Lesson 17: Baseflow Separation

Event-Based Baseflow Separation

Some baseflow separation methods are better suited to analyzing hydrographs for individual rainfall-runoff events. A few simple examples are given below.

Straight Line Method A (Horizontal Line)

Approach: Draw a horizontal line from the start of the rising limb (assuming a constant baseflow).

Steps:

- Identify when direct runoff begins (i.e., end of the baseflow-only period).
- Assume baseflow remains constant afterwards.

Straight Line Method B

Approach: Draw a line connecting the start of the rising limb to the start of the next baseflow recession.

Steps:

- Identify when direct runoff begins (i.e., end of the baseflow-only period).
- Identify the beginning of the next baseflow period (from a log $Q(t)$ versus t plot).
- Draw a line connecting these two points. This is the baseflow hydrograph.

Straight Line Method C

Approach: Draw a line connecting the start of the rising limb to the estimated end of the direct runoff period.

Steps:

- Identify when direct runoff begins (i.e., end of the baseflow-only period).
- Estimate the duration of the direct runoff period N by an empirical relationship.

  $N = A^{0.2}$ (N is in days; A is in mi^2)
- Draw a line connecting from the start to direct runoff to the end. This is the baseflow hydrograph.

Lesson 16: Baseflow Separation

Continuous Baseflow Separation

Other baseflow separation methods are better suited to analyzing continuous hydrographs over a long term period (e.g., years). A few simple examples based on digital filters are given below.

Digital Filter

Approach: Use a numerical algorithm (a digital filter) to partition the streamflow hydrograph into "high frequency" (direct runoff) and "low frequency" (baseflow) components.

Terms:

Q_k streamflow at time step k
R_k direct runoff at time step k
B_k baseflow at time step k

Initialize:

$R_0 = 0$

$B_0 = Q_0$ (baseflow period)

1) *Single Parameter Digital Filter (Nathan and McMahon, 1990)*

Parameter:

α baseflow filter parameter

Algorithm:

At each time step:

$$R_{k+1} = \alpha R_k + \frac{(1+\alpha)}{2}(Q_{k+1} - Q_k)$$

Check:

If $R_{k+1} < 0$, then $R_{k+1} = 0$
If $R_{k+1} > Q_{k+1}$, then $R_{k+1} = Q_{k+1}$

Compute baseflow:

$$B_{k+1} = Q_{k+1} - R_{k+1}$$

Reference: Nathan, R.J. and T.A. McMahon, 1990. Evaluation of Automated Techniques for Baseflow and Recession Analysis. *Water Resources Research*, 26(7):1465-1473.

Lesson 16: Baseflow Separation

2) Two Parameter Digital Filter (Eckhardt, 2005)

Parameters:

α baseflow filter parameter (Default: $\alpha = 0.98$)

BFI_{max} maximum value of long term ratio of baseflow to total streamflow

0.80 for perennial streams with porous aquifers,
0.50 for ephemeral streams with porous aquifers,
0.25 for perennial streams with hard rock aquifers.

Algorithm:

At each time step:

$$B_{k+1} = \frac{(1 - BFI_{\max}) \cdot \alpha \cdot B_k + (1 - \alpha) \cdot BFI_{\max} \cdot Q_{k+1}}{1 - \alpha \cdot BFI_{\max}}$$

Check:

If $B_{k+1} > Q_{k+1}$, then $B_{k+1} = Q_{k+1}$

Compute direct runoff:

$$R_{k+1} = Q_{k+1} - B_{k+1}$$

Reference: Eckhardt, K., 2005. How to Construct Recursive Digital Filters for Baseflow Separation. *Hydrological Processes*, 19(2):507-515.

Online Resources

HYSEP: Hydrograph Separation Program
http://water.usgs.gov/software/HYSEP/

WHAT: Web-based Hydrograph Analysis Tool
https://engineering.purdue.edu/~what/