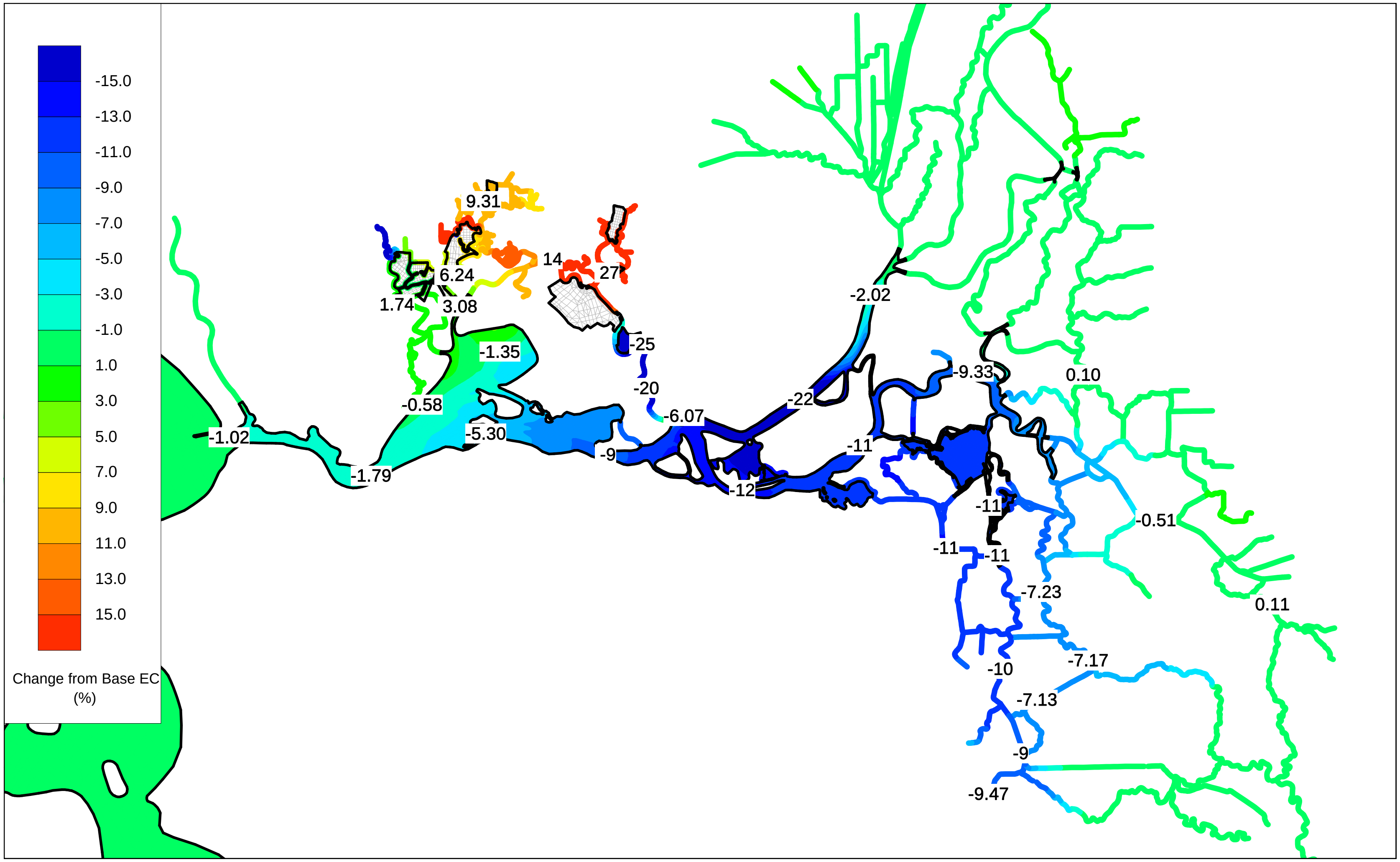


Figure 5-48 Set 1 EC % change from Base case – August 1, 2002.

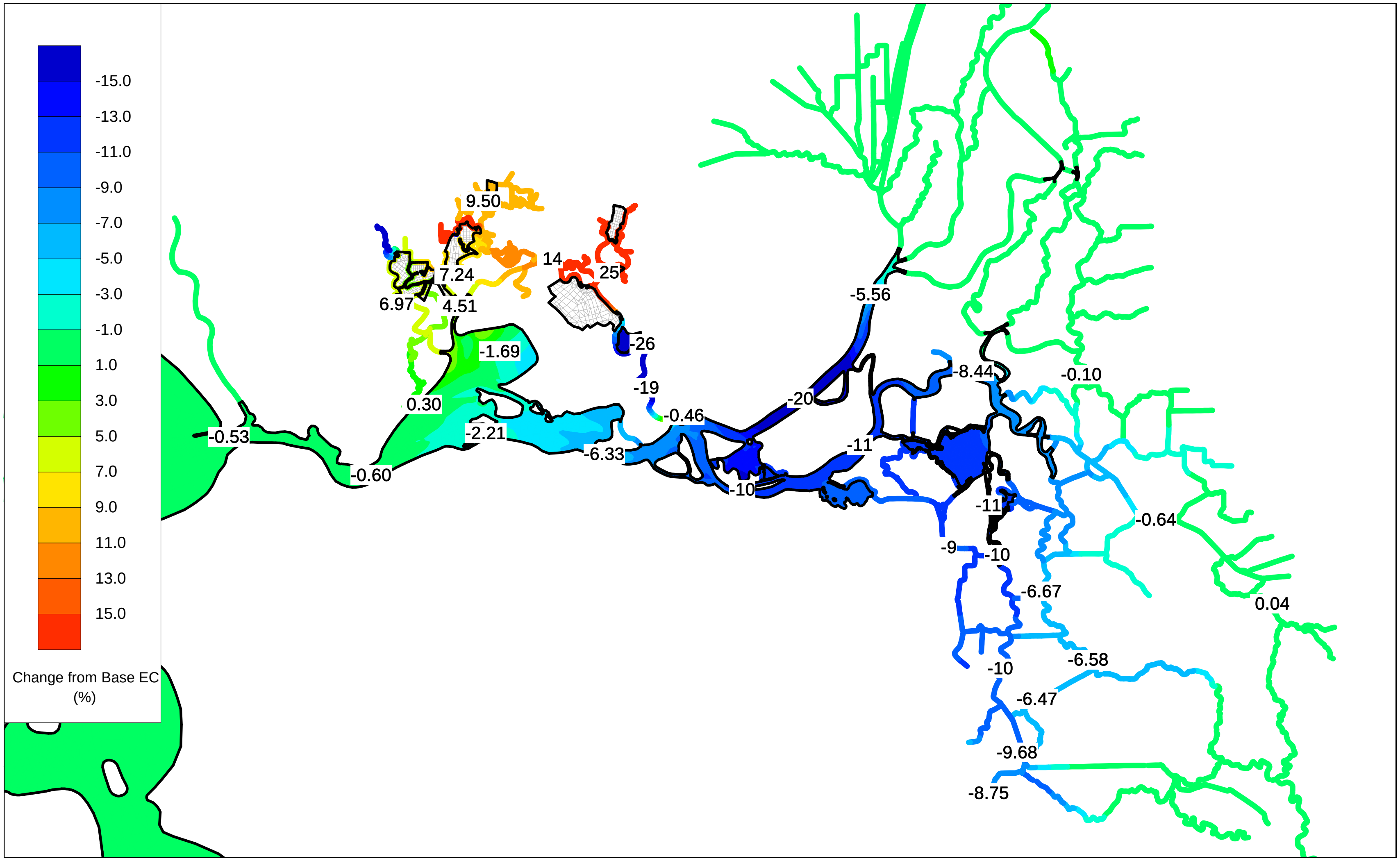


Figure 5-49 Set 1 EC % change from Base case – September 1, 2002.

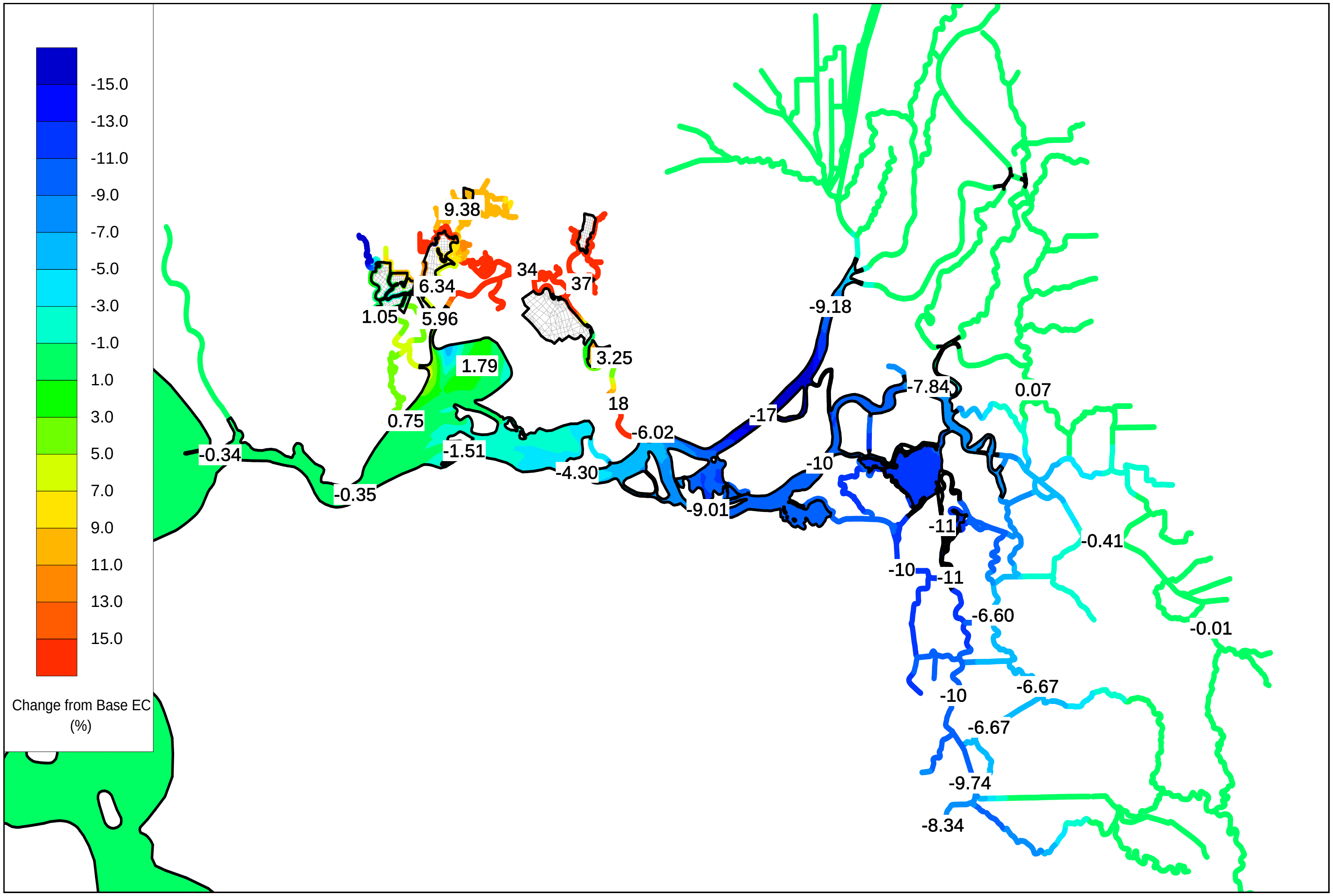


Figure 5-50 Set 1 EC % change from Base case – October 1, 2002.

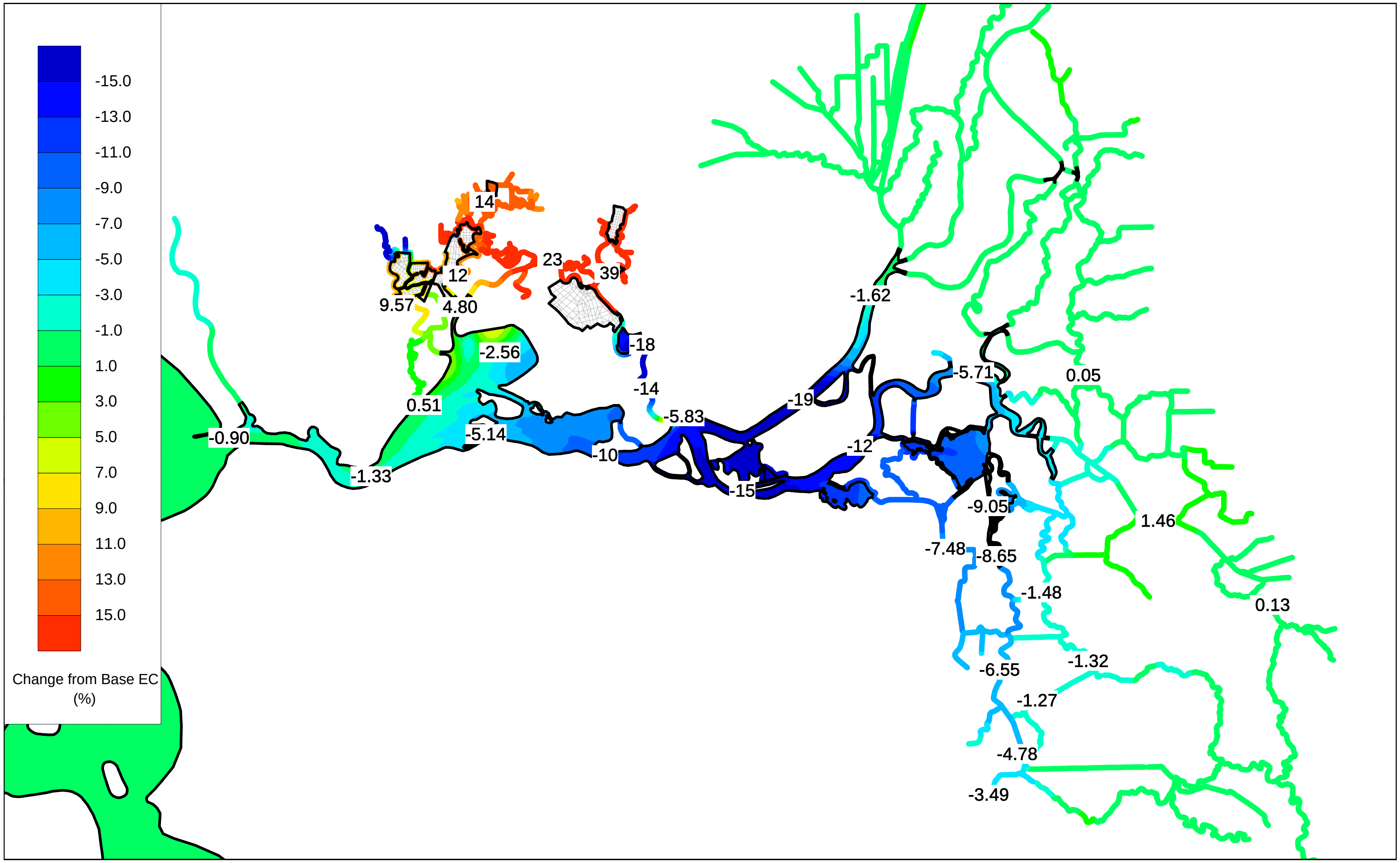


Figure 5-51 Set 1 EC % change from Base case – September 1, 2003.

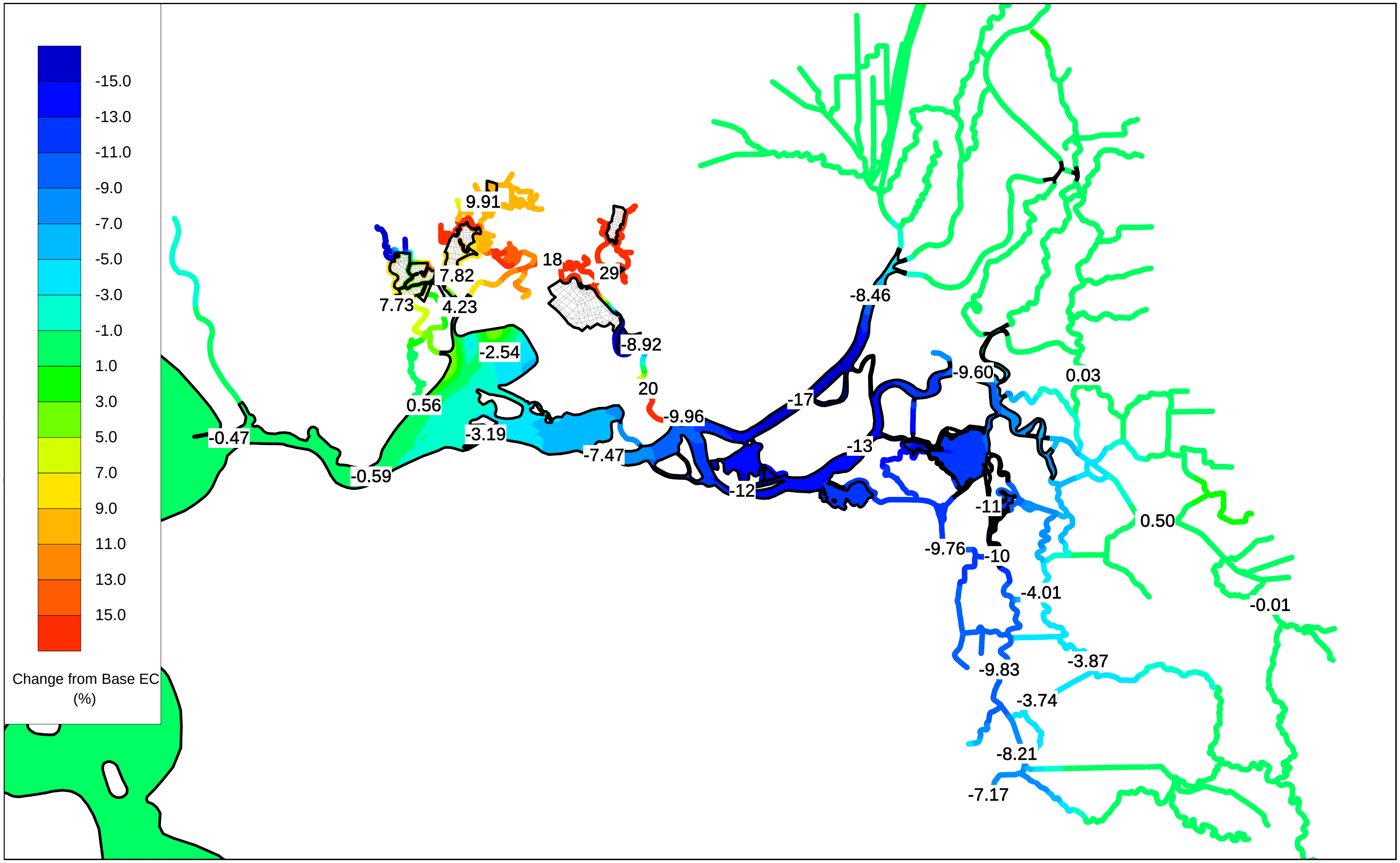


Figure 5-52 Set 1 EC % change from Base case – October 1, 2003.

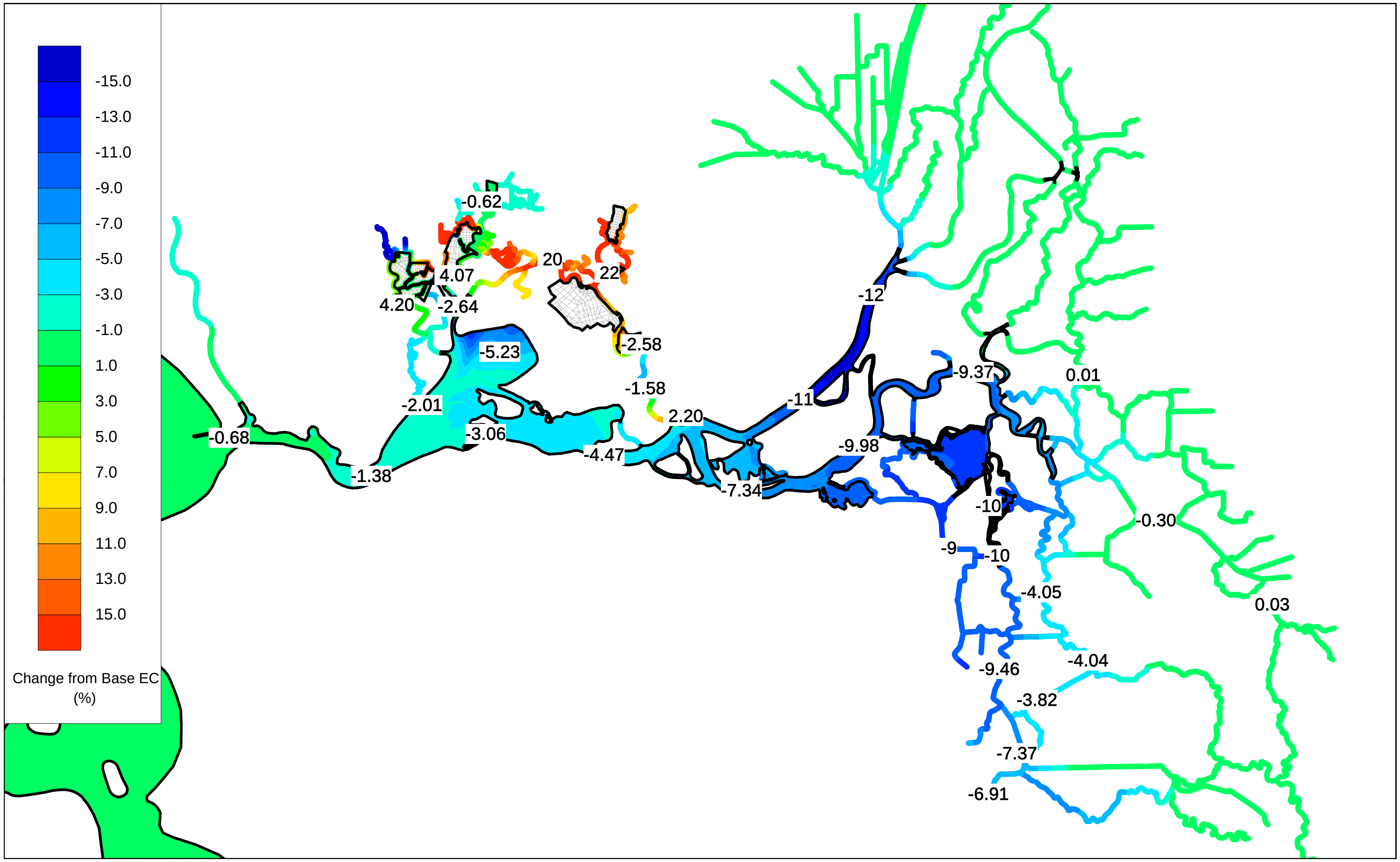


Figure 5-53 Set 1 EC % change from Base case – November 1, 2003.

5.7. Velocity Results – Scour Potential

5.7.1. Background

The creation of tidal marsh in restoration areas increased the volume of water flowing through downstream channels in Suisun Marsh each tidal cycle without a change in channel capacity. The result was an increase in velocity in some channels and sloughs and the potential for scour in channels and on banks and subsequent risk of levee failure.

The potential for channel scour and levee failure was evaluated using modeled velocity. Problem locations were identified as places where modeled velocity in the scenarios increased substantially with respect to the Base case during the July 2002 model period, in particular where velocity magnitude exceeded 2.0 ft/sec in the scenario but not in the Base case. Figure 5-54 gives location names for the six areas where potential scour problems were identified. Velocity changes in comparison with the Base case were generally small elsewhere.

Potential effects were assessed using exceedance plots of velocity distribution and magnitude. The velocity distribution plots show velocity versus the percent of time during July 2002 that each velocity was exceeded. Time series plots are also shown at some locations. Specific locations where results were assessed are indicated on velocity contour plots.

Although comparison locations for one and two-dimensional grids were selected at comparable geographical co-ordinates, comparisons between depth-averaged velocity at 2-dimensional *vs.* cross-sectionally averaged velocity at 1-dimensional grid locations should be interpreted with caution.

5.7.2. Scouring potential for the scenarios

Six locations were identified where the potential for scouring increased due to the incorporation of restoration area for the scenarios. Four of the six locations where large changes in velocity were identified occurred in channels adjacent to newly flooded areas. The maximum velocity at a given location did not occur at the same time or in the same tidal cycle in each scenario, partly due to shifts in stage timing. Velocity profiles at some problem locations exhibited a large asymmetry in velocity, e.g., the magnitude of the velocity on the incoming tide (negative velocity) increased substantially in comparison to increases on the outgoing tide.

The Set 1 and Set 2 scenarios each had the most extensive flooded areas, but the Zone 4 scenario resulted in the largest increases in channel velocity; it also reduced velocities at some locations in comparison with the Base case.

Figure 5-55 illustrates the magnitude and frequency of velocity changes at Beldon's Landing in Montezuma Slough for the scenarios. The velocity distributions for the scenarios vary in timing, as the percent of time with negative velocities (incoming tide) ranged from 47 to 49% in July, 2002. The Zone 4 restoration area has the greatest potential to influence sediment movement in Montezuma Slough, as both the Set 1 and

Zone 4 scenario velocities are nearly double the Base case values on both incoming (negative values) and outgoing (positive values) tides. Set 1 and Zone 4 velocity magnitudes were greater than 2.0 ft/sec ~ 25% of the time on both the incoming tide and outgoing tides, and were nearly symmetric with respect to tidal direction. These scenarios also produced the greatest tidal flow in Montezuma Slough (Figure 5-13).

Two points were examined at Hunter Cut: Point 1 at the bank (edge of the grid) and Point 2 in a mid-channel location (Figure 5-56). The Set 1 scenario (Figure 5-58) has the largest velocity effect mid-channel in Hunter Cut, which occurs on the outgoing tide. The large amount of restored area in the western marsh for Set 1 means that Suisun Slough and Hunter Cut contribute heavily to the channel conveyance for filling and draining the large volume of water in that restored area. Zone 1 contributes the greatest potential for scour on the levee bank in Set 2 with a large velocity magnitude on the incoming tide. The Zone 4 restoration area reduced tidal flow through Hunter Cut (Figure 5-13), as well as velocity in comparison with the Base case (Figure 5-58).

The other locations where velocity increases might result in scouring were all at the entrance to breaches at restoration areas within the marsh. Near the breach at Morrow Island (Figure 5-59), velocities are much higher for Set 2 and Zone 1 than the other scenarios (Figure 5-61). Velocities peak on the incoming tide, with the Zone 1 area contributing the majority of the velocity increase. Near the breach location at Meins Landing (Figure 5-62), the Zone 4 and Set 1 scenarios have similar velocity profiles (Figure 5-65), as both incorporate the Zone 4 region off of Montezuma Slough. Velocities on the bank (Point 1) and in mid-channel (Point 2) are very similar, while Point 3 near the entrance to the northern breach for the zone has an asymmetry profile which peaks on the incoming tide (negative velocity).

In the region near the Cross Slough (Figure 5-66), only the Set 2 scenario exhibits scour potential in comparison with the Base case. There are large velocity asymmetries in all three Set 2 points, with the mid-channel point showing the greatest potential for scour (lower right plot, Figure 5-66). Near the breach for the Duck Clubs restoration, the Set 1 scenario (Figure 5-68) has complex velocity profiles (Figure 5-69, lower plot). The modeled velocity profiles at the five points in Set 1 (Figure 5-70 and Figure 5-71) indicate that there is a high potential for scour in the channels and possibly to the levee banks, in some cases on the incoming tide (Points B and C, negative) and in others on the outgoing tide (Point B, positive).

5.7.3. **Summary**

Of the six locations identified as problematic for scouring, only two (Beldon's Landing and Hunter Cut) were located away from breach locations. The other four locations were located directly upstream of the breach. The grid development for channels near breach locations conforms to the existing channel configuration, and breaches were opened at the width of the channel at the location of the breach. Depending on the location in this channel, the increase in velocity magnitude could indicate potential problems with scour leading to failure on a levee bank (i.e., at the edge of the 2-dimensional grid) or scouring of the channel.

Changes to the channels such as deepening or widening could be modeled to assess the ability reduce scour potential both on levees and on levee banks.

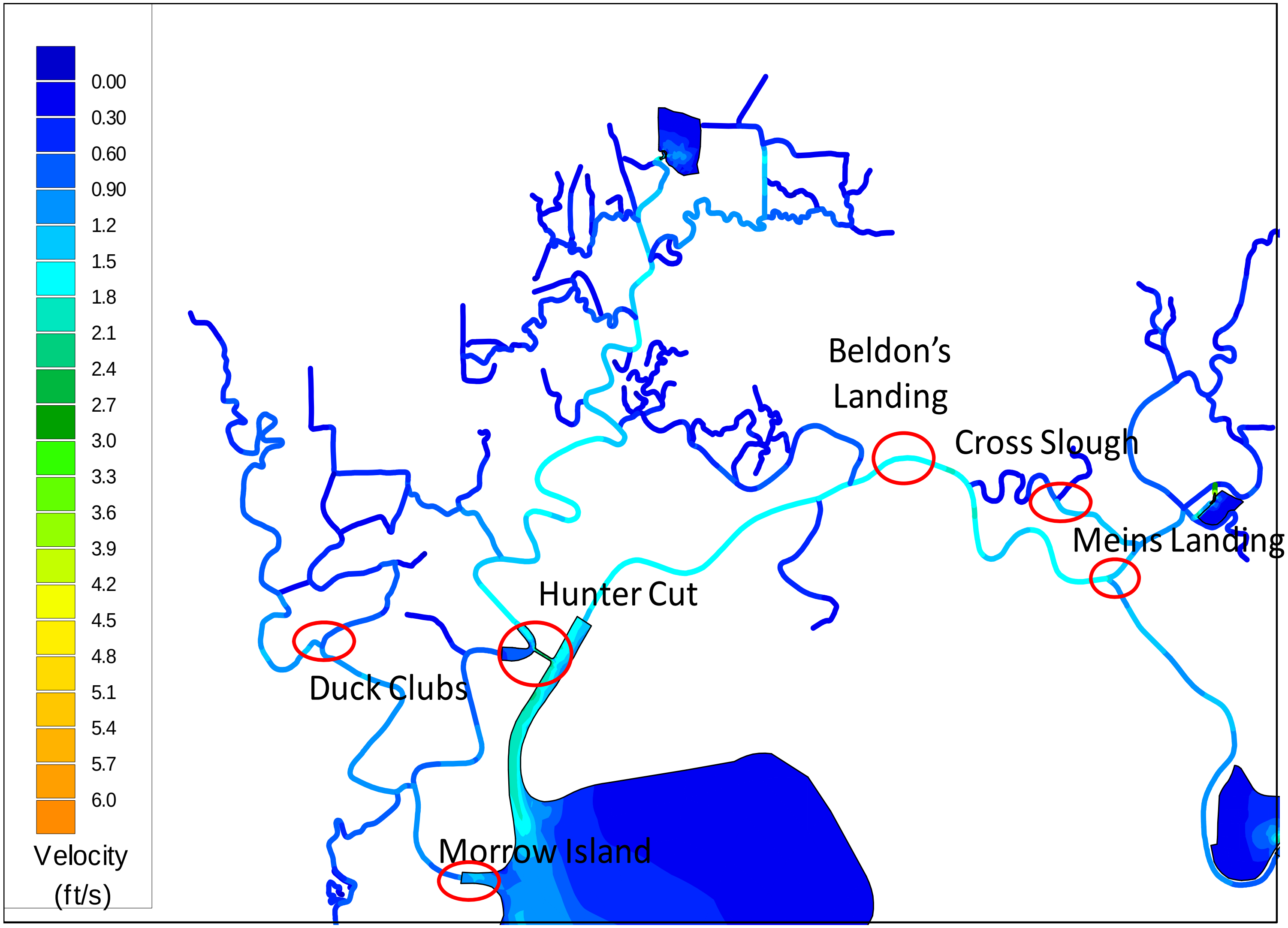


Figure 5-54 Location names for the areas examined for scouring potential.

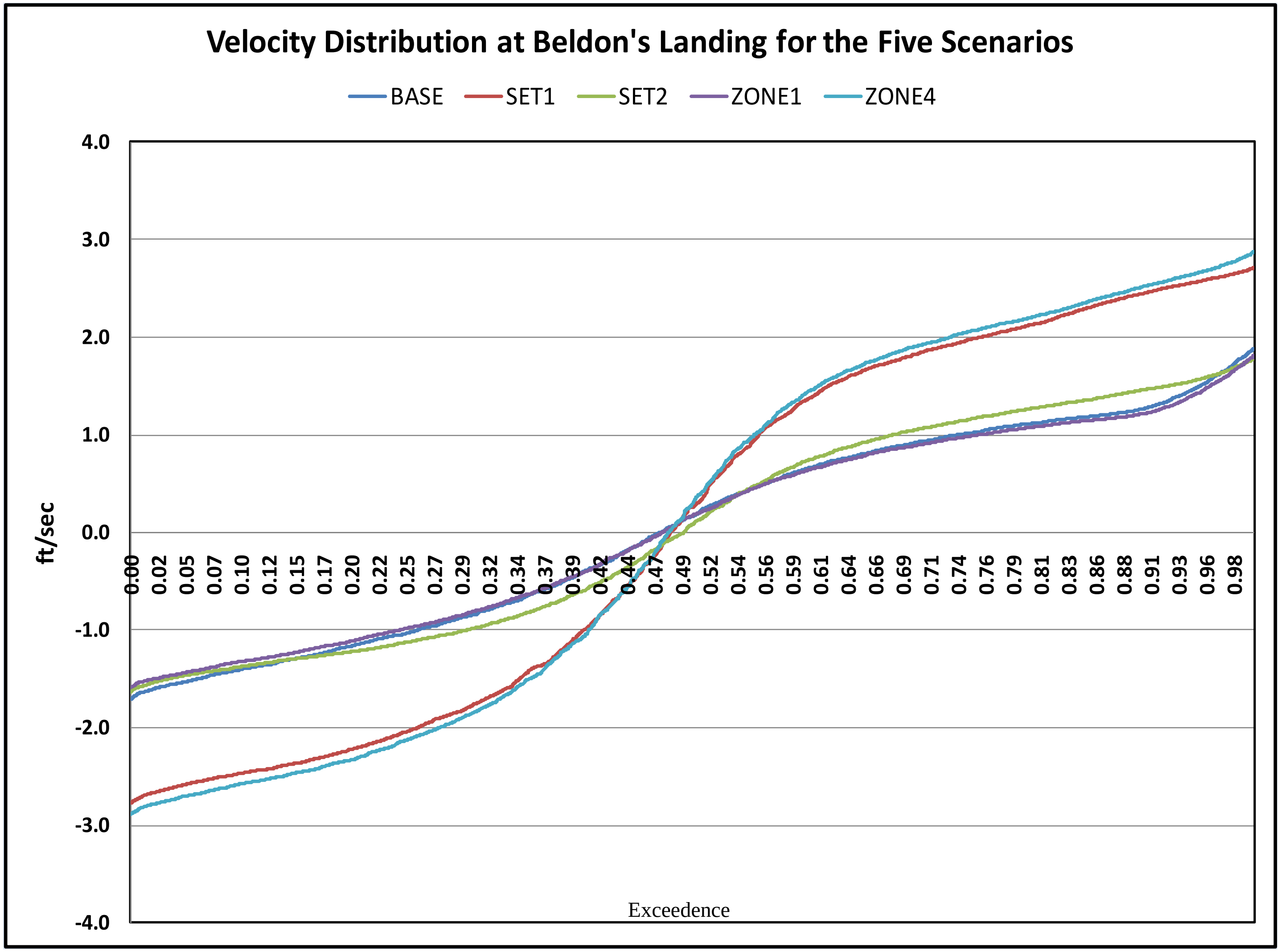


Figure 5-55 Velocity distributions for the five scenarios at Beldon's Landing, July 2002.

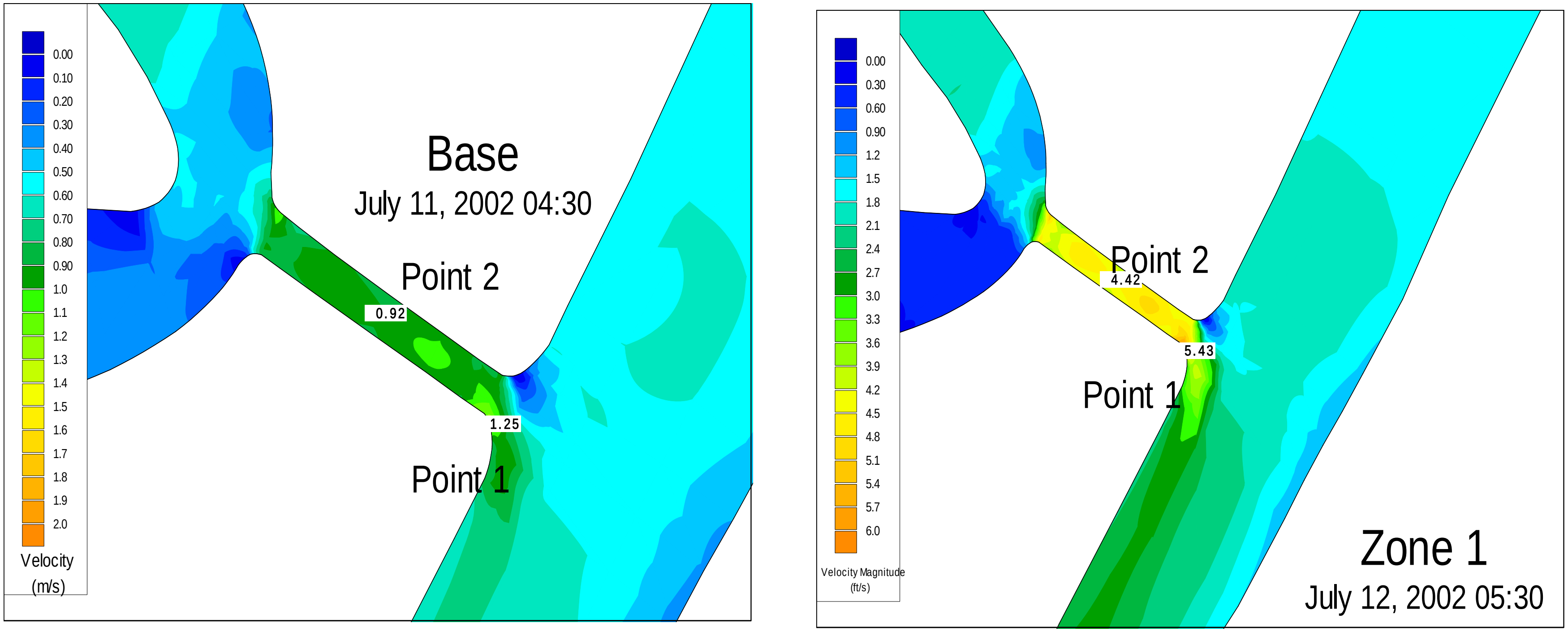


Figure 5-56 Color contour plots of velocity for Base case and Zone 1 at Hunter Cut in July 2002. Points analyzed: Point 1 on bank Point 2 mid-channel.

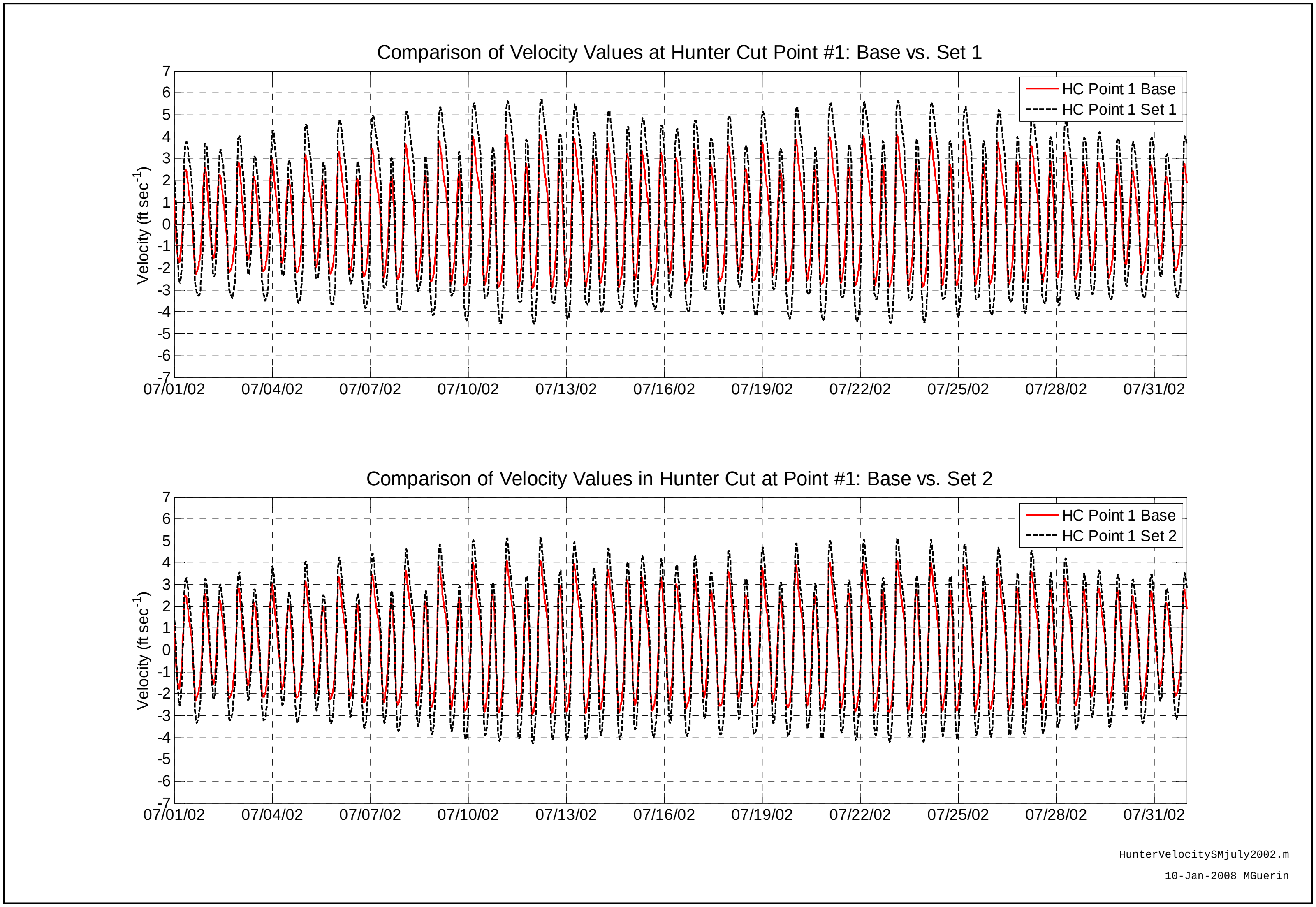


Figure 5-57 Hunter Cut velocity at Point 1 for Sets 1 and 2 in comparison with the Base case.

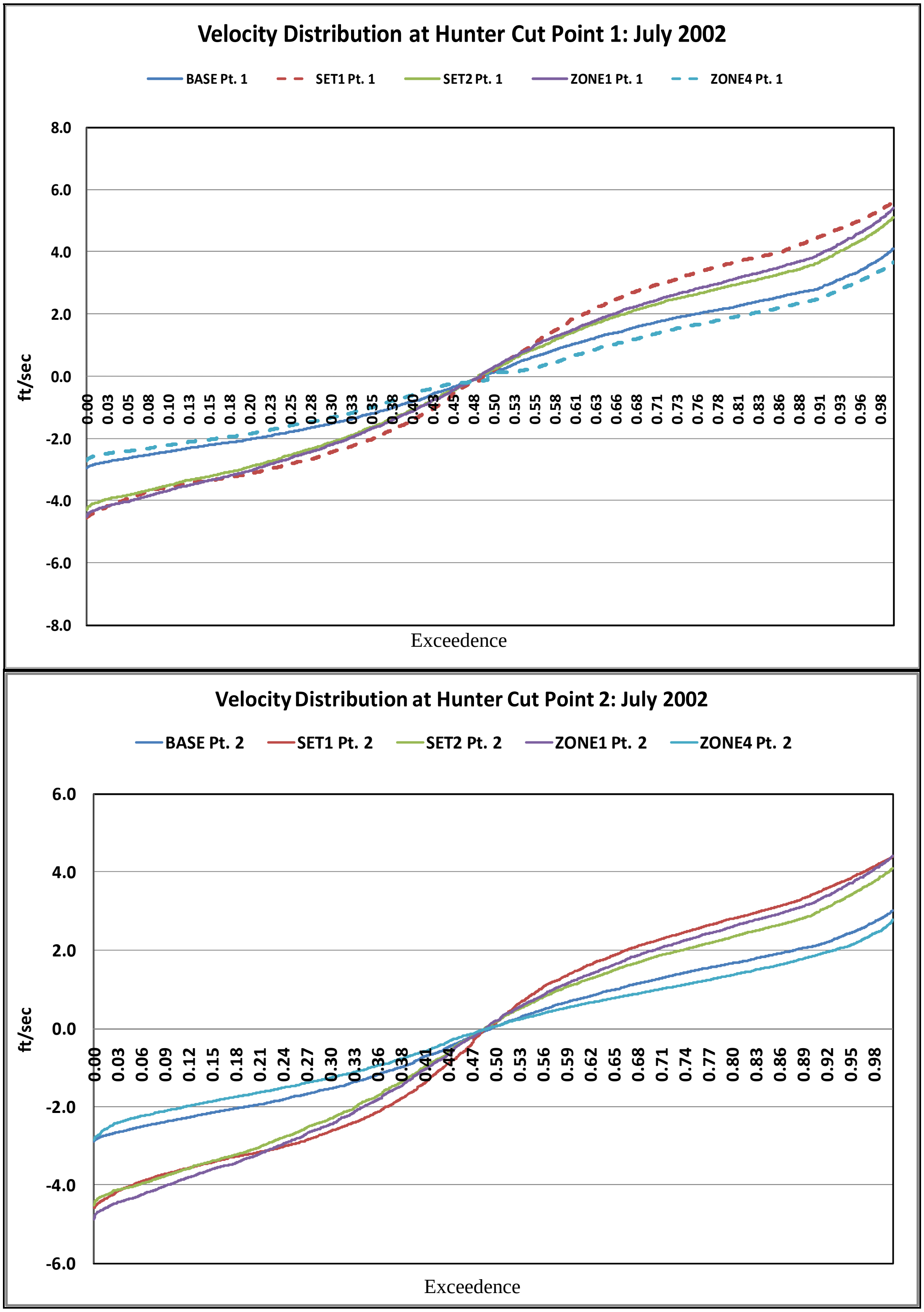


Figure 5-58 Velocity distributions for points 1 (bank) and 2 (mid-channel) at Hunter Cut.

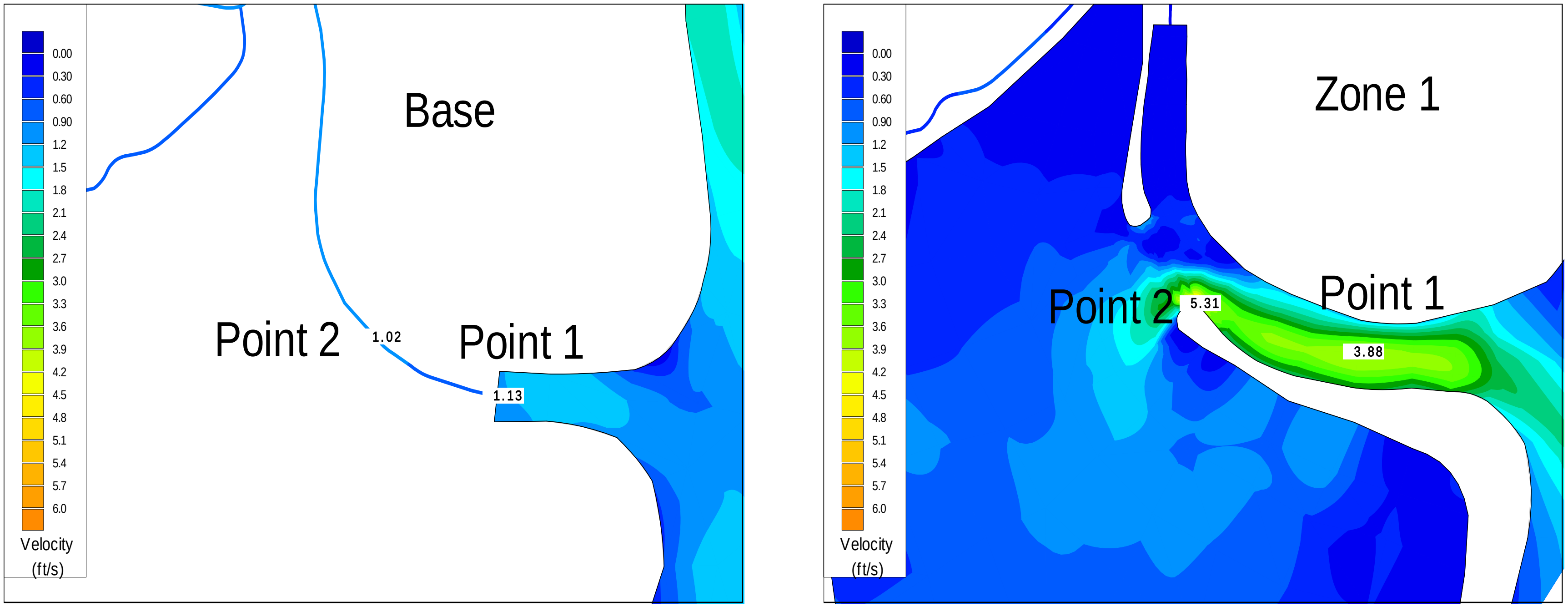


Figure 5-59 Color contour plots of velocity for Base case and Zone 1 near Morrow Island on July 12, 2002 14:00. Points analyzed: channel (Point 1) and bank (Point 2).

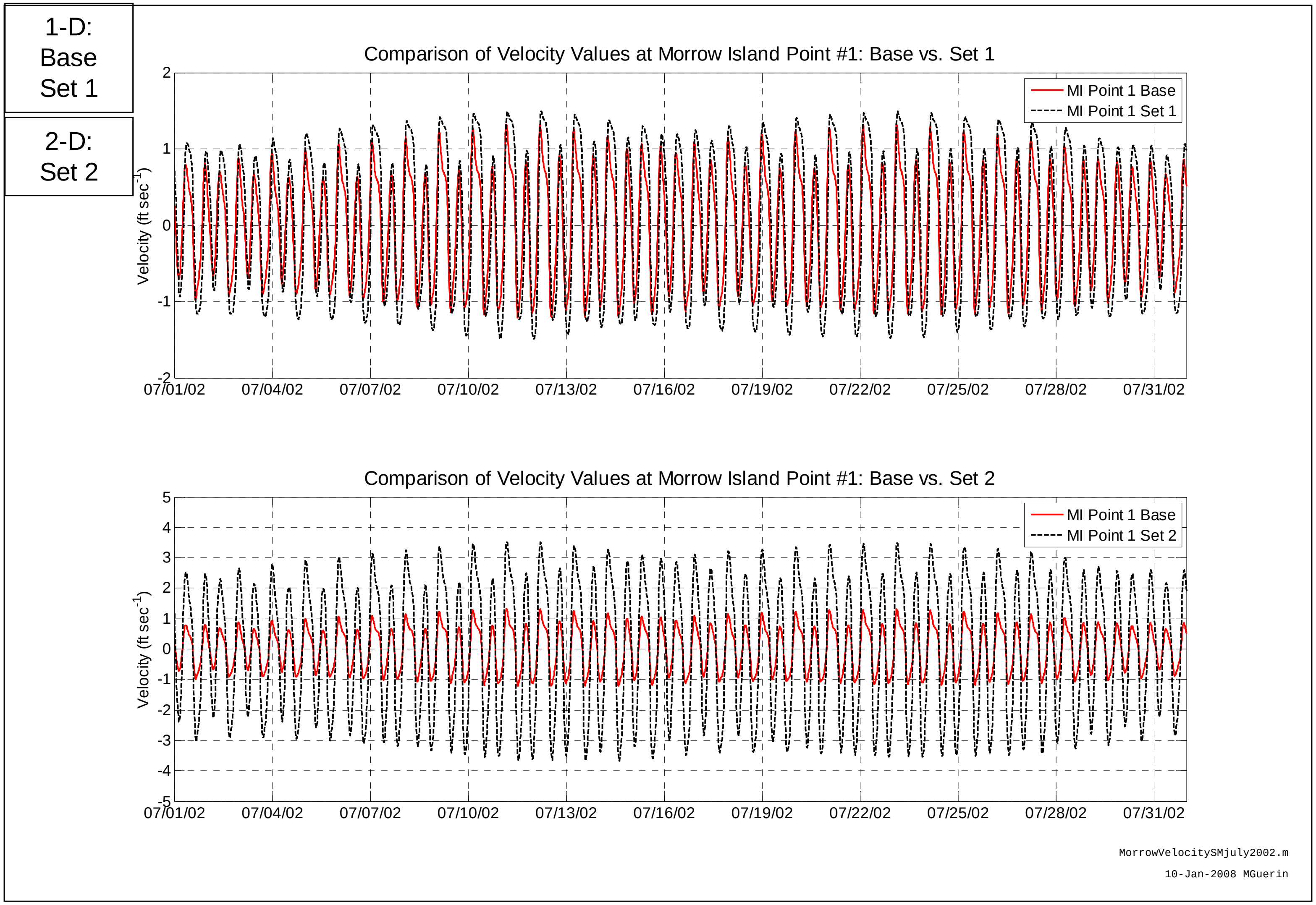
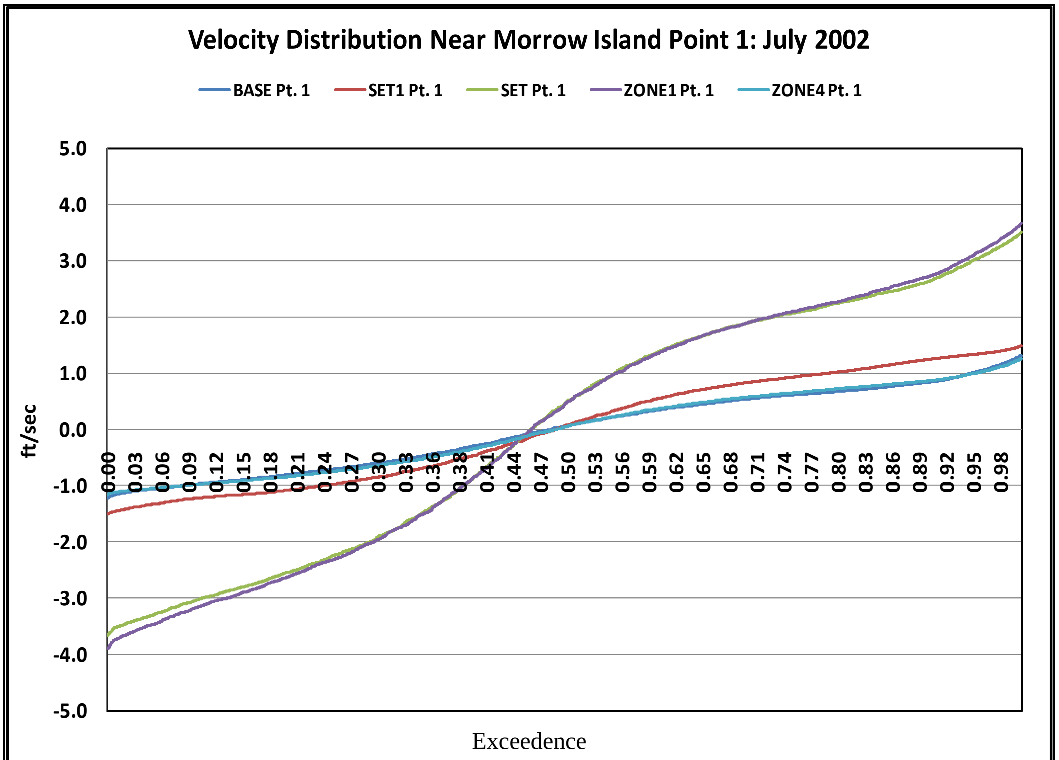


Figure 5-60 Morrow Island velocity at Point 1 for Sets 1 and 2 in comparison with the Base case.



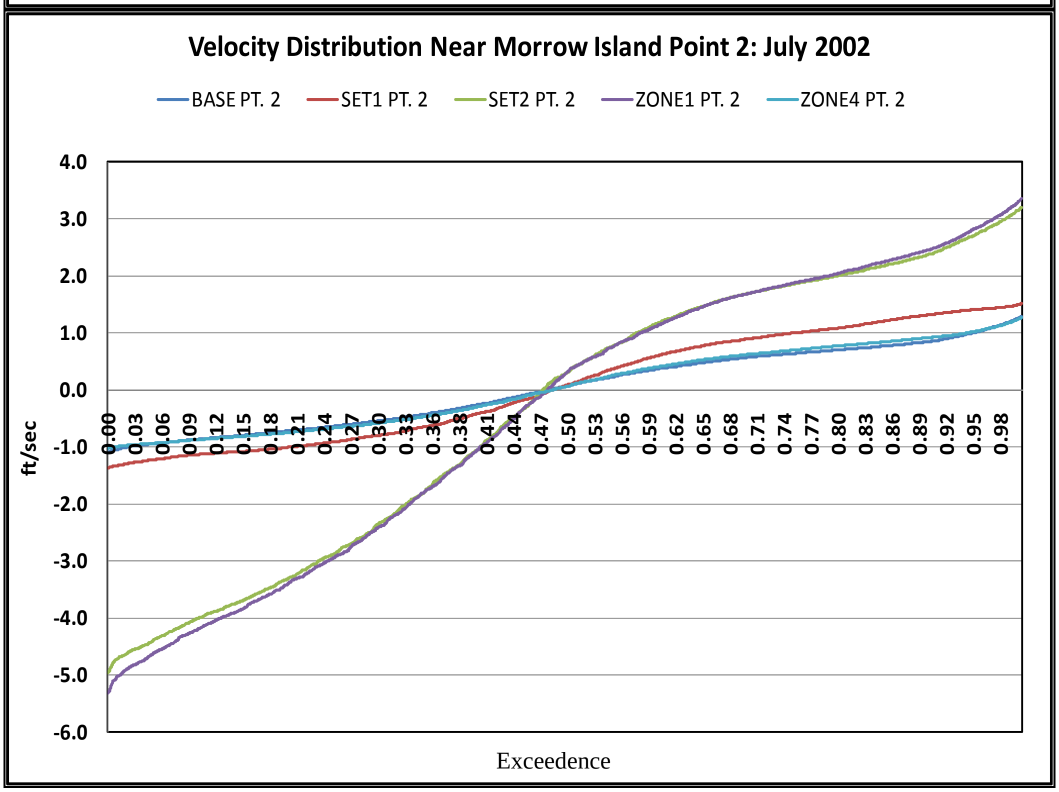


Figure 5-61 Velocity distributions for points analyzed near Morrow Island: point 1 (channel) and point 2 (bank).

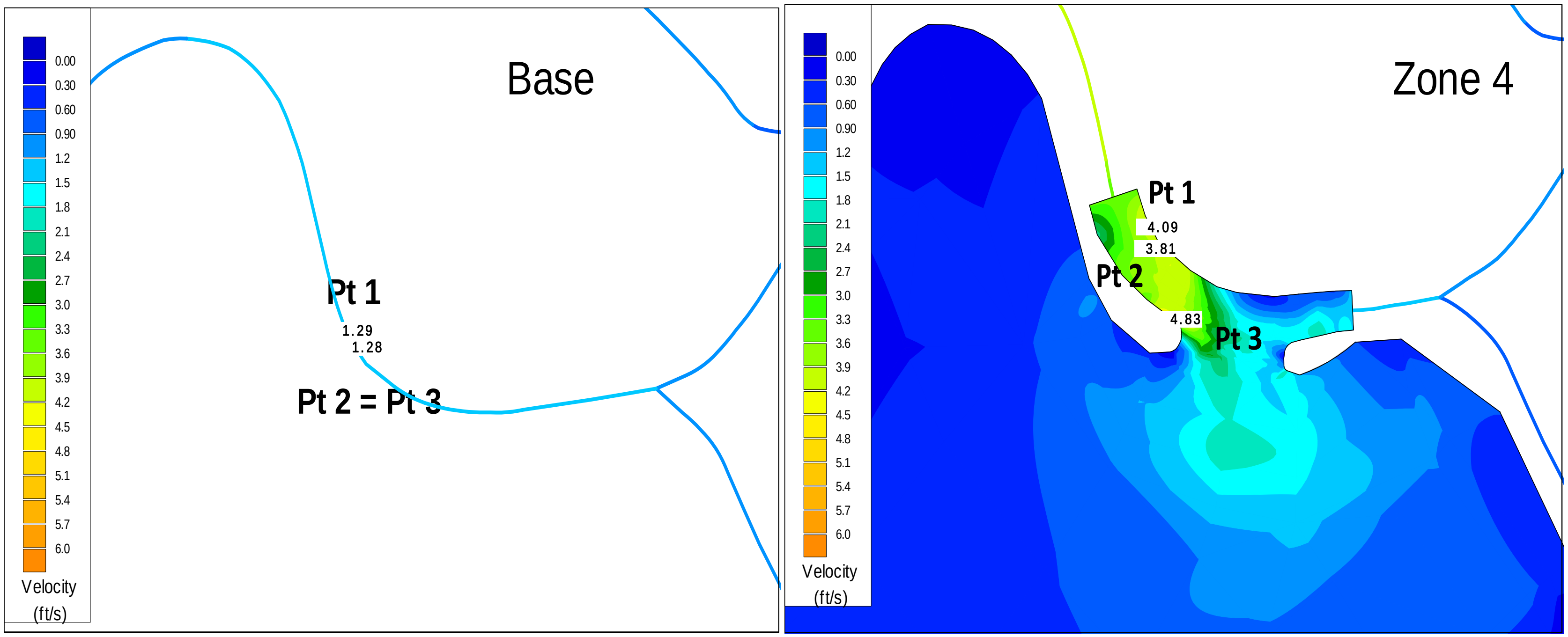


Figure 5-62 Color contour plots of velocity for Base case and Zone 4 near Meins Landing on July 17, 2002 1915. Points analyzed: points 1 and 3 (bank) and point 2 (mid-channel).

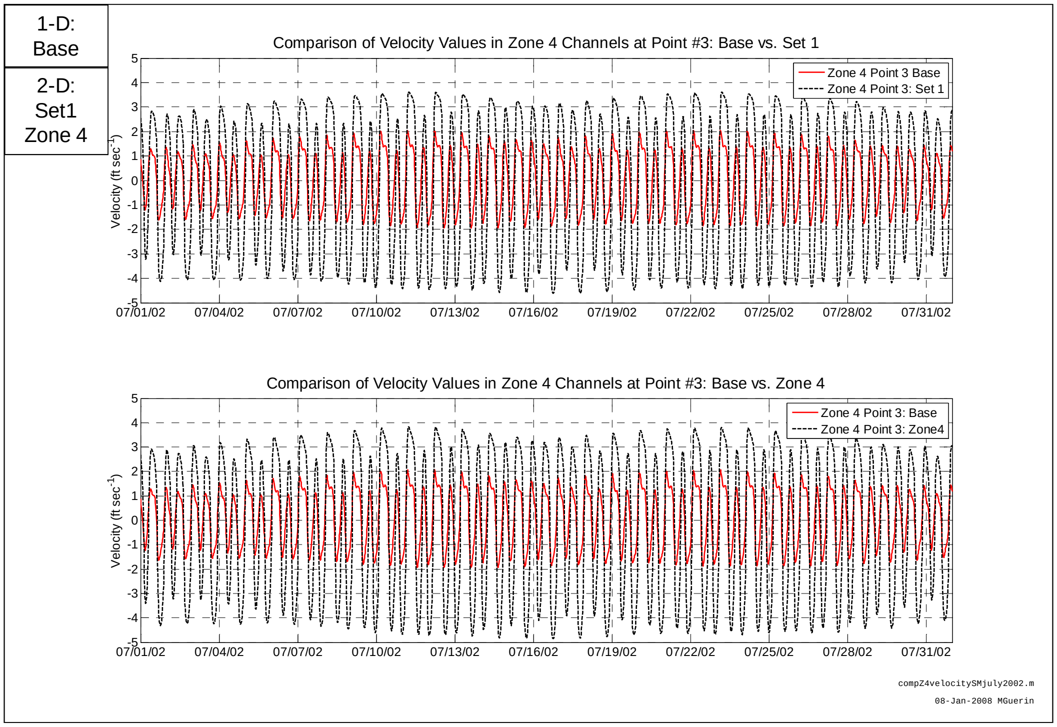


Figure 5-63 Meins Landing velocity at Point 2 for Set 1 and Zone 4 in comparison with the Base case.

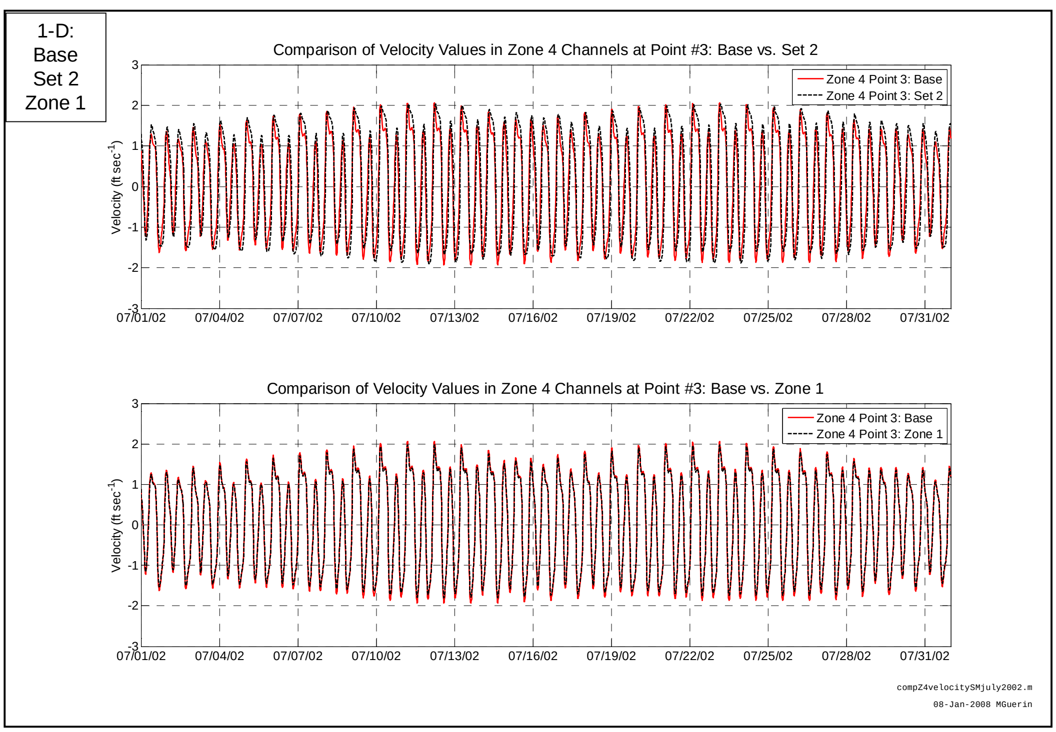


Figure 5-64 Meins Landing velocity at Point 2 for Set 2 and Zone 1 in comparison with the Base case.

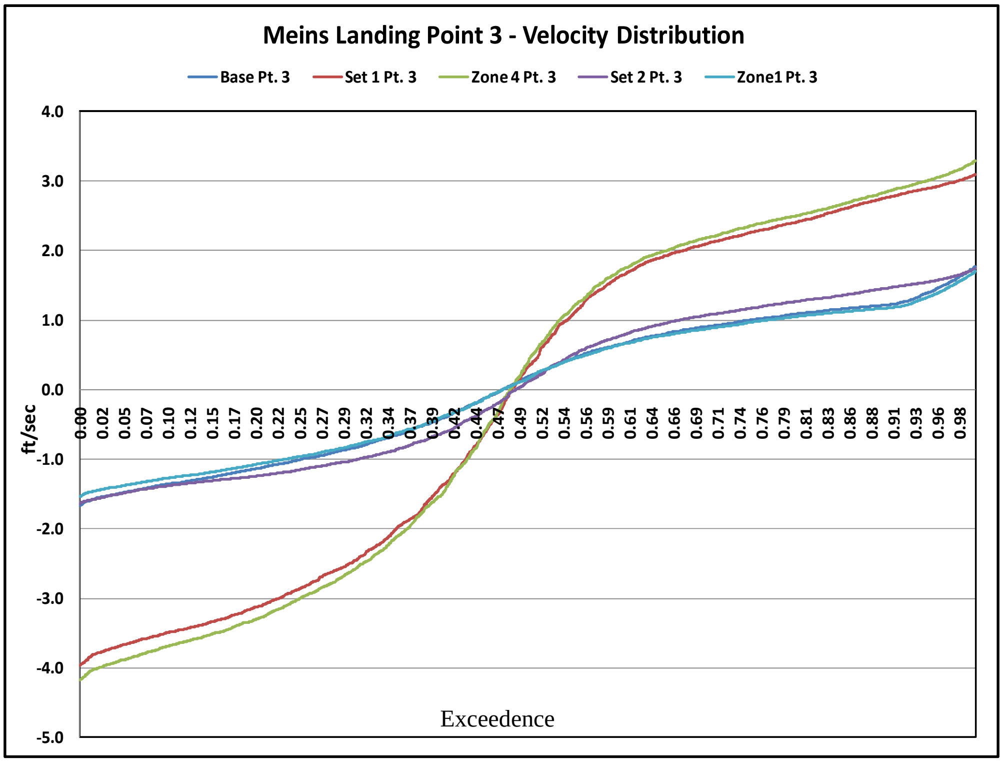


Figure 5-65 Velocity distributions for Point 3 (bank) analyzed near Meins Landing.

Exceedence

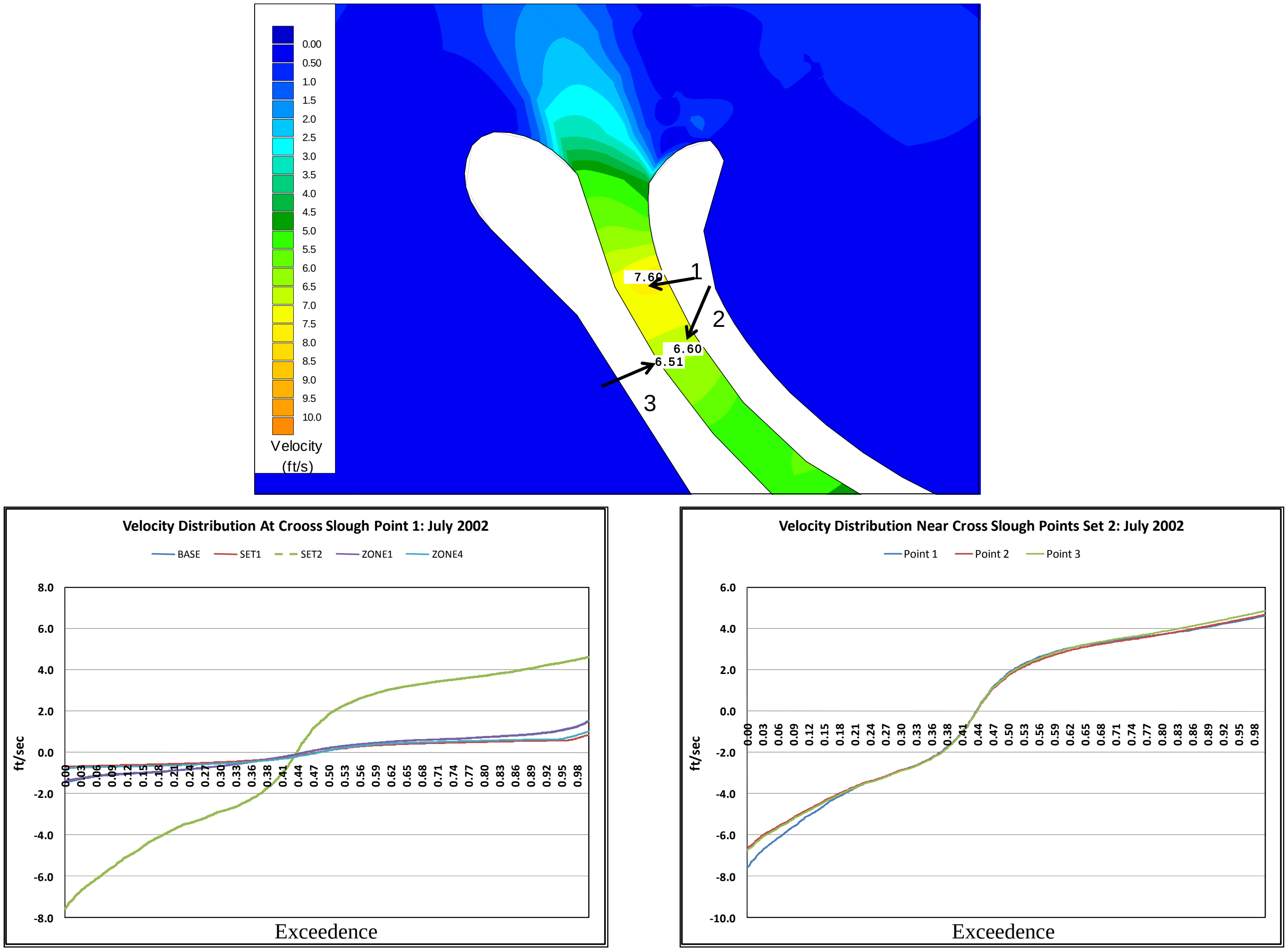


Figure 5-66 (Above) Color contour plot of Set 2 velocity near Cross Slough on July 19, 2002 23:15. (Below) Velocity distributions in Cross Slough. Points analyzed: points 1 and 2 mid-channel.

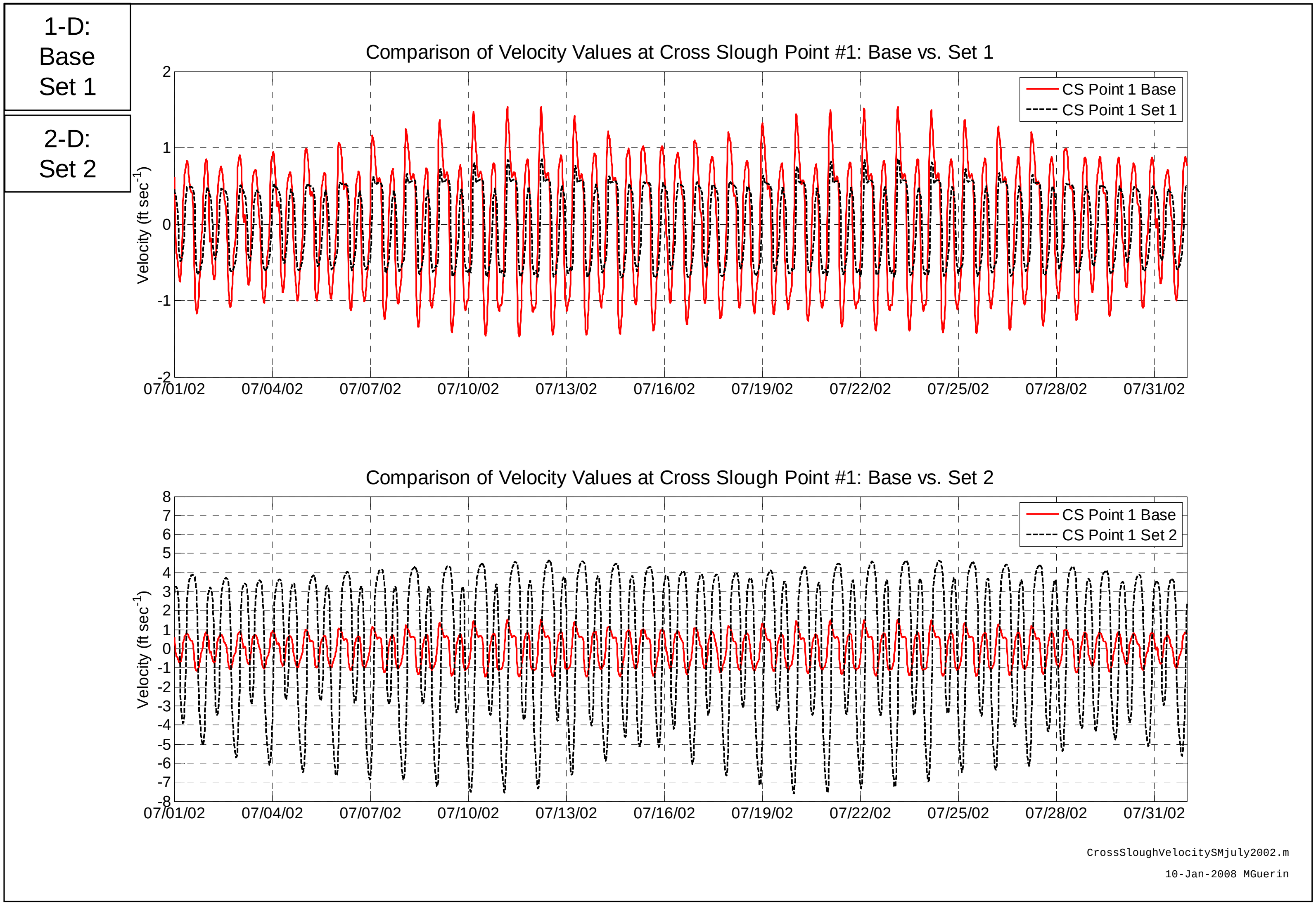


Figure 5-67 Cross Slough velocity at Point 1 for Set 1 and Set 2 in comparison with the Base case.

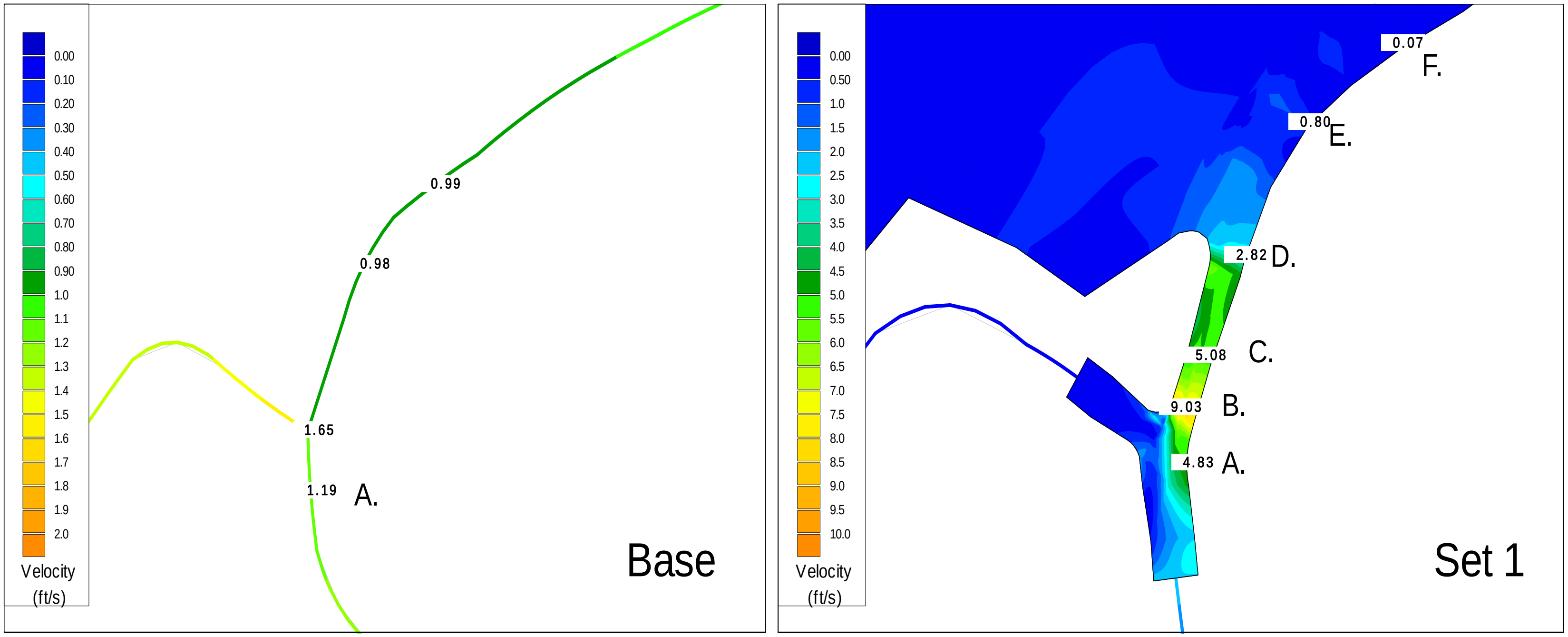
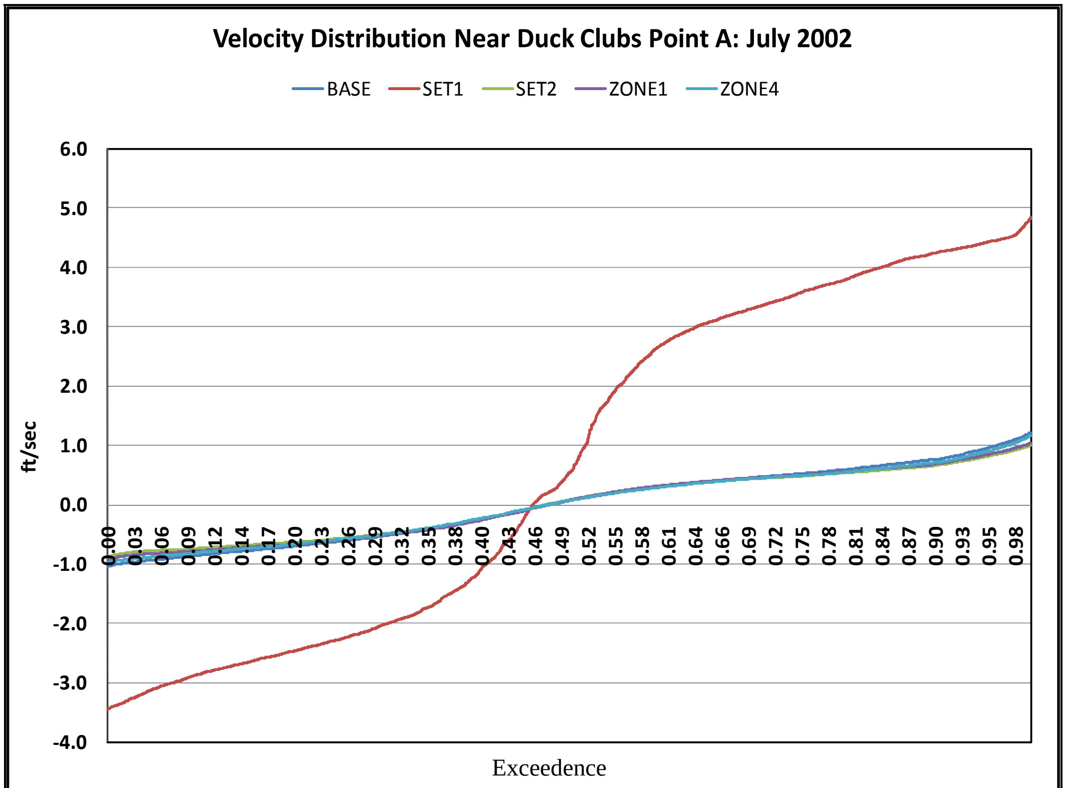


Figure 5-68 Color contour plots of velocity for the Base case and set 1 scenario on July 11, 2002 04:45 (note scale differences on contour plots). Points analyzed near the Duck Club location are indicated.



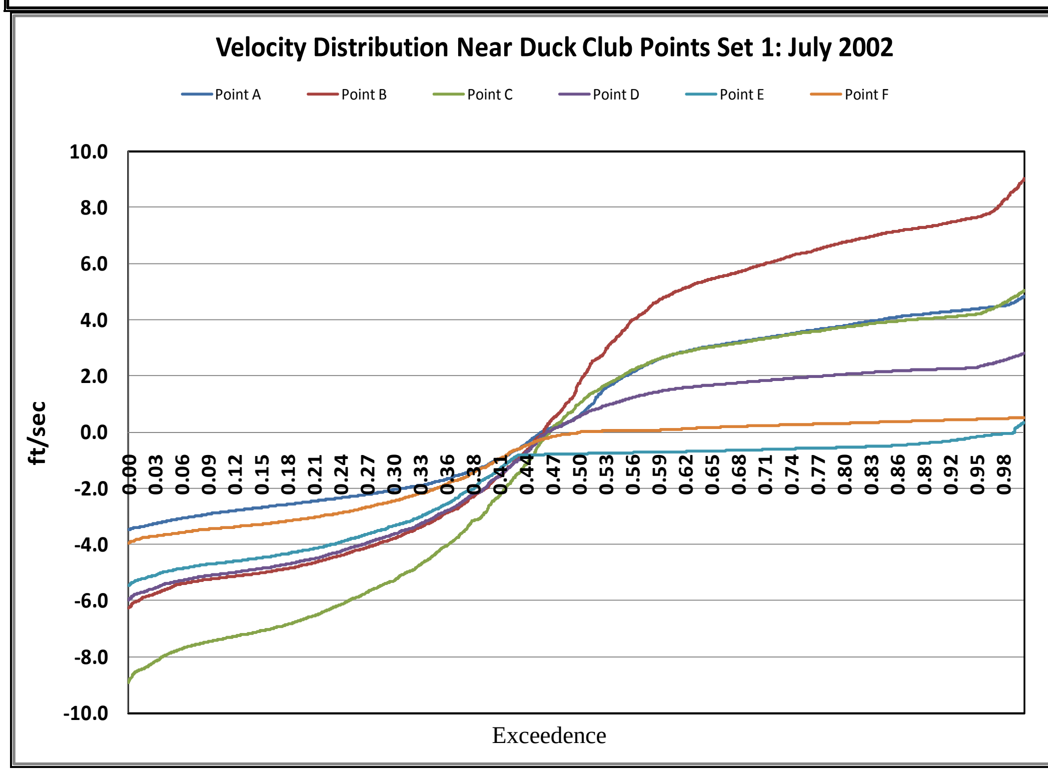


Figure 5-69 Velocity distributions for points analyzed near the Duck Club location. Lower plot shows velocity distributions for Set 1 at six points.

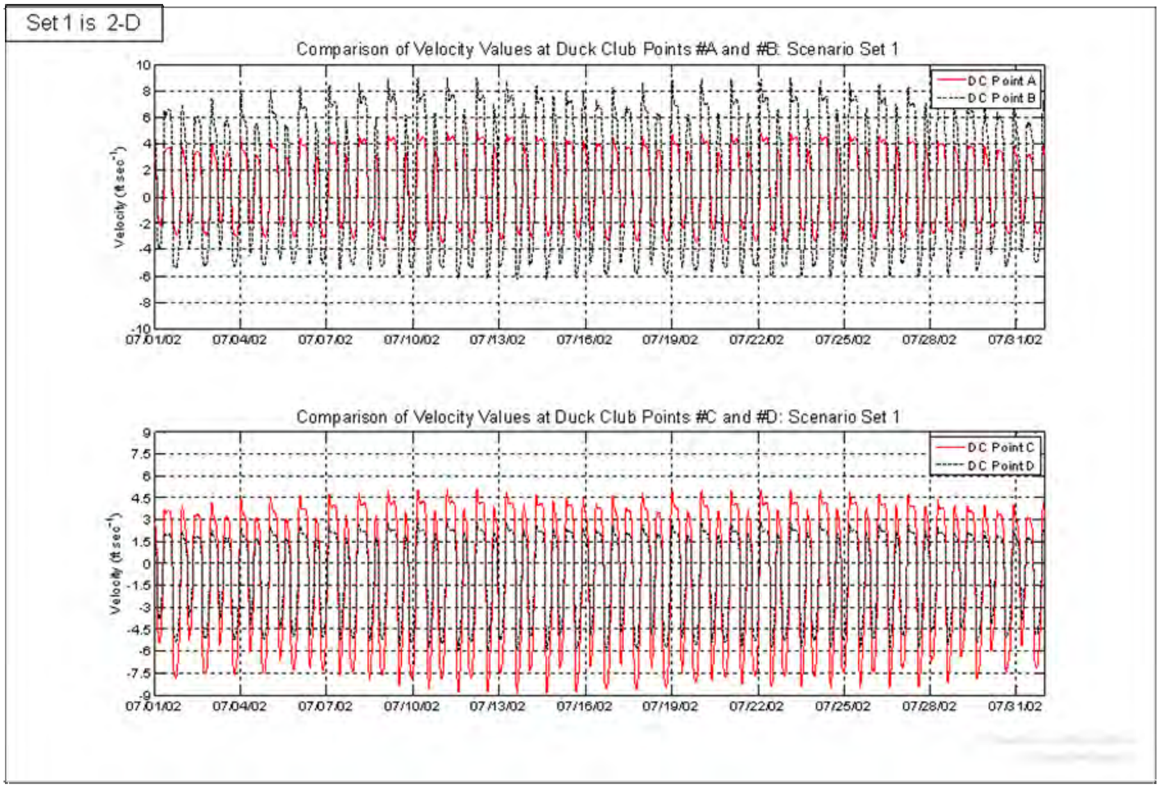


Figure 5-70 Velocity time series for points A - D analyzed near the Duck Club location.

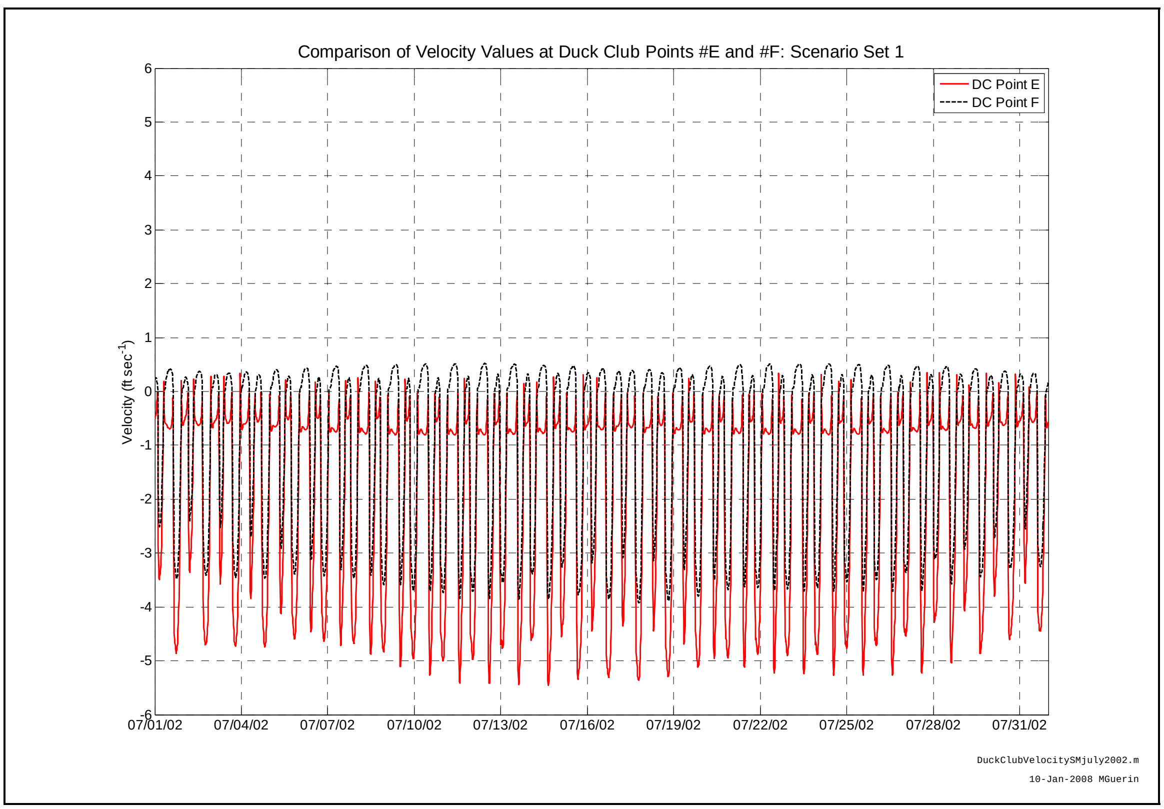


Figure 5-71 Velocity time series for points E and F analyzed near the Duck Club location.

6. Discussion/Summary/Conclusions

The representation of the Suisun Marsh area in RMA's current numerical model of the San Francisco Bay and Sacramento-San Joaquin Delta system was refined to simulate the current hydrodynamics and EC of the Suisun Marsh as well as the changes to this regime under a set of four marsh restoration scenarios.

Refinement in the Suisun Marsh area involved addition of increased detail to represent off-channel storage in overbank/fringe marsh regions, a better representation of precipitation and evaporation, estimation of local creek flows, inflows and withdrawals within the Suisun Marsh, and an overall refinement of the mesh. These additions generally improved the representation of tidal dynamics and EC in Suisun Marsh.

Stage calibration was generally good in Suisun Marsh. Flows in the smaller sloughs were greatly improved by the increased detail and refinement of the grid, the addition of off-channel storage, withdrawals for managed wetlands, and representation of evaporation in the tidal marsh areas. Flow through Montezuma Slough was low in comparison with measured data, and low flows through Hunter Cut were compensated by higher flows through Suisun Slough. These results have the potential of biasing modeled EC in the marsh restoration scenarios.

EC calibration results were variable, with some areas showing good correspondence with measured data, while other areas suffered from the lack of sufficient data or from approximations intrinsic to the model. In general, EC was low everywhere in the marsh in winter 2003. EC was low year-round in the eastern end of Montezuma Slough. Problems with flow calibration in Montezuma Slough or with insufficient representation of local effects are potential causes.

Density stratification is not explicitly represented in the 2-dimensional depth-averaged formulation used in the Bay-Delta model, leading to variations in the representation of EC. In the current model, diffusion coefficients are used to approximate effects due to density stratification. The use of diffusion coefficients to improve the representation of EC during high flow periods tends to bias modeled EC when outflow is low. As a consequence, modeled EC at Martinez is low winter through spring and high summer through fall. This bias in modeled EC at Martinez propagates through western Suisun Marsh.

Using the calibrated model, four marsh restoration scenarios - Zone 1, Zone 4, Set 1 and Set 2 - were simulated and compared to a Base case. Analysis of the results indicated that each of the scenarios increased the tidal prism, but muted the tidal range and shifted stage timing throughout the marsh in comparison with the Base case. Average tidal flow generally increased in the larger sloughs and decreased in smaller sloughs in the interior regions of Suisun Marsh. Tidal flow downstream of the restoration areas will likely increase, but reduced tidal range will reduce tidal flow at the sloughs upstream of the restored areas. The peak velocity increased in sloughs near the breaches of the flooded areas, with the largest changes localized at and near the mouths of the breached levees.

This increases the potential for failure on the banks of some of the affected levees or for scouring in some of the channels.

Water quality model results for the marsh restoration scenarios indicated that Delta EC decreased during July through December for the Zone 4 and Set 1 scenarios where the breached areas were located in channels further from Suisun Bay. The Set 2 scenario resulted in EC increase in the Delta due to tidal trapping in the breached area adjacent to Suisun Bay. Tidal trapping with the Zone 1 scenario caused only minor increases in Delta EC.

Scenarios that decreased Delta EC tended to increase EC in Suisun Marsh, although changes in the details of the EC profile for each scenario depended on the particular location examined, the operation of the Suisun Marsh Salinity Control Gate (SMSCG), and the season. The Zone 1 scenario was again most similar to the Base case, with little or no EC change in the eastern marsh but some increase in the west. The Zone 4 scenario decreased EC in most of the marsh whenever the SMSCG was operating, except in eastern Montezuma Slough where it increased EC. The Set 1 scenario generally resulted in the highest EC conditions in the Marsh, except upstream of the Zone 4 breaches on Montezuma Slough.

In comparison with the Base case:

- Each of the Alternatives resulted in increased EC in Montezuma Slough at Beldon's landing either because of pulling more water from the west, as in the cases of Zone 4 and Set 1, or because of increases in EC at the west end of Montezuma Slough, as in the cases or Zone 1 and Set 2.
- Zone 1 showed little difference in EC compared with the Base case in the eastern Marsh and at Morrow Island, but resulted in at least some EC increase in the western marsh and a small increase in Montezuma Slough at Beldon's Landing. The salinity increases are due in part to large volumes of higher salinity water being pulled into the marsh through Suisun Slough and Hunter Cut.
- When the SMSCG is open, Set 1 tends to have the most pronounced EC increase of all the scenarios in all areas of the Marsh except eastern Montezuma Slough, where Set 1 has greatest EC decrease. This is because of the locations and extent of the Set 1 restoration areas result in large volumes of (higher velocity) water being pumped through the main channels and sloughs in the marsh on both incoming and outgoing tides.
- When the SMSCG is operating, Zone 4 resulted in the greatest EC reduction throughout the western and northern Marsh, and increased EC at Beldon's Landing and eastward in the Marsh. The increases occur because the fresher water from Collinsville is entering the Zone 4 area rather than moving westward and northward in the marsh. With the gates open, EC was decreased in eastern Montezuma Slough and increased in Nurse Slough and at Beldon's Landing. Locations east of the breach benefit from the additional inflow of fresher water from the east, whereas less of the fresher water makes it past the breach to the west and north. Effects elsewhere were minor.

- At most locations, Set 2 increased EC when the gates were operating and otherwise resulted in increased EC or little change, in general. In the western marsh at Ibis, Cygnus and Morrow, very small decreases occurred when the SMSCG were operating. EC decreased only in eastern Montezuma Slough when the gates were open, due to increased flow of lower EC water from the east.

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