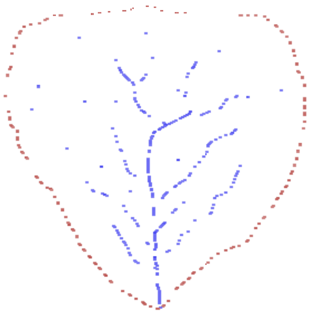
ES322 In-Class Exercise **Watershed Dynamics and Channel Flow Problem**

INTRODUCTION

Watersheds are comprised of a network of fluvial channels that drain runoff and sediment over time. The discharge of a watershed is a function of variables including geology, tectonics, climate, and landuse. All of these factors commonly result in an empirical relationship between discharge and drainage area. Generally speaking, discharge increases as a function of catchment area at a exponential rate depending on the cumulative influencing factors. The map diagram below illustrates a watershed network.

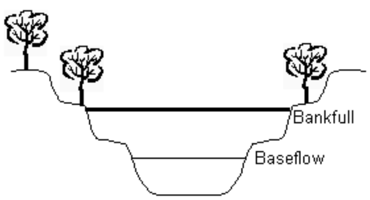


Q = discharge of sediment and water = volume/time

The scaling of discharge and drainage area can be empirically described as: $Q = k(A_d)^c$

where Q is river discharge, Ad is drainage area, and k and c are scaling constants. The variable k is not often illustrative of watershed processes, but the constant c represents the rate at which discharge (Q) increases downstream when compared to drainage area (A_d).

The term "bankfull" was originally used to describe the incipient elevation on the bank where flooding begins. In many stream systems, the bankfull discharge is associated with the stage that just fills the channel to the top of its banks and at a point where the water begins to overflow onto a floodplain.

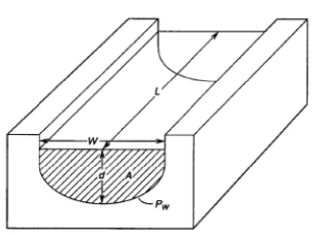


At any given segment of the channel network, a commonly applied methodology for measuring, and estimating, the discharge of a river is based on a simplified form of the continuity equation. The equation implies that for any incompressible fluid, such as liquid water, the discharge (Q) is equal to the product of the stream's cross-sectional area (A) and its mean velocity (u), and is written as:

$$Q = A\,\bar{u}$$

where

- Q is the discharge ($[L^3T^{-1}]$; m^3/s or ft^3/s)
- A is the cross-sectional area of the portion of the channel occupied by the flow ($[L^2]$; m^2 or ft^2)
- $\bar{u}$ is the average flow velocity ($[LT^{-1}]$; m/s or ft/s)
- Cross-sectional Area, A is equal to the depth of the channel x the width (A = d x w)



EXERCISE

The objective of this exercise is to gain knowledge regarding the variables that influence watershed discharge and to develop skills of quantitative problem solving. Let's consider a watershed with a drainage area of 100 mi^2 ($A_d = 100\ mi^2$) and a channel geometry at its outlet with a depth of 4 m (d = 4 m) and width of 20 m (w = 20 m). The channel gradient at the outlet involves an elevation drop of 72 ft over 13.6 miles. For the region, 30 watersheds were analyzed by comparing their drainage areas (A_d) to their bankfull discharges at the outlet, the following relationship was derived as statistically significant:

$$Q_b = 150(A_d)^{0.8}$$

Where Q_b is bankfull discharge in ft^3/sec and Ad is watershed drainage area in mi^2. The coefficient c = 150 and exponent = 0.8; both of which are a function of the local watershed variables including geology, tectonics, climate, and landuse. Using the above equations and relationships, calculate the following parameters (SHOW ALL OF YOUR MATH WORK AND UNIT ALGEBRA).

Draw a sketch of the cross-sectional channel geometry at the outlet (width, depth, cross-sectional area).

Watershed Discharge at outlet in cfs and cms __________ ft^3/sec __________ m^3/sec

Channel flow velocity at outlet in ft/sec and m/sec __________ ft/sec __________ m/sec

Channel gradient at outlet (dimensionless ratio) __________ (ft/ft)

Total Channel Stream Power in watts** __________ watts

*** Note: use your class notes, equation lists or favorite web resource to figure out how to calculate stream power*