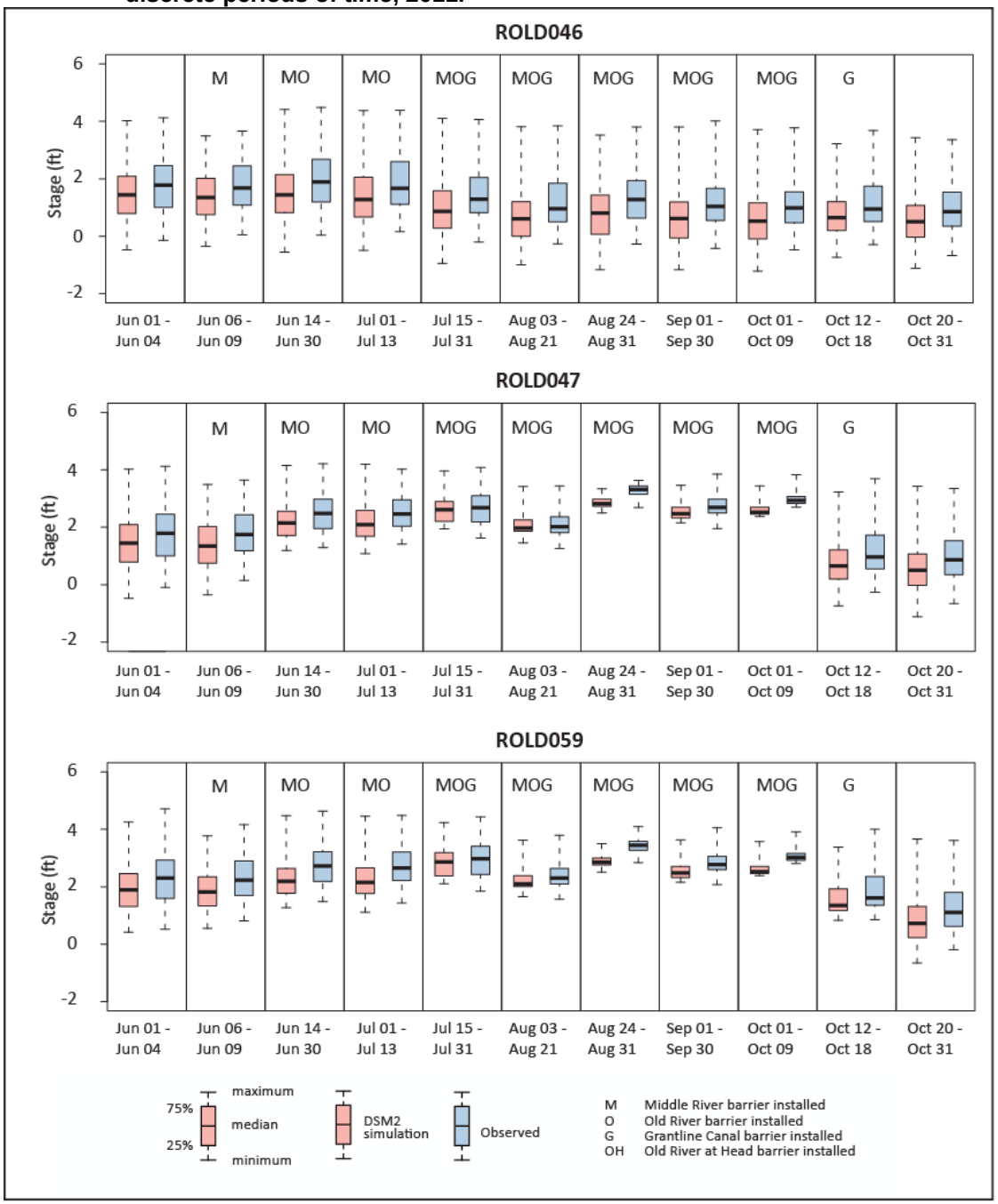


Figure C-5 (cont). Distribution of DSM2-simulated and observed 15-minute water levels for discrete periods of time, 2011.

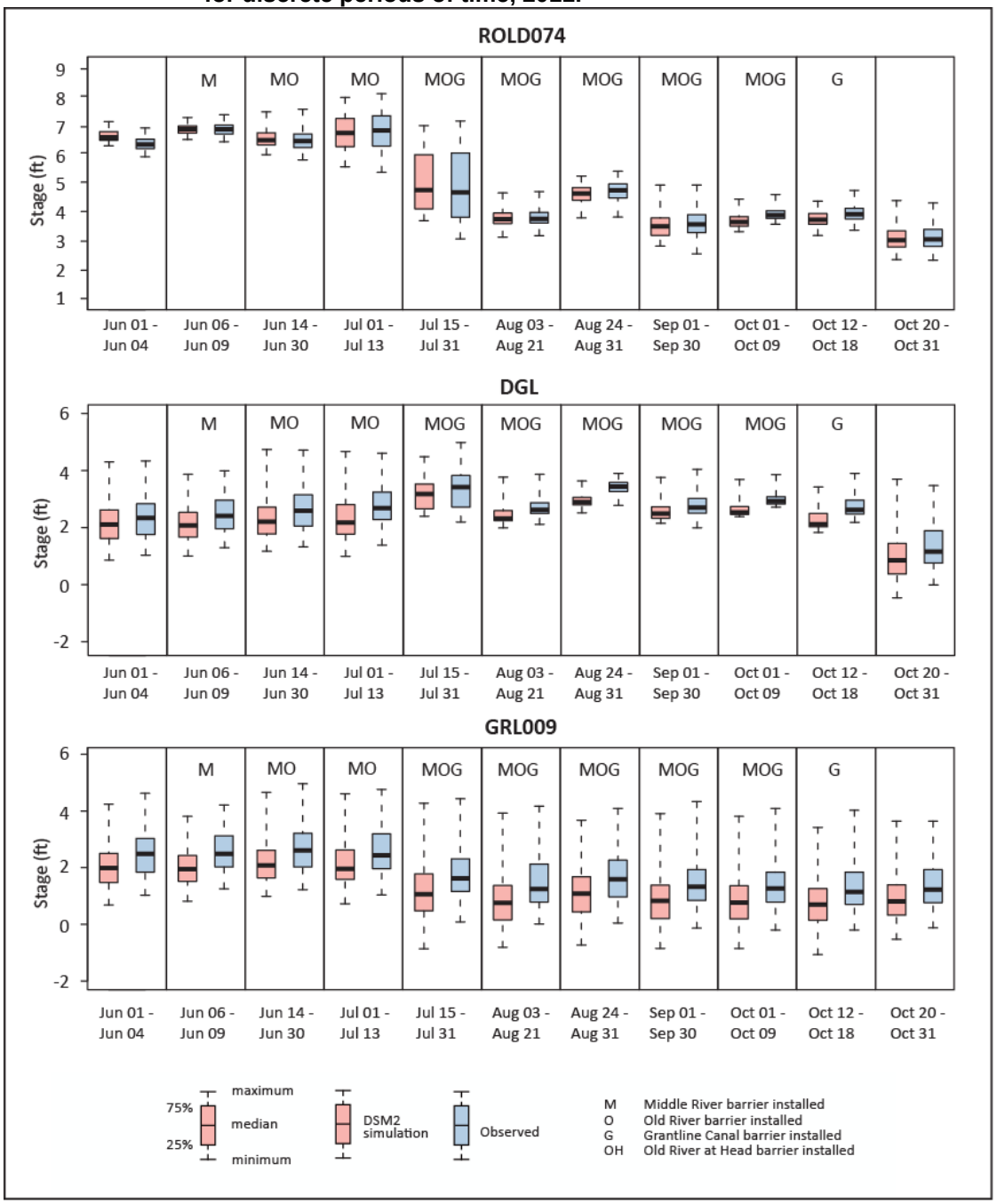


Figure C-5 (cont). Distribution of DSM2-simulated and observed 15-minute water levels for discrete periods of time, 2011.

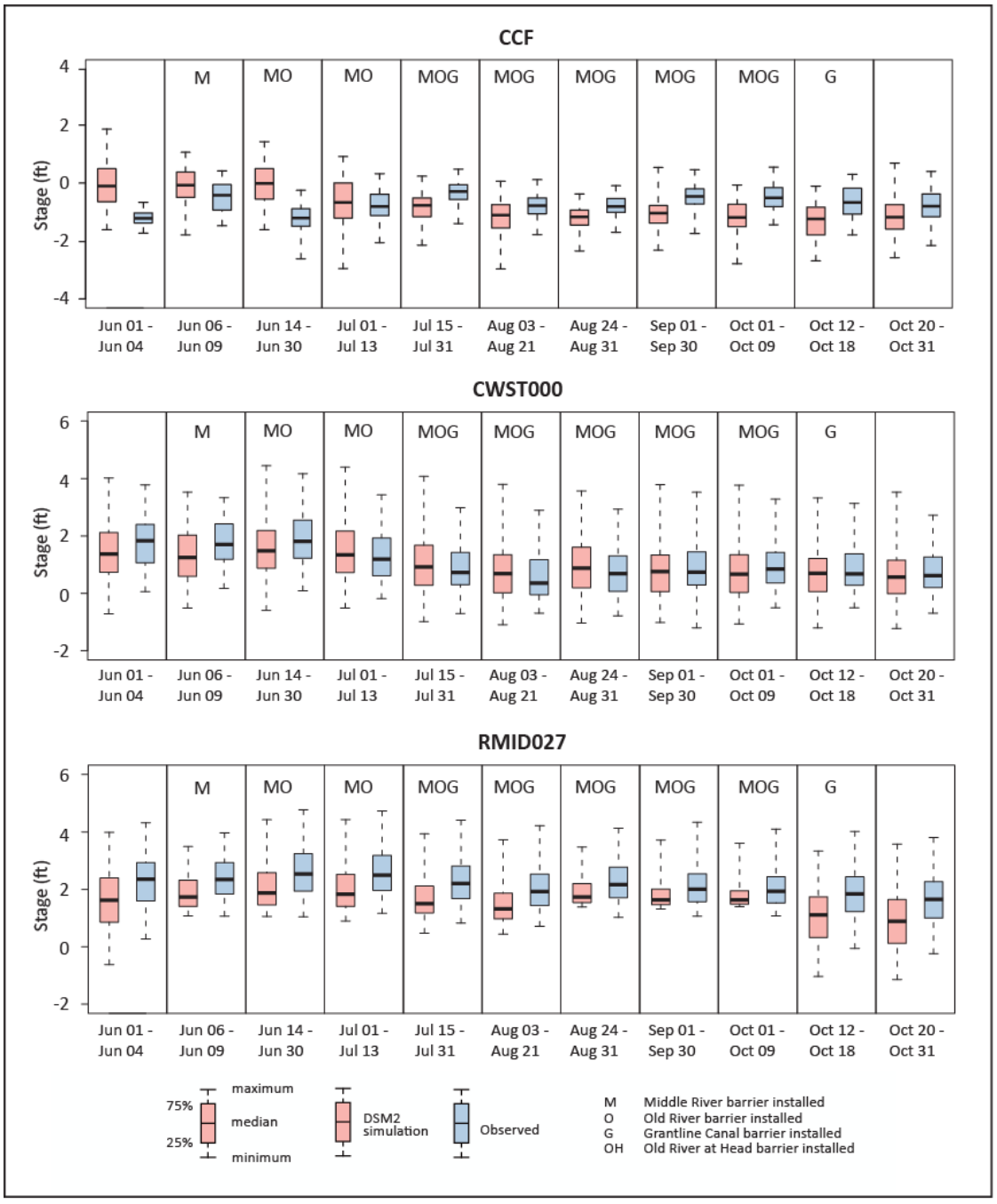


Figure C-5 (cont). Distribution of DSM2-simulated and observed 15-minute water levels for discrete periods of time, 2011.

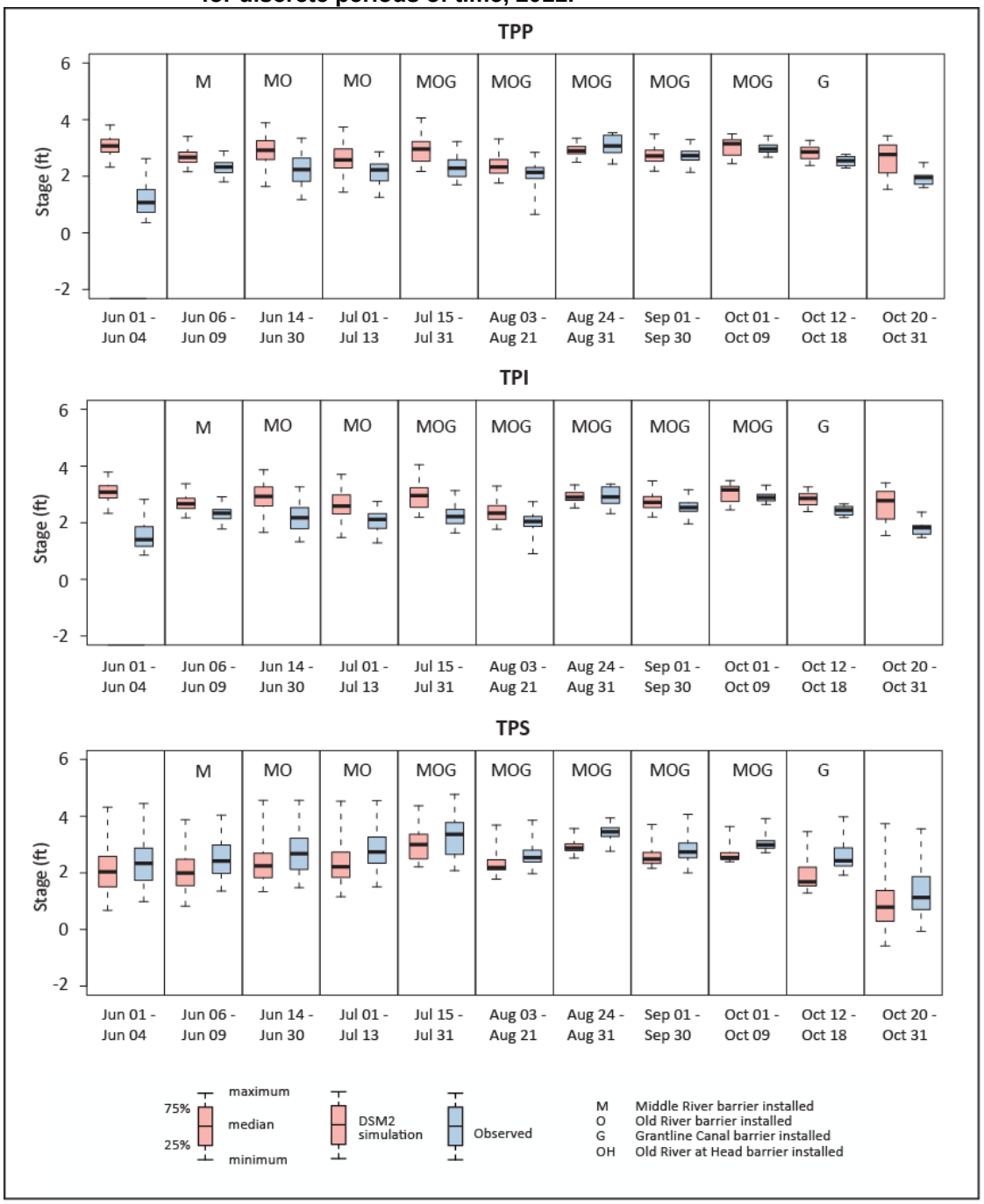


Figure C-6. Distribution of DSM2-simulated and observed 15-minute flows for discrete periods of time, 2011.

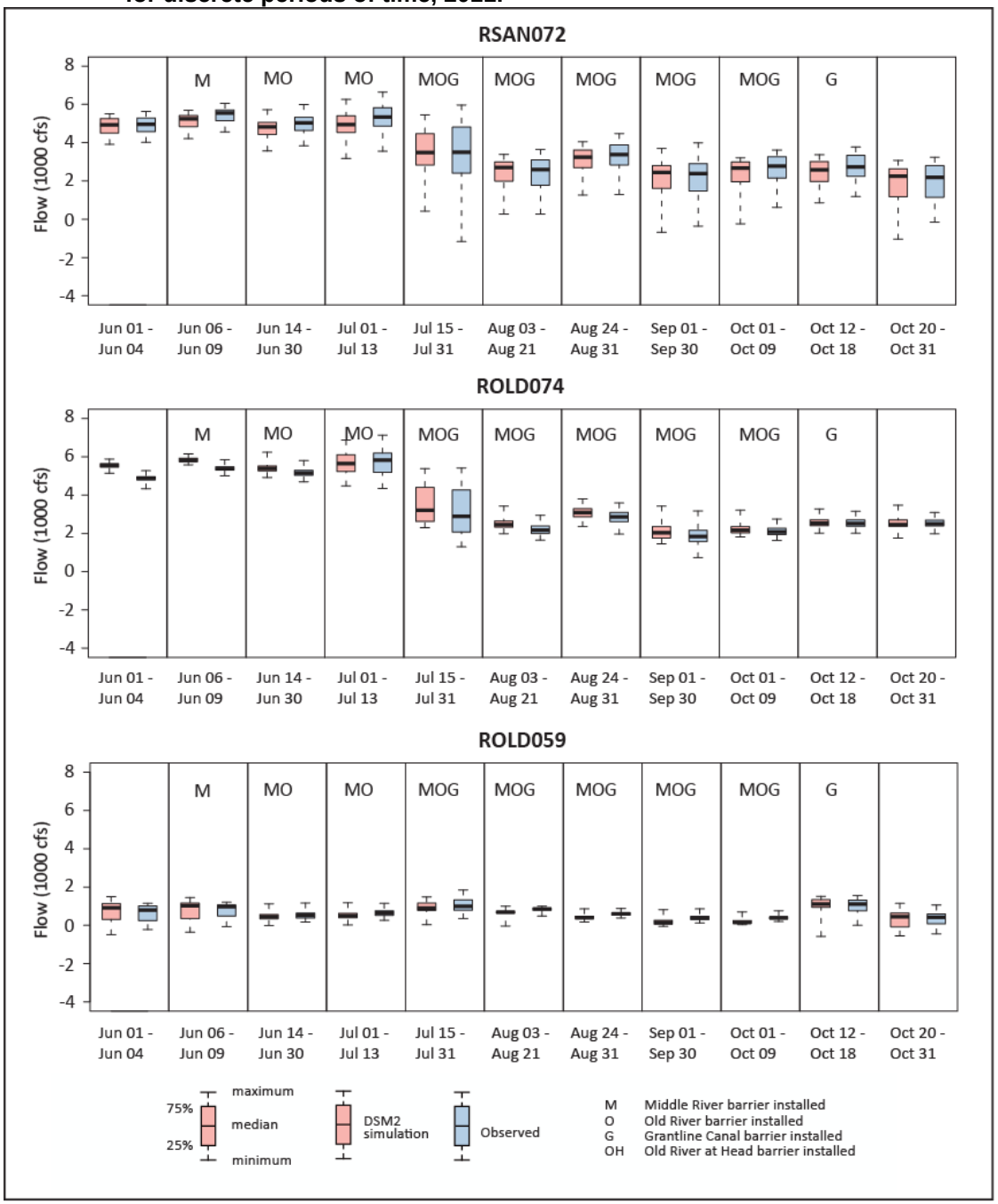


Figure C-6 (cont). Distribution of DSM2-simulated and observed 15-minute flows for discrete periods of time, 2011.

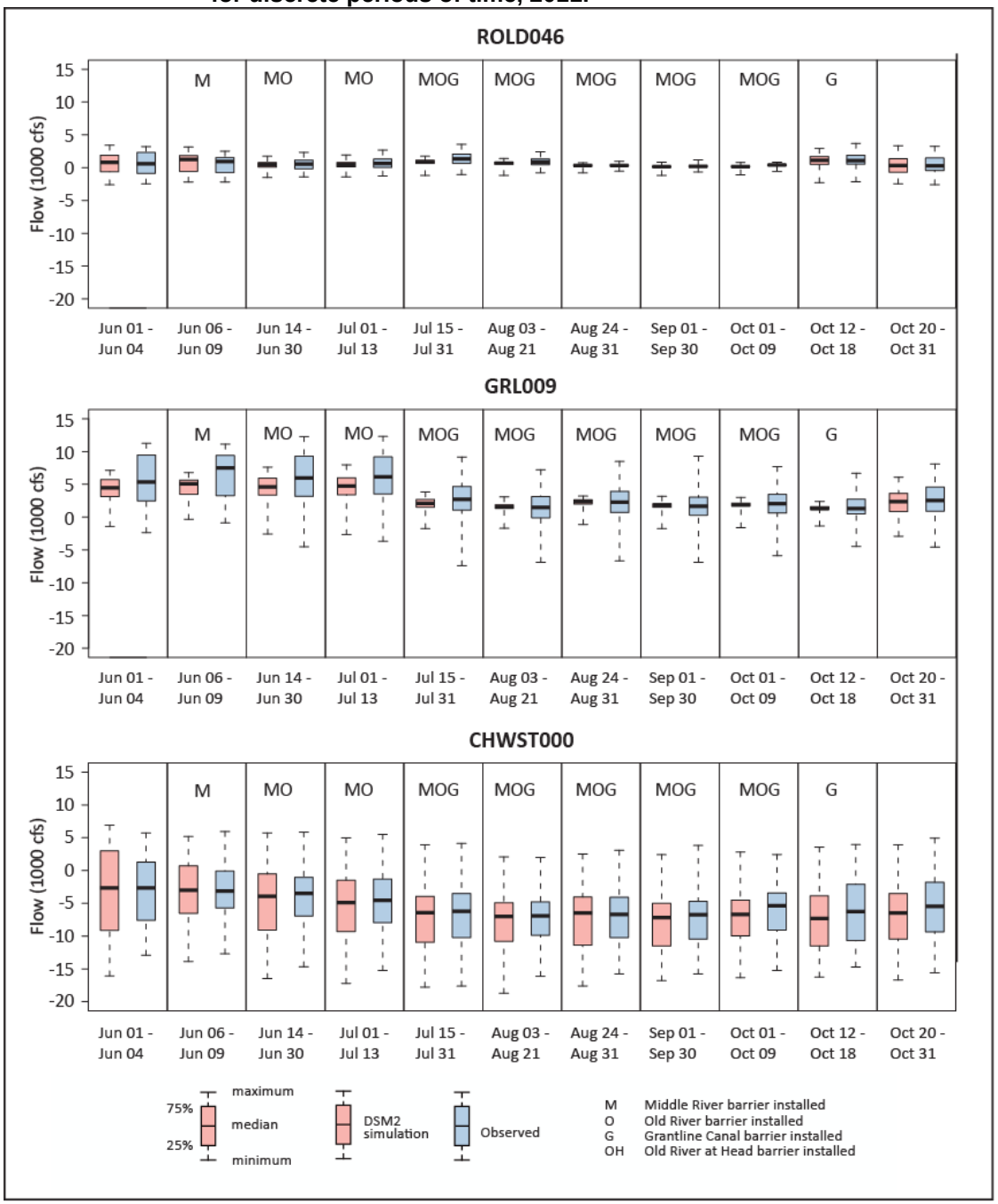


Figure C-6 (cont). Distribution of DSM2-simulated and observed 15-minute flows for discrete periods of time, 2011.

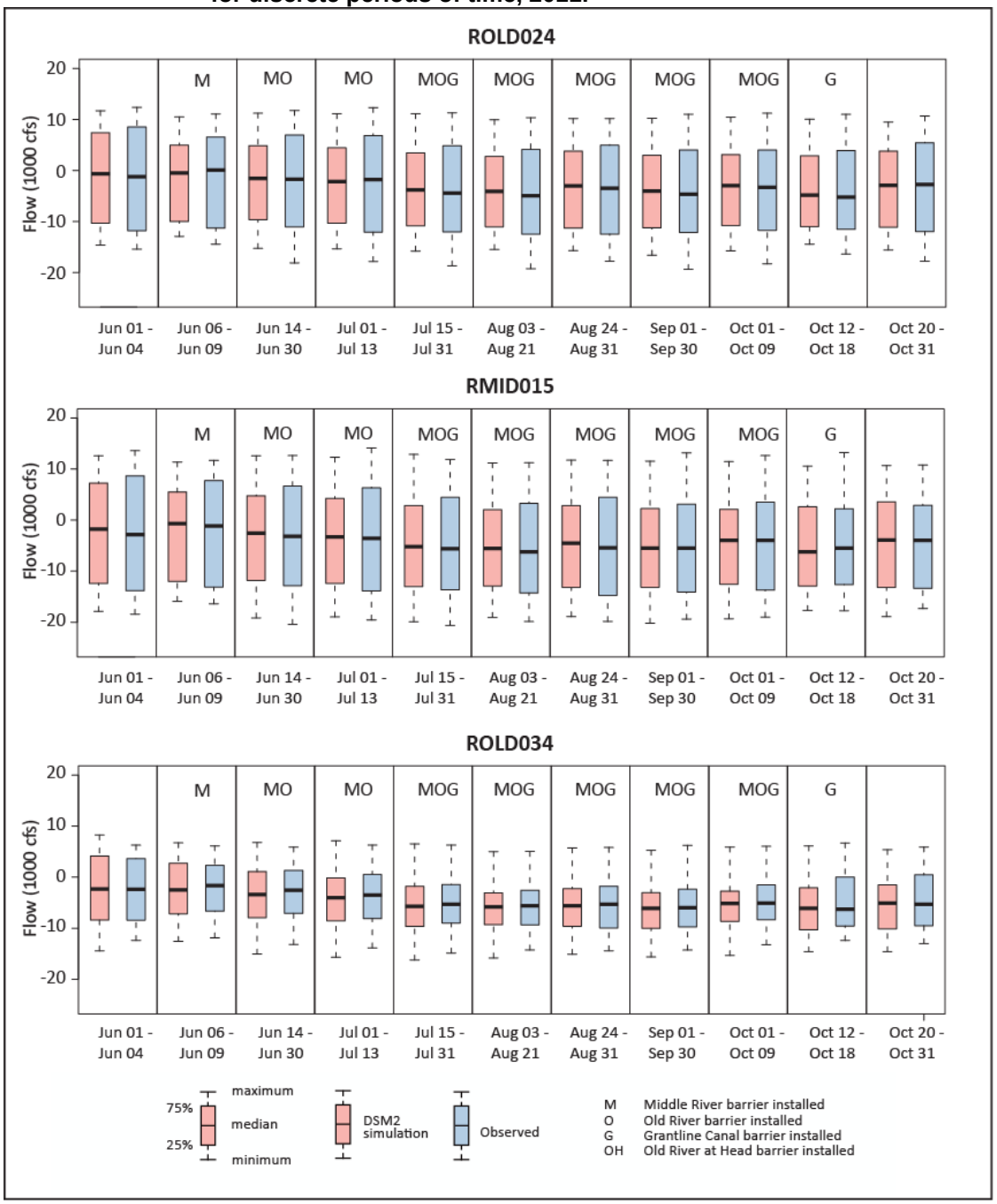


Figure C-7. Observation-based and DSM2- based flow schematic for discrete periods of time, 2011

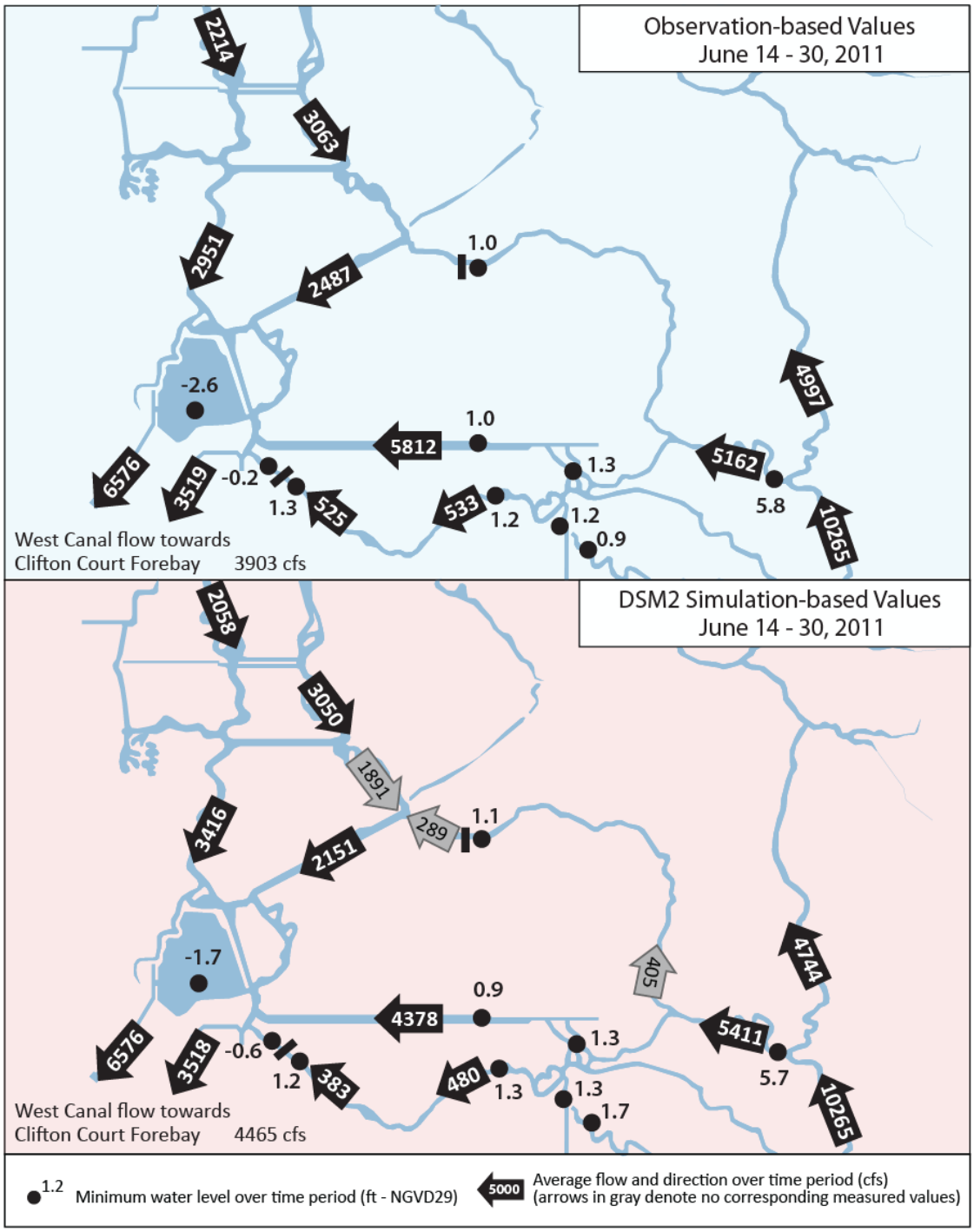


Figure C-7 (cont). Observation-based and DSM2- based flow schematic for discrete periods of time, 2011

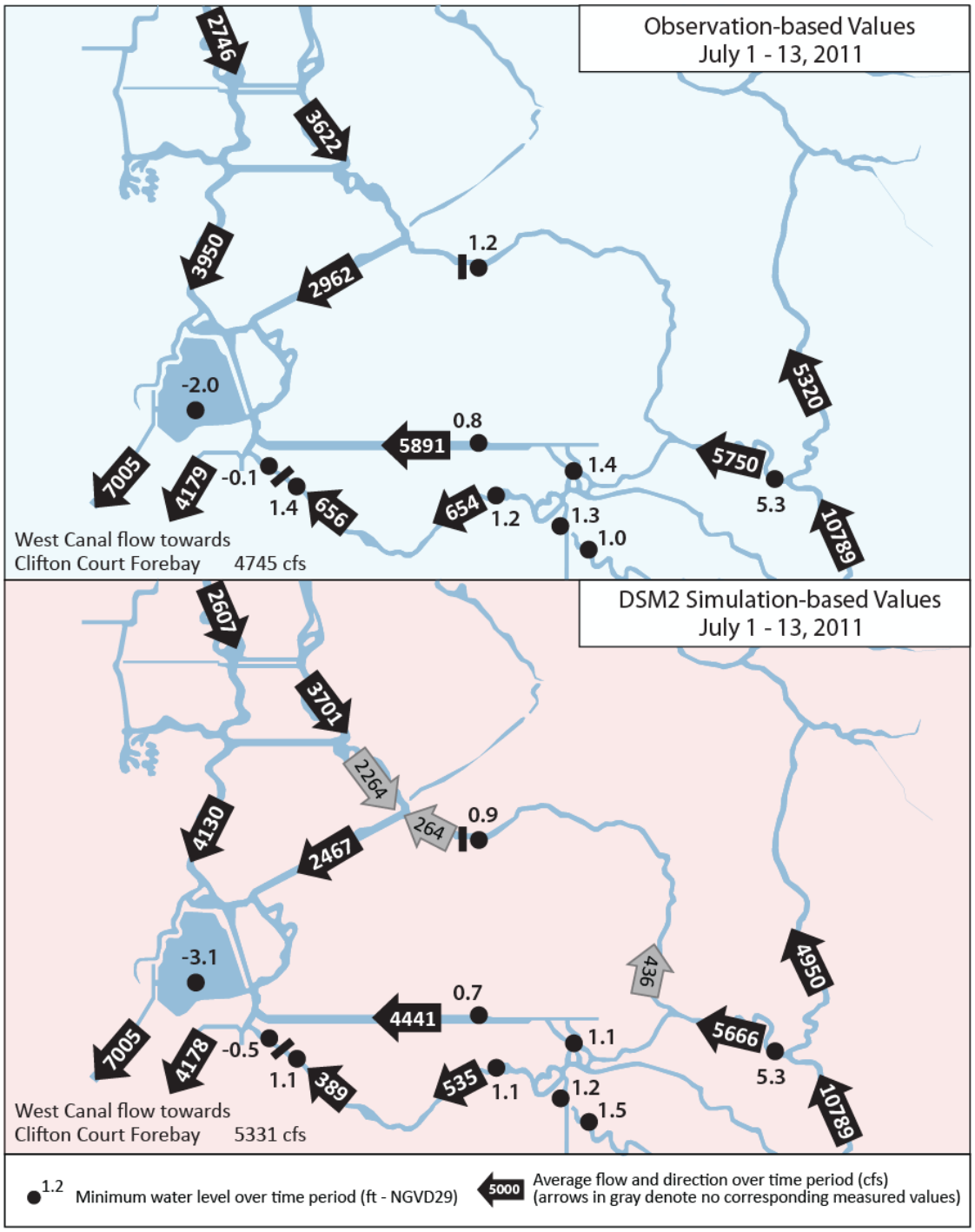


Figure C-7 (cont). Observation-based and DSM2- based flow schematic for discrete periods of time, 2011

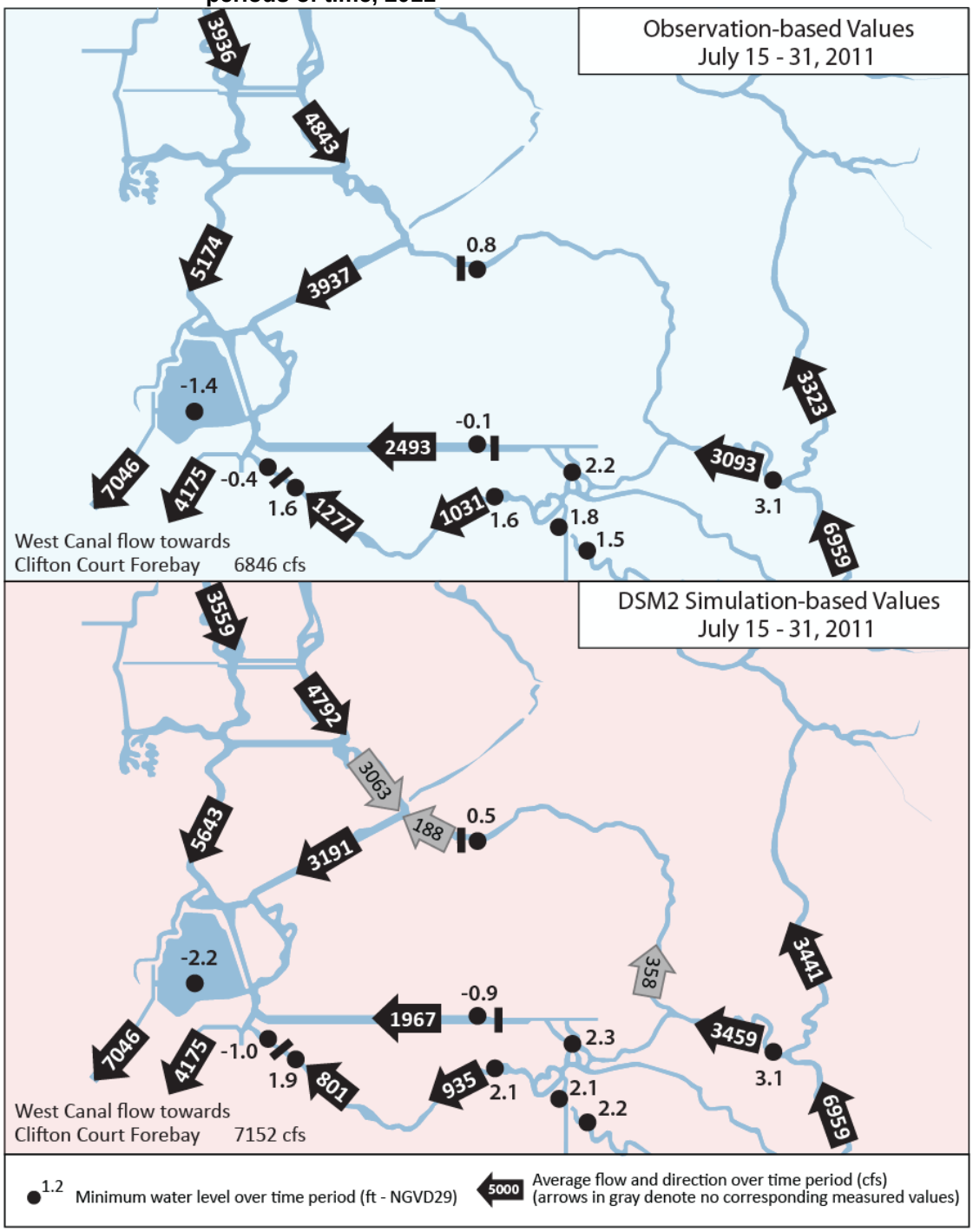


Figure C-7 (cont). Observation-based and DSM2- based flow schematic for discrete periods of time, 2011

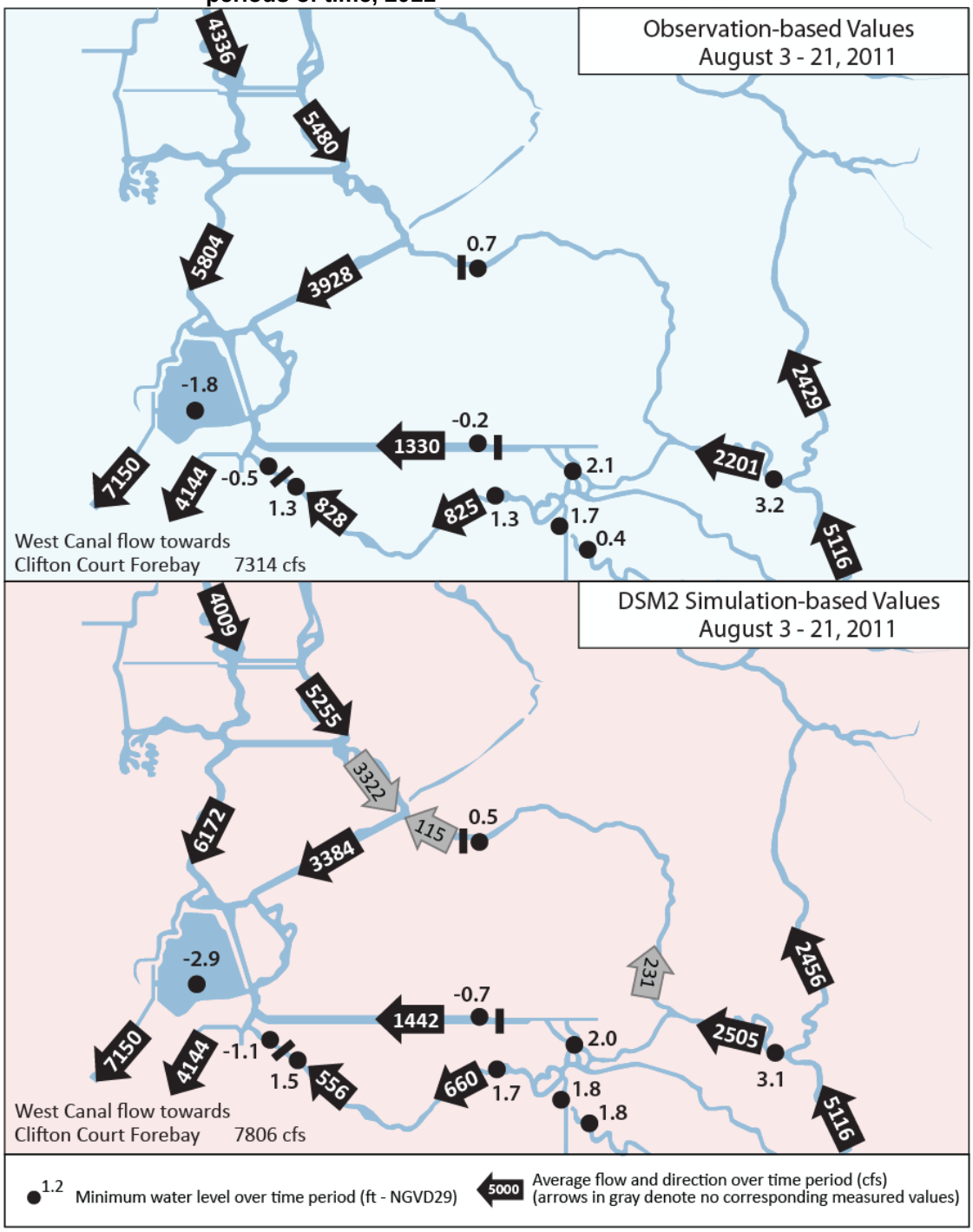


Figure C-7 (cont). Observation-based and DSM2- based flow schematic for discrete periods of time, 2011

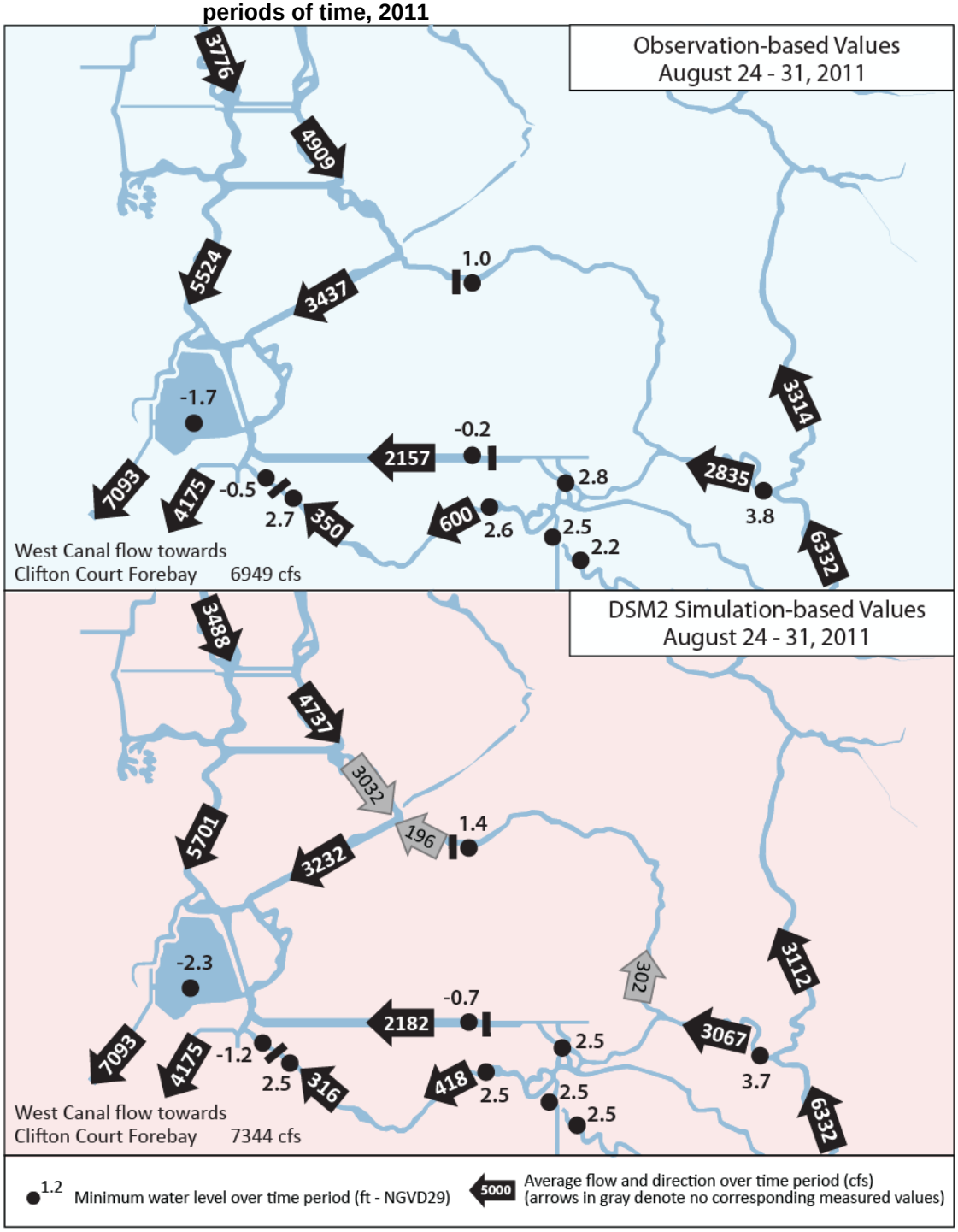


Figure C-7 (cont). Observation-based and DSM2- based flow schematic for discrete periods of time, 2011

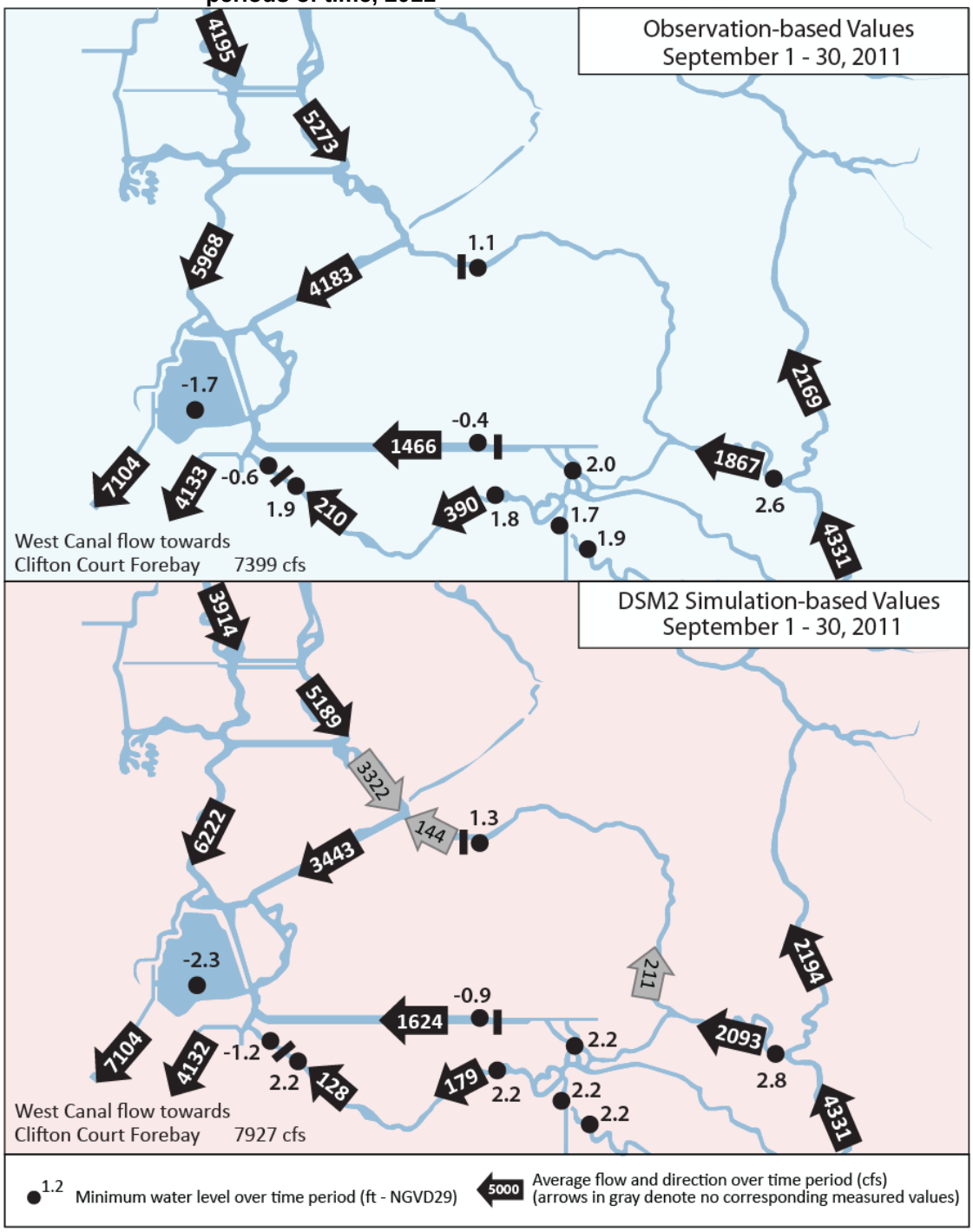


Figure C-7 (cont). Observation-based and DSM2- based flow schematic for discrete periods of time, 2011

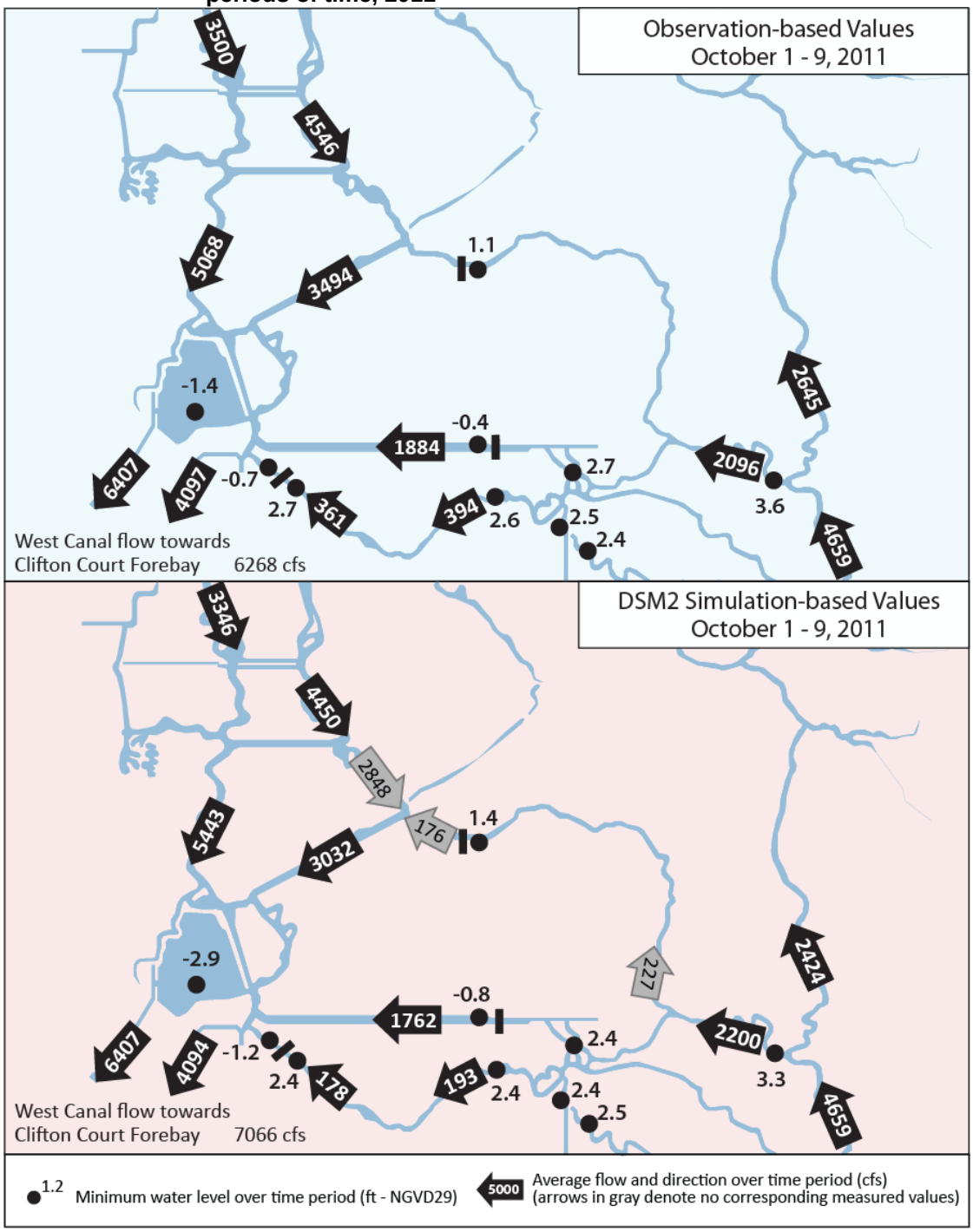


Figure C-7 (cont). Observation-based and DSM2- based flow schematic for discrete periods of time, 2011

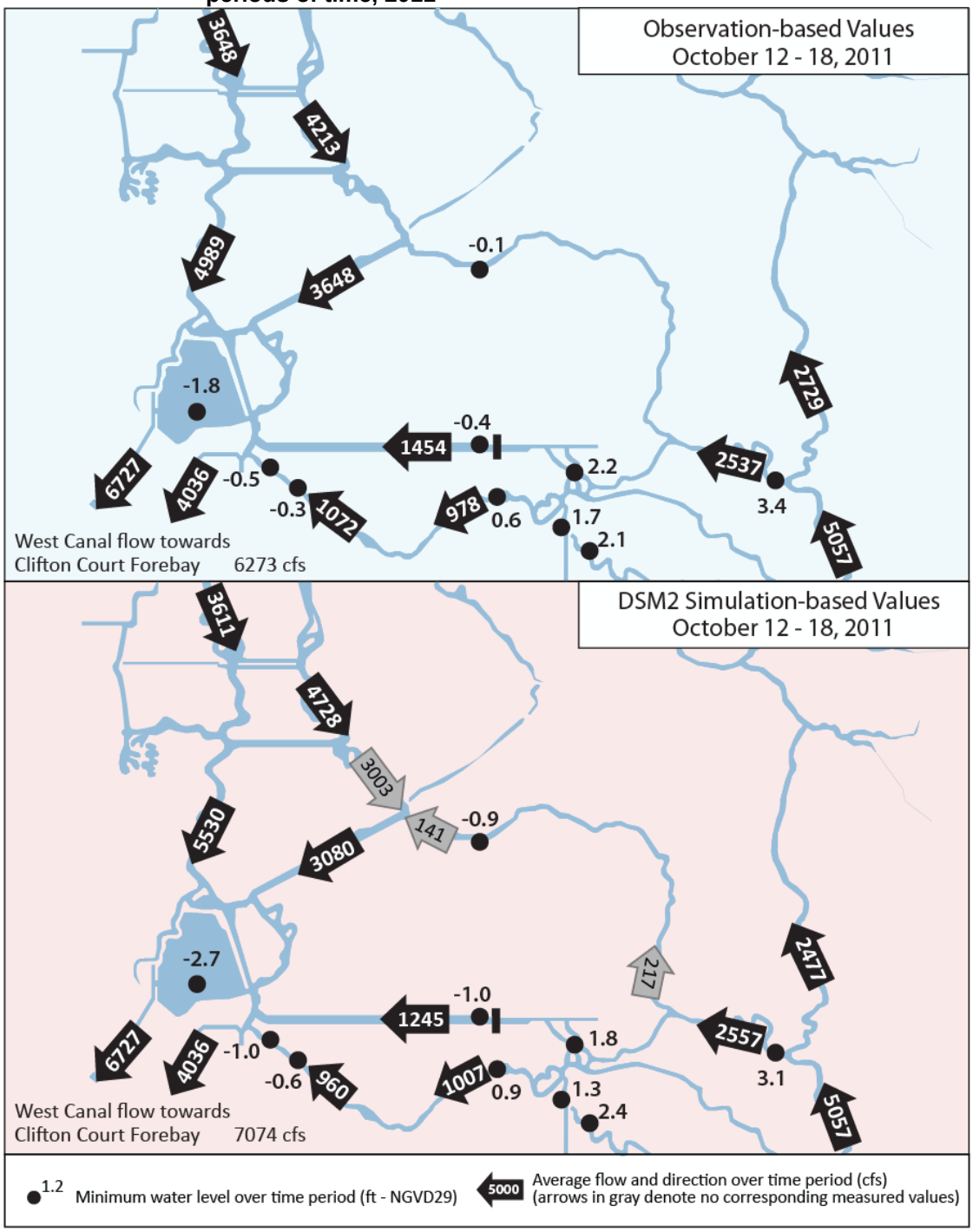


Figure C-7 (cont). Observation-based and DSM2- based flow schematic for discrete periods of time, 2011