CEE3430 Engineering Hydrology

Homework 4. Unit Hydrograph Applications and Snowmelt

Date: 1/31/11
Due: 2/7/11

Objective. After completing this assignment you should be able to:

- determine the design hydrograph of a given frequency for a small watershed accounting for infiltration losses
- use SCS curve number methods to calculate runoff from rainfall
- combine and route watershed hydrographs using unit hydrograph methods
- perform simple snowmelt calculations

1. Bedient 2.11

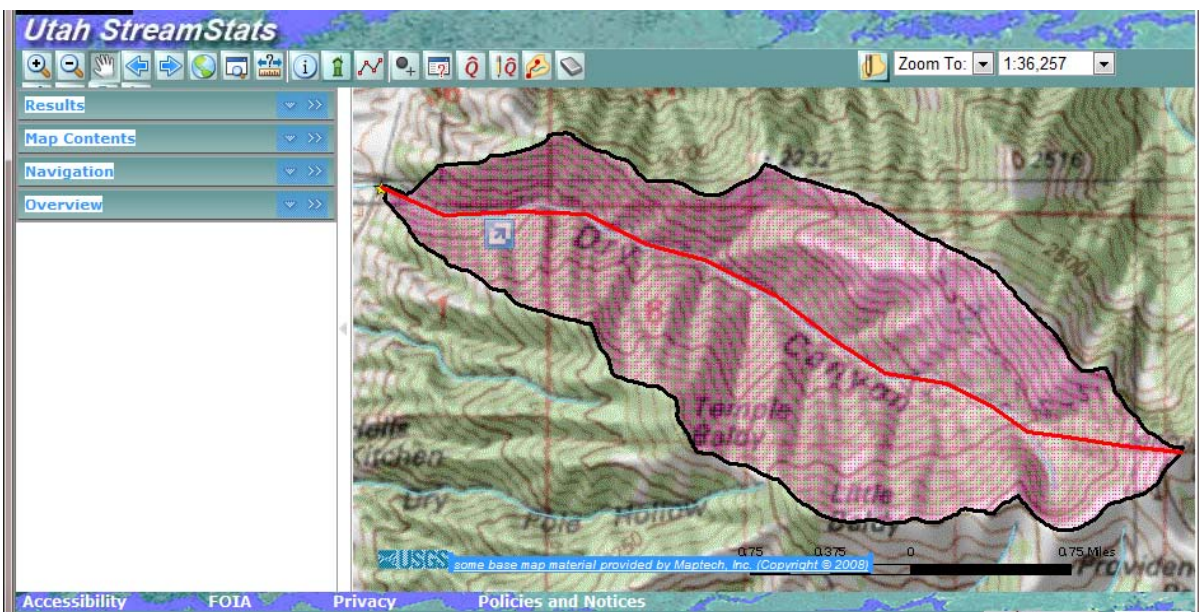
2. Bedient 2.19

3. Bedient 2.20

4. Bedient 2.21

5. Bedient 2.28

6. In previous homeworks you have worked with Logan Dry Canyon Watershed with parameters from streamstats A=3.58 mi^2, L=4 mi, L_{ca}=2 mi.



Calculate an SCS unit hydrograph for this watershed by doing the following

a) Use streamstats to determine the basin characteristics and report the following:
   i. Area covered by herbaceous upland in percent
   ii. Area covered by forest in percent
   iii. Average basin slope
b) Refer to TR55 (http://www.cpesc.org/reference/tr55.pdf) table 2-2d. Assume that the watershed is 60% soil group B and 40% soil group C. Assume that the herbaceous upland is

in fair condition and that the forest is 50% Oak-aspen and 50% Pinyon-Juniper, both in good condition. Assume that the remainder of the area is Desert shrub in Fair condition. Calculate the average CN.

c) Calculate t_p using equation 2-18
d) Take D=0.25 hr, use equations 2-17 and 2-15 to determine T_R and B, and 2-16 to determine Q_p.
e) Plot the SCS triangular unit hydrograph to scale, labeling Q_p, T_R and B
f) Plot the SCS curvilinear unit hydrograph to scale (using data from the spreadsheet on the website), labeling Q_p, T_R and B.
g) Plot the Snyders unit hydrograph from your previous homework.
h) Comment on differences between the 3 unit hydrographs from (e), (f) and (g).

7. Calculate a design hydrograph for Logan Dry Canyon by doing the following
   a) Refer to the NOAA Precipitation frequency data server (http://hdsc.nws.noaa.gov/hdsc/pfds/) and determine annual maximum precipitation depths for a 1 in 100 year storm for durations in increments of 15 min (0.25 hours) out to 3 hours.
   b) Follow the procedure of problem 1.15 d to develop a design storm of 3 hour duration in 15 min steps
   c) Use the CN from problem 6 to calculate S and given the total precipitation P in 3 hours, calculate Q using equation 2-20.
   d) Calculate the initial abstraction (I_a=0.2S) and storm infiltration loss (F=P-I_a-Q). Assume that the initial abstraction occurs at the beginning of the storm and that after that, infiltration losses are uniform across the duration of the storm. Calculate the rainfall excess hyetograph with infiltration and initial abstraction extracted.
   e) Use the excess rainfall hyetograph with SCS curvilinear unit hydrograph (from question 6 f) to calculate and plot the design hydrograph.
   f) Report the peak value from the design hydrograph
   g) Use streamstats to estimate flows using regression equations (button $\hat{Q}$) and comment on differences between the peak flow estimated using the USGS regression equations and the SCS CN methods.

8. Consider a snowpack with snow water equivalent, SWE = 5 cm, density ρ_s = 200 kg/m^3, and temperature T_s= -3 C.
   a) Calculate the depth of the snow
   b) Calculate H_1 (equation 2-35), the heat required to warm the snow to freezing.
   c) Assume that θ_{ret}= 0.03 (3%), calculate H_2 (equation 2-36), the energy required to ripen the snow. [Note that the text incorrectly gives L = 79.8 KJ/kg. L is correctly 79.8 cal/g = 333 KJ/kg]
   d) Calculate H_3 (equation 2-37), the heat required to melt the snow completely.
   e) Equation 2.38 expresses the energy required to melt a given amount of snow

      $\Delta H = (\rho_w L)\ M$ in cal cm^{-2} day^{-1}, where L = 80 cal/g and ρ_w= 1 g/cm^3.

      Now consider the snow melt equation given Table 2-2 for the Montana Rockies M=0.408T_m for T_m in C and M changed to cm/day. Combining this with the equation for ΔH results in $\Delta H = 0.408\ (\rho_w L)\ T_m$ cal cm^{-2} day^{-1} as the energy added to snow each day, based on mean daily air temperature. Given an air temperature of 5 C, calculate the energy added to snow each day based on this equation.
   f) Given the energy added each day calculated in (e), calculate the number of days it would take under these conditions for the snow to first warm (energy from b), ripen (energy from c) and then melt completely (energy from d) assuming a steady temperature of 5 C.