UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 6 Examination in Engineering: November 2017

Module Number: CE6303 Module Name: Engineering Hydrology

[Three Hours]

[Answer **all questions**, each question carries 10 marks]

Q1

a) Briefly explain the hypothesis of the SCS method.

[02 Marks]

b) A catchment of 400 hectares comprises of 80 hectares of low lying area with soil containing heavy plastic clays and remaining area (located at upstream of the catchment) categorized into two separate areas according to the surface topography; 1. High-land comprises of sandy loam and 2. Moderate-land comprises of soils usually high in clay. The land use of the entire catchment is identified as poor cover forest land except the low lying area that has been used for paddy cultivation.

A real estate developer is planning to convert the entire catchment (excluding the cultivated land) into a housing scheme with projected land use as given below;

Land Use	Elevation category	Area (hectares)
Residential area with 30% average imperviousness	High	96
Residential area with 65% average imperviousness	High	64
Open land with grass cover on 80% of the area	Moderate	64
Parking lots, schools and so on (all impervious)	High	48
Paved roads with curbs and storm sewers	High	24
Paved roads with curbs and storm sewers	Moderate	24
	Total	320

In order to get the Urban Development Authority (UDA)'s approval, it is required to estimate possible storm water generation change due to the proposed development. A 100-year frequency value of 127 mm rainfall has been suggested to use as the design precipitation. State all the assumptions.

The excess precipitation or direct runoff from a storm is given by

$P_e = \frac{(P-0.2S)^2}{P+0.8S}$ Where $S = \frac{1000}{CN} - 10.$

CN correction factors are $CN_I = \frac{4.2CN_{II}}{10-0.058CN_{II}}$ and $CN_{III} = \frac{23CN_{II}}{10+0.13CN_{II}}$

(All the terms have their usual meanings). Runoff curve numbers and Soil type classification are given in Table Q1.1 and Table Q1.2 respectively.

[06 + 02 Marks]

Q2

a) Distinguish between Evaporation and Evapotranspiration. Briefly discuss the concept of potential evapotranspiration and reference crop evapotranspiration.

[02 + 02 Marks]

b) Explain why Evaporation and Evapotranspiration are considered as very important components in determining crop water requirement in irrigation engineering.

[02 Marks]

c) The monthly values of reference crop evapotranspiration E_{tr}, for average conditions in Sevenagala, Sri Lanka and the crop coefficients for sugar cane at different growth stages are given in Figure Q2. Calculate the actual evapotranspiration from this crop assuming a well-watered soil.

[04 Marks]

Q3

a) Darcy's Law was developed to relate the moisture flux, q to the rate of head loss per unit length of medium, S_f;

$$q = K\,S_f$$

Briefly explain how it operates in an unsaturated porous medium.

[04 Marks]

b) There are two tensiometers installed at depths 1.0 m and 2.0 m in a soil at a site in order to estimate soil moisture flux between depths. The total head at 1.0 m and 2.0 m from the ground surface are given at weekly time intervals in columns 2 and 3 of Table Q3. The relationship between hydraulic conductivity (K) and soil suction head (φ) is given by $K = 250(-\varphi)^{-2.11}$, where K is in *cm/day* and φ is in *cm*.

(i) Briefly explain why both z and φ are negative.
(ii) Calculate the soil moisture flux, q (*cm/day*) between depths 1.0 m and 2.0 m in the soil for 10 weeks period. Complete the Table Q3.
(iii) Plot soil moisture flux and saturated hydraulic conductivity variation in Figure Q3.

[01 + 04 + 01 Marks]

Q4

a) What are meant by 'Probability of Exceedance' and Return Period'?
Derive expressions for;
(i) Probability that an event will occur at least once within a given period.
(ii) Risk of exceeding the design return period within the expected life of a structure.

[02 + 02 Marks]

Q4 continued to page 3 …

Q4 continued from page 2 …

b) The study of extreme hydrologic events involves the selection of a sequence of the largest or smallest observations (maximum or minimum) from the data set (complete duration series).
Briefly discuss why the extreme value distribution follows different probability distribution function than that of parent population.

[04 Marks]

c) What is meant by **design horizon**? Briefly discuss how the design horizon defers from design return period.

[02 Marks]

Table Q1.1: Runoff curve numbers (antecedent moisture condition II, Ia = 0.2S)

Land Use Description		Hydrologic Soil Group			
		A	B	C	D
Cultivated land[1]: without conservation treatment		72	81	88	91
with conservation treatment		62	71	78	81
Pasture or range land: poor condition		68	79	86	89
good condition		39	61	74	80
Meadow: good condition		30	58	71	78
Wood or forest land: thin stand, poor cover, no mulch		45	66	77	83
good cover[2]		25	55	70	77
Open Spaces, lawns, parks, golf courses, cemeteries, etc.					
good condition: grass cover on 75% or more of the area		39	61	74	80
fair condition: grass cover on 50% to 75% of the area		49	69	79	84
Commercial and business areas (85% impervious)		89	92	94	95
Industrial districts (72% impervious)		81	88	91	93
Residential[3]:					
Average lot size	Average % impervious[4]				
1/8 acre or less	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
Paved parking lots, roofs, driveways, etc.[5]		98	98	98	98
Streets and roads:					
paved with curbs and storm sewers[5]		98	98	98	98
gravel		76	85	89	91
dirt		72	82	87	89

[1]For a more detailed description of agricultural land use curve numbers, refer to Soil Conservation Service, 197? Chap. 9

[2]Good cover is protected from grazing and litter and brush cover soil.

[3]Curve numbers are computed assuming the runoff from the house and driveway is directed towards the street with a minimum of roof water directed to lawns where additional infiltration could occur.

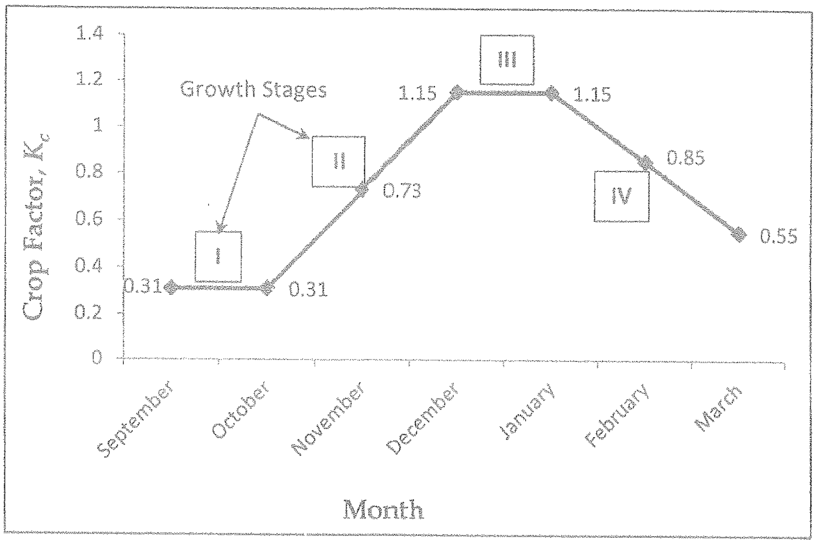
[4]The remaining pervious areas (lawn) are considered to be in good pasture condition for these curve numbers.

[5]In some warmer climates of the country a curve number of 95 may be used.

Table Q1.2: Soil type classification by SCS

Group	Soil characteristics
A	Deep sand, deep loess, and aggregated silts
B	Shallow loess and sandy loam
C	Clay loams, shallow sandy loam, soils in organic content, and soils usually high in clay
D	Soils that swell upon wetting, heavy plastic clays, and certain saline soils

Month	E_{tr} (mm)
January	5.1
February	5.6
March	6.0
April	5.8
May	5.3
June	5.1
July	5.5
August	5.6
September	5.4
October	5.1
November	4.7
December	4.6



Growth Stage	Crop condition
I	Initial stage
II	Development stage
III	Mid-Season stage
IV	Late season stage

Figure Q2: Monthly average E_{tr} and K_c variation (for sugar cane) at Sevenagala

Table Q3: Computation of soil moisture flux between 1.0 m and 2.0 m depth

1	2	3	4	5	6	7	8
Week	Total head h_1 at 1 m	Total head h_2 at 2 m	Suction head Ψ_1 at 1 m	Suction head Ψ_2 at 2 m	Unsaturated hydraulic conductivity K	Head difference $h_1 - h_2$	Moisture flux q
	(cm)	(cm)	(cm)	(cm)	(cm/day)	(cm)	(cm/day)
1	-145	-230					
2	-165	-235					
3	-130	-240					
4	-100	-230					
5	-135	-215					
6	-150	-240					
7	-150	-230					
8	-190	-245					
9	-220	-265					
10	-270	-275					

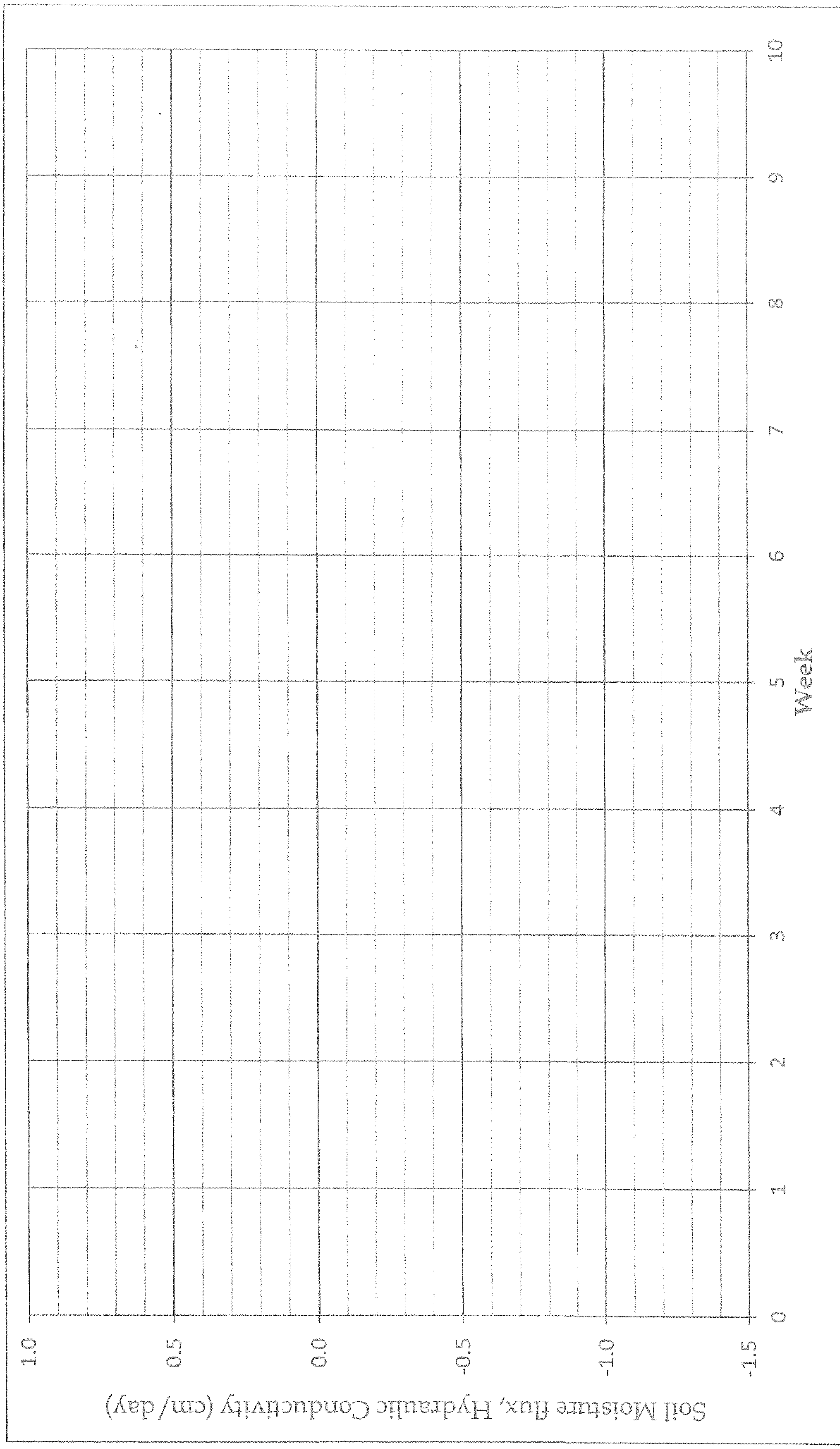


Figure Q3: Variation of Soil Moisture Flux and Hydraulic Conductivity