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RMA Turbidity and Adult Delta Smelt Behavioral Model Covering the Forecast Period Jan. 12, 2012 to January 26, 2012

Date:	January 13, 2012
To:	Chuching Wang, Senior Engineer, Metropolitan Water District
	Paul Hutton, Senior Engineer, Metropolitan Water District
From:	Marianne Guerin, Senior Water Resources Specialist
	Steve Andrews, Water Resources Engineer
Subject:	Results of Recent Forecasting Work

Summary Assessment

PERIOD: The Delta turbidity and adult delta smelt forecast was produced this week, and this documentation covers the forecast period January 12, 2012 to January 26, 2012 plus a period of historical conditions.

PRE-FORECAST SUMMARY: Leading up to the forecast, Delta inflows and turbidity have been low due to dry conditions.

TURBIDITY 3-STATIONS PERFORMANCE & SUMMARY EVALUATION: Turbidity was low throughout the Delta, ranging from about 5 - 40 NTU in the raw data at nearly all locations. Turbidity was below compliance values (12 NTU) at two of the three compliance locations: at Holland Cut, the turbidity went above the compliance value for several days in early December, late December, and early January almost certainly due to wind events. The forecast does not anticipate any storms or significant turbidity events.

SMELT MOVEMENT SUMMARY: As a result, the forecast does not anticipate smelt movement into the south Delta.

Background

This document provides a summary of the fourth forecast for WY2012 prepared by RMA on January 12, 2011. The forecast was developed using the RMA models for hydrodynamics, salinity, and turbidity and particle tracking using the Adult Delta Smelt Behavioral model. Figures are provided to document the results of the modeling with a focus on turbidity.

Additional documentation can be found on the Bay-Delta Live website: http://www.baydeltalive.com/ .

Boundary Condition Development and Simulation Timing

Model BCs (Boundary Conditions) for the forecast models were developed using several sources for historical and forecast conditions including: CNRFC flow data and predictions, CDEC and USGS data, and DWR-supplied model inputs and results from their flow and salinity forecasts. BCs were prepared using these data sources and using professional judgment where necessary to resolve data discrepancies and to piece the data together for reasonable BC.

The RMA modeled period was November 01, 2011 to January 31, 2012 for flow, salinity and turbidity, and this document presents results for the period December 01, 2011 through January 26, 2012, which include two weeks of forecast period. DWR Operations and Maintenance (O&M) group provided RMA with BC they used in the DSM2 HYDRO and QUAL/salinity models for a combined historical and forecast period December 30, 2011 through January 17, 2012 – the three week DWR forecast period was January 10 through January 31, 2012. Additional flow, turbidity and EC data was downloaded for the period January 11 – 12, 2012 from the CDEC, CNRFC and USGS websites to fill-in historical conditions in the RMA forecast models.

Historical and forecast BC for flow, turbidity and salinity were developed from sources as summarized in Table 1 through Table 3 below. Stage and export BC were compiled solely from DWR O&M sources. Due to low turbidity at the model boundaries, forecast turbidity was modeled as a constant.

Examination of the CDEC and USGS flow time series for the San Joaquin River at Vernalis showed a shift in the flow rating on December 13, 2011 of about +240 cfs. The new flow time series was used for the Vernalis flow BC for the "historical" period. The downloaded CNRFC "observed" and "forecast" flows incorporate the shift in the flow rating.

As with the previous forecast, two "internal" turbidity boundary conditions were applied in the turbidity modeling. The two internal turbidity boundaries were located on the Sacramento River at Mallard Island and Cache Slough at Ryer Island (Figure 1).

Flow and Turbidity Model Results

Boundary inflow was low during this period as there have been no recent rain events, and turbidity measurements indicate suspended sediment loading from the watersheds is very low. Depending on time and location within the Delta, measured turbidity was instead partly due to resuspension of sediments due to tidal action and/or wind events. Turbidity was low throughout the Delta, ranging from about 5 - 40 NTU in the raw data at nearly all locations. Turbidity data was noisy at many locations, which was particularly evident as turbidity values were so low.

These types of conditions - low boundary inflow and low watershed sediment loading with in-Delta turbidity due to sediment resuspension - are outside the current turbidity model design as turbidity is being modeled not suspended sediment. Additionally, the turbidity model calibration was optimized for high flow conditions with substantial loading from the watersheds, conditions that are hypothesized to lead to movement of delta smelt into the interior of the Delta as they follow flow and turbidity cues.

Flow and turbidity BC are illustrated in Figure 2 through Figure 8, while Figure 9 through Figure 12 illustrate export levels and Old+Middle River flows. Using information supplied by O&M for historical and forecast State (SWP) and Federal (CVP) exports, Figure 9 illustrates that daily-averaged exports decreased from a maximum of ~10,000 cfs in early December to ~ 6,000 cfs by the end of January,. Figure 10 and Figure 11 are plots of Old River and Middle River flows and daily-averaged flows, respectively, while Figure 12 illustrates the combined Old+Middle River flow criterion (3-day center-weighted average) compared with CDEC data.

Figure 13 is a comparison of model output and data at the three compliance locations, and Figure 14 is a similar plot in the SWP export area. Note that Figure 14 is a comparison of data inside Clifton Court Forebay with model output at the entrance to the Forebay. For these two figures, data were cleaned (noisy values removed) and missing data filled with linear approximation. The cleaned and filled data were also daily averaged for comparison with daily-averaged model output.

Turbidity was below compliance values (12 NTU) at two of these three locations. At Holland Cut, the turbidity went above the compliance value for several days in early December, late December, and early January almost certainly due to wind events (see first WY2012 forecast report).

Figure 15 and Figure 16 illustrate the progression of the main turbidity boundary conditions at Freeport and Vernalis down the Sacramento and San Joaquin Rivers, respectively. Figure 17 through Figure 23 are plots of model output compared with raw CDEC turbidity data at several in-Delta locations - these locations can be found on a map of the Delta in Figure 24. The turbidity model captured the very low measured turbidity in the south and central Delta (see, for example Figure 22 and Figure 23).

Adult Delta Smelt Particle Tracking Model Results

Figure 25 through Figure 28 present the turbidity contour plots and particle tracking model results for the runs using the data-derived turbidity and EC boundary conditions listed in Table 2 and Table 3 - RMA-modeled turbidity is in left plot and particle tracking model results are in the right plot. The Delta Smelt behavioral model was run November 01, 2011 to January 31, 2012 - 50,000 particles were inserted on November 01. These plots illustrate that just prior to and during the forecast period, modeled turbidity in the Delta was very low. The delta smelt behavioral model results illustrate that the distribution of the particles is centered along the Sacramento River and the region at the confluence with the San Joaquin River. A few particles stray into the Cache Slough area after Jan 01. However, no particles reached the export locations by the end of the simulation.

MWD Training

Model input files and results were provided to Chuching Wang for remote access on the RMA intranet.

List of Acronyms:
WY ~ Water Year
SWP ~ State Water Project
CCFB ~ Clifton Court Forebay
CNRFC ~ California-Nevada River Forecasting Center
CDEC ~ California Data Exchange Center
CIMIS ~ California Irrigation Management System

CDEC Stations:
FPT ~ Freeport
MAL~ Sacramento River at Mallard Island
RYI ~ Cache Sl. at Ryer Island
SMR ~ South Fork Mokelumne River
MRZ ~ Martinez
VNS ~ Vernalis

DSM2 Boundary Locations:
RMKL070 ~ Mokelumne River
RCSM075 ~ Cosumnes River
RCAL009 ~ Calaveras River
RSAN112 ~ San Joaquin River
BYOLO040 ~ Yolo Bypass
RSAC054 ~ Martinez

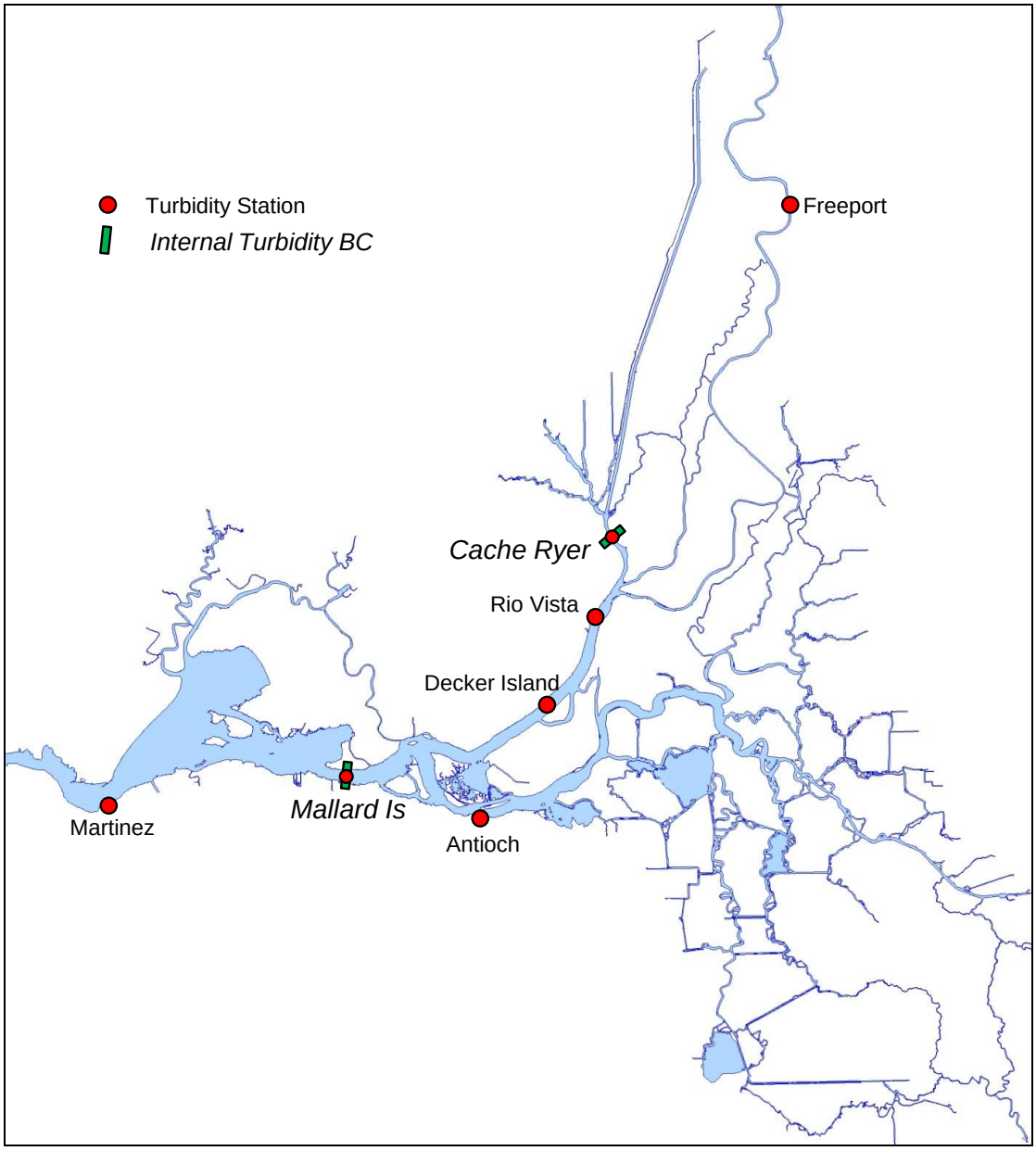

Figure 1 Locations of the internal turbidity boundary conditions added in the current turbidity forecast model run. The internal boundary conditions are located at the Sacramento River at Mallard Island and Cache Slough at Ryer Island.

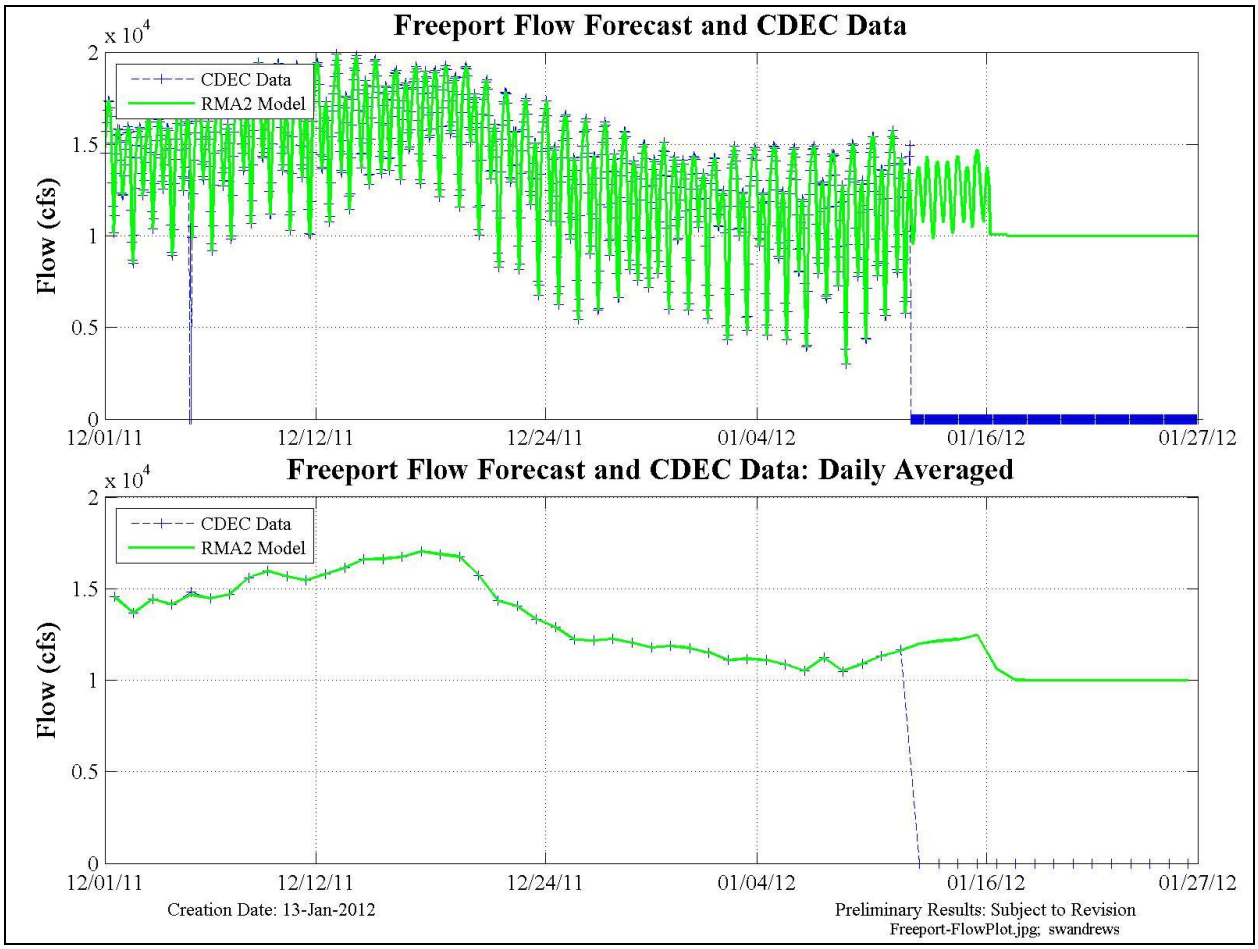

Figure 2 Freeport flow BC was compiled using CDEC data, CNRFC forecast and then extended as a constant. Note y-axis unit is cfs*10,000. Zero values indicate the end of data (blue).

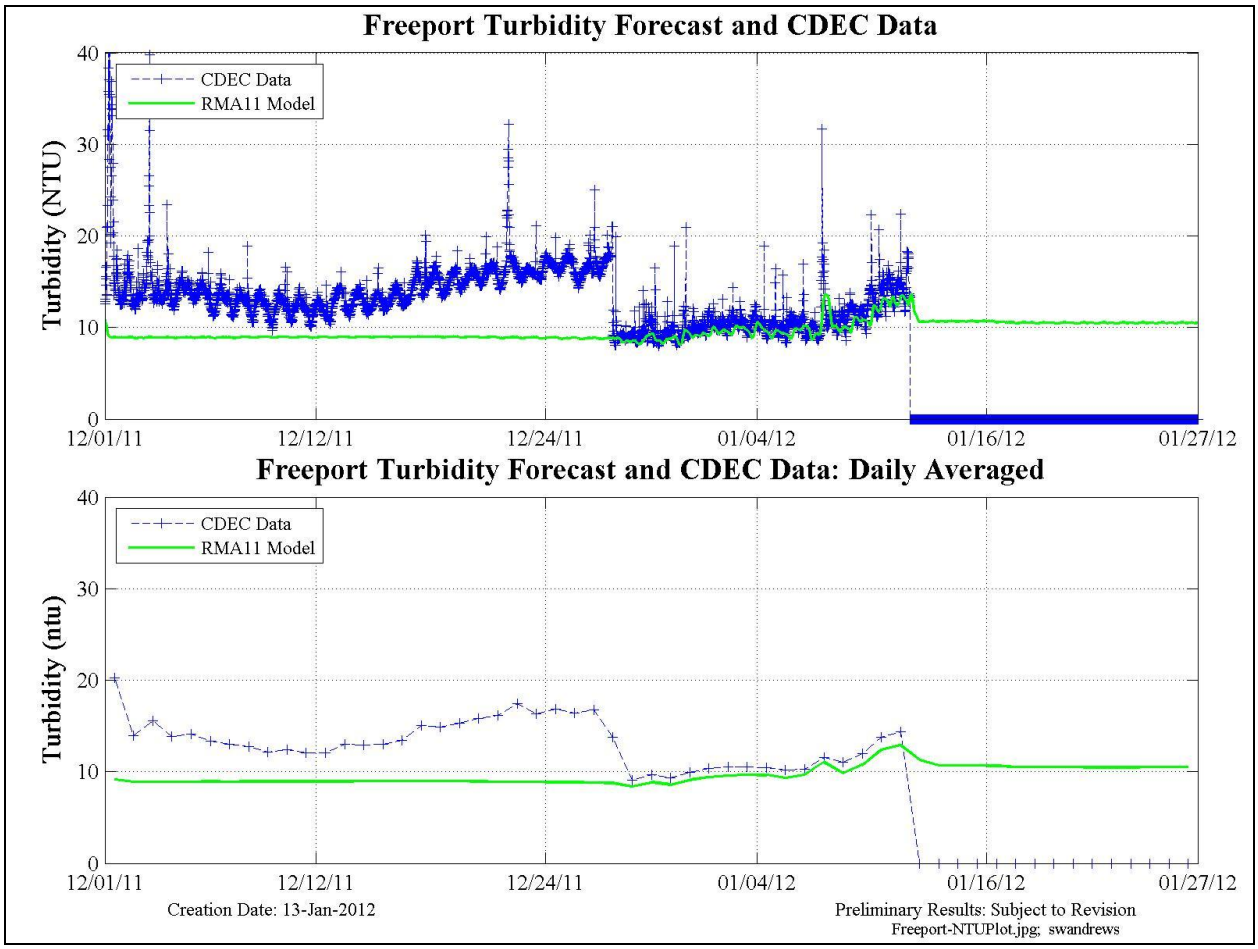

Figure 3 Freeport turbidity BC was compiled using CDEC data, and then extended as a constant. Zero values indicate the end of data (blue). Data prior to Dec. 27, 2011 was linearly interpolated after a comparison to the SRH CDEC station indicated unrealistically high turbidities at the FPT station.

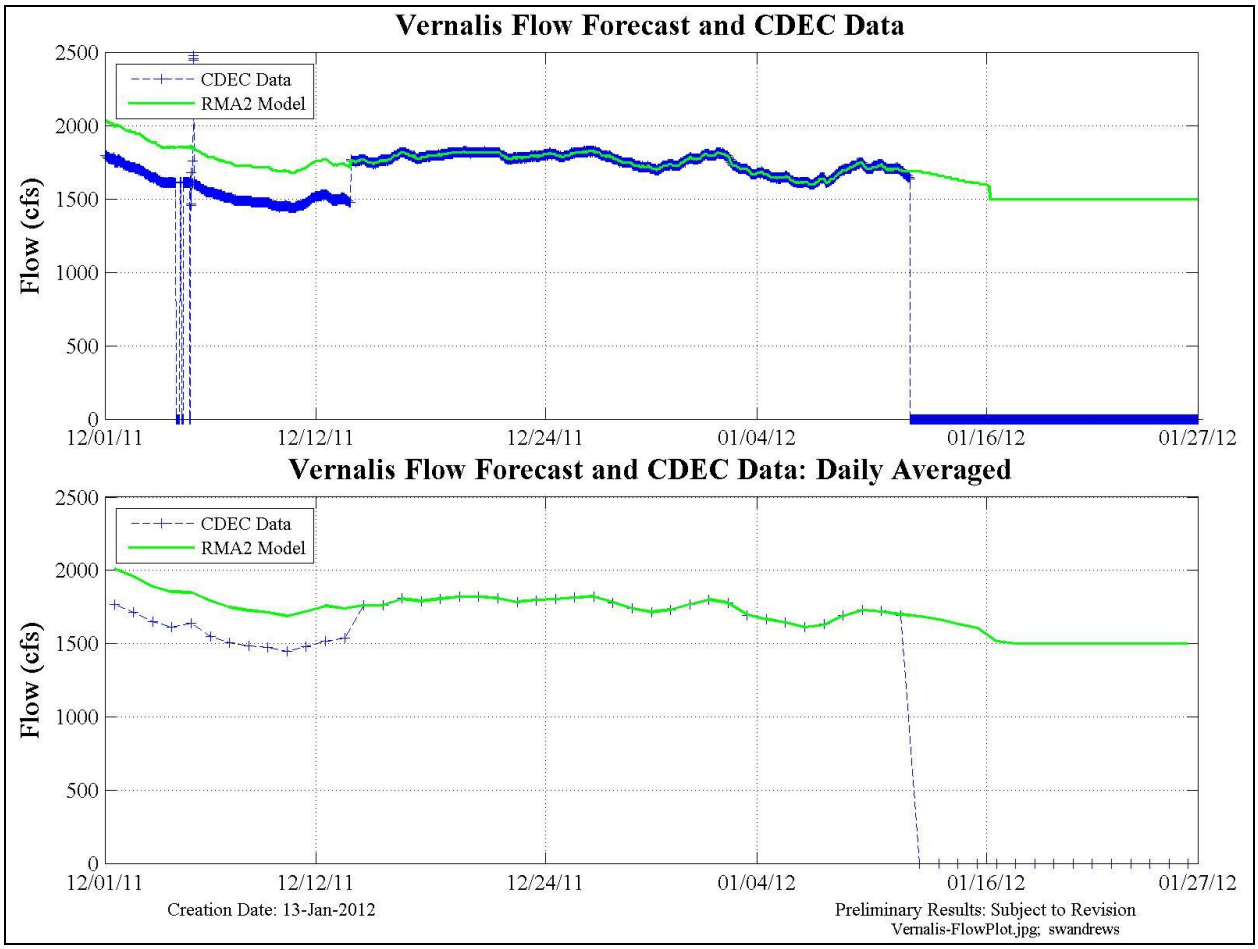

Figure 4 Vernalis flow BC was compiled using CDEC and USGS data and DWR forecast flow. Zero values indicate the end of data (blue). The USGS rating for Vernalis changed Dec. 13, 2011 and is reflected in the RMA2 model flow. The flow was not shifted in the CDEC database prior to Dec. 13, 2011.

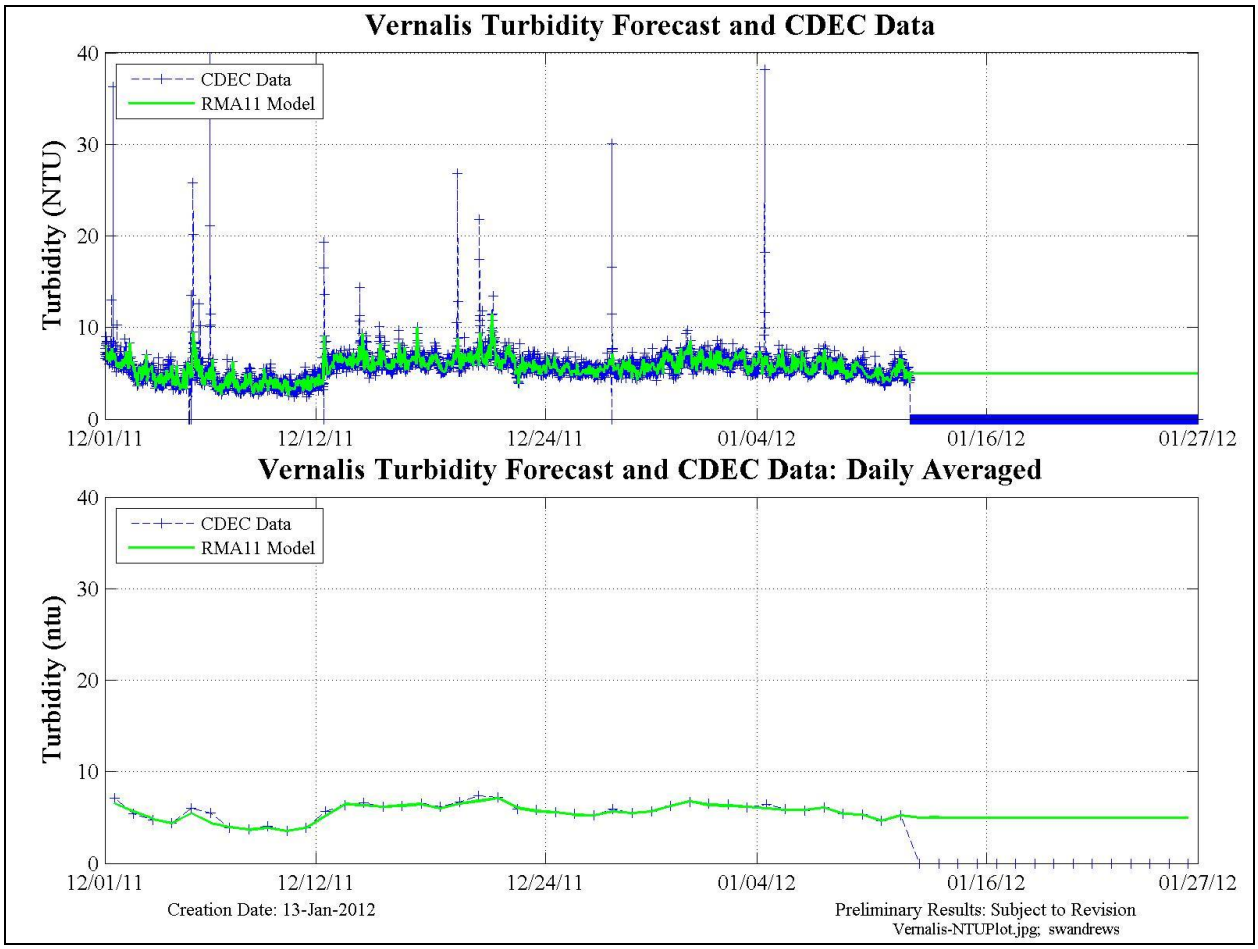

Figure 5 Vernalis turbidity BC was compiled using CDEC data, then extended as a constant. Zero values indicate the end of data (blue).

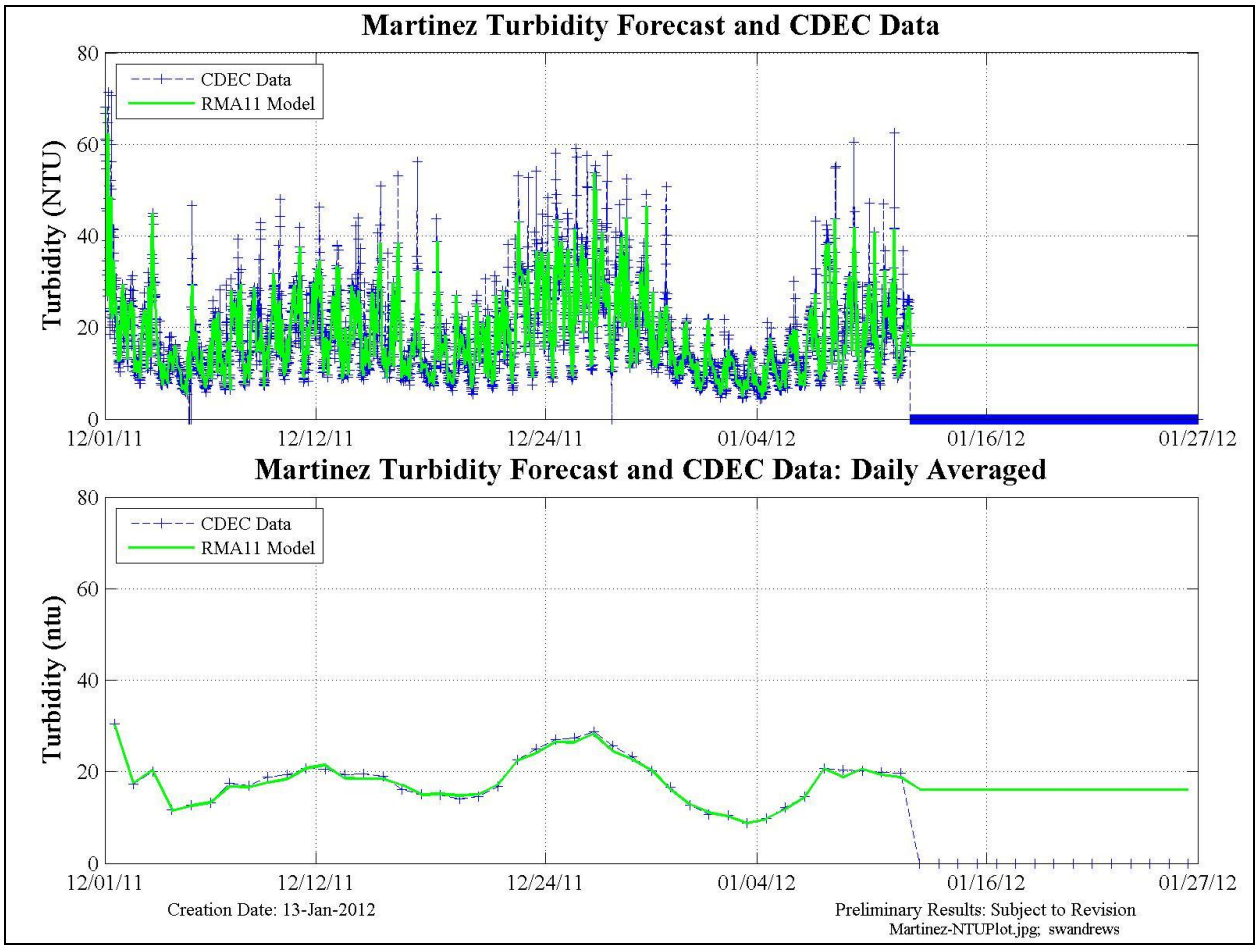

Figure 6 Martinez turbidity BC was compiled from CDEC data then extended linearly to a value of 16 NTU. Zero values indicate the end of data (blue).

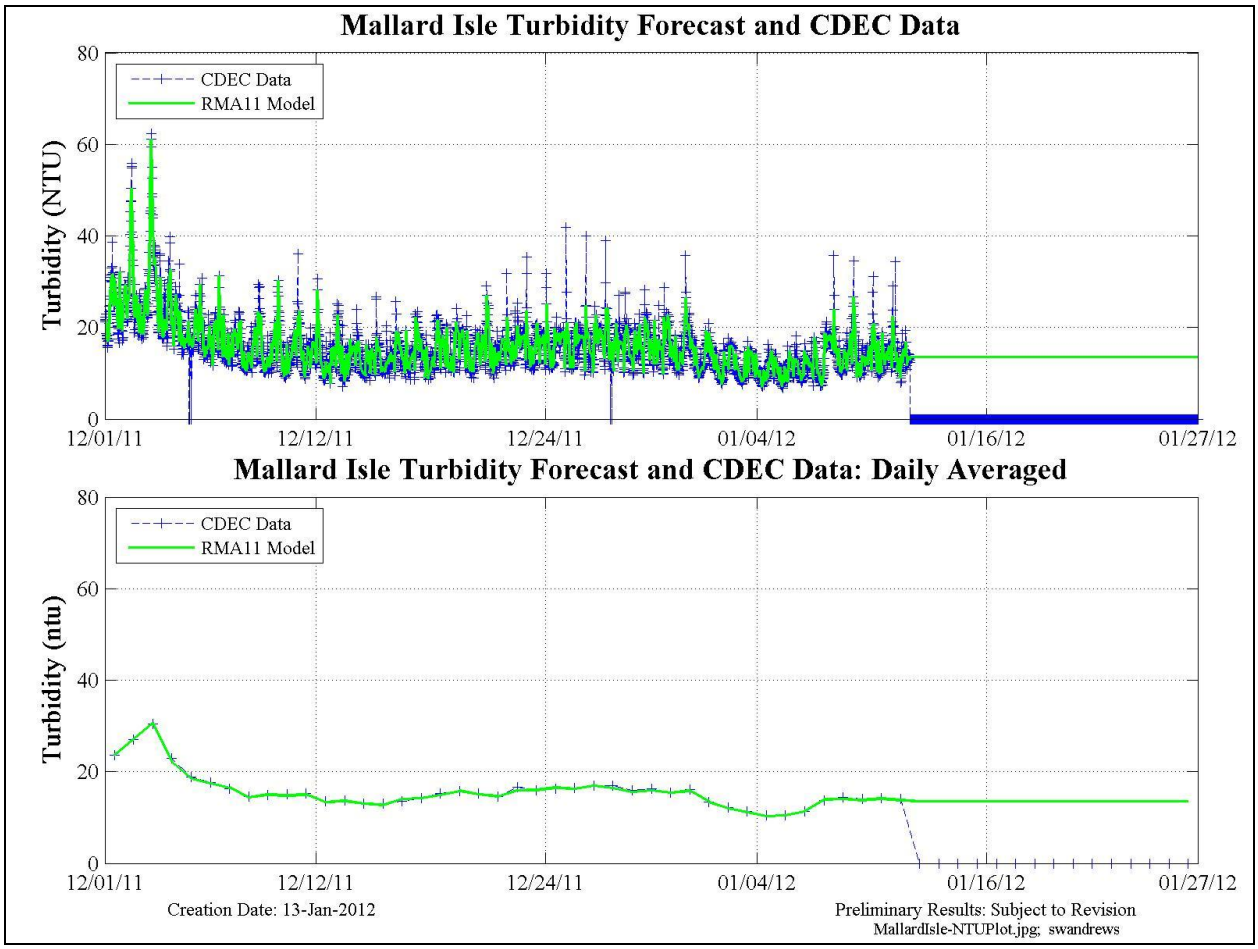

Figure 7 The Sacramento River at Mallard Island internal turbidity BC compiled from CDEC data then extended linearly to a value of 13.5 NTU. Zero values indicate the end of data (blue).

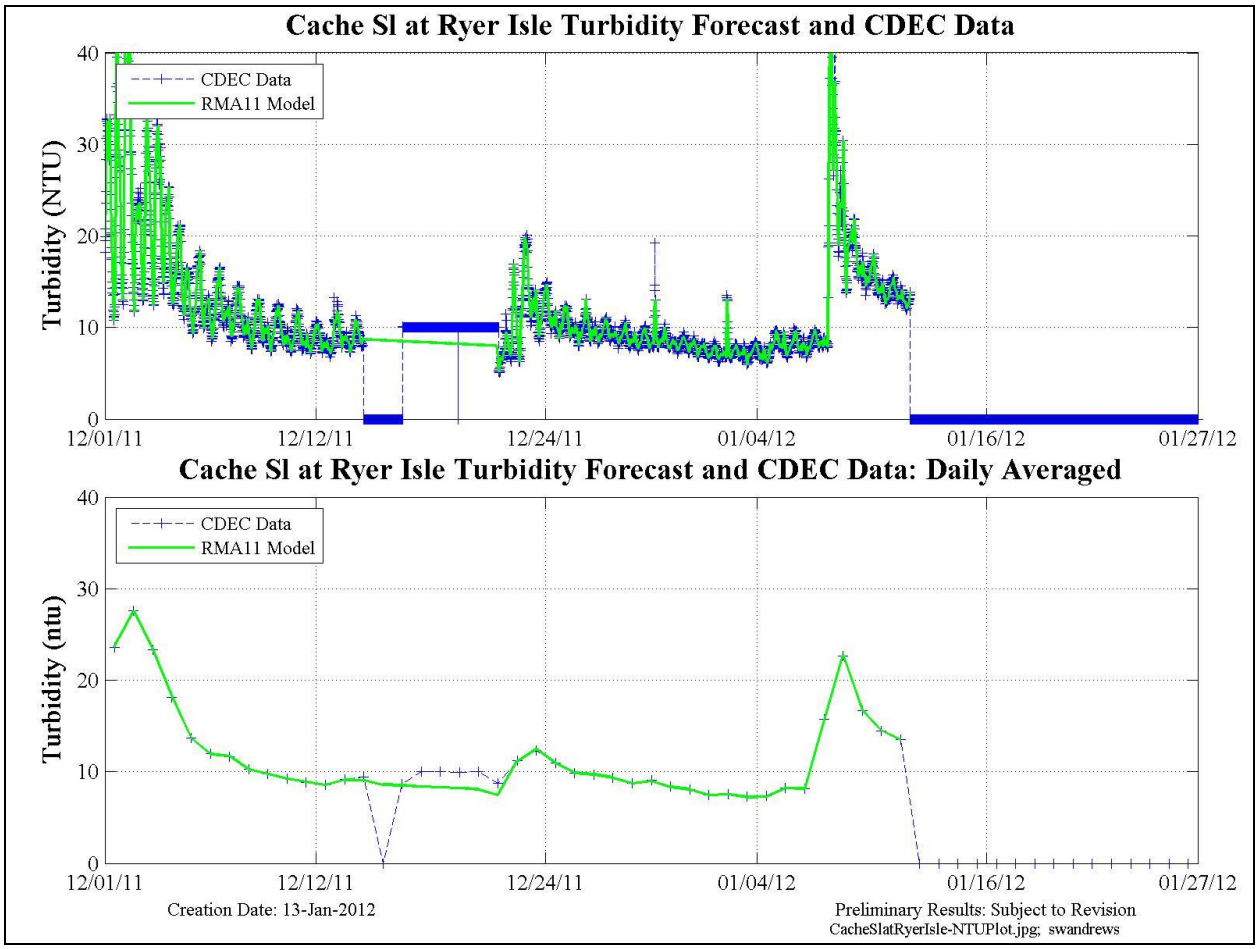

Figure 8 The Cache Slough at Ryer Island internal turbidity BC compiled from CDEC data. The boundary condition was not applied beyond the end time of the observed data. Zero values indicate the end of data application period (blue).

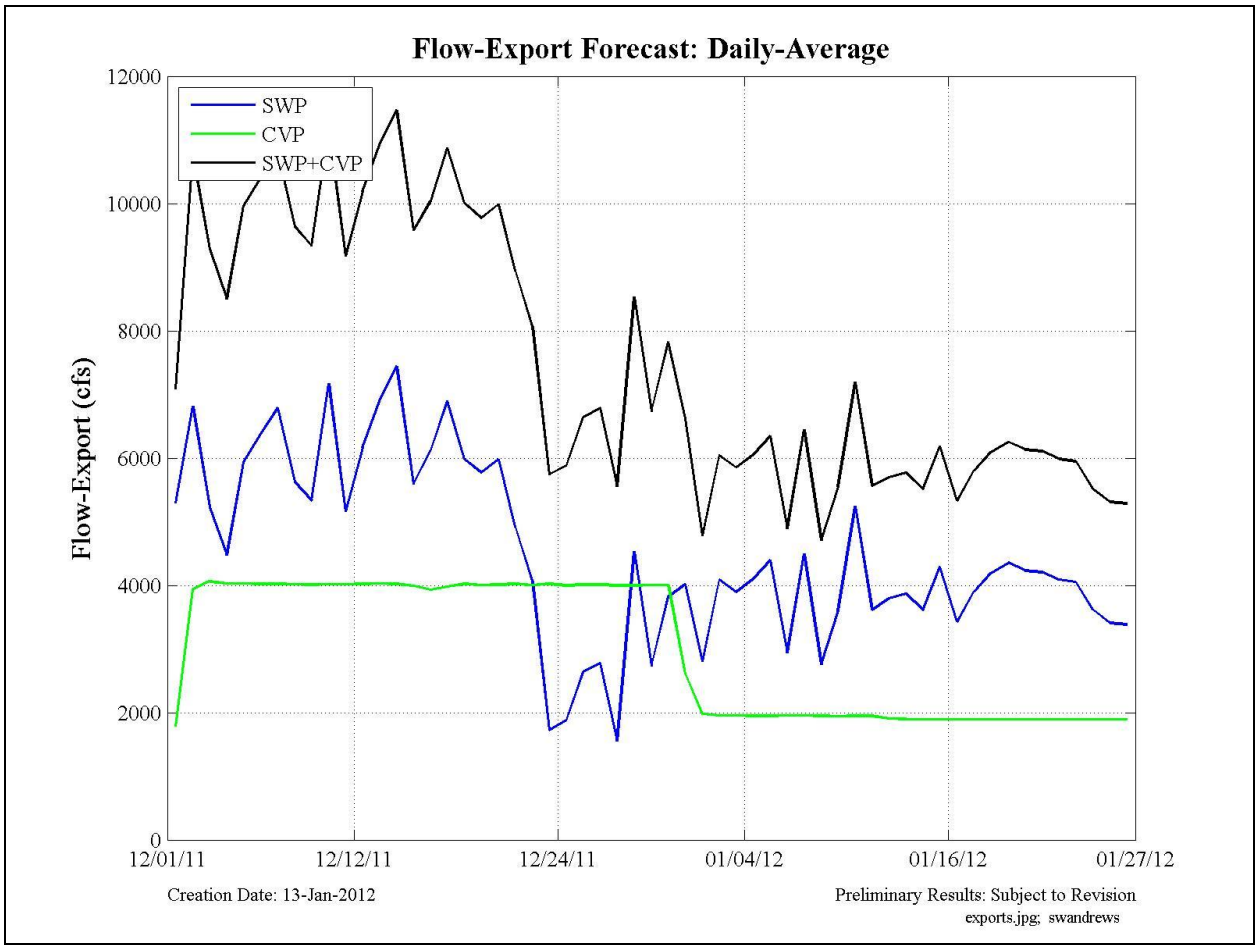

Figure 9 The plot illustrates modeled daily-averaged exports at the SWP and CVP export locations, and the combined SWP+CVP exports.

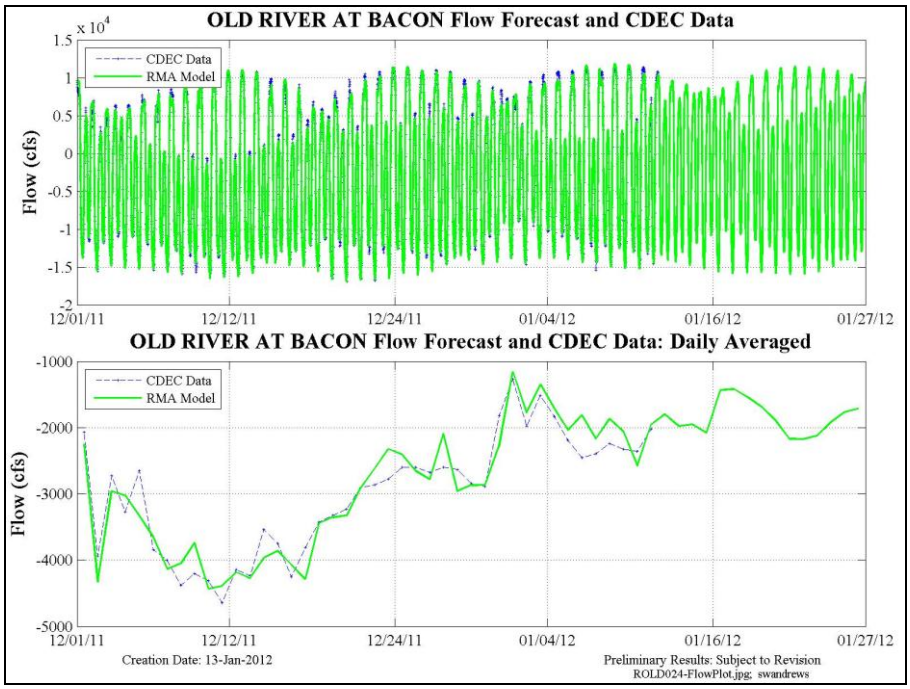

Figure 10 Model flow forecast output and raw CDEC data at Old River at Bacon (ROLD024) location. Both 15-min (upper) and daily averaged (lower) plots are shown.

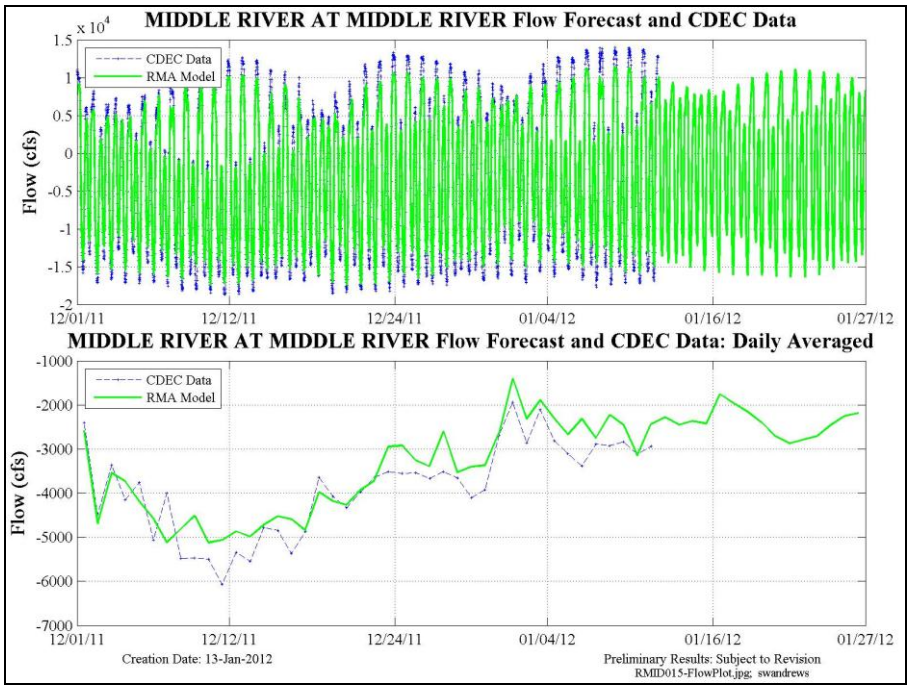

Figure 11 Model flow forecast output and raw CDEC data the Middle River-at-Middle (RMID015) location. Both 15-min (upper) and daily averaged (lower) plots are shown.

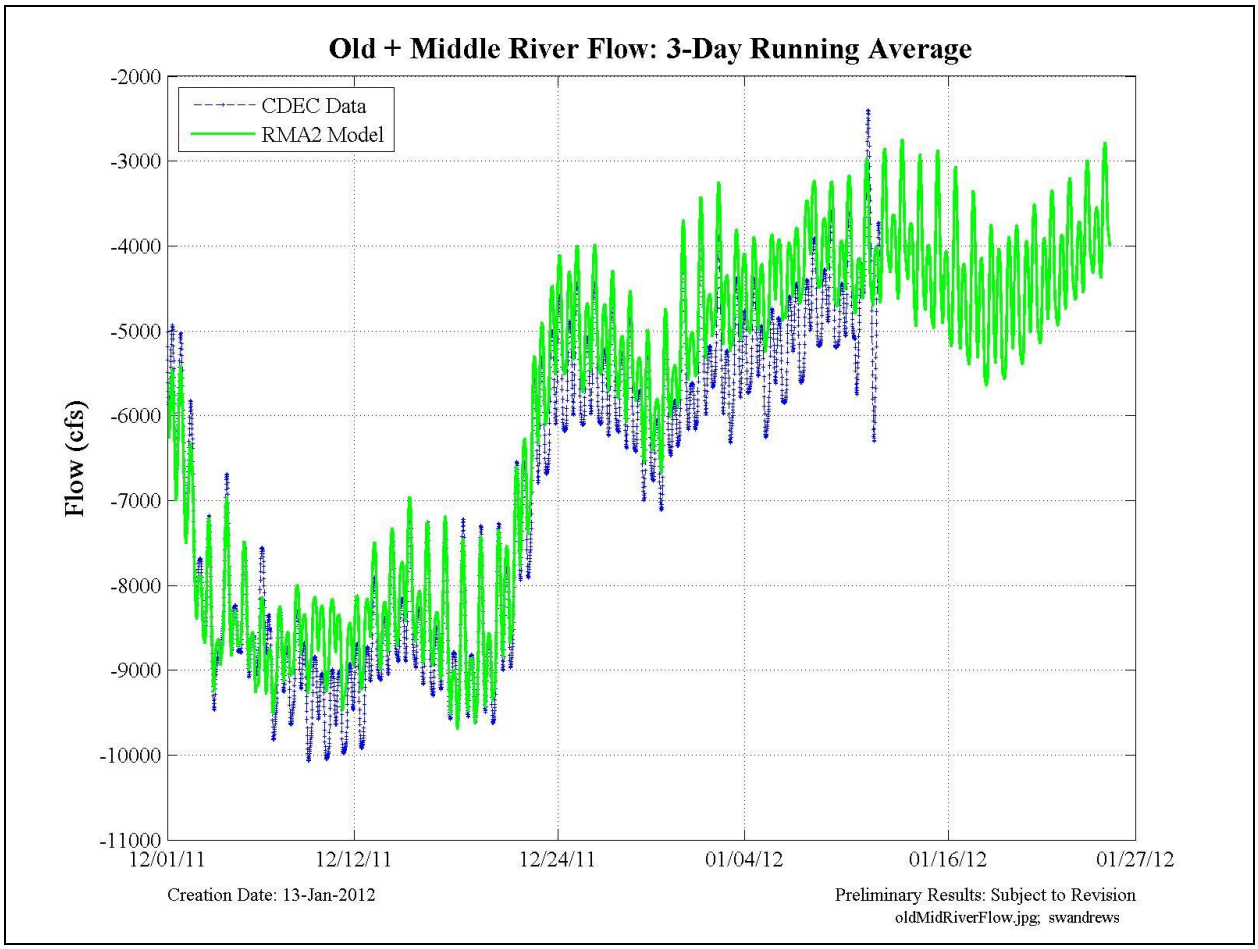

Figure 12 Model flow forecast output and raw CDEC data for the Old+Middle River flow criterion for three-day running-average flow.

Table 1 Boundary condition development for flow for this forecast period.

January 12, 2012	Historical DWR BC	Definition Historical Flow	Definition Forecast Flow	Comment
BC Location				
Yolo Bypass	Not used	Hourly CDEC LIS, cleaned+filled	Hourly CNRFC forecast (Yolo at Lisbon) for 5 days, 300 cfs after	ignored DWR predicted flow, was too low, kept with constant flow from previous week
Sacramento River at Freeport	Not used	Hourly CDEC FPT, cleaned+filled	Hourly CNRFC forecast (Sac R at I St.) for 5 days, Daily DSM2 RSAC155 after	
Mokelumne River	Daily DSM2 RMKL070, converted to hourly	Not used	Daily DSM2 RMKL070, converted to hourly	
Cosumnes River	Not used	Hourly CNRFC Cosumnes-McConnell, cleaned+filled	Hourly CNRFC forecast (Cosumnes R at McCon) for 5 days, Daily DSM2 RCSM075 after	
Calaveras River	Not used	Hourly CDEC MRS, cleaned+filled	Daily DSM2 RCAL009, converted to hourly	Shifted CDEC data 28Nov-12Dec +37cfs to account for jump in data record
San Joaquin River at Vernalis	Not used	Hourly CDEC VNS, cleaned+filled	Hourly CNRFC forecast (SJ R at Vernalis) for 5 days, Daily DSM2 RSAN112 after	CDEC data shifted 240 cfs prior to Dec 13 to match USGS site data
Stage - Martinez		15MIN CDEC Martinez stage, cleaned+filled, and shifted -2.38 ft.		

Table 2 Boundary condition development for turbidity for this forecast period.

January 12, 2012	Definition Historical NTU	Definition Forecast NTU	Comment
BC Location			
Yolo Bypass	15min CDEC RYI, cleaned+filled, hourly averaged	extended as constant	
Cache Slough at Ryer internal BC	15min CDEC RYI, cleaned+filled, hourly averaged	not applied	
Sacramento River at Freeport	15min CDEC FPT, cleaned+filled, hourly averaged then shifted -15hrs to account for travel time from upstream boundary	extended as constant	Constant value of 9.5NTU used between Dec. 1 and Dec. 27 because of FPT sensor problem
Mokelumne River	15min CDEC SMR, cleaned+filled, daily averaged then converted to hourly	extended as constant	
Cosumnes River	15min CDEC SMR, cleaned+filled, daily averaged then converted to hourly	extended as constant	
Calaveras River	15min CDEC RRI, cleaned+filled, hourly averaged	extended as constant	
San Joaquin River at Vernalis	15min CDEC SJR, cleaned+filled, hourly averaged	extended as constant	
Sacramento River at Mallard Island internal BC	15min CDEC MAL, cleaned+filled, hourly averaged	extended as constant	
Martinez	15min CDEC MRZ, cleaned+filled, hourly averaged	extended as constant	

Table 3 Boundary condition development for EC for this forecast period.

December 29, 2011	Historical DWR BC	Definition Historical EC	Definition Forecast EC	Comment
BC Location				
Yolo Bypass	Not used	15min CDEC RYI, cleaned+filled, hourly averaged	extend as constant	
Sacramento River at Freeport	Not used	15min CDEC FPT, cleaned+filled, hourly averaged	extend as constant	Shift back 15 hrs
Mokelumne River	Not used	15min CDEC SMR, cleaned+filled, filtered to remove tidal spikes in EC from the Sac River, daily averaged then converted to hourly	extend as constant	Daily-avg to remove tidal variation, filter when when DCC open
Cosumnes River	Not used	15min CDEC SMR, cleaned+filled, filtered to remove tidal spikes in EC from the Sac River, daily averaged then converted to hourly	extend as constant	Daily-avg to remove tidal variation, filter when when DCC open
Calaveras River	Not used	15min CDEC RRI, cleaned+filled, hourly averaged	extend as constant	tidal variation not removed
San Joaquin River at Vernalis	Not used	15min CDEC SJR, cleaned+filled, hourly averaged	extend as constant	
Martinez	Not used	15min CDEC MRZ, cleaned+filled, hourly averaged	DWR forecast (quality.dss)	

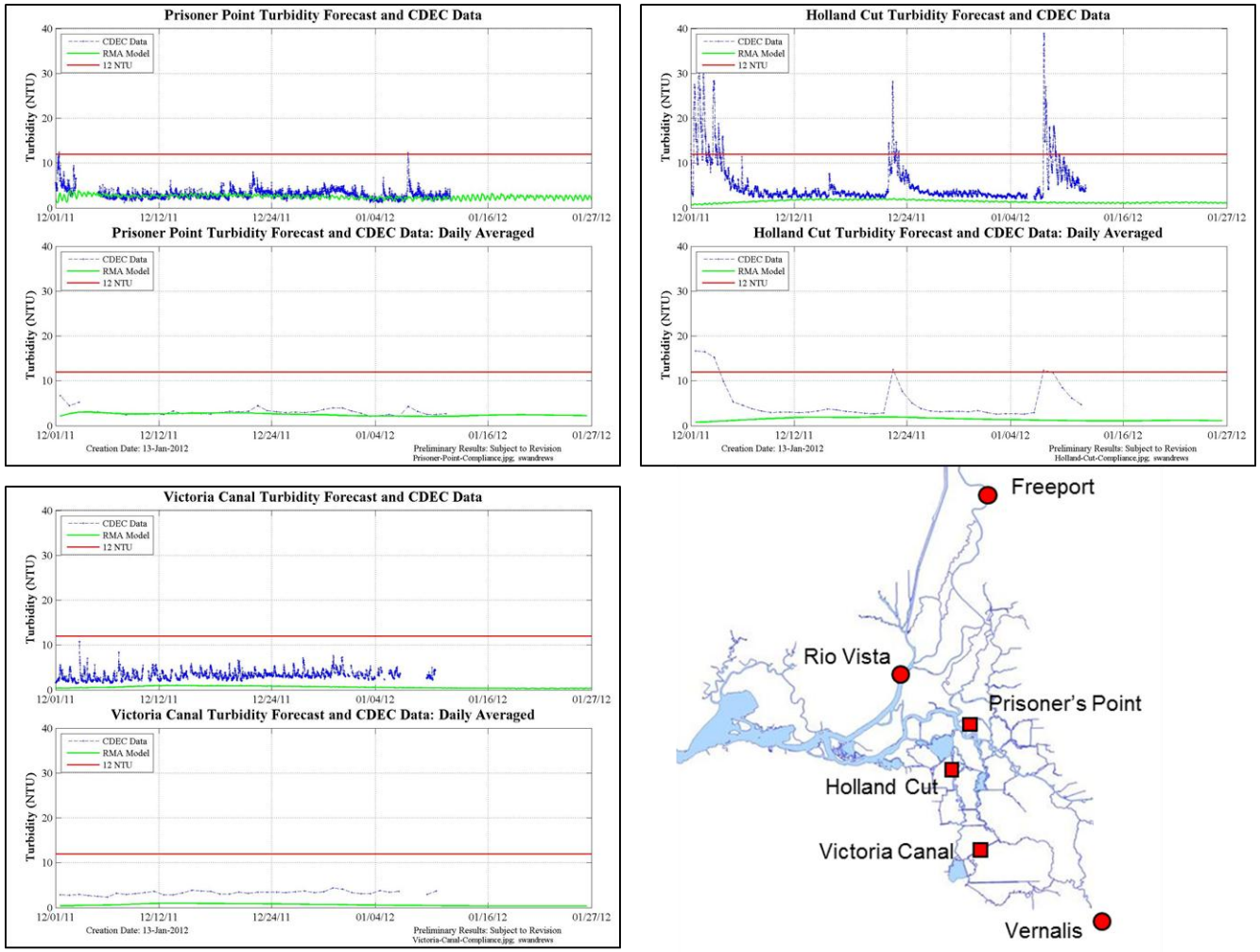

Figure 13 Modeled turbidity and data (cleaned and filled) at the three compliance locations. Both 15-min model output and data and daily averaged plots are shown. Red line illustrates the 12-NTU compliance value.

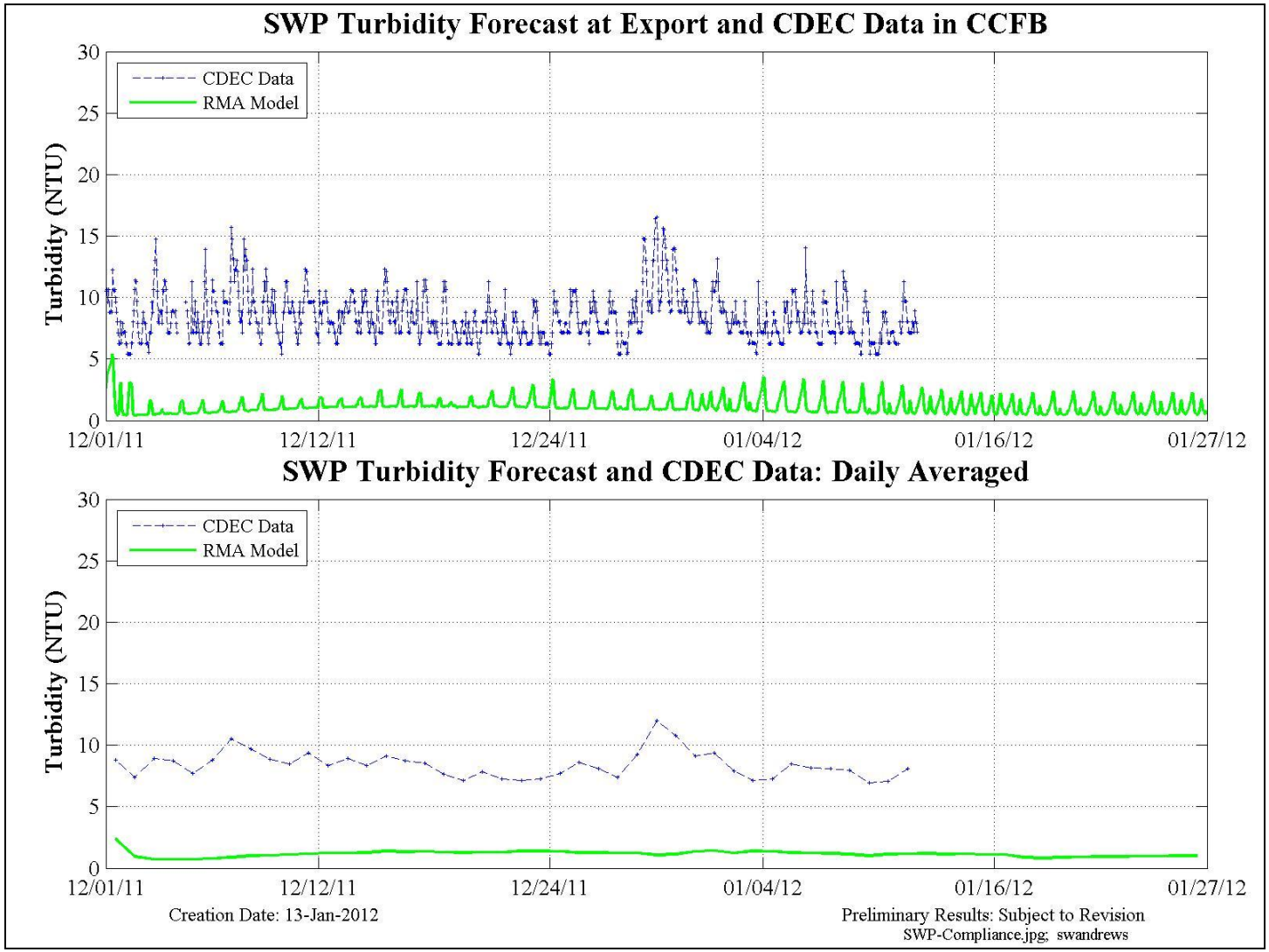

Figure 14 Plots compare model output at the SWP export location with data gathered inside Clifton Court Forebay. Both 15-min model output and daily averaged plots are shown.

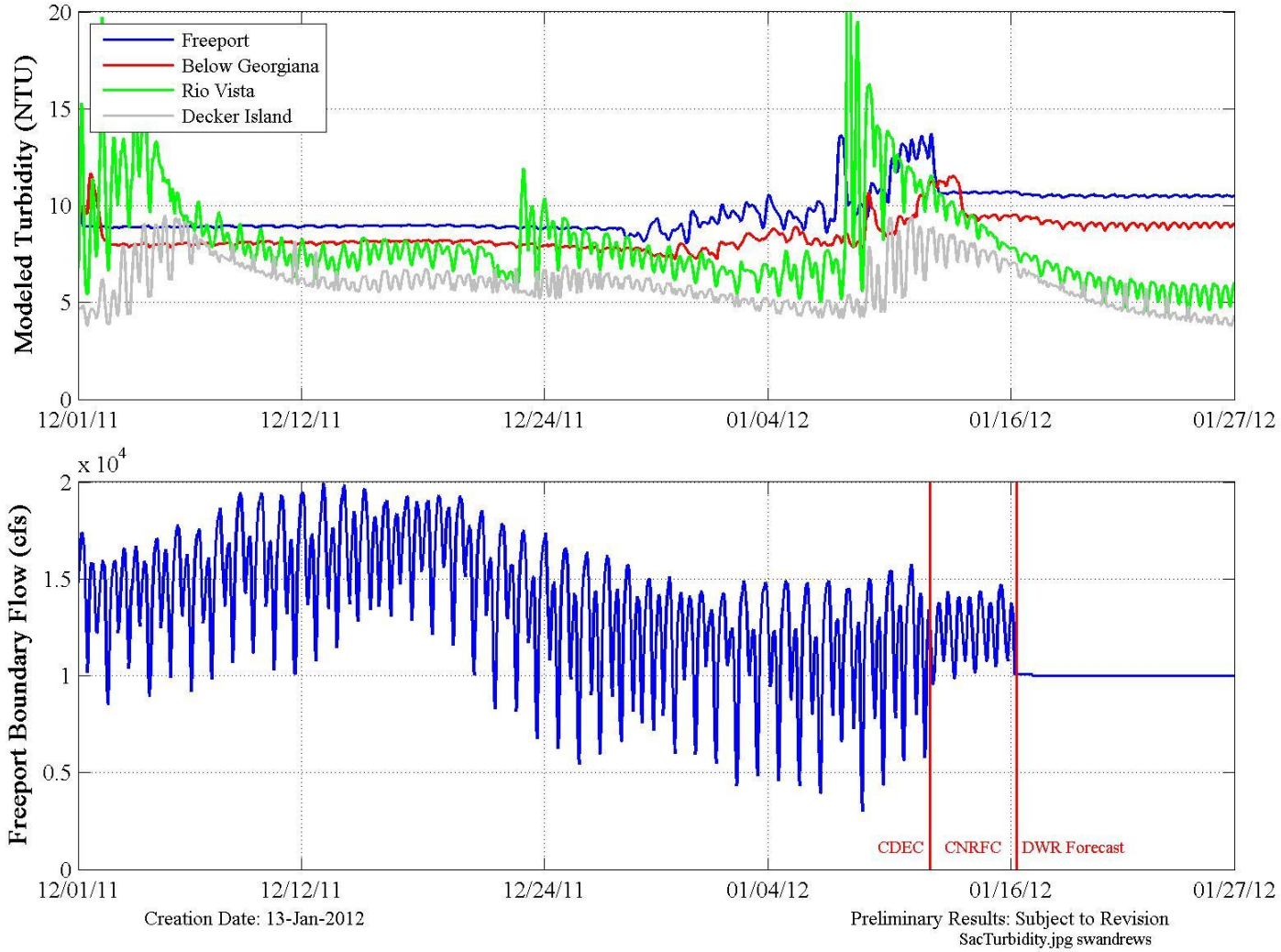

Figure 15 Freeport turbidity boundary condition progression down the Sacramento R. (upper plot) along with the flow boundary (lower plot) used during the historical and forecast periods. Forecast began on Jan. 12, 2012.

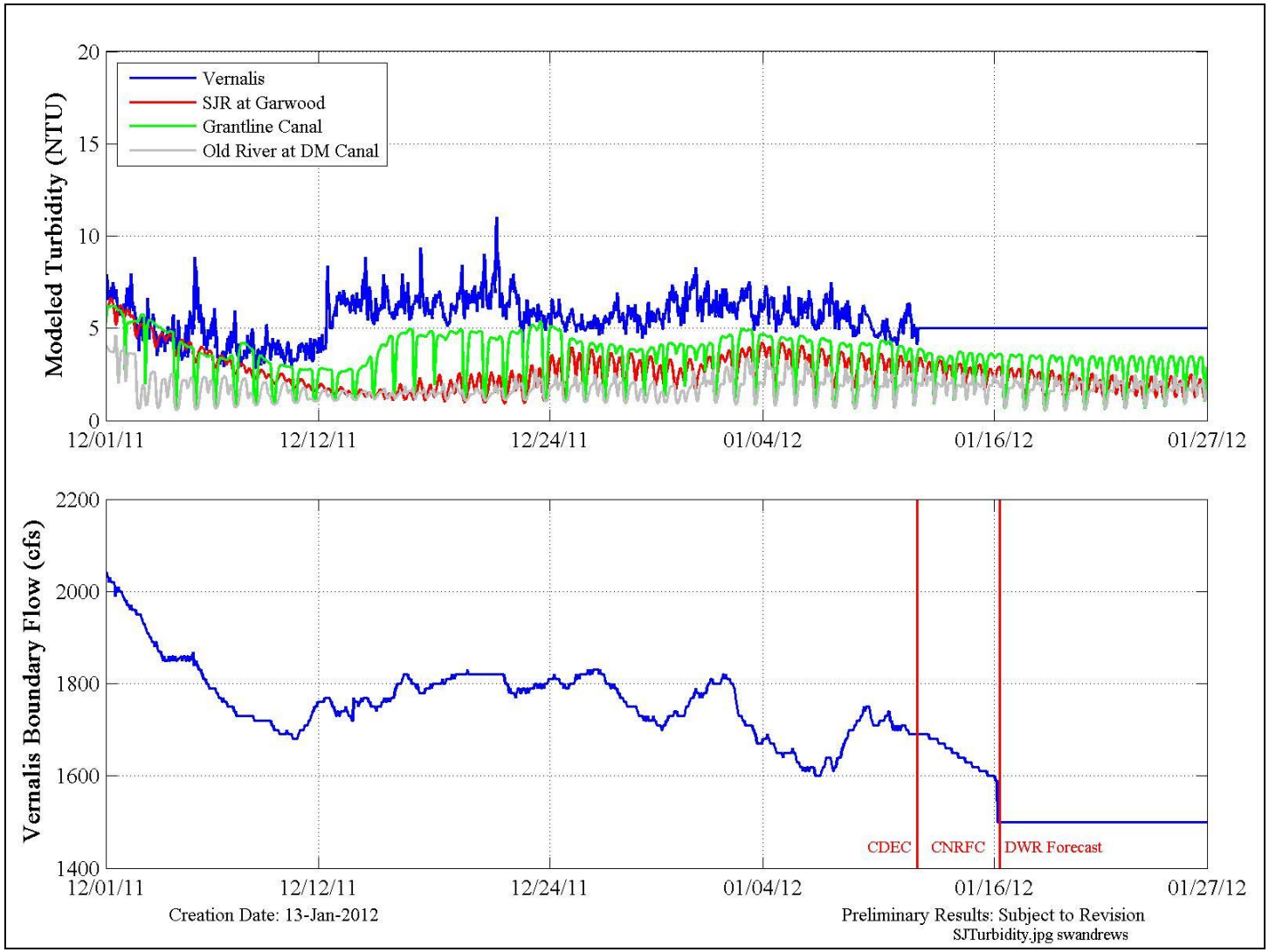

Figure 16 Progression of the turbidity boundary condition from Vernalis down the San Joaquin R. to Garwood, and down Old River. Vernalis flow forecast periods indicated by red lines (upper plot). Flow boundary conditions at Vernalis are shown in the lower plot.

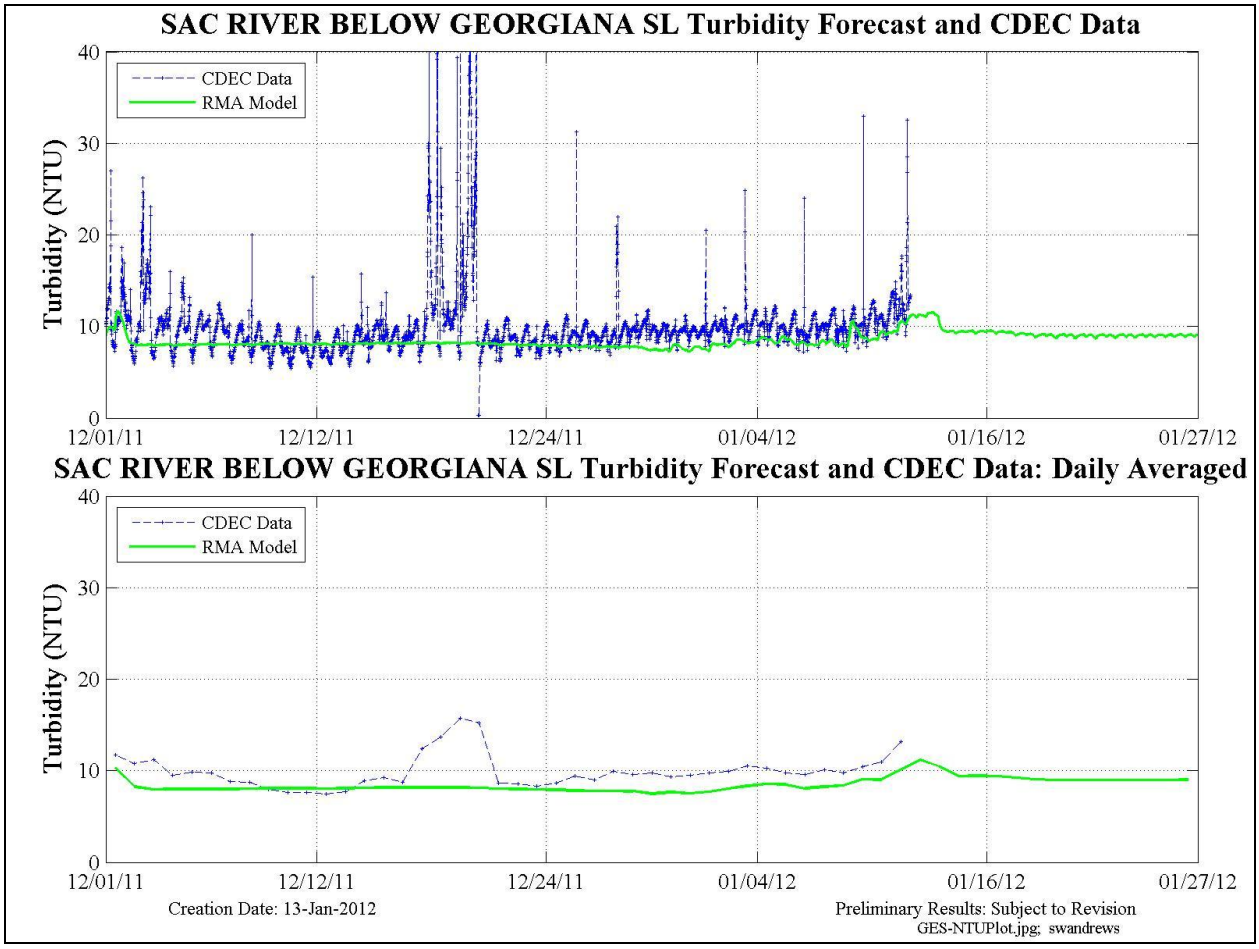

Figure 17 Model forecast and raw CDEC data at Sac. River Below Georgiana Sl. Both 15-min (upper) and daily averaged (lower) plots are shown.

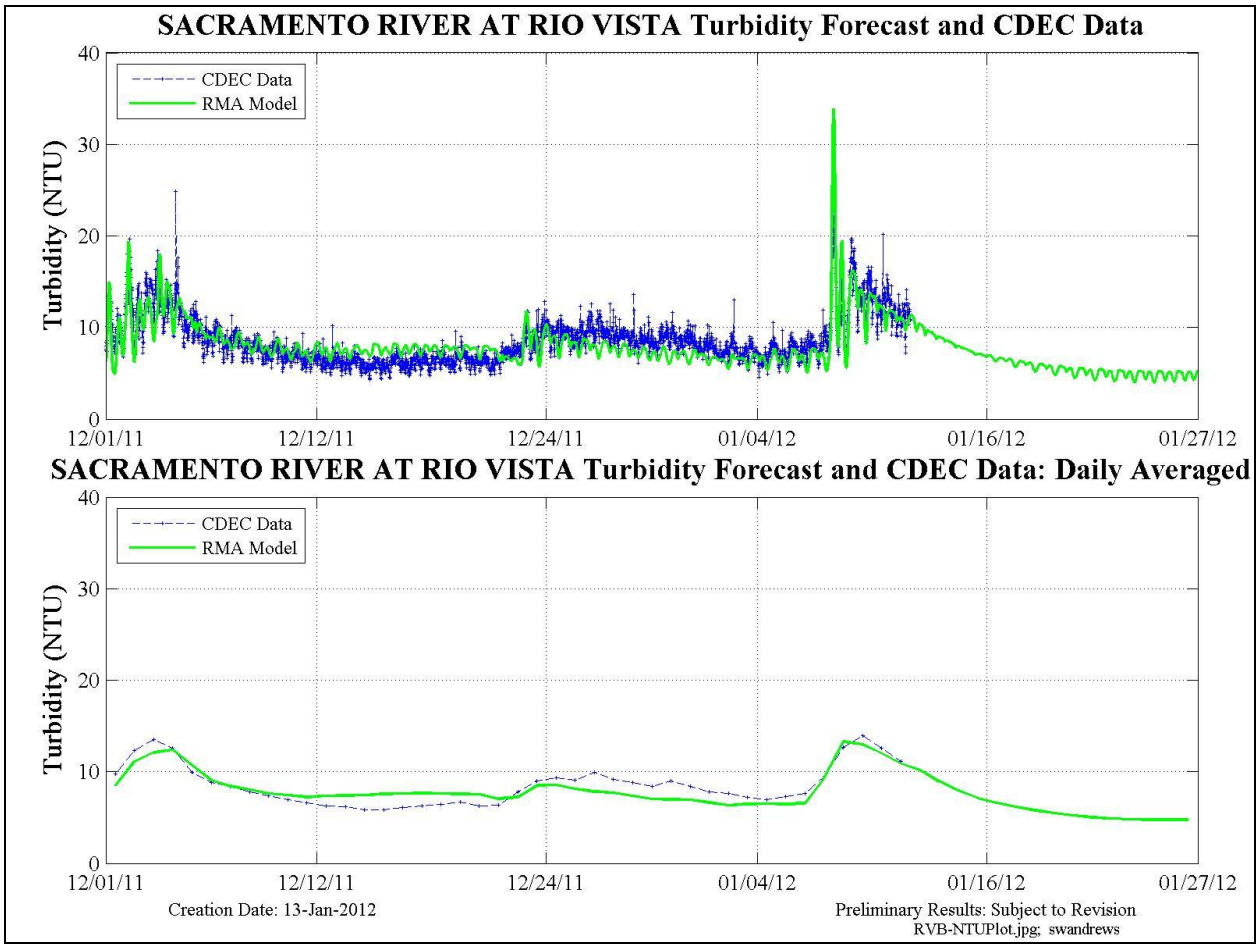

Figure 18 Model forecast and raw CDEC data at Rio Vista. Both 15-min (upper) and daily averaged (lower) plots are shown.

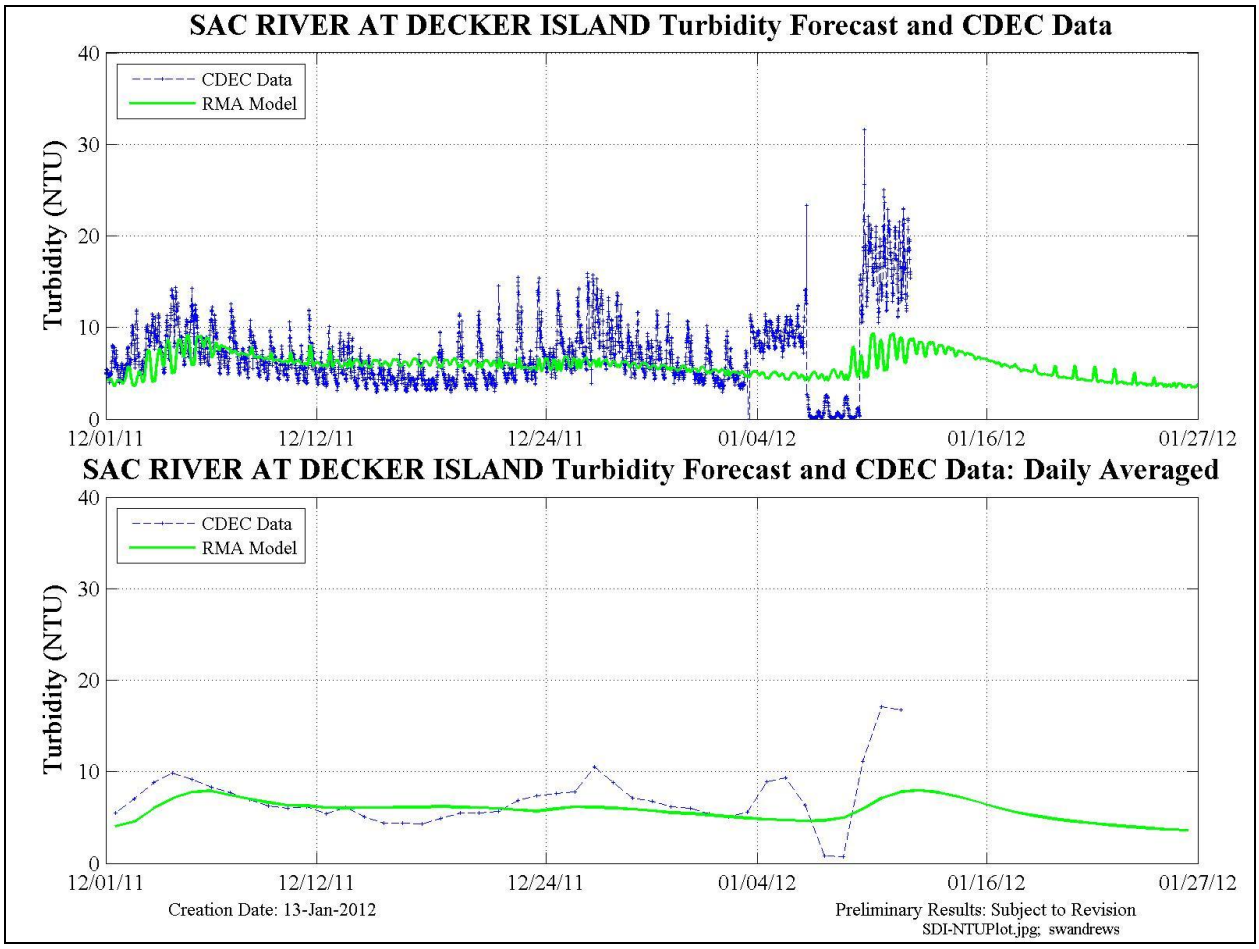

Figure 19 Model forecast and raw CDEC data at Decker Island. Both 15-min (upper) and daily averaged (lower) plots are shown.

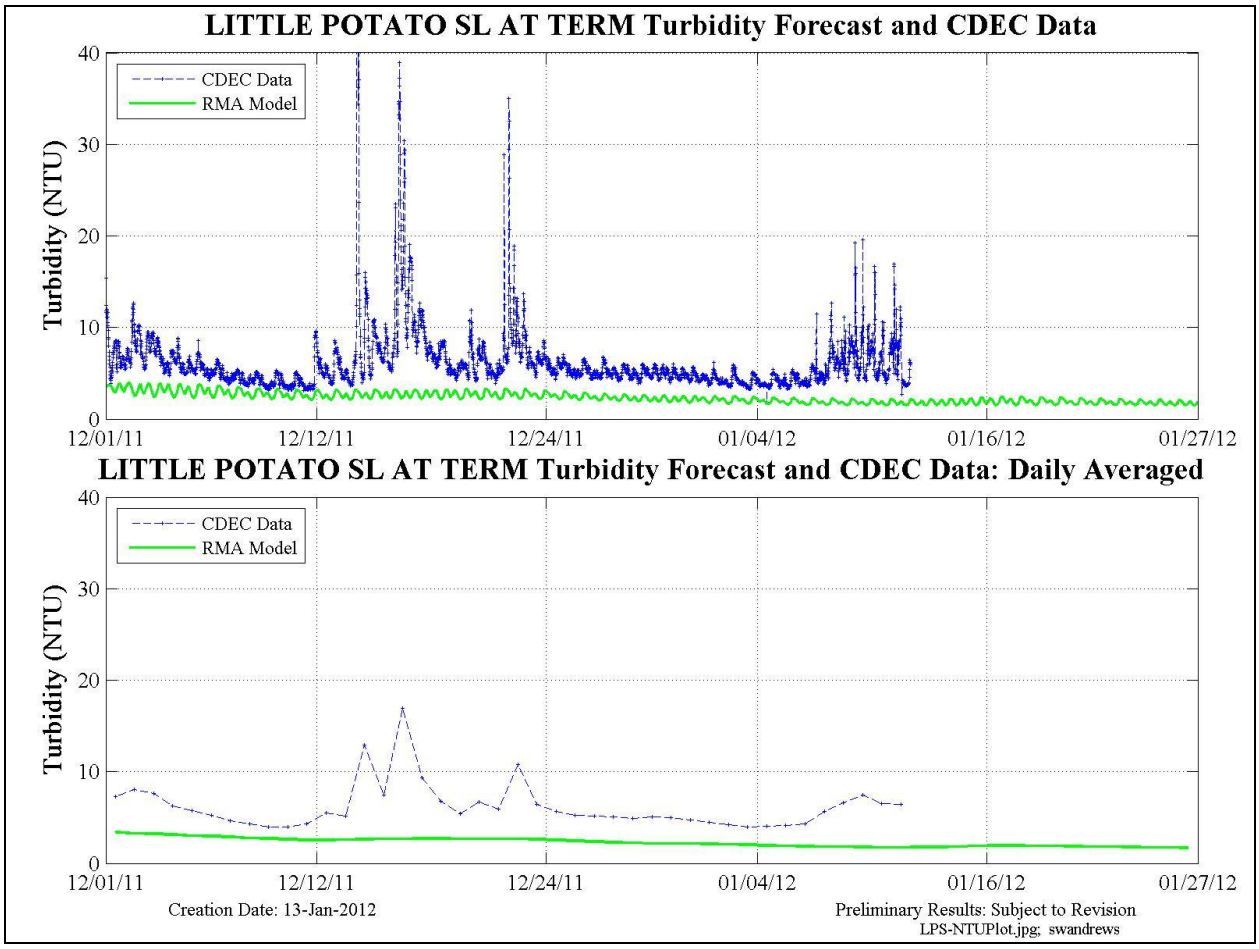

Figure 20 Model forecast and raw CDEC data at Little Potato Slough at Terminous. Both 15-min (upper) and daily averaged (lower) plots are shown.

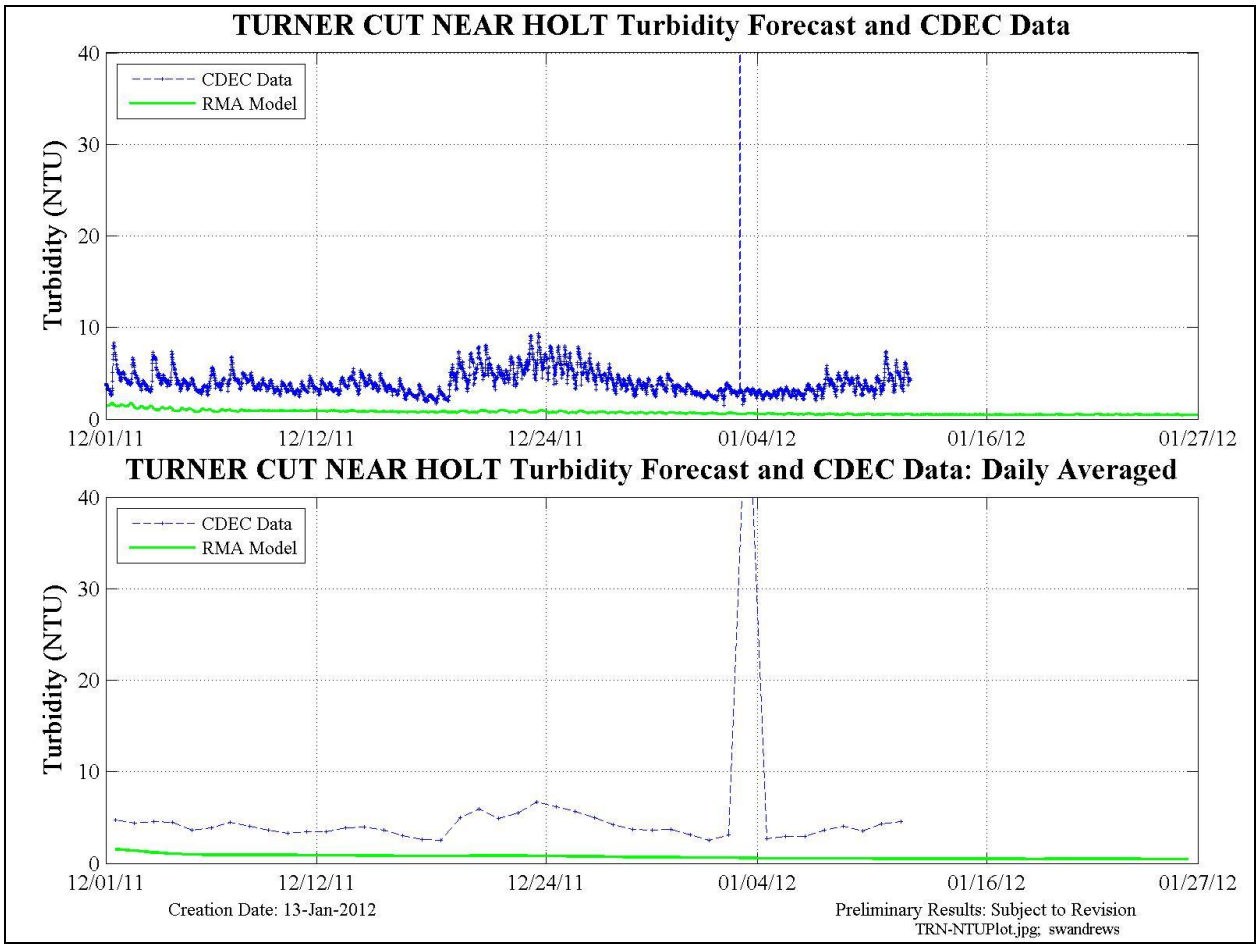

Figure 21 Model forecast and raw CDEC data at Turner Cut near Holt. Both 15-min (upper) and daily averaged (lower) plots are shown.

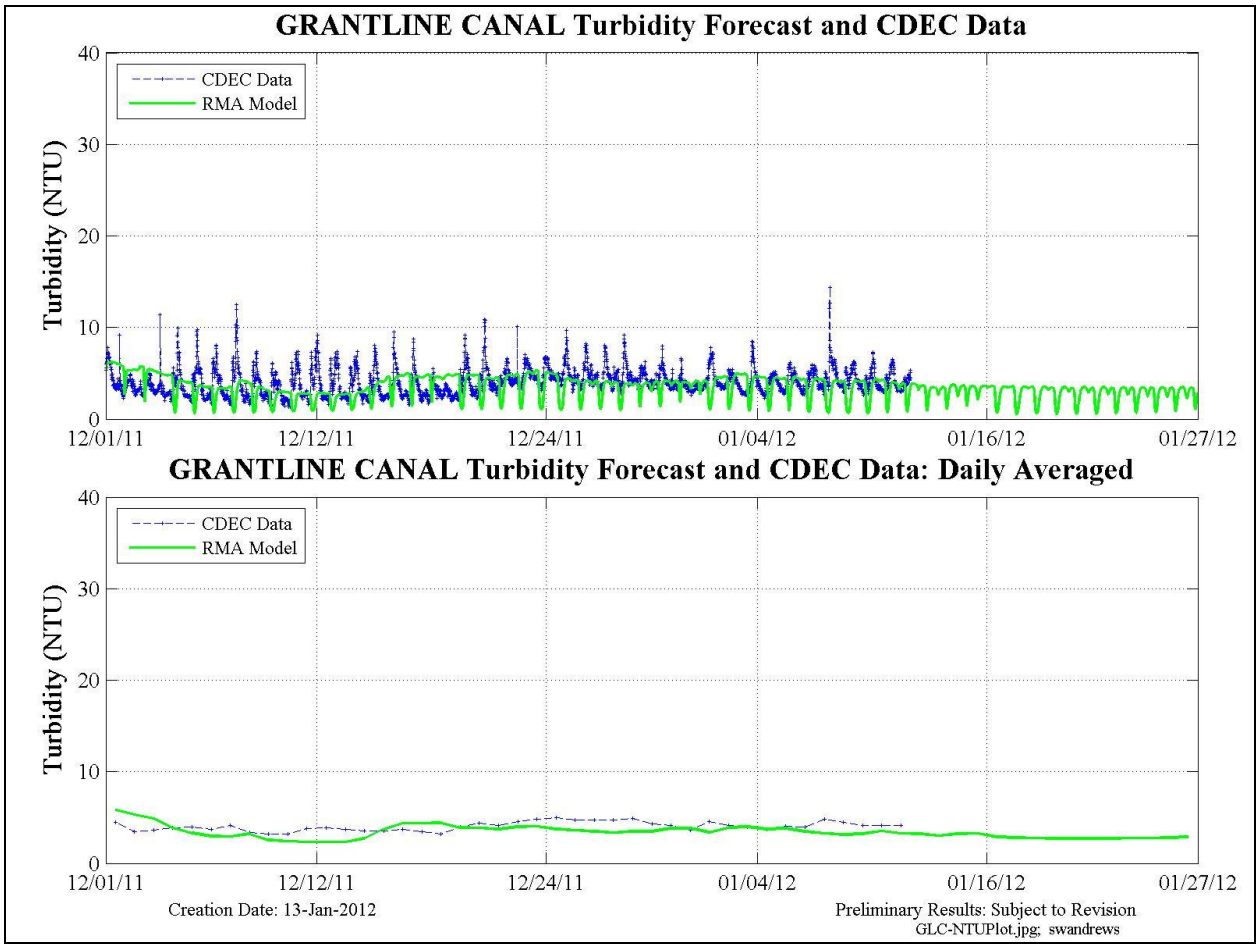

Figure 22 Model forecast and raw CDEC data at Grant Line. Both 15-min (upper) and daily averaged (lower) plots are shown.

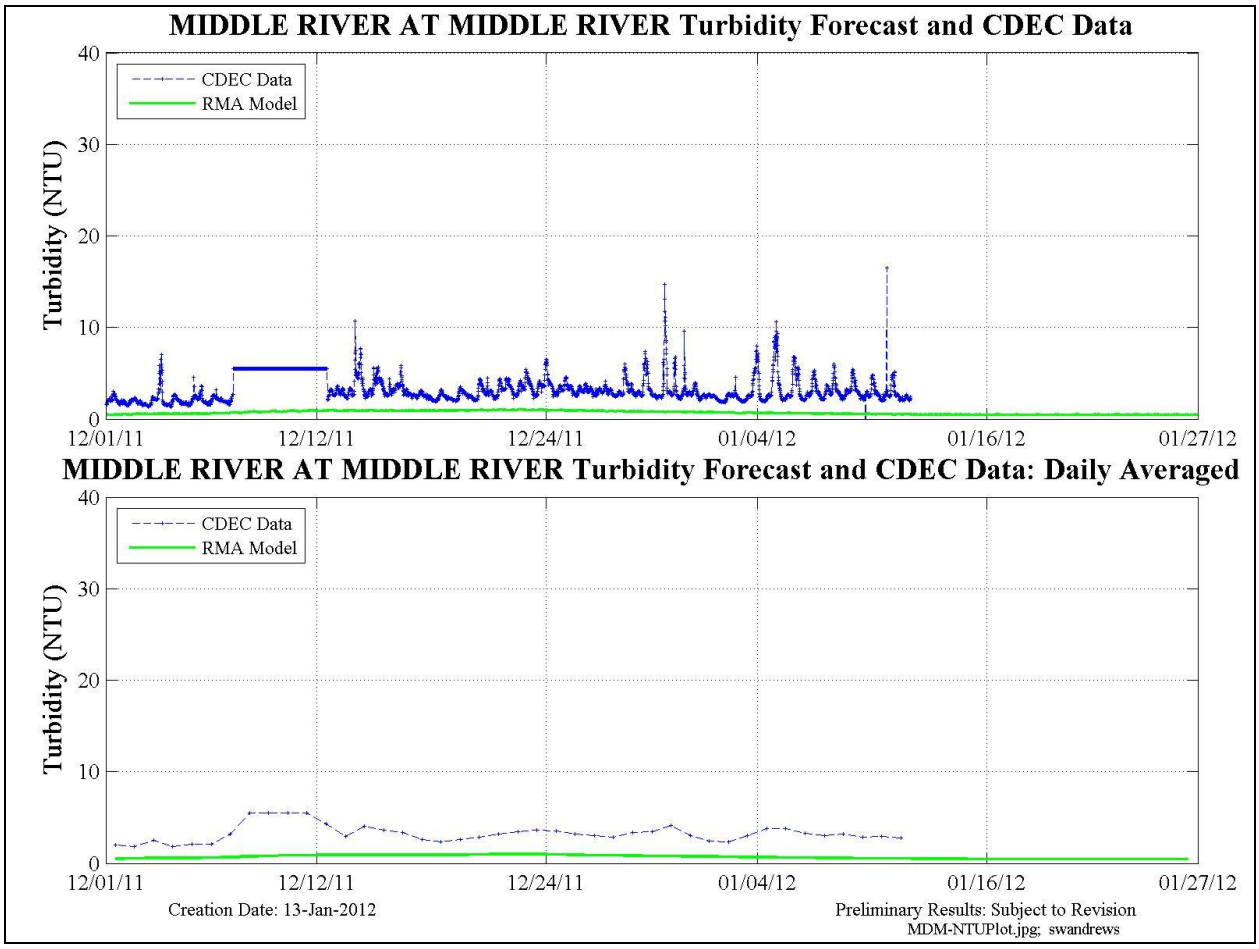

Figure 23 Model forecast and raw CDEC data at Middle R. at Middle R. Both 15-min (upper) and daily averaged (lower) plots are shown.

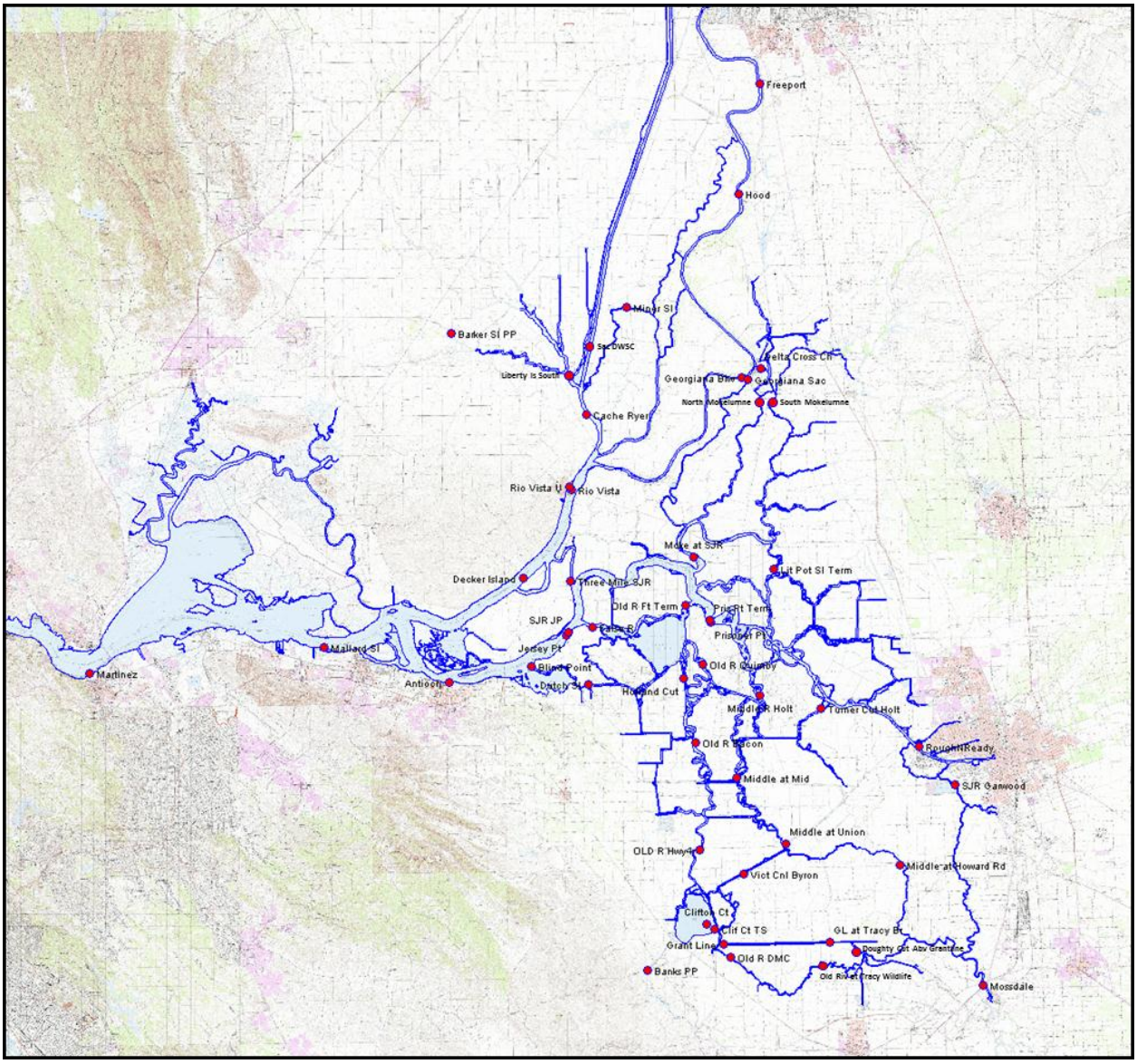

Figure 24 Figure illustrating model output and data collection locations.

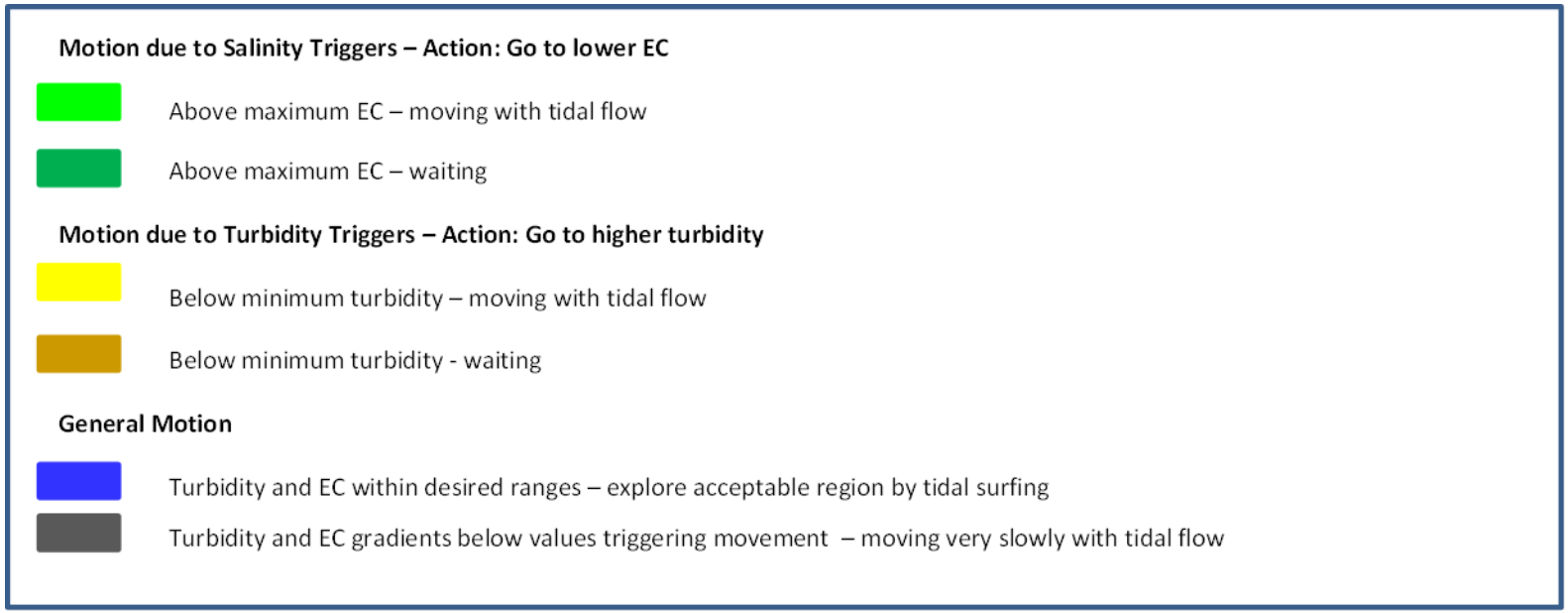

Figure 25 Particles in the Adult Delta Smelt particle tracking model are color-coded by the triggers influencing their behavior during the simulation. Use this figure to interpret the simplified color scale in the next three figures.

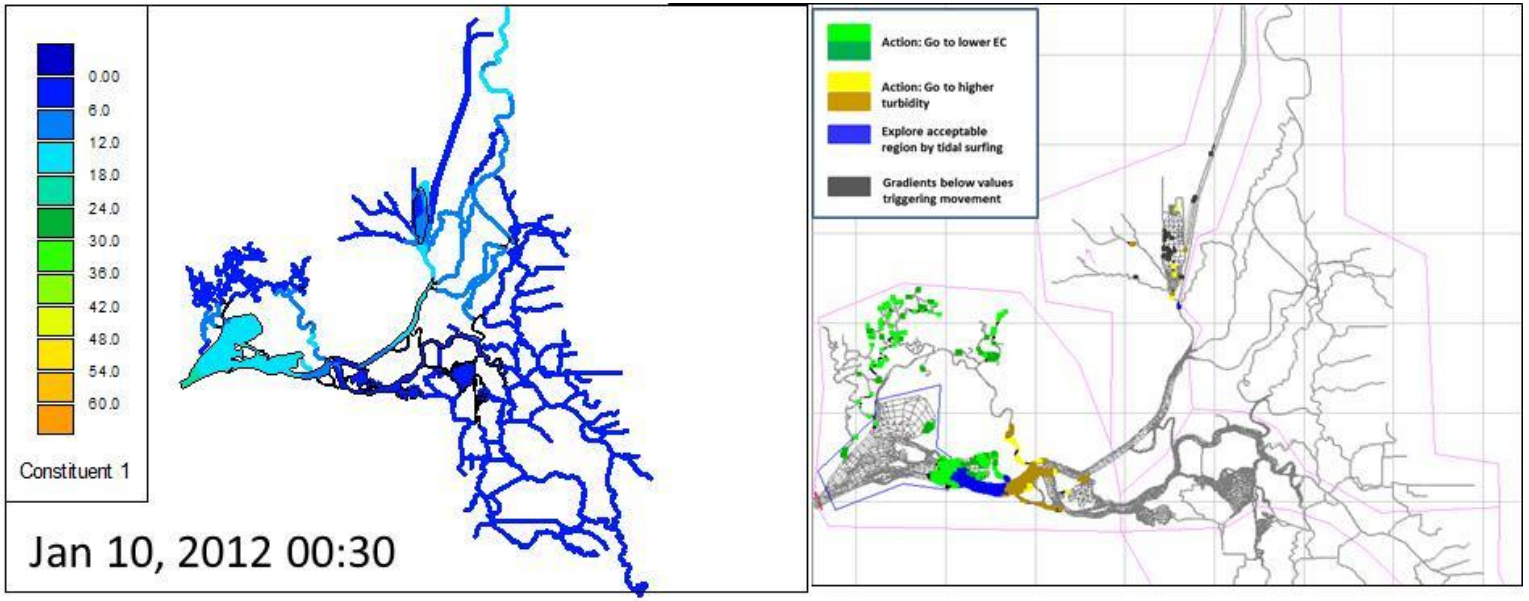

Figure 26 Turbidity contours and particle location in the RMA model grid on Jan. 10, 2012.

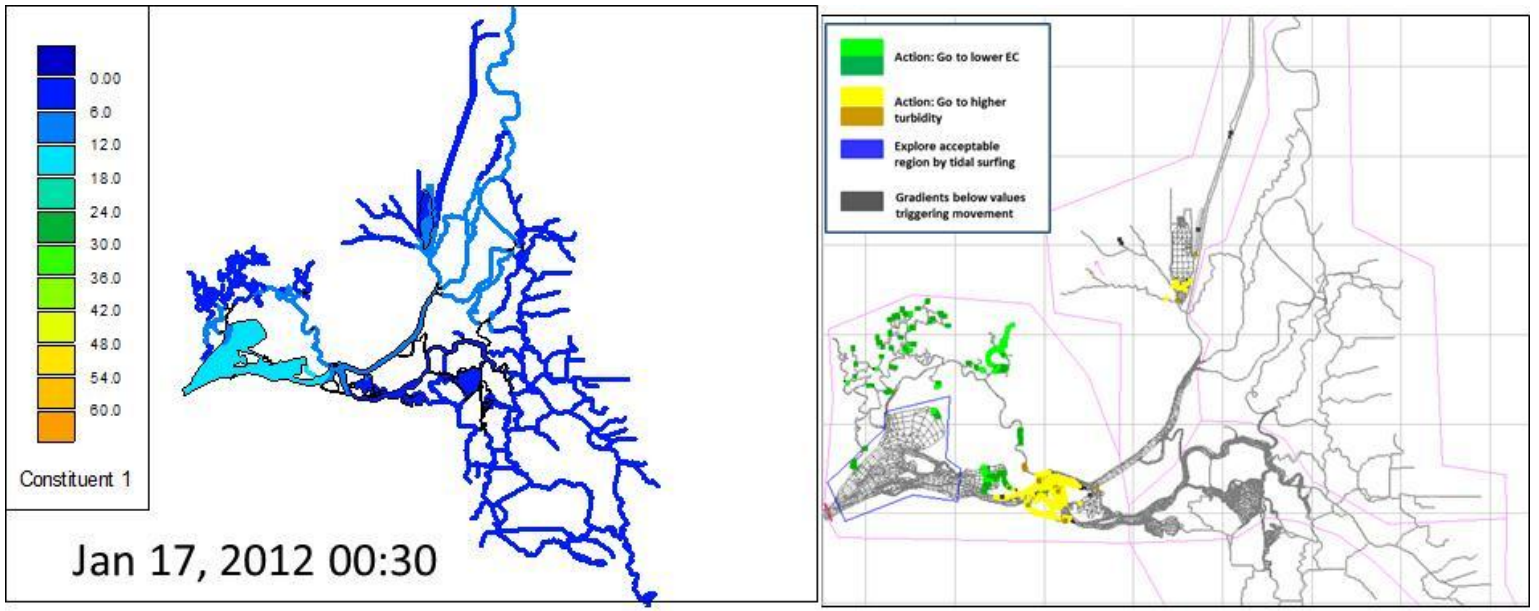

Figure 27 Turbidity contours and particle location in the RMA model grid on Jan. 17, 2012.

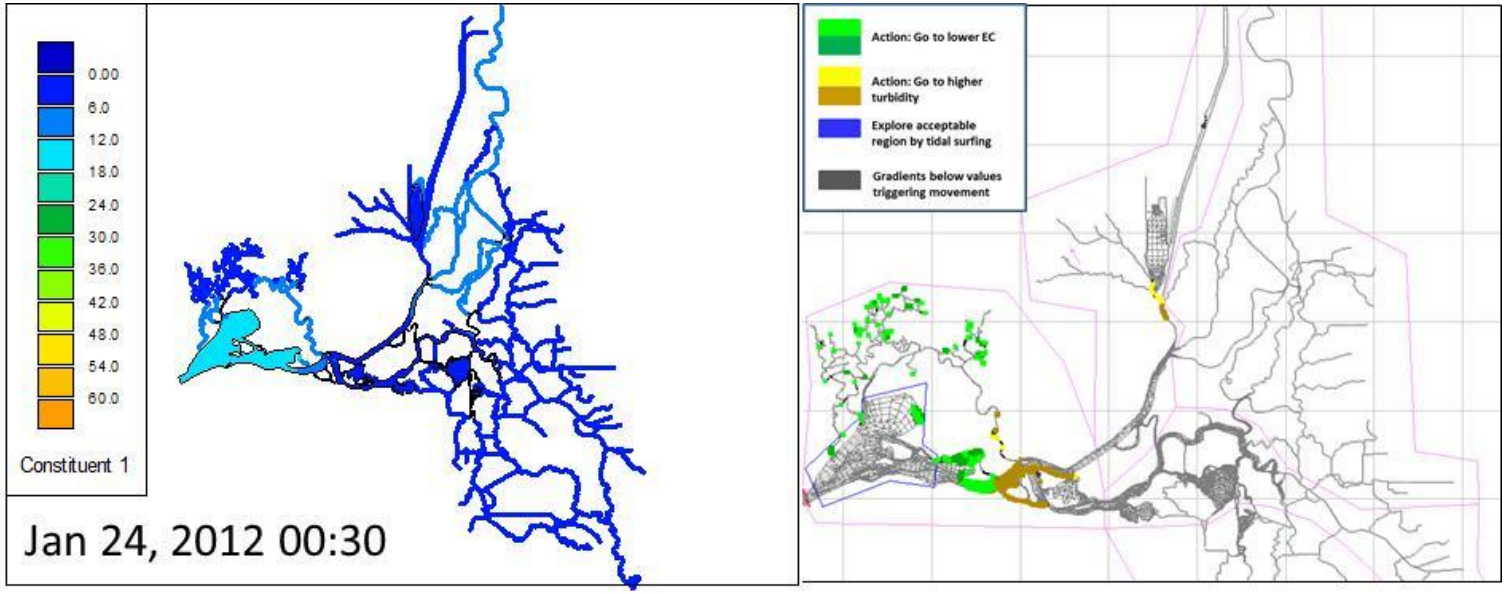

Figure 28 Turbidity contours and particle location in the RMA model grid on Jan. 24, 2012.