OLLSCOIL NA hÉIREANN, GAILLIMH
NATIONAL UNIVERSITY OF IRELAND, GALWAY

B.E. Degree – Civil Engineering
Environmental Engineering

EH 407 – Engineering Hydrology II

SUMMER EXAMINATIONS 2001

Examiners: Professor P.E. O'Connell
Professor K.M. O'Connor
Professor C. Cunnane

Time allowed: Two hours
Attempt four questions

1. (a) Distinguish *briefly* (but *clearly*) between the following categories of rainfall-runoff models:

Black-box Models **Conceptual Models**

Physically-based Distributed Models *[2 marks]*

(b) With reference to the schematic line diagram provided for the lumped conceptual **Soil Moisture Accounting and Routing (SMAR) model** (on Page 2), identify its two **principal components or modules** and, *very briefly,* **explain the role** of each of the nine parameters involved in the transformation of the rainfall and evaporation data into the simulated discharge series of the SMAR model.

[2½ marks]

(c) Supposing that the optimised five parameters of the **water balance component** of the **SMAR Conceptual Model** have the following values;

T = 0.9	H = 0.25	Y = 100 mm/day	Z = 40 mm	C = 0.8

and assuming that the **Rainfall** (R) and **Pan Evaporation** (E_{pan}) data for **two consecutive days** on the catchment are as follows;

Rainfall R (mm/day)	2	40
Pan Evaporation E_{pan} (mm/day)	32	10

determine the generated runoff (i.e. that *prior* to the routing process), for each of these two days, assuming also that **all of the soil layers are initially full of moisture**, the capacity of all layers (except possibly the bottom layer) being 25 mm.

[8 marks]

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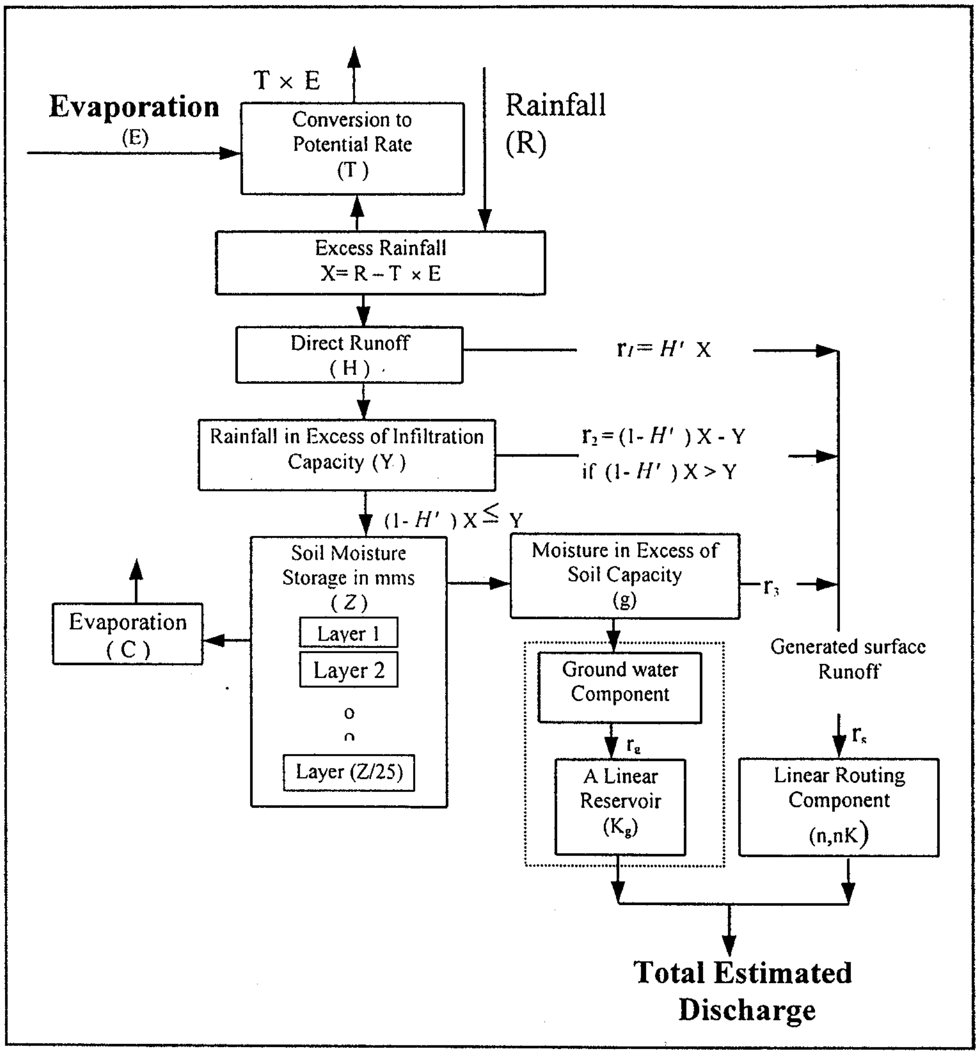


Schematic Line Diagram of the SMAR Conceptual Model.

2. (a) Using the **continuity equation**, $I(t) - Q(t) = \frac{dS(t)}{dt}$, or otherwise, show that, in the case of **reservoir routing**, for an isolated storm event, the **peak of the outflow hydrograph** $Q(t)$ *always* lies at the time **point** t_m **on the *recession* curve of the inflow hydrograph** $I(t)$, such that $I(t_m) = Q(t_m)$ and the corresponding live storage $S(t_m) = S_{maximum}$. *[2 marks]*

(b) An **artificial lake**, of area $A = 1\,km^2$, with **vertical sides**, is controlled by a **broad-crested weir** having the discharge/head relation of the form $Q = 1.7BH^{3/2}\,m^3s^{-1}$, the width of the weir being $B = 10\,m$. For the 'routing period' $\Delta T = 6$ hours, and taking the storage unit as ΔT cumec hours, show that the **live storage-discharge relation for the weir** has the form $S = 7.0024Q^{2/3}$. *[4 marks]*

(c) Given that the *initial* water surface level in the artificial lake is *just at* the crest of the weir (i.e. $H = 0.0$m), for the inflow hydrograph (I) given below, **check *any one* outflow value** (Q) in the following computer output table, using the **Puls (Storage Indication) Reservoir Routing Method**, for that period $\Delta T = 6$ hours. *[4 marks]*

Time t (hours)	6	12	18	24	30	36	42
Inflow I (m^3s^{-1})	10	20	40	50	40	30	20
Outflow Q (m^3s^{-1})	0.55394	3.94232	13.1164	27.4219	36.3244	35.6325	30.2005

(d) If the lake area A **is *reduced* by 10%**, for all values of H, e.g. by a landslide, **what corresponding percentage change** (increase or decrease?) **in the weir width B would yield *exactly* the same outflow hydrograph** (Q) as that given above, for the *same* initial storage conditions and the *same* inflow hydrograph (I)? *[2½ marks]*

3. (a) Design flood estimates for an ungauged catchment can be based on either

(i) an expression relating mean or median annual flood to catchment characteristics or descriptors or

(ii) a design storm – unit hydrograph approach.

State briefly the relative advantages/disadvantages of these two approaches. *[5 marks]*

(b) In the UK FSR/FEH design storm – unit hydrograph method determine, for a catchment whose main characterised are listed below:

/..Question 3(b) continued overleaf

(i) the ordinates of the unit hydrograph at appropriate intervals of time. *[3 marks]*

(ii) the gross rainfall depth for a design storm intended for estimating the 50 year return period flood peak. *[3.5 marks]*

(iii) the net rainfall depth for this storm. *[1 mark]*

Catchment characteristics are:

Area = 70 km^2,	Channel length = 12 km,	Channel slope = 10 m/km,
Rsmd = 40 mm,	Soil index G = 0.28,	2 day R_5 = 65 mm
Mean annual rainfall = 1250 mm,		60 min R_5/2 day R_5 = r = 0.30.

4. (a) The dispersion or spread of a set of hydrological data can be expressed by the second L-moment, which in common notation is defined as ½ E $(X_{2:2} - X_{2:1}) = 2\,M_{110} - M_{100}$. Explain in words what this expression conveys. *[3 marks]*.

(b) The annual maximum floods of the River Quick at Easyford have the following values of probability weighted moments:

$M_{100} = 87.60$, $M_{110} = 59.37$, $M_{120} = 45.55$

Calculate the corresponding L-Moments and L-Moment ratios. *[3 marks]*

(d) Calculate the generalised logistic GLO growth curve ordinates for return periods T = 2, 5, 10, 25, 50, 100 years and display these as a curve on a diagram in which the abscissa is the standardised logistic variable y_L. *[6.5 marks]*

5. (a) How does potential evaporation from soil and vegetated surfaces differ from potential open water evaporation? *[2 marks]*

(b) Distinguish between potential evaporation and actual evaporation in the context of vegetated surfaces. *[3 marks]*

(c) Explain the terms field capacity, soil moisture deficit and wilting point *[3 marks]*

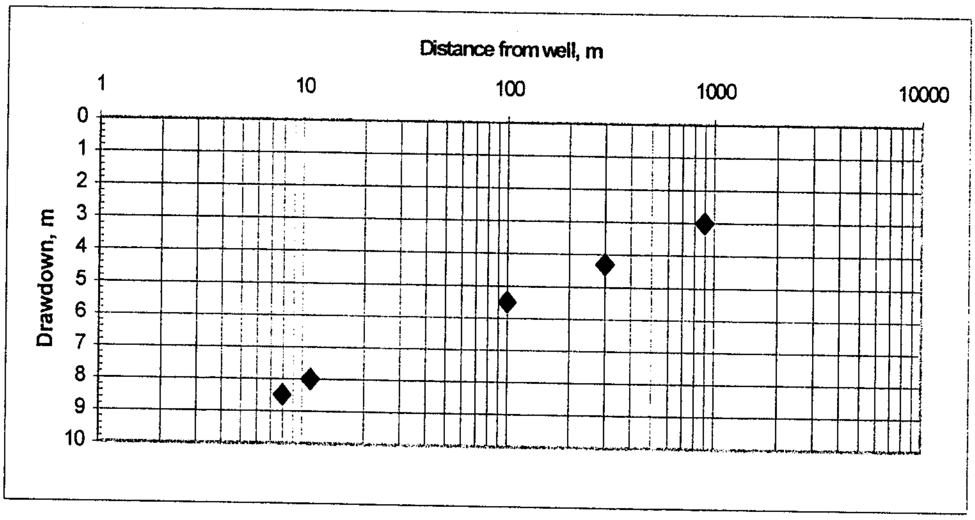
(e) Explain Penman's assumption about the manner in which actual evaporation from a vegetated surface decreases as soil moisture content decreases. How is actual evaporation calculated in Penman's scheme? *[4.5 marks]*.

6. (a) The transmissivity T and storativity S of an ideal aquifer can be determined from pumping test data by either a Theis curve matching method or by a Jacob approximation method – either time drawdown or distance drawdown.

In what circumstances is it valid to use the Jacob methods? *[2 marks]*

(b) Determine T and S from the well test pump data displayed on the following graph. The rate of pumping is $Q = 10m^3/min$ and the time of observation, since commencement of pumping, is 3.5 days. *[5 marks]*

(c) In the Theis curve matching method two graphs are used. These are a semi log plot of observed drawdown versus time and the well function type curve showing W(u) as a function of 1/u on a log-log plot. Explain the basis of this method. *[5.5 marks]*



A larger working version of this diagram is attached.