CEE3430 Engineering Hydrology

Homework 8. Hydrographs, Hydrologic Modeling and Routing

Date: 4/9/12
Due: 4/13/12 and 4/23/12

Note. The first part of this test is a repeat of concepts from test 2. This part is due 4/13/12. The balance is due 4/23/12.

Part 1 - Due 4/13/12

1. Consider a watershed with **sandy clay** soil and Green-Ampt parameters given in Mays Table 7.4.1 (page 317). Assume that the soil has initial moisture content equal to residual moisture content. Calculate the following using the Green-Ampt approach.

   a) The maximum infiltration rate (infiltration capacity) after 2 cm of infiltration in cm/hr.
   b) The minimum infiltration rate (infiltration capacity in cm/hr.

   Now consider a storm where 2 cm of rainfall occurs in 3 hours and calculate the following
   c) Time to ponding in hr.
   d) Depth of infiltration excess runoff generated from this storm in cm.

2. Rework problem 1 assuming that the soil has an initial effective saturation s_e =0.5.

3. Consider a watershed similar to Logan Dry Canyon with the following watershed properties
   A=8 mi^2, L=6 mi, L_c=3 mi
   Assume
   C_t=1.5, C_p= 0.8

   a) Find the peak discharge Q_p, the basin lag time t_p, and the time base of the unit hydrograph T_b using Snyder's method. (Follow Mays pages 338-339 and Table 8.4.1.) Find the corresponding duration of rainfall D, and sketch the Snyder unit hydrograph.

   Assume a hydrologic soil group B and land use with curve numbers as follows

Forest-range - herbaceous (fair condition)	65 %	CN=71
Juniper-grass (fair condition)	35 %	CN=58

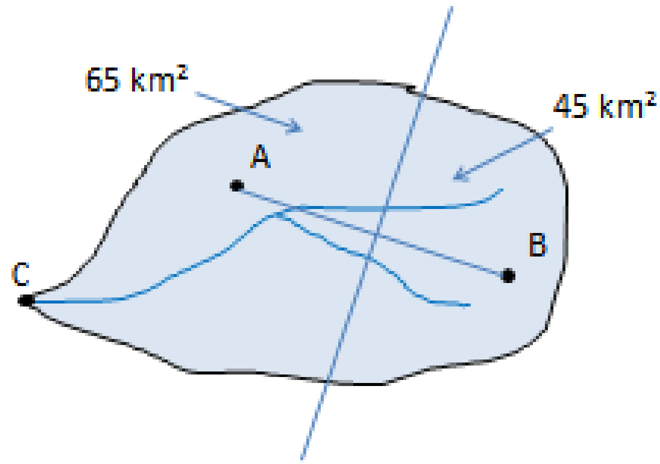
   Assume average antecedent moisture conditions. From the NOAA PDFS website (http://hdsc.nws.noaa.gov/hdsc/pfds) the 100 yr 60 min cumulative precipitation is 1.54 in, 2 hr cumulative precipitation is 1.84 in and 3 hr cumulative precipitation is 1.99 in. On the basis of these the hyetograph for a design storm is

Time	Hour 1	Hour 2	Hour 3
Rainfall	0.3 in	1.54 in	0.15 in

Determine the following

b) Excess precipitation in each time interval
c) Peak discharge based on the Snyder Unit Hydrograph above. Interpolate Unit Hydrograph values to even intervals as needed

4. A 110 km^2 total watershed has two precipitation gages in locations indicated



The cumulative (accumulated) rainfall in each gage is given below

Time (min)	A (mm)	B (mm)
0	0	0
30	0	0
60	10	5
90	25	12
120	30	12
150	30	12

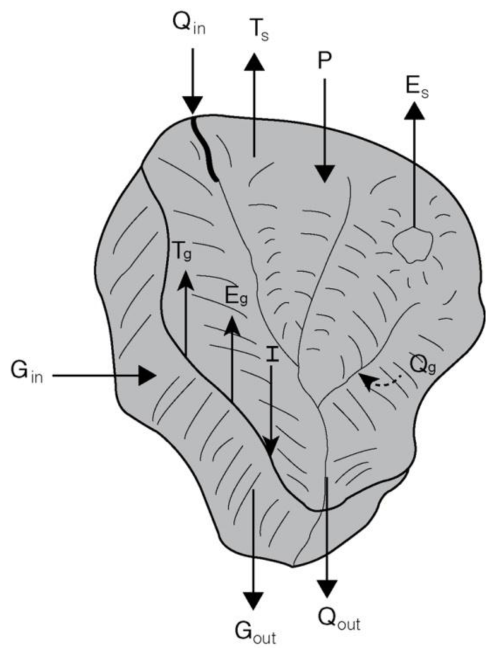
An outlet hydrograph measured at location C is

Time (min)	Discharge at C (m^3/s)
0	20
60	20
120	150
180	120
240	80
360	20

Assume a constant baseflow of 20 m^3/s

a) Calculate the area average total precipitation from this storm
b) Calculate the area average precipitation hyetograph for each 30 min increment from this storm
c) Separate the baseflow from direct storm runoff using the assumed constant baseflow and calculate the volume and depth of direct runoff from this storm
d) Assume a constant rate of abstractions and calculate the ϕ-index for this storm

e) Draw a graph of the 30 min excess precipitation hyetograph for this storm
f) Assume that the ϕ-index calculated in (d) apples separately to the parts of the watershed represented by gages A and B and calculate the total depth of excess precipitation generated in each part of the watershed
g) Calculate the total depth of excess precipitation over the watershed by combining the contributions from each part
h) Explain why your result in (g) may be different from the total depth of excess precipitation obtained in (e)
i) Consider the watershed water budget depicted by the following figure (From Mays 7.1.11). Fill in the following table for the quantities symbolized for the period of data given above. Please use depth in mm for the values



Symbol	Name	Value (mm)
P		
I		
Q_{out}		
Q_g		

Part 2 - Due 4/23/12

1. Solve Part 1, problem 3 above using HEC-HMS. The standard lag referred to in the inputs (and on page 156 of the HEC-HMS manual) is t_p from equation 8.4.1. The peaking coefficient is C_p.

2. Mays 9.2.1

3. Mays 9.2.2

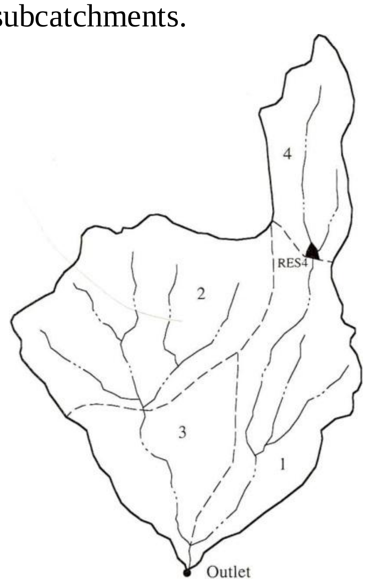
4. Solve Mays 9.2.2 using HEC-HMS

5. Mays 9.3.5

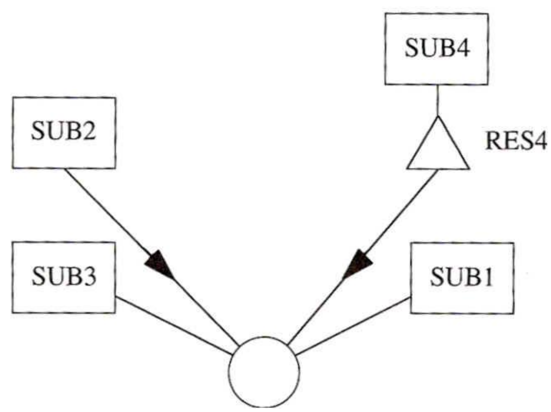
6. Mays 9.3.6

7. This question is adapted from an example in Chow et al. [1988]

   Develop a rainfall-runoff model using HEC-HMS for the Castro Valley Creek catchment, shown below in order to analyze the effects of urbanization. The catchment is divided into four subcatchments.



Castro Valley Creek



Castro Valley Creek Schematic

Subcatchment 4 is undergoing urbanization through development of a new residential area, and a detention reservoir in subcatchment 4 and downstream channel modifications are being investigated, the purpose of which is to reduce the effects of the additional flow resulting from the development. The objective of the problem is to calculate the runoff hydrograph at the catchment outlet for three different conditons: (1) the existing condition throughout the catchment, (2) the existing condition in subcatchments 1 to 3 with subcatchment 4 urbanized, and (3) the same as (2) but with a modified channel and a reservoir in subcatchment 4. Subarea runoff computations are performed using Snyder's synthetic unit hydrograph with rainfall loss rates determined using the SCS curve number method, channel routing is carried out by the Muskingum method, and routing through the reservoir by the level-pool method.

The following table presents the existing characteristics of the subcatchments. The total watershed area is 5.51 mi^2.

Subcatchment	Area (mi^2)	Watershed length L (mi)	Length to centroid, L_c (mi)	SCS curve number, CN
1	1.52	2.65	1.40	70
2	2.17	1.85	0.68	84
3	0.96	1.13	0.60	80
4	0.86	1.49	0.79	70

The parameters for Snyder's synthetic unit hydrograph for the existing condition are C_p = 0.25 and C_t = 0.38. The flood wave travel time (Muskingum coefficient *K)* for the stream reach passing through subarea 3 is estimated as 0.3 h, and the travel time for subarea 1 is estimated as 0.6 h. The Muskingum X has been approximated as 0.2 for each of the two stream reaches.

The design rainfall is a hypothetical 100-year-return-period storm defined by the following depth-duration data.

Duration	5 min	15 min	1 h	2 h	3 h	6 h	12 h	24 h
Rainfall (in)	0.38	0.74	1.3	1.7	2.1	3	5	7

A residential development in subcatchment 4 will increase the impervious area so that the developed SCS curve number will be 85. The unit hydrograph parameters are expected to change to C_t = 0.19 and C_p = 0.5. Modification of the channel through subcatchment 1 will change its Muskingum routing parameters to *K* = 0.4 h and X = 0.3. The detention reservoir to be constructed at the outlet of subcatchment 4 has the following characteristics:

		Reservoir Capacity (acre-ft)	Elevation (ft above MSL)
Low Level Outlet			
Diameter	5 ft		
Cross-sectional area	19.63 ft^2	0	388.5
Orifice Coefficient	0.71	6	394.2
Centerline elevation	391 ft	12	398.2
	(above MSL)	18	400.8
Overflow spillway (ogee type)		23	401.8
Length	30 ft	30	405.8
Weir coefficient	2.86		
Crest elevation	401.8 ft (above MSL)		

Chow, V. T., D. R. Maidment, and L. W. Mays (1988), *Applied Hydrology*, 572 pp., McGraw Hill.