# Increasing Delta Exports for Maximum Water Supply

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California was looking for water conservation measures in 2014 and 2015. We might consider reducing Delta outflow to a specified minimum outflow objective that adequately limits seawater intrusion and protects some estuarine fish habitat (X2), while increasing Delta exports to capture the remaining Delta inflows. This possible water conservation strategy can be illustrated and explored by comparing the historical WY 2014 and WY 2015 daily Delta flows with D-1641 critical year objectives and with modified Delta objectives. For example, the greatest likely Delta water supply would result from modified objectives assuming 3,000 cfs outflow for salinity control, with a 65% E/I ratio for the entire year, and with a full export capacity of 15,000 cfs. No OMR restrictions, no SJR inflow restrictions, and no reduced E/I ratios of 45% in February or 35% in March-June were included in this maximum water supply case.

## Water Year 2014 Delta Operations

Figure 1 shows the daily historical Delta inflow, Delta exports (CVP and SWP), and estimated Delta outflow (from DAYFLOW) for WY 2014. Also shown are the calculated Delta exports with the D-1641 critical year outflow (X2) limits, E/I ratios, OMR flow restrictions, and SJR inflow restrictions on exports, with a minimum export of 1,500 cfs allowed (for health and safety). Some of the D-1641 critical year outflow limits were reduced in the various TUCP orders that were requested by DWR/Reclamation and generally granted with some changes by SWRCB. The total Delta inflows for WY 2014 were 7,545 taf, the net Delta consumptive uses (seasonal ET minus rainfall) was estimated to be 1,212 taf (16% of inflow), the historical Delta exports (CVP and SWP) were 1,890 taf (25% of inflow) and the historical Delta outflow was 4,295 taf (57% of inflow, 5,930 cfs average). The calculated exports with the D-1641 outflow limits were 2,219 taf (29% of inflow), which was about 17% higher than historical CVP and SWP exports. Historical exports were less than the calculated exports with D-1641 limits in late November and December, because of reduced exports to protect delta smelt during first flush storm with higher turbidity. Historical exports were greater than the D-1641 limits with OMR restrictions in March, because the OMR flow restrictions were relaxed (allowing higher exports). The calculated outflow of 3,966 taf (53% of inflow) was 329 taf less than the historical outflow because a minimum export of 1,500 cfs was allowed, causing periods with outflow deficits (less than required outflow) of 256 taf. The calculated exports and outflows with D-1641 critical year objectives were reasonably close to the historical flows in most months suggesting that the daily calculations of Delta exports and outflows with specified objectives provide an accurate evaluation tool.

Figure 2 shows the daily calculated Delta exports and outflow for the maximum water supply case, with 3,000 cfs required outflow for the entire year (2,172 taf for the year), an adjusted E/I of 65% for the entire water year, no OMR flow or SJR inflow restrictions on exports, a minimum export of 1,500 cfs and full export capacity of 15,000 cfs. The Delta inflows and net Delta consumptive uses remained unchanged. The calculated Delta exports were increased to 3,329 taf (44% of inflow, 1,110 taf more than calculated for D-1641 with OMR limits) and the Delta outflow was reduced to 2,856 taf (38% of

inflow, 3,900 cfs average outflow), but with no outflow deficits. Full export capacity of 15,000 cfs would have been used in about 21 days and would have provided 110 taf of additional exports during the three major inflow events in February-April of WY 2014. This maximum water supply case for WY 2014 would have shifted about 15% of the Delta inflows (about 1,100 taf) from outflow to exports for increased water supply (greater than Folsom Reservoir storage). The possible effects of the reduced outflow and increased exports on fish populations are not evaluated in this analysis.

The calculated outflow was reduced from October to January by about 1,000 cfs and the calculated outflow was reduced by about 5,000 cfs during the three storms in February, March and April. The peak outflows were reduced from 25,000 cfs in February and March to about 17,500 cfs and the periods of high outflow (>10,000 cfs) were reduced from about 40 days for historical conditions (with required X2 outflow of 7,100 cfs in February and 11,400 cfs in March and most of April) to about 15 days for the maximum water conservation case. The calculated outflow was also reduced by about 1,000 cfs in May, June and July. The average outflow for this WY 2014 maximum export case was reduced by about 1,500 cfs compared to the outflow for the D-1641 case. The changes in calculated exports were primarily in the months of February-April when the three major storm events in WY 2014 provided much higher inflows. By relaxing the export limits (65% E/I with no OMR restriction) and reducing the outflow objective to 3,000 cfs, about 1,100 taf more water could have been exported in WY 2014. A thorough evaluation of the likely salinity effects and the possible fish effects of these changes (reductions) in Delta outflow should be undertaken, to determine if this water conservation strategy for dry years should be adopted by the SWRCB in their revised Delta objectives. This evaluation might also consider whether the north Delta intakes would reduce or increase the effects of low Delta outflow on salinity and fish.

## Water Year 2015 Delta Operations

Figure 3 shows the daily historical Delta inflow, Delta exports, and estimated Delta outflow for WY 2015. Also shown are the calculated Delta exports with the D-1641 critical year outflows, E/I ratios, OMR flow restrictions, and SJR inflow restrictions on exports, with a minimum export of 750 cfs allowed (less than allowed in 2014). The D-1641 critical year outflow limits (gold line) were reduced in the various TUCP orders that were requested by DWR/Reclamation and generally granted with some changes by SWRCB. The total Delta inflows for WY 2015 were 8,697 taf (1,150 taf higher than 2014), the net Delta consumptive use (seasonal ET minus rainfall) was estimated to be 1,197 taf (14% of inflow), the historical Delta exports were 1,834 taf (21% of inflow) and the historical Delta outflow was 5,571 taf (64% of inflow, 7,965 cfs average). The calculated exports with the D-1641 critical year outflows and OMR limits were 2,034 taf (23% of inflow), about 200 taf more than the historical exports. Historical exports were slightly more than the D-1641 limits in March because the high outflow requirement for X2 (11,400 cfs) was relaxed by the TUCP. The calculated outflow of 5,343 taf (61% of inflow) was similar to the historical outflow, although minimum exports of 750 cfs reduced the outflow slightly, while the historical outflow was higher than required in October and November for salinity control.

The calculated daily outflows and exports matched the historical outflows and exports reasonably well in 2015. The calculated exports were even higher than the historical exports when the TUCP adjustments in required Delta outflows were used, because historical operations normally include a small (e.g., 250-500 cfs) outflow buffer to assure compliance with the outflow and salinity objectives.

During dry years such as 2014 and 2015, the measured salinity (e.g., EC and X2) and the estimated Delta outflow index (NDOI), which is calculated from the inflows minus the exports minus the estimated net Delta consumptive uses, should be compared and evaluated to determine if the outflows can be more accurately estimated. This would allow the Delta outflow to be regulated with a smaller outflow buffer, to maximize the water supply benefits from reducing the Delta outflow objectives in dry years.

Figure 4 shows the daily calculated Delta exports and outflow for the 2015 maximum water supply case, with 3,000 cfs required outflow for the entire year, an adjusted E/I of 65% for the entire water year, no OMR flow or SJR inflow restrictions, a minimum export of 750 cfs and full export capacity of 15,000 cfs. The Delta inflow and net Delta consumptive uses remained unchanged. The calculated Delta exports were increased to 3,462 taf (40% of inflow) which was 1,425 taf more than calculated for D-1641 critical year objectives, and the Delta outflow was reduced to 3,911 taf (45% of inflow, 5,400 cfs average). Full export capacity of 15,000 cfs would have been used in about 43 days and would have provided 281 taf of additional exports during the two major inflow events in December and February of WY 2015. This maximum water supply case for WY 2015 would have shifted about 15% of the inflow (about 1,425 taf) from outflow to exports for increased water supply. The calculated exports were increased primarily in the months of December-March with the relaxation of the export limits and reduction of the outflow objective to 3,000 cfs. The salinity changes (e.g., EC and X2) in the estuary (i.e., fish habitat effects) and in the exports (i.e., water quality effects) caused by reduced outflow, and the fish effects from increased exports (e.g., straying, entrainment) during low inflow conditions should be further evaluated to determine if this maximum water supply strategy for dry and critical years should be adopted by the SWRCB as revised Delta objectives.

During dry years such as 2014 and 2015, when water supply is a SWRCB priority, the possibility of adjusting the required minimum outflow objective to 3,000 cfs in all months should be seriously considered, because reducing the outflow by 1,000 cfs would allow 2,000 acre-feet per day (60 taf per month) of increased exports. As a comparison, the Poseidon desalination plant, recently completed in San Diego, with a capacity of 50 million gallons per day (mgd), will produce about 60 taf per year. The increased water supply that could have been achieved with these maximum export operations in WY 2014 (1,100 taf) would have been equivalent to the annual production from about 18 of these (50-mgd) desalination plants, or about 1.75 Folsom Reservoirs (assuming useable storage of 750 taf). The increased water supply that could have been achieved in WY 2015 (1,425 taf) would have been equivalent to the annual production from about 24 (50-mgd) desalination plants, or about 2 Folsom Reservoirs. This would have been a substantial increase in California's water supply, allowing reduced groundwater pumping for agricultural water. The maximum water supply operations in 2014 would have provided an increased water supply of about 50% of the Governor's 25% urban water conservation mandate to save about 2,000 taf per year (i.e., 25% of the 8,000 taf/yr estimated urban water use in California). The maximum water conservation operations in 2015 would have provided an increased water supply of about 75% of the Governor's 25% urban water conservation goal.

## Recommendations

1. Reducing the minimum required Delta outflow objective to 3,000 cfs should be considered as an adaptive water management strategy during dry and critical years. The D-1641 objectives for

outflow, X2, E/I, maximum export capacity and salinity should be modified for dry and critical years (e.g., 35% of years with lowest runoff) to allow maximum possible exports. The additional exports for 2014 (1,100 taf increase) and for 2015 (1,425 taf increase) would have been substantial. Incorporating these adaptive water management adjustments in the outflow, X2, salinity and E/I objectives ahead of time would reduce the administrative stress and uncertainty associated with the TUCP process.

2. The effects of reduced minimum outflows (e.g., 3,000 cfs for the entire year) on seawater intrusion and EC at the Delta salinity monitoring stations can be accurately calculated and evaluated. The potential effects on estuarine fish habitat conditions (shifted salinity gradient location) caused by reduced net outflows and increased fish entrainment losses at the CVP and SWP exports would be more difficult to quantify, but should be more extensively evaluated. The minimum outflow objectives could be increased in specific months if substantial fish habitat or fish survival benefits were identified, while still achieving substantial water supply benefits in dry and critical water years.

3. The possibility for determining the daily Delta outflow more accurately, using a combination of measured inflows and exports (i.e., water budget), measured tidal flows (USGS), and measured salinity (EC and X2) should be further investigated by Reclamation, DWR and SWRCB. Determining the daily Delta outflows more accurately would allow Delta operations to more closely follow the outflow and salinity objectives, and would thereby allow maximum water supply benefits during dry and critical years while satisfying the required Delta outflow and salinity objectives.

4. The daily flows and EC data that are measured in the Delta and used to control Delta operations should be compiled and integrated in an official daily Delta data website, that would allow everyone involved or interested in Delta operations and environmental conditions to review the operations and adaptive management choices during each year. This dataset should include as many of the actual operational decisions as possible (e.g., maintenance activities, unscheduled events, water transfers), to provide a better match between Delta outflow objectives and export limits and the actual Delta operations (outflow, EC, X2, exports). This suggested website would extend the existing data provided by Reclamation (CVO) and DWR (SWP O&M) and could include graphical and statistical analyses and summaries. This daily Delta data website should be a cooperative effort of the Interagency Ecological Program agencies, so that daily data related to Delta water management and Delta fish protection could be integrated and compared.

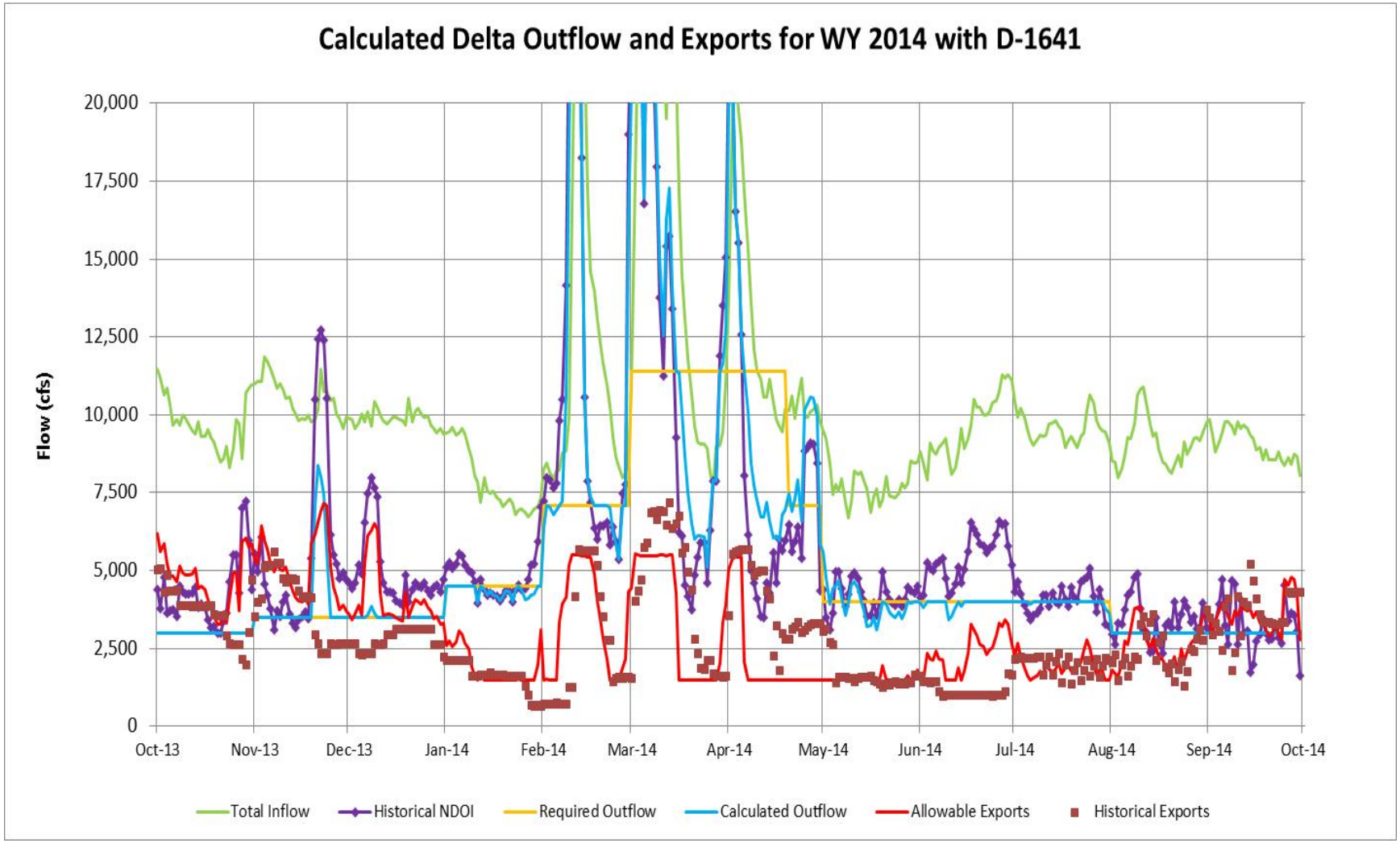


Figure 1. WY 2014 Historical (symbols) and Calculated (lines) Exports and Outflow with D-1641 Critical-Year Required Outflow, E/I, OMR and SJR Export Limits.

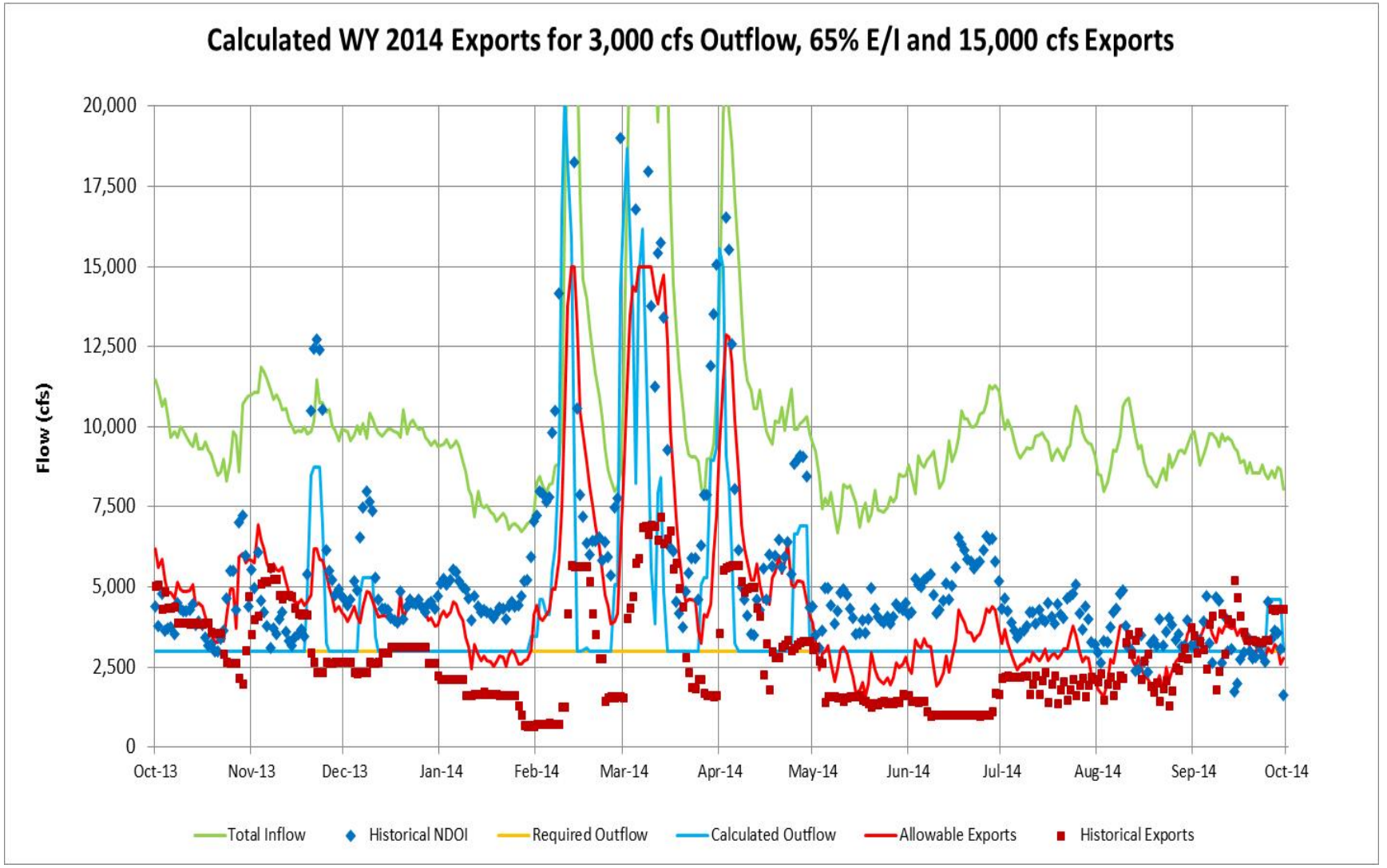


Figure 2. WY 2014 Historical (symbols) and Calculated (lines) Exports and Outflow with 3,000 cfs Required Outflow, 65% E/I, no OMR or SJR Export Limits and 15,000 cfs Export Capacity

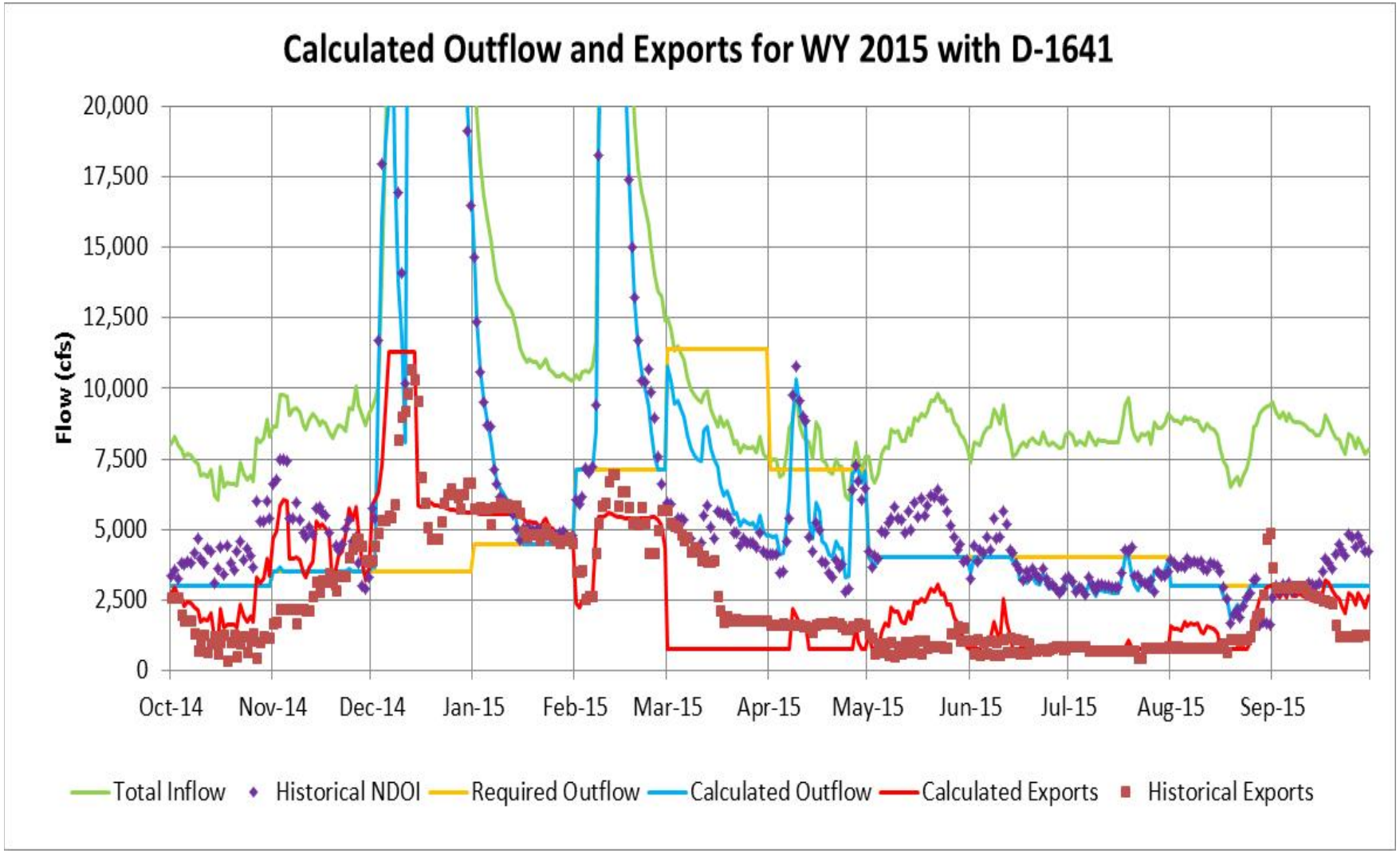


Figure 3. WY 2015 Historical (symbols) and Calculated (lines) Exports and Outflow with D-1641 Critical-Year Required Outflow, E/I, OMR and SJR Export Limits

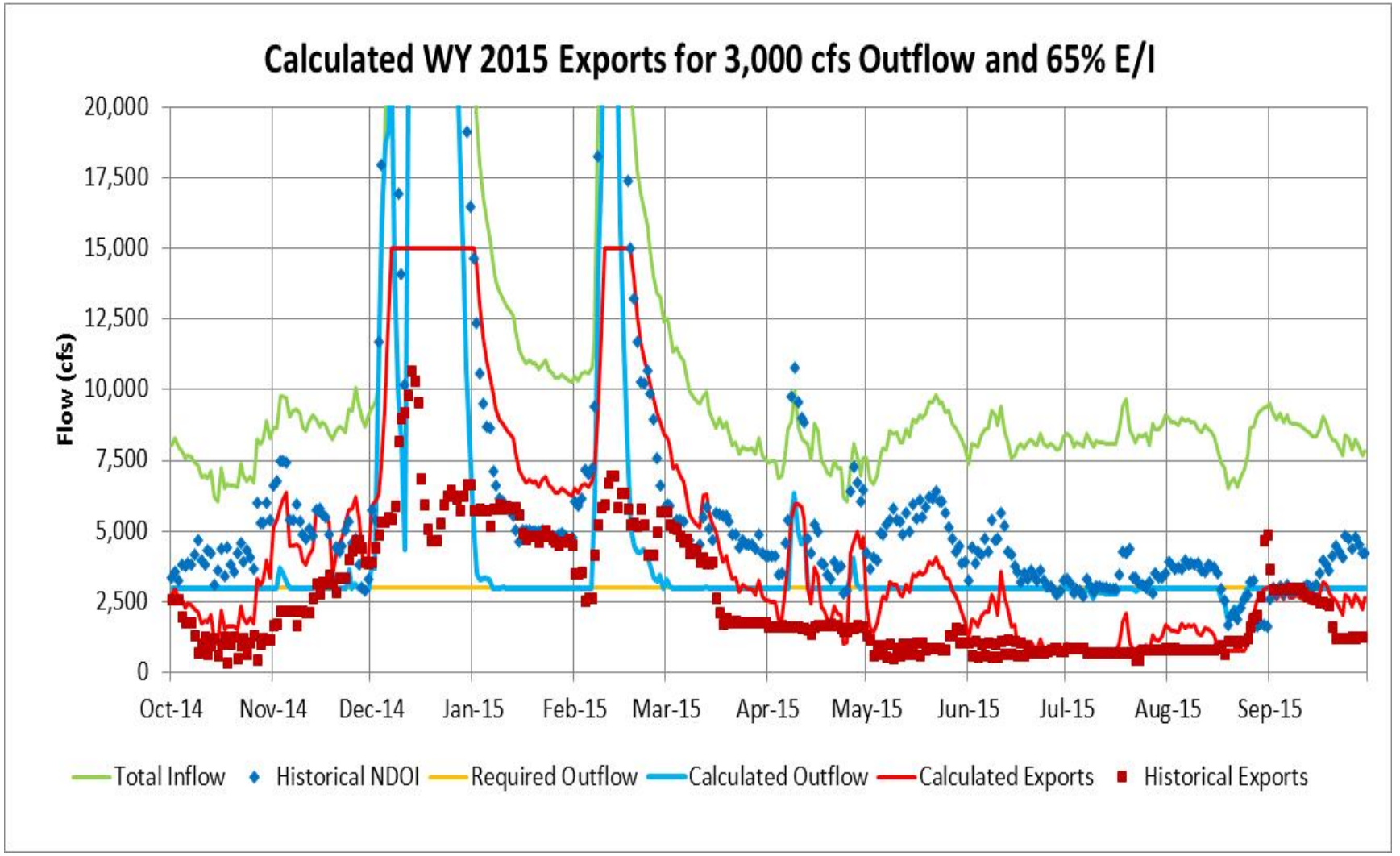


Figure 4. WY 2015 Historical (symbols) and Calculated (lines) Exports and Outflow with 3,000 cfs Required Outflow, 65% E/I, no OMR or SJR Export Limits and 15,000 cfs Export Capacity