ORDRE DES INGÉNIEURS DU QUÉBEC

NOVEMBER 2011 SESSION

Open book examination
Calculators : only authorized models
Duration : 3 hours

98-CIV-B4 ENGINEERING HYDROLOGY

Question 1 (20 pts)

A time series of maximum annual flows Q of the Noire River covers years 1961-2000. The following statistics were retrieved from this 40-year time series:

Q_{mean} = 550 m^3/s

s = 155 m^3/s

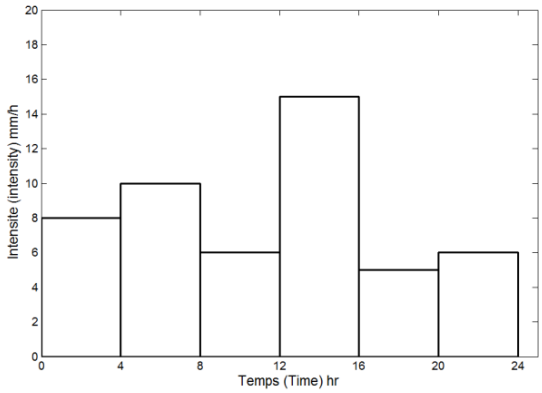
where Q_{mean} is the average of the maximal annual flows and s is the standard deviation.

A histogram plot of the time series confirms that Q follows a normal distribution.

a) Compute the maximal annual flow corresponding to a return period of 100 years. (5 pts)
b) What is the probability that the maximal annual flow will be between 700 and 800 m^3/s? (5 pts)
c) The municipality of Belle Rivière gets flooded when the river flow exceeds 850 m^3/s. Compute the return period associated with this event. (5 pts)
d) A time series of flows of the Noire River measured between 1921 and 1960 was found in archives. Q_{mean} and s of this time series is 520 and 145 m^3/s, respectively. Verify the hypothesis that Q_{mean} computed of the 1961-2000 period is statistically similar to Q_{mean} of the 1921-1960 period. (5 pts)

Question 2 (20 pts)

A raingage recorded the hyetograph below, corresponding to a 24-hour rainfall event:



This rainfall event occurred uniformly over a watershed having a surface area of 295 ha.

The total runoff volume measured at the watershed outlet is 75000 m^3. Base flow in the river draining the watershed was constant at 0.3 m^3/s during the storm. Compute the SCS runoff curve number (CN) of this watershed.

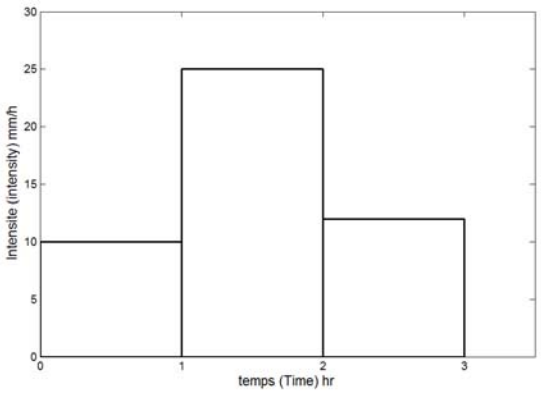
Question 3 (20 pts)

Calculate the net rainfall hyetograph from the total rainfall hyetograph below, using the following infiltration parameters of the Horton model:

f_o = 30 mm/h

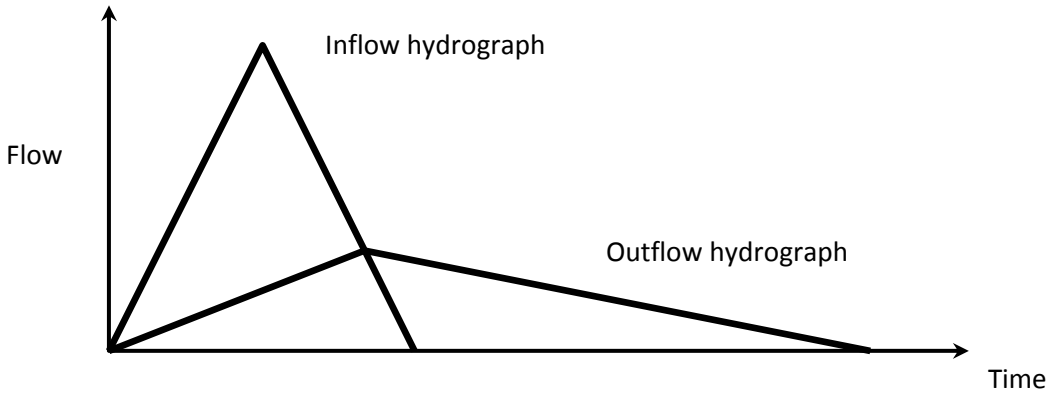
f_c = 5 mm/h

k = 1.5 h^{-1}



Question 4 (20 pts)

The volume of an existing detention basin with vertical walls is 10000 m^3. It is proposed to replace the current outlet by a smaller one because of recurring flooding problems downstream from the basin. Maximum flow at the basin outlet will be 0.5 m^3/s. The inflow and outflow hydrographs are approximated by triangular shapes as presented in the figure below.



For safety reasons, the time to fill/empty the detention basin has been established to 10 hours.

a) What is the maximum peak flow of the inflow hydrograph that the detention basin can accept? Base flow of the inflow hydrograph is 1.5 hour. (10 pts)
b) The watershed that generates the runoff entering the detention basin has an area of 44 ha, a time of concentration of 12 minutes and a runoff coefficient C=0.35. Calculate the return period of the maximum peak flow entering the detention basin. Use the idf curves below for the computations. (10 pts)

$$i = \frac{a}{t + c}$$ t in minutes, i in mm/h

T (years)	c	a (mm/h)
2	13	1778
5	13	2464
10	16	2819
25	24	4318
50	27	4750
100	28	5588

Question 5 (20 pts)

Compute and plot the direct runoff hydrograph resulting from the convolution of the unit hydrograph and the total runoff hyetograph below. What are the peak flow Q_p, time to peak t_p and base flow t_B of the direct runoff hydrograph?

The unit hydrograph is for a net rainfall of 1 cm depth and 3 hour duration.

It is assumed that the initial soil infiltration capacity is 14 mm/h and decreases linearly to reach 2 mm/h after 12 hours.

Unit hydrograph

Time (hours)	HU (m^3/s)
0	0
3	40
6	120
9	90
12	50
15	0

Total rainfall hyetograph

Time (hours)	Precipitation (mm/h)
0h00- 3h00	15.5
3h00- 6h00	4
6h00- 9h00	3
9h00- 12h00	7.5