Chapter 11

H8: Lateral Inflows

Contents

11.1 Problem Specification

H8 Lateral inflows

Focus agricultural diversions and drainage returns, network connectivity.

Channel geometry is similar to schematic application H6 and H7, but without the underflow gate.

Channel bed is horizontal from upstream point A to downstream point D. The trapezoidal channel bed width B is 50 ft. At A, $x_A = 0$ ft and $Z_A =$ -20.0 ft. At D, $x_D =$ 50,000 ft and $Z_D =$ -20.00 ft. Channel friction factor is constant at Darcy-Weisbach $f = 0.03$ or Manning $n = 0.02$.

An agricultural diversion is located at $x_B = x_C = +20{,}000$ ft, with point B on the upstream side, and point C on the downstream side. The agricultural diversion withdraws flow Q_{BC} but negligible streamwise momentum from the channel. Its operational characteristics are

$$Q_{BC} = \begin{cases} 0 & \text{for } t < 0 \\ 500 \text{ ft}^3/\text{s} & \text{for } t \geq 0 \end{cases} \tag{11.1.1}$$

The hydrodynamic initial conditions in the channel at $t = 0$ s are quiescence:

$$\eta(x,0) = 0 \qquad \text{and} \qquad Q(x,0) = 0 \tag{11.1.2}$$

Open boundary conditions for the channel are fixed at

$$Q_A(t) = +10,000 \text{ ft}^3/\text{s} \quad \text{and} \quad \eta_D(t) = +0 \text{ ft} \qquad \text{for all } t > 0 \tag{11.1.3}$$

Use a fixed computational space step $\Delta x = 500$ ft and a fixed computational time step $\Delta t =$ 30 s.

Compute and write to file in the STANDARD FORMAT the initial conditions at $t = 0$ and the model predictions for every 90 s (3 time steps) for 2.5 hours.

If necessary, continue this computation for sufficient additional time steps as is necessary to reach the STEADY STATE. Append this solution to the end of the output file.

11.2 Background

Agricultural diversions and returns are a common feature of Bay-Delta channels. They are essentially point sinks or sources of mass. In a hydrodynamic model, they become discontinuities in mass flow rate, with the potential for mischief in a hyperbolic system.

11.3 Contra Costa Water District

From perusing the CCW data file, it appears that diversions are accommodated in the CCW model as point sinks at a two-node junction.

Figure 11.1 shows the CCW-predicted η and Q evolution toward the steady state. The characteristic paths (especially A123 in Figure 9.3) are shown very clearly, in particular the initial disturbance propagating from the upstream boundary, and the reflection of this disturbance from the downstream boundary (in the Q plot). The water surface approaches a classical H2 gradually-varied flow profile, with presumably a minor slope discontinuity at the diversion. This seems a very credible result[1], except for the apparent heavy damping of shorter wave length responses that was identified in the H6 discussion. But there does seem to be a problem with the flow boundary condition at $x = 0$. The $Q(0, t)$ trace in Figure 11.1 shows that the flow increases above the Equation 11.1.3 boundary condition of $Q_A(t) = +10{,}000$ ft^3/s at $t \approx 4{,}000$ s, where the initial characteristic from A has been reflected from D and has arrived back at A. The incoming disturbance should be reflected from A without changing the boundary condition. There appears to be a problem with the flow boundary condition at A. As Delta flows are boundary driven, this may be a serious problem.

Figure 11.2 shows a detail in the neighborhood of the diversion. The η trace seems continuous across the step change in Q at the diversion. Surprisingly perhaps, the diversion seems neither to reflect nor initiate any disturbances. In principle, there must be an influence, but it seems that the diversion is not sufficiently strong.

[1]The CCW prediction for the asymptotic H2 profile in Figure 11.1a is very different from subsequent DWR and RMA predictions, Figures 11.4a and 11.7a respectively. The CCW model is restricted to a rectangular channel. The width was set at the initial surface width of the trapezoidal channel. The CCW channel has a much larger cross-sectional area, initially 2600 ft^2 compared to 1800 ft^2, which is directly responsible for the differences.

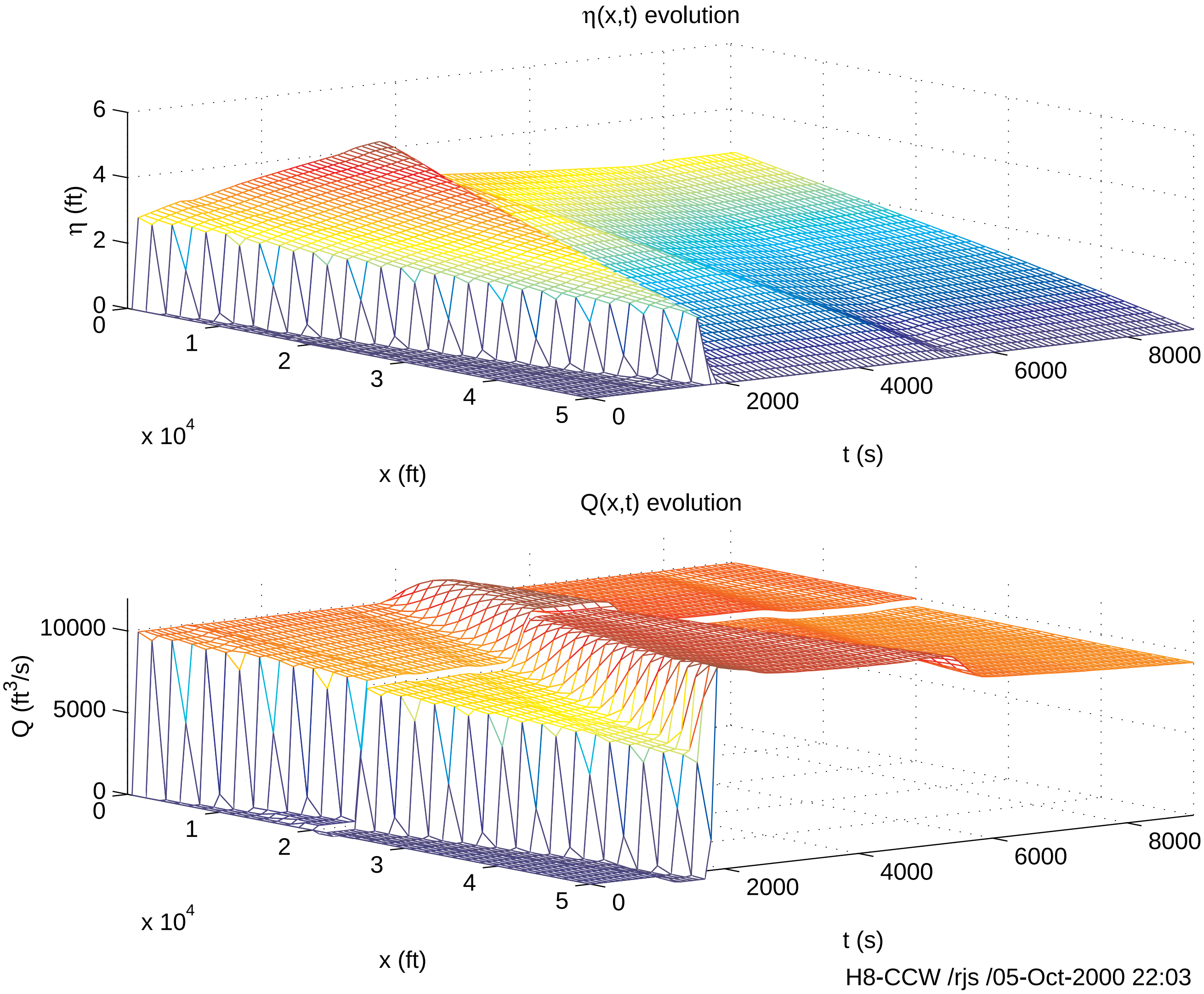

Figure 11.1: H8 CCW-predicted η and Q solution field evolution.

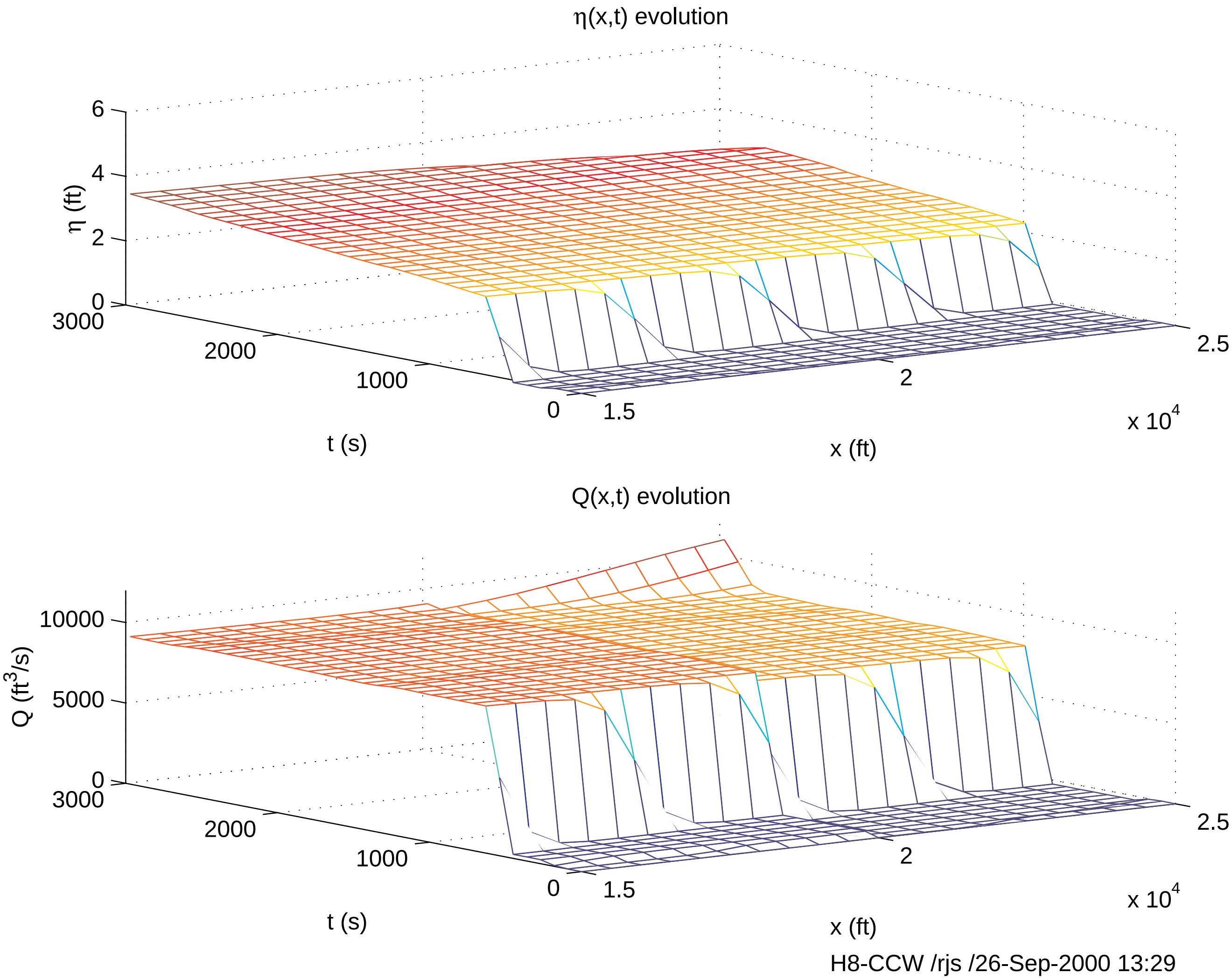

Figure 11.2: H8 CCW-predicted η and Q solution field evolution in neighborhood of diversion.

Figure 11.3 shows the time history of the mass and momentum balances at locations $x = 3{,}000$ ft and 23,000 ft. Excluding the rapidly-varied segments associated with passage of the disturbance along the A123 path (Figure 9.3), both mass and momentum are conserved. This seems to be the expected result.

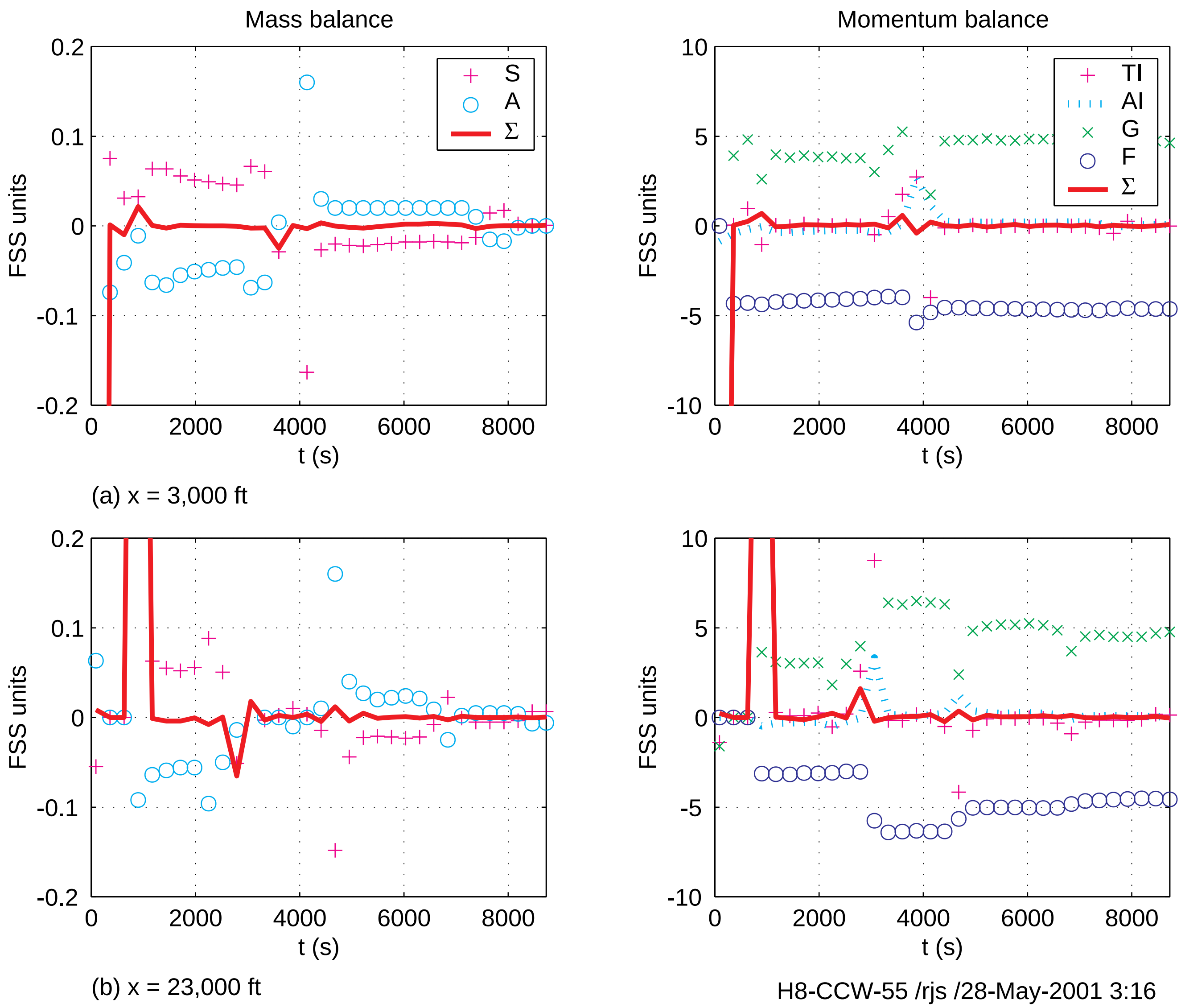

Figure 11.3: H8 CCW-predicted conservation balances at x = 3,000 ft and 23,000 ft.

11.4 Department of Water Resources

From perusing the DWR data file, it appears that diversions are accommodated in the DWR model as point sinks at a two-node junction.

Figure 11.4 shows the DWR-predicted[2] η and Q evolution toward the steady state. The characteristic paths (especially A123 in Figure 9.3) are shown very clearly, in particular the initial disturbance propagating from the upstream boundary, and the reflection of this disturbance from the downstream boundary (in the Q plot). The water surface approaches a classical H2 gradually-varied flow profile, with presumably a minor slope discontinuity at the diversion. This is a very credible result, except for the apparent heavy damping of shorter wave length responses that was identified in the H6 discussion. Figure 11.5 shows a detail in the neighborhood of the diversion. The η trace is continuous across the step change in Q at the diversion. Surprisingly perhaps, the diversion seems neither to reflect nor initiate any disturbances. In principle, there must be an influence, but it seems that the diversion is not sufficiently strong.

Figure 11.6 shows the time history of the mass and momentum balances at locations $x = 3{,}000$ ft and 23,000 ft. The rapidly-varied segments associated with passage of the disturbance along the A123 path (Figure 9.3) is clearly identified in the separate terms in the mass and momentum balances, but not in the overall balances, perhaps because of heavy numerical damping[3].

Mass and momentum are conserved, which is the expected result.

[2]The DWR data file reports the output time step as 1 s; it was apparently not the specified 90 s, but 60 s. The data file time step has been changed to 60 s for the following analyses.

[3]See §9.3 and §9.5

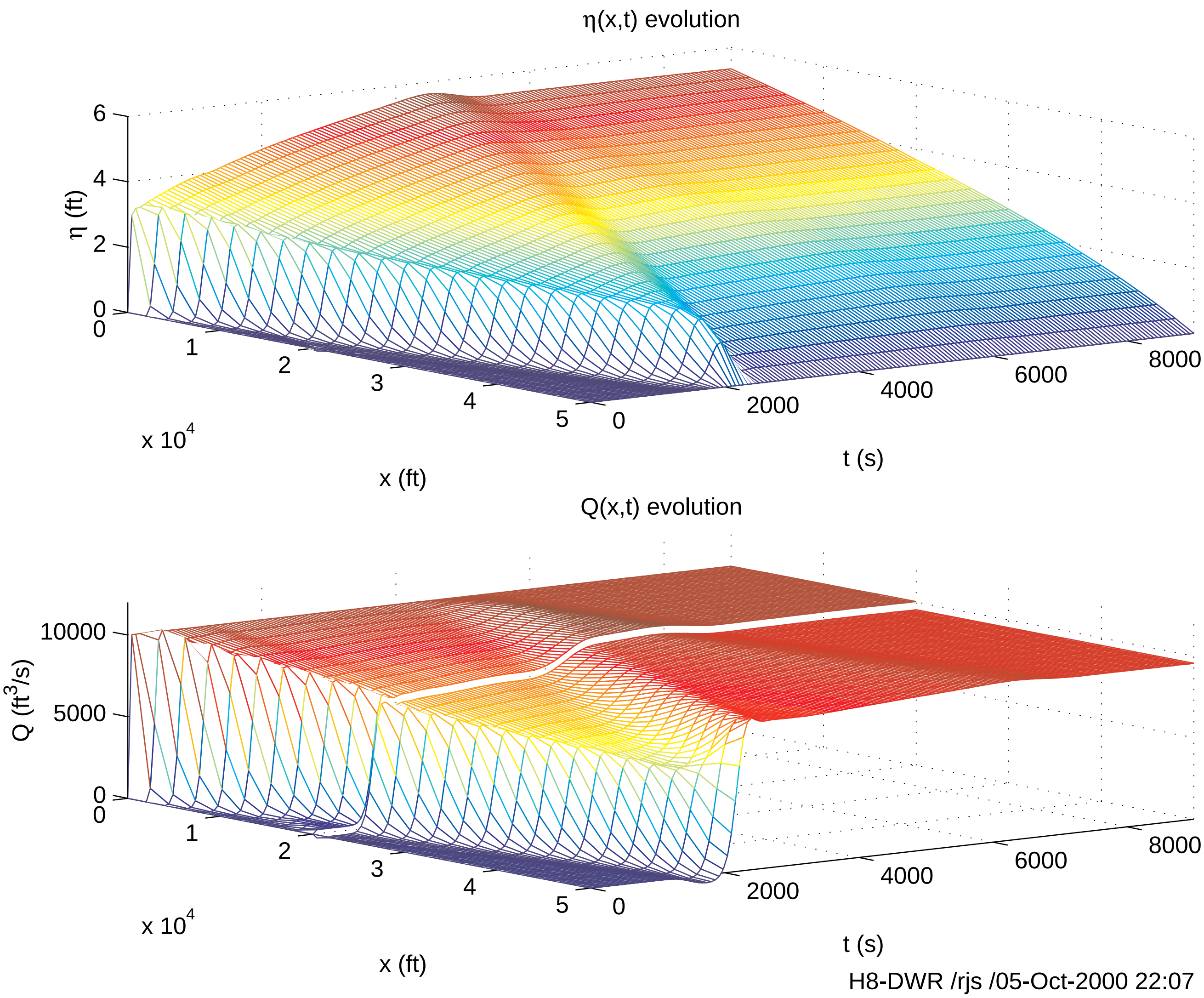

Figure 11.4: H8 DWR-predicted η and Q solution field evolution.

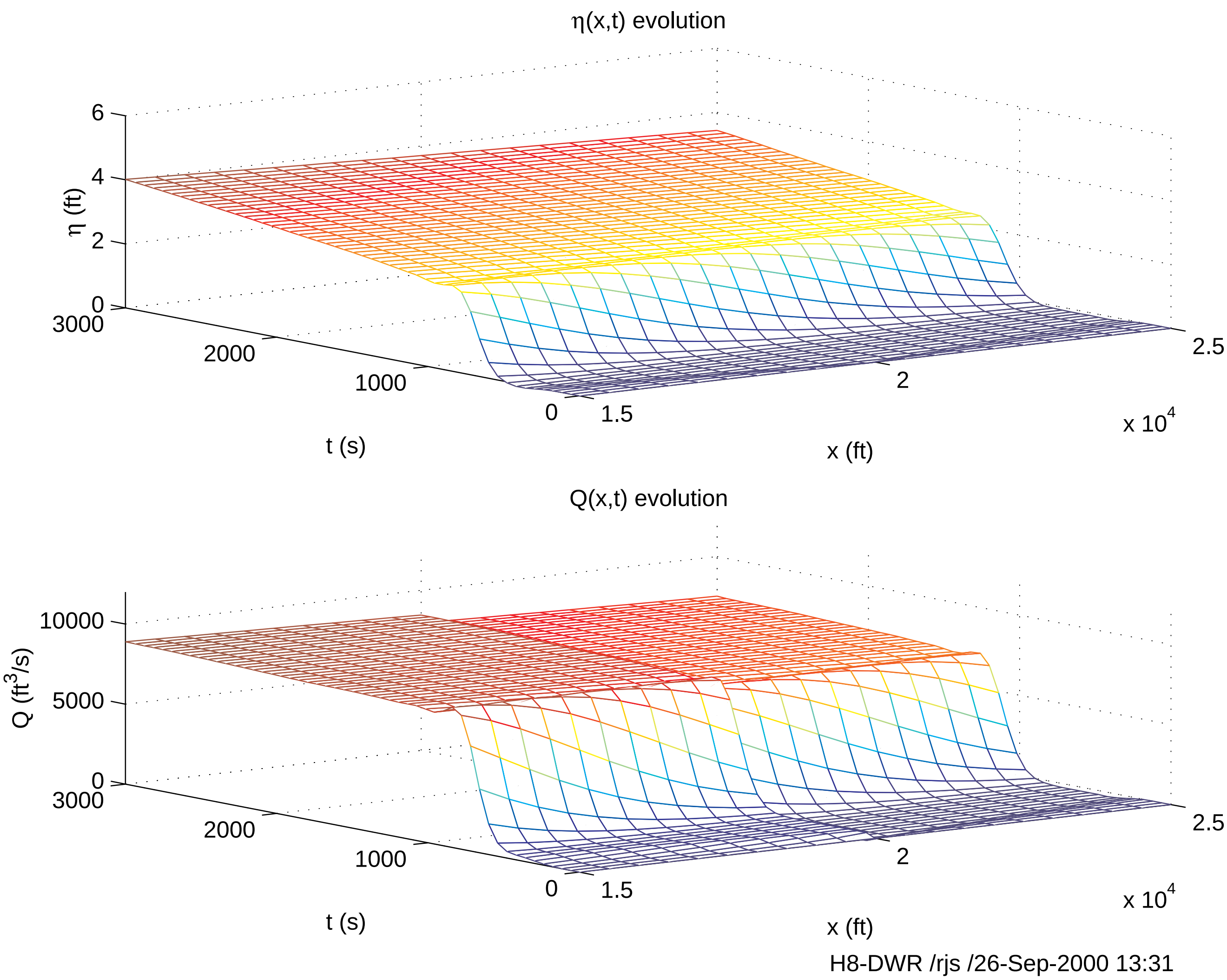

Figure 11.5: H8 DWR-predicted η and Q solution field evolution in neighborhood of diversion.

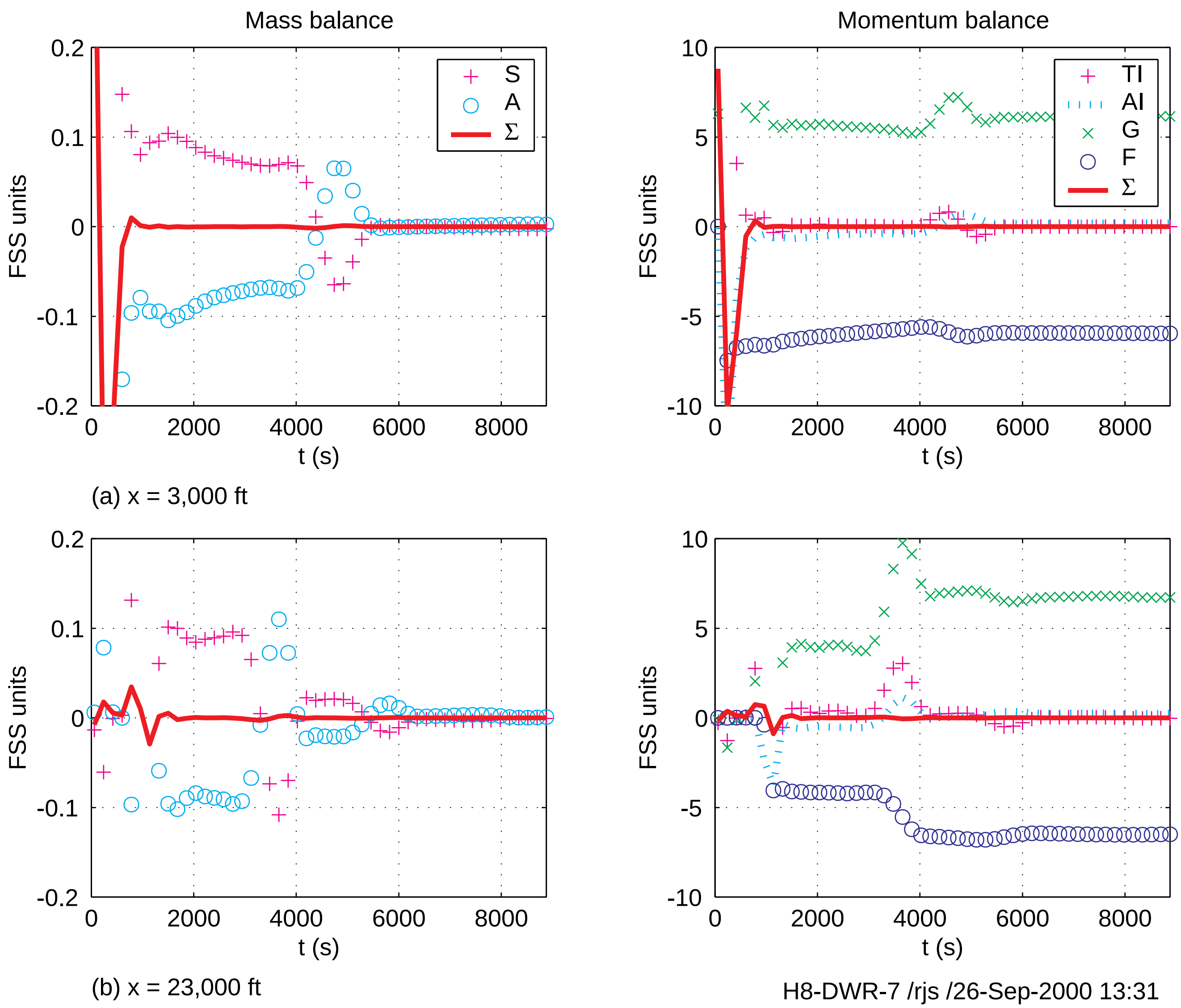

Figure 11.6: H8 DWR-predicted conservation balances at x = 3,000 ft and 23,000 ft.

11.5 Resource Management Associates

From perusing the RMA data file, it appears that diversions are accommodated in the RMA model not as point sinks, but as sinks distributed over a finite length of reach in the neighborhood of the diversion; 10 ft in this case.

Figure 11.7 shows the RMA-predicted[4] η and Q evolution toward the steady state. The characteristic paths (especially A123 in Figure 9.3) are shown very clearly, in particular the initial disturbance propagating from the upstream boundary, and the reflection of this disturbance from the downstream boundary (in the Q plot). The expected initial transients are evident along the A12 path. The water surface approaches a classical H2 gradually-varied flow profile, with presumably a minor slope discontinuity at the diversion. This is a very credible result. Figure 11.8 shows a detail in the neighborhood of the diversion. The η trace seems continuous across the step change in Q at the diversion. Surprisingly perhaps, the diversion seems neither to reflect nor initiate any disturbances. In principle, there must be an influence, but it seems that the diversion is not sufficiently strong.

Figure 11.9 shows the time history of the mass and momentum balances at locations $x = 3{,}000$ ft and 23,000 ft. Excluding the rapidly-varied segments associated with passage of the disturbance along the A123 path (Figure 9.3), both mass and momentum are conserved. There is no suggestion that this is other than a good prediction.

[4]The RMA predictions have used a space step Δx of 250 ft, not the required 500 ft.

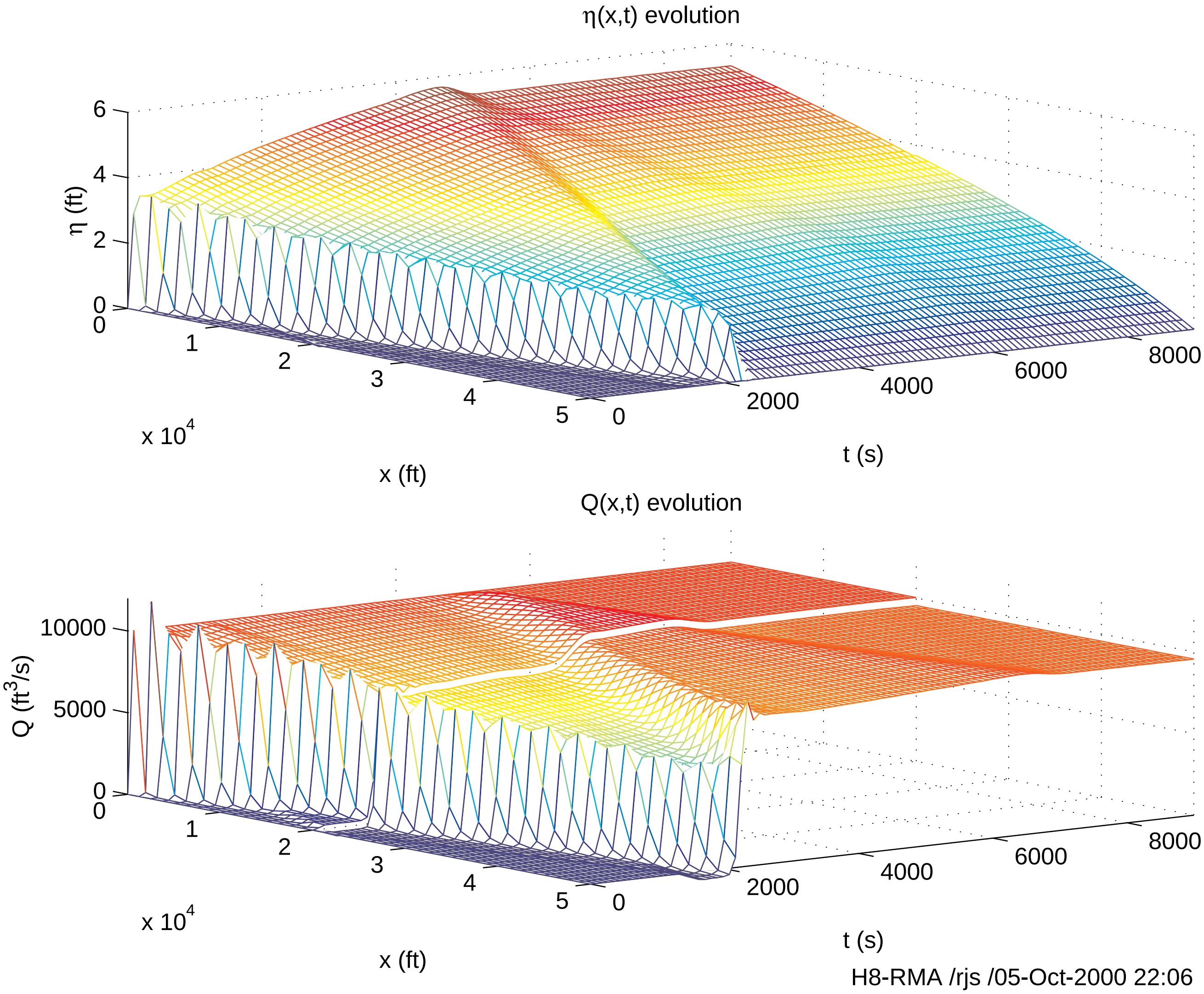

Figure 11.7: H8 RMA-predicted η and Q solution field evolution.

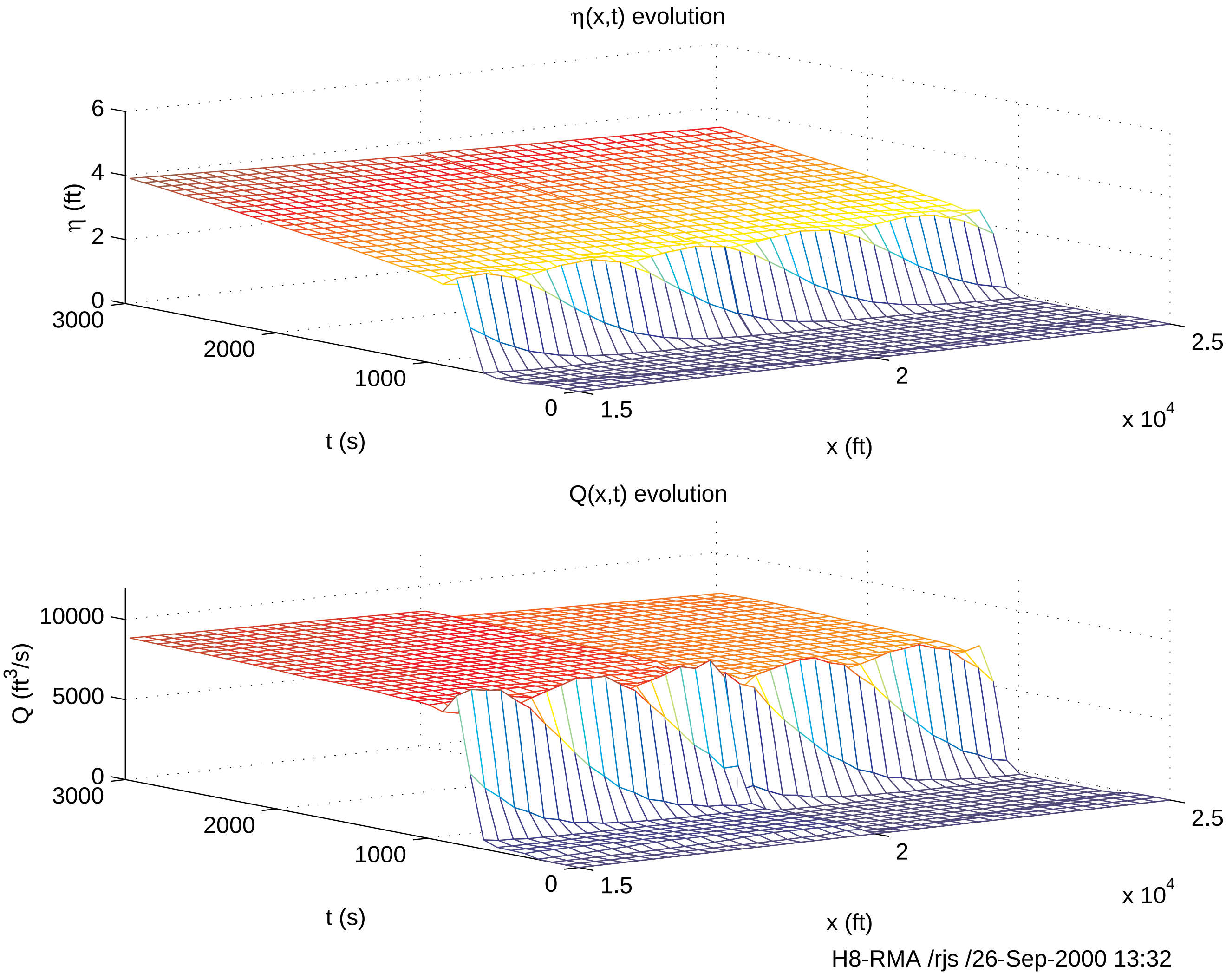

Figure 11.8: H8 RMA-predicted η and Q solution field evolution in neighborhood of diversion.

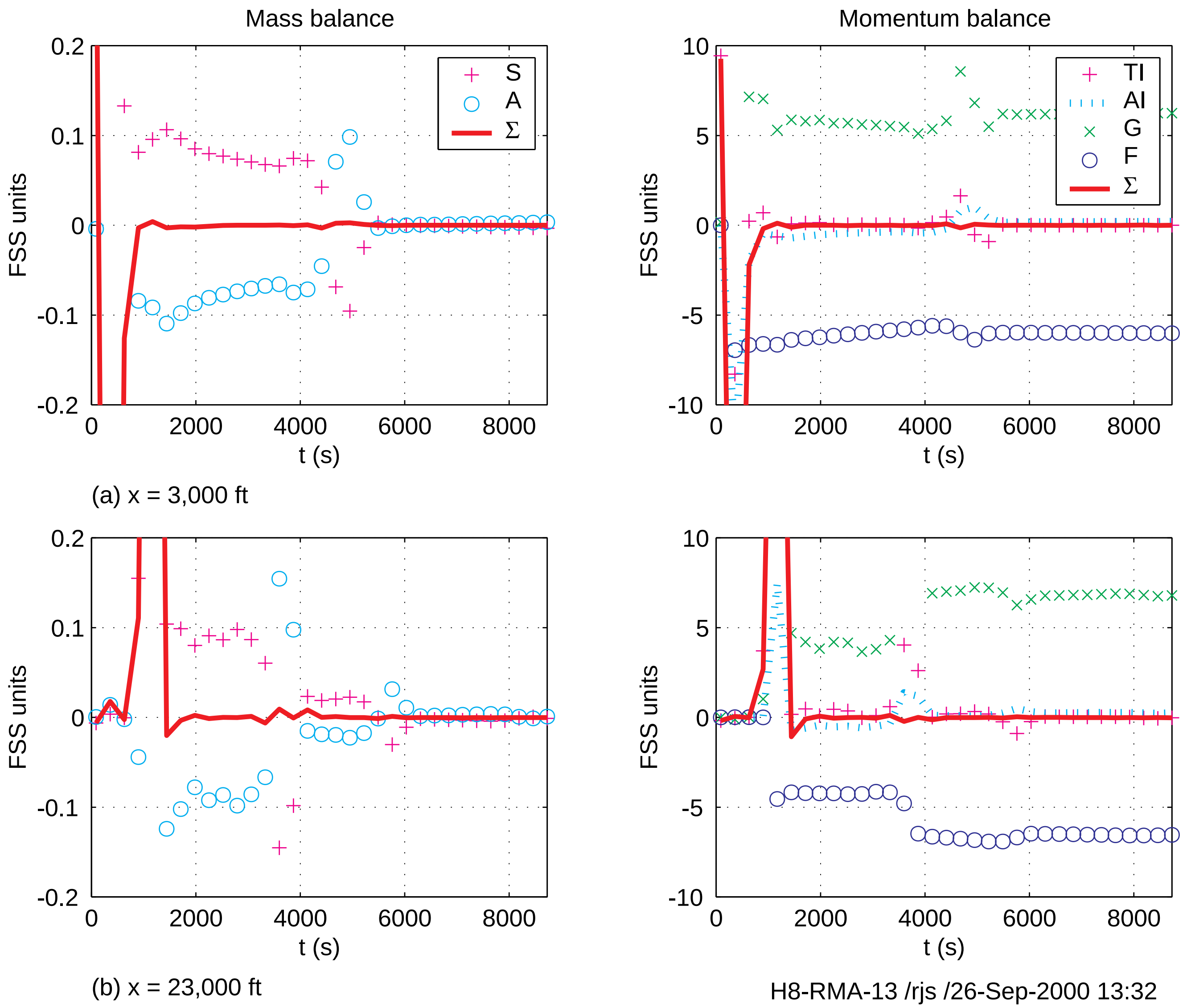

Figure 11.9: H8 RMA-predicted conservation balances at x = 3,000 ft and 23,000 ft.