University of Asia Pacific

Department of Civil Engineering

Final Examination Spring 2013

Program: B.Sc. Engineering (Civil)

Course title: Engineering Hydrology **(SECTION A)** Course code: CE 363

Time: 3 hours Total Marks: 150

Use Two Separate Answer Scripts for Section I and Section II

Section I

Answer any **FOUR** from the following questions: (4 x 25=100)

1. (a) Differentiate between the following (5)
   i) Float gauge stage recorder and Bubble gauge stage recorder
   ii) Vertical axis current meter and Horizontal axis current meter

   (b) The following data were collected for a 24m wide stream at a gauging station. Compute the discharge. (15)

Distance from left water Water edge (m)	Depth, d(m)	Revolution of current meter at 0.6d below water surface REV	Duration of Observation SEC
0	0	0	0
2	0.5	80	180
4	1.1	83	120
6	1.95	131	120
9	2.25	139	120
12	1.85	121	120
15	1.75	114	120
18	1.65	109	120
20	1.50	92	120
22	1.25	85	120
23	0.75	70	150
24	0	0	0

   Calibration equation of current meter: $v = 0.32N + 0.032$, N = revolutions per seconds, v = velocity, m/s.

   (c) List different types of streamflow measurement techniques (at least five). (5)

2. (a) Define the following terms: (5)

   i. Normal precipitation ii. Return period iii. Double mass curve technique

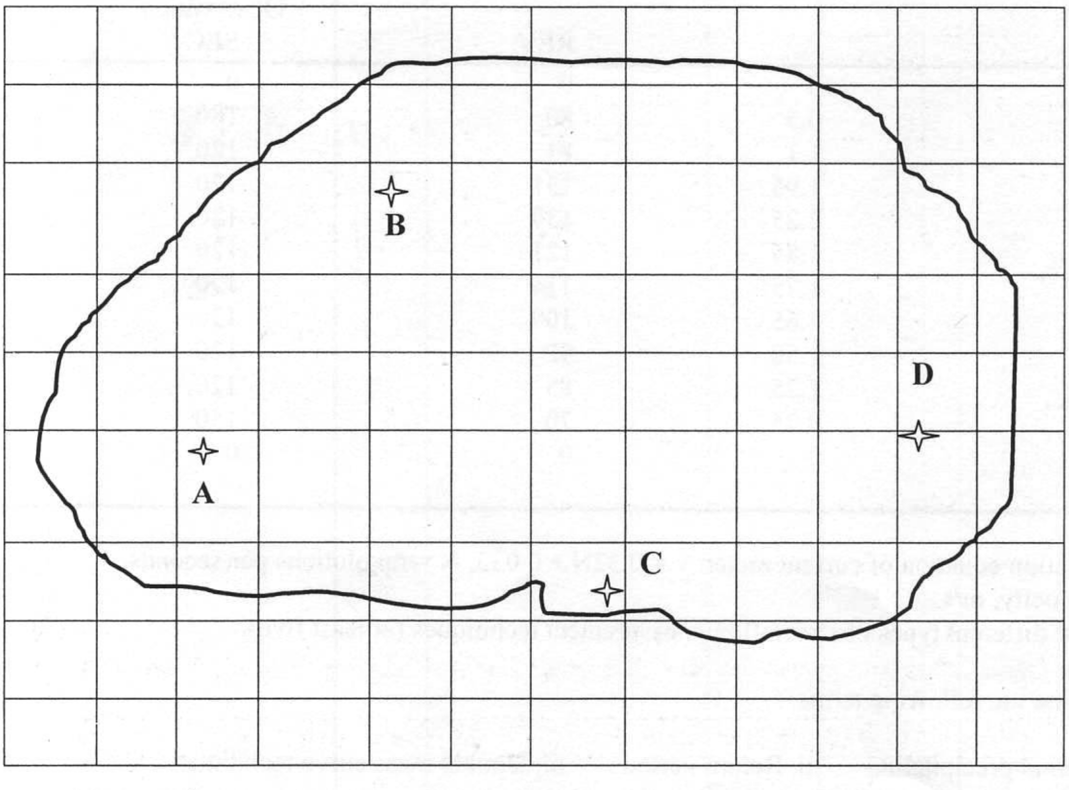
(b) Annual rainfall depth data are available below (Table 1) for three consistent gauges (A, B, C) and one inconsistent gauge D. Gauge D was relocated at the end of 1993. Therefore rainfall data for gauge D for the period 1991-1993 must be adjusted to the rainfall characteristics at the new location. Find the adjusted values (use graph paper).

Table 1 (20)

Year	Annual rainfall (in)			
	A	B	C	D
1991	22	26	23	28
1992	21	26	25	33
1993	27	31	28	38
1994	25	29	29	31
1995	19	22	23	24
1996	24	25	26	28
1997	17	19	20	22
1998	21	22	23	26

3. (a). In a catchment area (shown below), four rainfall stations are situated inside the catchment. Given are the annual precipitation recorded by the four stations in 2010: A = 130.2 cm, B= 145cm, C=112cm and D= 100cm. Determine the average annual precipitation by the Thiessen polygon method. Consider each square as 1 sq km. (16)

(Attach this page with Answer Script, if you answer this question)



(b) Briefly describe two methods that are used to estimate missing rainfall data. (4)

(c) Provide short description on i) Moving boat method ii) Tipping bucket rain gauge (5)

4. (a) A drainage basin comprising five subcatchments is shown in the following figure. Determine the pipe diameters for AB, BC and DB for a five year return period storm. The area, runoff coefficients, and inlet time for each subcatchments are given in Table 1.0. The length and slope for each pipe is also given in the Table 2. The design precipitation intensity for this catchment is given by

$$i = 120\ T^{0.175} / (t_d + 27)$$

where i is in in/hr, T is return period, and t_d is duration in minutes. Assume n= 0.015. (20)

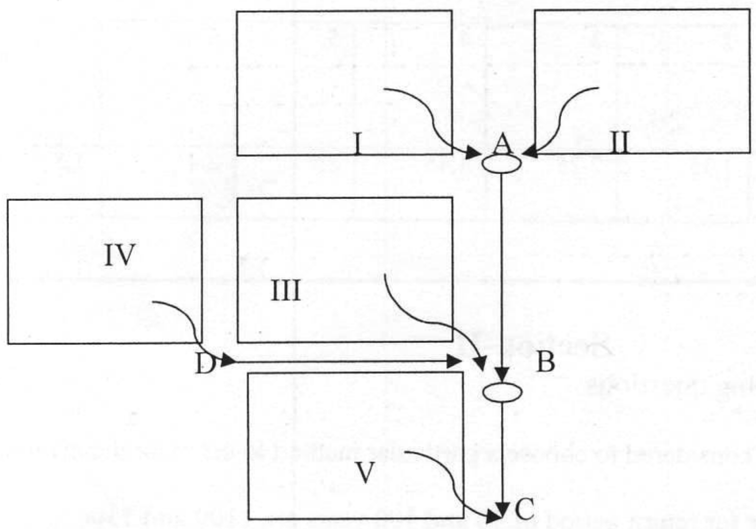


Table 1

catchment	Area A(ac)	Runoff coeff C	Inlet time (min)
I	2	0.7	5
II	3	0.7	7
III	4	0.6	10
IV	5	0.5	15
V	4.5	0.5	15

Table 2

Pipe name	Length (ft)	Slope (ft/ft)
AB	550	0.0081
BC	400	0.0064
DB	450	0.0064

(b) Define 'Stormwater modeling' in your own words. What are the uses of a 'stormwater model'? (5)

5. (a) Explain the following (10)

i) Aerodynamic Method for estimating Evaporation
ii) Pan-coefficient
iii) Horton's method of calculating infiltration capacity

(b) The evaporation from a lake is to be calculated by the water balance method. Inflow to the lake occurs through three small rivers A, B and C. The outflow occurs through river D. Calculate the evaporation from the lake surface during summer (May to August) if the water level was at elevation +571.04m on May 1 and +571.10 on August 31. The lake surface area is 100 sq. km. The precipitation P during the period was 100 mm. Average inflows and outflows are given below: (15)

River	Catchment (sq km)	Q average (m3/s)
A	150	15
B	120	11
C	121	17
D		45

6. (a) Distinguish between the following (9)

i) Actual and potential evaporation
ii) Field capacity and wilting point
iii) Φ-index and W-index

(b) Discuss about the following weather systems for precipitation (provide sketch):
Orographic, Convective and Frontal. (7)

(c) A storm with 15 cm precipitation produced a direct runoff of 8.7 cm. The time distribution of the storm is as follows. Estimate the φ-index of the storm. (9)

Time from start (hr)	1	2	3	4	5	6	7	8
Incremental rainfall (cm)	0.6	1.35	2.25	3.45	2.7	2.4	1.5	0.75

Section-II

Answer any **TWO** from the following questions (2x25= 50)

7. (a) What are the factors need to be considered to choose a particular method to estimate the magnitude of flood peak. (3)

(b) The flood magnitudes of a river for return period of 50 and 100 years are 1100 and 1300 m^3/s respectively. These were found based on 30 years of data using Gumble method. (22)

i) Determine the mean and standard deviation of the data used.
ii) Estimate the magnitude of a flood with a return period of 500 years.
iii) What are the (a) 80% (b) 95% confidence limits for the estimate in (ii)?

8. (a) Define Prism and Wedge storage with sketch. (5)

(b) The inflow and outflow hydrographs for a reach of a river is given below. Determine the best values of the Muskingum coefficients 'k' and 'x' for the reach. (20)

Time (hr)	0	3	6	9	12	15	18	21	24	27
Inflow (cumec)	20	60	80	210	240	215	170	90	40	16
Outflow (cumec)	20	30	50	150	225	220	185	120	85	23

9. (a) A basin has 400 km^2 of area ,L=35 km and L_{ca}=10 km. Assuming C_t=1.5 and C_p=0.7, develop a 3-hr unit hydrograph for this basin using Snyder's method. (10)

(b) Using the 12-hr unit hydrograph given below, compute the ordinates of a 3-hr unit hydrograph. (15)

Time (hr)	0	6	12	18	24	30	36	42	48	54	60	66	72
Ordinate of 12-hr unit hydrograph (m^3/s)	0	10	37	76	111	136	150	153	146	130	114	70	30

CE 363 - FORMULAE

$$Q = \sum_{i=1}^{N-1} \Delta Q_i \qquad \Delta A_1 = \overline{W}_1 y_1$$

$$\Delta Q_i = y_i \times \left(\frac{W_i}{2} + \frac{W_{i+1}}{2} \right) \times v_i \qquad \textbf{for } i = 2 \text{ to } (N-2)$$

where $\overline{W}_1 = \dfrac{\left(W_1 + \dfrac{W_2}{2} \right)^2}{2\, W_1}$

and $\Delta A_N = \overline{W}_{N-1}\, y_{N-1}$

where $\overline{W}_{N-1} = \dfrac{\left(W_N + \dfrac{W_{N-1}}{2} \right)^2}{2\, W_N}$

to get

$$\Delta Q_1 = \bar{v}_1 \,.\, \Delta A_1 \quad \text{and} \quad \Delta Q_{N-1} = \bar{v}_{N-1}\, \Delta A_{N-1}$$

$Q = (1.49/n)\, S^{0.5}\, AR^{2/3}$ in fps system

$Q = (1/n)\, S^{0.5}\, AR^{2/3}$ in SI system

Q = C i A

c in per cent	50	68	80	90	95	99
$f(c)$	0.674	1.00	1.282	1.645	1.96	2.58

TABLE 7.3 REDUCED MEAN $\bar{y}_n$ IN GUMBEL'S EXTREME VALUE DISTRIBUTION

N = sample size

N	0	1	2	3	4	5	6	7	8	9
10	0.4952	0.4996	0.5035	0.5070	0.5100	0.5128	0.5157	0.5181	0.5202	0.5220
20	0.5236	0.5252	0.5268	0.5283	0.5296	0.5309	0.5320	0.5332	0.5343	0.5353
30	0.5362	0.5371	0.5380	0.5388	0.5396	0.5402	0.5410	0.5418	0.5424	0.5430
40	0.5436	0.5442	0.5448	0.5453	0.5458	0.5463	0.5468	0.5473	0.5477	0.5481
50	0.5485	0.5489	0.5493	0.5497	0.5501	0.5504	0.5508	0.5511	0.5515	0.5518
60	0.5521	0.5524	0.5527	0.5530	0.5533	0.5535	0.5538	0.5540	0.5543	0.5545
70	0.5548	0.5550	0.5552	0.5555	0.5557	0.5559	0.5561	0.5563	0.5565	0.5567
80	0.5569	0.5570	0.5572	0.5574	0.5576	0.5578	0.5580	0.5581	0.5583	0.5585
90	0.5586	0.5587	0.5589	0.5591	0.5592	0.5593	0.5595	0.5596	0.5598	0.5599
100	0.5600									

TABLE 7.4 REDUCED STANDARD DEVIATION S_n IN GUMBEL'S EXTREME VALUE DISTRIBUTION

N = sample size

N	0	1	2	3	4	5	6	7	8	9
10	0.9496	0.9676	0.9833	0.9971	1.0095	1.0206	1.0316	1.0411	1.0493	1.0565
20	1.0628	1.0696	1.0754	1.0811	1.0864	1.0915	1.0961	1.1004	1.1047	1.1086
30	1.1124	1.1159	1.1193	1.1226	1.1255	1.1285	1.1313	1.1339	1.1363	1.1388
40	1.1413	1.1436	1.1458	1.1480	1.1499	1.1519	1.1538	1.1557	1.1574	1.1590
50	1.1607	1.1623	1.1638	1.1658	1.1667	1.1681	1.1696	1.1708	1.1721	1.1734
60	1.1747	1.1759	1.1770	1.1782	1.1793	1.1803	1.1814	1.1824	1.1834	1.1844
70	1.1854	1.1863	1.1873	1.1881	1.1890	1.1898	1.1906	1.1915	1.1923	1.1930
80	1.1938	1.1945	1.1953	1.1959	1.1967	1.1973	1.1980	1.1987	1.1994	1.2001
90	1.2007	1.2013	1.2020	1.2026	1.2032	1.2038	1.2044	1.2049	1.2055	1.2060
100	1.2065									

University of Asia Pacific

Department of Civil Engineering

Final Examination Spring 2013

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Section-II

Answer any **TWO** from the following questions (2x25= 50)

7. (a) What are the factors need to be considered to choose a particular method to estimate the magnitude of flood peak. (3)

(b) The flood magnitudes of a river for return period of 50 and 100 years are 1100 and 1300 m^3/s respectively. These were found based on 30 years of data using Gumble method. (22)

i) Determine the mean and standard deviation of the data used.
ii) Estimate the magnitude of a flood with a return period of 500 years.
iii) What are the (a) 80% (b) 95% confidence limits for the estimate in (ii)?

8. a) What are the different alternative methods to estimate the magnitude of a flood peak? Explain the rational method of computing the peak discharge. (8)

b) Describe the factors affecting a flood hydrograph. (8)

c) Write short notes on the following (3x3=9)

i) Effective rainfall
ii) Unit Hydrograph
iii) Confidence limit

9. (a) A basin has 400 km^2 of area ,L=35 km and L_{ca}=10 km. Assuming C_t=1.5 and C_p=0.7, develop a 3-hr unit hydrograph for this basin using Snyder's method. (10)

(b) Using the 12-hr unit hydrograph given below, compute the ordinates of a 3-hr unit hydrograph. (15)

Time (hr)	0	6	12	18	24	30	36	42	48	54	60	66	72
Ordinate of 12-hr unit hydrograph (m^3/s)	0	10	37	76	111	136	150	153	146	130	114	70	30

University of Asia Pacific

Department of Civil Engineering

Final Examination Spring 2013

Program: B.Sc. Engineering (Civil)

Course title: Engineering Hydrology (**SECTION B**) Course code: CE 363

Time: 3 hours Total Marks: 150

Use Two Separate Answer Scripts for Section I and Section II

Section I

Answer any **TWO** from the following questions: 25 x 2 = 50

1. (a) Differentiate between the following (5)
   i) Float gauge stage recorder and Bubble gauge stage recorder
   ii) Vertical axis current meter and Horizontal axis current meter

   (b) The following data were collected for a 24m wide stream at a gauging station. Compute the discharge. (15)

Distance from left water Water edge (m)	depth, d	Revolution of current meter at 0.6d below water surface REV	Duration of observation SEC
0	0	0	0
2	0.5	80	180
4	1.1	83	120
6	1.95	131	120
9	2.25	139	120
12	1.85	121	120
15	1.75	114	120
18	1.65	109	120
20	1.50	92	120
22	1.25	85	120
23	0.75	70	150
24	0	0	0

   Calibration equation of current meter: $v = 0.32N + 0.032$, N = revolutions per seconds, v = velocity, m/s.

   (c) List different types of streamflow measurement techniques (at least five). (5)

2. (a) Define the following terms: (5)
   i. Normal precipitation ii. Return period iii. Double mass curve technique

(b) Annual rainfall depth data are available below (Table 1) for three consistent gauges (A, B, C) and one inconsistent gauge D. Gauge D was relocated at the end of 1993. Therefore rainfall data for gauge D for the period 1991-1993 must be adjusted to the rainfall characteristics at the new location. Find the adjusted values (use graph paper). (20)

Table 1

Year	Annual rainfall (in)			
	A	B	C	D
1991	22	26	23	28
1992	21	26	25	33
1993	27	31	28	38
1994	25	29	29	31
1995	19	22	23	24
1996	24	25	26	28
1997	17	19	20	22
1998	21	22	23	26

3. (a). In a catchment area (shown below), four rainfall stations are situated inside the catchment. Given are the annual precipitation recorded by the four stations in 2010: A = 130.2 cm, B= 145cm, C=112cm and D= 100cm. Determine the average annual precipitation by the Thiessen polygon method. Consider each square as 1 sq km. (16)

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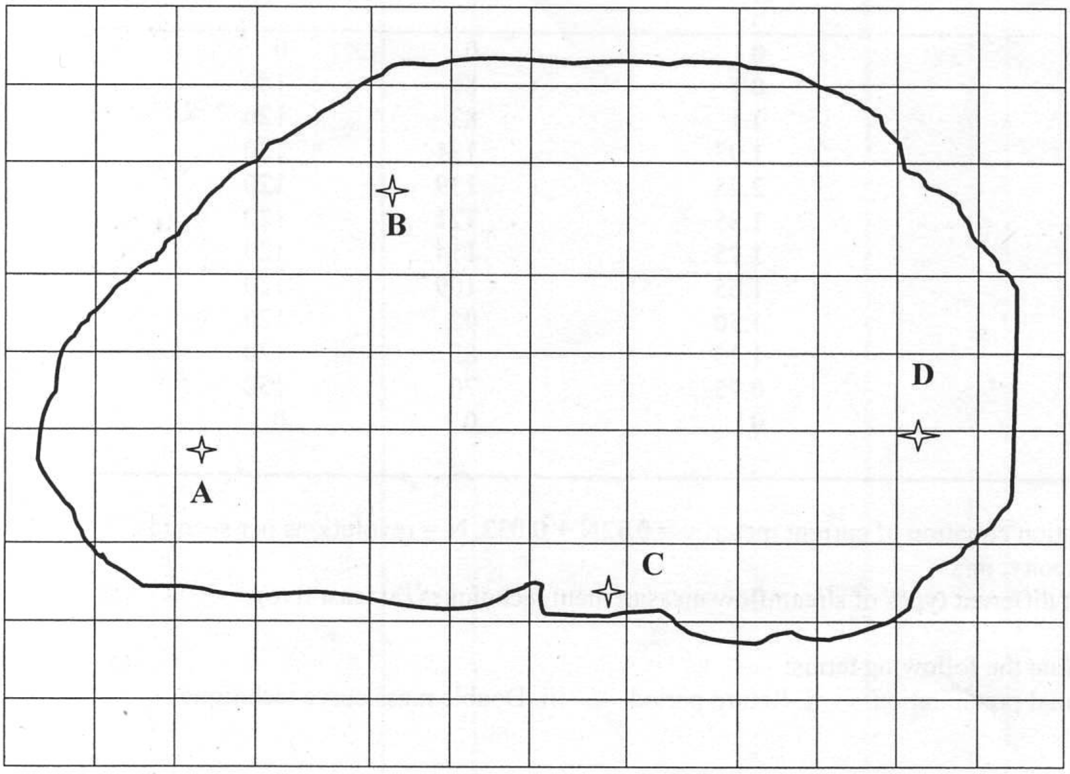

(b) Briefly describe two methods that are used to estimate missing rainfall data. (4)

(c) Provide short description on i) Moving boat method ii) Tipping bucket rain gauge (5)

Section-II

Answer any **FOUR** from the following questions: (4x25=100)

4. a) What factors need to be considered to choose a particular method to estimate the flood peak magnitude? (5)

   b) The flood magnitudes of a river for return period of 50 and 100 years are 1100 and 1300 m^3/s respectively. These were found based on 30 years of data using Gumble method. (20)

   i) Determine the mean and standard deviation of the data used.

   ii) Estimate the magnitude of a flood with a return period of 500 years.

   iii) What are the (a) 80% (b) 95% confidence limits for the estimate in (ii)?

5. a) Define 'Prism Storage' and 'Wedge storage' with sketch. (5)

   b) The inflow hydrograph for a channel reach are given below, for which the Muskingum coefficient k= 2.3 hr, x= 0.15 and Δt=1 hr. Route the flood through the reach and determine the attenuation and time lag of outflow. The initial outflow is 85 ft^3/s. (20)

Time (hr)	0	1	2	3	4	5	6	7	8	9	10
Inflow (cfs)	85	93	137	208	320	442	546	630	676	691	675

Time (hr)	11	12	13	14	15	16	17	18	19	20
Inflow (cfs)	675	634	571	477	329	247	184	134	108	90

6. a) Define synthetic hydrograph. Explain the procedure of deriving a synthetic unit hydrograph for a catchment by using Snyder's method. (10)

   b) Rainfall of magnitude 3.8 cm and 2.8 cm occurring in two consecutive 6-h duration on a catchment of area 30km^2 produced the following hydrograph. Estimate the rainfall excess and φ index. (15)

Time from start of rainfall (h)	-6	0	6	12	18	24	30	36	42	48	54
Observed flow (m^3/s)	8	7	15	28	23	18	14	11	5	4.5	4.5

7. a) A basin has 400 km^2 of area , L=35 km and L_{ca}=10 km. Assuming C_t=1.5 and C_p=0.7, develop a 3-hr unit hydrograph for this basin using Snyder's method. (10)

b) Using the 12-hr unit hydrograph given below, compute the ordinates of a 3-hr unit hydrograph. (15)

Time (hr)	0	6	12	18	24	30	36	42	48	54	60	66	72
Ordinate of 12-hr unit hydrograph (m^3/s)	0	10	37	76	111	136	150	153	146	130	114	70	30

8. a) A reservoir has the following elevation, discharge and storage relationships: (25)

Elevation (m)	Storage (10^6 m^3)	Outflow discharge (m^3/s)
100.00	3.350	0
100.50	3.472	10
101.00	3.380	26
101.50	4.383	46
102.00	4.882	72
102.50	5.370	100
102.75	5.527	116
103.00	5.856	130

When the reservoir level was at 100.50 m the following flood hydrograph entered the reservoir.

Time (h)	0	6	12	18	24	30	36	42	48
Discharge (m^3/s)	10	20	55	80	65	50	30	20	11

Route the flood and obtain the outflow hydrograph.

9. a) What are the different alternative methods to estimate the magnitude of a flood peak? Explain the rational method of computing the peak discharge. (8)
b) Describe the factors affecting a flood hydrograph. (8)
c) Write short notes on the following (3x3=9)
i) Effective rainfall
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CE 363 - FORMULAE

$$Q = \sum_{i=1}^{N-1} \Delta Q_i \qquad \Delta A_1 = \overline{W}_1 y_1$$

$$\Delta Q_i = y_i \times \left(\frac{W_i}{2} + \frac{W_{i+1}}{2} \right) \times v_i \qquad \text{for } i = 2 \text{ to } (N-2)$$

where $$\overline{W}_1 = \frac{\left(W_1 + \frac{W_2}{2} \right)^2}{2\, W_1}$$

and $$\Delta A_N = \overline{W}_{N-1}\, y_{N-1}$$

where $$\overline{W}_{N-1} = \frac{\left(W_N + \frac{W_{N-1}}{2} \right)^2}{2\, W_N}$$

to get

$$\Delta Q_1 = \overline{v}_1 \,.\, \Delta A_1 \quad \text{and} \quad \Delta Q_{N-1} = \overline{v}_{N-1}\, \Delta A_{N-1}$$

$Q = (1.49/n)\, S^{0.5} AR^{2/3}$ in fps system

$Q = (1/n)\, S^{0.5} AR^{2/3}$ in SI system

$Q = C\, i\, A$

c in per cent	50	68	80	90	95	99
$f(c)$	0.674	1.00	1.282	1.645	1.96	2.58

TABLE 7.3 REDUCED MEAN $\bar{y}_n$ IN GUMBEL'S EXTREME VALUE DISTRIBUTION

N = sample size

N	0	1	2	3	4	5	6	7	8	9
10	0.4952	0.4996	0.5035	0.5070	0.5100	0.5128	0.5157	0.5181	0.5202	0.5220
20	0.5236	0.5252	0.5268	0.5283	0.5296	0.5309	0.5320	0.5332	0.5343	0.5353
30	0.5362	0.5371	0.5380	0.5388	0.5396	0.5402	0.5410	0.5418	0.5424	0.5430
40	0.5436	0.5442	0.5448	0.5453	0.5458	0.5463	0.5468	0.5473	0.5477	0.5481
50	0.5485	0.5489	0.5493	0.5497	0.5501	0.5504	0.5508	0.5511	0.5515	0.5518
60	0.5521	0.5524	0.5527	0.5530	0.5533	0.5535	0.5538	0.5540	0.5543	0.5545
70	0.5548	0.5550	0.5552	0.5555	0.5557	0.5559	0.5561	0.5563	0.5565	0.5567
80	0.5569	0.5570	0.5572	0.5574	0.5576	0.5578	0.5580	0.5581	0.5583	0.5585
90	0.5586	0.5587	0.5589	0.5591	0.5592	0.5593	0.5595	0.5596	0.5598	0.5599
100	0.5600									

TABLE 7.4 REDUCED STANDARD DEVIATION S_n IN GUMBEL'S EXTREME VALUE DISTRIBUTION

N = sample size

N	0	1	2	3	4	5	6	7	8	9
10	0.9496	0.9676	0.9833	0.9971	1.0095	1.0206	1.0316	1.0411	1.0493	1.0565
20	1.0628	1.0696	1.0754	1.0811	1.0864	1.0915	1.0961	1.1004	1.1047	1.1086
30	1.1124	1.1159	1.1193	1.1226	1.1255	1.1285	1.1313	1.1339	1.1363	1.1388
40	1.1413	1.1436	1.1458	1.1480	1.1499	1.1519	1.1538	1.1557	1.1574	1.1590
50	1.1607	1.1623	1.1638	1.1658	1.1667	1.1681	1.1696	1.1708	1.1721	1.1734
60	1.1747	1.1759	1.1770	1.1782	1.1793	1.1803	1.1814	1.1824	1.1834	1.1844
70	1.1854	1.1863	1.1873	1.1881	1.1890	1.1898	1.1906	1.1915	1.1923	1.1930
80	1.1938	1.1945	1.1953	1.1959	1.1967	1.1973	1.1980	1.1987	1.1994	1.2001
90	1.2007	1.2013	1.2020	1.2026	1.2032	1.2038	1.2044	1.2049	1.2055	1.2060
100	1.2065									