GX698

OLLSCOIL NA hÉIREANN, GAILLIMH
NATIONAL UNIVERSITY OF IRELAND, GALWAY

SUMMER EXAMINATIONS 1999

B.E. DEGREE (CIVIL) EXAMINATION - ENGINEERING HYDROLOGY (EH402)

Examiners: Professor P.E. O'Connell
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Time allowed is three hours

Attempt *five* questions. All questions carry equal marks.

1. Write brief notes on any five of the following:

   (a) The role of water vapour in the earth's hydrological and energy cycles.

   (b) The effect of hydrogen bonding in the water molecules on the behaviour and properties of water.

   (c) Global warming and its effect on the Irish climate.

   (d) The difference between absorption of water and adsorption of water by soils.

   (e) Measurement of rainfall

   (f) Thin plated weirs versus short crested (e.g. Crump) or broad crested weirs for river flow measurement

   (g) Partial area theory of runoff formation.

   [4 marks each]

2. (a) State the requirements of a good quality river flow gauging site *[4 marks]*

   (b) Draw a sketch of the velocity profile of river flow, between the bed and the surface. What practical use is made of velocity measured at 20%, 60% and 80% of the depth? *[4 marks]*

   (c) Water level in a lake falls linearly from 1.2 m above the crest of an outflow control weir to 1.0 m above the crest during a 24 hour period. The weir is a Crump Weir ($Q = 1.96\ B\ H^{3/2}$), with crest length B = 10 m. Calculate the mean daily flow for that day in m^3/s.
   [8 marks]

   (d) Explain what is meant by a flow duration curve and give an example of where it might be useful in practice *(4 marks).*

3. (a) In the context of soil moisture define the following terms
   (i) Soil moisture tension
   (ii) pF
   (iii) Soil moisture deficit (SMD)
   (iv) Penman's root constant. *[4 marks]*

   (b) The following table shows the values of measured rainfall and potential evaporation, PE, calculated by the Penman method, at the climatological station at Casement Aerodrome during the dry year of 1975. *[The same data are tabulated in the attached calculation sheet].*

   Assuming zero soil moisture deficit at the end of March, calculate actual SMD and actual evaporation for the months of April to September inclusive for both grassland and woodland areas. *[12 marks]*

   (c) Calculate also the areal values of SMD and actual evaporation assuming that 60% of the land is grassland, 20% is woodland and 20% is riparian. *[4 marks]*

Month	Jan	Feb.	Mar.	April	May	June
PE (mm)	14.7	15.8	28.9	55.2	76.6	107.7
Rainfall (mm)	121.9	20.0	31.1	48.2	44.3	5.6

July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
97.6	78.5	52.8	22.7	8.5	3.0	562.3
36.4	30.0	102.5	47.3	47.6	38.2	573.1

4. In a particular reservoir/lake the relationships between outflow Q, lake water level H and lake storage S can be expressed as follows, in all cases for $H \geq 85$ m:

$$Q = 19.62\,(H - 85)^{3/2} \quad m^3/s$$

$$S = 5.0\,(H - 85) + 0.175\,(H - 85)^2 \text{ million } m^3 \quad \text{so that}$$

$$S = 0.6874\,Q^{2/3} + 0.0033\,Q^{4/3} \text{ million } m^3$$

Starting with a water level of 85.5 m use the piecewise linear reservoir routing equation

$$Q_t = C_0\,Q_{t-1} + C_1\,I_t + C_2\,I_{t-1}$$

to determine the lake outflow corresponding to the following sequence of inflows, expressed as mean daily flow rates, in m^3/s: 5.1, 16.3, 27.5 and 23.7. *[16 marks]*

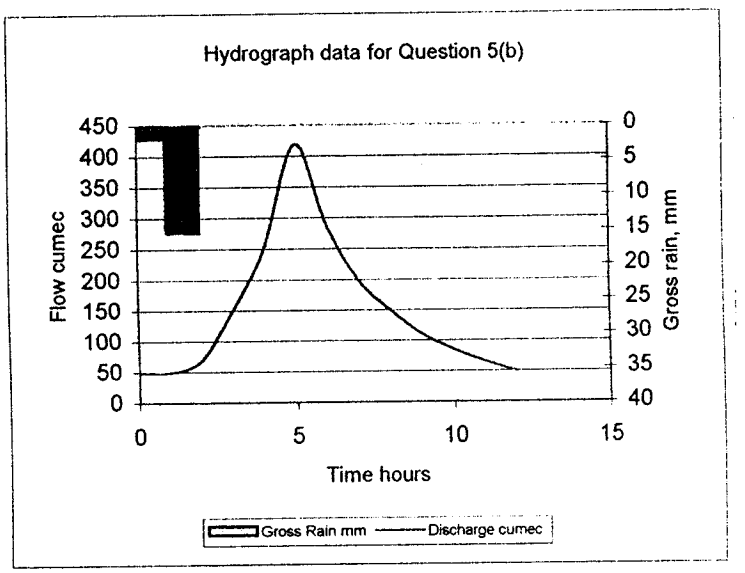
Calculate also the corresponding water levels *[4 marks]*

5. (a) With reference to either the O'Donnell model or the UCG-SMAR model explain how a simple lumped conceptual rainfall runoff model might be formulated. *[8 marks]*

(b) (i) Using the rainfall and discharge data supplied below derive a 1 hour unit hydrograph, 1UH. The catchment area is 489 km^2. Make any simplifying assumptions you feel are necessary. *[Note that the same data are tabulated on the attached calculation sheet].* *[8 marks]*

(ii) Hence obtain the peak flood runoff corresponding to three successive hourly rainfalls of 3.5 mm, 19.9 mm and 8.4 mm assuming a runoff percentage of 60%. *[4 marks]*

Time hours	Gross Rain mm	Discharge cumec
0	1.9	50
1	15.4	50
2		70
3		150
4		250
5		420
6		290
7		200
8		150
9		110
10		85
11		65
12		50



The above data are also supplied in the attached worksheet.

6. (a) Calculate the Probability Weighted Moments M_{100}, M_{110} and M_{101} from the following small sample of annual maximum floods, in m^3/s,

85 , 97 , 68 , 54 , 81 *[7 marks]*

(b) (i) If for a particular annual maximum flood series the values of M_{100}, M_{110} and M_{101} are 11.69 , 7.11 and 4.58 respectively, all in m^3/s, calculate an estimate of the flood quantile of 50 year return period assuming that an Extreme Value Type 1 distribution (EV1) is appropriate. *[5 marks]*

(ii) List the main sources of errors in such an estimate. *[2 marks]*

(iii) What is the risk, r, that a 50 year return period value is exceeded at least once in any 50 years? *[2 marks]*

Question 6 continued overleaf.../

(c) A short sequence of peaks over a threshold of 50 m^3/s occurring over a 4 year period are as follows:

54.0 62.1 79.7 51.2 89.3 95.2 72.8

Making any reasonable assumptions necessary calculate from these data an estimate of mean annual flood $\bar{Q}$ for use in a regional flood frequency estimation scheme in which

$Q_T = \bar{Q}.X_T$ and X_T = Regional growth factor $Q_T/\bar{Q}$ *[4 marks]*

7. (a) (i) Outline the major issues involved in a water resources investigation *[7 marks]*

(ii) List some of the main analysis techniques that might be used in such an investigation. *[3 marks]*

(b) (i) A probability plot of annual minimum flows for the River Barrow at Levitstown is attached. Comment on the wisdom, or otherwise, of a proposal to extract 50000 m^3/day from the river at this point for a regional water supply scheme. *[5 marks]*

(ii) A table of mean daily flows for the same gauging station for the dry year of 1976 is shown. What volume of stored water would be required to sustain a demand flow of 250000 m^3/day during that year? *[5 marks]*

8. (a) State briefly your understanding of the roles of the Flood Studies Report (1975) and the Flood Estimation Handbook (1999) in flood hydrology in these islands.*[5 marks]*

(b) Publications such as FSR and FEH provide a variety of equations for mean annual flood $\bar{Q}$ for example:

$$\bar{Q} = 0.67\, A^{0.77}$$

$$\bar{Q} = 0.00042\, A^{0.95}\, Fs^{0.22}\, G^{1.18}\, \bar{R}^{1.05}\, W^{-0.93}\, S^{0.19}$$

When is it permissable to used such equations? What is their main disadvantage and, in the context of a large project, what are the alternatives? *[5 marks]*

(c) FSR and FEH both recommend that for flood design calculations by the design rainfall-unit hydrograph procedure that the unit hydrograph, in the case of ungauged catchments, be triangular in shape. Why is it

(i) necessary
(ii) permissable

to adopt such a simple shape? *[5 marks]*

(d) In the design rainfall-unit hydrograph method for design flood calculation what are the two weakest links? *[5 marks]*

9. Answer parts (a) and (b)

(a) A well installed in a confined aquifer is pumped at a rate of 0.3 m^3/minute. Drawdowns are recorded at an observation well located 35 metres away, and are plotted against time on semi-log paper. A best-fit line is drawn through the data points. The line goes through the points (t = 10 minutes, s = 0.4 metres) and (t = 100 minutes, s = 1.0 metres).

(i) Plot these points on the semi-log paper provided (time on the log axis) and determine values of t_0 and Δs. *[2 marks]*

(ii) Calculate T in m^2/minute for the aquifer *[4 marks]*

(iii) Calculate S for the aquifer *[4 marks]*

(b) A confined aquifer is 75 metres thick. The hydraulic conductivity of the aquifer is estimated to be 10^{-3} m/s, and the storativity is estimated to be 10^{-5}.

(i) What is the pumping rate recommended for the test if it is desired that there be an easily measured drawdown of at least two metres within the first day of the test at an observation well located 64 metres from the pumping well? *[7 marks]*

(ii) Give three assumptions about the aquifer properties (not including that the aquifer is confined) that are required for the analysis used. *[3 marks]*.