A four component hydrograph separation technique

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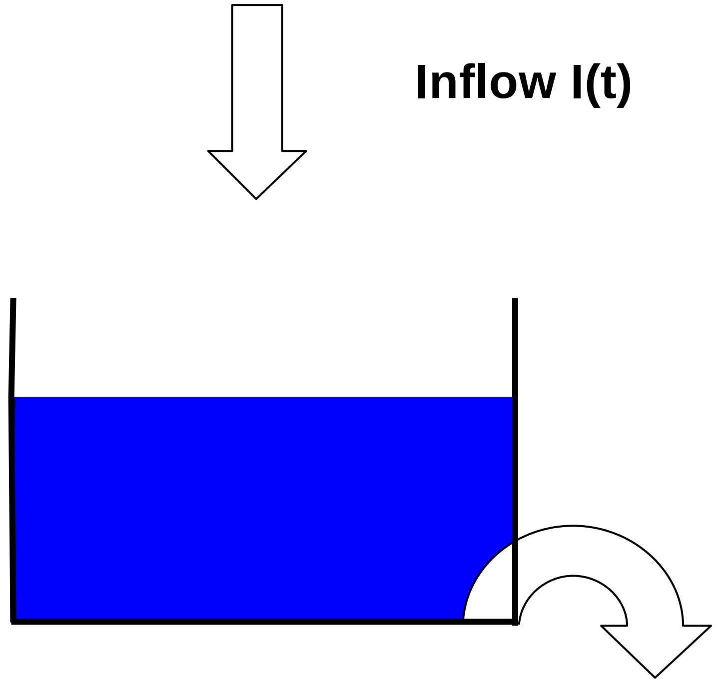
Summary

- Parallel structure of fast and slow responses is adopted to represent the routing component, in the analysis of a single observed storm hydrograph;
- Each of these responses is represented by a non-linear conceptual reservoir: this avoids the linear system constraint inherent in the alternative linear transfer function model;
- The resulting four component hydrograph separation technique is used to gain insights into four existing hydrograph separation techniques;

Non-linear conceptual reservoir

Inflow I(t)

Storage S(t)

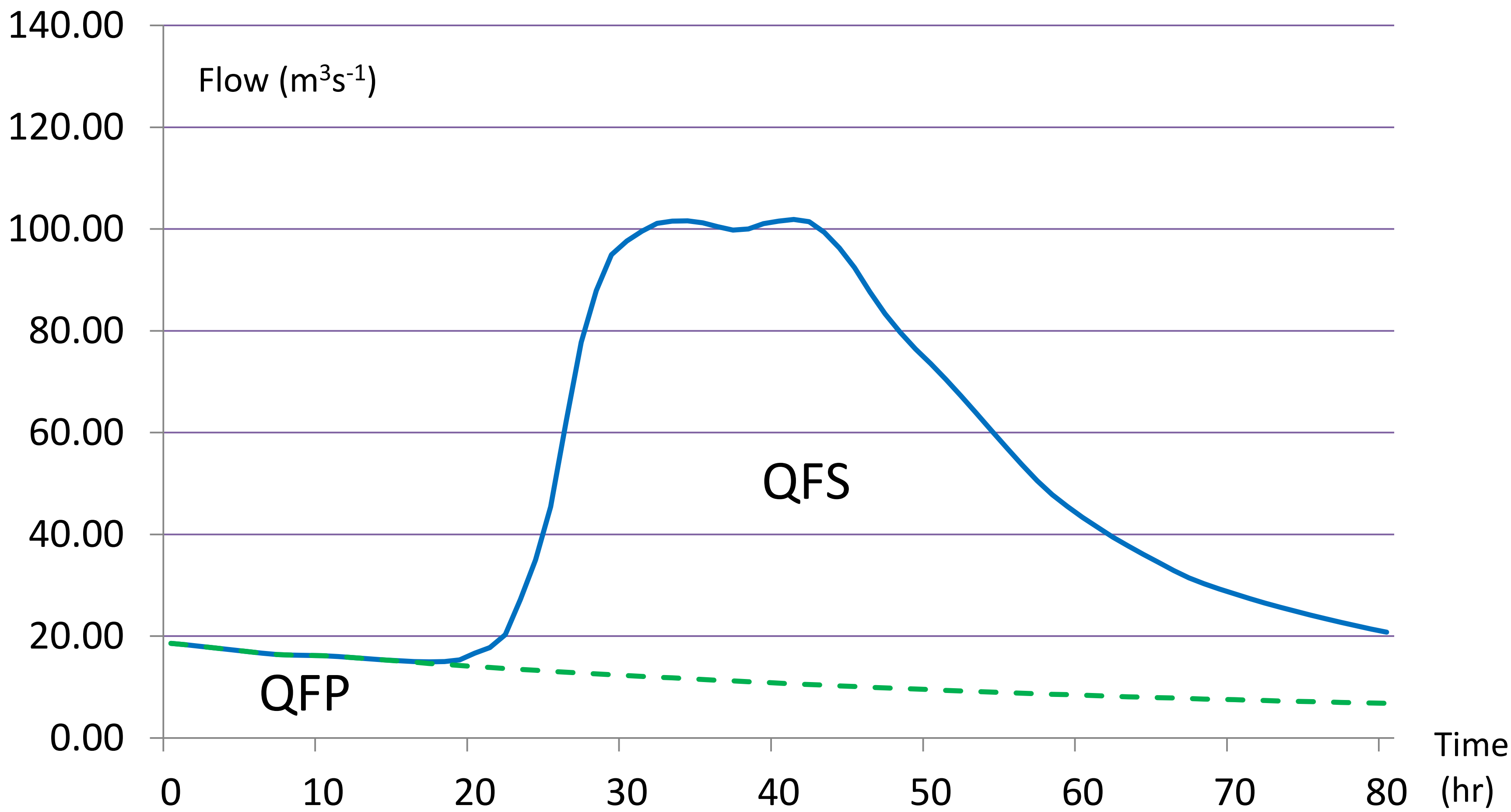


Outflow
Q(t)

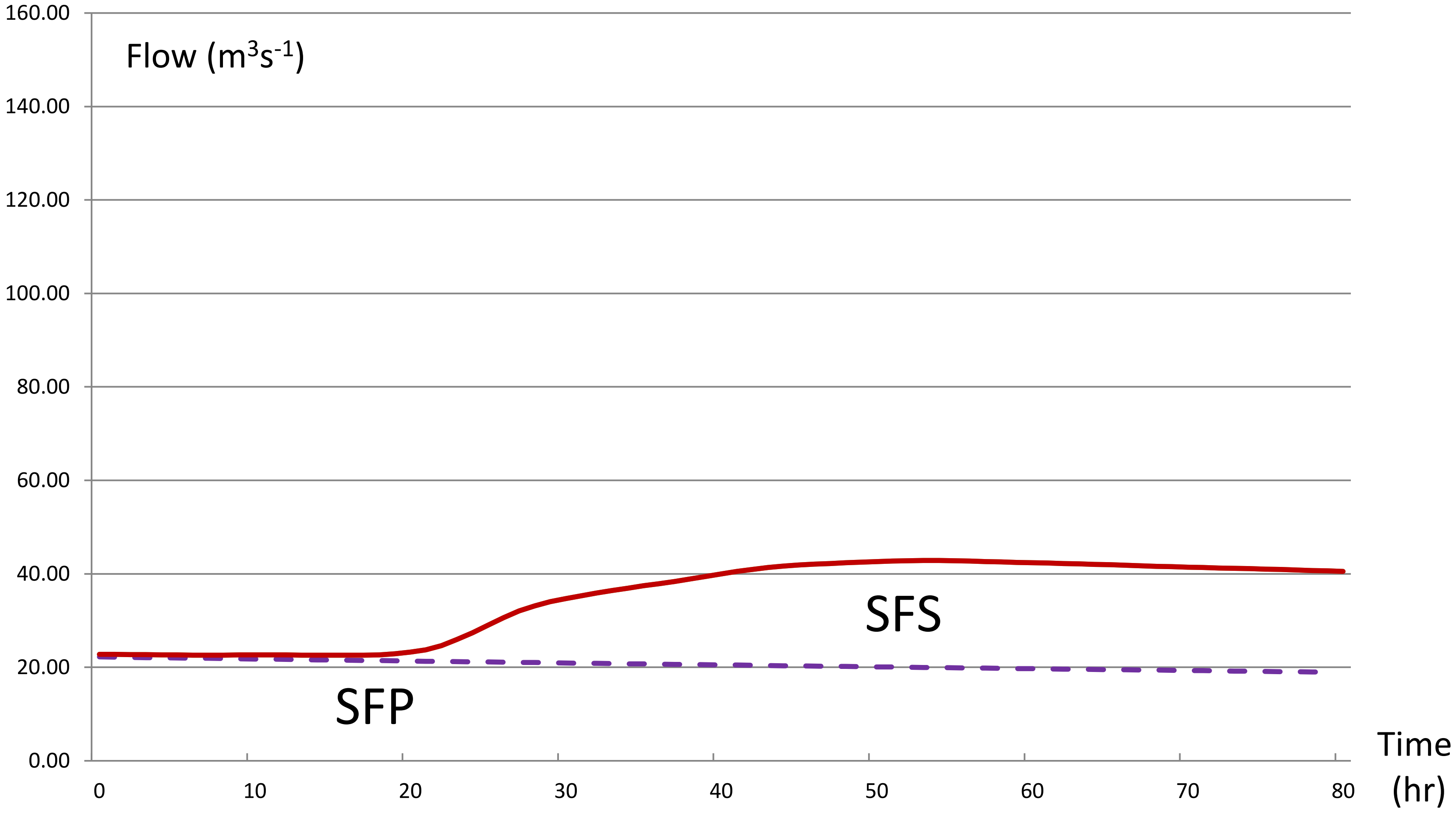
Storage outflow relation

$S(t) = a[\ Q(t)\ ]^b$

The quickflow hydrograph component showing subcomponents QFP and QFS



The slowflow hydrograph component showing subcomponents SFP and SFS



Assumptions

i) The pre-event and post-event quickflow recessions are formed of different portions of the same quickflow master recession curve;

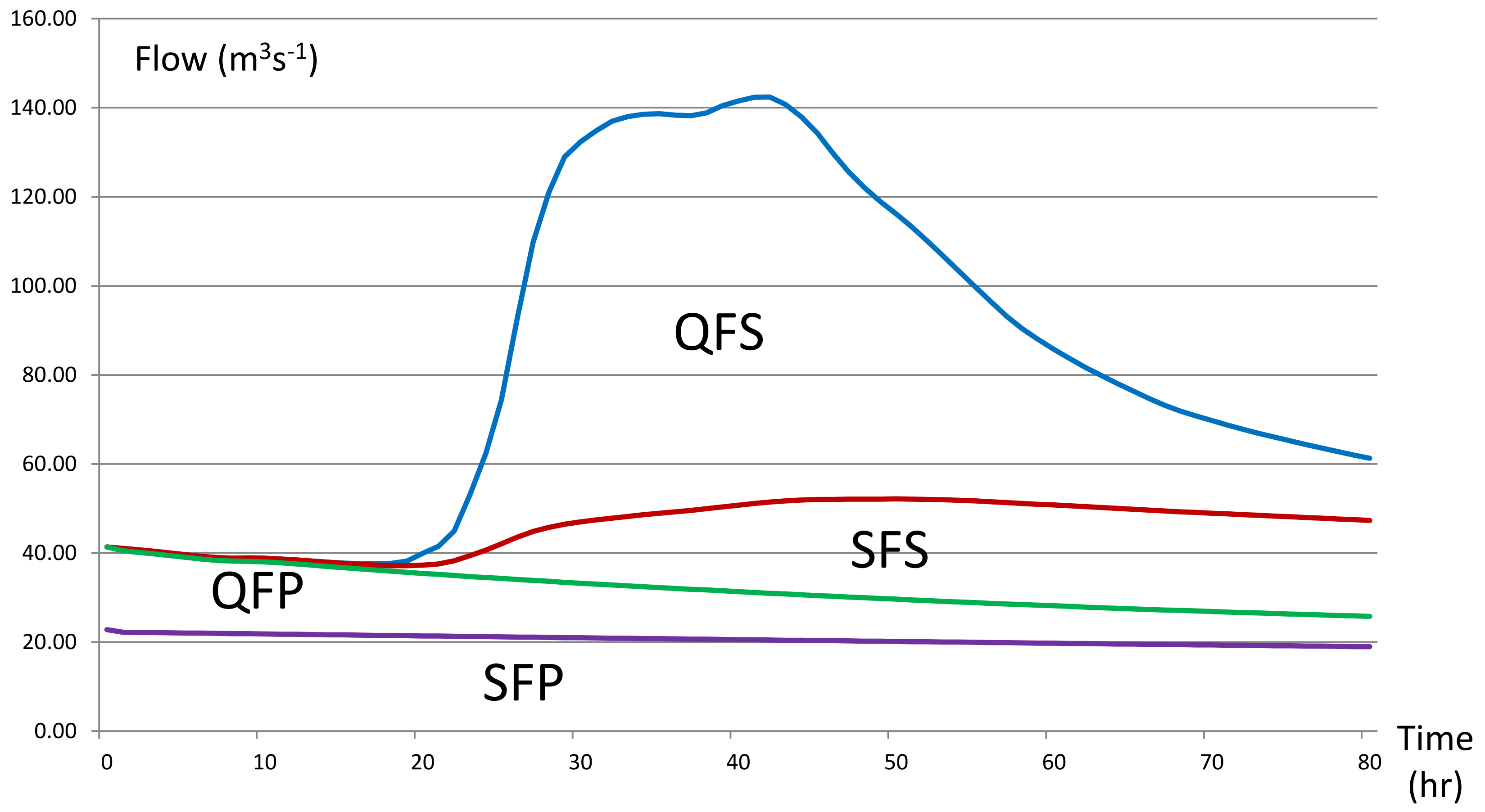
ii) The pre-event and post-event slowflow recessions are formed of different portions of the same slowflow master recession curve;

Assumptions (continued)

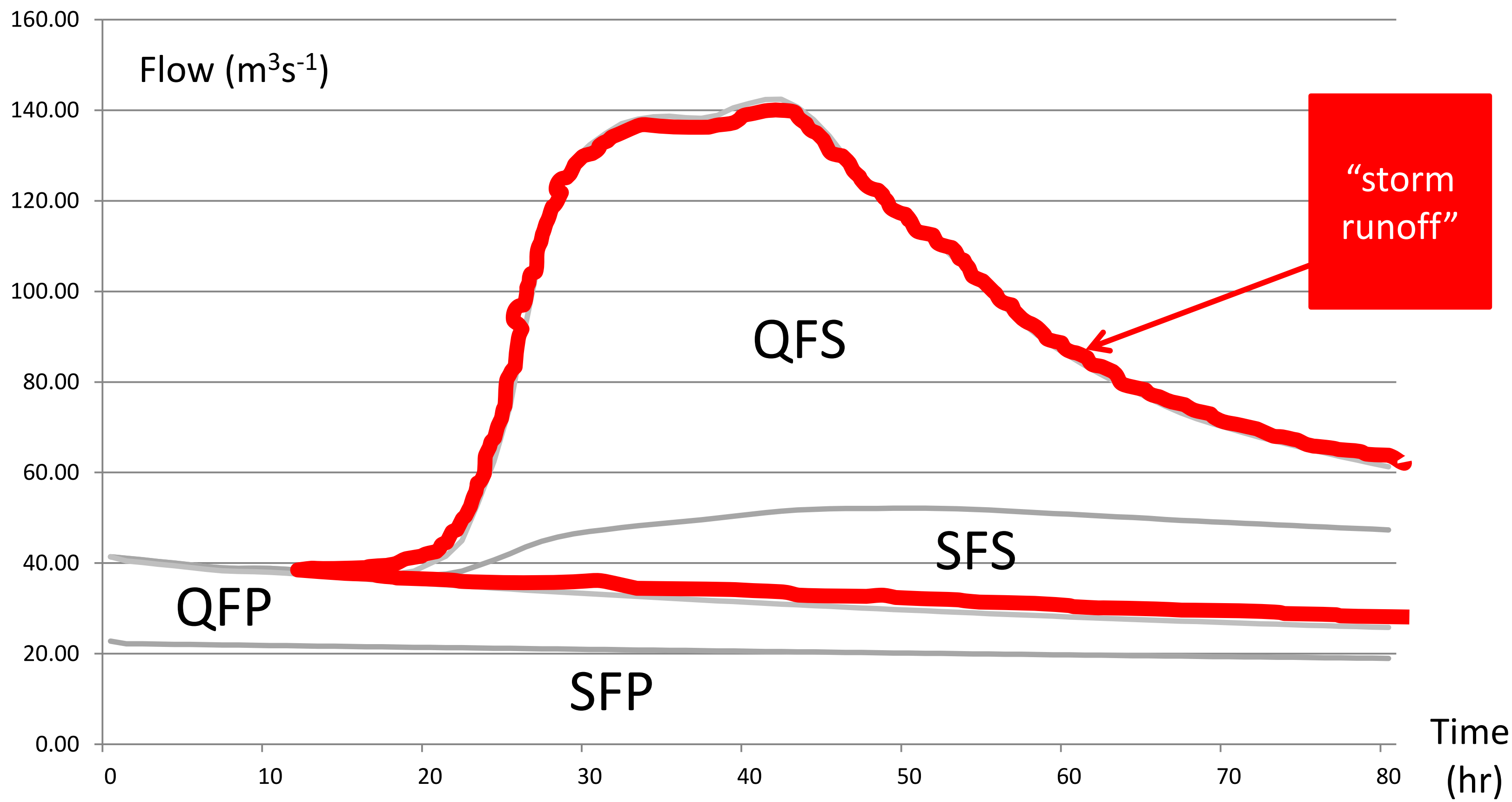
iii) The rising section of the slowflow hydrograph occurs during exactly the same period of time as the inflow section of the quickflow hydrograph, namely starting a few ordinates prior to the time of minimum quickflow and finishing at the time of the inflection point on the quickflow hydrograph recession curve;

iv) Although the slowflow response is much more damped than that of the quickflow response, there is no lag or attenuation of the slowflow response compared to that of quickflow.

The first method of combining the four subcomponents to represent an observed storm hydrograph



The general separation technique applied to an observed storm hydrograph



General separation technique

- The volume of runoff under the extended pre-event recession curve is the sum of the slowflow preceding runoff SFP and the quickflow preceding runoff QFP;

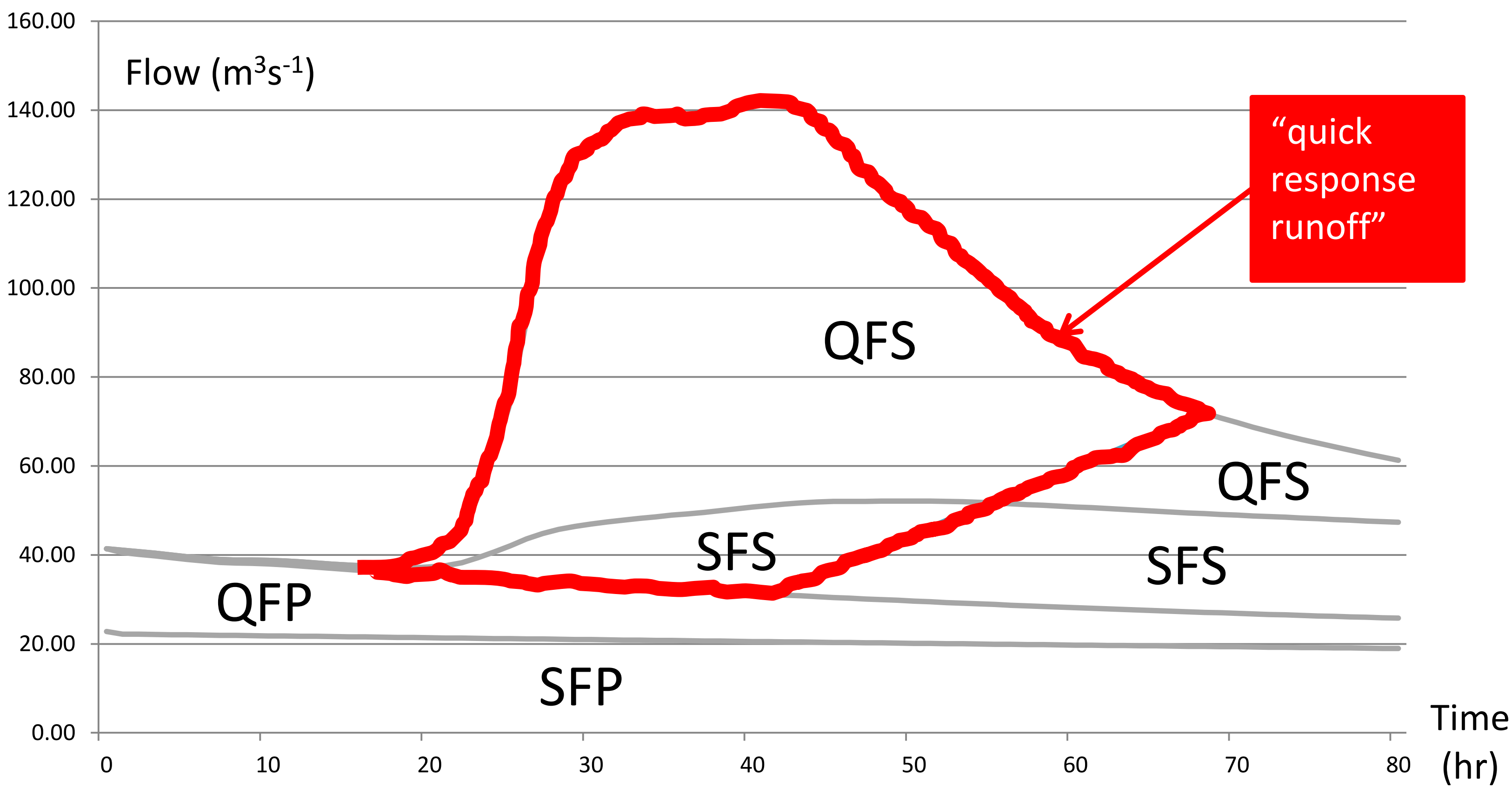
- “storm runoff” is identified as lying beneath the observed hydrograph and between the extensions of the pre-event and post-event recessions;

- “storm runoff” is the sum of the quickflow storm runoff QFS and slowflow storm runoff SFS, and not just the quickflow storm runoff QFS, as identified in a previous review; i.e.

  “storm runoff” = QFS + SFS

- An additional step in the technique is therefore needed to separate QFS from SFS;

The FSR separation technique applied to an observed storm hydrograph

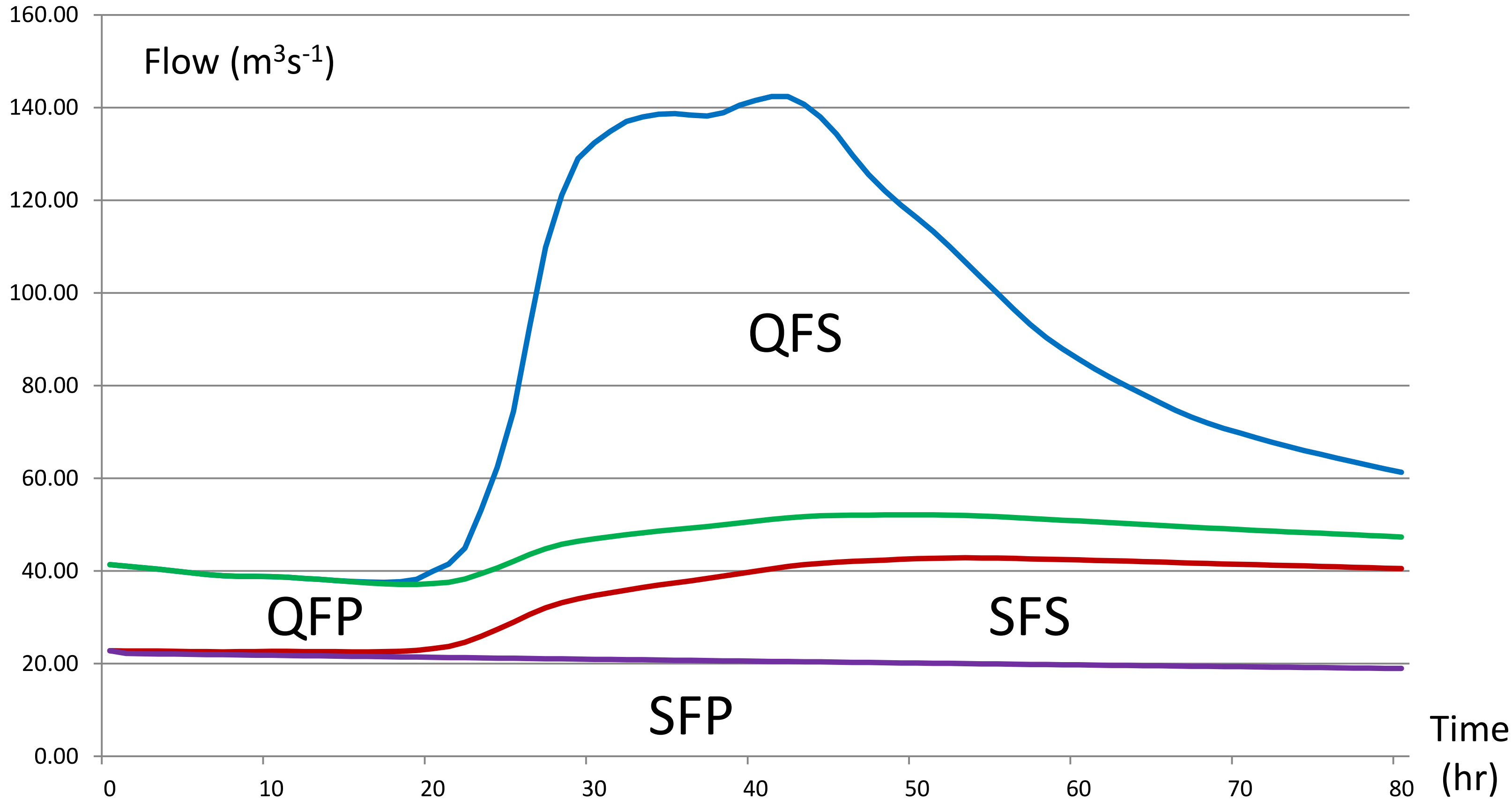


FSR separation technique

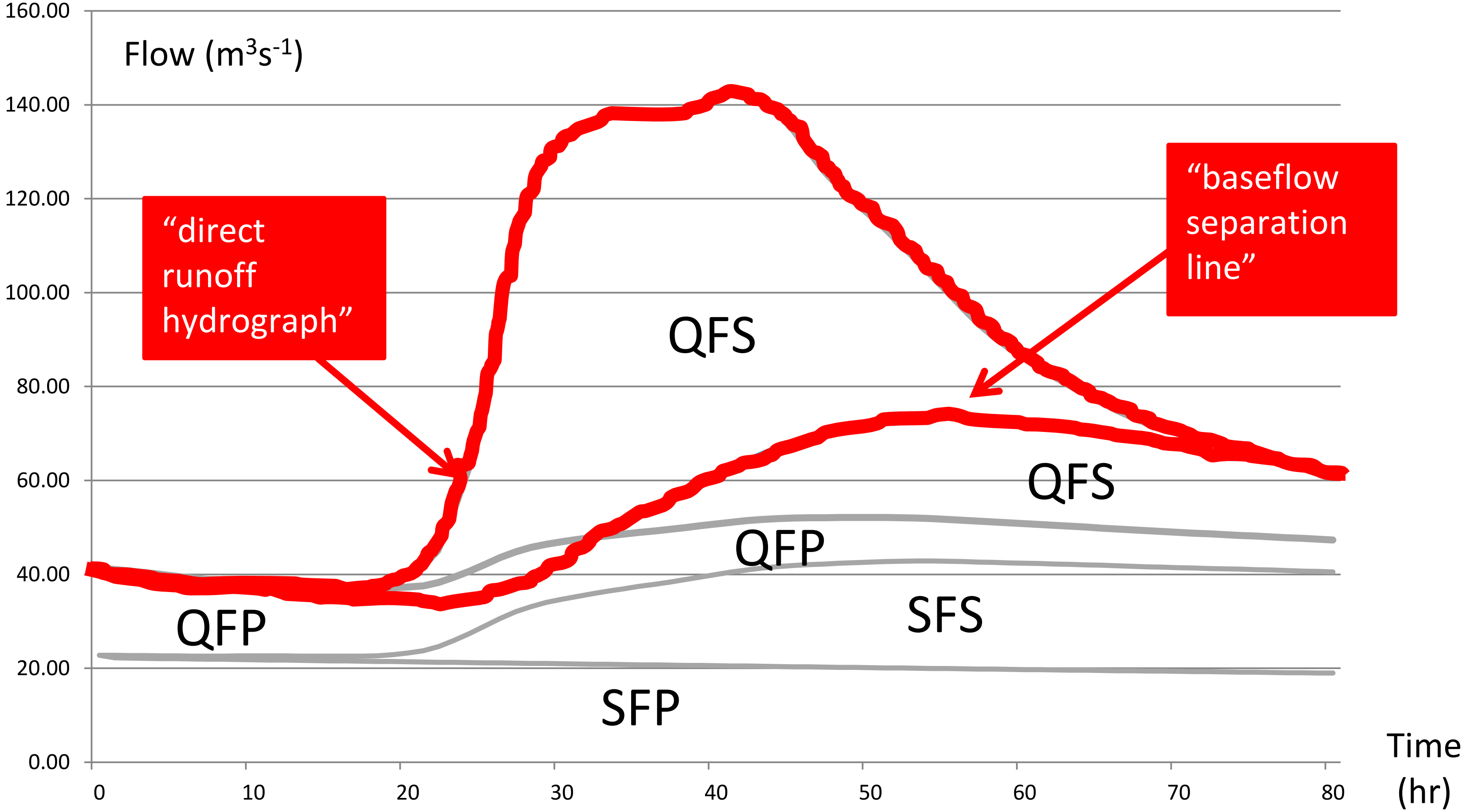
- Technique appears to be theoretically unsound;
- Estimate of “quick response runoff” is found to be a combination of arbitrary proportions of quickflow and slowflow storm runoffs, i.e.

  “quick response runoff” = α.QFS + β.SFS
- Choosing the terminology “nonseparated flow”, to describe the flow remaining after separating off the “quick response runoff”, is to be commended;

The second method of combining the four subcomponents to represent an observed storm hydrograph



The ReFH separation technique applied to an observed storm hydrograph



ReFH separation technique

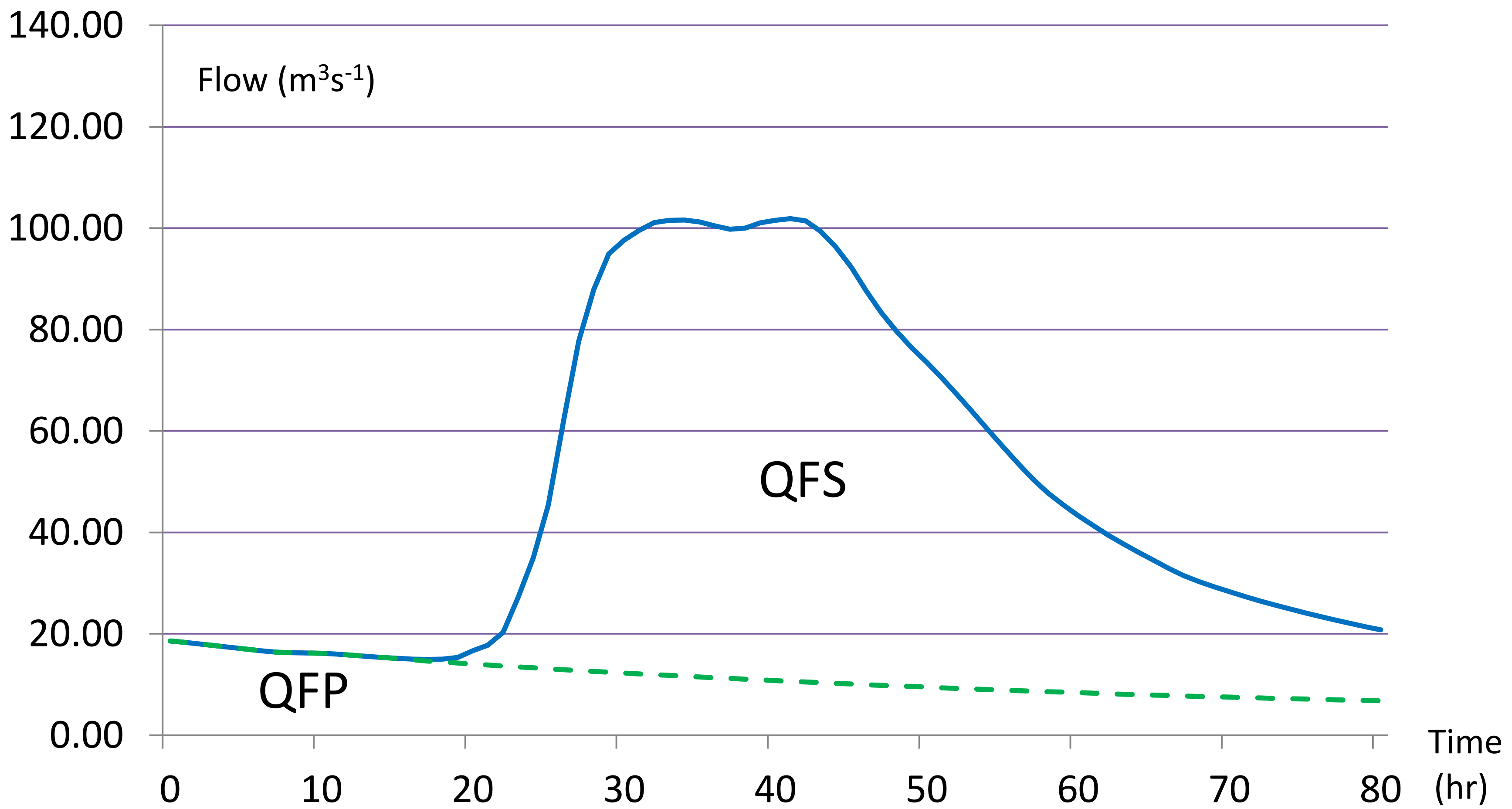
- This method of separating the "direct runoff hydrograph" is found to have much greater theoretical justification, due to incorporating a linear conceptual reservoir to generate a slowflow response;

- Queries remain about the initial and final flow values chosen to determine the "baseflow separation line";

- This technique does not possess a parallel transfer function structure, as the input to the slowflow reservoir is taken as a proportion of the quickflow hydrograph, which is itself the output from the quickflow transfer function;

- The quickflow preceding runoff contribution to the observed storm hydrograph appears to have been disregarded;

The quickflow hydrograph component showing subcomponents QFP and QFS



The RIS separation technique

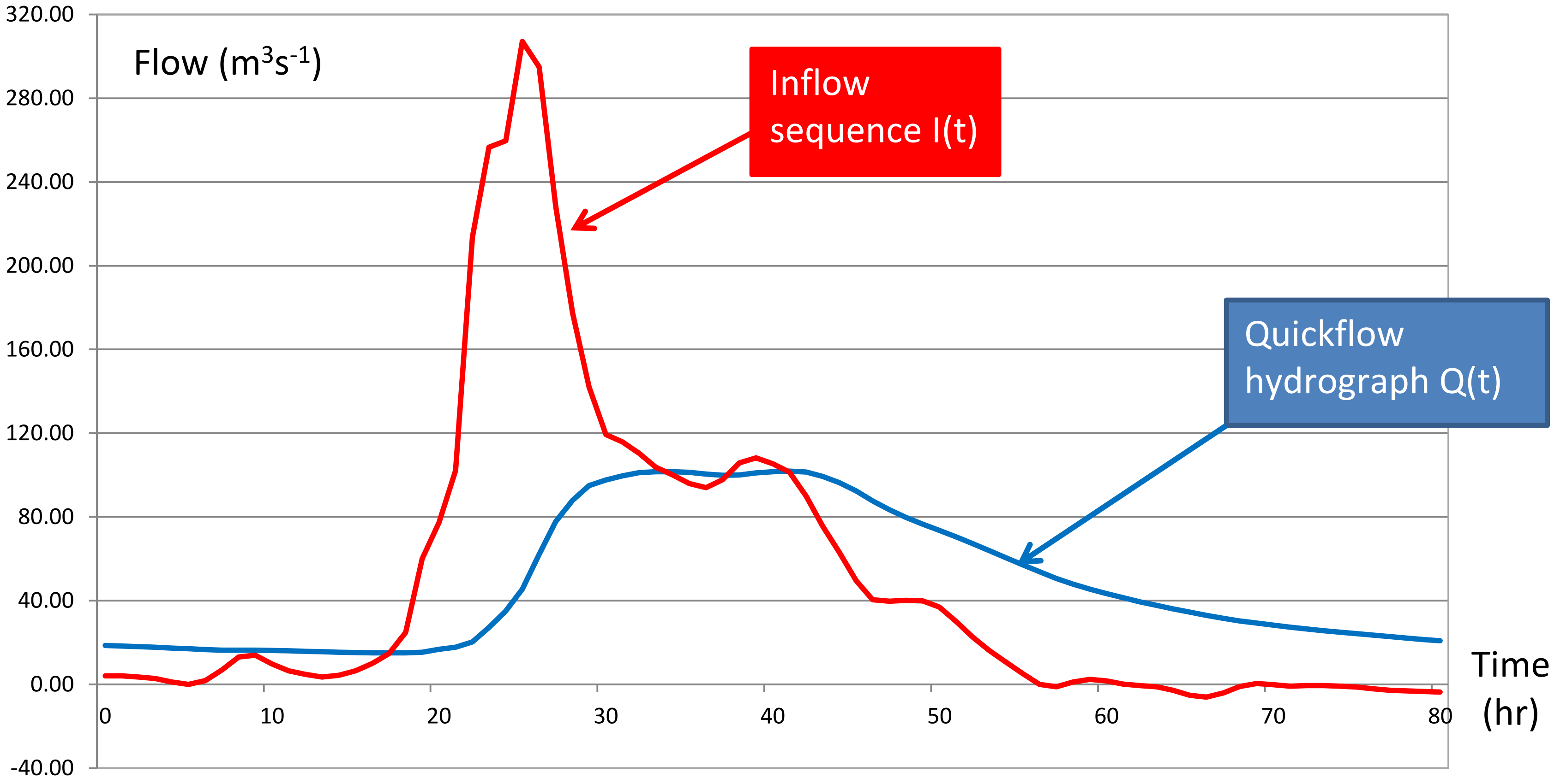
- Technique described in more detail in the proceedings of the 2004 BHS International Conference held in London;

- The Recession Gradient Function $m_r\{Q(t)\}$ is identified, which relates the gradient m_r , occurring at a typical point on the quickflow recession curve, to its corresponding flow value Q(t);

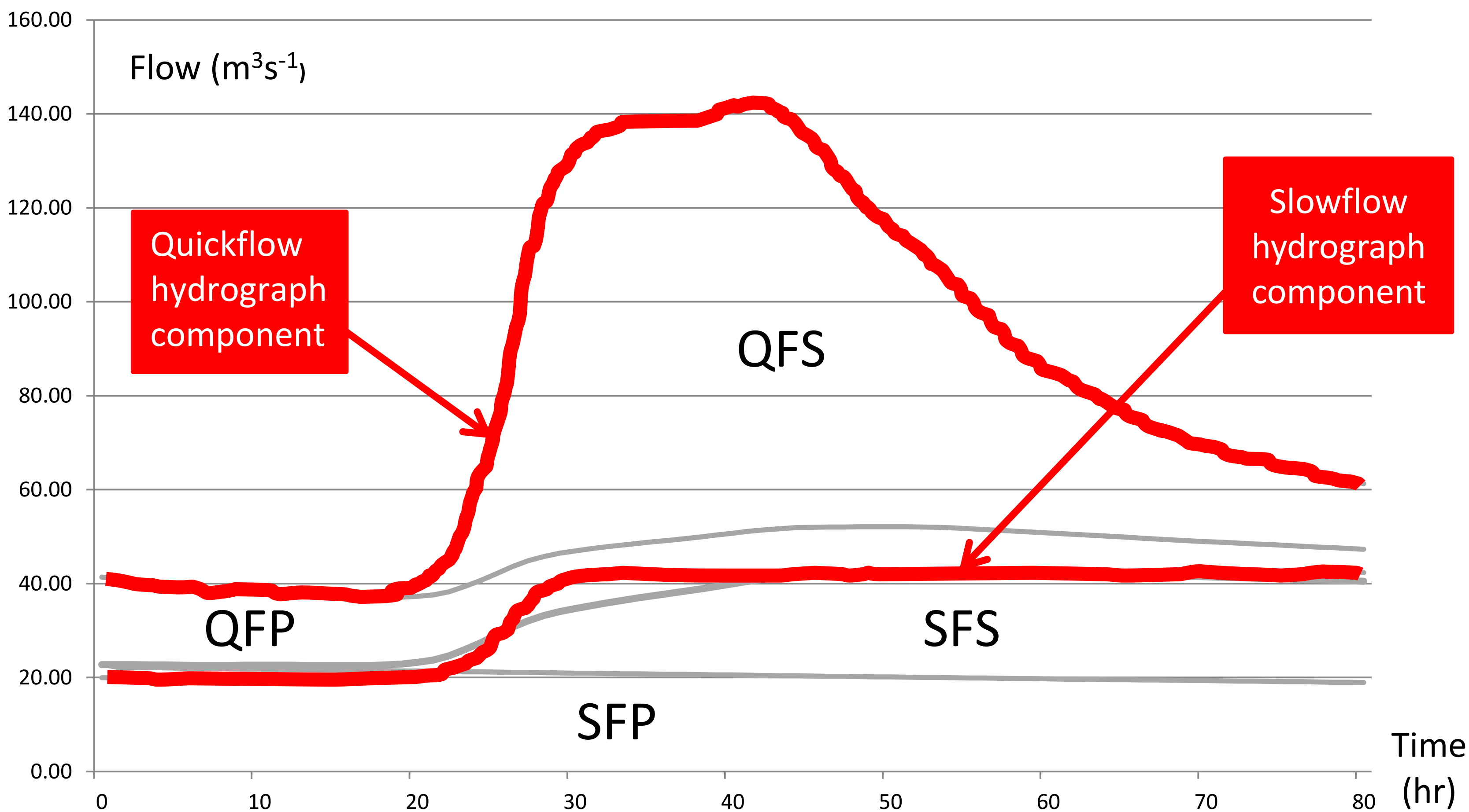
- The RIS formula is applied to the whole of the quickflow hydrograph, Q(t), to determine the corresponding values of inflow I(t):

$$I(t) = Q(t)[\ 1 + \{dQ/dt\}/(\ -m_r\{Q(t)\}\ )\ \ ]$$

The inflow sequence I(t) obtained from applying the RIS technique to a typical quickflow hydrograph Q(t)



The RIS separation technique applied to an observed storm hydrograph



RIS separation technique

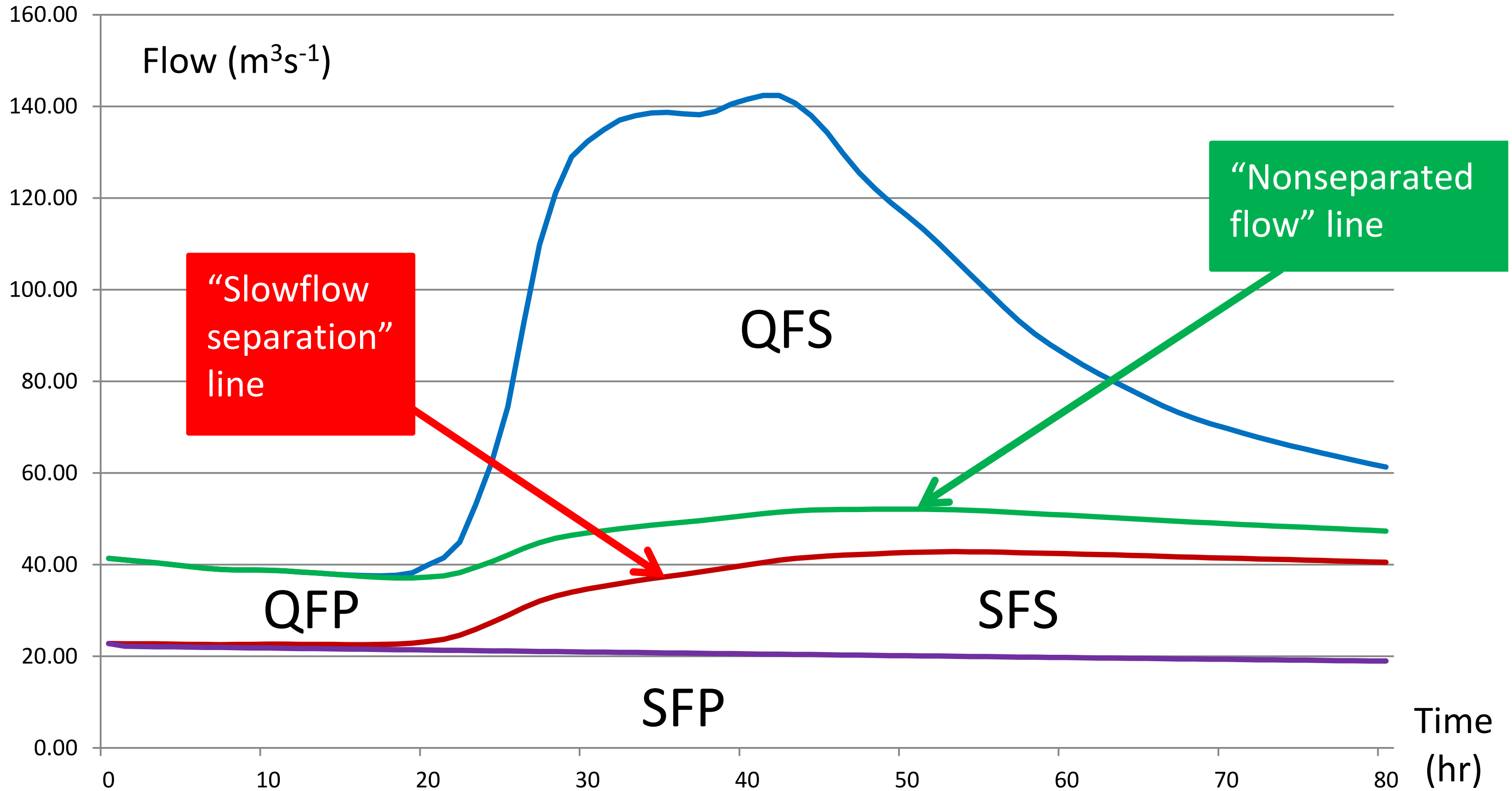
- Reasonable estimates of the pre-event and post-event slowflow recessions can be made;
- The method for interpolating the central portion of the slowflow hydrograph still needs strengthening;
- If the quickflow component can be isolated from that of slowflow, the subsequent procedure for estimating the “quickflow storm runoff” is considered to be not only exact theoretically, but also has been found viable as a practical procedure;

Conclusion common to all separation techniques

Much more care is required in naming the flow lines separating out each of the four components making up the observed storm hydrograph.

Certainly a distinction needs to be made between the “nonseparated flow” and “slowflow separation” lines.

Suggested terminology for distinguishing between different lines separating hydrograph components

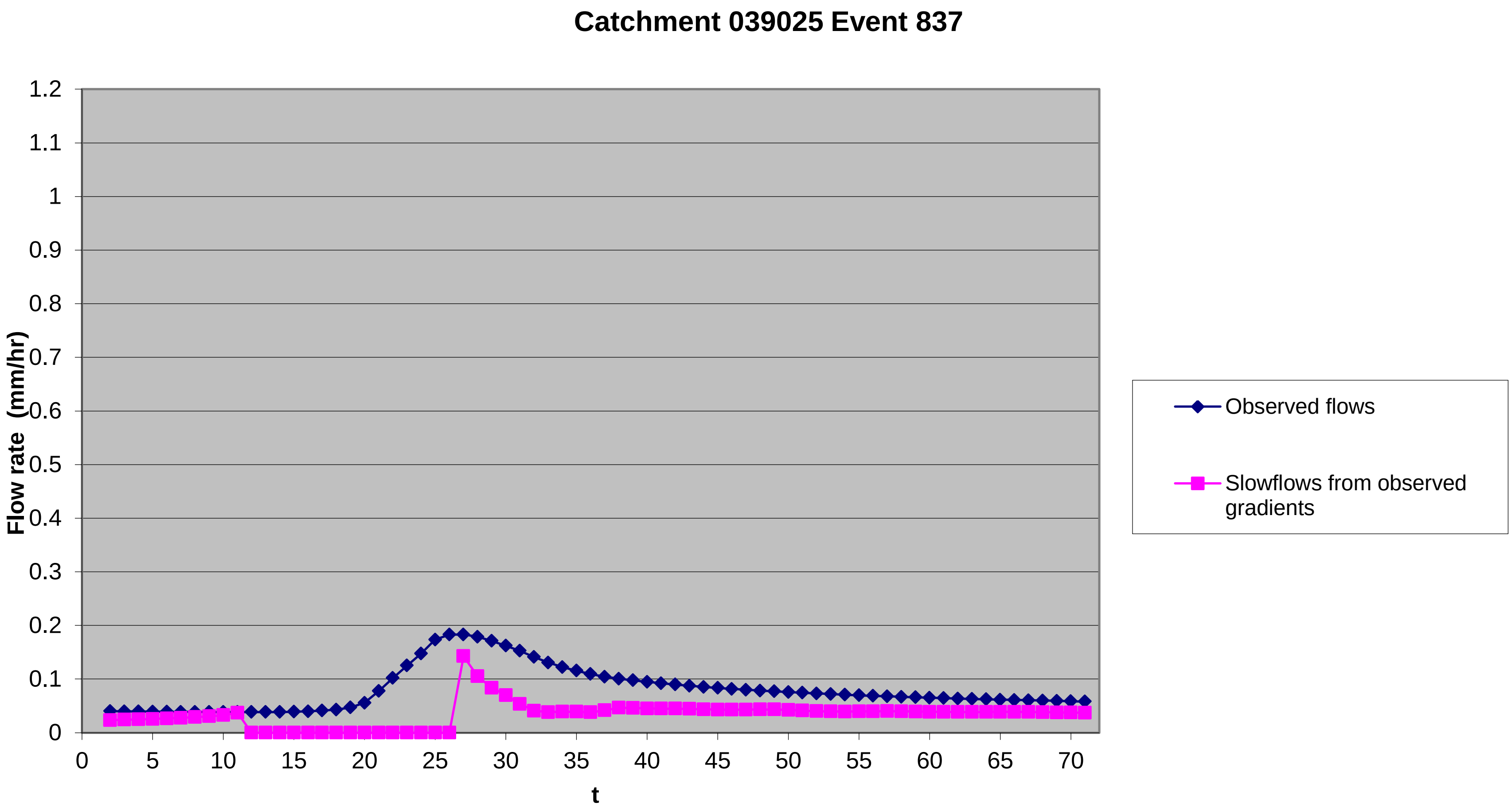


The End

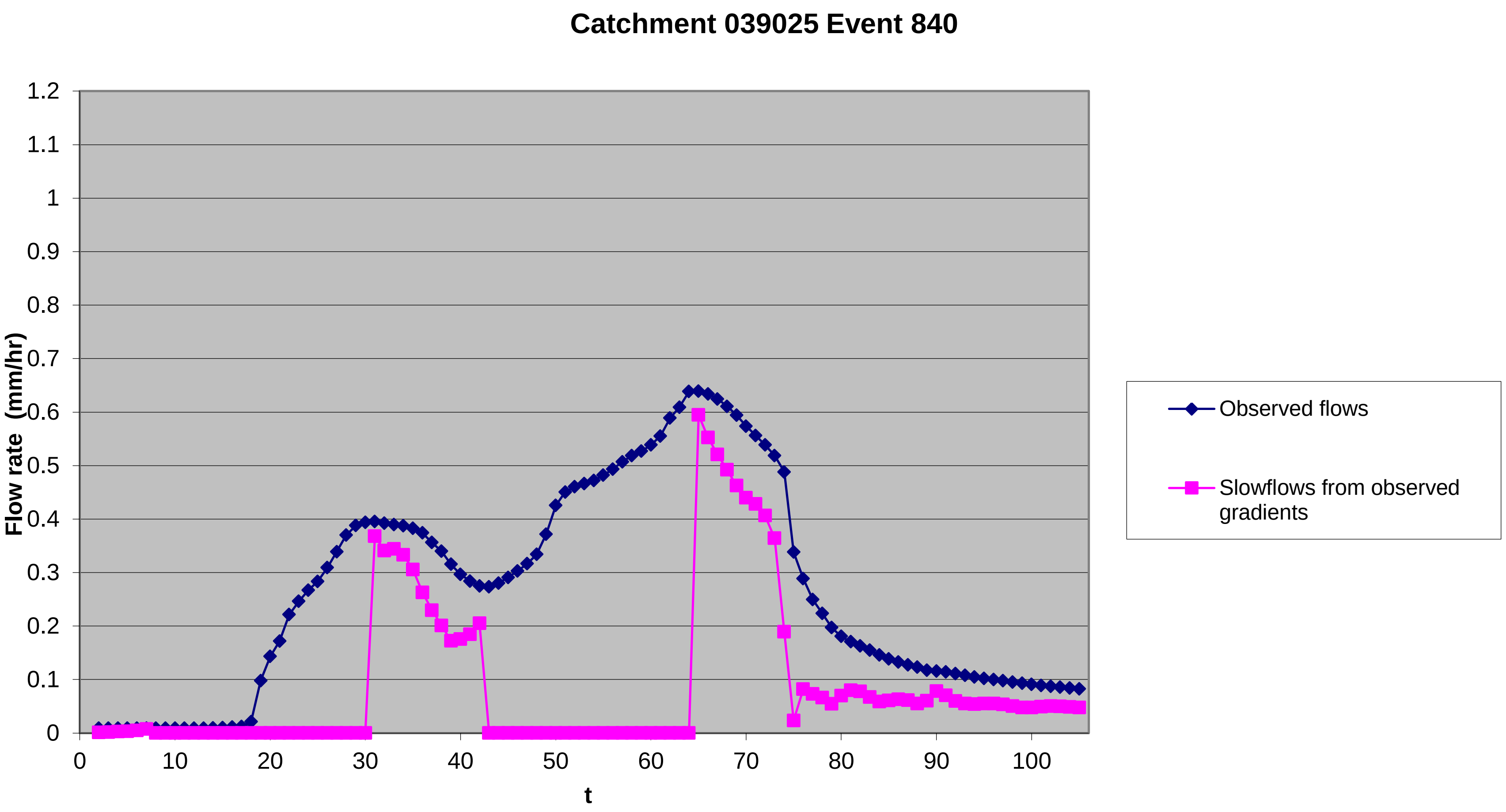
Additional slides to answer potential questions

- Gauging station No: 39/25
- River name: Enborne at Brimpton
- Catchment area: 147.6 km^2
- IH Baseflow index (BFI): 0.53

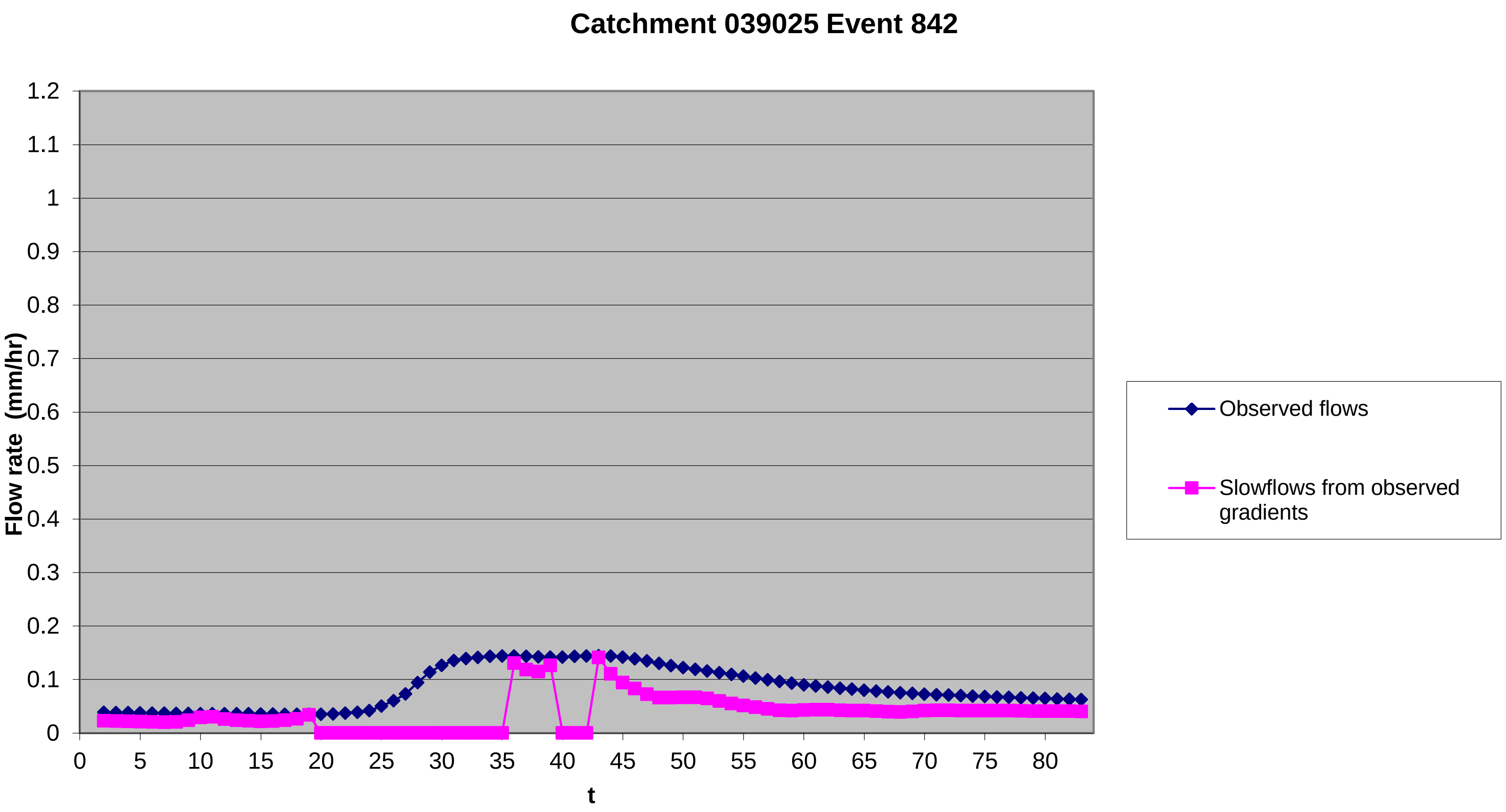
Estimation of pre-event and post-event slowflow values



Estimation of pre-event and post-event slowflow values

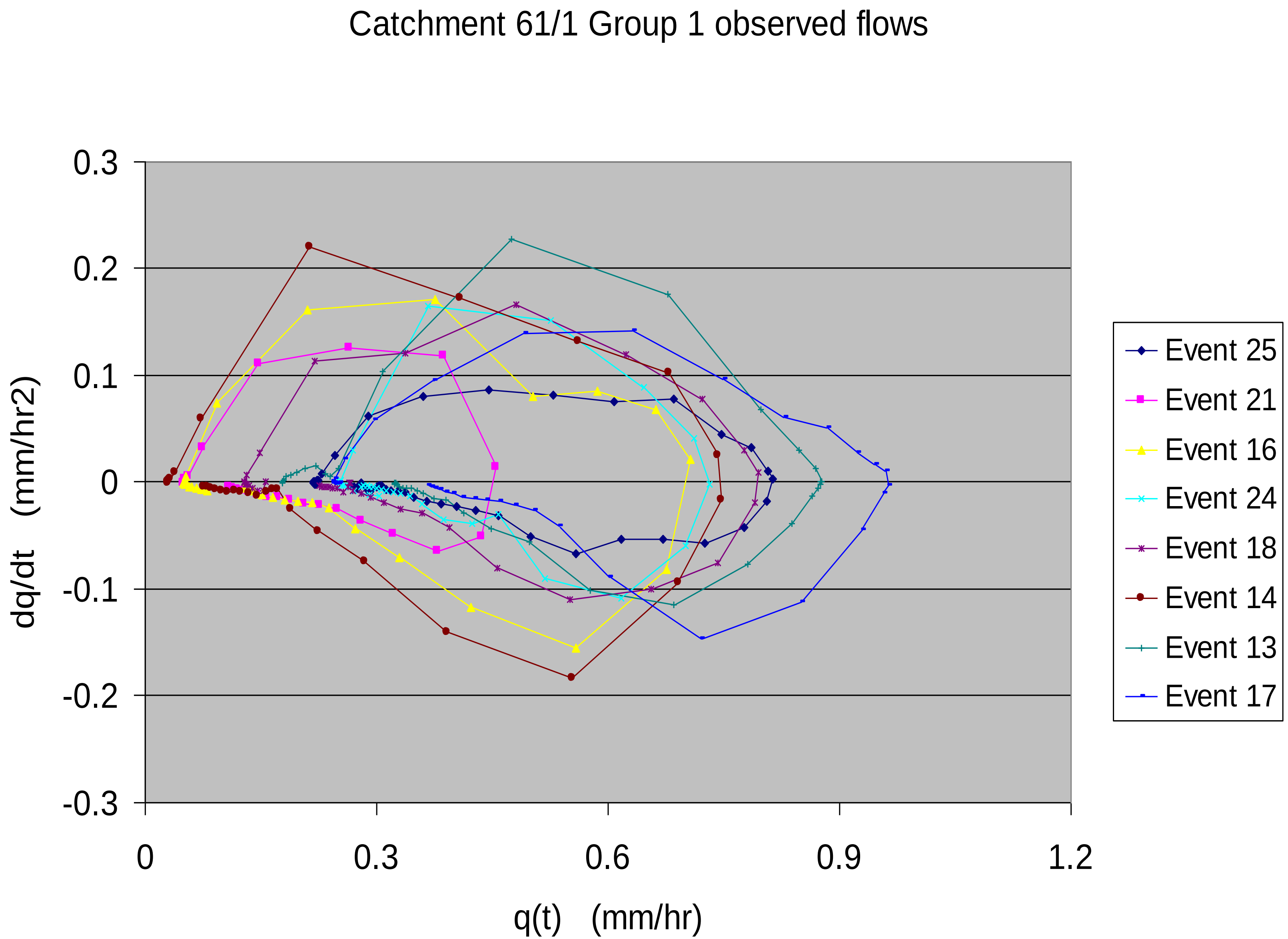


Estimation of pre-event and post-event slowflow values

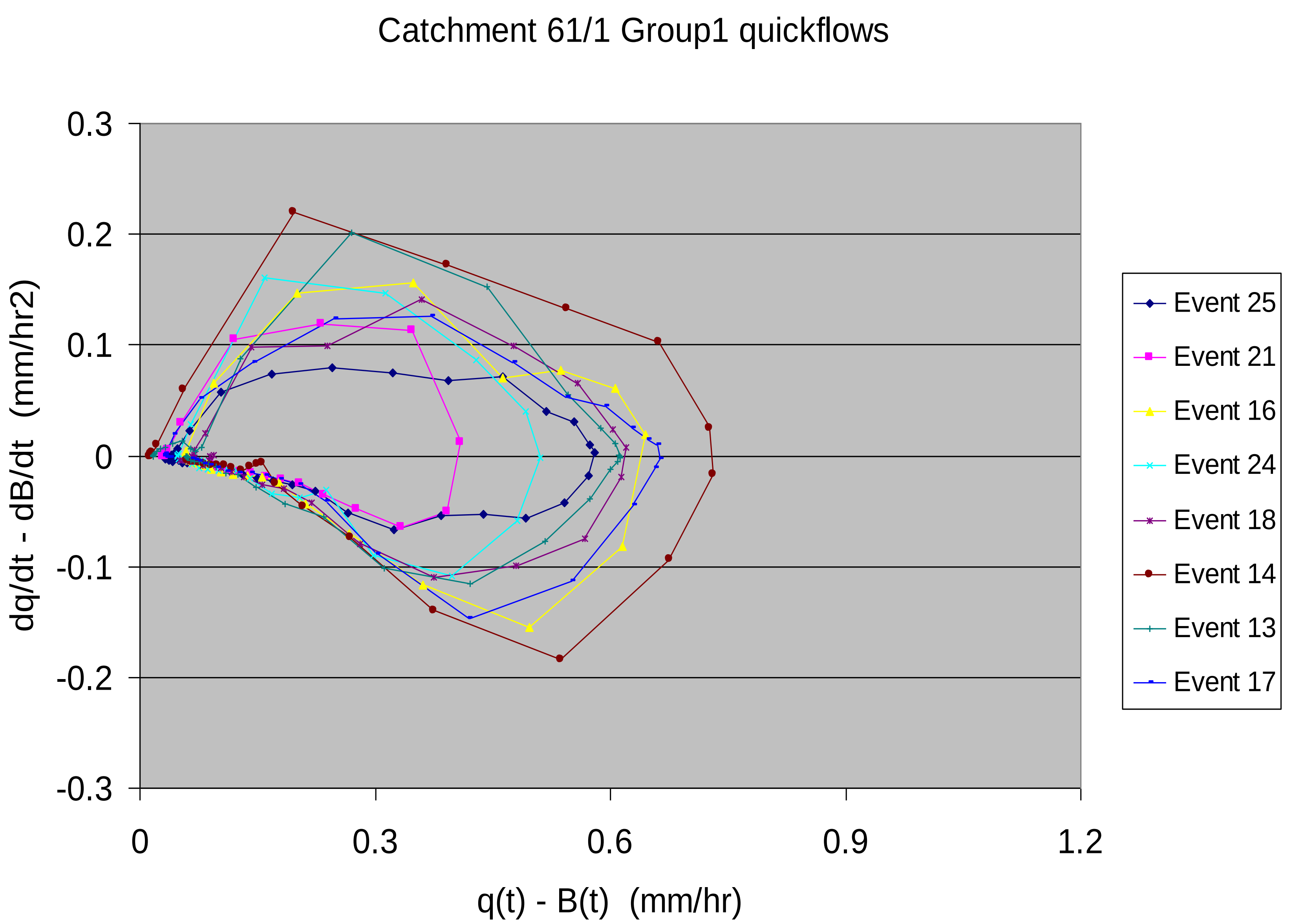


Additional slides to answer potential questions

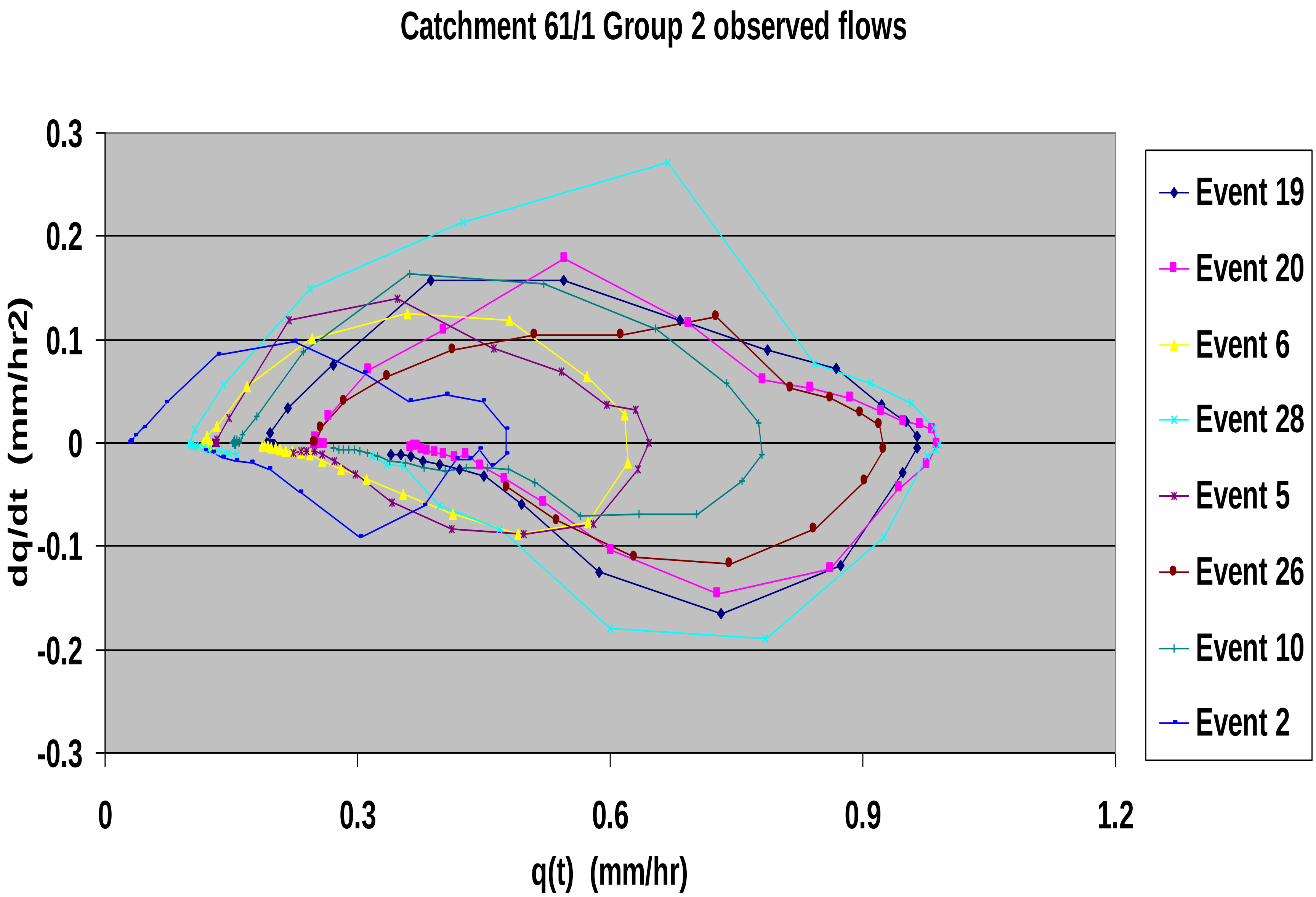
- Gauging station No: 61/1
- River name: Western Cleddau at Prendergast Mill
- Catchment area: 197.6 km^2
- IH Baseflow Index (BFI): 0.63

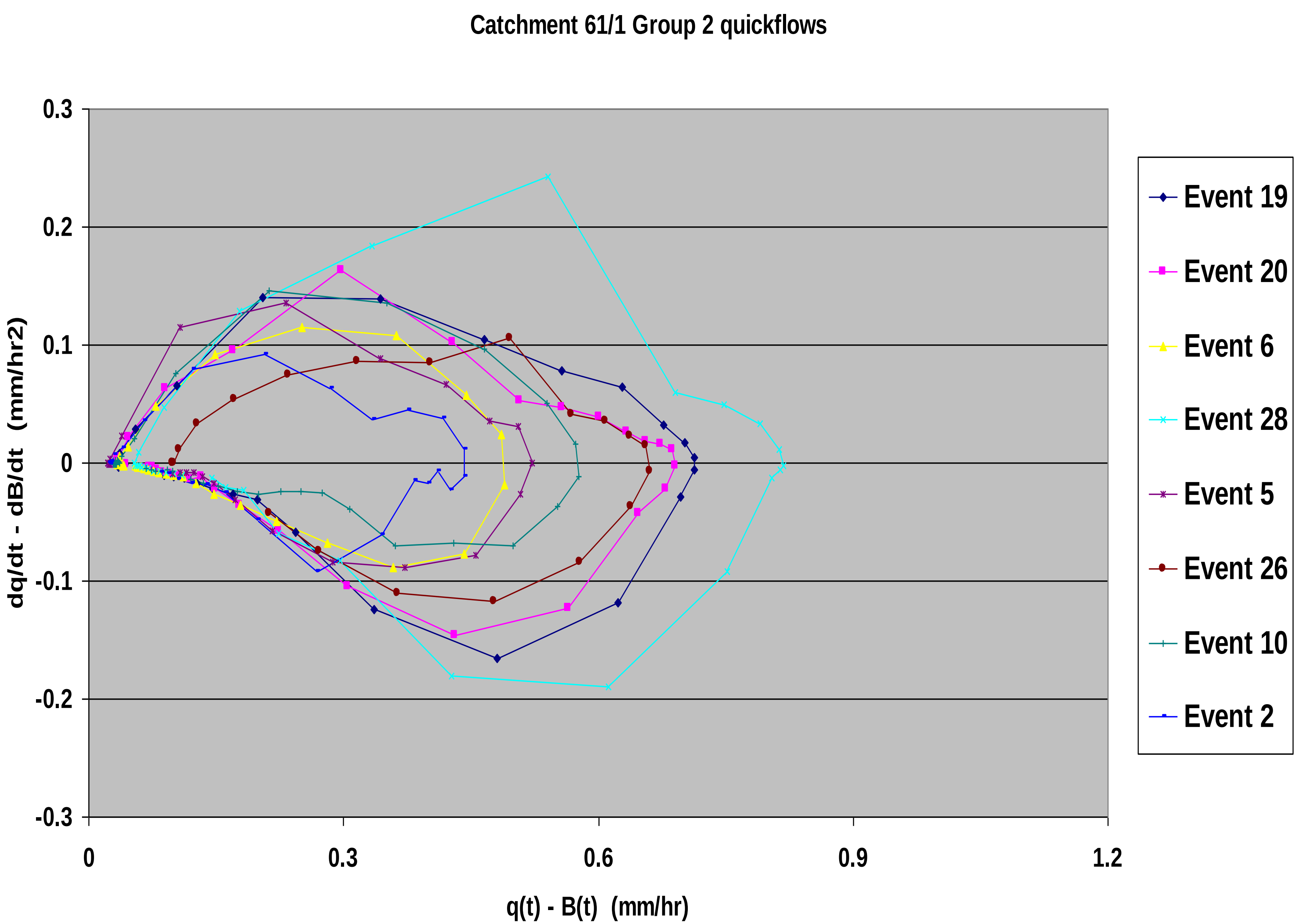


Catchment 61/1 Group 1 observed flows
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
dq/dt (mm/hr2)
0
0.3
0.6
0.9
1.2
q(t) (mm/hr)
Event 25
Event 21
Event 16
Event 24
Event 18
Event 14
Event 13
Event 17

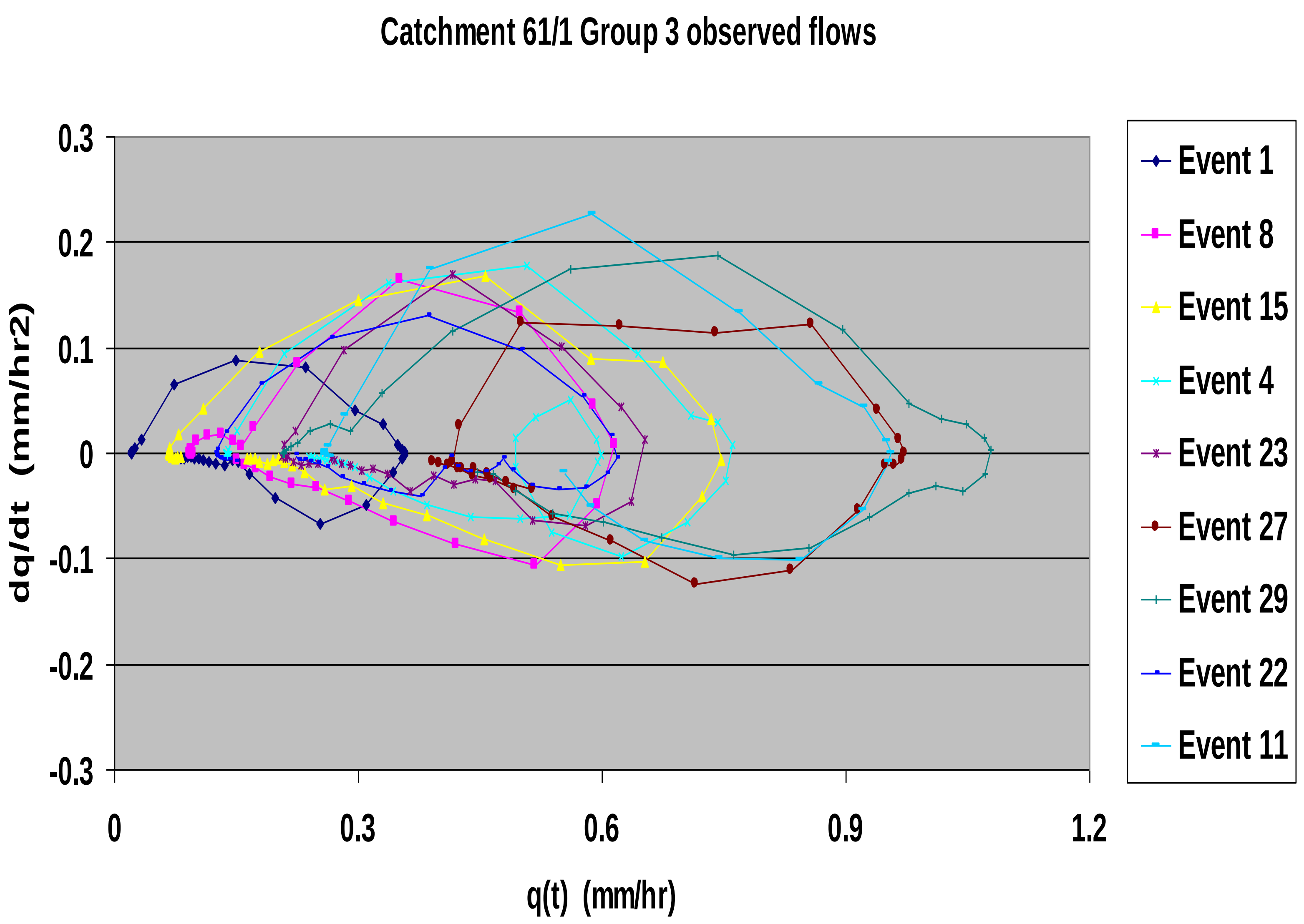


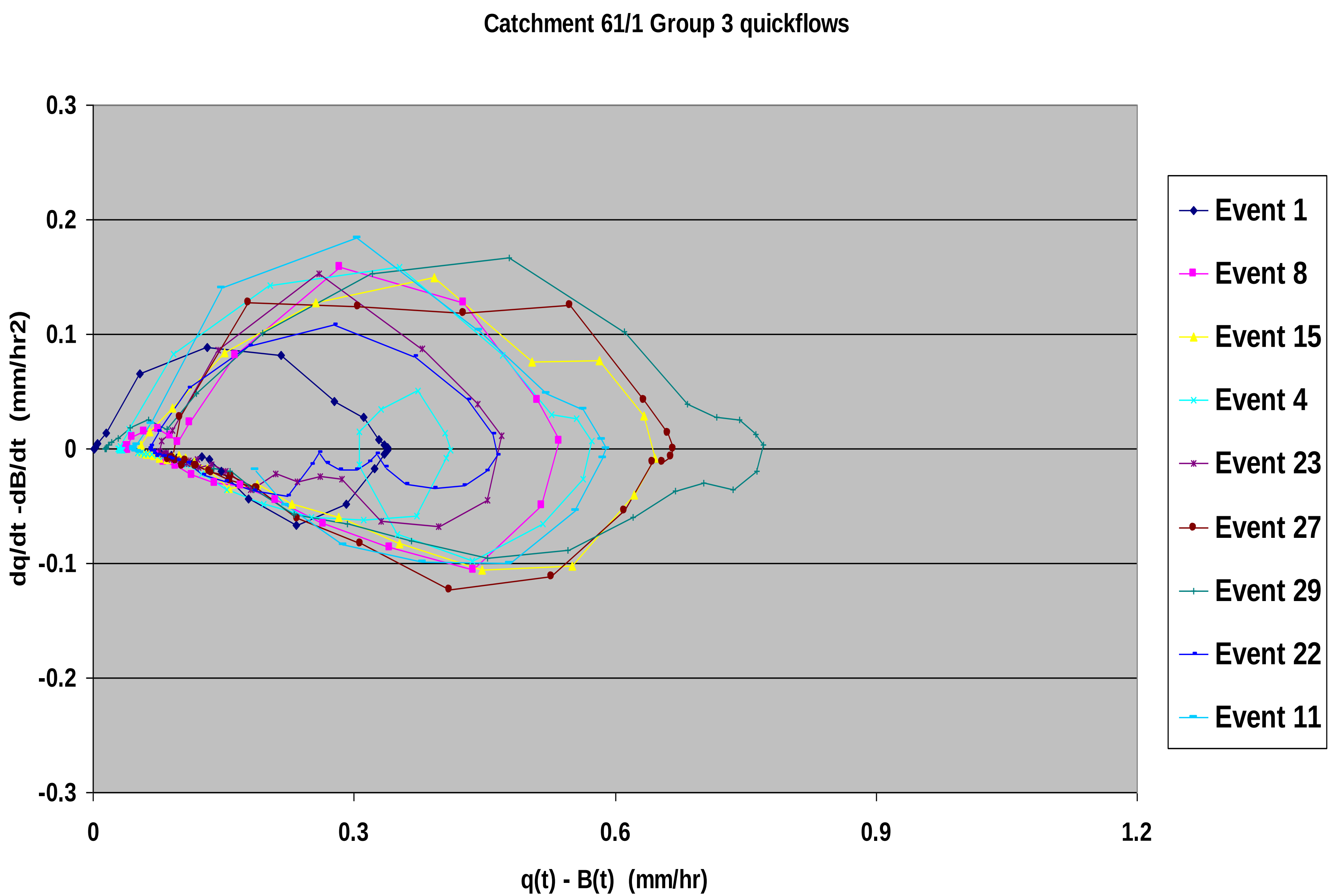
Catchment 61/1 Group1 quickflows
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
dq/dt - dB/dt (mm/hr2)
0
0.3
0.6
0.9
1.2
q(t) - B(t) (mm/hr)
Event 25
Event 21
Event 16
Event 24
Event 18
Event 14
Event 13
Event 17


Catchment 61/1 Group 2 observed flows
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
dq/dt (mm/hr2)
0
0.3
0.6
0.9
1.2
q(t) (mm/hr)
Event 19
Event 20
Event 6
Event 28
Event 5
Event 26
Event 10
Event 2



Catchment 61/1 Group 2 quickflows
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
dq/dt - dB/dt (mm/hr2)
0
0.3
0.6
0.9
1.2
q(t) - B(t) (mm/hr)
Event 19
Event 20
Event 6
Event 28
Event 5
Event 26
Event 10
Event 2


Catchment 61/1 Group 3 observed flows
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
dq/dt (mm/hr2)
0
0.3
0.6
0.9
1.2
q(t) (mm/hr)
Event 1
Event 8
Event 15
Event 4
Event 23
Event 27
Event 29
Event 22
Event 11



Catchment 61/1 Group 3 quickflows
dq/dt -dB/dt (mm/hr2)
q(t) - B(t) (mm/hr)
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
0
0.3
0.6
0.9
1.2
Event 1
Event 8
Event 15
Event 4
Event 23
Event 27
Event 29
Event 22
Event 11