Chapter 13

H10: Unsteady Flow through a Simple Channel Network

Contents

This problem was contributed by Peter E. Smith.

13.1 Problem Specification

H10 Unsteady flow through a simple channel network

Revised Problem H5 rectangular channels, no bed slope

Focus network connectivity, steady circulation.

Channel network geometry is the same as schematic application H9. Also, use the same fixed Δt and Δx as in H9.

Open boundary conditions are

$$\begin{aligned} \eta_A(t) &= \begin{cases} 5 & \text{for } t \le 0 \\ 5 + 3\sin\omega t & \text{for } t > 0 \end{cases} \\ Q_D(t) &= 4,000 \text{ ft}^3/\text{s for all } t \\ Q_E(t) &= 2,000 \text{ ft}^3/\text{s for all } t \end{aligned} \tag{13.1.1}$$

where $\omega = 2\pi/T$, the tidal period T being 12.0 hours.

As initial conditions, use the STEADY STATE solution from application H9.

Compute and write to file in the STANDARD FORMAT the initial conditions at $t = 0$ and the model predictions for every[1] time step to $t = 6T$.

13.2 Background

The CCW model is restricted to rectangular channels. The DWR model is restricted to a computational time step of 60 s and tidal periods of 12 hours. This problem provides an opportunity to compare all three models under exactly the same conditions.

13.3 Contra Costa Water District

Figures 13.1 and 13.2 shows the CCW-predicted η and Q evolution throughout the sixth tidal cycle. The response patterns show the expected time periodic flow. The Q evolution seems to be a stepped response. It should be continuous, like the η response.

Figure 13.3 shows the instantaneous flow or mass balances at junctions B, C and F. The evolution of these Q's is again stepped. It seems unlikely that the CCW model can predict continuous η's but discontinuous Q's; this must be a data reporting error. A similar stepped response was observed in Figure 6.4a, the mass balance in problem H3. Otherwise, this is the expected response, Mass is conserved at all three junctions.

Figures 13.1 though 13.3 are the expected response.

[1] The data files are very large and surface plots are very dense. For the following presentations, data file entries every 300 s for $5T \leq t \leq 6T$ have been plotted.

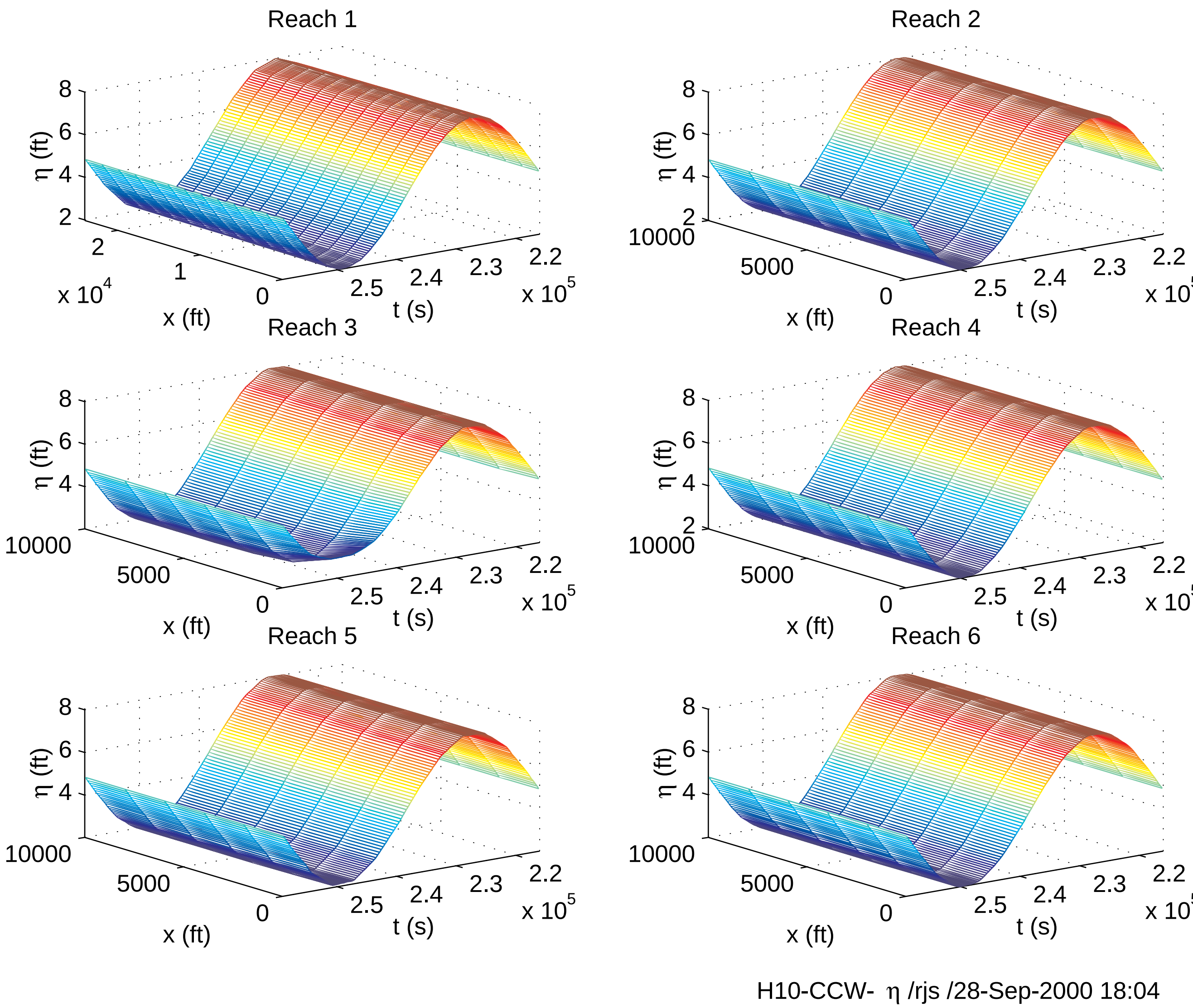

Figure 13.1: H10 CCW-predicted η solution field evolution.

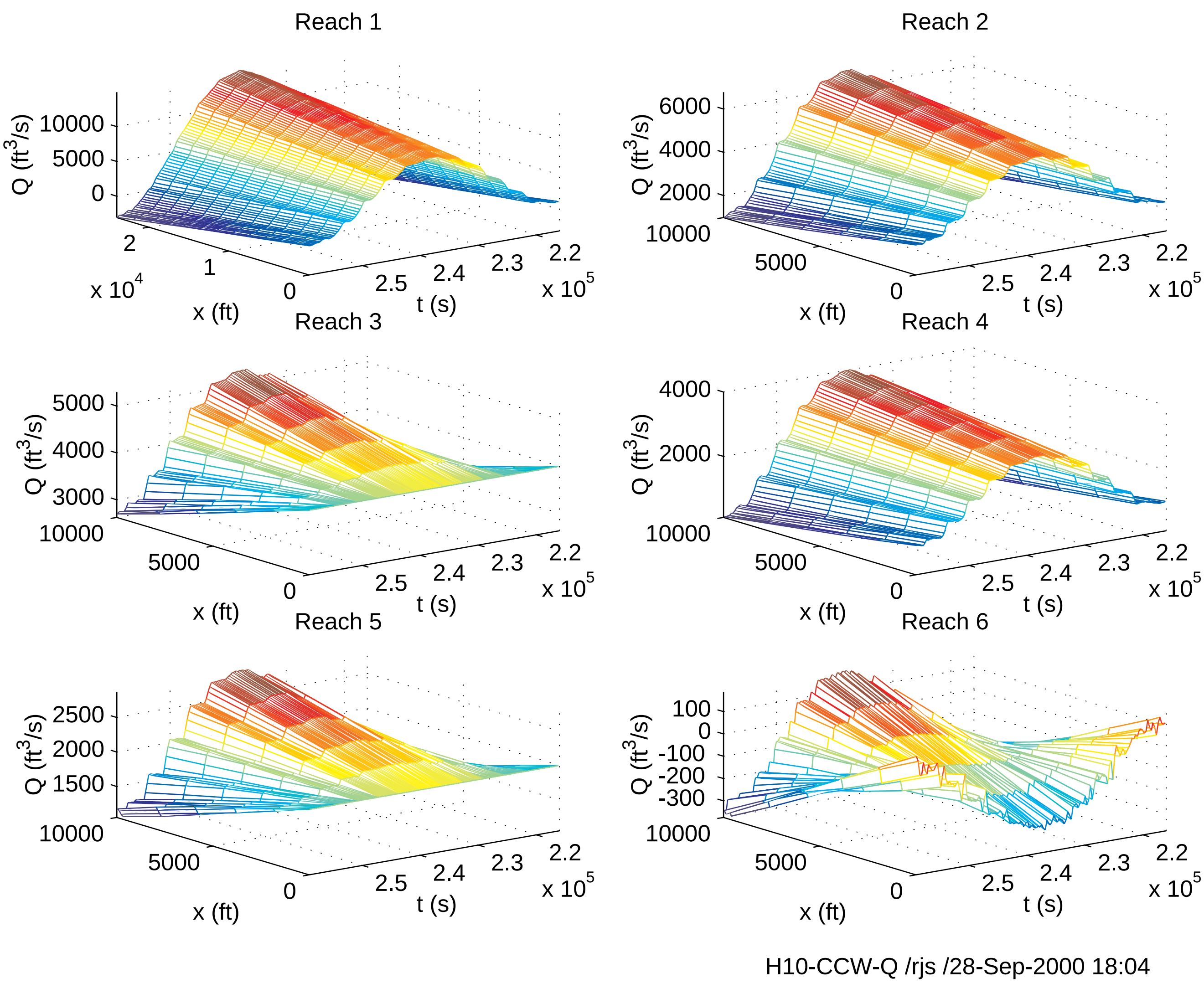

Figure 13.2: H10 CCW-predicted Q solution field evolution.

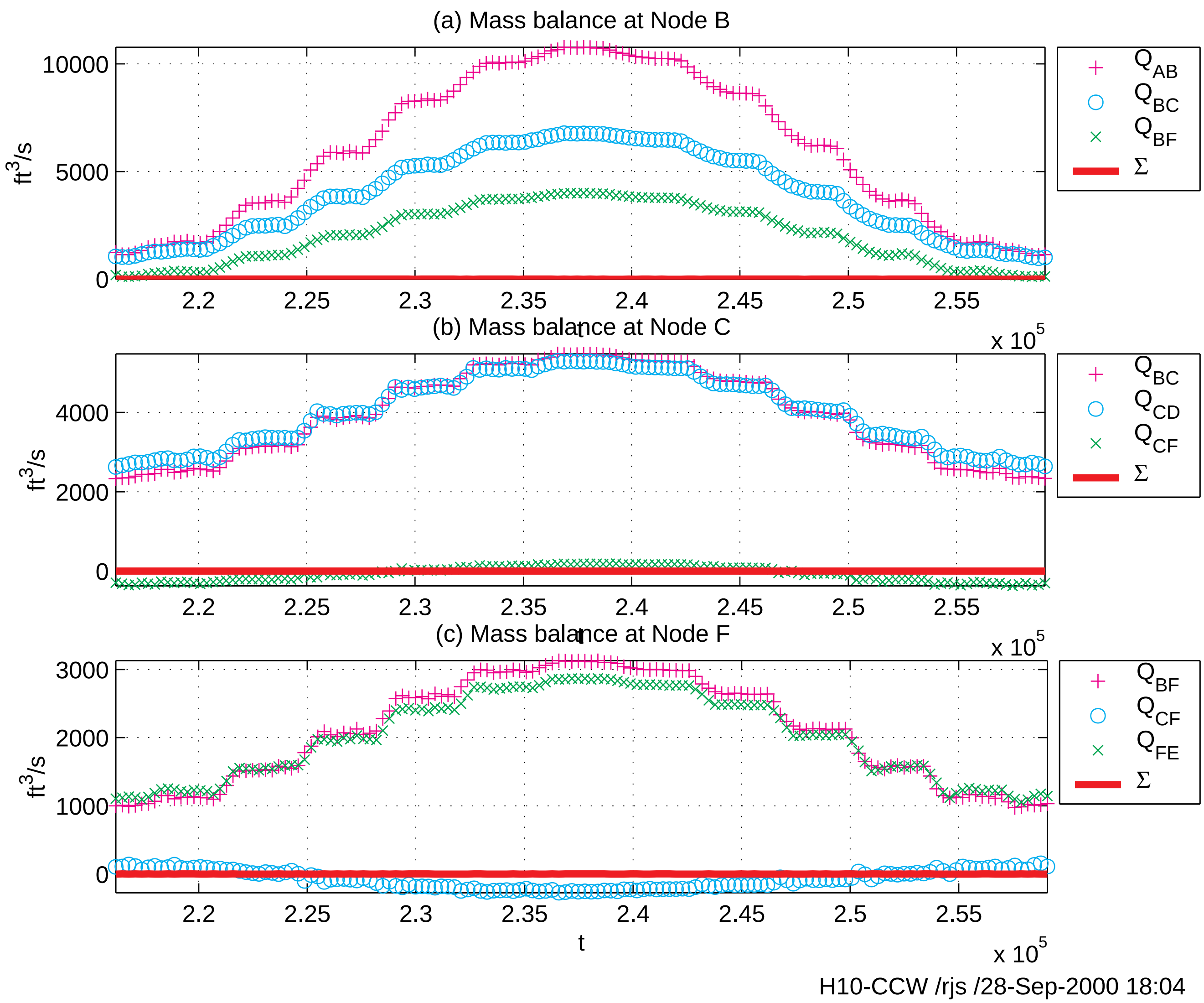

Figure 13.3: H10 CCW-predicted mass balances at network nodes.

13.4 Department of Water Resources

Figures 13.4 and 13.5 shows the DWR-predicted[2] η and Q evolution evolution throughout the sixth tidal cycle. The response patterns show the expected time periodic flow.

Figure 13.6 shows the instantaneous flow or mass balances at junctions B, C and F. Mass is conserved at all three junctions.

Figures 13.4 though 13.6 are the expected response.

[2]The DWR data file reports the computational time step Δt as 1 s; it was apparently the specified 60 s. The time step has been changed to 60 s for the following analyses. The x axes are also directed in the wrong direction.

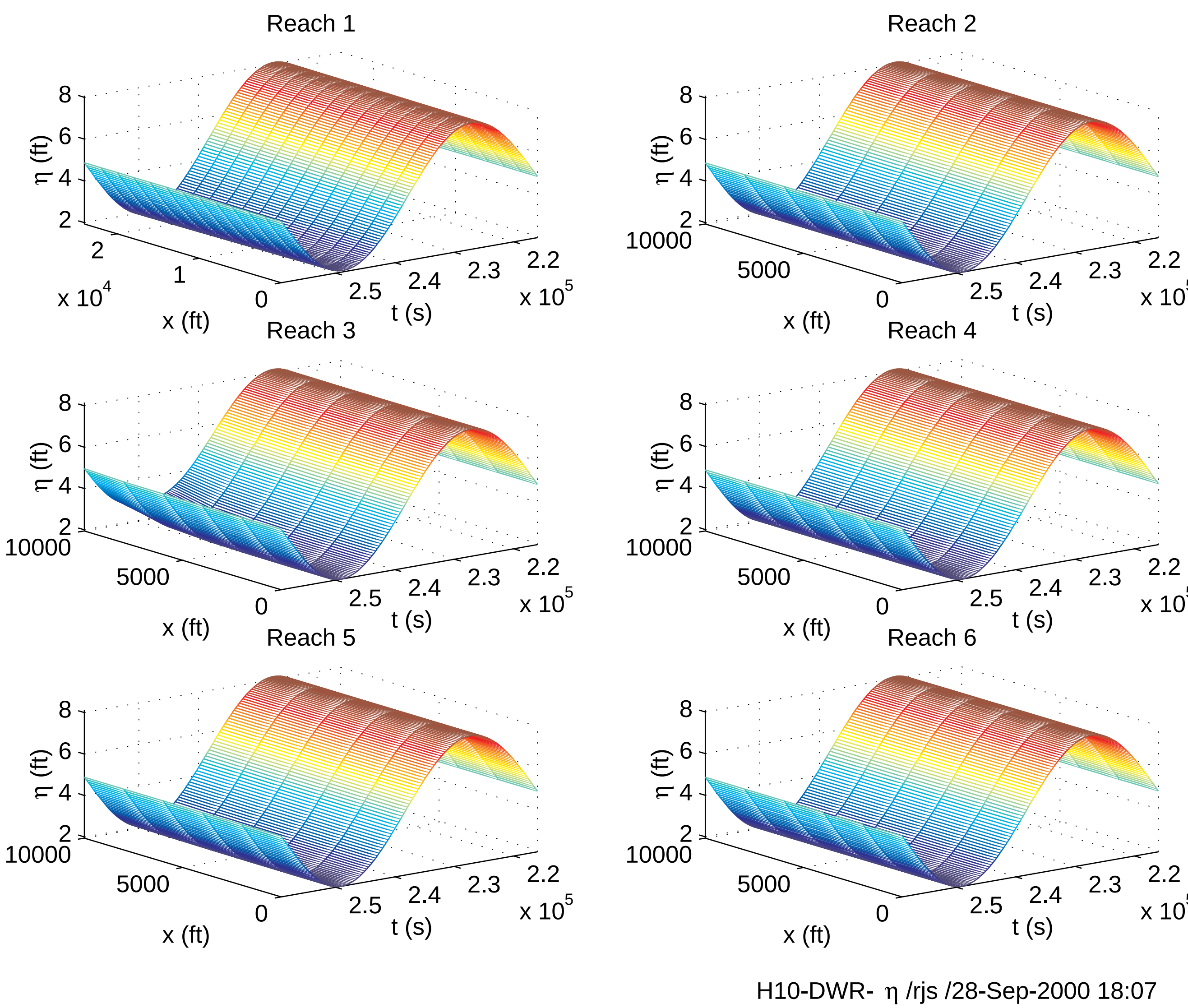

Figure 13.4: H10 DWR-predicted η solution field evolution.

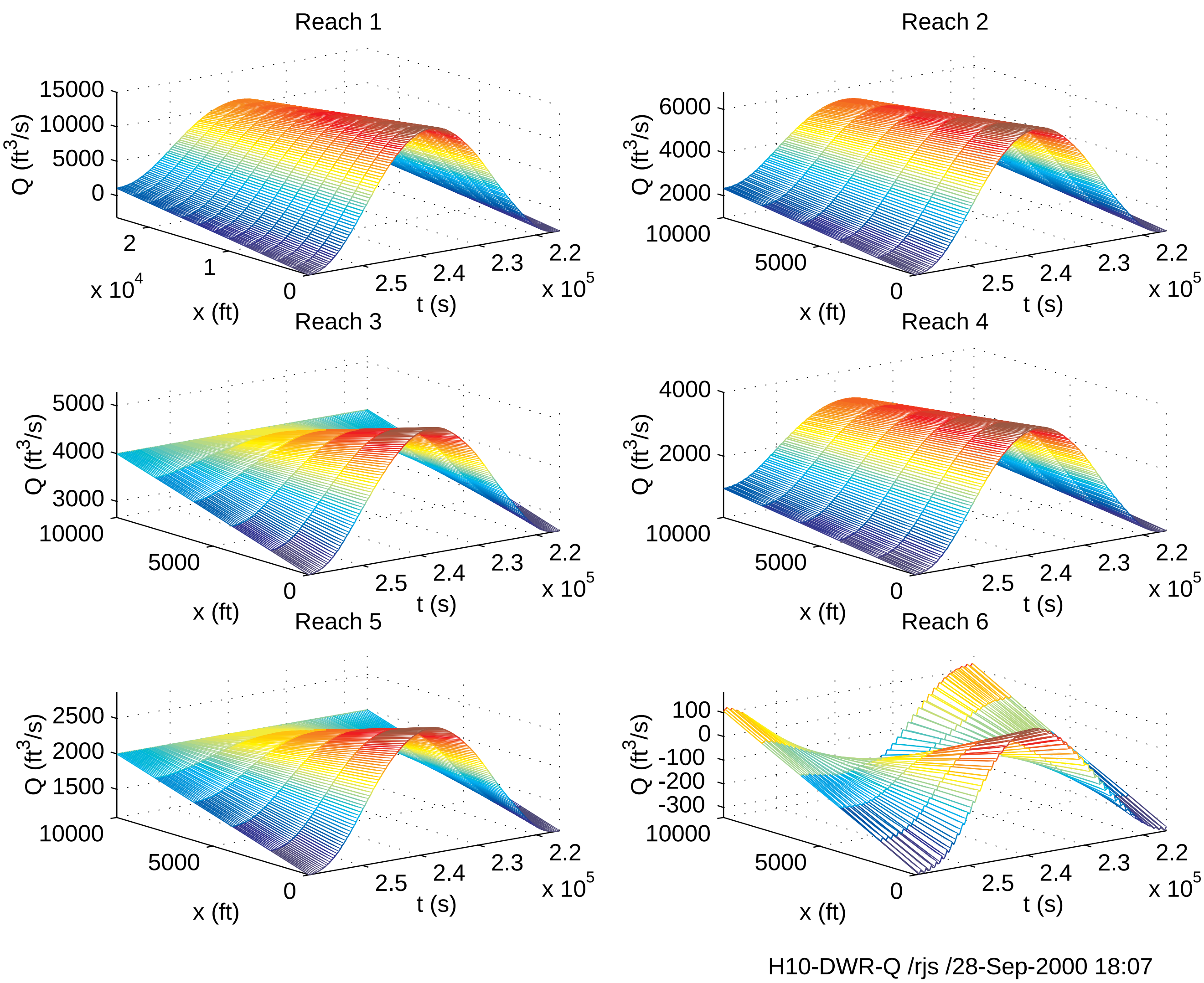

Figure 13.5: H10 DWR-predicted Q solution field evolution.

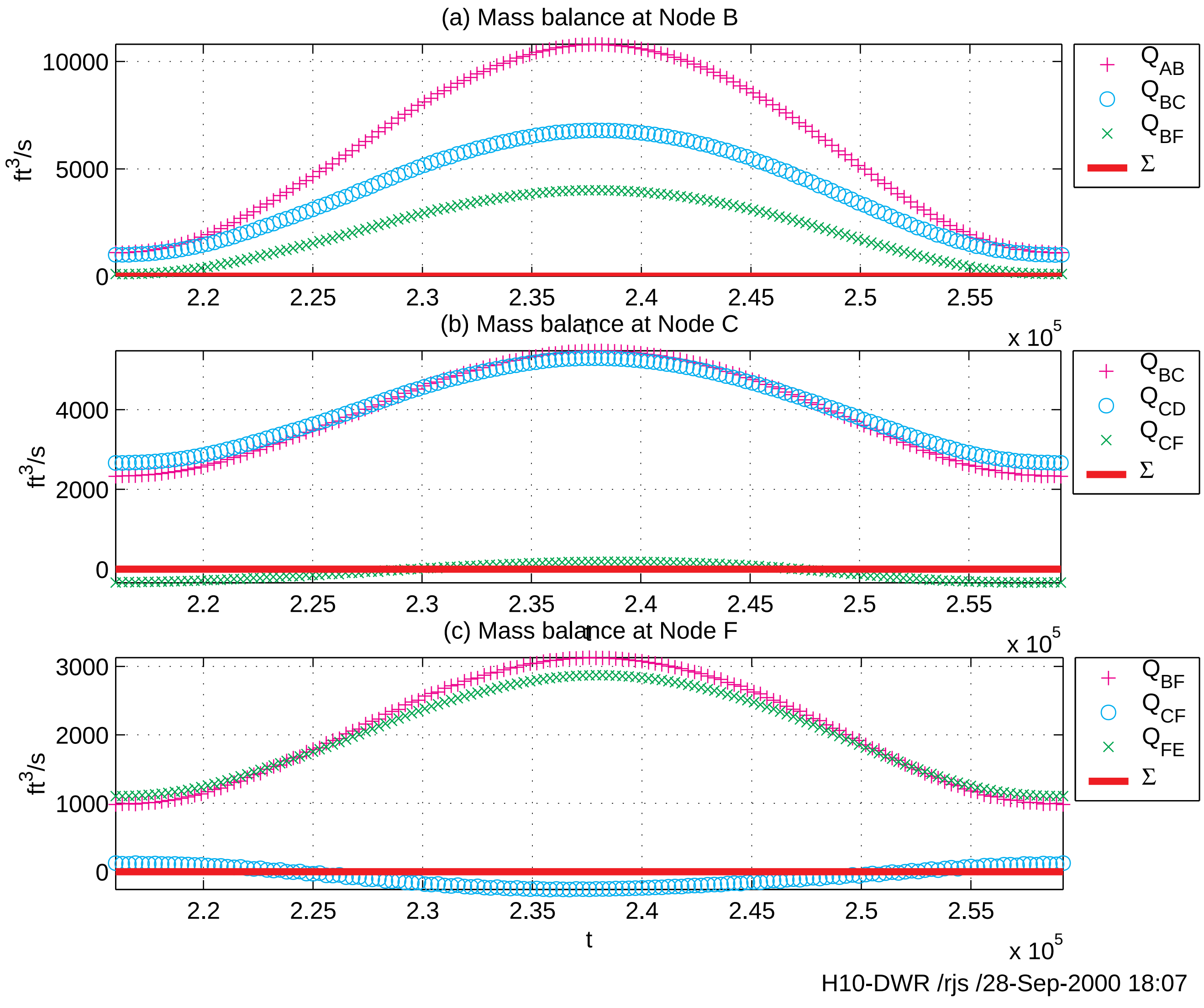

Figure 13.6: H10 DWR-predicted mass balances at network nodes.

13.5 Resource Management Associates

Figures 13.7 and 13.8 shows the RMA-predicted[3] η and Q evolution throughout the sixth tidal cycle. The response patterns show the expected time periodic flow.

Figure 13.9 shows the instantaneous flow or mass balances at junctions B, C and F. Mass is conserved at all three junctions.

Figures 13.7 though 13.9 are the expected response.

[3]RMA have used the specified Δx of 2,000 ft only in reach 1 (AB). They have used $\Delta x = 1{,}000$ ft for reaches 2 through 6.

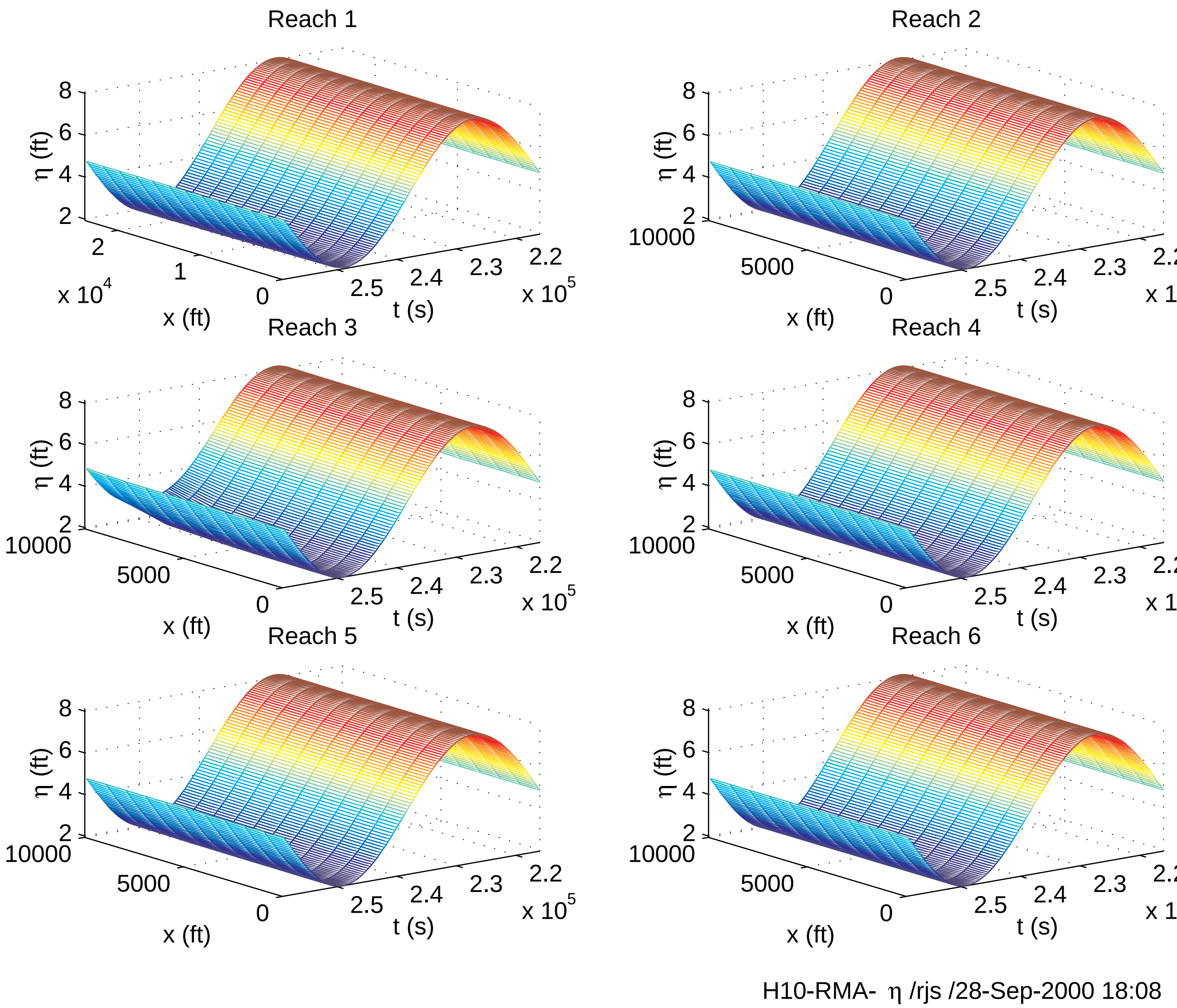

Figure 13.7: H10 RMA-predicted η solution field evolution.

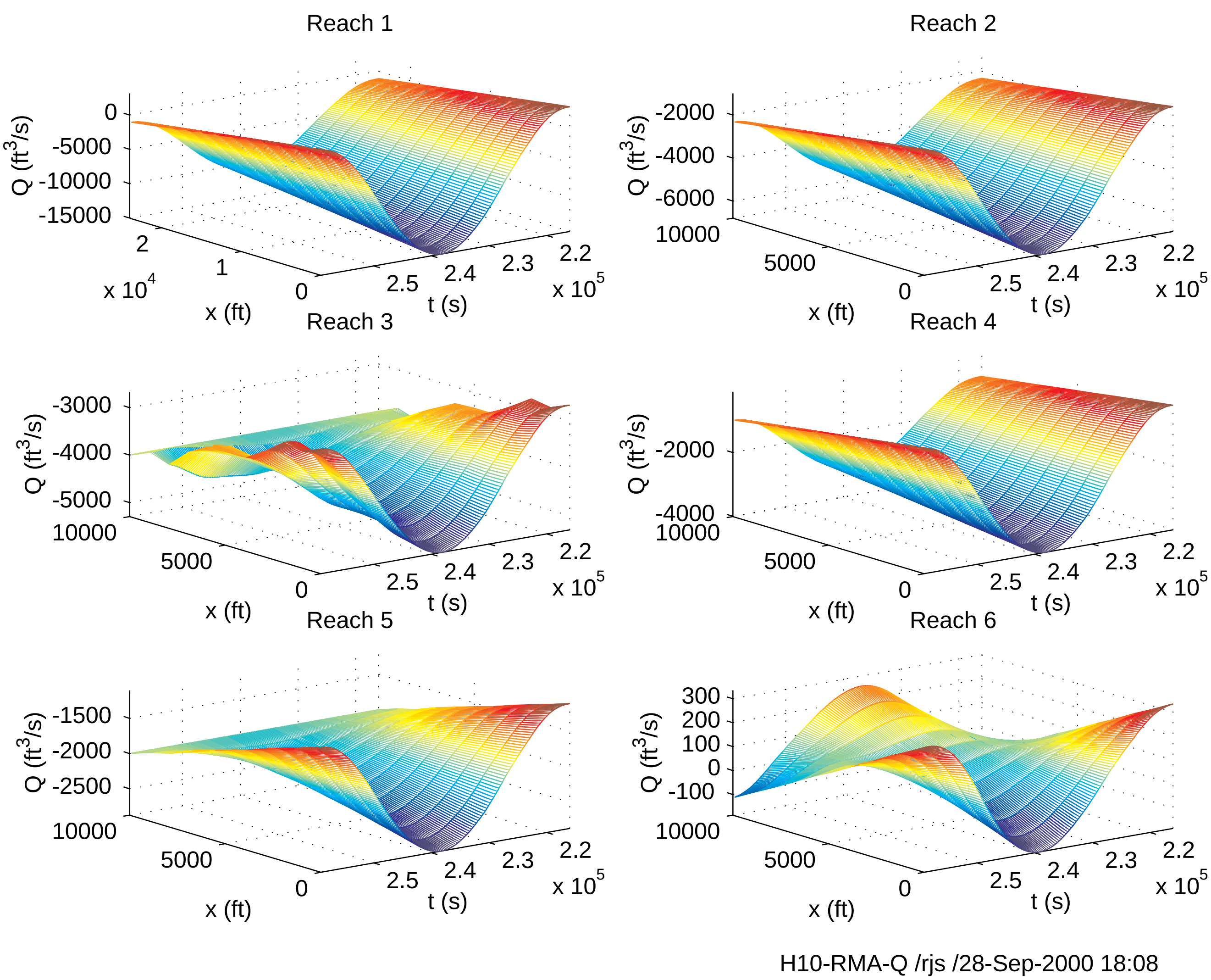

Figure 13.8: H10 RMA-predicted Q solution field evolution.

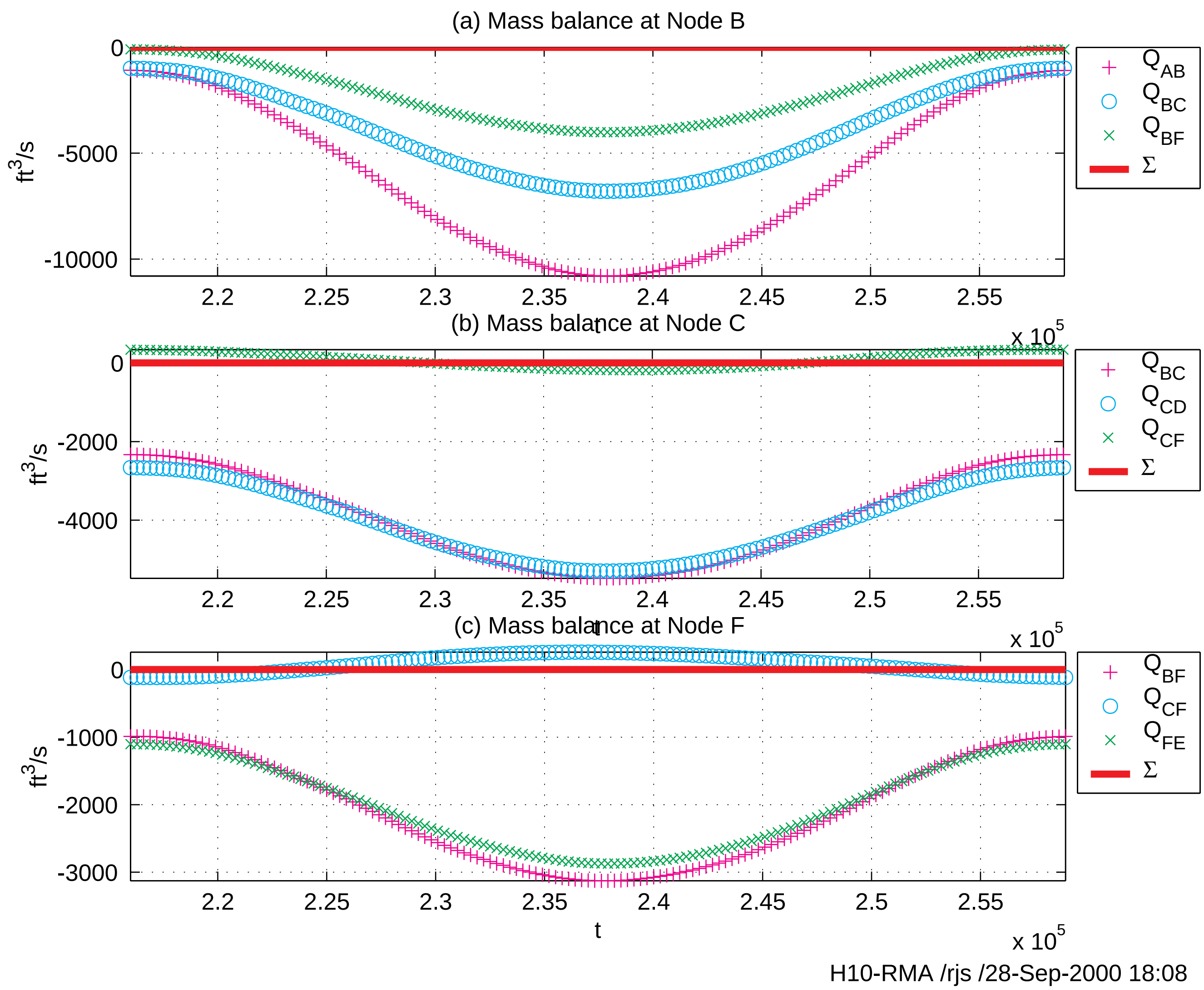

Figure 13.9: H10 RMA-predicted mass balances at network nodes.

13.6 Response Comparisons

The CCW model is restricted to rectangular channels. The DWR model is restricted to a computational time step of 60 s. This problem, a revision of H5, provides an opportunity to compare all three models under exactly the same conditions. As for problem H9, attention will focus on the network link CF/Reach 6.

Figure 13.10 shows the CCW-predicted, DWR-predicted and RMA-predicted water surface evolutions and flows at nodes C and F. The general impression is excellent agreement with the water surface traces from all three models. The free modes that are forced by the initial condition persist only for a half-tidal cycle, after which the response is the expected forced tidal circulation. All three results for η_c and η_F plot over each other.

The flow traces from the DWR and RMA predictions also show excellent agreement. There does seem to be a problem with the CCW prediction????

????In summary, these results follow the expected pattern. There is no suggestion that this is other than an excellent result for all three algorithms.

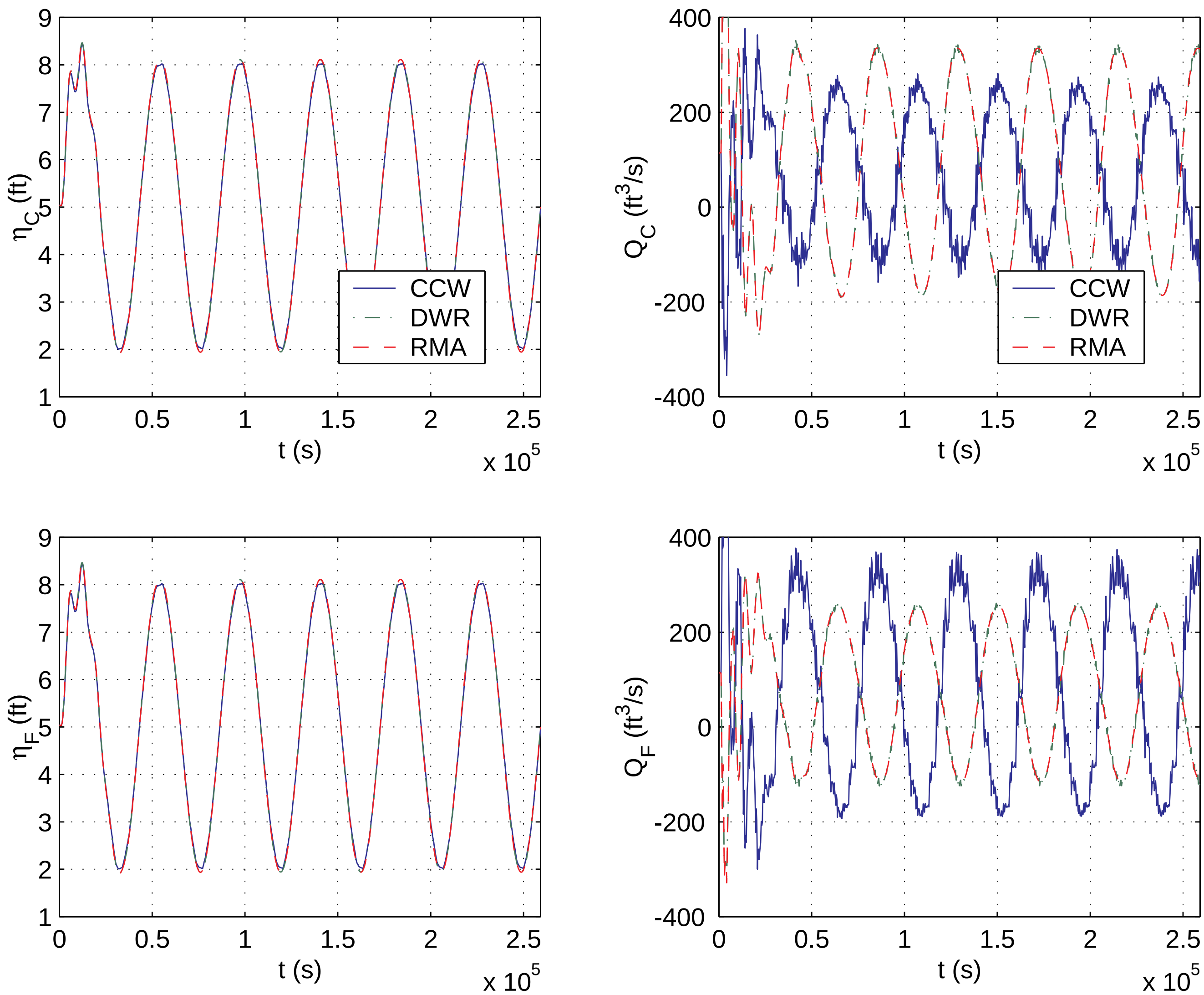

Figure 13.10: Water surface and flow evolution at Nodes C and F in Reach CF.