1. Downstream of Kinston

On 28 May 2004, discharge measurements were made at sites 2, 1, and 0 to evaluate how discharge varied from Kinston (site 2) to the confluence of Little Contentnea and the Neuse River (site 0). The difference in discharge between sites 0 and 2 was 1.13 ± 3.05 m^3/s (Fig. 1). Also, there are three NPDES permitted discharges between sites 2 and 0. Discharge (and thus stage) was decreasing at the USGS gauging sites at Kinston and near Goldsboro during measurements (Fig. 1); thus water was coming out of storage to supply "Q_2" (downstream measurement), which in turn would lower the calculated inflow (i.e., after accounting for change in storage the difference in discharge between sites 2 and 0 is probably less than 1.13).

Conclusion: This seemed to rule out work downstream of Kinston (though it was only 1 measurement at low flow, see Figs. 2 and 3)

2. Goldsboro to Kinston

On 28 May 2004, discharge measurements were made at sites 40, 15, and 2 to evaluate how discharge varied from Goldsboro (site 40) to Kinston (2). The difference in discharge was 6.19 ± 1.18 m^3/s between sites 40 and 15, 10.86 ± 2.27 m^3/s between sites 40 and 2, and 4.67 ± 2.39 m^3/s between sites 15 and 2.

Conclusions: Significant increase in discharge between sites 40 and 2. Results merit further study.

Open questions: Could not determine the groundwater component because tributaries were not measured.

On 18 June 2004, a discharge of 0.56 ± 0.11 was measured at Falling Creek (site 5), the largest tributary between sites 15 and 2. Using discharge values from the USGS gauging station at Kinston as an index of flow conditions, we calculated that discharge at site 5 on 28 May 2004 would have been about 65% greater than that on 18 June 2004, or about 1.0 m^3/s. Since there are only four small tributaries between sites 15 and 2 (whose combined discharge is likely less than 1 m^3/s), and the difference in discharge between sites 2 and 15 on 28 May 2004 was 4.67 ± 2.39 m^3/s, it seems possible that a quantifiable amount of groundwater in-seepage occurred between sites 15 and 2 on May 28 2004.

Conclusions: Flow conditions on 18 June were close to normal (historical mean = 47 m^3/s; Kinston gauging station = 49 m^3/s), which suggests that at normal conditions Falling Creek is not a large point source.

Open questions: Reach 15-2 may have potential, but results were not conclusive.

To the extent practical, we want to choose a study reach with very few significant point sources. Between sites 40 and 2, there are several small streams, two medium stream (Walnut Creek, Hardy Mill Run), and two large streams (Falling Creek, Bear Creek). On 25 June 2004, we studied two reaches that did not include either of the large streams: reach 30-20 (extending from sites 30 to 20) was west of Bear Creek and reach 15-10 (extending from sites 15 to 10) was west of Falling Creek and east of Bear Creek. We calculated an apparent inflow of 12.25 ± 1.20 m^3/s to reach 30-20, and 3.34 ± 2.94 m^3/s to reach 15-10 (Fig. 4). Reach 30-20 includes Walnut Creek, which was not measured on this day and could have contributed significantly to the inflow of 12.25 m^3/s. Accounting

for Bear Creek (discharge = 4.1 m^3/s), there was an inflow of 5.61 ± 2.35 m^3/s to reach 20-15, though this reach also includes Hardy Mill Run. There was also an inflow of about 13.45 m^3/s between sites 15 and the Kinston USGS gauging station (essentially site 2); however, discharge was far from steady at the Kinston station (Fig. 4) and it is possible that the inflow of 13.45 m^3/s was due, at least in part, to a hydrograph moving through the reach.
Conclusions: Data suggest that at high flow there is greater inflow than at low flow (inflow between site 15 and 2 on 28 May and 25 June).
Open questions: Movement of hydrograph through reach probably affected calculation of inflow. Need an analytical framework for calculation of hydrograph movement and changes in channel storage. Investigate this possibility and re-do measurement

On 7 July 2004, we decided to study reaches similar to those studied on 25 June 2004 and to also account for all point sources within those reaches (in this case, small tributaries). We chose reach 15-10a (10a being just upriver of site 10) and reach 20-17. There was an inflow of 1.17 ± 1.57 m^3/s to reach 15-10a, and 1.65 ± 2.40 m^3/s to reach 20-17 (Fig. 5). Accounting for Bear Creek (1.3 m^3/s, USGS gauging station) and Hardy Mill Run (0.49 ± 019 m^3/s), there was an inflow of 3.84 ± 1.60 m^3/s to reach 20-15. Changes in storage would lead to a lower inflow (Fig. 5).
Conclusions: At low flow (Figs. 2 and 3), there is little inflow to reaches 15-10a and 20-17. However, there appears to be significant inflow to reach 20-15.
Open questions: Measure discharge at Bear Creek, instead of using USGS estimate. Changes in channel storage need to be accounted for in analysis of reach 20-15.

The reaches studied on 7 July 2004 were relatively small, 15-10a being about 6 km long and 20-17 being about 4 km. As such, on 13 July 2004 we decided to select reaches that were as long as possible without including any large or medium streams. We chose reach 26-19, which is about 12 km long, and reach 15-4, which is about 11 km long. Unfortunately, our measurements were made right as a hydrograph was moving through this section of the Neuse River, so it is difficult to conclude anything from these data (Fig. 6).
Open questions: Movement of hydrograph through reach probably affected calculation of inflow. Need an analytical framework for calculation of hydrograph movement and changes in channel storage. Investigate this possibility and re-do measurement.

On 17 August 2004, we went near Goldsboro to evaluate reach 28-17 at high flow conditions (Figs. 2 and 4). The conditions were not ideal, but we found no measurable inflow to this reach (Fig. 7).
Open questions: Measurements may have been affected by unsteadiness (Fig. 7)

On 29 October 2004, we decided to evaluate reach 4-2. We found that inflow to reach 4-2 was 1.08 ± 0.93 m^3/s (Fig. 8)
Conclusions: At very low flow, there is little inflow to reach 4-2.

3. Clayton to Goldsboro

On 14 July 2004, we decided to study two reaches west of Goldsboro, one in Clayton (70-60) and another in between Clayton and Goldsboro (55-51). At reach 70-60, we found an inflow of 2.34 ± 1.25 m^3/s, which was promising since there are no significant point sources to this reach. Discharge decreased from sites 55 to 51, although there are no surface water supplies in this area (http://www.ncwater.org/). The decrease in discharge from sites 55 to 51 could be due to a slight unsteadiness in flow (Fig. 9).
Open questions: Movement of hydrograph through reach probably affected calculation of inflow. Need an analytical framework for calculation of hydrograph movement and changes in channel storage. Investigate this possibility and re-do measurement.

On 16 August 2004, a day after hurricane Charley had passed trough N.C., we went to Clayton to evaluate inflow at high flow conditions (Figs. 2 and 3). Unfortunately, we were only able to make one discharge measurement on the Neuse River under these extremely high flow conditions. Using this measurement (site 80), the discharge value at the USGS gauging station near Clayton, and accounting for surface water inputs, we calculated an inflow of 34.33 ± 10.79 m^3/s to reach 80-75 (Fig. 10), though this apparent inflow is likely affected by a hydrograph moving through the reach.
Open questions: Movement of hydrograph through reach probably affected calculation of inflow. Need an analytical framework for calculation of hydrograph movement and changes in channel storage. Investigate this possibility and re-do measurement.

On 12 September 2004, we chose to conduct a thorough analysis of the section of the Neuse River near Clayton. We evaluated reaches 80-75 and 70-60, both of which are separated by a large tributary (site 72). Inflows were –0.12 ± 2.66 m^3/s and 0.50 ± 2.12 m^3/s to reaches 80-65 and 70-60, respectively (Fig. 11).
Conclusions: At very high flow (Fig. 2 and 3) there is little inflow to reaches 80-75 and 70-60.

We were discouraged by the results on 12 September, but we thought we might be able to reduce the measurement uncertainty by employing a new measurement technique in which a tag-line is used to tow the RiverCat across the river. As such, on 24 September 2004 we went back to Clayton to evaluate reach 76-60. The results showed a low inflow of 0.52 ± 2.12 m^3/s (Fig. 8).
Conclusions: At low flow (Fig. 2 and 3), there is little inflow to reach 76-06.

By 29 October 2004, we thought we had a good understanding of inflow near Clayton, and a fair understanding of inflow between Kinston and Goldsboro. Only once had we evaluated the section of the Neuse River in between Clayton and Goldsboro. Thus, we decided to study reach 46-55. We found that inflow to reach 46-55 was 1.2 ± 0.66 m^3/s (Fig. 8).
Conclusions: At very low flow, there is little inflow to reaches 4-2 and 46-51.

4. Recommendations

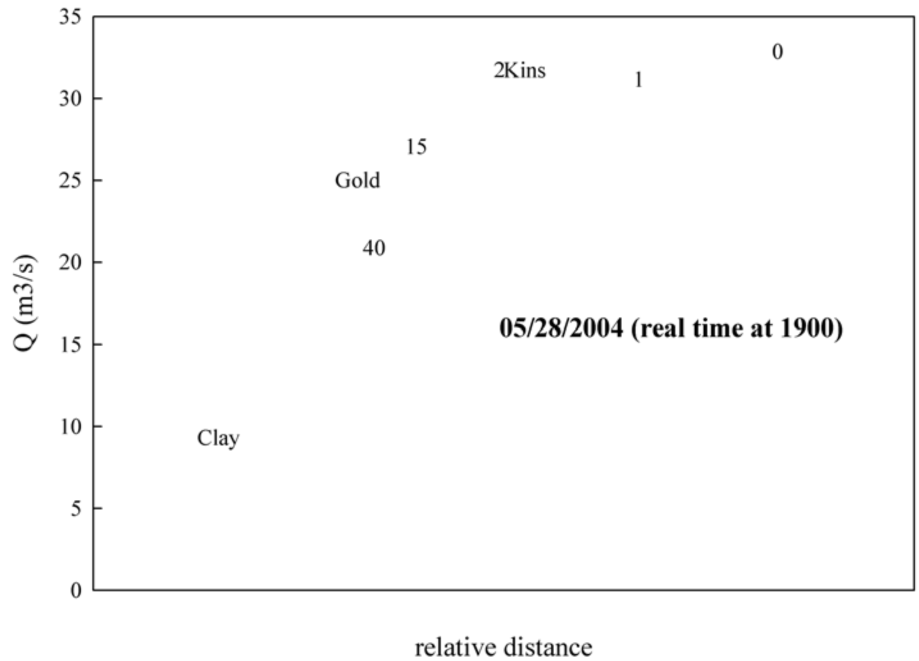
Downstream of Kinston
We only have one measurement downstream of Kinston, and that measurement was at low flow. It may be a good idea to make a few more measurements at higher flow. Access to site 0 is not good, but there appears to be a road located at "Bectons Oil Field Landing" that leads to the Neuse (north side) just upstream of site 0. Making measurements at this site, site 1, and Stonyton Creek (tributary between site 0 and Bectons Oil Field Landing) at higher flow would be useful in evaluating inflow downstream of Kinston.

Goldsboro to Kinston
In summary,

- 4-2 no good at low flow (10/29/2004)
- 15-10 and 20-17 ruled out (7/7/2004)

At higher flow, one day should consist of measuring sites 15, 4, 2, and Falling Creek, and another measuring sites 26, 20, 18 (Hardy Mill Run), 15, and Bear Creek. Together, the results from these two days would give us a better understanding of inflow between Goldsboro and Kinston and higher flow. Also, it appears reach 30-20 may have potential as well.

Clayton to Goldsboro
At high and low flow there was little inflow to the reaches in Clayton. Thus, we should probably not use any section of the Neuse in Clayton as the study reach.



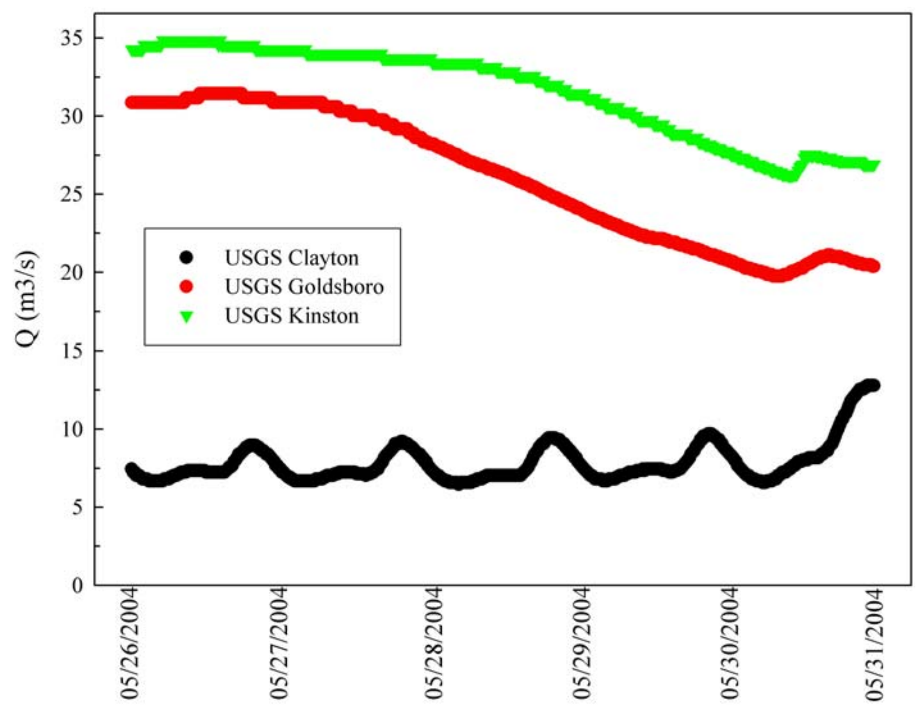


Fig. 1. Discharge versus relative distance for USGS gauging stations (Clay = Clayton; Gold = Goldsboro; Kins = Kinston) and sites measured on 28 May 2004 (top). "Real time" corresponds to the time the estimate of discharge at the USGS gauging station was recorded and to the time the field measurement was made. Discharge versus time for USGS gauging stations (bottom).

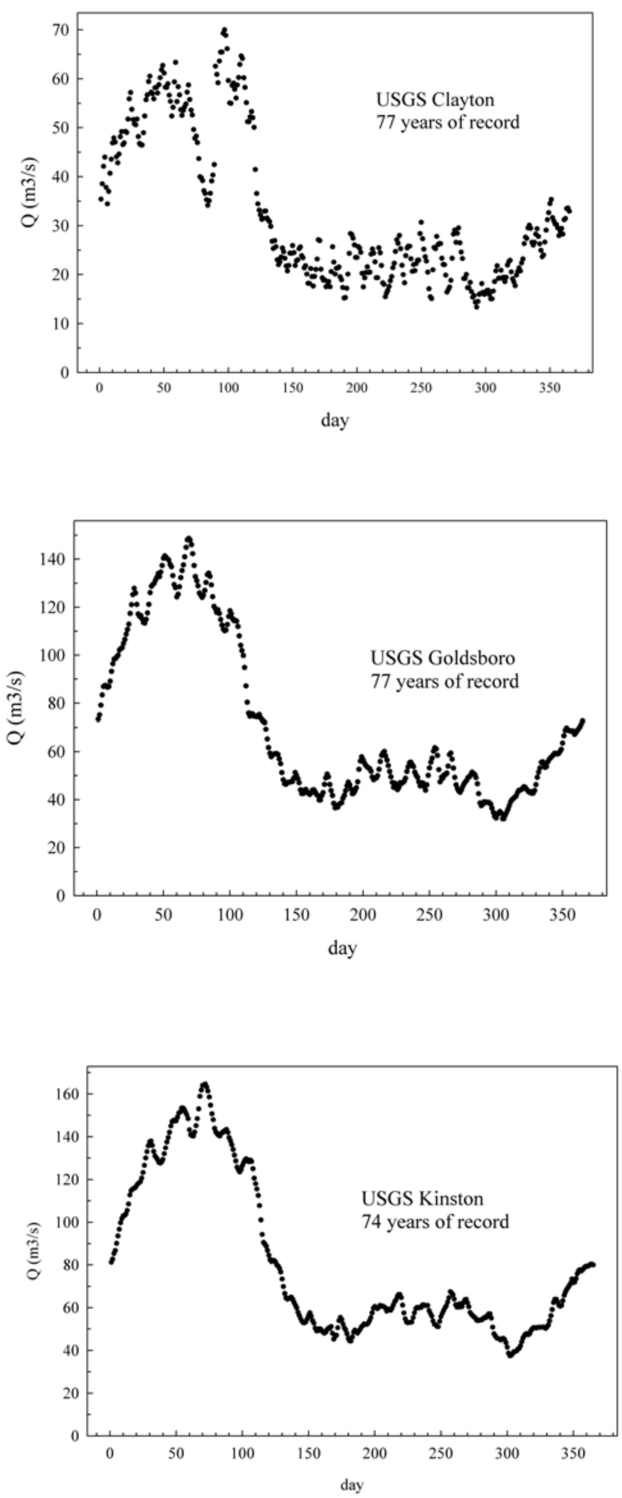


Fig. 2. Historical mean daily discharge for the USGS gauging stations.

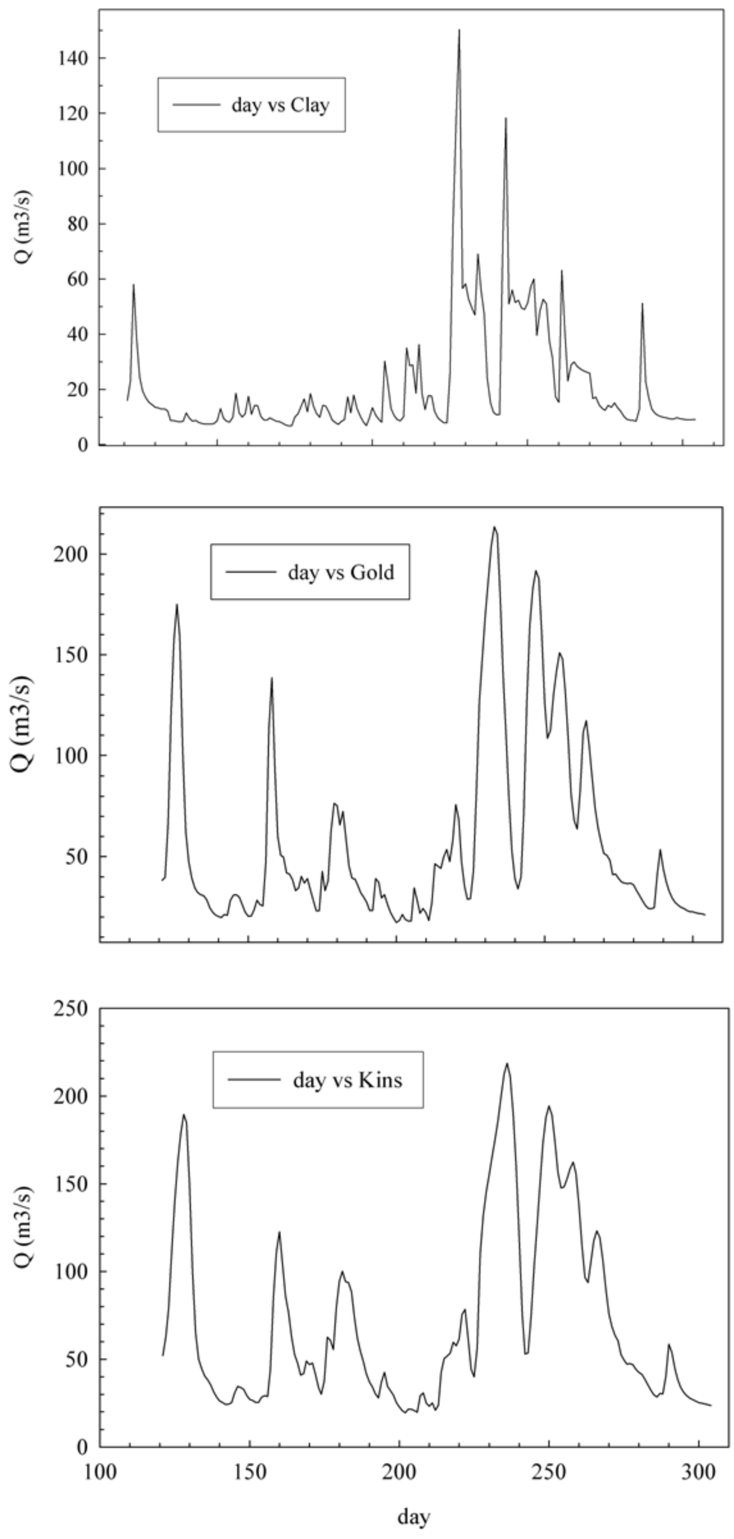
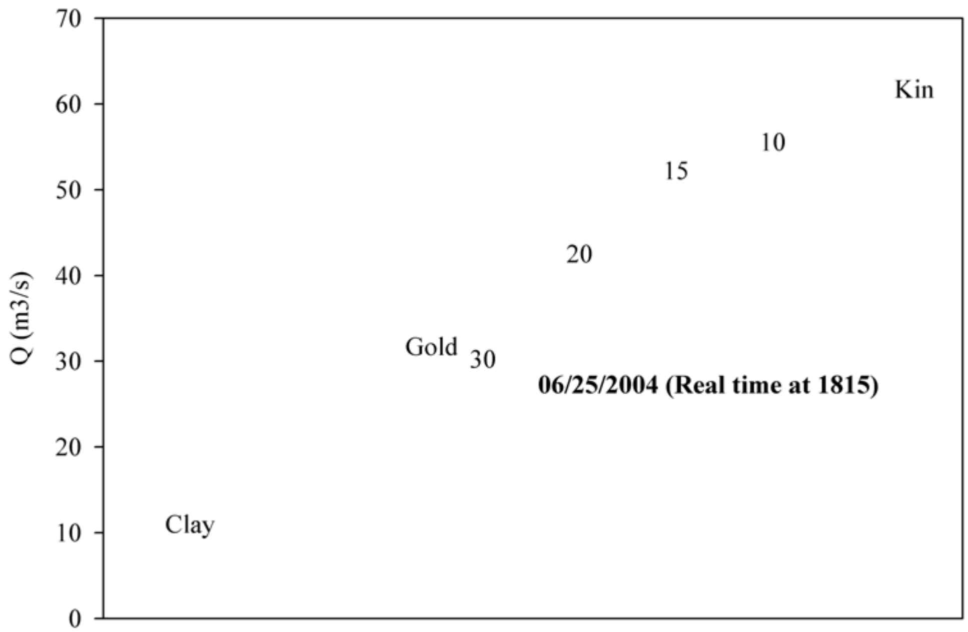


Fig. 3. Mean daily discharge for the USGS gauging stations from 01 May 2004 (day 112) to 31 October 2004.



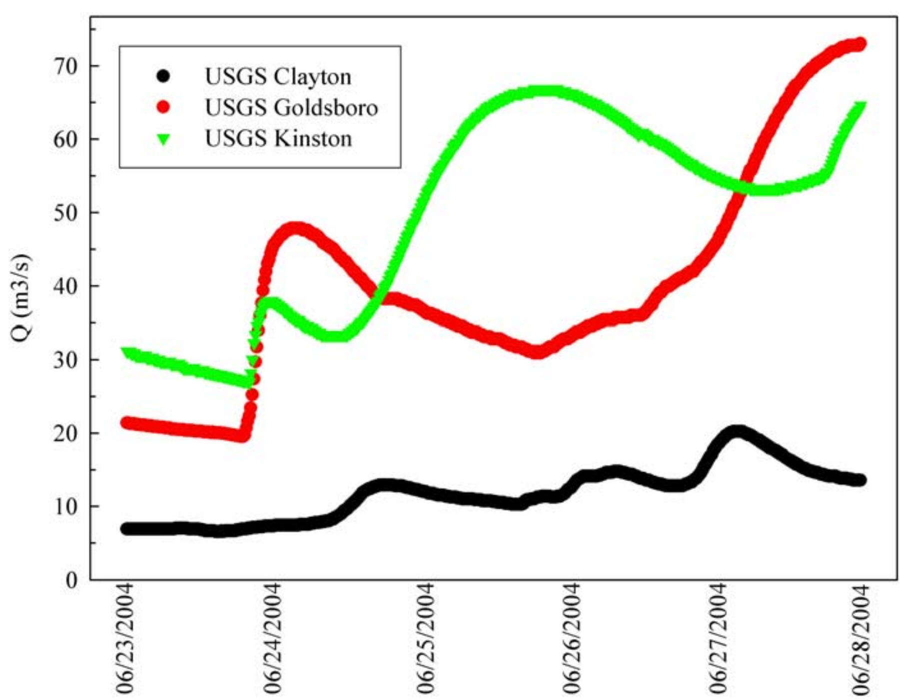
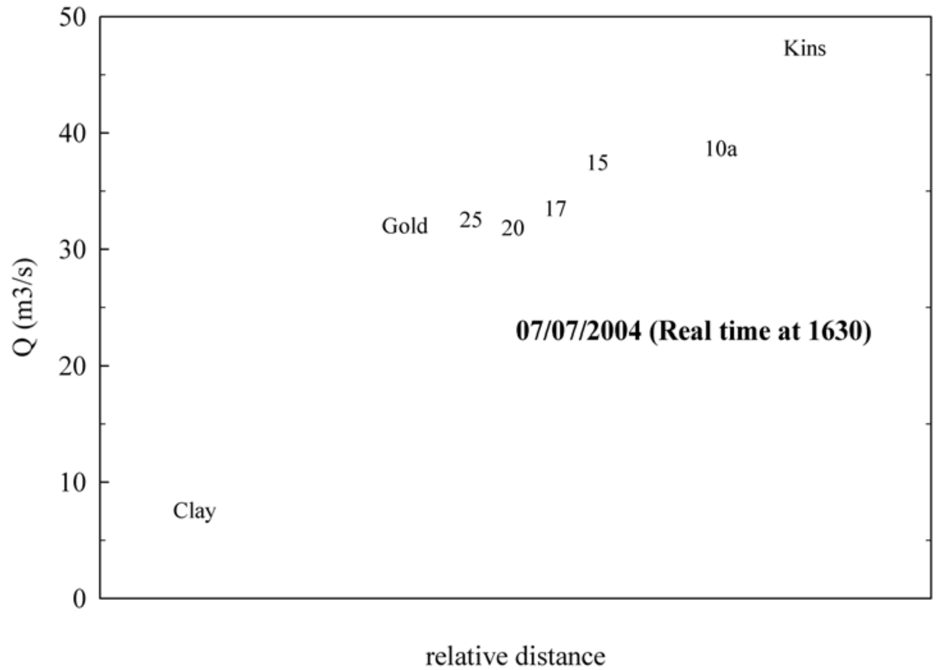


Fig. 4. Discharge versus relative distance for USGS gauging stations and sites measured on 25 June 2004 (top). "Real time" corresponds to the time at which the estimate of discharge at the USGS gauging station was recorded and to the time at which the field measurement of discharge was made. Discharge versus time for USGS gauging stations (bottom).



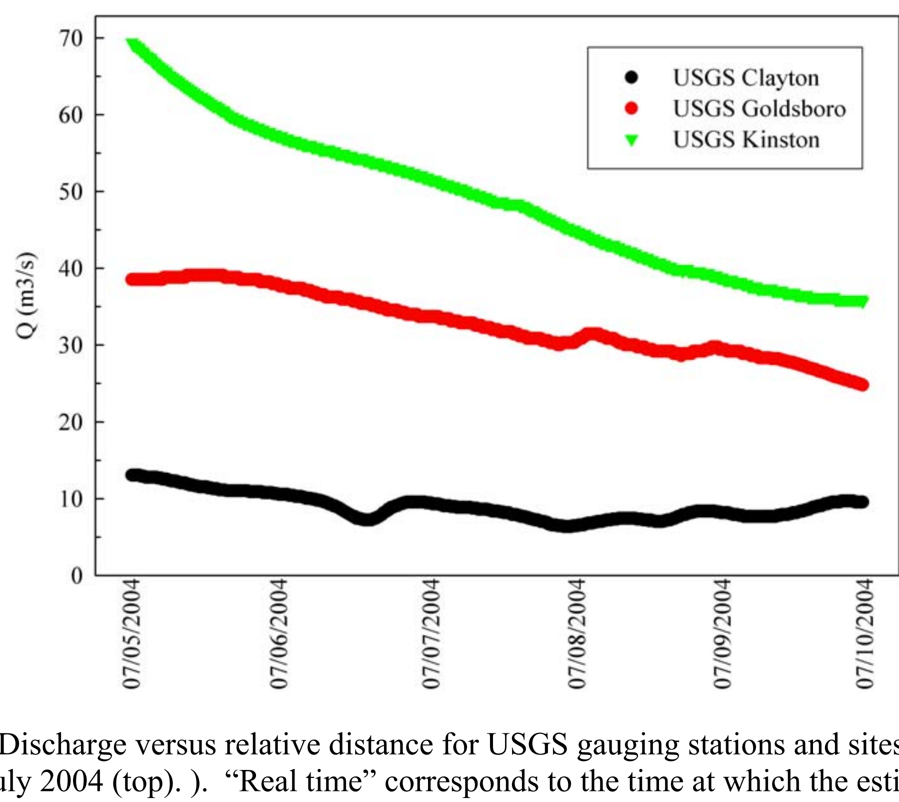
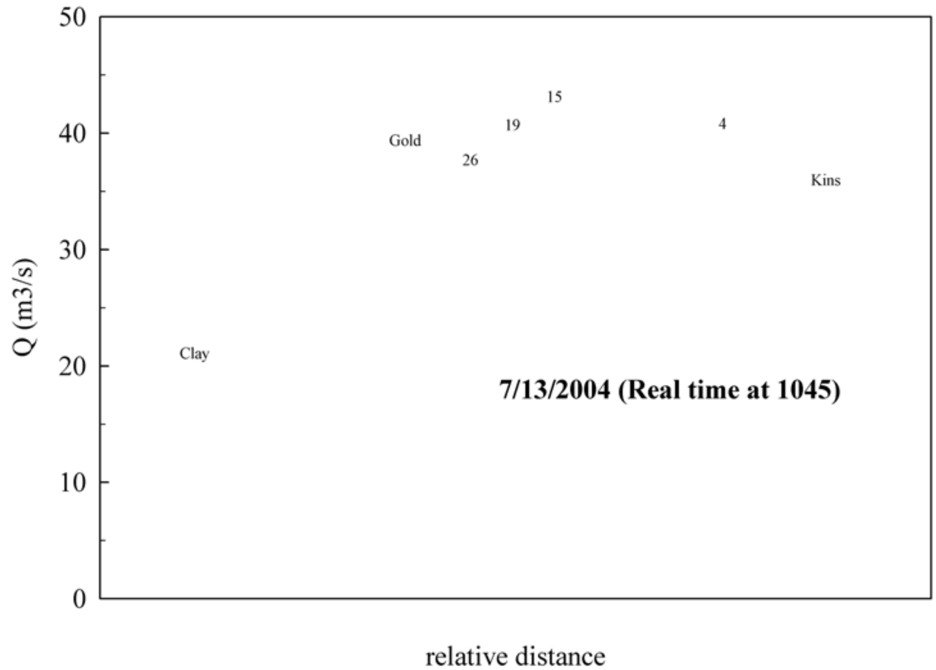


Fig. 5. Discharge versus relative distance for USGS gauging stations and sites measured on 07 July 2004 (top).). “Real time” corresponds to the time at which the estimate of discharge at the USGS gauging station was recorded and to the time at which the field measurement of discharge was made. Discharge versus time for USGS gauging stations (bottom).



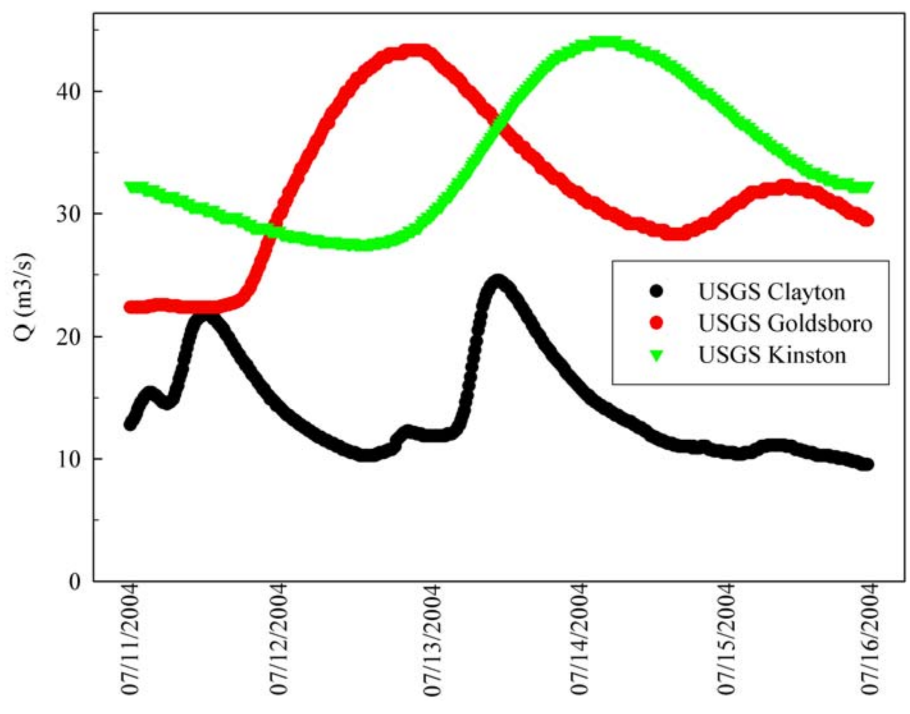
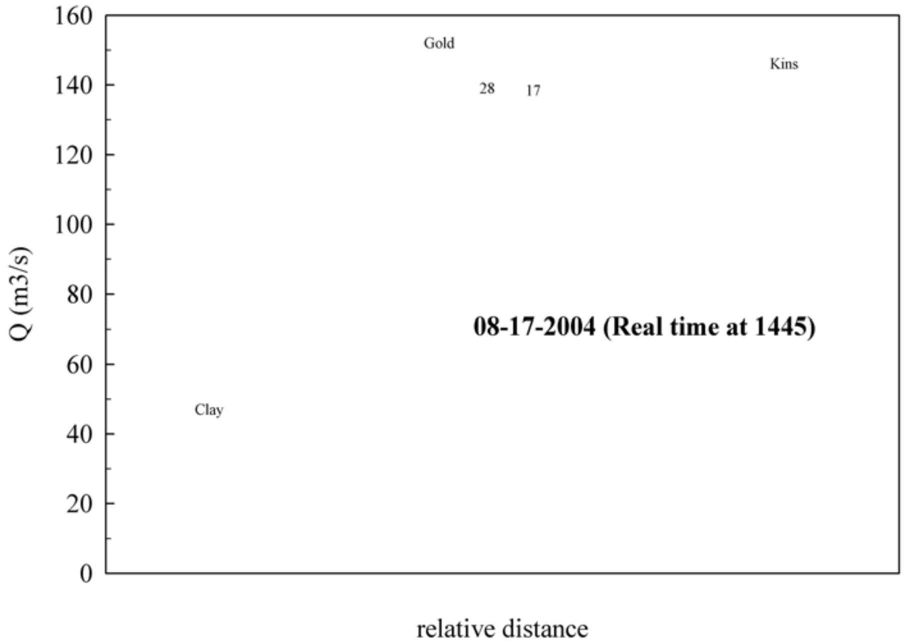


Fig. 6. Discharge versus relative distance for USGS gauging stations and sites measured on 13 July 2004 (top).). "Real time" corresponds to the time at which the estimate of discharge at the USGS gauging station was recorded and to the time at which the field measurement of discharge was made. Discharge versus time for USGS gauging stations (bottom).



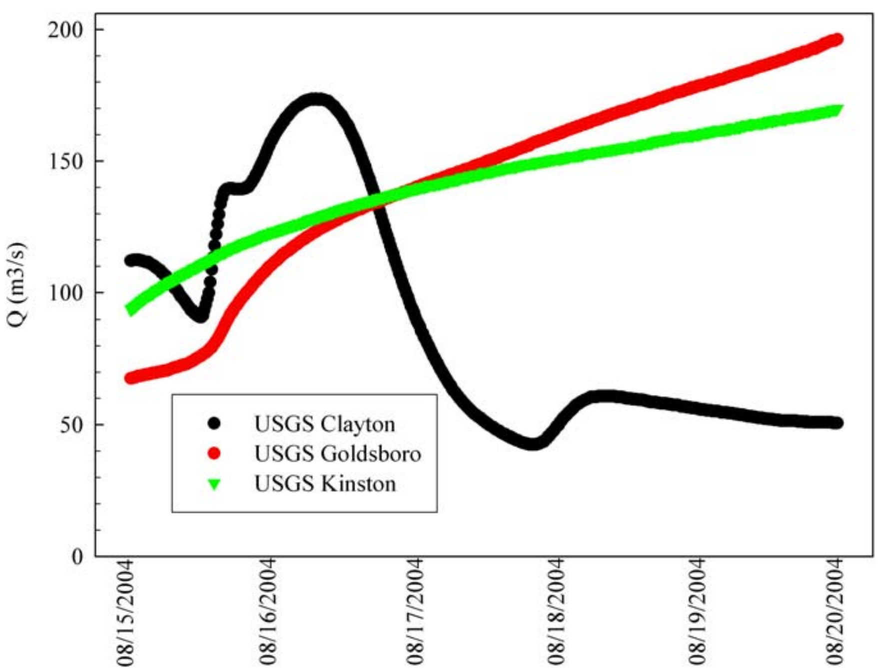
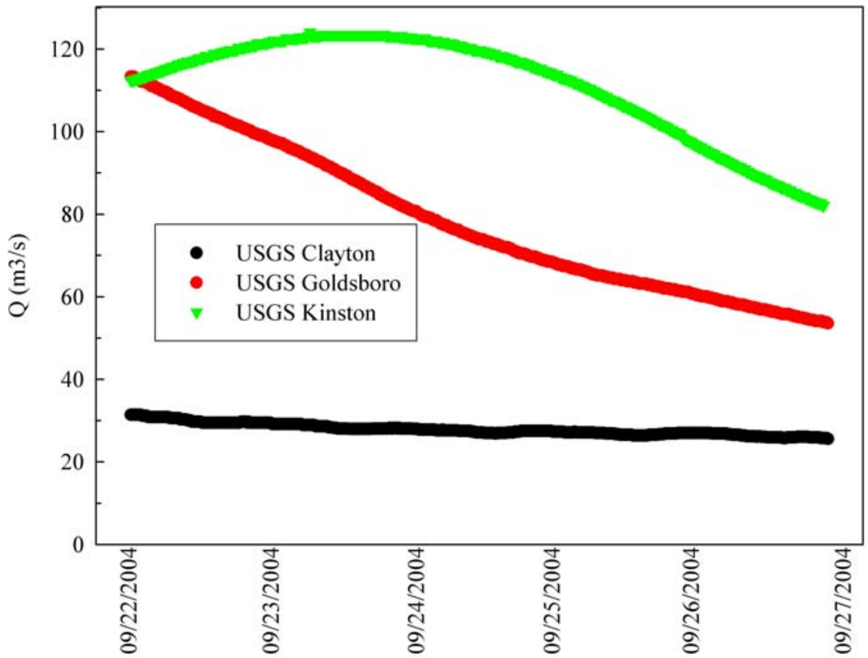


Fig. 7. Discharge versus relative distance for USGS gauging stations and sites measured on 17 August 2004 (top).). "Real time" corresponds to the time at which the estimate of discharge at the USGS gauging station was recorded and to the time at which the field measurement of discharge was made. Discharge versus time for USGS gauging stations (bottom).



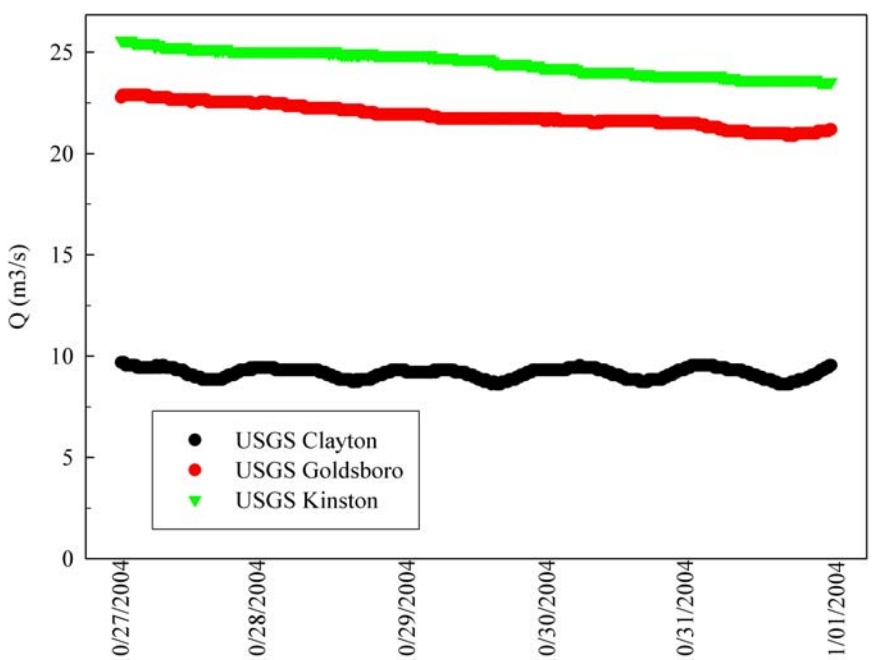
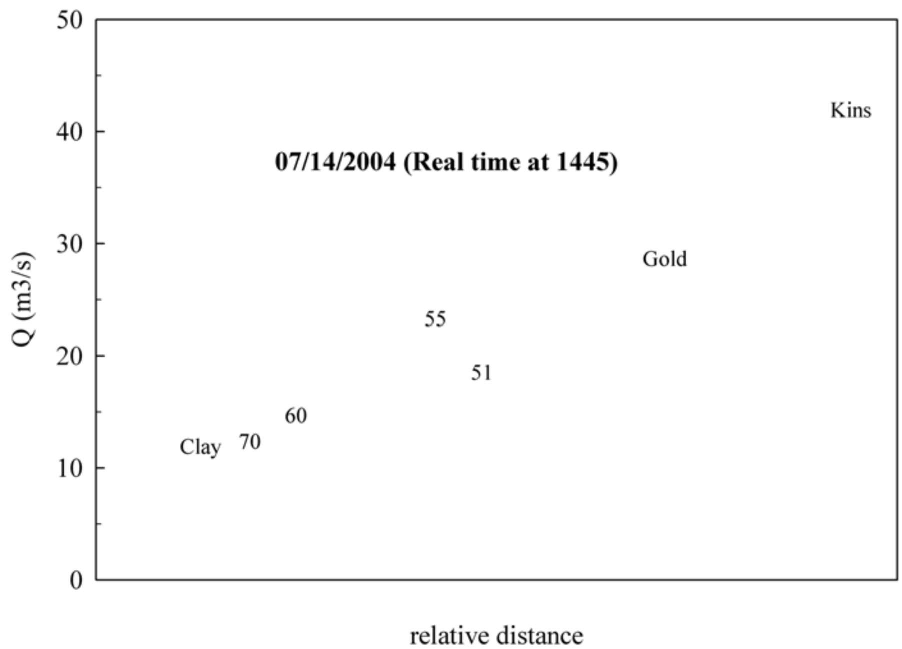


Fig. 8. Discharge versus time for USGS gauging stations (09/24/2004, top; 10/29/2004, bottom).



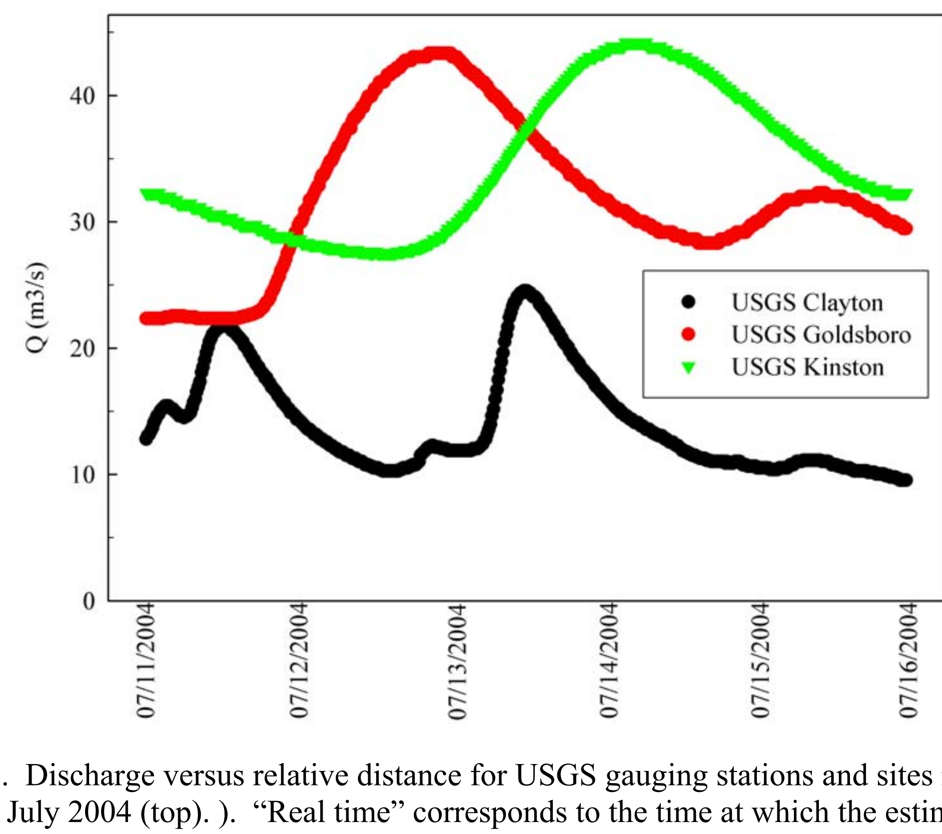
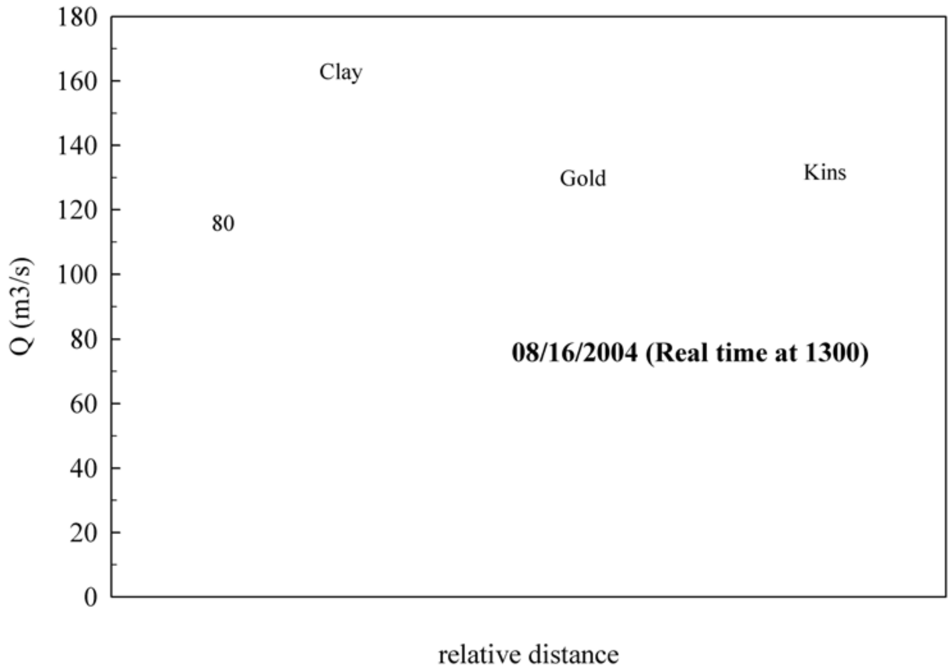


Fig. 9. Discharge versus relative distance for USGS gauging stations and sites measured on 14 July 2004 (top).). "Real time" corresponds to the time at which the estimate of discharge at the USGS gauging station was recorded and to the time at which the field measurement of discharge was made. Discharge versus time for USGS gauging stations (bottom).



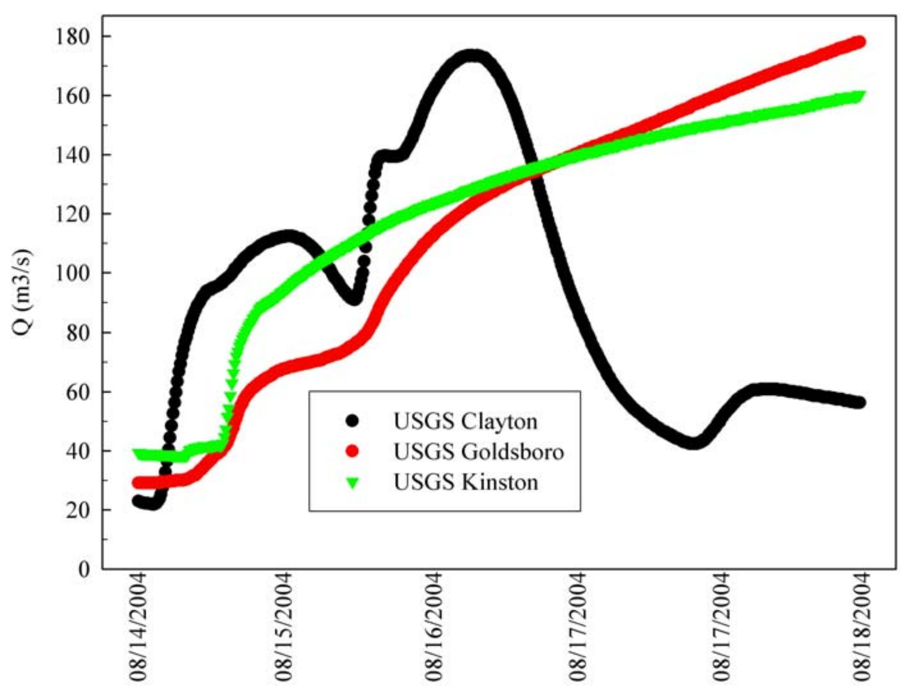
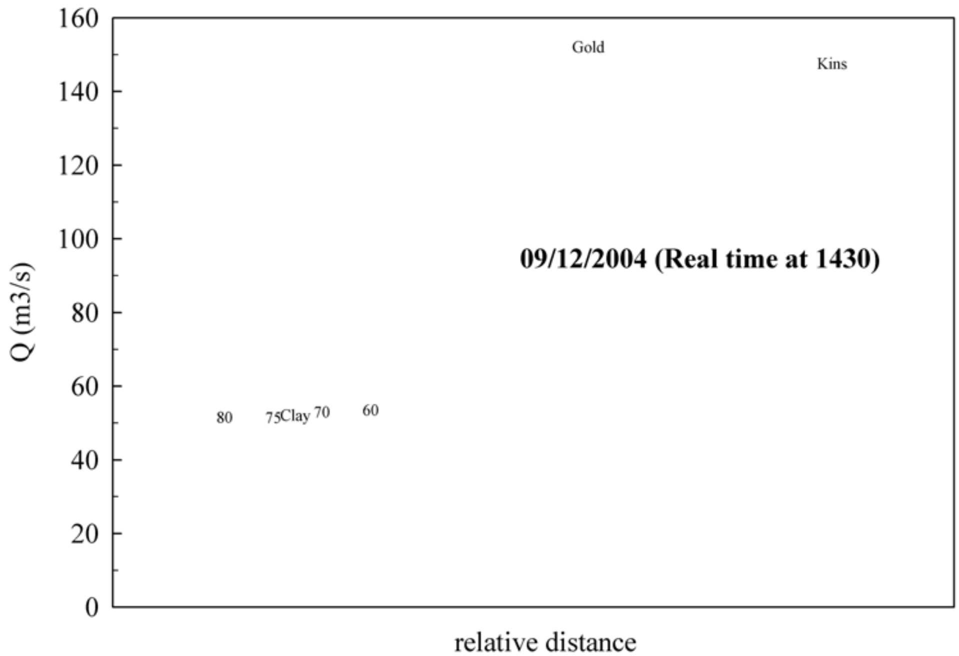


Fig. 10. Discharge versus relative distance for USGS gauging stations and sites measured on 16 August 2004 (top). "Real time" corresponds to the time at which the estimate of discharge at the USGS gauging station was recorded and to the time at which the field measurement of discharge was made. Discharge versus time for USGS gauging stations (bottom).



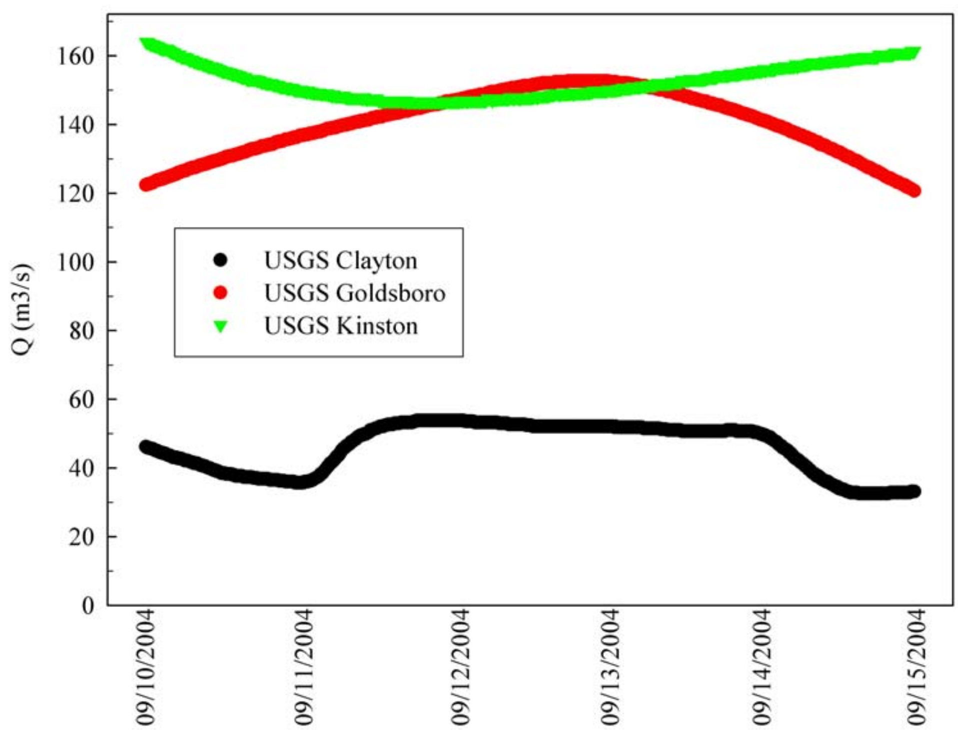


Fig. 11. Discharge versus relative distance for USGS gauging stations and sites measured on 12 September 2004 (top).). "Real time" corresponds to the time at which the estimate of discharge at the USGS gauging station was recorded and to the time at which the field measurement of discharge was made. Discharge versus time for USGS gauging stations (bottom).

Discharge Summary

	5/28/2004	6/18/2004	6/25/2004	7/7/2004	7/13/2004	7/14/2004	8/16/2004	8/17/2004	9/12/2004	9/24/2004	10/29/2004
CLAY	9.32		11.0	7.6	21.1	11.9	162.84	47.01	52.1	27.2	9.2
GOLD	25.0		34.8	31.7	39.4	28.6	129.71	152.08	152.1	78.73	21.70
KINS	31.72	49.27	66.0	47.3	36.0	41.9	131.69	146.13	147.6	118.95	24.67
0	32.86 (3.04)										
1	31.16 (0.26)										
2	31.73 (2.18)										22.72 (0.52)
4					40.80 (1.66)						21.64 (0.77)
5		0.56 (0.11)									
10			55.56 (2.13)								
10a				38.63 (0.56)							
15	27.06 (0.99)		52.22 (2.04)	37.44 (1.47)	43.11 (1.39)						
17				33.46 (2.32)				138.46 (8.55)			
19					40.70 (2.13)						
18				0.49 (0.16)				0.98 (0.29)			
20			42.51 (1.16)	31.81 (0.61)							
24				0.022 (0.001)							
25				32.52 (1.60)							
26					37.68 (1.71)						
28								139.04 (4.05)			
30			30.26 (0.30)								
40	20.87 (0..65))										
46											16.02 (0.56)
49											1.70 (0.05)
50											0.27 (0.28)
51						18.52 (1.60)					
55						23.28 (0.39)					12.85 (0.20)
60						14.68 (0.92)			53.41 (2.41)	27.34 (1.75)	
70						12.34 (0.85)			52.91 (2.60)		
72									0.056 (0.0008)		
75						11.6 (USGS)	162.84 (USGS)		51.40 (2.30)		
76										26.79 (1.20)	
77							7.01 (0.51)		0.28 (0.28)		
80							115.74 (10.78)		51.52 (1.22)		