ORDRE DES INGÉNIEURS DU QUÉBEC

MAY 2019 SESSION

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

14-CI-B3 HYDROLOGY

Question 1 (20 points)
The watershed you are currently working on has a total area of 12 km^2 (as shown on Figure 1). You have been given access to three (3) meteorological stations. At first glance, you seem to notice that a portion of the data is corrupted.

Table 1 Gross rainfall

	i[mm/hr]		
T[min]	Station A	Station B	Station C
0-10	24	54	30
10-20	60	*	75
20-30	30	18	12

a) From the sample of the data presented in Table 1, you must suggest and apply two methods to fill in the missing data. (4 points)
The average rainfall on an annual basis for all stations is within 10% of each other
b) After a bit of hard work by your intern, the corrupted data is recovered (the missing data in your sample in Table 1 is 36 mm/hr).
With the help of Thiessen's polygon method, you must calculate the average gross rainfall for each timestep. (8 points)
c) If the infiltration index is constant and worth 24 mm/hr ($\Phi_{[mm/hr]}$=24mm/hr), you must calculate the runoff depth for each timestep. You must present your results within a hyetogram and identify gross rainfall, runoff depth and the infiltration index. (8 points)

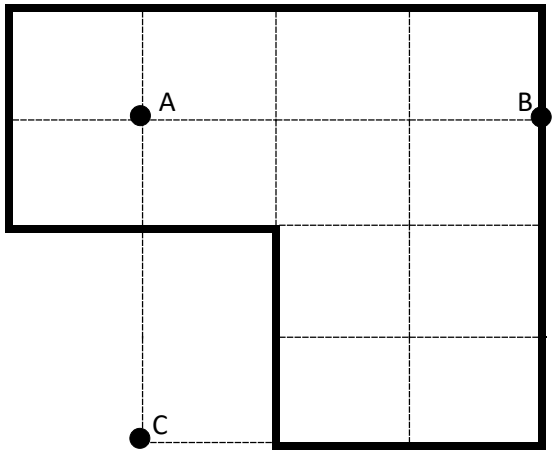

Figure 1 Territory (1km x 1 km squares, total area 12 km^2)

Question 2 (20 points)

The city of Candiac has mandated you for a hydrological study concerning a bridge connecting the city to Delson. The river in question is the La Tortue river and there is a hydrometeorological station just upstream.

You have access to the following data for the station:

$\overline{Q} = 30\ m^3/s$	$\sigma = 10 m^3/s$
Mean	Standard deviation
$\overline{\log(Q)} = 1.455\ m^3/s$	$S = 0.153\ m^3/s$
Mean of the log(Q)	Standard deviation of log(Q)

a) You are in charge of evaluating the flow in the river for a return period of 50 and 100 years presuming a normal distribution; (5 points)
b) Following your recommendation, the client has asked you to evaluate these same return periods but for a log-normal distribution; (5 points)
c) It seems you've peaked your client's interest as he's now looking to better understand the concept of return periods. You must now demonstrate mathematically the risk and reliability associated with a 50 year return period for a hydrological structure that has a total life span of 50 years. (5 points)
d) Following your explanations, the client would like to know the return period to use in order to have a hydrological risk of 5% during an electoral cycle (4 years). (5 points)

Question 3 (15 points)

While working on a project pertaining to water management in the county of Saint-Apex, you are called upon to use the SCS-Curve Number method.

50% of the surface area is covered in pavement, 30% is covered by roofs and 20% are green spaces. The whole watershed is roughly 2 ha. You must identify the infiltration depth at each timestep for the rain presented in Table 2.

Note that the soil is initially very dry before the rain starts and that C_a=0.2

<u>Curve Number</u>

$CN_{pava.} = 98$
$CN_{toit} = 98$
$CN_{vert} = 39$

Table 2 Gross rainfall

t[min]	0-30	30-60
P[mm]	1	5

Question 4 (15 points)

Your intern has produced a unit hydrogram (1h and 1 mm – HU_{1h}) under your supervision and (A) you must validate his work before using said unit hydrogram (see Figure 2). If any corrections to the unit hydrogram are necessary, do them now. (6 points)

Table 3 Flow runoff data following a 3.5mm rain runoff over 1h

t[Hours]	0	1	2	3	4	5	6
Q[m^3/s]	0	10,5	42	31,5	21	10,5	0

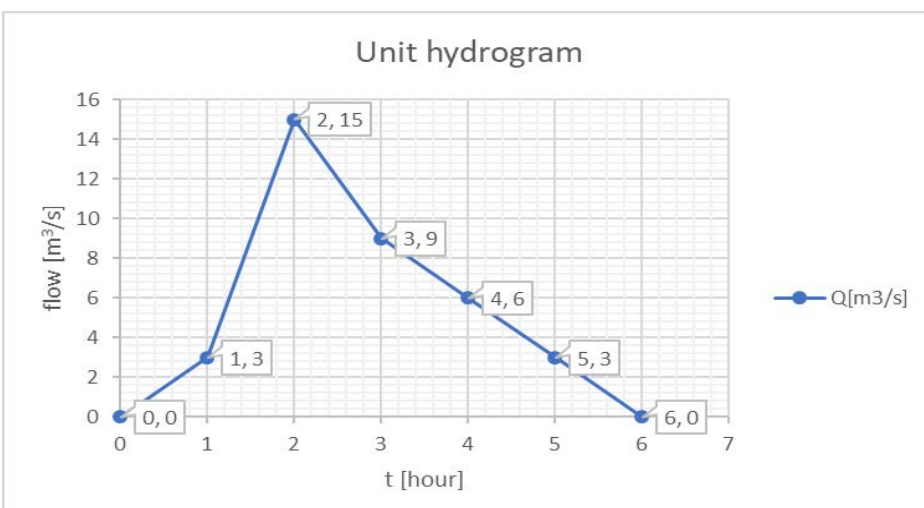

Figure 2 Unit hydrogram produced by your intern based on the data from Table 3

(B) With the help of your corrected unit hydrogram, you must produce the resulting hydrogram for the rainfall runoff presented in Figure 3. Identify what the peak flow is and when it occurs. (9 points).

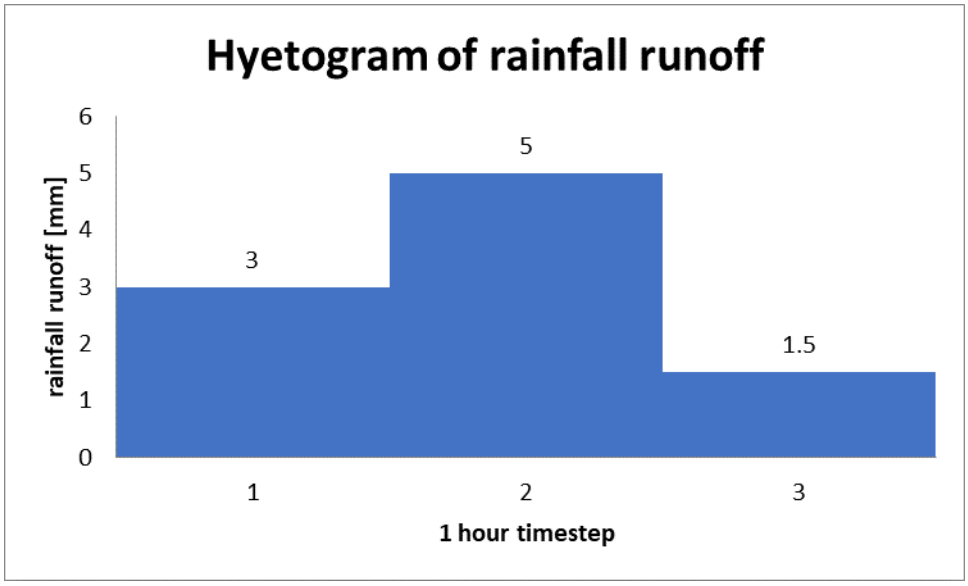

Figure 3 Hyetogram of rainfall runoff

Question 5 (25 points)

By using the Muskingum-Cunge method, you must rout the flow presented in Table 4:

Table 4 Flow coming in to the river segment (I) being studied

t[min]	I[m^3/s]
0	50
30	75
60	200
90	150
120	100
150	50

You have the following data:

1. The average speed for a representative flow is 1.5 m/s;
2. The representative flow for the river is 50 m^3/s;
3. The width of the surface of the river is 30m;
4. The slope of the river is 551×10^{-6} m/m;
5. The distance between the entry and exit point for the river segment is 2.5km.

It is your responsibility to identify the lag time. You may limit your calculations to the time steps presented in Table 4. **In the event that you are unable to calculate the necessary**

components for the required method, you may present an intelligent hypothesis in order to continue and demonstrate the method.

Question 6 (5 points)

You managed to snag a highly sought-after contract and the junior engineer working with you wants to help out on the project.

The water management project covers a watershed of roughly 3000 ha in a rural area with multiple natural reservoirs along a small river that run through most of the territory.

During the start-up meeting, the junior engineer confides in you that he believes the rational method would be quick and efficient for this project.

You must write down the advice you would give him. Be precise and concise.