5.4. Stage Results

5.4.1. Background

Tidal damping can occur if channels are not large enough to convey the full tidal prism of the restored areas. This effect will persist until channel scour (or levee breaches) increase the capacity of the channels feeding the upstream marshes. Velocity results indicate that some channels (Montezuma Slough, Hunter Cut) will be subject to scouring and tidal damping until sufficient conveyance is established.

5.4.2. Results

Each scenario resulted in reduced tidal amplitude throughout Suisun Marsh, and a shift in timing. These changes were generally the most pronounced in Set 1 and Set 2 scenarios, and varied depending on location in the marsh (Figure 5-7). Time series plot of stage at Beldon's Landing, S-49, during October 2003 (Figure 5-8, duck clubs filling) shows that the Set 1 and Zone 4 scenarios have the most prominent effect at this location, while the Zone 1 scenario has very little effect.

The significant dampening effect for the Set 1 scenario can be seen in plots of MHHW and MLLW for April and October 2003, shown in Figure 5-9 and Figure 5-10, respectively. During these months, MHHW was reduced by as much as 0.8 ft and MLLW increased by as much as 1.2 ft. Greater differences are seen in the immediate vicinity of the breaches in the western marsh.

Although the restriction of Set 1 restoration area to Zone 4 (not shown) had less effect in the western marsh, with no breaches there, in the eastern portion, MHHW was reduced by as much as 0.6 ft and MLLW increased by as much as 1.1 ft.

Set 2 restoration areas resulted in MHHW reduced by up to 0.3 ft and an increase in MLLW of up to 0.2 ft (Figure 5-11). Restriction of Set 2 restoration area to Zone 1 (not shown) demonstrated this area had minimal effect on stage throughout Suisun Marsh. The tidal dampening effect was generally less than 0.1 ft overall.

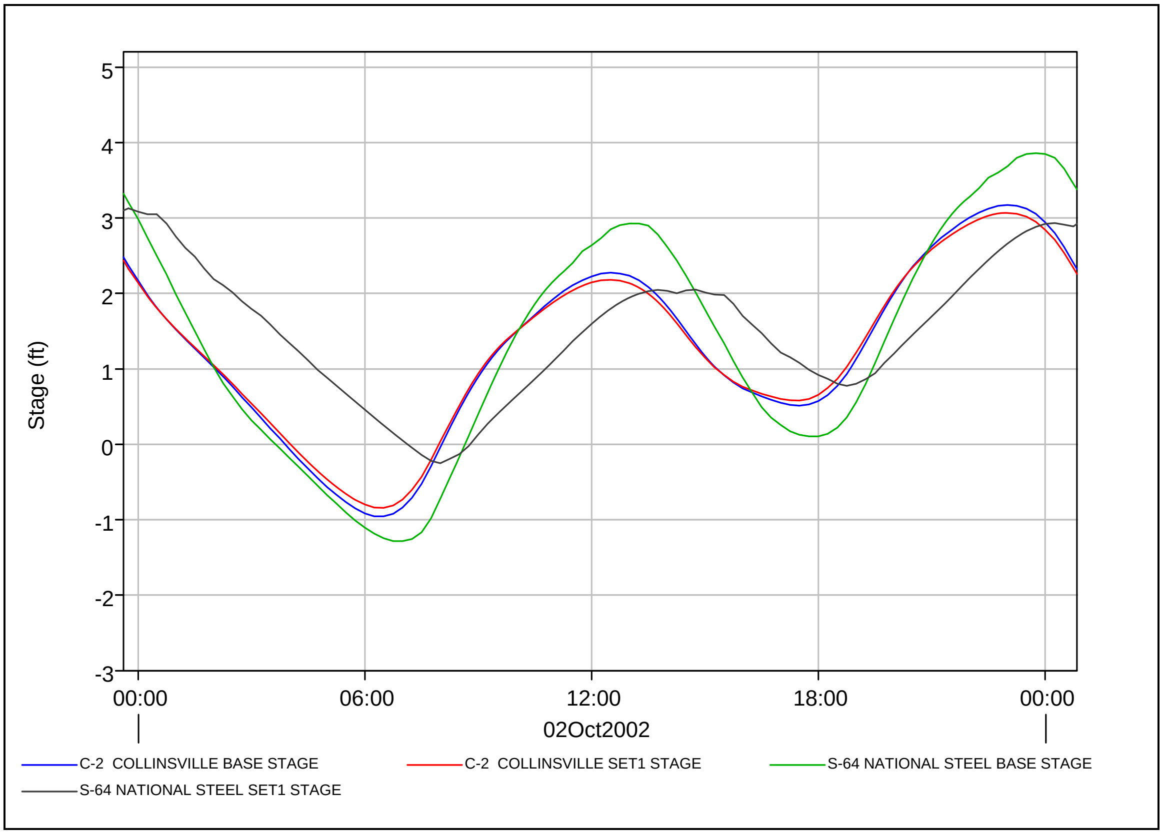


Figure 5-7 Stage time series showing stage shifts at Collinsville monitoring station C-2 and National Steel monitoring location S-64 for Base and Set 1 Scenarios.

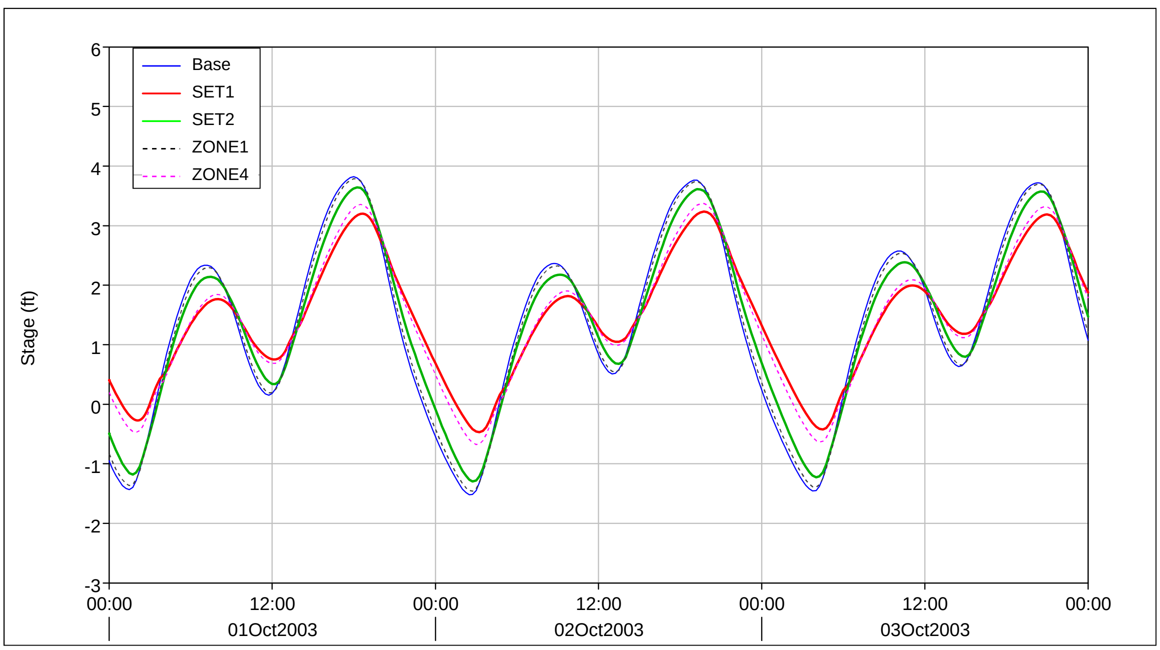


Figure 5-8 Stage time series at monitoring station S-49 at Beldon's Landing when Duck Clubs in the Suisun Marsh region are filling in the fall.

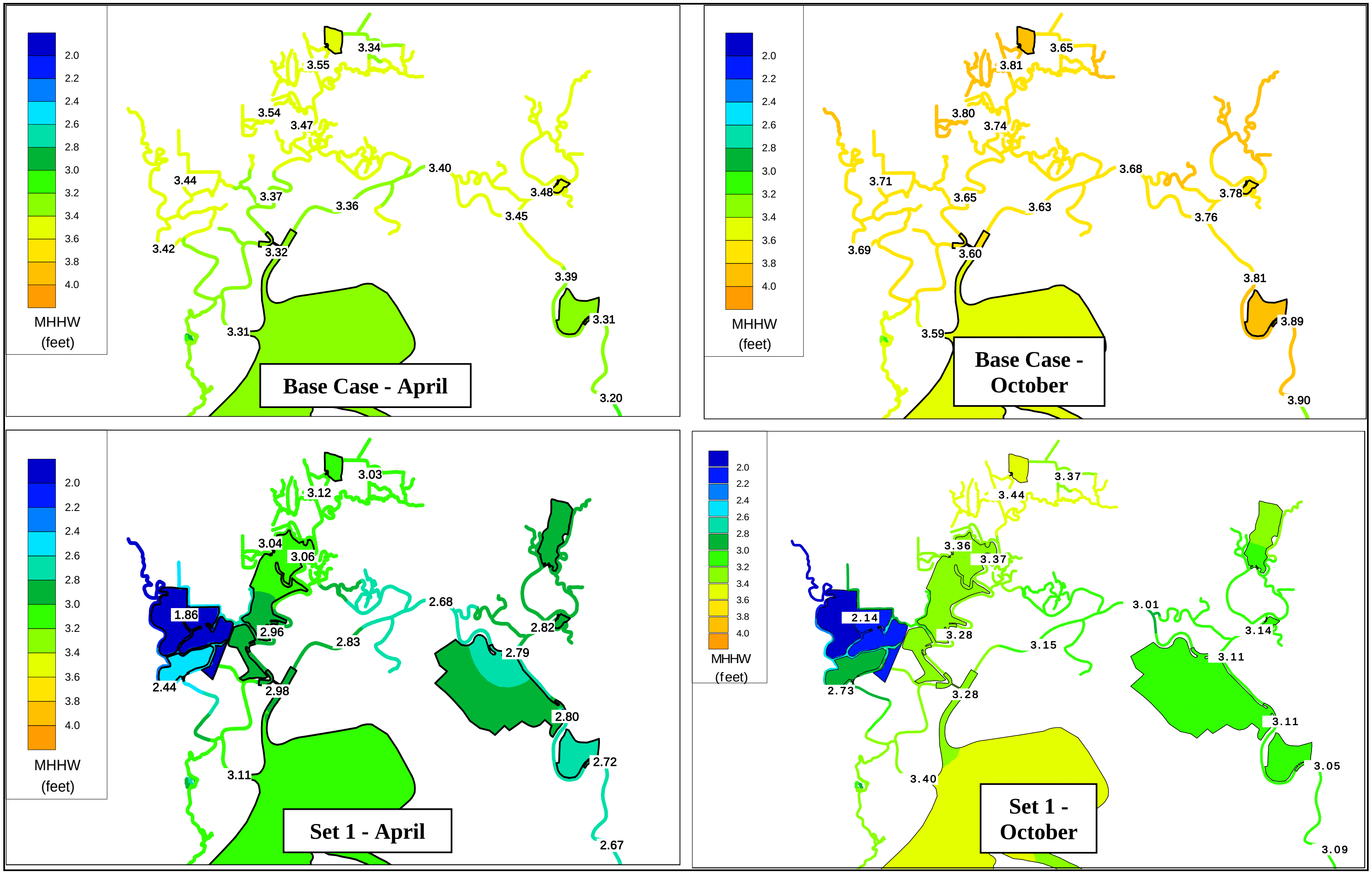


Figure 5-9 Color contour plots of Base case (upper) and Set 1 (lower) MHHW elevations for April (left) and October (right) 2003.

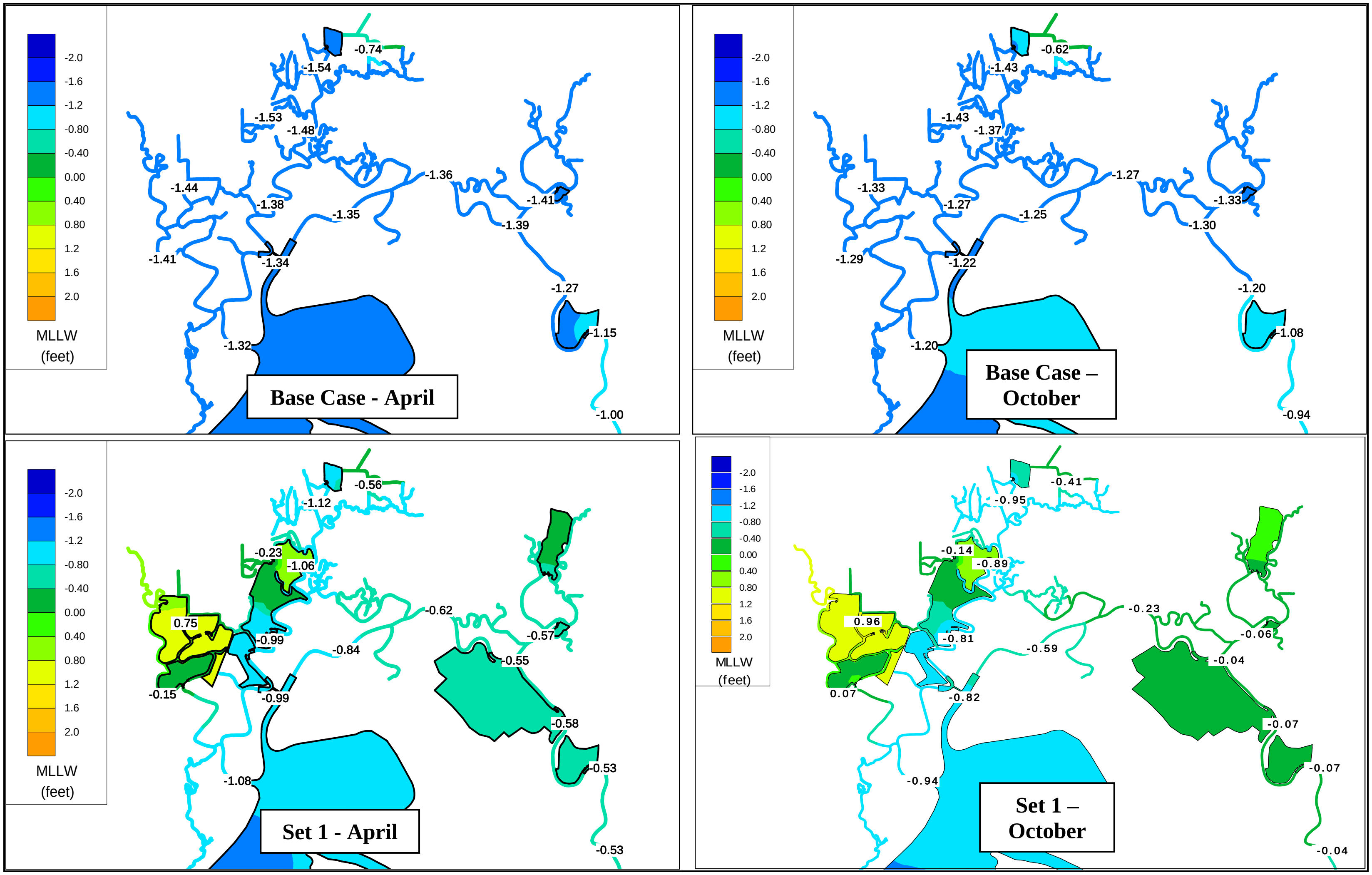


Figure 5-10 Color contour plots of Base case (upper) and Set 1 (lower) MLLW elevations for April (left) and October (right) 2003.

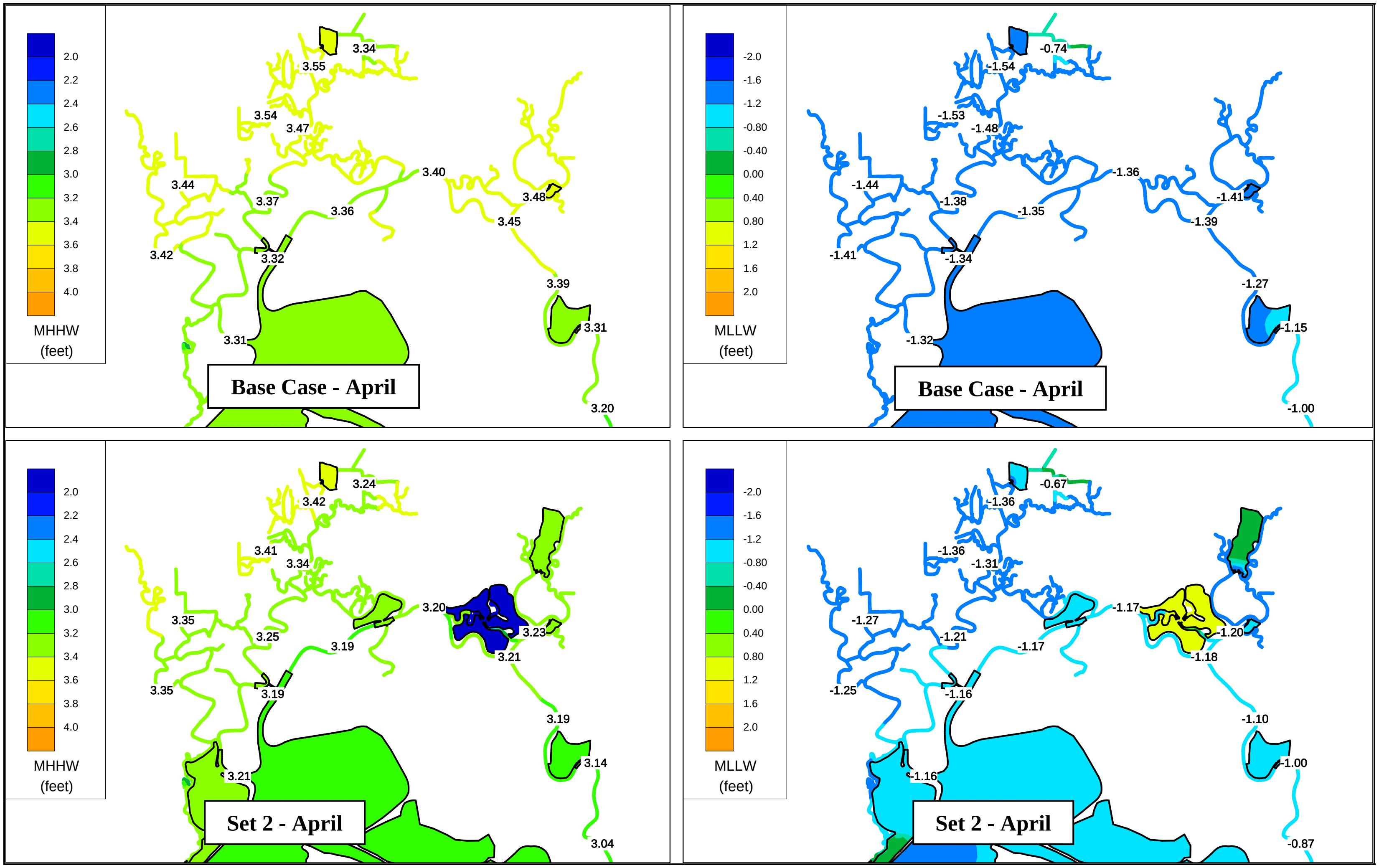


Figure 5-11 Color contour plots of Base case (upper) and Set 2 (lower) MHHW (left) and MLLW (right) elevations for April 2003 (note scale differences for MHHW and MLLW).

5.5. Tidal Prism Results

5.5.1. **General observations**

As expected, each of the scenarios increased the tidal prism, i.e., the volume of water exchanged in the Suisun Marsh area, in comparison with the Base case. Figure 5-12 shows locations where net tidal flow results are presented for July 2003. Values for tidal flow were calculated by accumulating ebb and flood (tidal) flow in ac-ft/day and averaging over the month. The results are grouped by general location in Suisun Marsh and by range of tidal flow.

The Set 1 scenario increased tidal flow everywhere except the boundary sloughs of the Marsh (e.g. Hill Slough) as flow increased through both ends of Montezuma Slough, and through Suisun Slough and Hunter Cut. Tidal flows in boundary sloughs decrease when tidal marsh restoration occurs at downstream locations because not as much of the tidal prism makes it past these new areas. For the Set 2 scenario, the increased flow in Suisun Slough and western Montezuma Slough increased tidal flow in the larger sloughs and adjacent sloughs, but decreased flow to the boundary areas of the Marsh and through the eastern end of Montezuma Slough. Zone 4 resulted in increased flow through Montezuma Slough and through the northern-central portion in the Marsh interior through Suisun Slough, but decreased tidal flow in the north eastern and western regions of the Marsh. Zone 1 decreased tidal flow everywhere, except in areas in the immediate vicinity (e.g., Hunter Cut) of the breached area.

5.5.2. **Central Marsh**

The increase in tidal flow through the largest sloughs in the central portion of the Marsh depended on the location of the breached area. Set 1 and Zone 4 increased average tidal flow through both ends of Montezuma Slough to fill the Zone 4 breached area. At the western end of Montezuma Slough, tidal flow increased ~ 24% for the Zone 4 scenario and ~ 48% for the Set 1 scenario in comparison with the base, and at the eastern end ~ 60% for both Zone 4 and Set 1. Zone 4 filled through the breaches at both ends, with the timing of the filling and draining of the eastern breach delayed for a short while in comparison with the western end.

Set 2 and Zone 1 also increased tidal flow through the western end of Montezuma Slough, but decreased tidal flow through the eastern end.

Changes in the Set 2 and Zone 1 scenarios were very similar, as tidal flow through the mouth of Suisun Slough to fill the Zone 1 breached area increased substantially, while the tidal flow increases were more moderate through Hunter Cut. Zone 1 flows were higher than Set 2 flows by ~ 7% in Hunter Cut, and by ~ 2 % at the mouth of Suisun Slough. Set 1 also increased flows in these two locations, except that the flow increase through Hunter Cut was larger than in Suisun Slough to fill the breached areas northeast of the Cut.

5.5.3. North Interior Marsh

The tidal flow in the northern region of the Marsh decreased as distance from Montezuma Slough increased, and all scenarios were less than the Base case at the four northernmost interior locations (Figure 5-14 and Figure 5-15) because of the downstream restoration areas.

5.5.4. Western Interior Marsh

Filling and draining of the Zone 1 breached area decreased the tidal flow in interior locations of the western Marsh, west and north of the breached area. Zone 1 and Set 2 tidal flows increased through Hunter Cut and the mouth of Suisun Slough (Figure 5-13), and decreased at the interior Suisun Slough locations(Figure 5-15). Flow through Goodyear Slough only increased at the southern end (Figure 5-16), and then only for the Zone 1 and Set 2 scenarios.

The Set 1 scenario increased flow through Hunter Cut and through portions of Suisun Slough south of the Cut to fill the breached areas in the western Marsh, partly through Cordelia Slough. For Zone 4, there were minor increases in tidal flows through Suisun Slough downstream of Hunter Cut, but decreases in Hunter Cut and in Suisun Slough upstream of Hunter Cut.

5.5.5. Comparison of flood flow for the scenarios

Figure 5-17 and Figure 5-18 illustrate the magnitude of flows ($ft^3 sec^{-1}$) near peak flood tide for the Set 1 and Set 2 scenarios on July 11, 2003 22:00. These results are also shown in Table 5-1 Flow magnitude (cfs) at four locations near peak flood tide (July 11, 2003 22:00)., below. The plots give the magnitude vectors at key locations in Suisun Marsh for the Base case and the two restoration configurations. The flow arrows are scaled by flow magnitude, which is indicated on each plot for the downstream openings at Suisun Slough, Montezuma Slough and Hunter Cut. The color scale gives water surface elevation (ft).

The plots show that when the area on Morrow Island is restored (Set 2, Figure 5-17), Hunter Cut provides almost all of the flow for Suisun Slough above the junction with Cordelia Slough. When filling the Zone 4 breached area in Set 1, most of the flow comes through the mouth of Montezuma Slough (Set 1, Figure 5-18). The red arrows in these figures give the direction and magnitude of the indicated flows.

Table 5-1 Flow magnitude (cfs) at four locations near peak flood tide (July 11, 2003 22:00).

	Base	Set1	Set2
Suisun Sl. @ Mouth	10,900 cfs	17,400 cfs	20,050 cfs
Montezuma Sl. - west	39,200 cfs	62.300 cfs	44,800 cfs
Hunter Cut	10,600 cfs	19,600 cfs	15,600 cfs
Montezuma Sl. - east	3,440 cfs	1,500 cfs	5,820 cfs

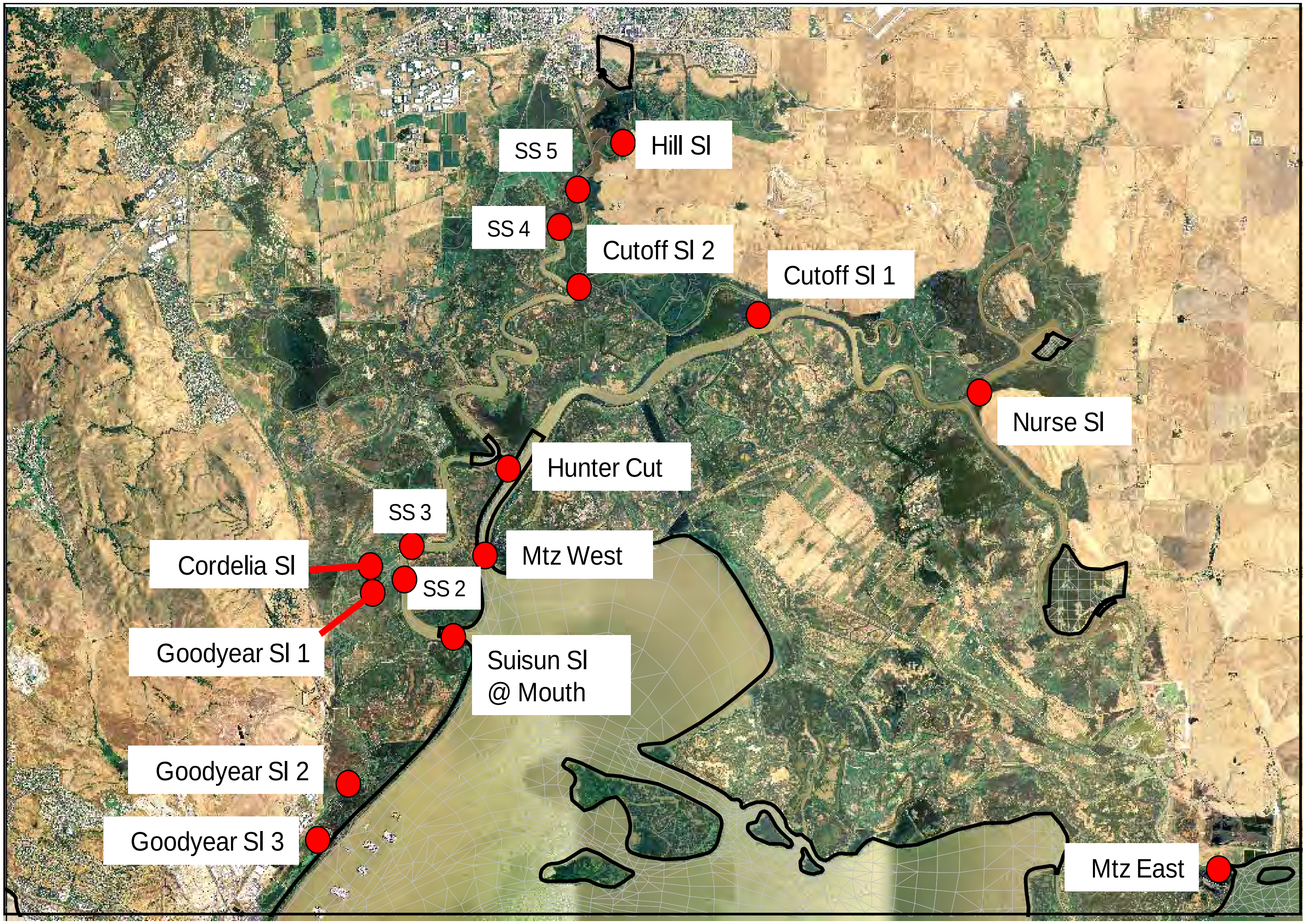


Figure 5-12 Locations where tidal flow was calculated (Base case grid).

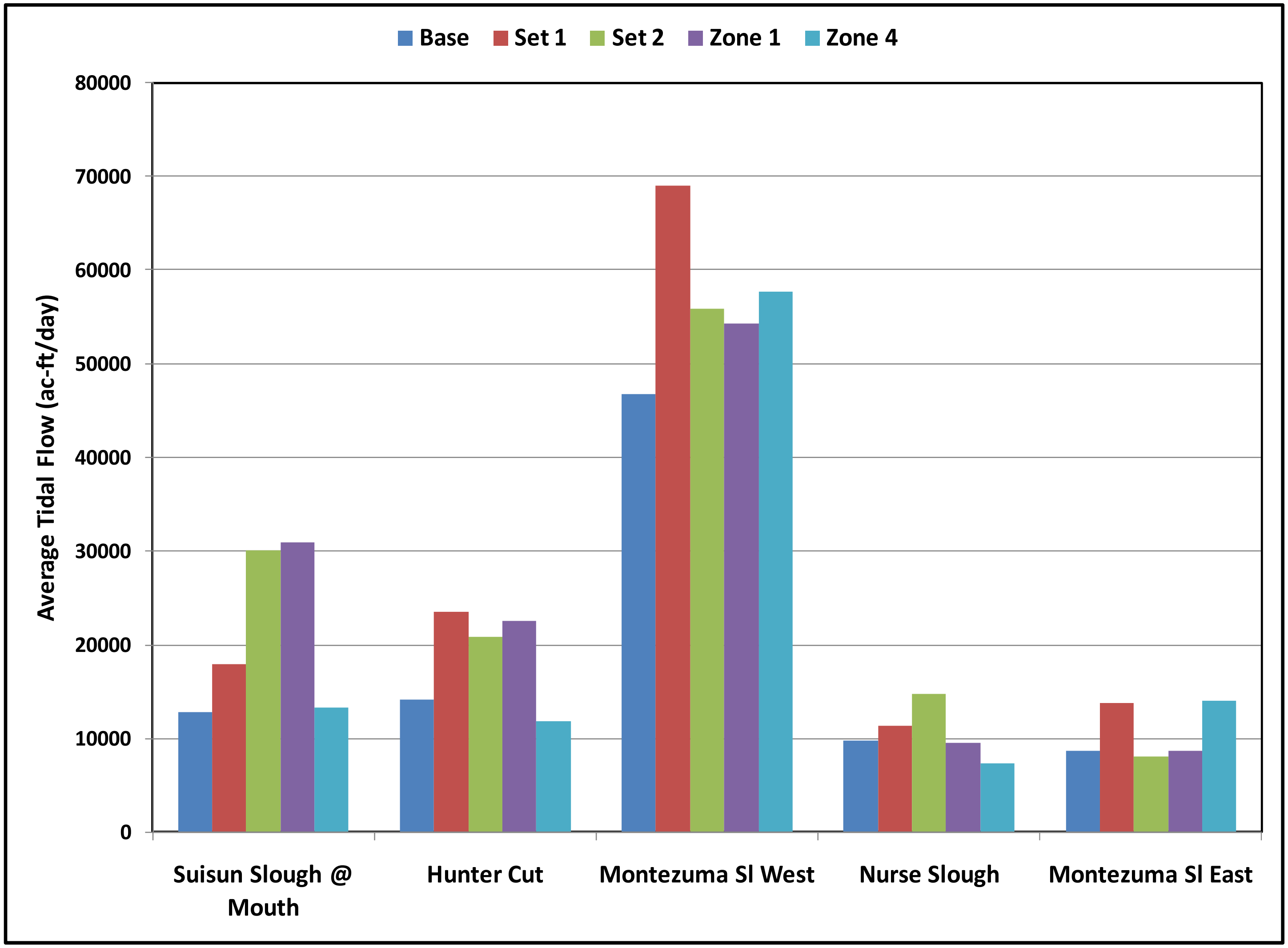


Figure 5-13 Average modeled tidal flow in the larger sloughs in central Suisun Marsh.

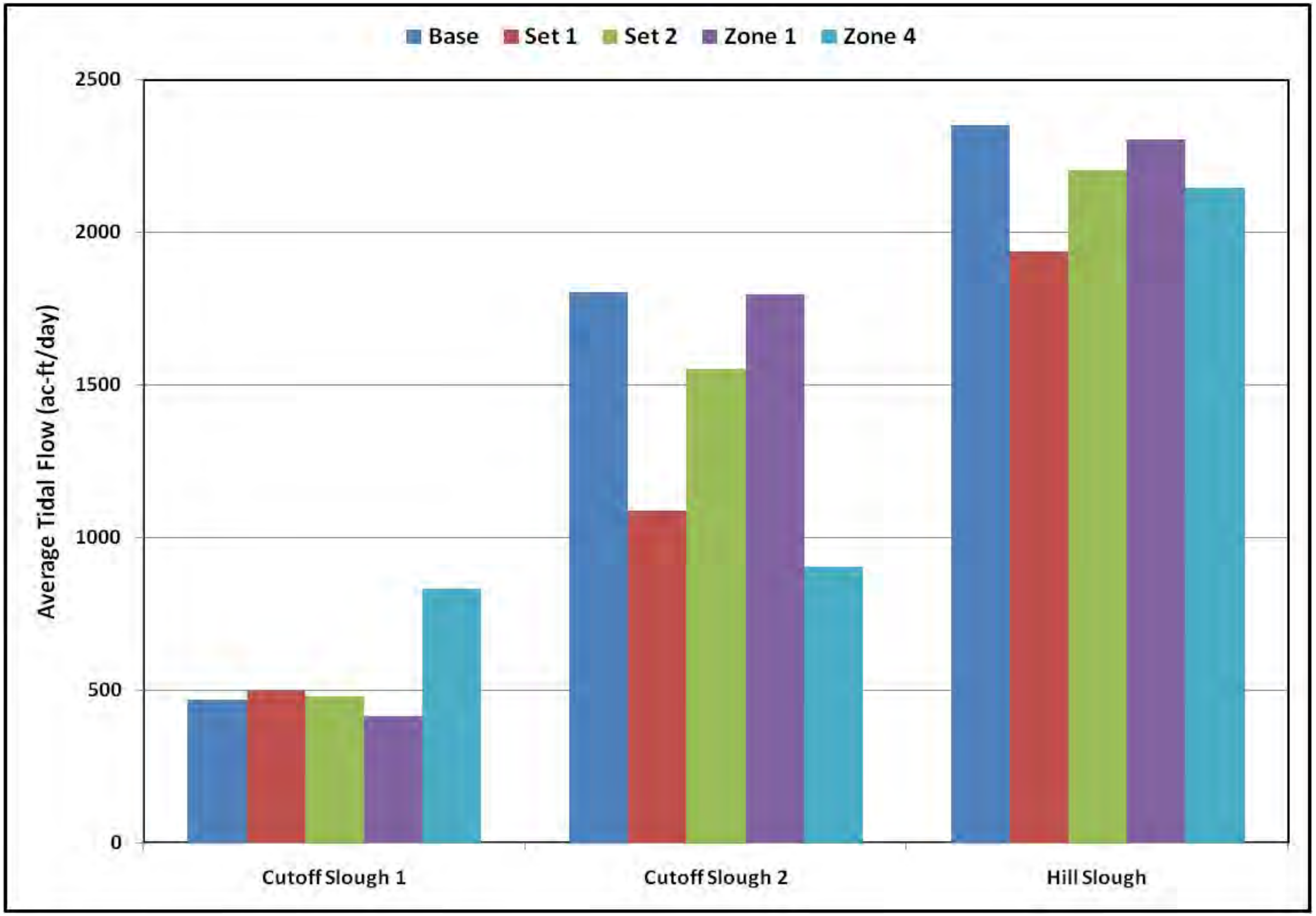


Figure 5-14 Average modeled tidal flow in the smaller sloughs in the northern interior region of Suisun Marsh.

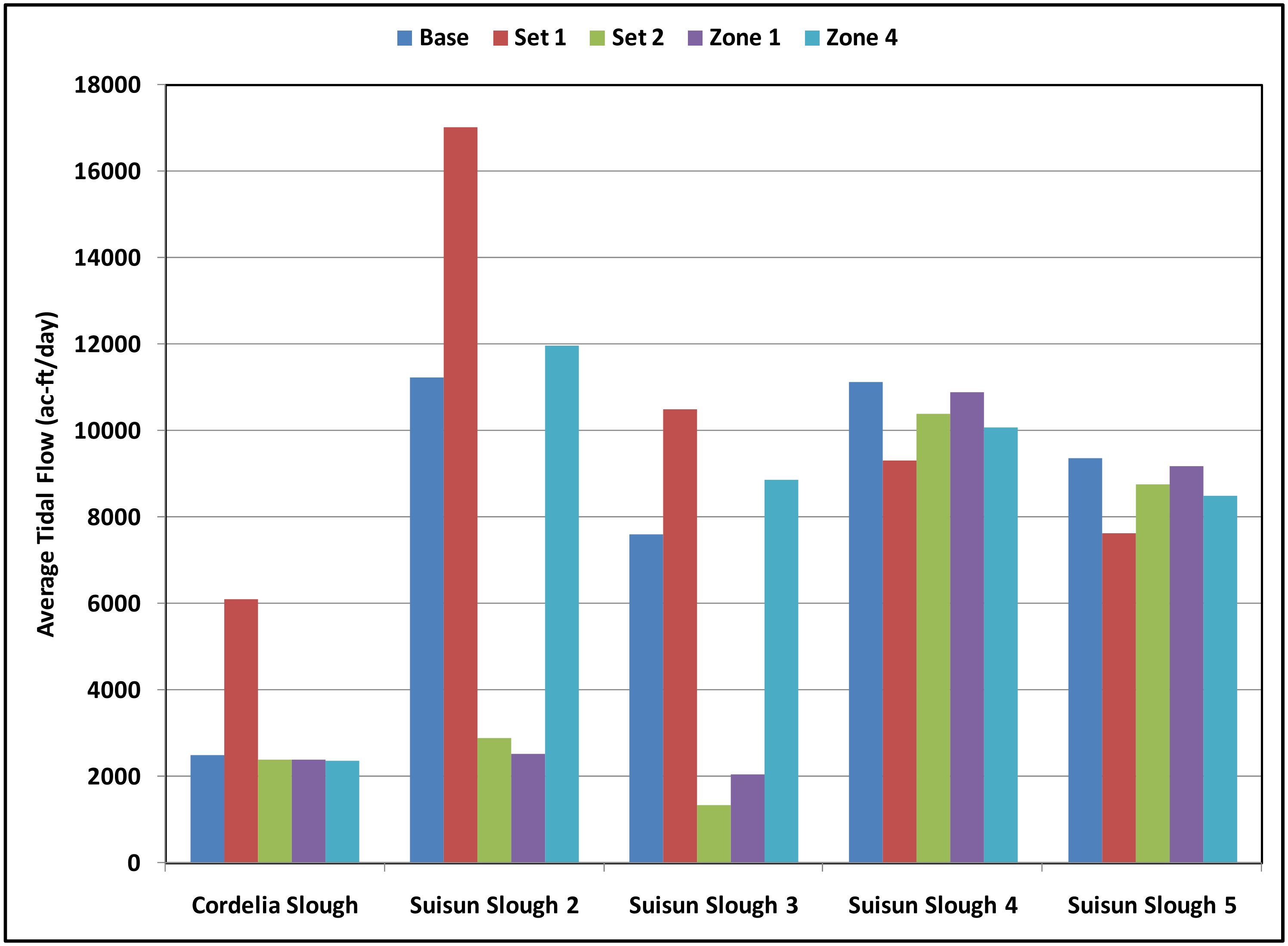


Figure 5-15 Average modeled tidal flow in the sloughs west and north of the Zone 1 area.

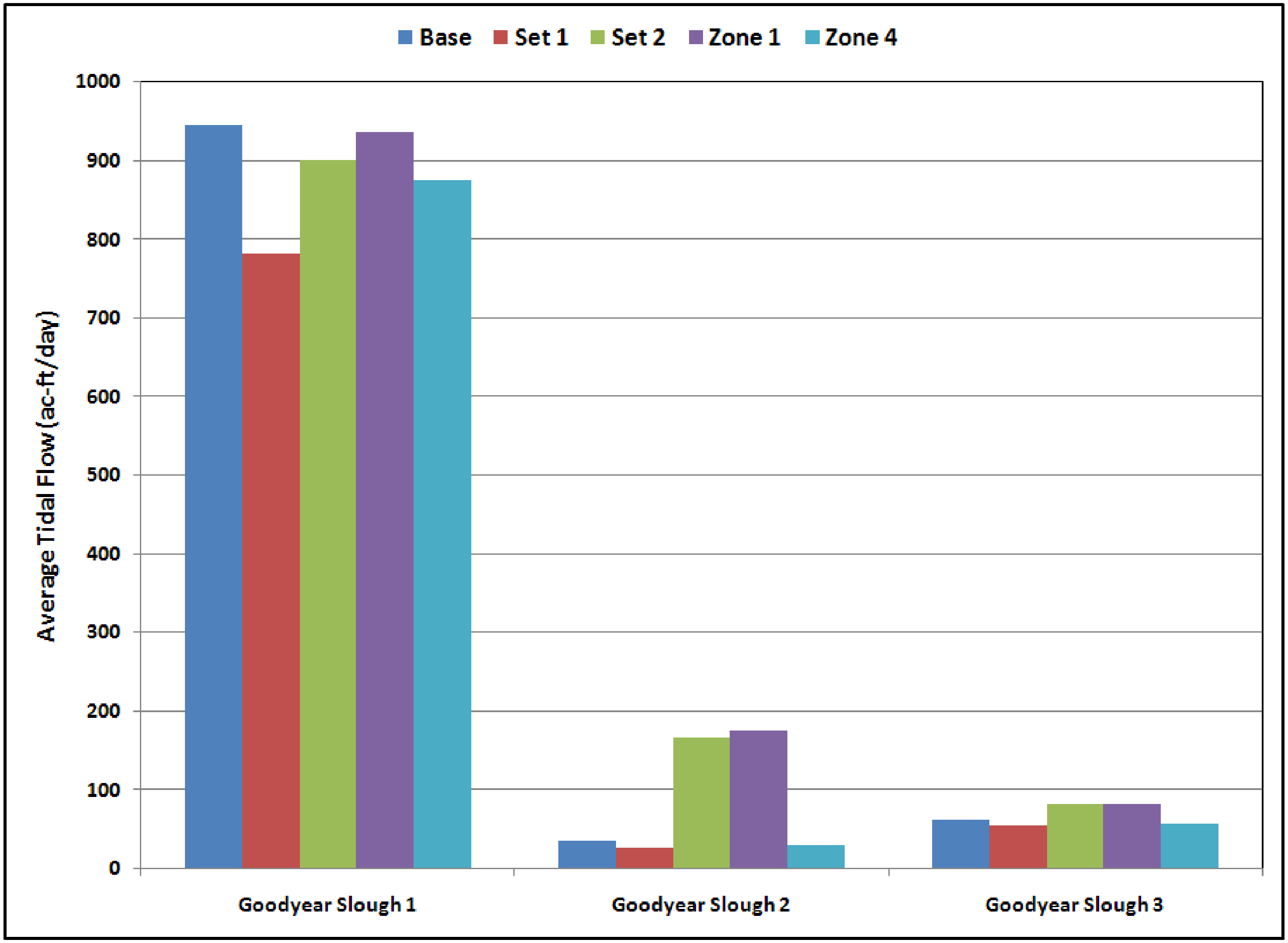


Figure 5-16 Average modeled tidal flow in Goodyear Slough.

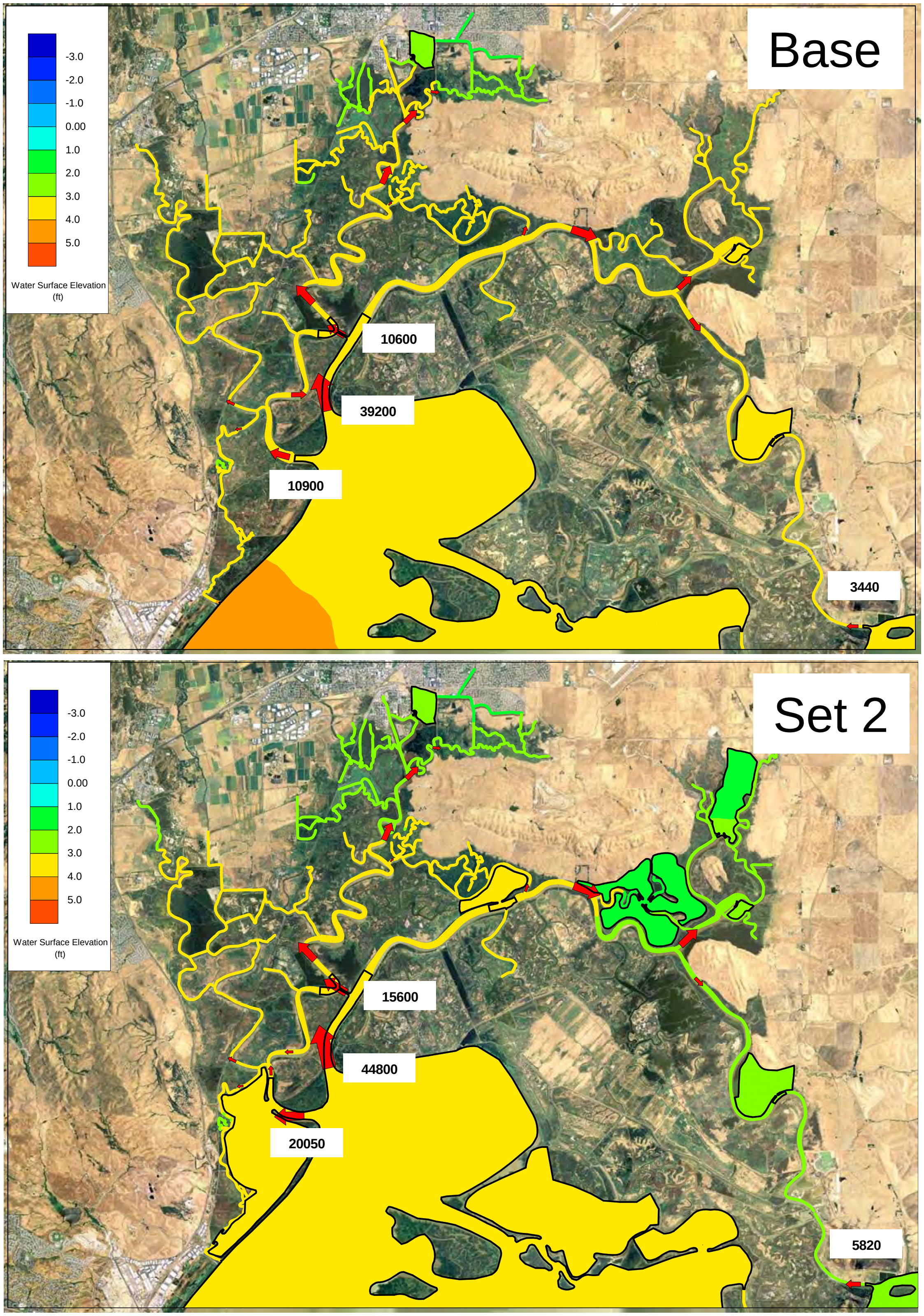


Figure 5-17 Red arrows illustrate flow magnitude (cfs) near peak flood tide (July 11, 2003 22:00) for Base case in comparison with Set 2. Color Scale is water surface elevation.

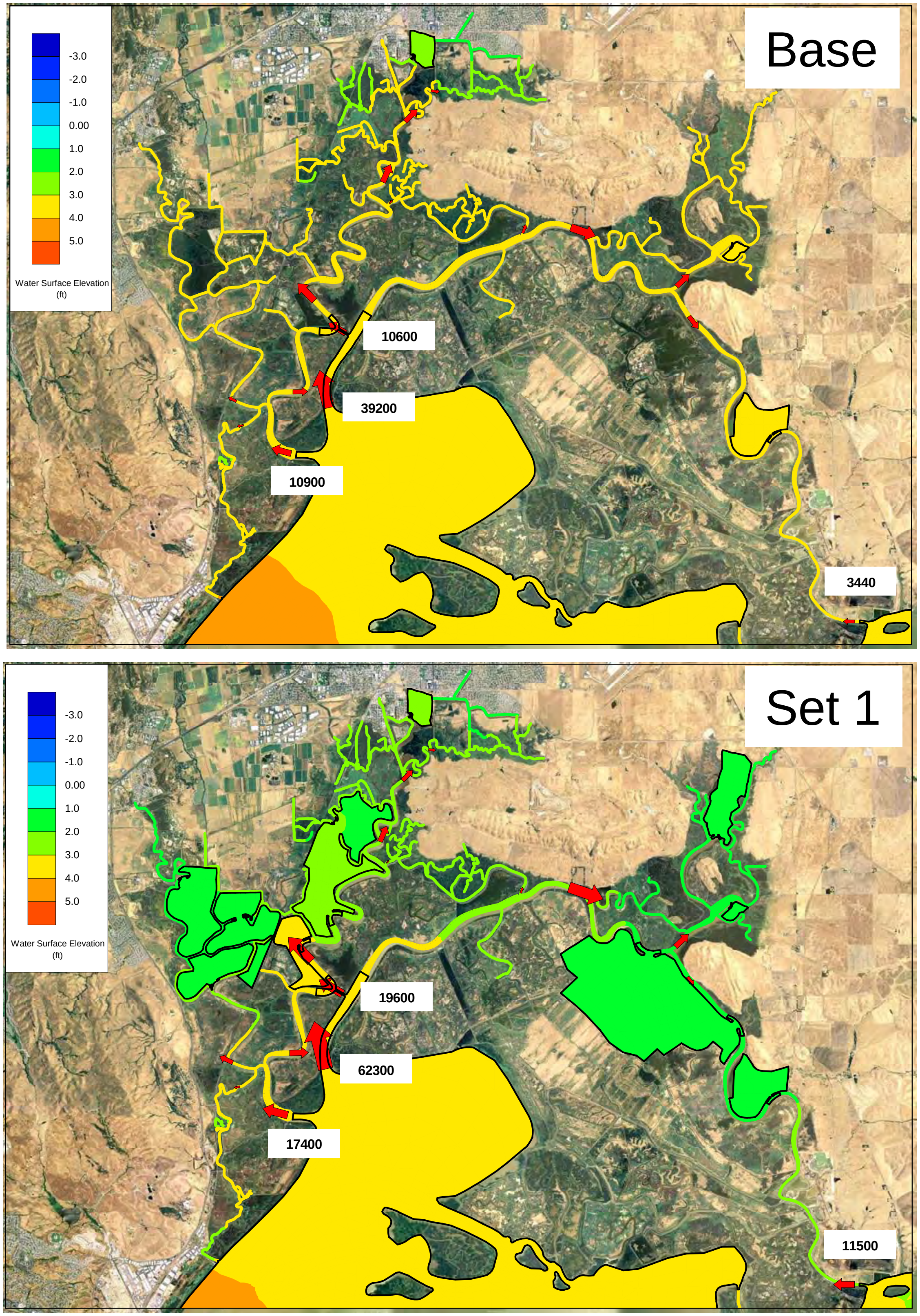


Figure 5-18 Red arrows illustrate flow magnitude (cfs) near peak flood tide (July 11, 2003 22:00) for Base case in comparison with Set 1. Color Scale is water surface elevation.

5.6. EC Results

To present a clear picture of the effects of the scenarios on EC in Suisun Marsh and in the Delta, several types of plots are provided. These include time series plots of the scenario EC at selected locations in Suisun Marsh and the Delta; color contour plots of percent change from base; comparison plots of Base case and scenario EC in Suisun Marsh; and comparison plots of Base case and scenario EC in the Delta. For all of the scenarios, large percent changes calculated in the winter are due to very low values, i.e. relatively small increases in modeled EC can translate to large percent increases. Therefore, contour plots of % change during the winter are not provided.

5.6.1. **Martinez to Collinsville**

Tidally averaged EC at Martinez (Figure 5-19) is relatively uniform between scenarios. However, upstream at Chipps and Collinsville, Figure 5-20 and Figure 5-21 respectively, the effect of the Set 2 tidal restoration with breaches between Honker and Grizzly Bays is seen as a pronounced increase in EC throughout the year.

5.6.2. **Suisun Marsh**

Changes in the details of the EC profile for each scenario depended on the particular location examined, the operation of the SMSCG, and the season. Each of the scenarios resulted in EC increases in Montezuma Slough at Beldon’s Landing. Tidally averaged EC for the Base case and the four restoration scenarios are plotted in Figure 5-22 through Figure 5-34 for locations throughout Suisun Marsh.

The Set 1 scenario produced the greatest increases in EC throughout much of Suisun Marsh, as most of the tidal marsh restoration occurs in the interior portions of the marsh and off of Montezuma Slough. See for example, stations S-49 at Beldon’s Landing, S-40 at Boynton Slough, and S-97 at Ibis in Figure 5-22 through Figure 5-24. At Beldon’s Landing, the Zone 4 breaches pull high salinity water in from western Montezuma Slough increasing EC there year-round. The Set 1 breaches in north-western Suisun Marsh increase EC near those locations, again through the increased volume of higher salinity moving up western Montezuma Slough.

Effects from Set 1 restoration in the western portions of the marsh primarily result from the breaches in that area, as can be seen when comparing results with the Zone 4 scenario results at station S-97, Figure 5-24. Zone 4 had very little effect on EC in the western and northern marsh when the SMSCG was open and decreased EC when SMSCG was operating, as illustrated in Figure 5-24 through Figure 5-31.

Zone 4 increased EC at Beldon’s landing regardless of the SMSCG status. In eastern Montezuma Slough at National Steel (Figure 5-33) and Roaring River (Figure 5-34), EC decreased when SMSCG was open and increased when the gates were operating.

In eastern Montezuma Slough, Set 1 reduced EC when the SMSCG was open (see station S-64 at National Steel, Figure 5-33 and station S-71 at Roaring River, Figure 5-34). The

Zone 4 breaches on Montezuma Slough pull high EC water into the marsh from the west during flood tide. Ebb flows on the upstream side of the breaches pull additional lower EC Sacramento River water into the eastern end of Montezuma Slough. This is illustrated in Figure 5-40, which shows color contours of EC for the Base case and Zone 4 scenario at the same timing on a flood tide and on an ebb tide.

The Zone 1 restoration increased EC throughout much of the marsh. As shown in the color contour plot of percent change in EC in Figure 5-47, % EC in Grizzly Bay at the mouth of Montezuma Slough is about 4.5% higher than the Base case with similar increases at the mouth of Suisun Slough. The flows that progress up Suisun Slough past the Zone 1 breach are smaller than in the Base case due to the breach, and the marsh is being filled with higher EC water from the mouth of Montezuma Slough in the west.

The Zone 1 scenario EC results were the most similar to the Base case, showing little difference from the Base case in the eastern Marsh (station S-64 at National Steel and station S-71 at Roaring River) and at Morrow Island (station S-35, Figure 5-26), but resulted in at least some EC increase in the western Marsh (for example, S-42 in Volanti Slough, Figure 5-27 and S-21 on Sunrise Slough, Figure 5-25) and in Montezuma Slough near Beldon's Landing.

The Set 2 scenario, which incorporates Zone 1, increased EC when the SMSCG was operating. In the western and central marsh (for example S-21 and S-49), EC was increased throughout the simulation, but at Morrow Island, Set 2 resulted in little change when the SMSCG was not operating. When the SMSCG was not operating, EC decreased appreciably only in eastern Montezuma Slough at S-64 and S-71.

Operation of the SMSCG acts to decrease EC in comparison to the Base case. Specific locations on Montezuma Slough illustrate the effect of SMSCG operation and changes in tidal flow due to the breaches.

- S-49 – Beldon's Landing (Figure 5-22): For the Set 2 scenario, the breaches north of Montezuma Slough only affect EC at Beldon's Landing when the SMSCG is operating. This can be seen because Set 2 and Zone 1 EC are nearly the same at this location when the gates are open.
- S-64 – National Steel (Figure 5-33): In general, all of the scenarios decrease EC at S-64 when the SMSCG is open because they decrease the flood tide flow of higher EC water to this location. When the gate is operating, EC increases for Set 2 because EC at the eastern end of Montezuma Slough near Collinsville is higher due to the breaches in Suisun Bay. On ebb tide, this higher EC water flows past S-64. For the Zone 1 scenario, the same thing occurs only the effect is much smaller. For the Set 1 and Zone 4 scenarios, the increase in EC is the result of a change in phasing. The breaches off of Montezuma Slough changed the tidal phasing and amplitude so that flow from Collinsville into Montezuma Slough occurs at high tide, when EC at Collinsville is highest.

5.6.3. **Delta**

Scenarios that tended to increase EC in Suisun Marsh tended to decreased Delta EC. Delta EC was similar to the Base case in all of the scenarios during early winter through spring, but changed in relation to the Base case during summer through fall. This can be seen in plots of tidally averaged EC for the Base case and four marsh restoration scenarios at several Delta stations in Figure 5-35 through Figure 5-39, and in contour plots of % change from base in Figure 5-41 to Figure 5-53.

The two scenarios incorporating Zone 4 (Zone 4 and Set 1) resulted in a decrease in Delta EC, while the two scenarios incorporating Zone 1 (Zone 1 and Set 2) resulted in an increase in summer through fall Delta EC. This is seen at locations from Jersey Point, Figure 5-35, to various locations in the central and south Delta - at Old River near Rock Slough (5-36), in Victoria Canal (5-37) and at the CVP (Figure 5-38) and SWP (Figure 5-39) export locations.

The Set 2 scenario causes the greatest increase in Delta EC, as shown in Figure 5-41 through Figure 5-46 for the months with the highest EC changes. An example is seen in the color contour plot of percent change from Base case EC for the Set 2 scenario on September 1, 2002 in Figure 5-42. At this time, EC at the SWP is 12% greater than Base and at the CVP, it is 10% greater than Base. These changes are due to tidal mixing in the breaches off of Suisun Bay, which causes increased EC there, and later in the year increased EC up the San Joaquin River into Franks Tract and the western Delta. A similar plot for the Zone 1 scenario, in Figure 5-47, shows that it has minimal change to Delta EC, as the largest increases at the export locations are approximately 2% during the at this time.

The Set 1 and Zone 4 scenarios generally reduce EC at the export locations and in the western Delta summer through fall, as shown in Figure 5-48 through Figure 5-53. The Set 1 scenario produces the largest reductions – approximately 10% near the export locations on September 1, 2002, as shown in the color contour plot in Figure 5-49, while the Zone 4 restoration area alone reduces EC by 5 – 6% near the exports (not shown).

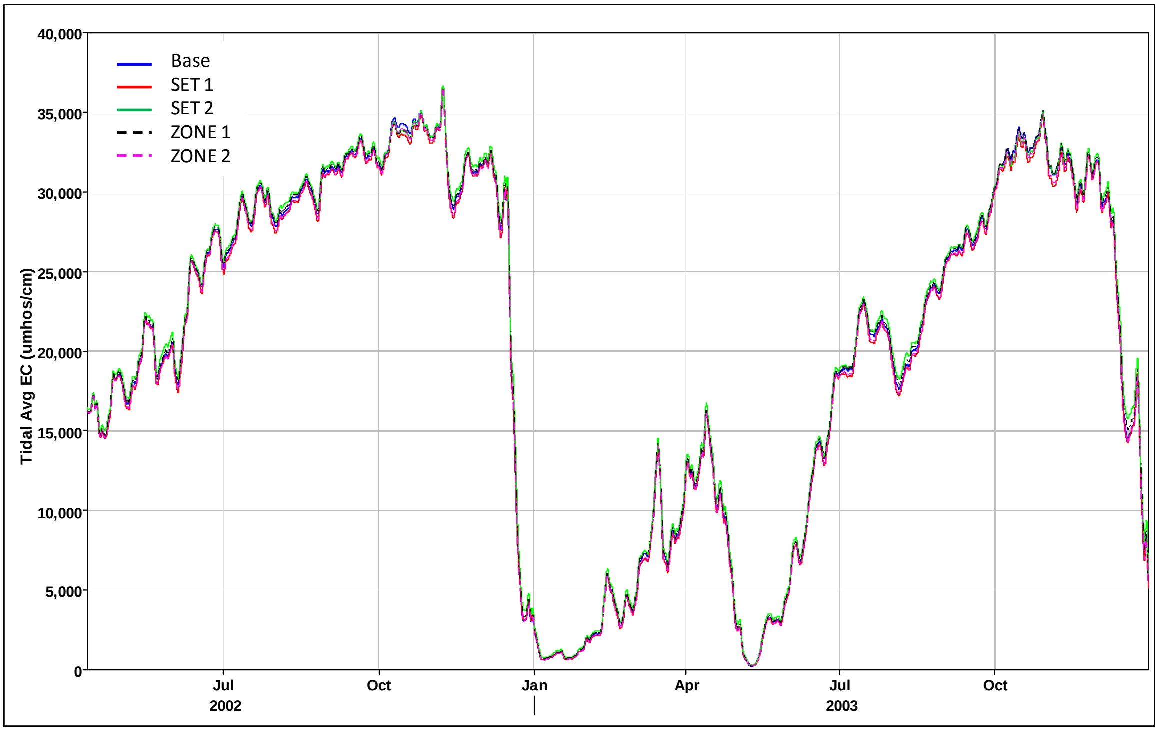


Figure 5-19 Tidally averaged computed EC at Martinez.

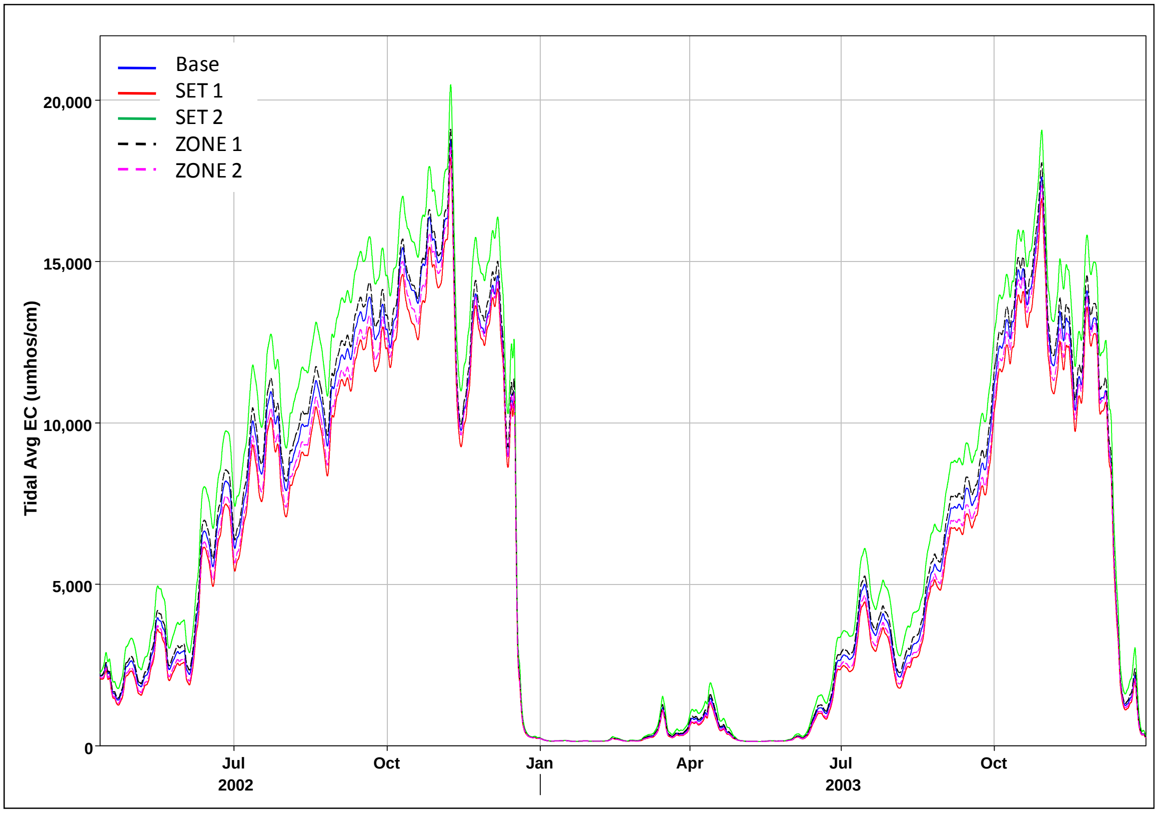


Figure 5-20 Tidally averaged computed EC at Chipps.

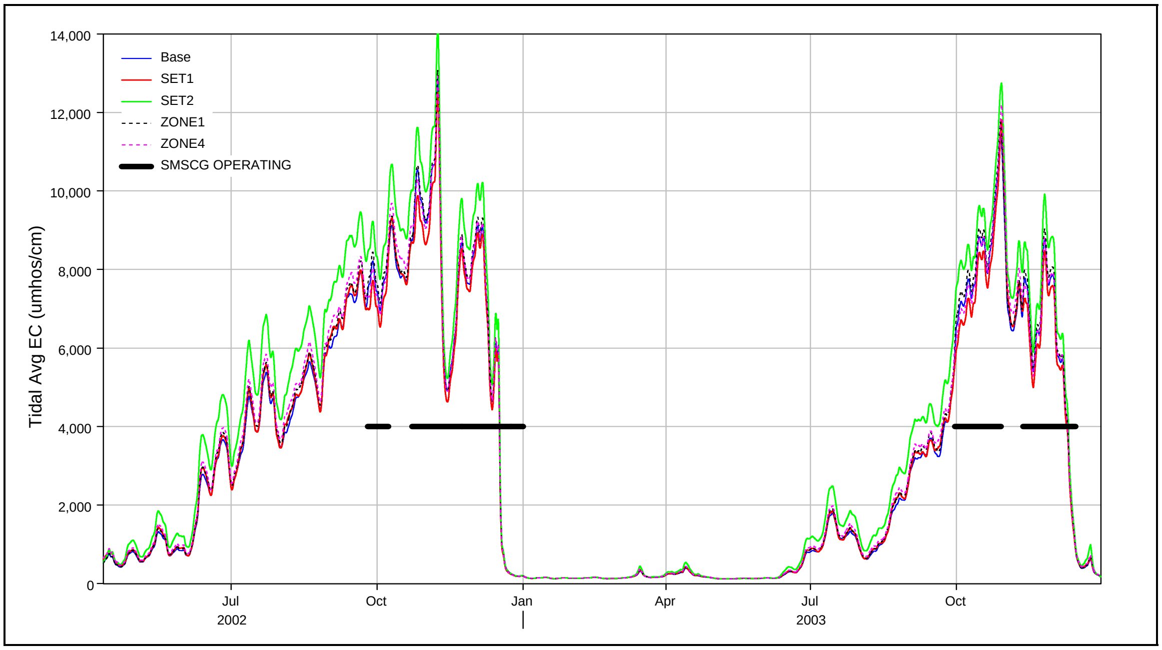


Figure 5-21 Tidally averaged observed and computed EC at Collinsville.

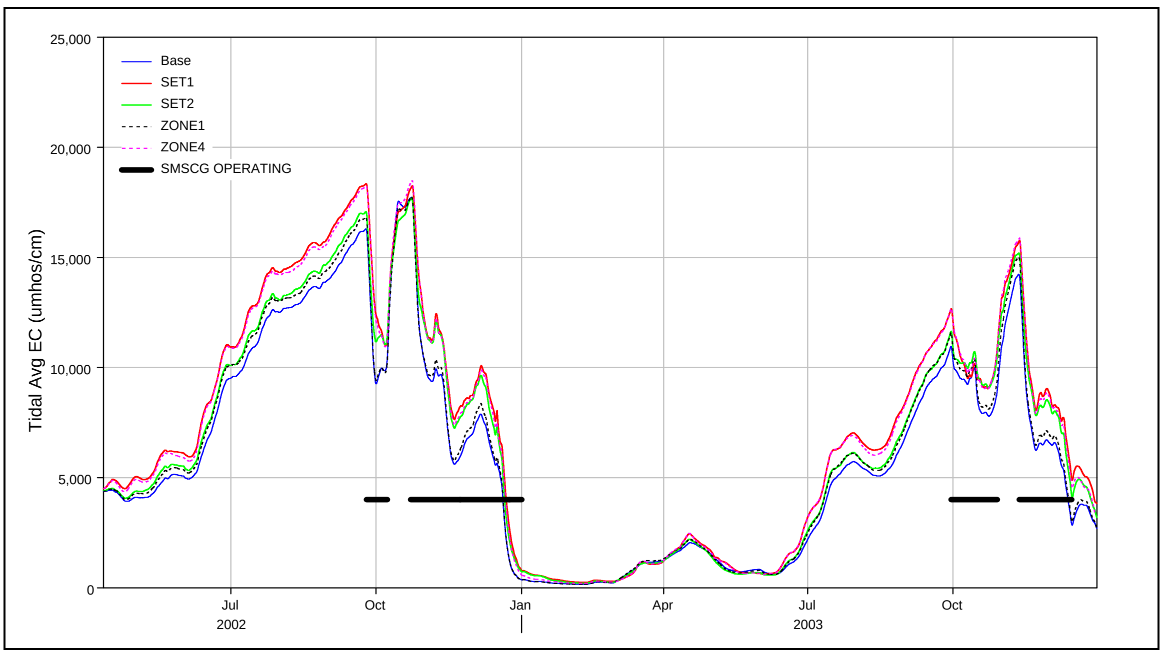


Figure 5-22 Tidally averaged computed EC at Beldon's Landing at monitoring station S-49 in Montezuma Slough.

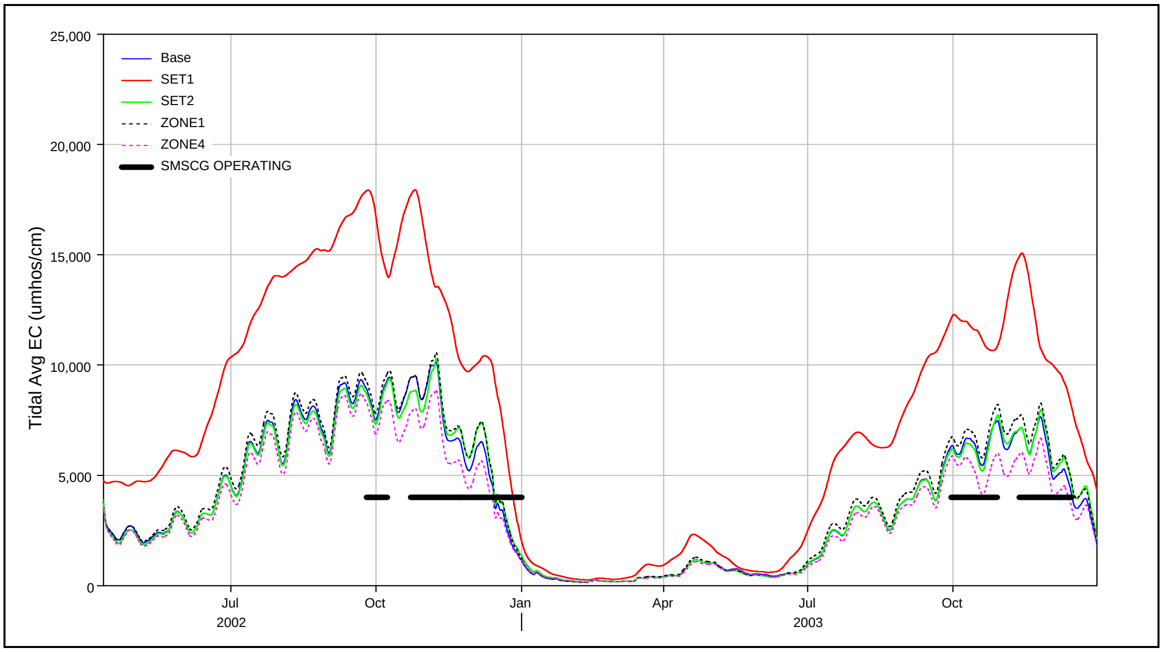


Figure 5-23 Tidally averaged computed EC at station S-40 on Boynton Slough.

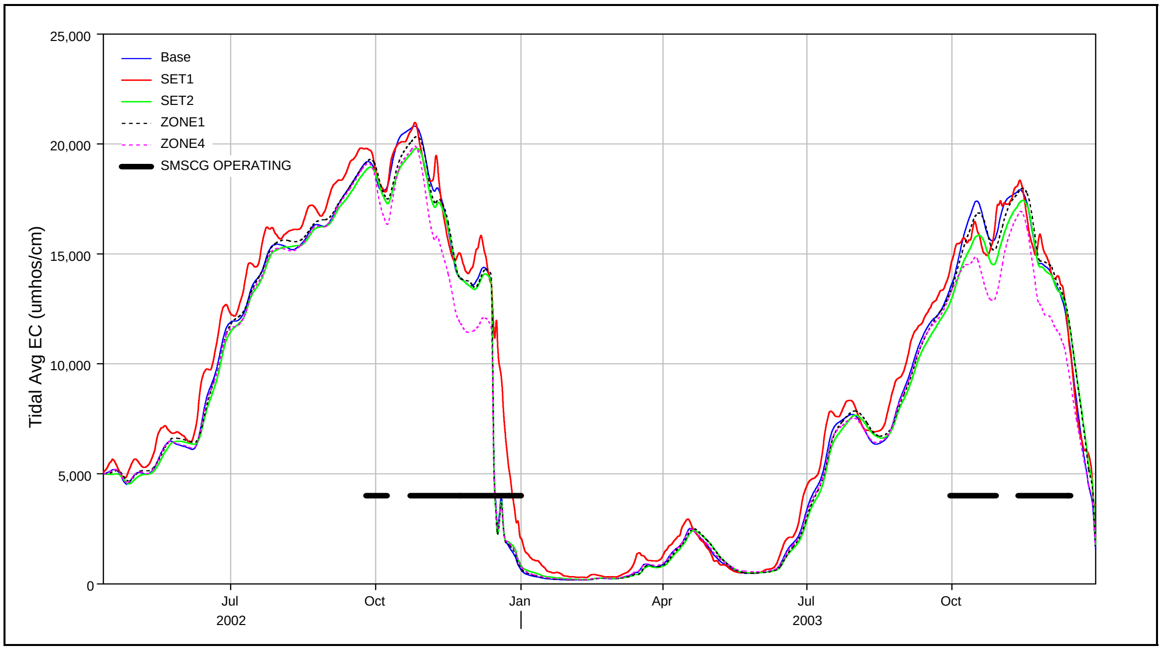


Figure 5-24 Tidally averaged computed EC at station S-97 on Ibis Slough.

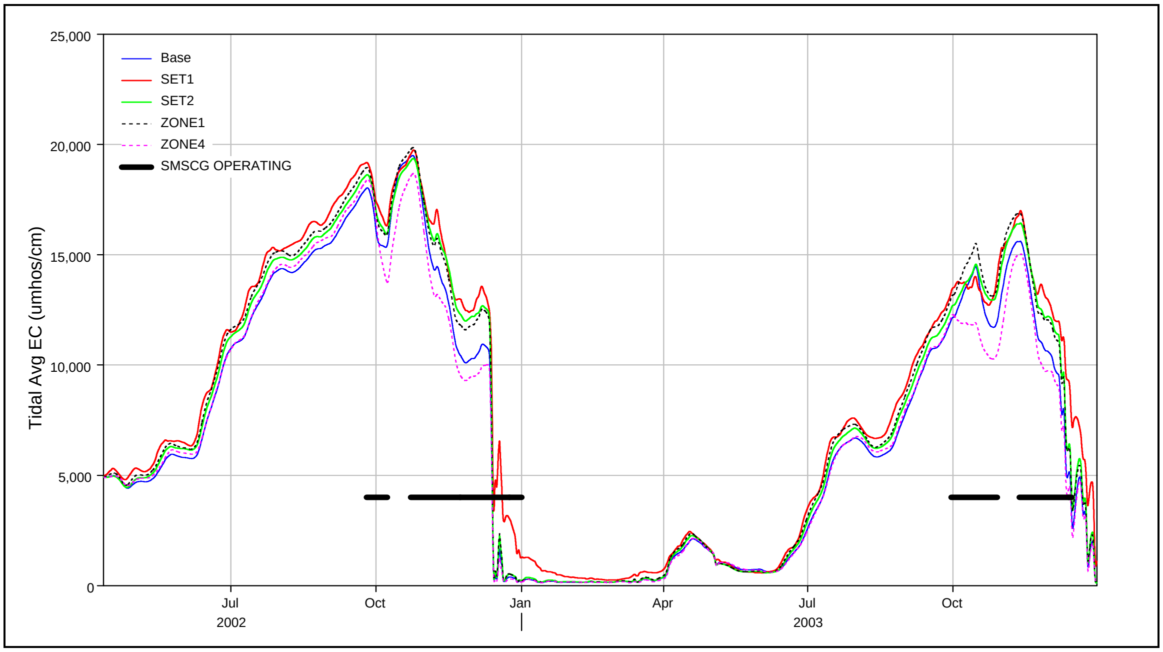


Figure 5-25 Tidally averaged computed EC at station S-21 in Sunrise Slough.

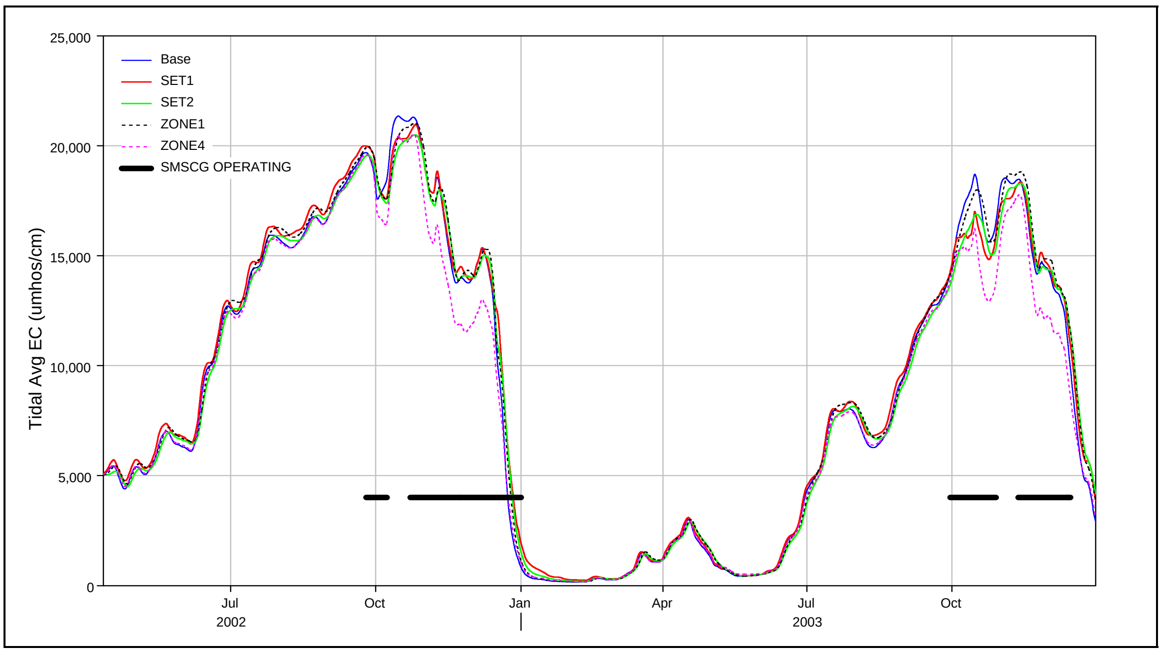


Figure 5-26 Tidally averaged computed EC at station S-35 at Morrow Island.

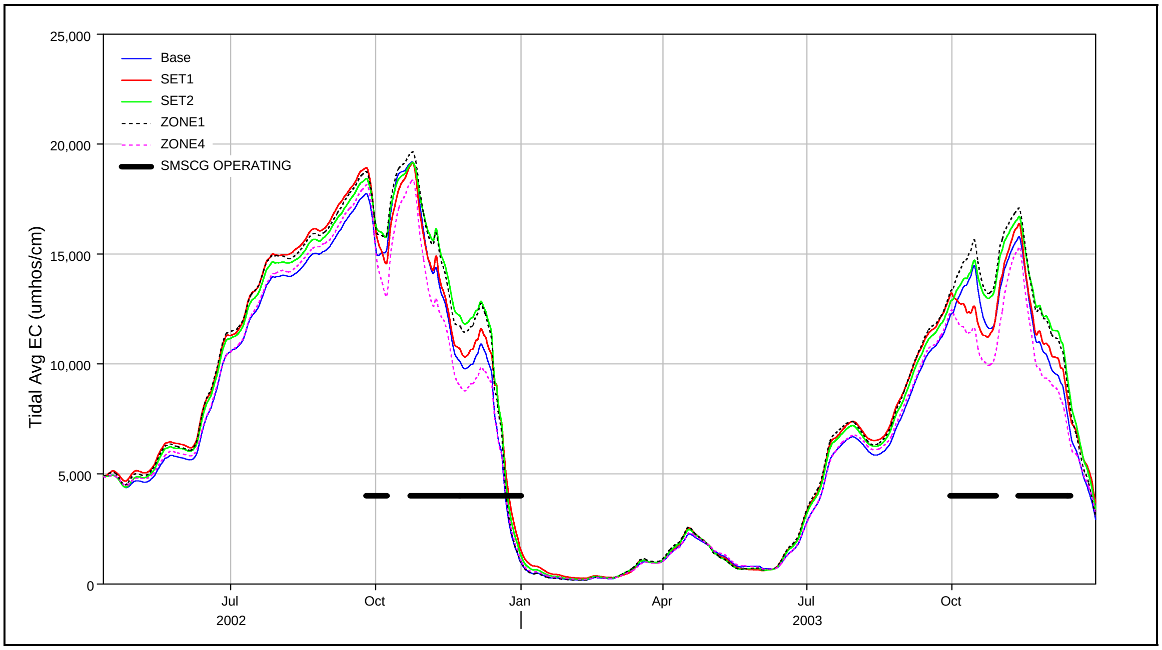


Figure 5-27 Tidally averaged computed EC at station S-42 on Volanti Slough.

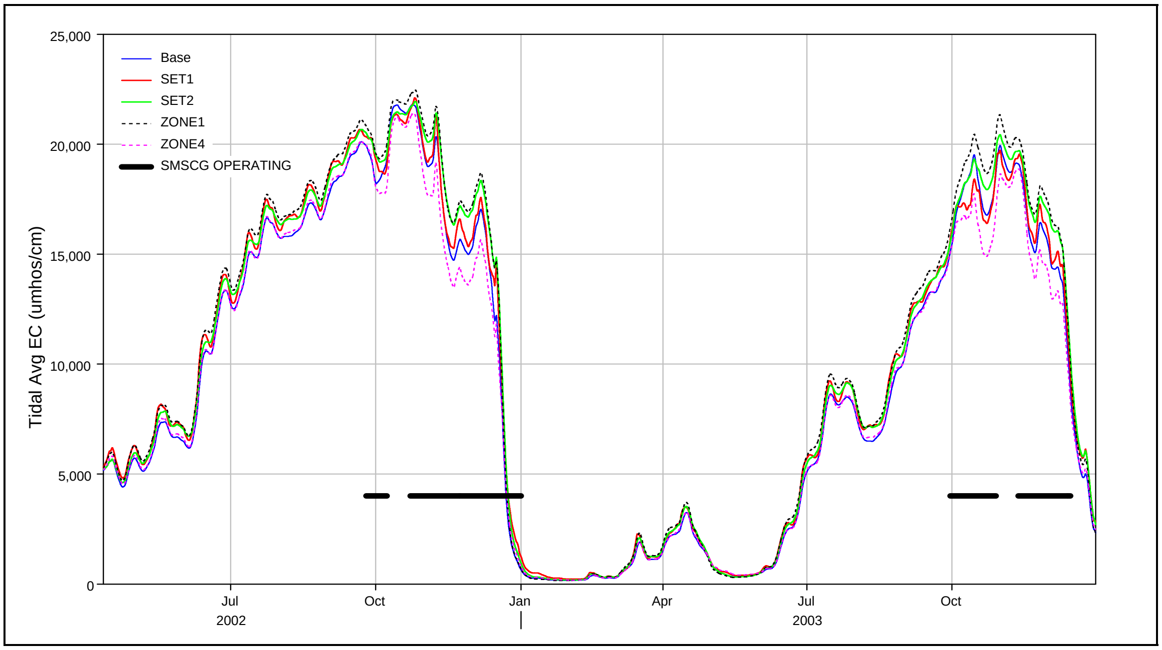


Figure 5-28 Tidally averaged observed and computed EC at station S-37 on Godfather Slough.

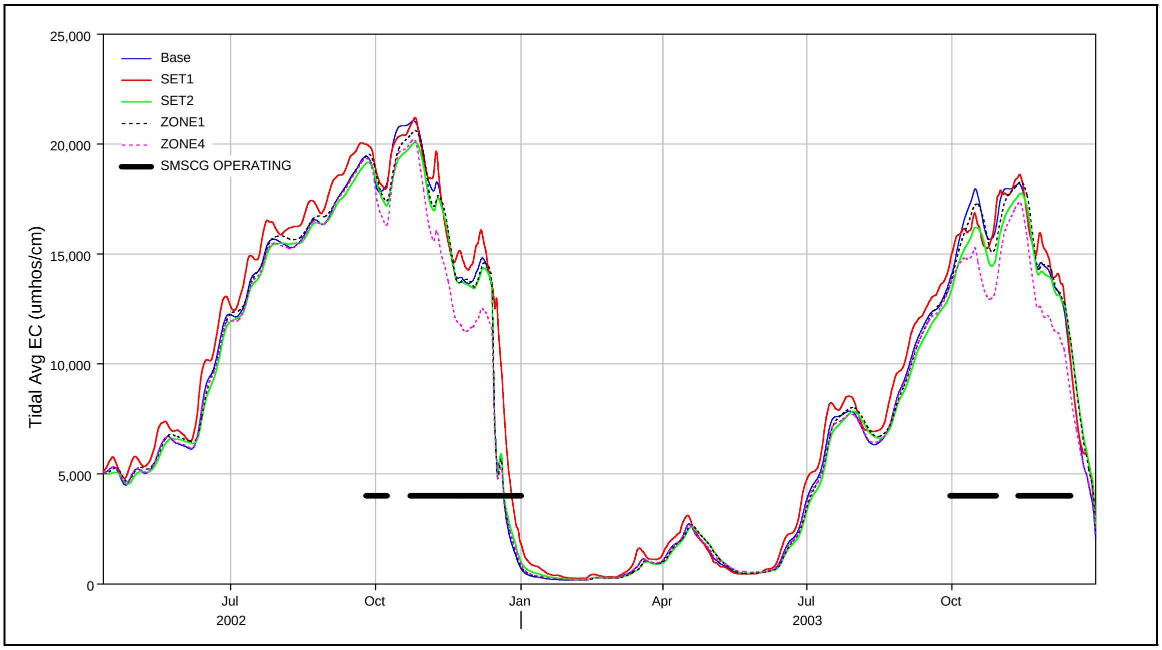


Figure 5-29 Tidally averaged observed and computed EC at station S-33 on Cygnus Slough.

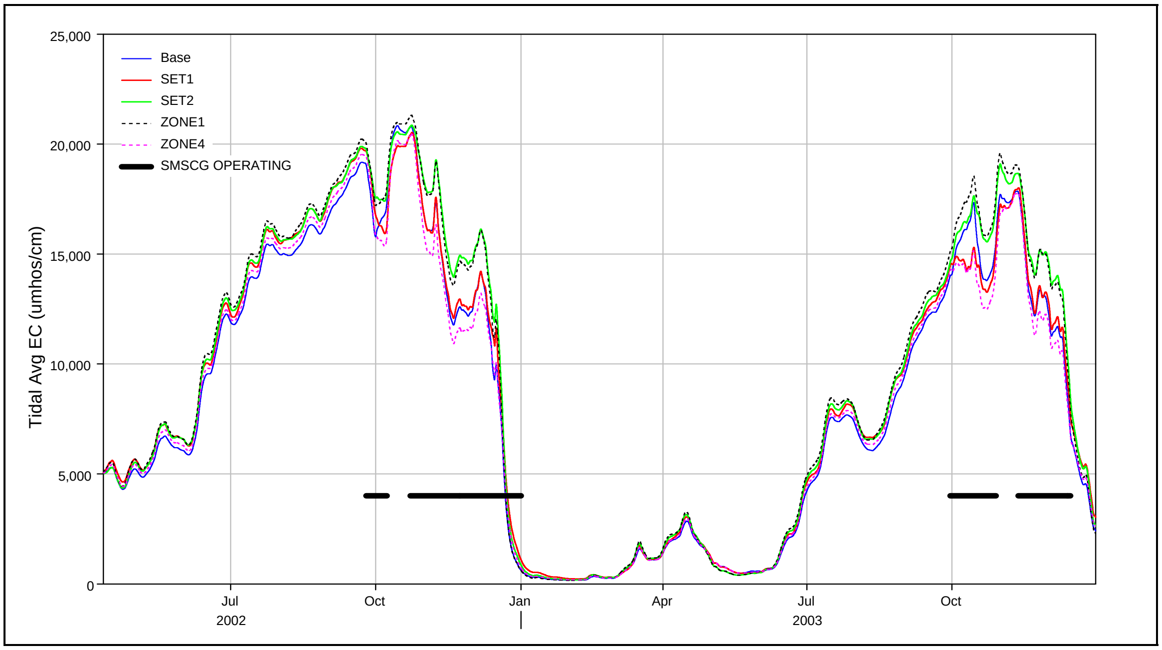


Figure 5-30 Tidally averaged observed and computed EC at station S-54 on Hunter Cut.

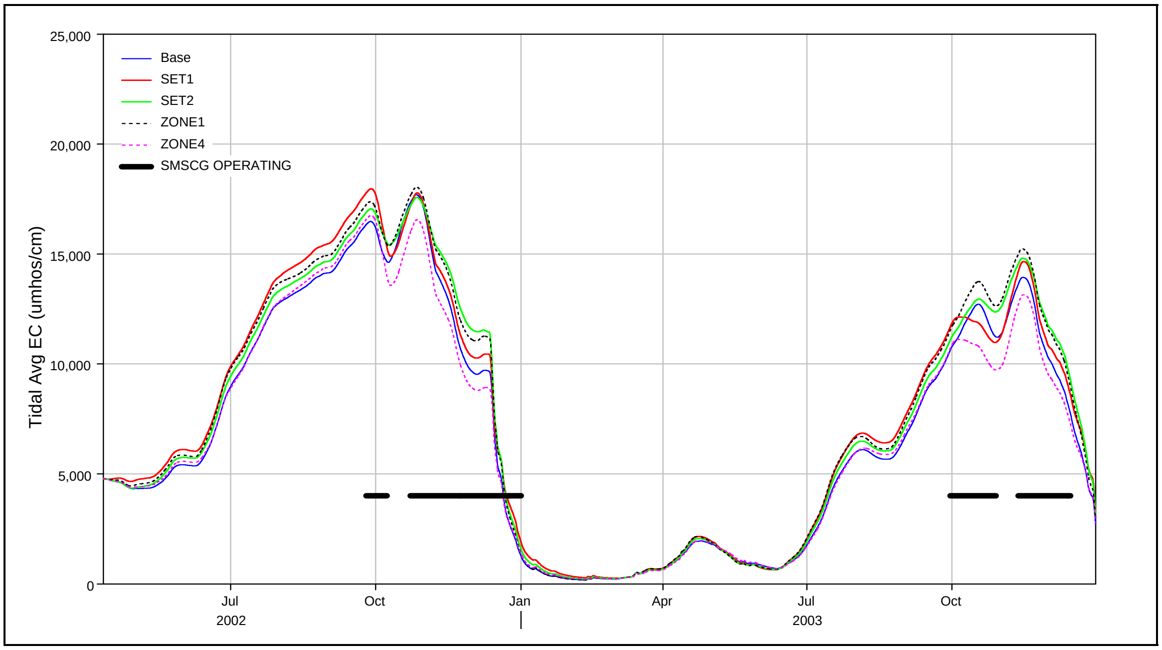


Figure 5-31 Tidally averaged observed and computed EC at station S-4 on Hill Slough.

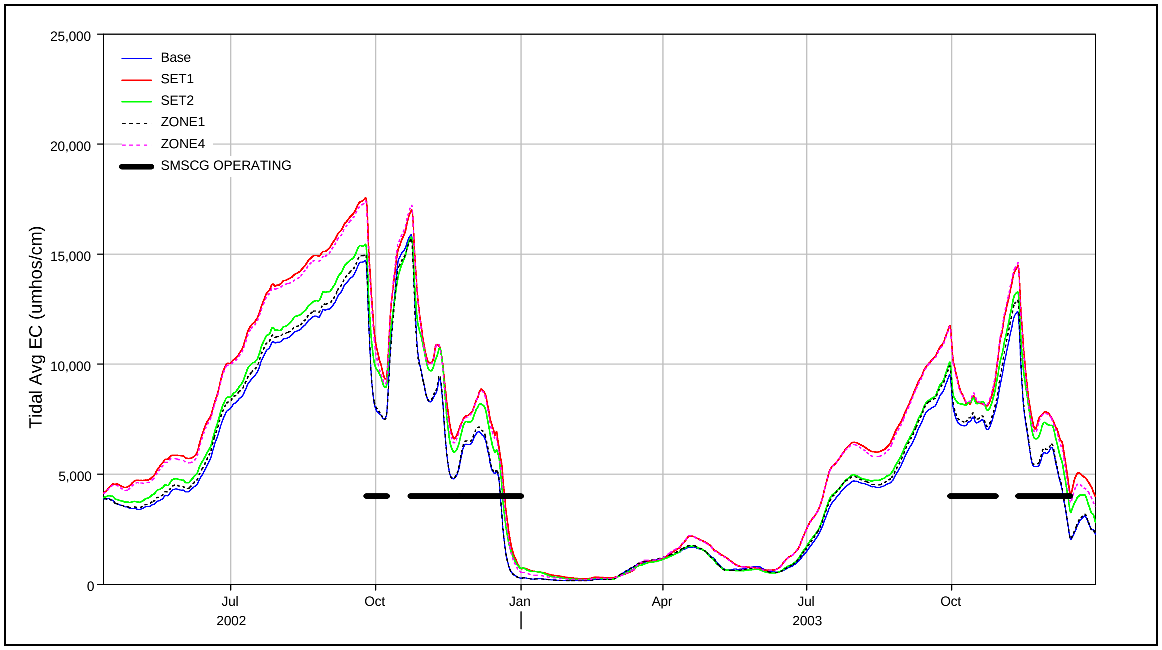


Figure 5-32 Tidally averaged observed and computed EC at station NS-1 on Nurse Slough.

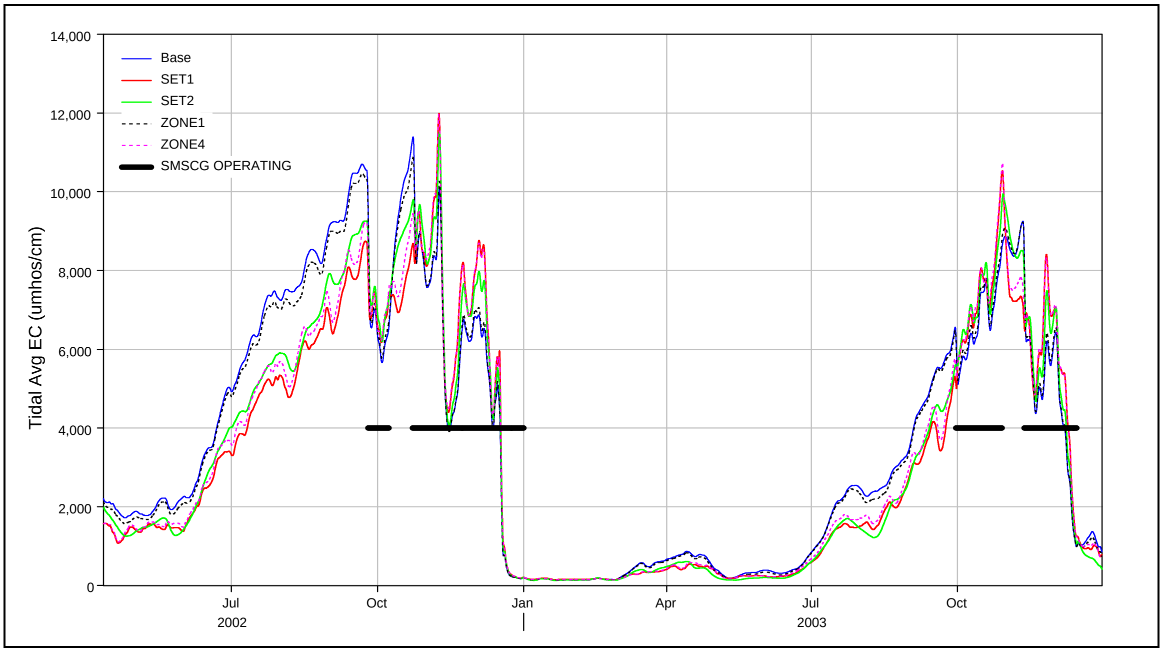


Figure 5-33 Tidally averaged computed EC at the S-64 monitoring location near National Steel on Montezuma Slough.

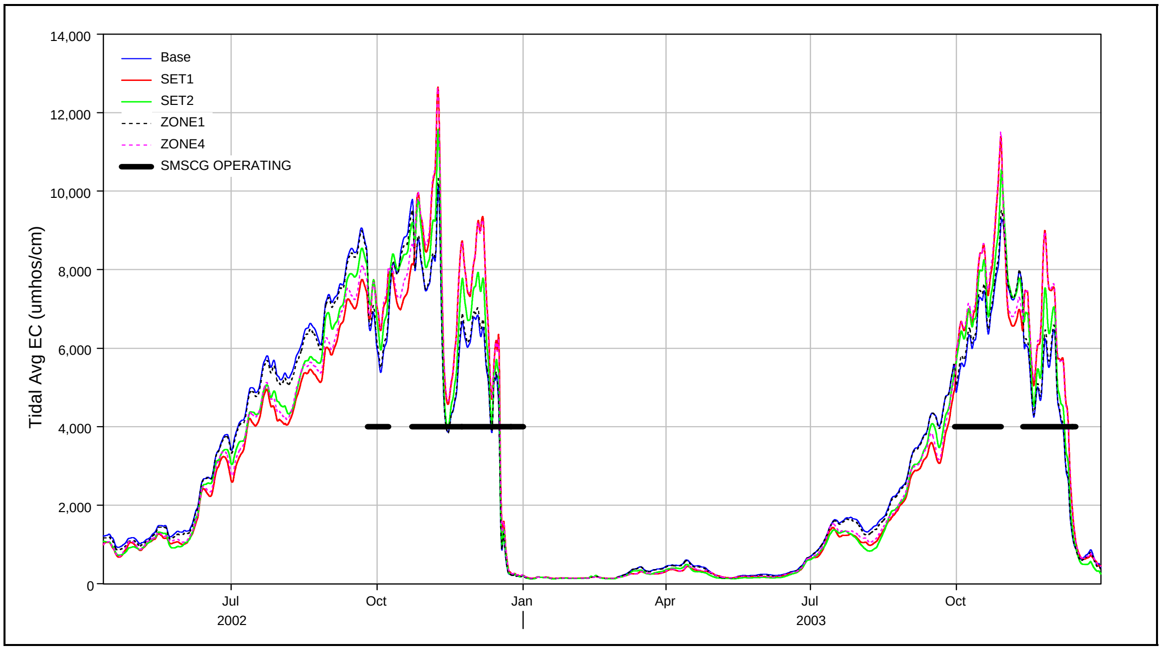


Figure 5-34 Tidally averaged computed EC at the S-71 monitoring location at Roaring River on Montezuma Slough.

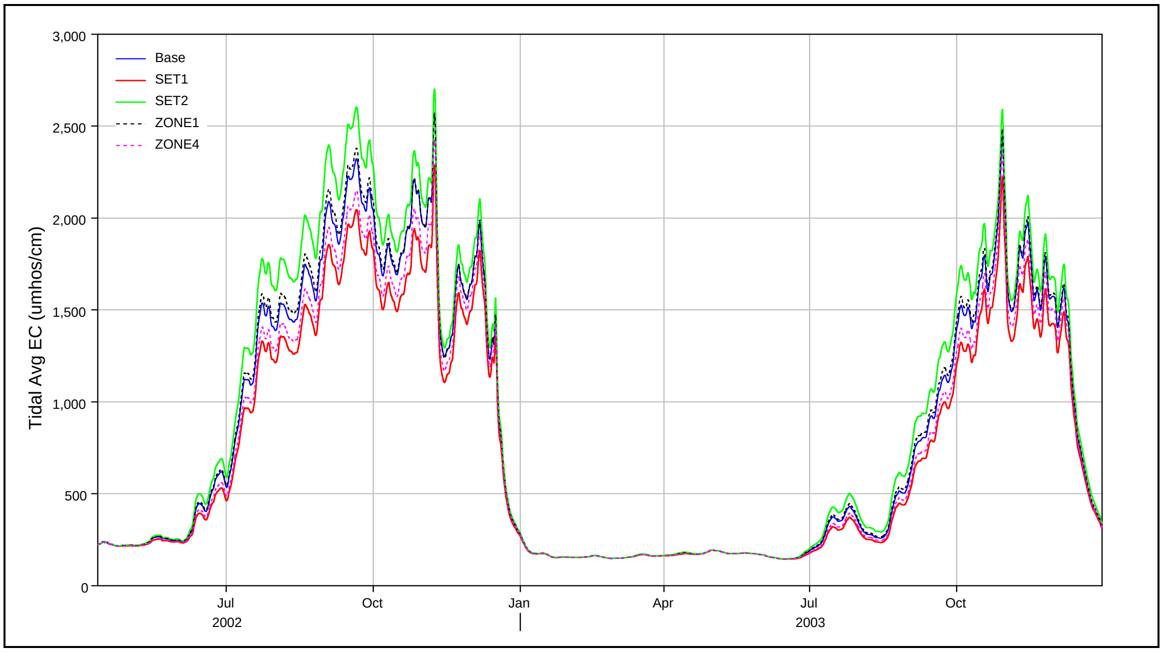
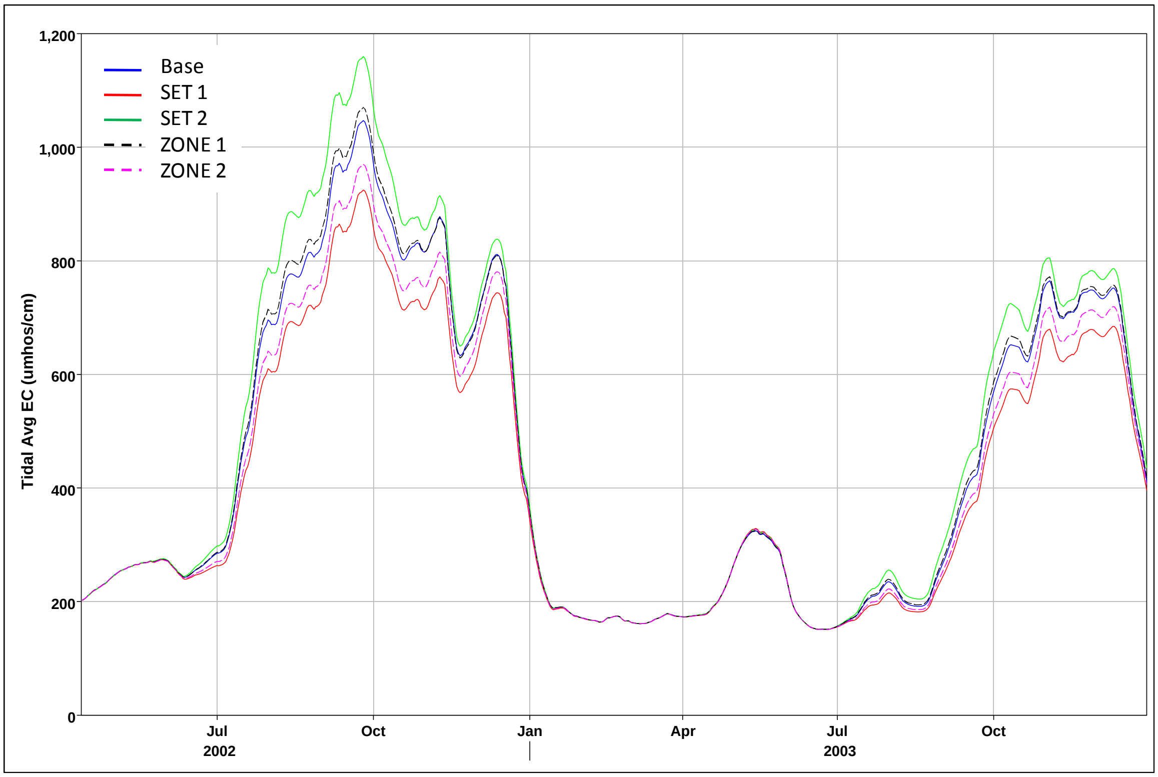
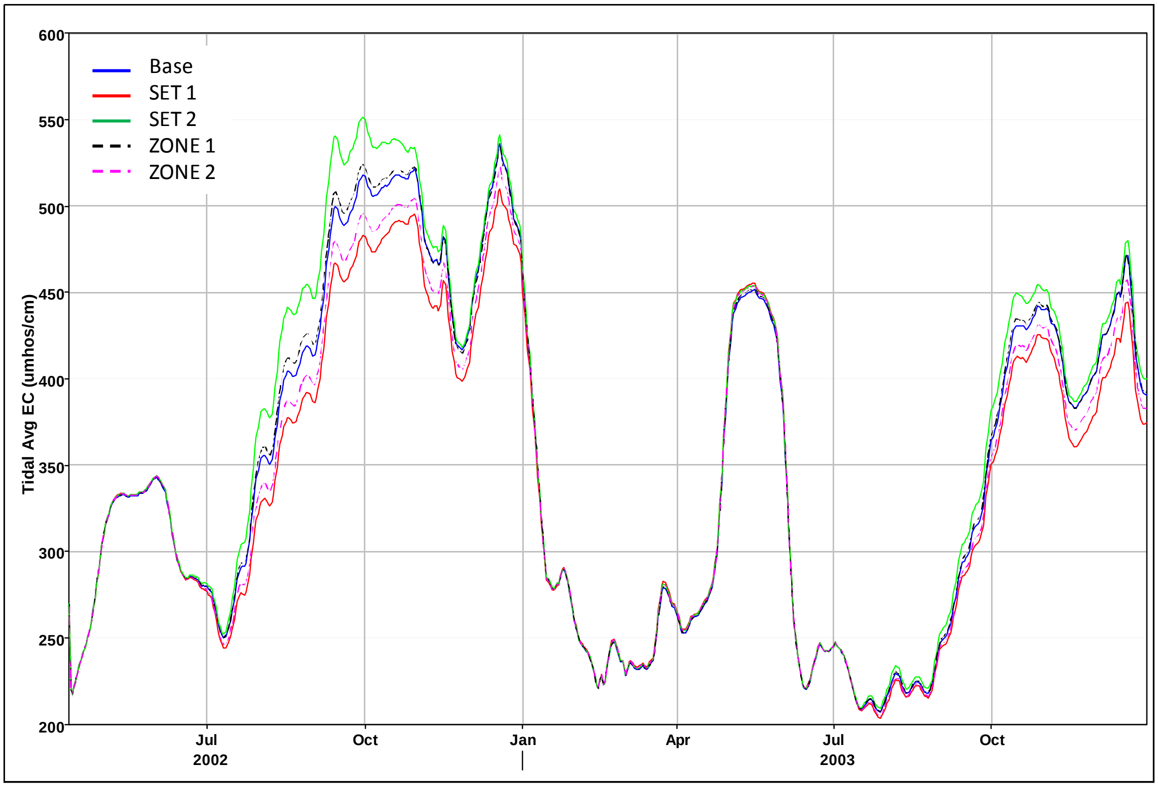


Figure 5-35 Tidally averaged computed EC time series at Jersey Point.



5-36 Tidally averaged computed EC time series at Old River at Rock Slough.



5-37 Tidally averaged computed EC time series at the CCWD Victoria Canal export location for Los Vaqueros.

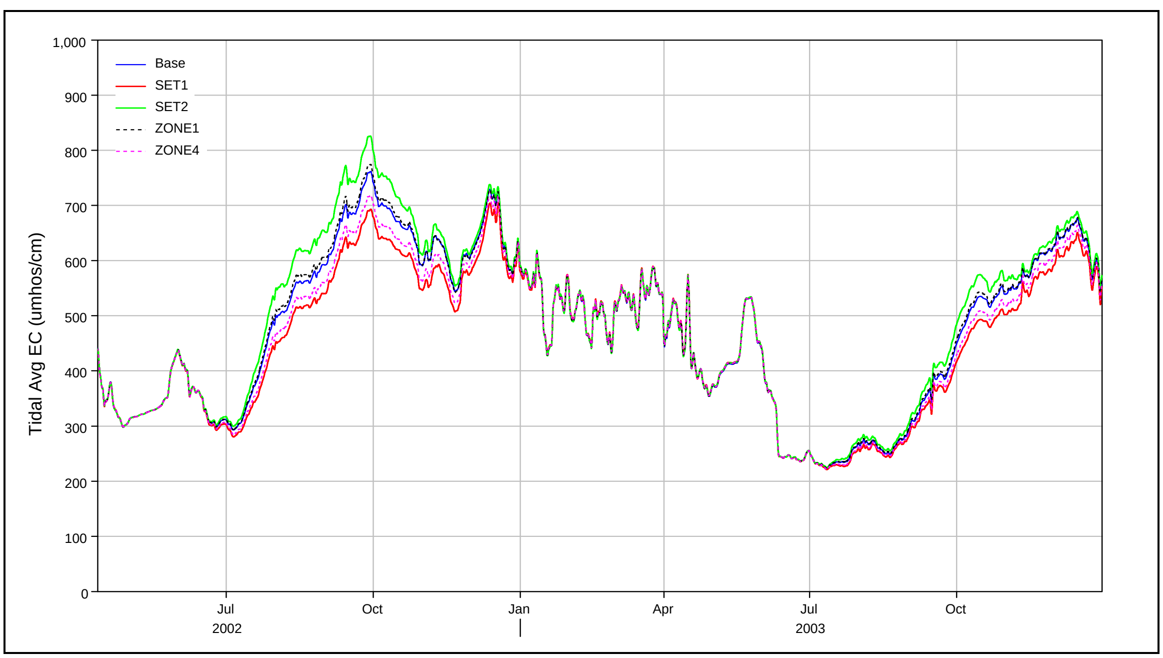


Figure 5-38 Tidally averaged computed EC time series at the CVP export location.

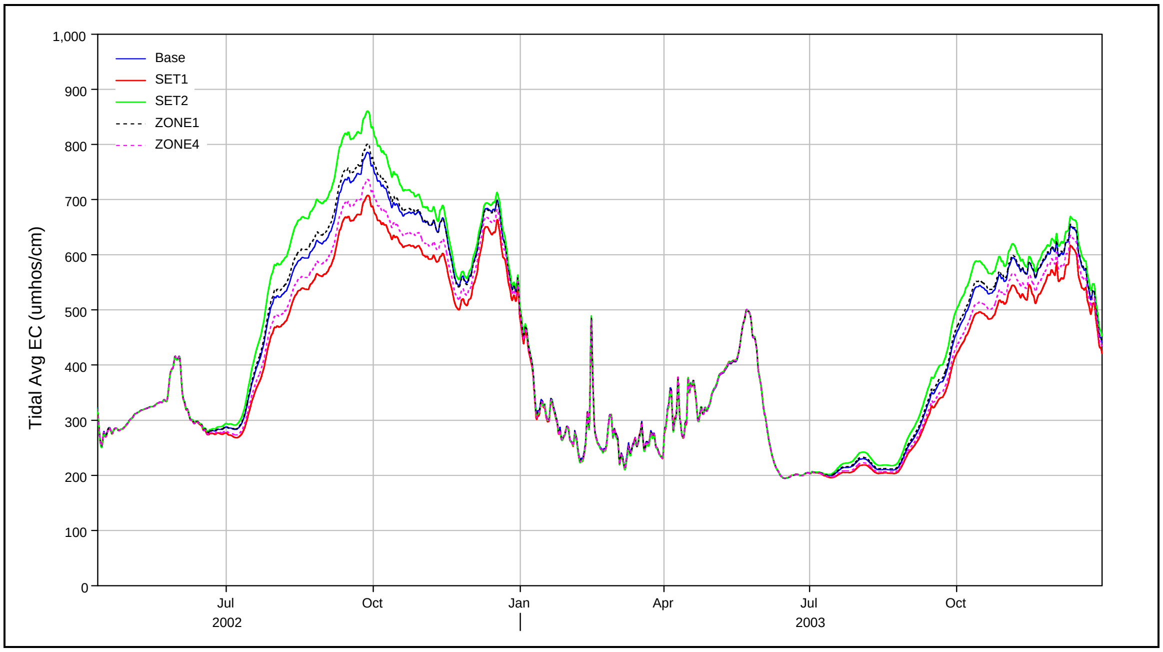


Figure 5-39 Tidally averaged computed EC time series at the SWP export location.