UNIVERSITY OF SWAZILAND

Faculty of Health Science

Department of Environmental Health Sciences

Main Examination 2010

Title of paper: WATER DRAINAGE AND SEWERAGE

Course code: EHS 587

Time allowed: 3 hours

Marks allocation: 100 Marks

Instructions:

1) Question 1(i) is multiple choice
2) Answer **FOUR (4)** questions
3) Each question is weighted 25 marks
4) Write neatly and clearly
5) Begin each question in a separate sheet of paper

This paper is not to be opened until the invigilator has granted permission

QUESTION 1

Write true or false for the following statements as they apply to water drainage and sewerage;

a) The design of open channels involves the selection of suitable sectional dimensions such that the maximum discharge will be conveyed within the section.

b) In rigid boundary (non-erodible) channels the designer will wish to maximize construction costs resulting in what is commonly termed “the most economic section”.

c) In the case of erodible channels, the design criterion will be that the boundary shear stress exerted by the moving liquid will exceed the “critical tractive force” of the bed and side material.

d) The tractive force is the force exerted by the water on the wetted area of a channel.

e) The critical tractive force of a particular material is the unit tractive force which will cause erosion.

f) Sewers are underground watertight conduits for conveying waste water by gravity flow from urban areas to points of disposal.

g) The gutter inlet has a vertical opening to catch gutter flow.

h) The disadvantage of having grate covering the gutter inlet is that debris collecting on the grate may result in plugging the gutter inlet.

i) Sewer pipes are set as deep as possible to maximize excavation while providing 0.6 to 1.2m of cover above the pipe to reduce the effect of wheel loading.

j) Small bore sewers are appropriate where septic tanks already exist but soakaways have failed or do not exist.

(20 Marks)

II.

If a 400mm sewer is placed on a slope of 0.02, what is the full quantity and velocity for (i) n = 0.013, and (ii) n = 0.015?

(5 marks)

QUESTION 2

(a) A rectangular open channel has a width of 6.5m and a slope of 1:800. Find the mean velocity of flow and the discharge when the depth of water is 1.5m and if C in the Chezy formula is 49.

(7marks)

(b) Design a branch within a storm sewer network which has a length of 100m, a bed slope of 1 in 150 and roughness size of 0.15mm which receives the storm run off form 3.5 hectors of impermeable surface using the Rational (Lloyd-Davies) Method. In designing the upstream pipes the maximum 'time of concentration' at the head of the pipe has been found to be 6-2minutes. The relationship between rainfall intensity and average storm duration is tabulated below.

Storm duration (mm)	2.0	3.0	4.0	5.0	6.0	7.0	8.0
Average rainfall intensity (mm/hr)	94.0	82.7	73.8	70.0	61.4	57.2	53.5

Note: The (Rational Lloyd-Davies) Method gives the peak discharge (Q_p) from the urbanized catchment in the form.

$$Q_p = \frac{1}{360} A_p i \ (m^3/s)$$

Where A_p = impermeable area (hectors)
i = average rainfall intensity (mm/h) during the storm)

(18 marks)

QUESTION 3

a) Compute the diameter of the outfall sewer required to drain storm water from the water shed described in figure 1 attached, which gives the lengths of lines, drainage areas, and inlet times. Assume the following: a rainfall coefficient of 0.50 for area 1; 0.10 for area 2; and 0.3 for area 3; the five year frequency curve from the above rainfall intensity curve, and a flowing full velocity of 0.9m/s in the sewers.

(15 Marks)

b) The measured flow in a 1200mm concrete storm sewer on a grade of 0.00015m/m is 740mm. What is the calculated quantity and velocity flow?

(5 Marks)

c) If a 250mm sewer is placed on a slope of 0.007, what is the flowing full quantity and velocity for (a) n = 0.013 and (b) n = 0.015?

(5 Marks)

QUESTION 4

a) Describe the design of sanitary sewers

(8 Marks)

b) A trapezoidal irrigation channel excavated in silty sand having a critical tractive force on the horizontal of 2.4 N/m^2 and an angle of $10m^3/s$ on a bed lope of 1:10000. The side slopes will be 1:2. n = 0.02. Determine the channel dimensions such that the mean velocity does not exceed 0.6m/s when conveying the discharge of $10m^3/s$.

(9 marks)

c) Briefly describe small-bore sewers as means of drainage in poor communities.

(8 Marks)

QUESTION 5

a) Describe the design of storm water sewers

(11 Marks)

b) A concrete-lined trapezoidal channel has a bed width of 3.5m, side slopes at 45^o to the horizontal, a bed slope 1 in 1000 and manning roughness coefficient of 0.015. Calculate the depth of uniform flow when the discharge is $20m^3/s$.

(8 Marks)

c) Describe the institutional aspects of drainage in poor countries.

(6 Marks)

FORMULARS

1. Cd = 0.61 and $T = \int dt = \frac{ZA(H_1^{1/2} - H_2^{1/2})}{Cda\sqrt{2g}}$

2. $Q = 2/3\ Cd \sqrt{2g}\quad b(H_1^{3/2} - H_2^{3/2})$

3. $Y_i = Y_S/2\ (\sqrt{1+8\beta f_S^2} - 1)$

4. $F_S = V_S/\sqrt{g}Y_S$

5. $(Y + V/2g) - (Y + V/2g)$

6. $\rho g y^2/2 + \rho q(V_1 - V_2) - \rho g Y_2^2 / F_X = 0$

7. $Y_G = Y_s\ \sqrt{1+2F_s^2}\ (1 - Y_S/Y_2)$

8. $Q = AV$

9. $Q = A/n\ R^{2/3}\ S_0^{1/2}$

10. $Y_i = Y_S/2\ (\sqrt{1+8\beta f_S^2} - 1)$

11. $F_S = V_S/\sqrt{g}Y_S$

12. $p_1/\rho g + v_1^2/2g = p_2/\rho g + v_2^2/2g + 0.03\ (p_1/\rho g - p_2/\rho g)$

13. $Q = 1.84BH^{3/2}\ [(1+ \alpha\ v^2/2g\ H)^{3/2} - (\alpha\ v^2/2g\ H)^{3/2}]$

14. $k=[(1+ \alpha\ v^2/2g\ H)^{3/2} - (\alpha\ v^2/2g\ H)^{3/2}]$

15. $h= (v^2/2g)(1+ A_1/A_2)^2 = v^2/2g\ (A_1/A_2 - 1)^2$

16. $W = \sum_{i=1} \frac{p^{2ms(1)} S_i}{\rho C}$, where ρC = 420 RAYLS.

17. $S.I.L = 10 \log_{10} (I) + 120$

18. $L_p = 10 \log (p_1/p_0)^2$ or
    $(p_1/p_0)^2 = 10^{Lp/10}$

19. $L_p(total) = 10 \log (p_{total}/p_0)^2$

20. $I = W/A$

22. $h = \frac{2\sigma \cos\theta}{R\rho g}$

23. $\frac{p_1}{\rho g} + \frac{v_1^2}{2g} = \frac{p_2}{\rho g} + \frac{v_2^2}{2g}$

24. $W = \rho g Q\, h_p,$

25. Turbine output = $\eta_t \rho g Q h_p,$

26. $k=[(1+ \alpha\, v^2/2g\, H)^{3/2} - (\alpha\, v^2/2g\, H)^{3/2}]$

27. $h= (v^2/2g)(1+ A_1/A_2)^2 = v^2/2g\, (A_1/A_2 - 1)^2$

28. $Q = a_1\, v_1 = a_1\, v_2$

29. $h_L = (1/C_c-1)^2\, V_1^2/2g$

30. $A = (b + Ny)y$

31. $P = b + 2\, y\, \sqrt{(1+N^2)}$

32. $\Delta Q = \frac{-\Sigma h}{2\, \Sigma h/Q}$

33. $S.R.I = 10 \log_{10} \frac{I_i}{I_t} = 10 \log_{10} \frac{1}{\tau} = T.L$

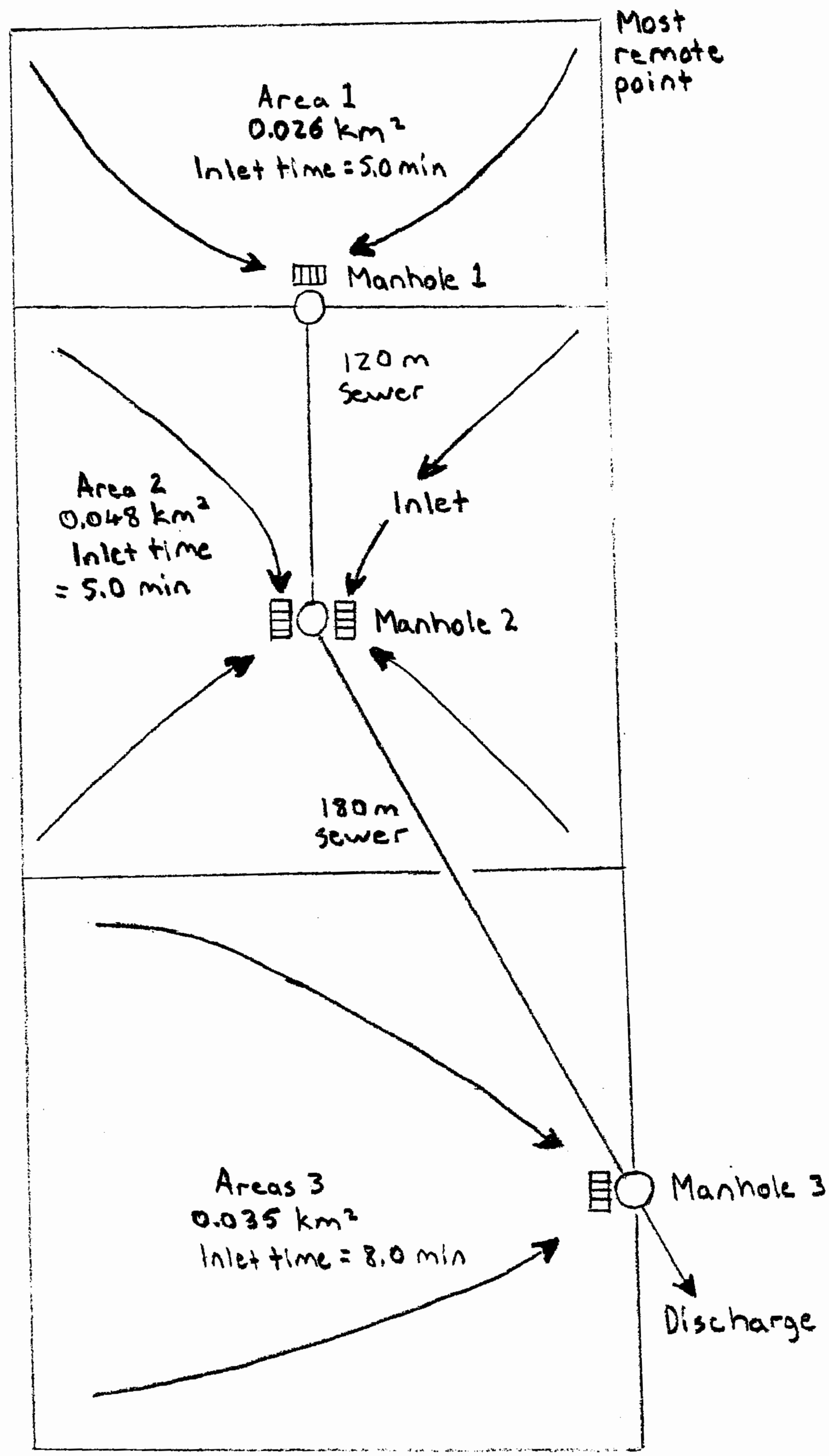

Most remote point
Area 1
0.026 km²
Inlet time = 5.0 min
Manhole 1
120 m Sewer
Inlet
Area 2
0.048 km²
Inlet time = 5.0 min
Manhole 2
180 m sewer
Areas 3
0.035 km²
Inlet time = 8.0 min
Manhole 3
Discharge

FIGURE 1

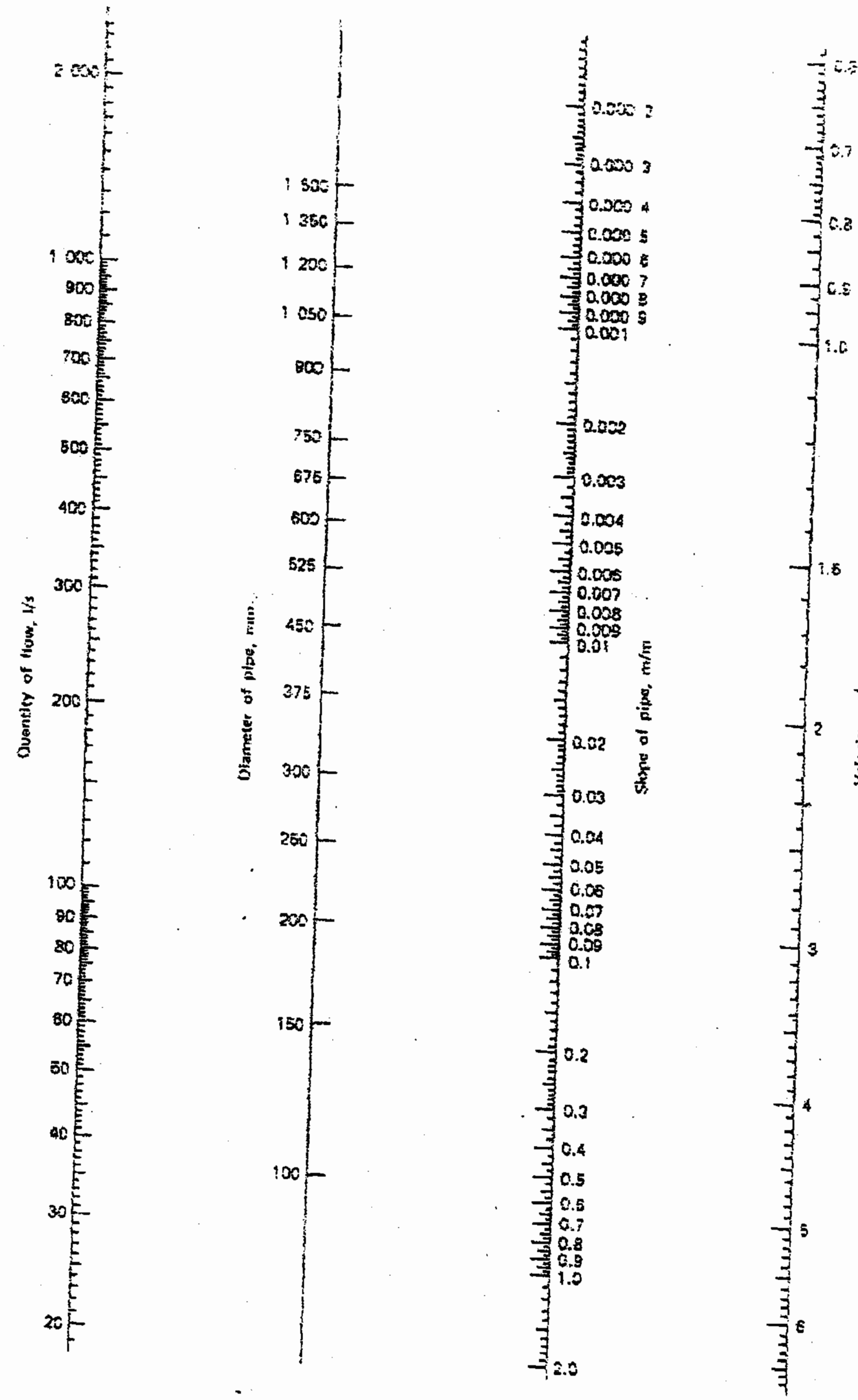

Quantity of flow, l/s
2 000
1 000
900
800
700
600
500
400
300
200
100
90
80
70
60
50
40
30
20
Diameter of pipe, mm
1 500
1 350
1 200
1 050
900
750
675
600
525
450
375
300
250
200
150
100
Slope of pipe, m/m
0.000 2
0.000 3
0.000 4
0.000 5
0.000 6
0.000 7
0.000 8
0.000 9
0.001
0.002
0.003
0.004
0.005
0.006
0.007
0.008
0.009
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
2.0
Velocity, m/s
0.6
0.7
0.8
0.9
1.0
1.5
2
3
4
5
6

FIGURE 6

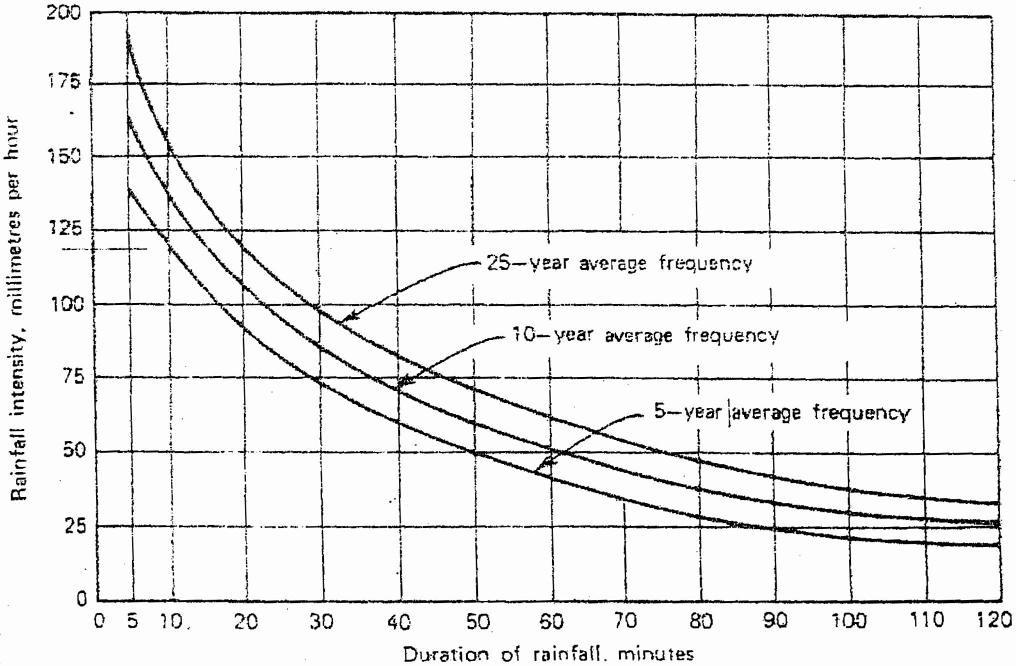


FIGURE 4

Hydraulics and Hydrology

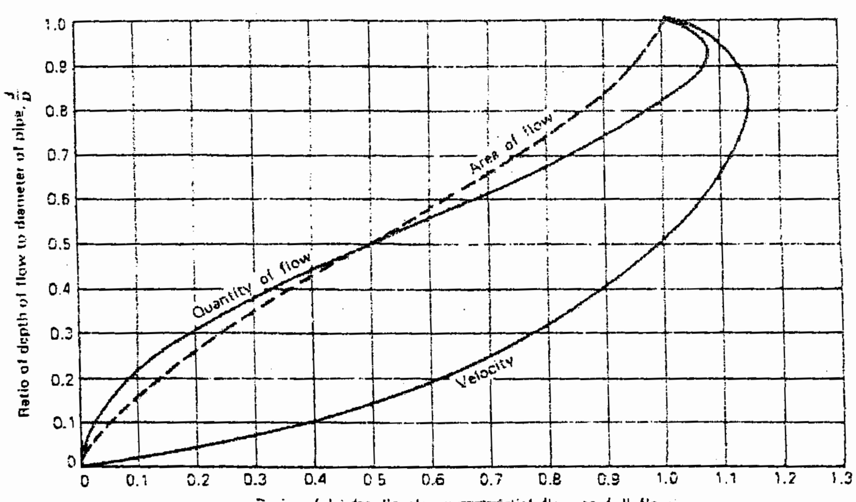
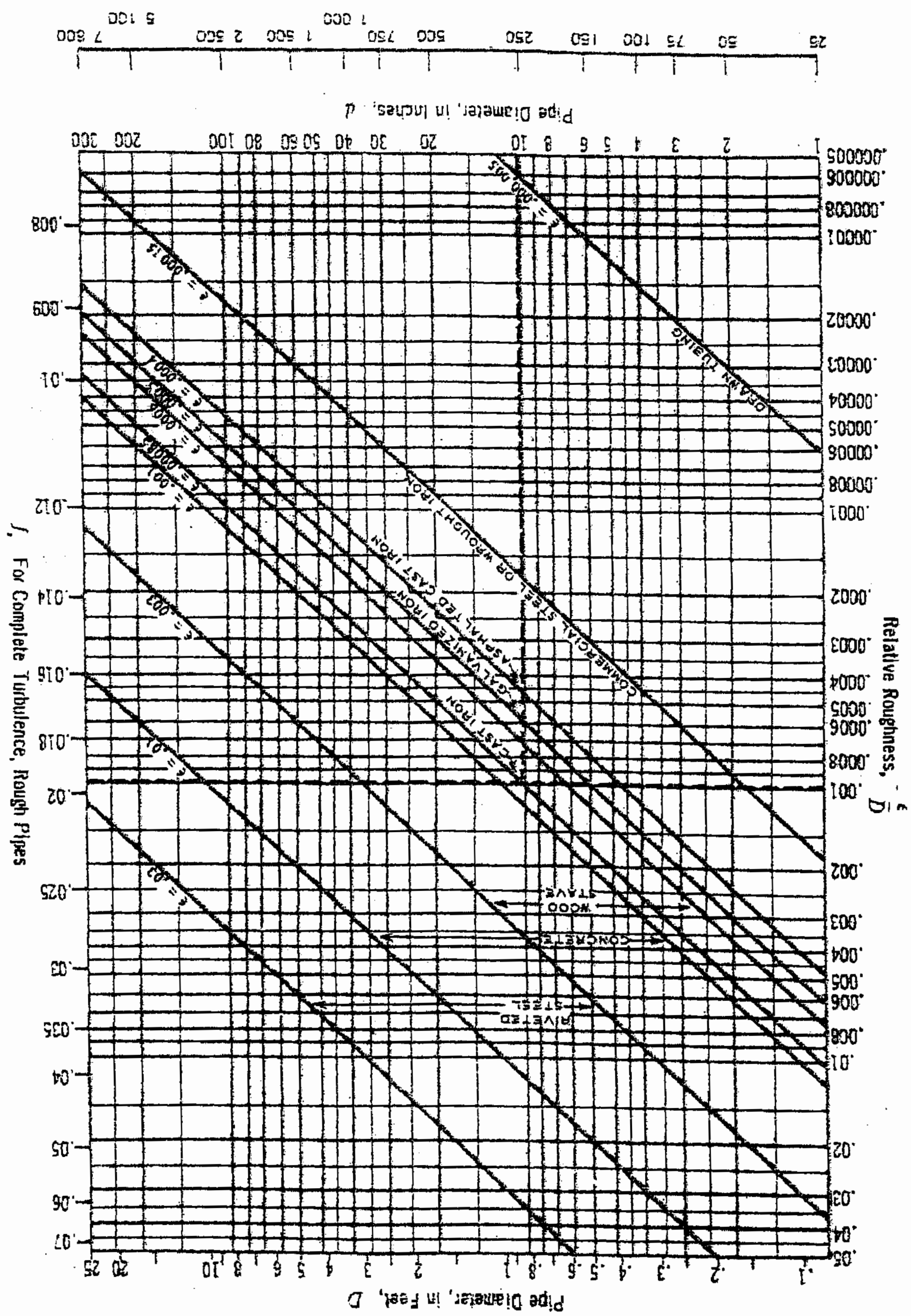


FIGURE 7



Pipe Diameter, in Inches, d
Pipe Diameter, in Feet, D
Relative Roughness, ε/D
f, For Complete Turbulence, Rough Pipes
DRAWN TUBING
COMMERCIAL STEEL OR WROUGHT IRON
ASPHALTED CAST IRON
GALVANIZED IRON
CAST IRON
WOOD STAVE
CONCRETE
RIVETED STEEL

FIGURE 8

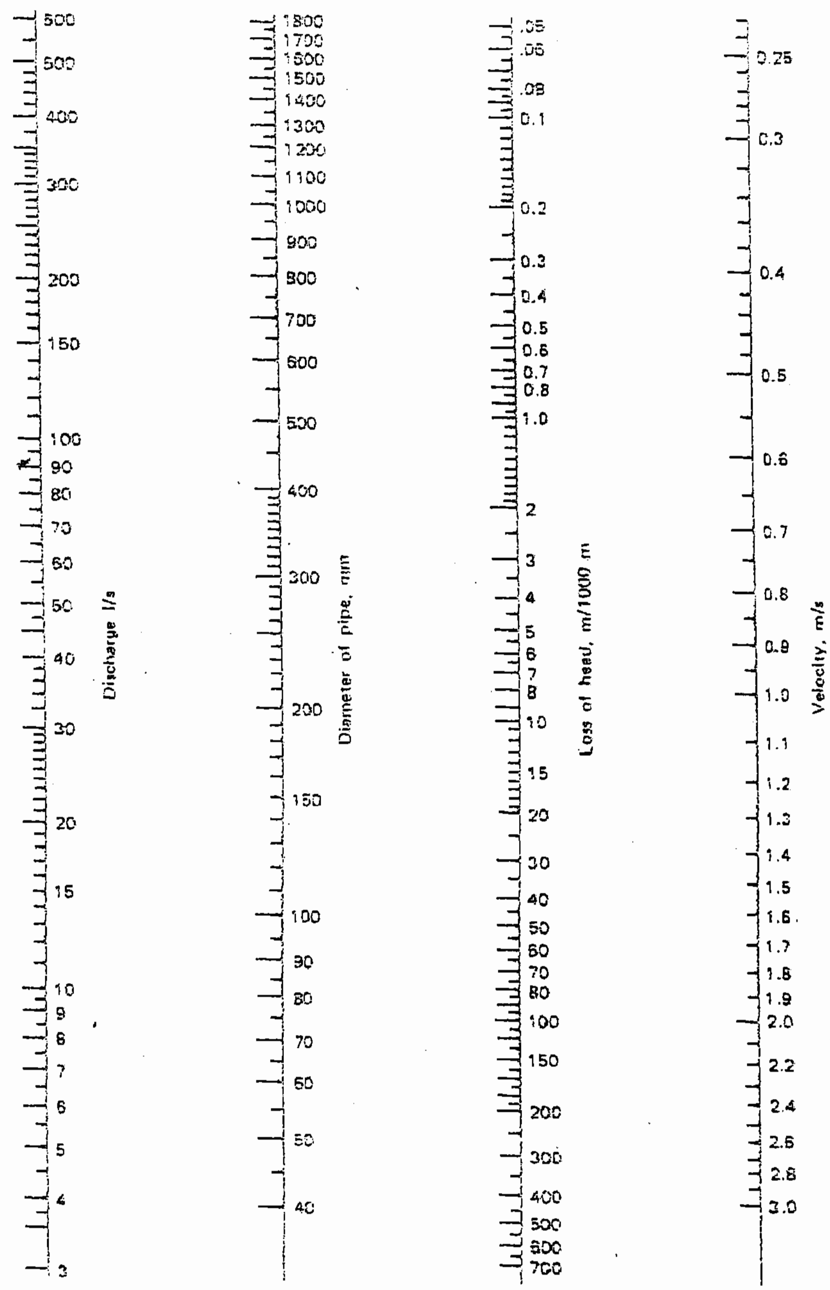

Discharge l/s
Diameter of pipe, mm
Loss of head, m/1000 m
Velocity, m/s

FIGURE 9