Université d'Ottawa – University of Ottawa

Faculté de génie – Faculty of Engineering

Département de génie civil – Department of Civil Engineering

uOttawa

L'Université canadienne
Canada's university

Date: Wednesday, October 19, 2016

Duration: 80 Minutes

Location: STE G0103

<u>Non-programmable calculators only</u>

Question 1. Multiple choice and short answer questions (use <u>answer booklet</u>) [10 Marks]

1. The hypsometric curve is a description of (a) the relation between stream order and the proportion of the drainage area associated with that stream order; (b) the cumulative relation between elevation and area within (time of travel) isochrones; (c) the cumulative relation between elevation and area within elevation intervals; (d) the relation between elevation and rainfall intensity within elevation intervals. **Answer=b**
2. When using Manning's equation for open-channel flow, it is common to assume that the hydraulic radius is equal to (a) the channel width; (b) one-fourth of the depth, D/4; (c) the square root of the wetted perimeter; (d) the depth of flow. **Answer=d**
3. Which one of the following is not a factor in estimating Manning's roughness coefficient? (a) Height of channel vegetation; (b) degree of stream meandering; (c) regularity of the channel cross sections; (d) channel slope; (e) all of the above are factors. **Answer=d**
4. Which one of the following is not a factor in controlling times of concentration of watershed runoff? (a) Drainage density; (b) roughness of the flow surface; (c) rainfall intensity; (d) flow lengths; (e) all of the above are factors. **Answer=e**
5. Which one of the following responses is not true? Probability is a scale of measurement that can be expressed as a percentage; (b) that can be used only with discrete random variables;

(c) that ranges from 0 to 1; (d) that provides a basis for making decisions under conditions of uncertainty; (e) that is used to describe the likelihood of an event. **Answer=b**

6. A mass function is used with (a) a cumulative density function; (b) continuous random variables; (c) probability density functions; (d) discrete random variables. **Answer=d**
7. Which one of the following responses is not true? For a probability mass function, the probability of an event or probabilities of all possible outcomes must (a) be less than or equal to 1; (b) sum to 1; (c) equal an integer value; (d) be greater than or equal to 0. **Answer=c**
8. Assume that the discrete random variable *X* can take on values of 2, 4, 6, and 8, with probabilities of 0.3, 0.2, 0.4, and 0.1, respectively. At *X* = 4, the value of the cumulative mass function is (a) 0.0; (b) 0.2; (c) 0.5; (d) 0.9. **Answer=c**
9. If the density function $f(i)$ of the infiltration rate i is 2.5 for i from 0 to 0.4 in./hr and 0 otherwise, then the probability that i is between 0.15 and 0.3 in./hr is (a) 0.15; (b) 0.30; (c) 0.375; (d) 0.4; (e) none of the above. **Answer=c**
10. The skew of a distribution of measured peak flood flow rates would reflect (a) the symmetry of large and small flood flows about the mean; (b) the closeness of the flood peaks to the mean; (c) the uniformity of the distribution of flood peaks; (d) the magnitude of the mean flow; (e) none of the above. **Answer=a**

Question 1. [20 Marks]

The water balance of a water body is function of rainfall (P), streamflow into the water body (Q), surface runoff (Q_r,), and subsurface runoff (Q_s)· Outflow from the water body could be evaporation (E), streamflow discharge from the water body (Q_0**)** and subsurface seepage losses (Q_d):

$$(P + Q + Q_r + Q_s) - (E + Q_o + Q_d) = \frac{dS}{dt}$$

The following table gives the monthly total precipitation (P), the monthly average streamflow into (Q) and out of (Q_0) a lake, and the net seepage ($Q_s - Q_d$) for a lake with a surface area of 0.5 miles 2 (1 mile =5280ft; 1ft=12in)

Month	P (in.)	Q (ft^3/sec)	Q_o (ft^3/sec)	$Q_s - Q_d$ (ft^3/sec)
April	3.0	31	30	−0.8
May	4.2	36	34	−1.8
June	3.8	34	35	2.1
July	4.9	30	32	3.6
August	4.0	27	30	4.8
September	4.0	26	29	4.6

Find the evaporation losses (in., in./day) using the water-budget equation, assuming that surface runoff (Q_r) is negligible and that the storage does not change.

Solution

$$E = \frac{ds}{dt} + P + Q + Qr + Qs - Q0 - Qd = P + Q - Q0 - (Qs - Qd)$$

Conversion factor between in/mon and ft^3/s:

For a month of 31 days: $1\frac{1in}{mon} = \frac{1}{12} ft * 0.5 * 5280 * \frac{5280}{31*24*3600} = 0.43 ft3/s$

Month	ndays	Conversion factor ft3/s to in/mon	Concersion factor in/mon to ft3/s	P(in)	P(ft3/s)	Q(in)	Q(ft3/s)	Q0(in)	Q0(ft3/s)	Qs-Qd (in)	Qs-Qd (ft3/s)	P+Q-Q0-(Qs-Qd), in/mon	P+Q-Q0-(Qs-Qd), ft3/s
April	30.0	2.2	0.45	3.0	1.3	13.5	31.0	13.0	30.0	-0.3	-0.8	3.8	1.7
May	31.0	2.3	0.43	4.2	1.8	15.7	36.0	14.8	34.0	-0.8	-1.8	5.9	2.5
June	30.0	2.2	0.45	3.8	1.7	14.8	34.0	15.2	35.0	0.9	2.1	2.5	1.1
July	31.0	2.3	0.43	4.9	2.1	13.0	30.0	13.9	32.0	1.6	3.6	2.5	1.1
August	31.0	2.3	0.43	4.0	1.7	11.7	27.0	13.0	30.0	2.1	4.8	0.6	0.3
September	30.0	2.2	0.45	4.0	1.8	11.3	26.0	12.6	29.0	2.0	4.6	0.7	0.3
										Evaporation per month		2.6	1.2
										Total evaporation		15.9	1.2

Question 2. [25 Marks]

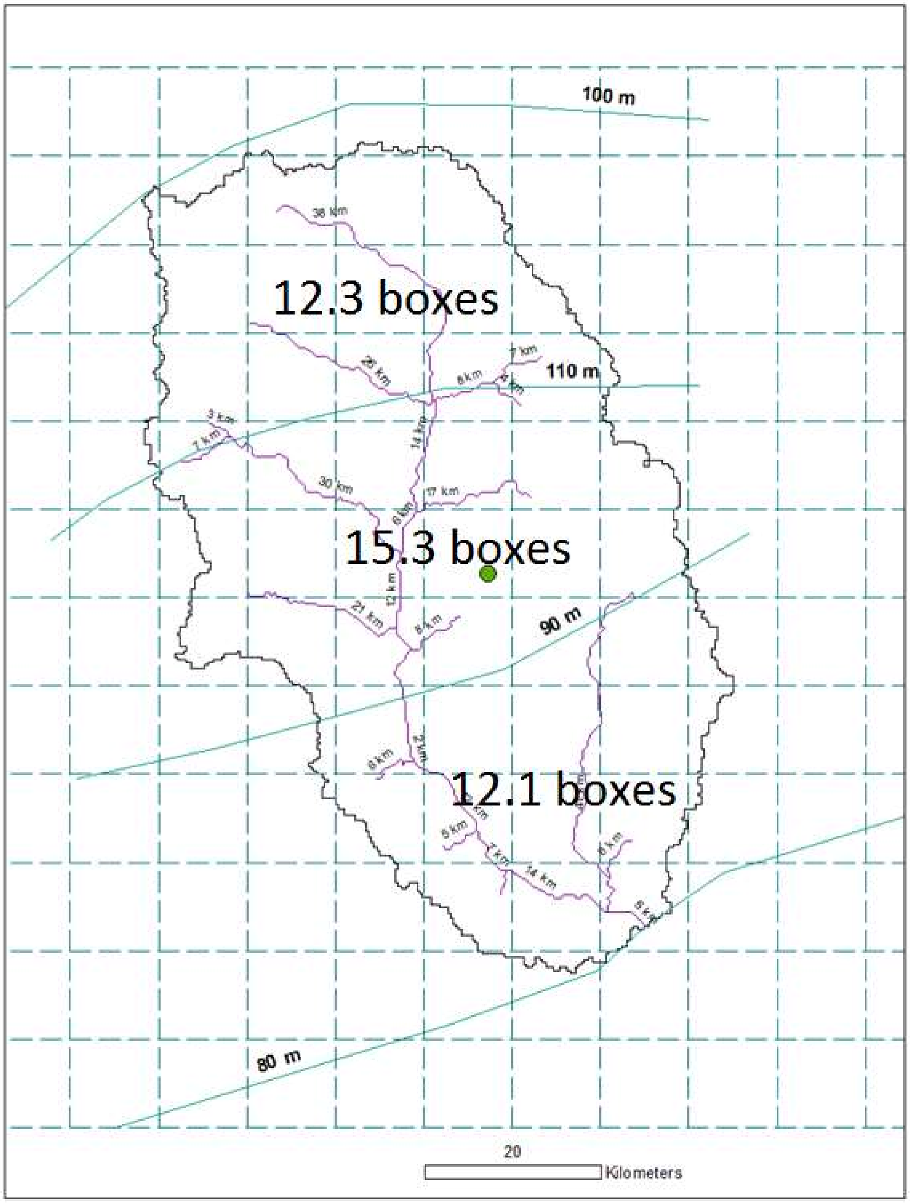
Illustrated in Figure 1 is a watershed with a perimeter of 414 km, find:

a) The standardized Hypsometric curve

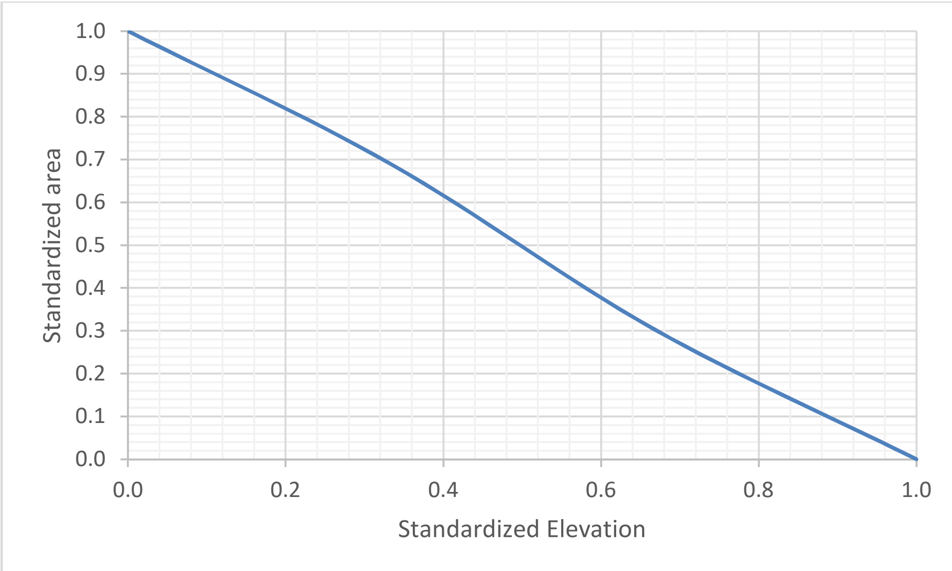
b) Find the circularity ratio, F_c, and the circularity ratio, R_c.

c) Find the travel time of the watershed assuming that the min channel is rectangular, is 200m wide and have a water depth of 3m and has a manning coefficient of 0.025. Use the average slope of the main channel.

Solution



Lower Altitude	Higher Altitude	Boxes	Area	Standardized Elevation	Standardized ara
80.0	90.0	12.3	39.7	0.0	1.0
90.0	100.0	15.3	27.4	0.3	0.7
100.0	110.0	12.1	12.1	0.7	0.3
110.0	120.0	0.0	0.0	1.0	0.0



b) Perimeter = 414km; Area=3970;

$$Fc = \frac{P}{\sqrt{4\pi A}} = \frac{414}{\sqrt{4\pi * 3970}} = 1.85$$

$$P = 414 \rightarrow R = \frac{P}{2\pi} \rightarrow A0 = \pi\left(\frac{P}{2\pi}\right)^2 = \pi\left(\frac{414}{2\pi}\right)^2 = 13646$$

$$Rc = \frac{A}{A0} = \frac{3970}{13646} = 0.290$$

d) Channel length= 36+14+12+6+2+12+7+14+5=108km; upstream altitude is about 108m; outlet altitude is 80m; $s = \frac{108-8}{108000} = 0.000259$

$$Rh = \frac{A}{P} = \frac{200 * 3}{200 + 2 * 3} = 2.91m$$

$$Q = \frac{1}{n} Rh^{2/3} s^{0.5} = \frac{1}{0.025} 2.91^{2/3} 0.000259^{0.5} = 13.13m3/s$$

Question 2 [25 Marks]

A farmer maintained records of the number (N) of times per year that flow in a specific irrigation canal exceeded its capacity.

1980	0	1984	0	1988	0	1992	0
1981	0	1985	5	1989	0	1993	0
1982	3	1986	0	1990	6	1994	0

1983	1	1987	0	1991	0	1995	1

1. Using the concept of relative frequency, what is the probability that in any one year the capacity will be exceeded (a) three times and (b) at least five times?
2. We assume that the channel has failed in a given year whenever it is flooded once within the year. Considering a life span of 15 years, calculate the reliability and the risk of the channel.
3. What intervention can the farmer do on the channel to improve its reliability? Provide two examples of interventions.

Solution

1) **a) 1/16=0.0625 (three times) or (3/16=0.1875); b) 2/16=0.125**
2) **p=5/16; reliability=$(1-5/16)^{15} = 0.03623$; risk=1-reliability=0.9963**
3) **Increase channel width or depth; improve bank material and decrease n; build storages upstream**

Question 3. [20 Marks]

Assuming a lognormal distribution, make a frequency analysis of the January rainfall, *P*, of Pigeon Lake for the period 1954-1971. Plot the data using the Weibull plotting-position formula. Based on the frequency curve, estimate

a) The 100-yr January rainfall
b) The probability that the January rainfall in any one year will exceed 7 in.

Year	P (in)	Year	P (in)
1954	6.43	**1958**	3.59
1955	5.01	**1959**	3.99
1956	2.13	**1960**	8.62
1957	4.49	**1961**	2.55

Solution:

Year	Rank	P (in)	Ln(P)	Weibul
1960	**1**	8.62	2.154085	0.111111
1954	**2**	6.43	1.860975	0.222222
1955	**3**	5.01	1.611436	0.333333
1957	**4**	4.49	1.501853	0.444444
1959	**5**	3.99	1.383791	0.555556
1958	**6**	3.59	1.278152	0.666667
1961	**7**	2.55	0.936093	0.777778
1956	**8**	2.13	0.756122	0.888889

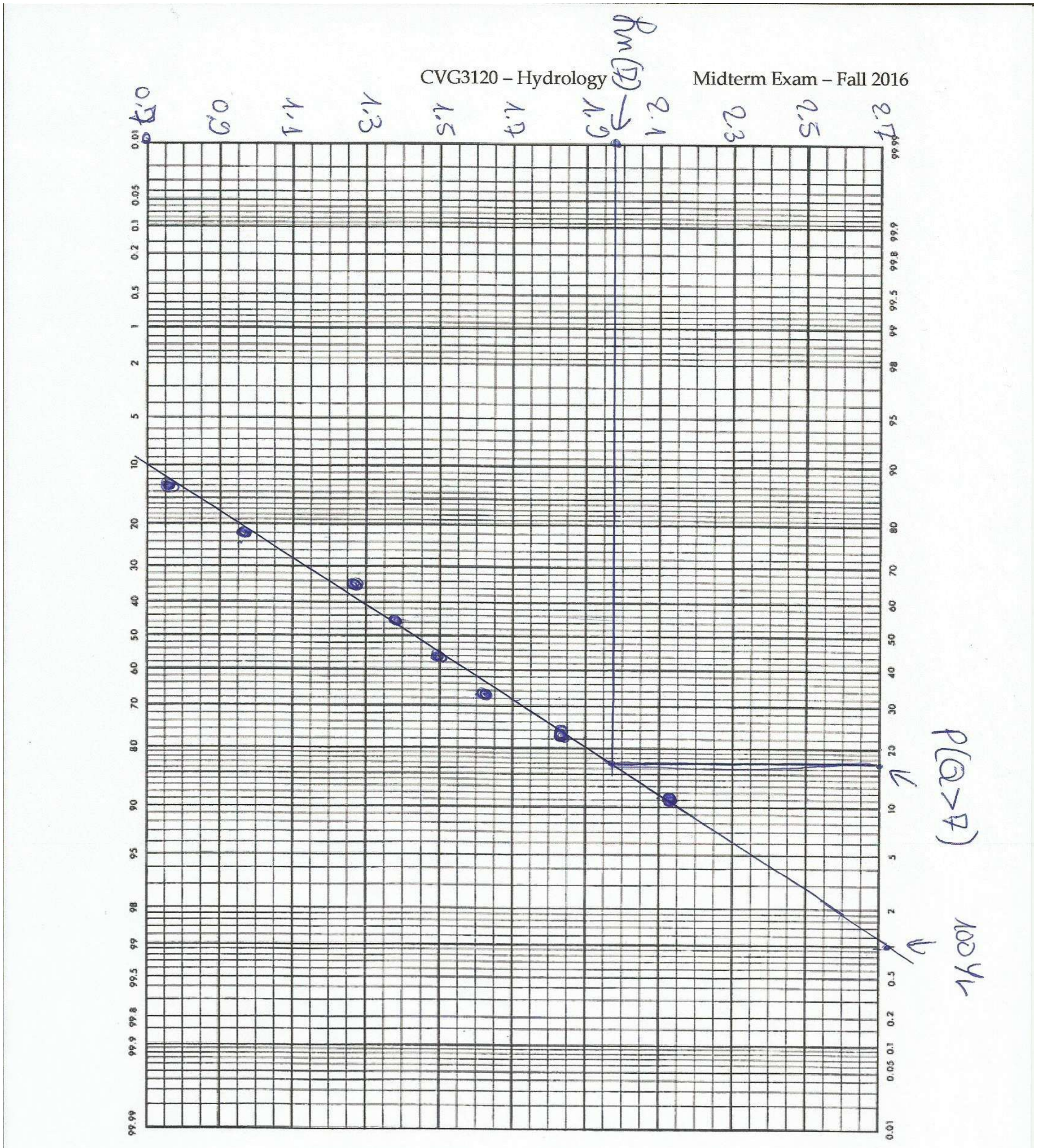


Figure 2: normal probability paper

a) Q100=exp(2.71)=15.03

b) Ln(7)=1.96; P(X>7)=0.17