

## Graphical Decision-Analysis for Daily Delta Operations and Salinity in WY 2014

SWRCB May 6, 2014 TUCP Workshop Comments from Russ Brown. E-mail: Russell.Brown@icfi.com

The historical daily Delta operations can be represented with a few time-series graphs of inflows, exports, depletions and outflow. The salinity within the Delta can also be displayed with several graphs of: 1) the effective outflow, which controls salinity (EC, chloride) in the western Delta (estuary); 2) the daily average EC at the western Delta stations; 3) the Sacramento River and SJR inflows and inflow EC values (minimum EC in the Delta); and 4) the daily average EC in the southern Delta and at the CVP and SWP export pumping plants.

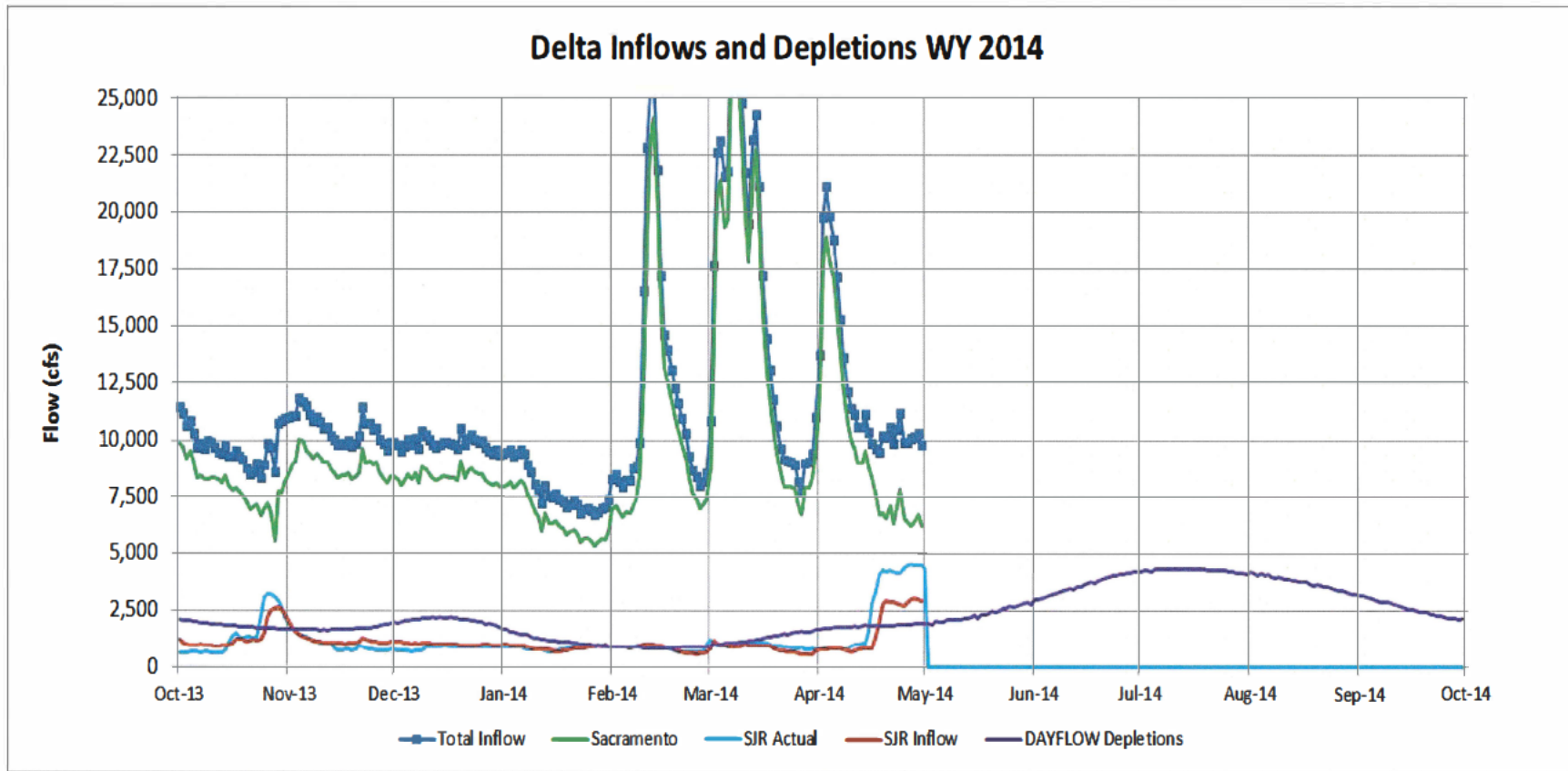
Daily inflows and daily exports are measured; the other Delta water balance terms must be estimated. Adjustments may be needed in the calculated outflow (NDOI) to match the measured EC patterns; the measured EC provides the best estimate of the actual Delta outflow. The calculated outflow is dependent on the estimated channel depletions in the Delta. Adjustments in the NDOI may reduce the allowable exports in periods when the D-1641 required Delta outflow is limiting exports. This is an important adjustment during low inflow conditions (WY 2014 drought).

The D-1641 TUCP discussions are centered on a relatively simple, yet very important question:

“What should be the required Delta outflow during a drought year like WY 2014?”

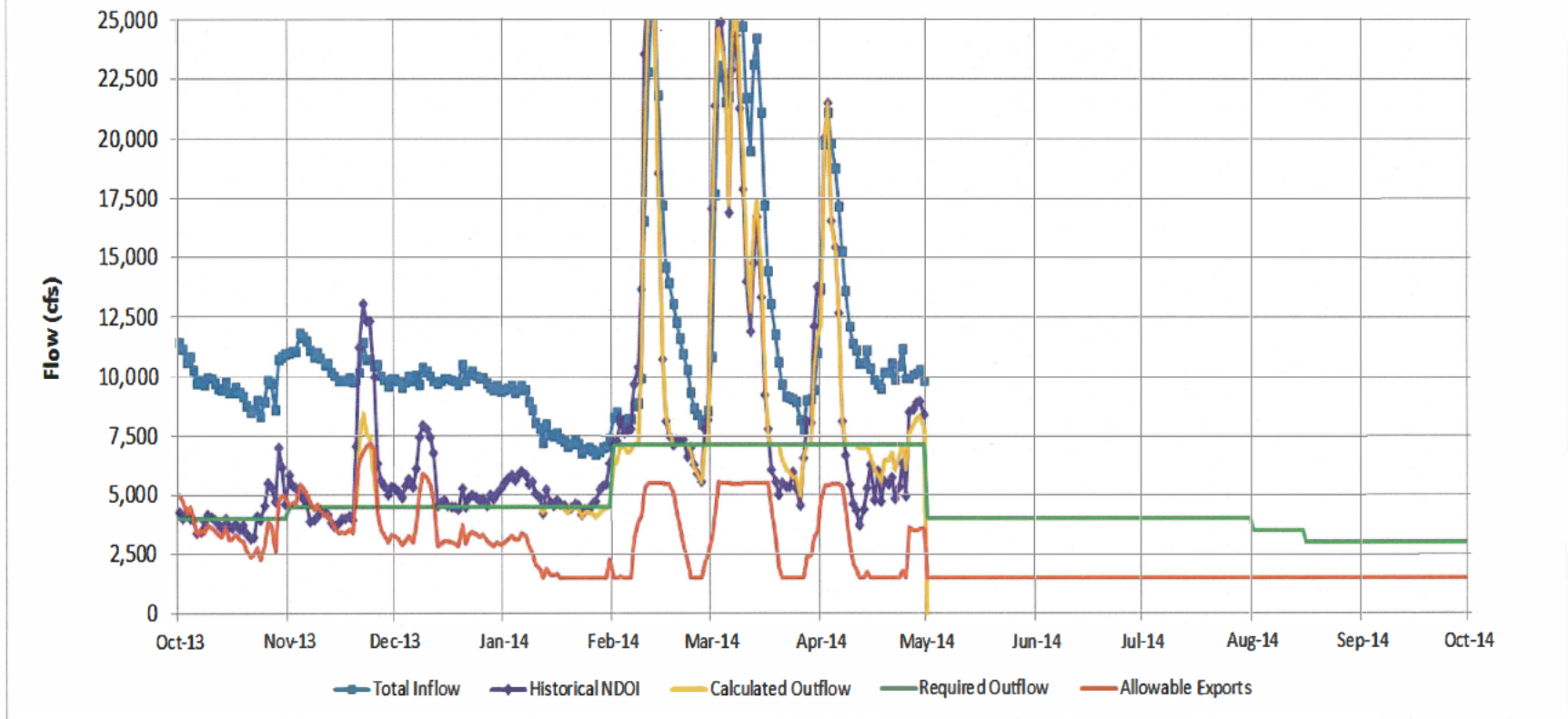
The following graphs illustrate the daily measured inflows, exports and salinity (EC), as well as the estimated Delta depletions, Delta outflow, effective Delta outflow (controlling salinity) and the various D-1641 objectives for required outflow and allowable exports. The OCAP RPA limits for Old and Middle River (OMR) flows and exports are also shown. The TUCP requests for this year (WY 2014) can be evaluated as alternative daily Delta operations during the February-September period. Daily Delta operations from October-January followed the existing D-1641 objectives.

Because Delta operations are controlled by several simultaneous objectives and limits, the increased outflow or the increased exports that would be achieved by an adjustment in one of the operating “rules” can only be calculated after the actual daily inflow sequence is known. Nevertheless, incremental adjustments in the operating “rules” for several representative years of daily historical Delta inflows is suggested as an appropriate method for exploring the likely results of adjusted D-1641 objectives and alternative RPA limits. Adding estimates of daily salinity effects and tracking the daily effects on Delta migration, survival, growth (size) and entrainment effects for several fish species would provide a powerful tool for planning, evaluating and approving proposed changes in Delta operations.



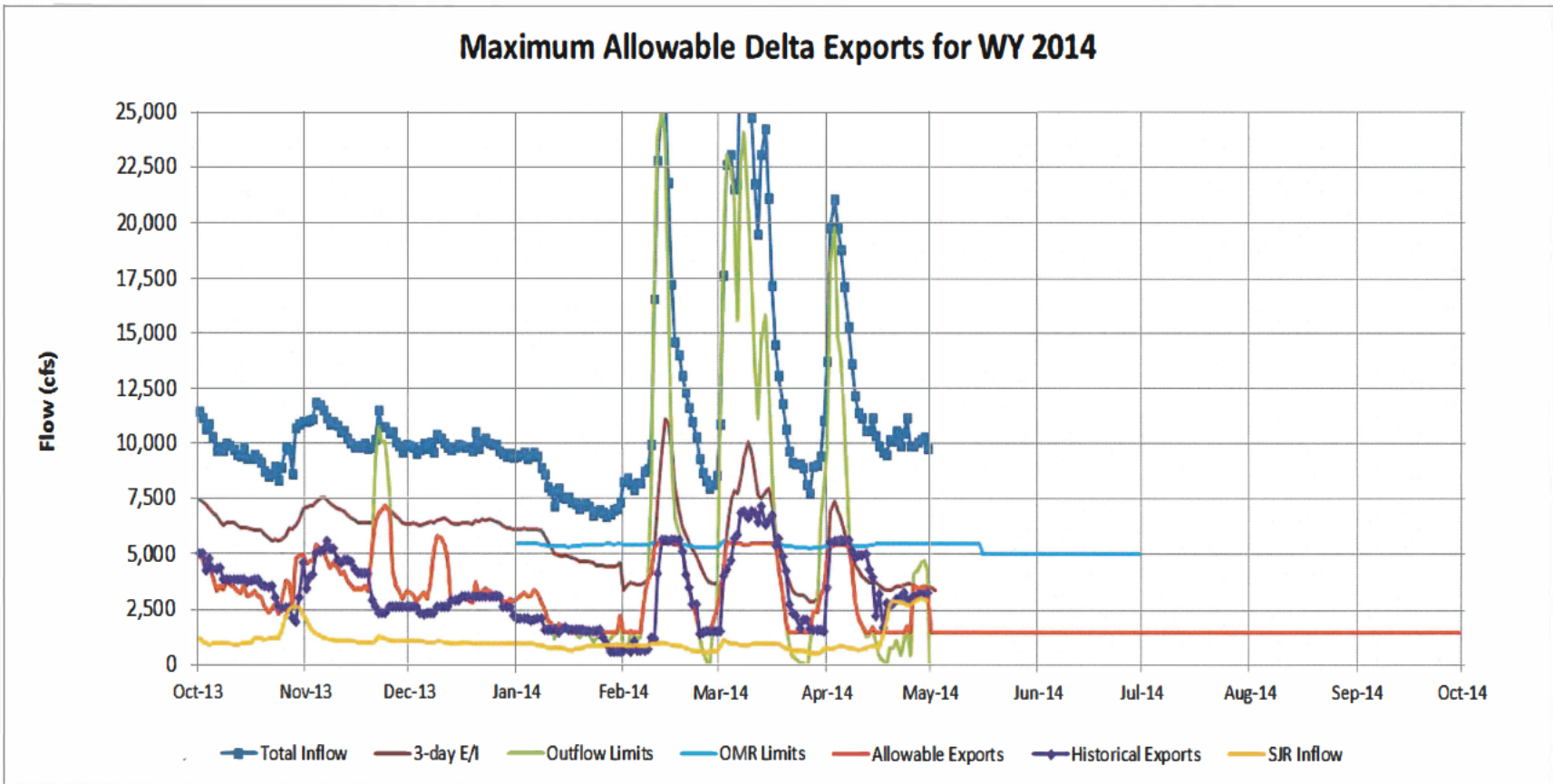
The measured Delta inflows in October-January of WY 2014 were very low; Sacramento River inflow was less than 10,000 cfs and SJR inflow was less than 1,000 cfs (except for the end-of-October pulse flow). The Delta diversions and depletions (seepage and evapotranspiration) were estimated to be about 2,000 cfs. The D-1641 required Delta outflow was about 4,000 cfs during this period, leaving very little water for CVP and SWP exports. As February 1 approached, with the higher Delta outflow requirement of 7,100 cfs (X2 at Collinsville), the first TUCP request was submitted by DWR and Reclamation. Visually, block the actual inflows for February, March and April. Imagine that the low rainfall-runoff conditions had continued- with only upstream reservoir releases available for providing Delta depletions, Delta outflow and Delta exports. Answer the question, “What should be the minimum required Delta outflow during a drought year like WY 2014?”

### Calculated Delta Outflow and Exports for WY 2014



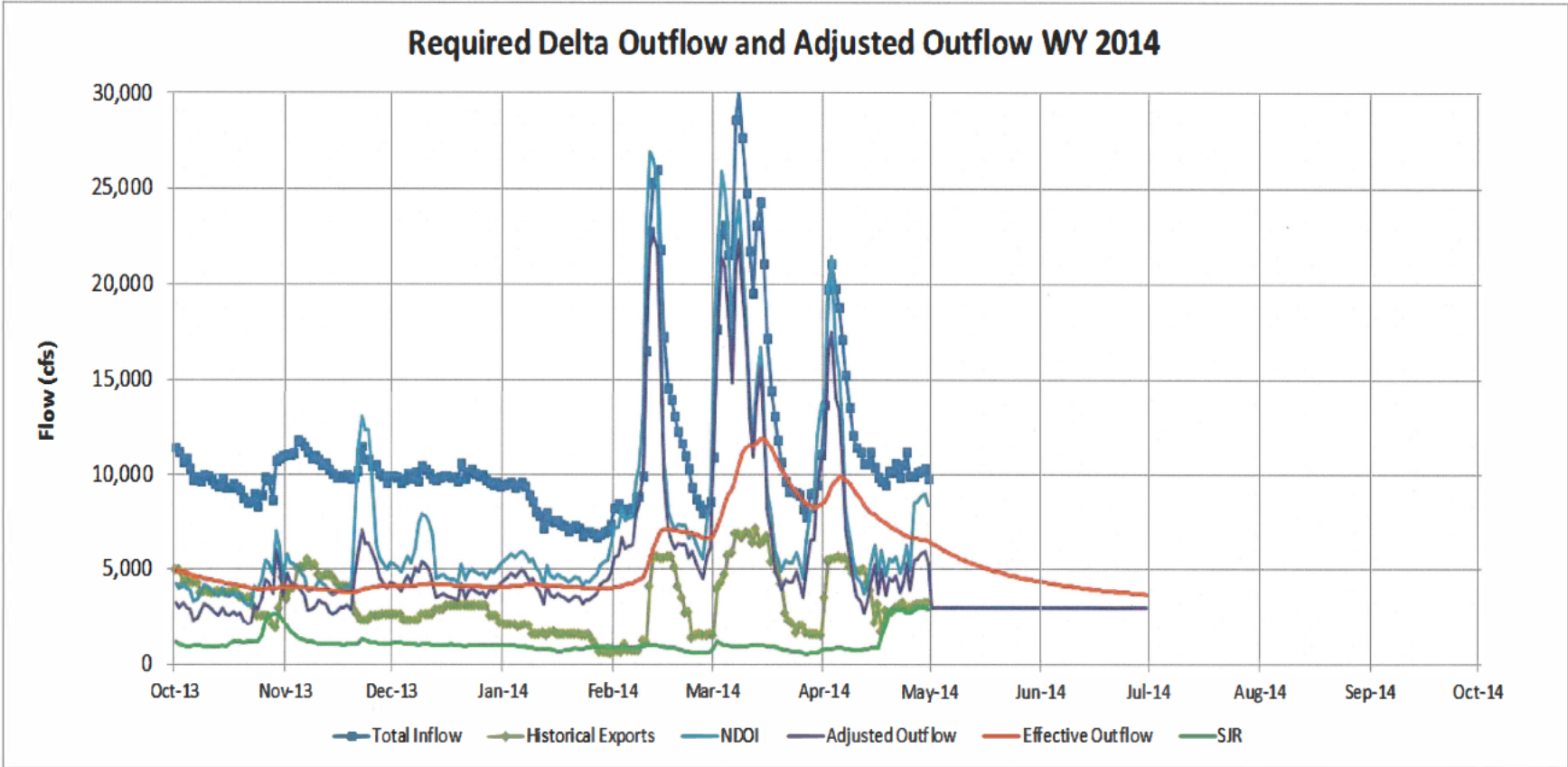
The low Delta inflows and the D-1641 required Delta outflows (green line) during the first four months of WY 2014 provided only limited water for Delta exports (red line). A small rainfall event around Thanksgiving provided a small increase in the Sacramento inflow, with a much larger calculated increase in the NDOI. It is likely that most of the rainfall in the Delta was retained as soil moisture, with only limited runoff. The D-1641 required Delta outflows for a critical year are relatively high in February-April (7,100 cfs), but are relaxed to 4,000 cfs in May and June, if the Sacramento River Index is less than 8.1 maf. The Emmaton EC objective of 2,780 uS/cm requires an outflow of about 3,500 cfs until August 15. Without the moderate storms that occurred in February, March and April, most of the required Delta outflow would have been released from upstream reservoirs.

### Maximum Allowable Delta Exports for WY 2014



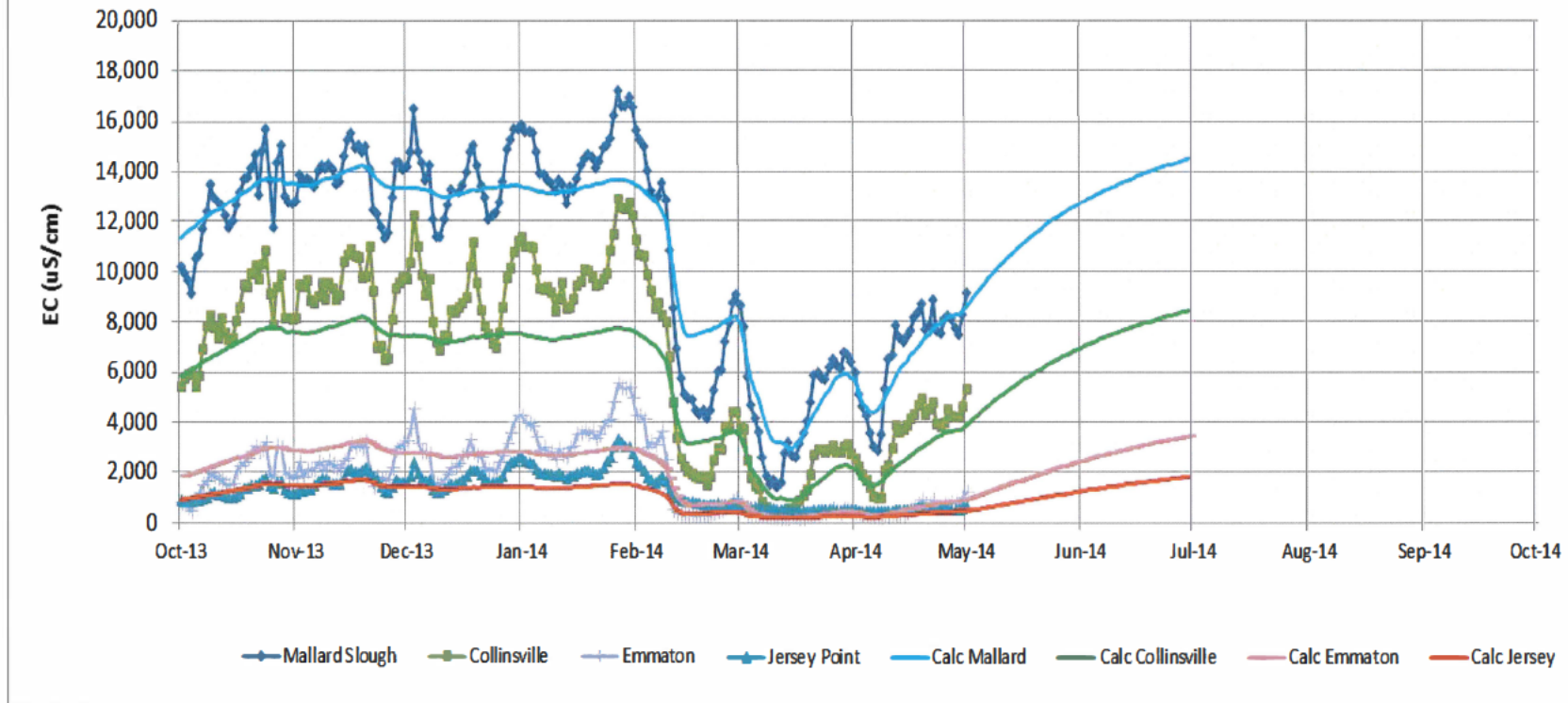
The maximum allowable Delta exports (CVP and SWP) are controlled by the D-1641 outflow requirements (light green line), or by the export/inflow ratio (brown line), or by the minimum allowable Old and Middle River (OMR) limits of -5,000 cfs during the January-June period (light blue line). The calculated allowable exports (red line) were similar to the historical exports (purple line) during the October-January period. The TUCP orders allowed a lower Delta outflow of 3,000 cfs with minimum exports of 1,500 cfs during the February-April period. The historical exports for October-April were 1,025 taf, while the calculated allowable exports were 1,120 taf. There are some additional details in the averaging periods for the D-1641 objectives and other operational considerations that cause the historical operations to differ from the calculated allowable exports, but the basic Delta conditions and export limits are well represented by the daily calculations.

**Required Delta Outflow and Adjusted Outflow WY 2014**



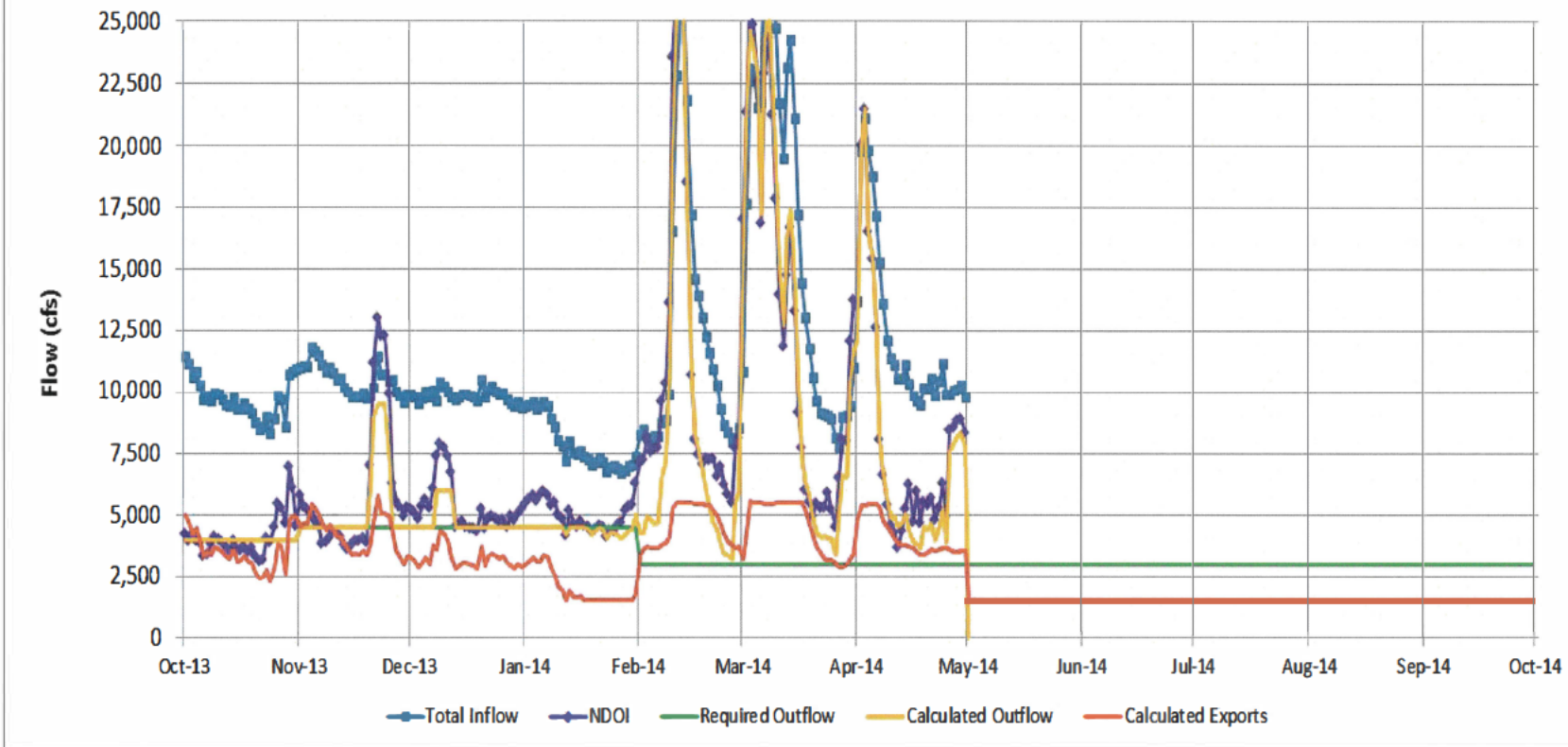
The effective Delta outflow controlling salinity (EC) at the western Delta can be calculated from the daily Delta outflow (red line). The daily average EC at each station can be estimated as a “negative exponential” function of the effective outflow. The EC increases rapidly with reduced outflow. Comparison of the calculated EC values with the measured EC values for WY 2014 indicated that the estimated NDOI (light blue line) was likely about 1,000 cfs higher than the actual outflow (purple line) during the October-January period. The allowable exports would have been reduced by about 45 taf to a total of 1,075 taf for the October-April period if the adjusted NDOI (1,000 cfs less) had been used for actual operations.

### Measured and Calculated EC for Outflow Reduction of 1000 cfs

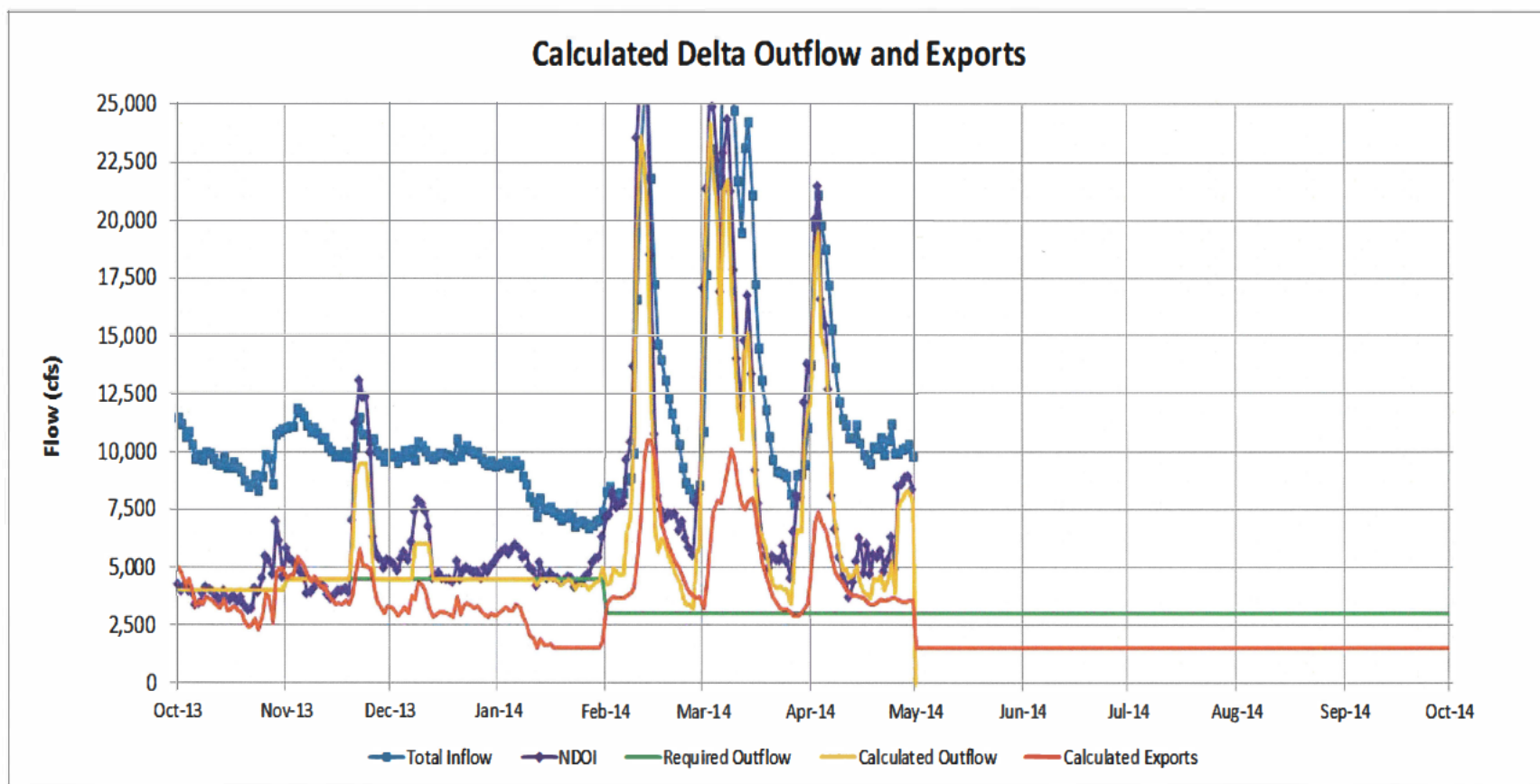


The calculated EC values, using the effective outflow with a negative exponential relationship, matched the measured EC values reasonably well if the NDOI was reduced by about 1,000 cfs. The daily average EC values at each station have a strong spring-neap tidal variation, caused by the slightly higher average tide elevations (upstream movement of the salinity gradient) during spring tides. The change in effective outflow and the corresponding changes in calculated EC values were not as rapid as the measured EC changes during the three storm events in February, March and April. The calculated EC for May and June assumes that the required outflow would be 3,000 cfs (as allowed in the current TUCP order). Because of the slowly adjusting effective outflow, the Emmaton EC would be about 3,500 uS/cm and the Jersey Point EC would be about 1,750 uS/cm at the end of June. Any additional outflow from a storm runoff event in May or June would reduce these projected EC values.

### Calculated Delta Outflow and Exports



The major change in the D-1641 objectives that was requested in the TUCP was that the required Delta outflow would be reduced from 7,100 cfs to 3,000 cfs for the February-June period. This reduced outflow would have allowed a 250 taf increase in total exports (to 1,230 taf) for the October-April period. Exports during the storm runoff events in February, March and April would have been limited by the minimum allowed OMR flow of -5,000 cfs. Exports would have been limited by the E/I ratio of 35% during the low inflow periods between the runoff events. These moderate storm runoff events have raised a second important question for the TUCP discussions: “What relaxations in the E/I limits or the OMR limits could be considered to increase the allowable exports during a drought year like WY 2014”?



Relaxing the OMR limits to -10,000 cfs would have allowed increased exports (red line) during the three storm runoff events; increasing the allowable exports by 107 taf to a total of 1,337 taf for the October-April period. Increasing the E/I ratio from 0.35 to 0.65 for the February-June period would have allowed an additional 278 taf of exports, for a total of 1,615 taf for the October-April period (case not shown). The incremental changes in Delta operations and the likely effects on salinity (EC) and on fish habitat conditions should be routinely calculated to evaluate the benefits (protections) from the existing D-1641 objectives, and the possible improvements in water supplies or fish habitat conditions that could be achieved with adjustments in the existing D-1641 objectives (e.g., adaptive operations). DAYFLOW (historical daily Delta water balance) might be expanded to include internal Delta channel flows, salinity and fish migration and habitat conditions; this would provide a common basis for discussions about Delta water operations and environmental protections.