OLLSCOIL NA hÉIREANN, GAILLIMH
NATIONAL UNIVERSITY OF IRELAND, GALWAY

B.E. Degree – Civil Engineering
Environmental Engineering

EH 407 – Engineering Hydrology II

SUMMER EXAMINATIONS 2003

Examiners: Professor K.J. Beven
Professor C. Cunnane

Time allowed: Two hours
Attempt four questions

1. (a) The relationships between lake water level, storage S, discharge Q and the quantities $S \pm Q\Delta T/2$ for a particular lake are shown in the diagrams overleaf. The lake has surface area $A(H) = 3.0 + 0.25\ (H-120)\ km^2$ and its outflow discharge is controlled by a Crump weir with crest level = 120 mOD and width B = 8 m.

Taking ΔT = 8 hours, verify by calculation the values of $S \pm Q\Delta T/2$ and S shown by the letters A, B and C on the diagrams. *[3 marks]*

(b) The first line of a Puls forward routing through this lake is as follows where initial water level was specified as 120.5 m.

Time hours	Inflow m3/s	$\Delta t(I_t+I_{t+1})/2$	S-QΔt/2 mill. m^3	S+QΔt/2 mill. m^3	H_t mill. m^3	Q_t m^3/s
0	75	2.592	1.45	4.042	120.5	5.54
8	105					
16	150					

Calculate the water levels and discharges for times t = 8 hours and t =16 hours. *[7 marks]*

(c) Calculate also the water level and discharge for time t = 8 hours by the piecewise linear reservoir method *[2.5 marks]*

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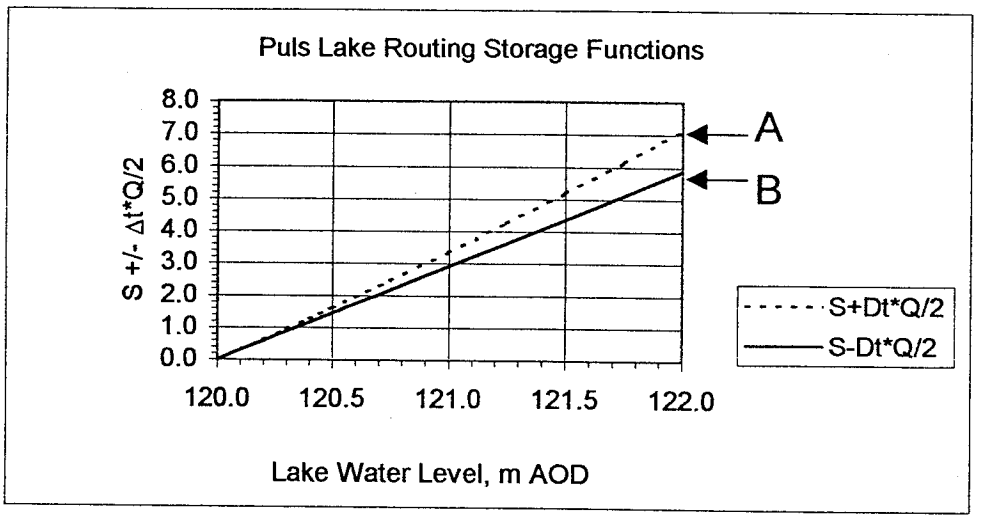
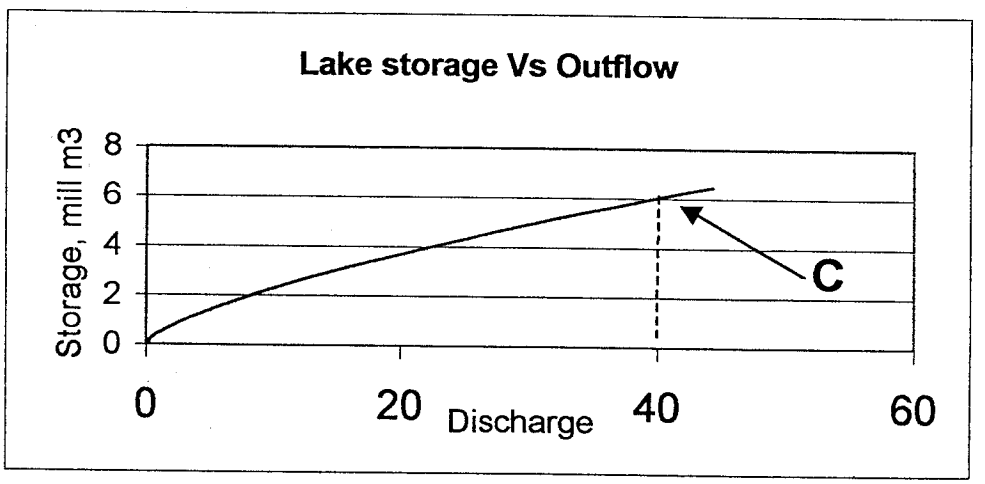
Diagrams for Question 1



A larger working version of this diagram is appended.



2. (a) Which of the attributes "black box", "conceptual" or "physically based" apply to the following hydrological models.

(i) SHE (Système Hydrologique Européen)
(ii) UCG-SMAR (Soil moisture, Accounting and Routing model)
(iii) Unit hydrograph.

Which, if any, of these is a distributed model? *[4 marks]*

(b) Determine the ordinates at one hour intervals of the UK FSR/FEH 1 hour triangular unit hydrograph for a catchment whose area is 60 km^2 and time to peak is $T_p = 5$ hours. *[3 marks]*

Hence determine the ordinates of the corresponding 2 hour unit hydrograph (2UH) by using the S-curve method and compare these graphically with the ordinates of the triangular 2UH obtained by use of the expression

$$T_p' = T_p + (\frac{\tau - 1}{2}) \qquad \textit{[5.5 marks]}$$

3. (a) Outline the two main approaches available for determination of a design flood and state the advantages (perceived or otherwise) and disadvantages of each method. *[4 marks]*

(b) In the UK FSR/FEH unit hydrograph for ungauged catchments explain why the base length T_B must be 2.52 T_p where T_p = time to peak. *[2 marks]*

(c) (i) Determine the gross rainfall depth of a design storm to be used in the UK FSR/FEH unit hydrograph method of design flood determination for the following circumstances:

Return period of required design flood = 25 years

2 day R_5 = 60 mm, 60 min R_5 = 15 mm
Mean annual rainfall = 1300 mm R_{smd} = 45 mm
Catchment area = 120 km^2, Channel Length = 14 km
Channel slope = 8 m/km, Urban fraction = 0.0
Soil index G = 0.36 *[5 marks]*

(ii) Determine also the corresponding net areal depth over the catchment of this design storm. *[1.5 marks]*

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4. (a) Explain briefly what is understood by the catchment descriptors : BFI, FARL, HOST. *[3 marks]*

(b) Discuss briefly the process of interception in catchment hydrology and explain the role of the constituent parts of the Merrian equation, expressed in the usual notation

$$I_{INT} = S_v[I - e^{-P/S_v}] + K.P$$

What effect does interception have on the water resources yield of a catchment?

[4 marks]

(c) Define the terms: field capacity, wilting point, soil moisture deficit and pF.

A grassland portion of a catchment had a soil moisture deficit of 85 mm at the end of July in a particular year. If the August potential evaporation and rainfall were 70 mm and 45 mm respectively determine the actual evaporation for that month. *[5.5 marks]*

5. (a) The regional average values of coefficient of variation and coefficient of skewness of annual maximum flood series in a region are 0.4 and 1.95 respectively. Using the Pearson Type III distribution determine the flood magnitude-return period (Q-T) relation for a catchment in the region whose mean annual flood is 75 m^3/s and display this relation on an EV1 type plot. *[6 marks]*

(b) The values of L-Cv and L-Skewness at three gauging sites in the same region are

Site No	L-Cv	L-Skewness
1	0.196	0.295
2	0.343	0.182
3	0.290	0.401

Using the GLO distribution determine the flood magnitude-return period (Q-T) relation for a catchment whose median annual flood is 70 m^3/s and display this relation on a logistic type plot where $y_L = \ln T$. *[6.5 marks]*

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6. (a) Show that in an ideal aquifer which is being pumped from a single well that drawdown s, at distance r from the well, can be expressed as a linear function of log t where t is the time elapsed since the commencement of pumping.

[3 marks]

Hence show that the expressions for aquifer transmissivity T and storativity S, in the Jacob time drawdown methods, are

$$T = \frac{2.30Q}{4\pi As} \text{ and } S = \frac{2.25Tt_o}{r^2}$$

respectively

[5 marks]

(b) A well is being pumped at a rate of 12 m^3/min and the following drawdowns were observed 2 days after commencement of pumping.

Distance from pumping well (m)	9	20	115
Drawdown (m)	8	7	5

From these data determine values of the aquifer parameter T and S.
[Note: Semi-log paper is attached].

What assumptions are implied in this method?

[4.5 marks]