GX698

OLLSCOIL NA hÉIREANN, GAILLIMH
NATIONAL UNIVERSITY OF IRELAND, GALWAY

SUMMER EXAMINATIONS 2000

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) Chemical composition of precipitation/acid rain.
(b) Effect of afforestation/deforestation on water resources.
(c) The role of water vapour in the Earth's hydrological and energy cycles.
(d) Climate change and/or El Niño.
(e) Horton's theory of runoff formation.
(f) The process of infiltration.
(g) Use of radar for rainfall measurement.

2. (a) In the context of hydrometry expalin what is meant by
(i) hydraulic controls and their effect on the rating curve
(ii) dilution gauging.

(b) What advantage(s) has a Crump weir ($Q = 1.96BH^{3/2}$) over a broad crested weir ($Q = 1.71BH^{3/2}$)?

(c) A conservative tracer solution of concentration 390 mg/litre is added to a river at its centreline at a constant rate of 2 litres/s. Concentration in the river water at a point 1500m downstream is found to reach a steady state of 0.040 mg/litre after 30 minutes.

If the background concentration is 0.0002 mg/litre determine the rate of flow Q in the river in m^3/s.

3. (a) In the context of moist air explain the following: Vapour pressure, psychrometric constant, dew point, relative humidity.

(b) If the dew point temperature of air is 8°C and its dry bulb temperature is 15 °C calculate relative humidity and wet bulb temperature.

(c) How much energy, in kJ/m^2/day, is required to evaporate 10mm water/day when water temperature is 21 °C ?

(d) Explain very briefly what the quantities r_s and r_a represent in the Penman - Monteith equation for evaporation, namely:

$$\lambda E = \frac{\Delta H + \rho c(e_a - e_d)/r_a}{\Delta + \gamma[1 + (r_s/r_a)]}$$

and give some typical values for these.

5. (a) Define: (i) Field Capacity, (ii) Soil Moisture Deficit (SMD).
If a soil moisture deficit exists, what effect, if any, does this have on actual evaporation?

(b) The following monthly data were measured/calculated in mm for two successive years. In each case calculate the actual evaporation for a woodland area for the months of July and August.

Year	Month	Rain	Pot. Evap.	
One	August	15	105	*At the end of July, Potential SMD = 150mm*
	September	60	80	
Two	August	35	85	*At the end of July, Potential SMD = 100mm*
	September	40	65	

An appropriate table of Actual SMD as a function of Potential SMD is appended to this paper (see page 5).

(c) A small upland catchment of 60 km^2 feeds a water supply reservoir of areal extent 300 ha. If in a particular calendar year the water level rose by 1.30 m while 44 x 10^6 m^3 of water was released, calculate the inflow in m^3 for that year. (1 ha = 10,000m^2.)

If during the same year three rain gauges in the catchment whose associated Thiessen areas are 24 km^2, 21 km^2, and 15 km^2 recorded total rainfall depths of 1240 mm, 1380 mm, and 1275 mm respectively, calculate the average catchment evaporation for the year.

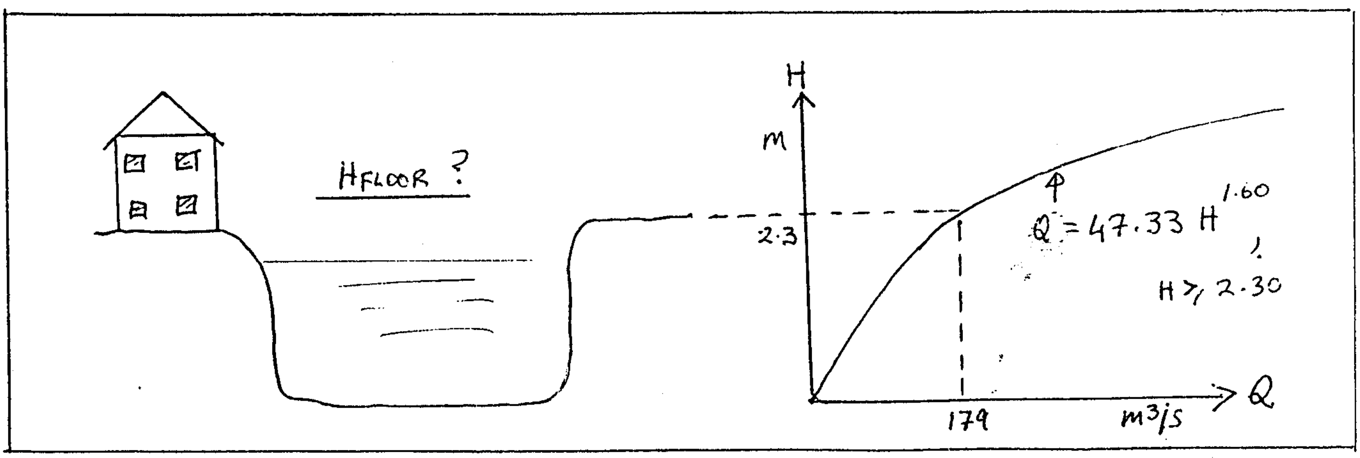
6. (a) What are the major sources of error in flood frequency analysis?
In particular, what is understood by the standard error of a flood quantile estimate?

(b) It is estimated that the annual maximum (AM) are EVI distributed at a point on a river on whose bank a building is to be constructed. The EVI parameters are u = 120 m^3/s and α = 30 m^3/s (i.e. $\bar{Q}$ = 137.3 m^3/s, σ = 38.5 m^3/s). The rating curve

$$Q = 47.33H^{1.60} \text{ m}^3/\text{s, for } H \geq 2.30 \text{ m, } Q \geq 179 \text{ m}^3/\text{s}$$

accounts for both the main channel and overbank components of the total flow.

The client has specified that the risk, r, of flooding over a 20 year period should be less than 25 percent. Calculate what a minimum ground floor elevation H_{Floor} should be. In doing so, add 25 percent to the estimated Q_{Design} values to allow for standard error and add 0.2 m to the estimated water level as an extra factor of safety.



7. (a) State the assumptions involved in the use of the unit hydrograph (UH) concept.

(b) A 10mm-2 hour UH has the following ordinates, given at two hour intervals:

t hours	0	2	4	6	8	10	12	14	16
U(2,t) m^3/s	0	2.5	18	57	46.5	22	10.5	4.5	0

Calculate the quick response runoff from the following sequence of net rainfall depths:

2-hour period no.	1	2	3
rain mm	18	40	14

i.e. a total of 72 mm in 6 hours duration.

(c) From the 2 hour UH in (b) calculate, using the S-curve method, the ordinates of the 1 hour UH. The U(2,t) ordinates at one hour intervals are as follows:
0.0, 0.5, 2.5, 7.5, 18, 38, 57, 59, 46.5, 32, 22, 15, 10.5, 7.5, 4.5, 1.5, 0.0.
These are also given on the attached optional worksheet.

8. (a) In the UK FSR approach a unit hydrograph for ungauged catchments is specified in the form of a triangle. Why is it:

(i) necessary
(ii) legitimate

to use such an approach?

(b) A design storm depth of seven hours duration and return period 42 years has a value of 60mm. It is to be applied to a catchment area of $50km^2$ to determine a 25 year return period design flood. The catchment unit hydrograph is estimated from observed data to have time to peak $T_P = 5$ hours. Assuming the FSR triangular shape for the unit hydrograph and taking areal reduction factor and 75 percent winter storm profile into account, calculate the first five hourly ordinates of the design flood hydrograph. Take percentage runoff as 60 percent.

9. Answer both (a) and (b).

(a) You are asked to design a pumping test for a confined aquifer that is 100 metres thick, and has a hydraulic conductivity, K, of roughly 10 m/s. The estimated storativity, S, for the aquifer is 10.

(i) What is the pumping rate that you would recommend for the test if it is desired that there be an easily measured drawdown of at least one metre after one hour of the test, at an observation well that is located 50 metres from the pumping well?

(ii) List three assumptions about the aquifer properties (not including that it is confined) that are required for the analysis used above.

(b) A well is installed in a confined aquifer whose properties meet all the assumptions of geometry required for analysis. The well fully penetrates the aquifer and is pumped at a constant rate of 50 litres/s i.e. $0.005m^3/s$. Transmissivity of the aquifer is 1.2×10^{-2} m^2/s and storativity is 2×10^{-4}.

Calculate the drawdown that would occur in a set of observation wells at distances of 1, 3, 5, 10 and 100 metres from the pumping well at a time 180 minutes after the start of pumping.