Rainfall-Runoff

Learning Objectives

1. **Describe** and **represent** the physical processes that transform rainfall to runoff
2. **Apply** the SCS method to **estimate** a composite curve number, time of rise, and peak flow for a rainfall-runoff event
3. **Construct** a unit hydrograph for a small catchment
4. **Convolve** unit hydrographs to **develop** a storm runoff hydrograph

1. Physical runoff processes

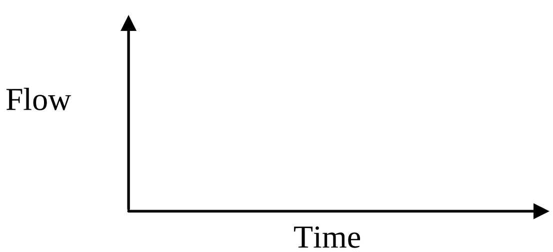
- Process: rainfall exceeds infiltration rate => water accumulates in small depressions => depression storage fills => overland flow => flow concentrates into small rivulets + channels => into larger streams. Also baseflow from Groundwater + Snow melt.

- Quantify surface runoff generated in a catchment for given rainfall pattern. How much runoff do we have to manage?

- How can we quantify and represent the above through time?

- Partition rainfall in infiltration and runoff

- Hydrograph is continuous plot of instantaneous discharge versus time. Aggregates physiosocialgeographic and meteorological conditions in a watershed (climate, storage, losses, landuse, coverage, runoff, baseflow, + runoff effects) at all upstream-points basin.



Q_p = D =

T_R =

t_p =

- Today, we will build the hydrograph for a storm event in a small, ungaged catchment.

2. *SCS* Method

- There are many empirical and theoretical approaches to estimate runoff from rainfall
- Choice depends on location, catchment size, governing processes, available data, and regulation requirements.
- Here we will focus on the SCS method because it's specified in the Logan City code.

  Advantages: Empirical database, widely known and used, computer codes to implement
  Disadvantages: Difficult to match measured hydrographs in areas with high water tables

A. Time of rise

- The time from the beginning of rainfall excess to the peak observed flow.
- If uniform rainfall over time, estimate from lag time.
- [hr] [SCS now NRCS empirical equation]

  l = length to divide (ft)

  y = average watershed slope (%)

  S = Potential Abstraction = 1000/CN – 10 [inches]

  CN = (See Table)

Example 1: Estimate the Curve Number and lag time for runoff originating from the Lundstrum Park/Hillcrest neighborhood in Logan.

1. **What is the land use and soil type? --**
2. **What is the Curve Number?**
3. **What is the length to the divide?**
4. **What is the slope?**
5. **S =**
6. **t_p =**

B. Runoff

- Based on an empirical relationship, peak flow (Q_p) for 1” of excess precipitation:

  Q_p =

  Where A = catchment area (square miles)

3. Construct a unit hydrograph

Multiply Q/Q_p by Q_p to get Q (for each time step)

Similarly multiply t/T_R by T_R to get t.

What is T_R ???

Quick and easy in a spreadsheet. We can call this U(t).

Remember, the unit hydrograph represents runoff generated by 1” of excess precipitation falling uniformly on the catchment.

See Excel Example 2.

4. Convolve unit hydrographs to estimate a storm hydrograph

We first need to develop the design hyetograph.

Example 3: Use the 10-year 6-hour design rainfall event for Layton, UT to develop a design net hytegraph. Assume infiltration losses are 0.1 inches in the first two hours and 0.05 inches afterward.

Example 3B: What is the design net nytegraph if we instead use the SCS method?

Convolution means adding the lagged unit hydrographs that result from each hour of excess rainfall.

The first hour of rainfall generates P_1 U(t) = 0.01 * U(t)

The 2nd hour of rainfall generates P_2 U(t-1) = 0.01 * U(t-1) [lagged one hour]

The 3rd hour of rainfall generates P_3 U(t-2) = 0.18 * U(t-2) [lagged two hours]

Summing everything up gives $Q(t) = \sum_{d=1}^{\min(D,t)} P_d U(t-d+1)$

Where t=time, d=hour of rainfall excess, and D is the duration of rainfall excess.

Example 4: Develop the storm hydrograph for the Hillcrest/Lundstrum Park Neighborhood using the design storm from Example 3 in Layton, UT

Wrap up

1. Physical properties of rainfall=>runoff
2. Estimating the time to rise for a storm event
3. Apply the SCS method to determine Curve Number, runoff, and unit hydrograph
4. Complication: what if there are multiple land use types in a catchment?
5. Convolute unit hydrographs to develop runoff hydrograph
6. How will we use this runoff hydrograph?

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Today's Date: September 27, 2012

Today's Topic: Rainfall / Runoff

Two Minute Feedback on Today's Class

1. What was the most important/useful thing you learned today?

2. What remains unclear (that you would like me to clarify next time)?

3. Anything else that you need to tell me?