UNIVERSITY OF SWAZILAND
FACULTY OF HEALTH SCIENCES
DEGREE IN ENVIRONMENTAL HEALTH SCIENCES
(FINAL EXAMINATION)

TITLE OF PAPER : **WATER DRAINAGE AND SEWARAGE**

COURSE CODE : **EHS 587**

TIME : **3HOURS**

TOTAL MARKS : **100**

INSTRUCTIONS:

- **ANSWER ANY FOUR QUESTIONS**
- **QUESTION 1 (I) IS MULTIPLE CHOICE**
- **ALL QUESTIONS ARE WORTH 25 MARKS EACH**
- **NO FORM OF PAPER SHOULD BE BROUGHT IN OR OUT OF THE EXAMINATION ROOM**
- **BEGIN THE ANSWER TO EACH QUESTION IN A SEPARATE SHEET OF PAPER.**

DO NO OPEN THIS EXAMINATION PAPER UNTIL PERMISSION HAS BEEN GRANTED BY THE INVIGILATOR.

QUESTION 1.

I.

Multiple choice: Write True or False against each letter corresponding to the following statements as they apply to water drainage and sewerage.

a) Sewers are designed to be laid at a gradient which ensures that peak flows carry away any solids deposited during periods of low flow.

b) Storm sewers are usually designed to have sufficient capacity so that they do not run full when conveying the computed surface run off.

c) Pipe network analysis involves the determination of the pipe flow rates and pressure heads which do not satisfy the continuity and energy conservation equations.

d) For a common block shallow sewer the self cleansing velocity should be 0.5m/s and the maximum diameter should be 100mm and the minimum gradient 1:167.

e) The "critical tractive force" theory and the "maximum permissible velocity" concept are commonly used in the design of erodible channels for stability.

f) Most sulphate reducing bacteria live in slime layers on sewer walls and require a flow of sewage to bring them flesh supplies of bio chemical food and sulphate.

g) Waste water sewers are designed using a general flow at six times the dry weather flow.

h) The depth of flow to the diameter of sewer (d/D) at peak flow should be 0.8 minimum and 0.2 maximum

i) For the design of shallow sewers, the minimum peak flow should be 2.2 l/s.

j) Conventional sewerage is too expensive; small bore sewerage, with several households connected to individual interceptor tanks, is a possibility and is low-cost them shallow sewers.

(20 Marks)

II.

If a 250 mm sewer is placed on a slope of 0.010, what is the full quantity and velocity for (i) n = 0.013, and (ii) n = 0.015?

(5 marks)

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QUESTION 2

a) Compute the diameter of the outfall sewer required to drain storm water from the watershed described in figure 3, which gives the lengths of lines, drainage areas, and inlet times. Assume the following: a rainfall coefficient of 0.30 for the entire area, the five-year frequency curve from figure 4, and a flowing full velocity of 0.75 m/s in the sewer.

(15 marks)

b) The measured of flow in a 1200 mm concrete storm sewer on a grade of 0.0015 m/m is 740. What is the calculated quantity and velocity of flow?

(5 marks)

c) A 450 mm sewer pipe, n = 0.013, is placed on a slope of 0.0025. At what depth of flow does the velocity of flow equal 0.60 m/s?

(5 marks)

QUESTION 3

A trade waste treatment plant works on a batch system taking a discharge of up to 1000 m^3 from a 2000 m^3 capacity tank at regular hourly intervals. The tank receives waste from a number of units of process plant, each of which discharges 500 m^3 when it empties. The number of units emptied in any one hour is random and independent. There is a 25 per cent probability of only one unit being emptied in an hour, a 50 per cent probability of two units being emptied in an hour, and a 25 per cent per cent of three units being emptied in an hour. If the tank is full when a unit is to be emptied, the waste is discharged untreated to the nearby river instead. Estimate the probability of such an occurrence.

(25 marks)

QUESTION 4

a) 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.

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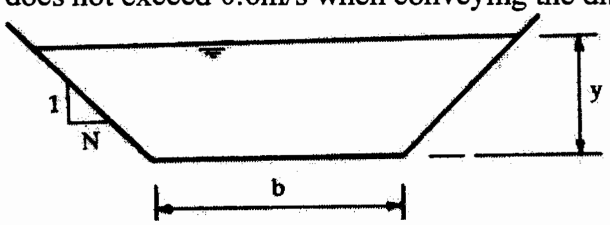
$$Q_p = \frac{1}{360} A_p \, i \ (m^3/s)$$

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

(18 marks)

b) A trapezoidal irrigation channel excavated in silty sand having a critical force on the horizontal of 2.4 N/m^2 and angle of friction 30^0 is to be designed to convey a discharge of 10m^3/s on the bed slope of 1: 10 000. The side slopes will be 1(vertically): 2 (horizontally). 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.



(7 marks)

QUESTION 5

A vertical sluice gate with an opening of 0.67 m produces a down stream jet depth of 0.40m when installed in a long rectangular channel 5.0 m wide conveying a steady discharge of 20.0m^3/s. Assuming that the flow downstream of the gate eventually returns to the uniform flow depth of 2.5m.

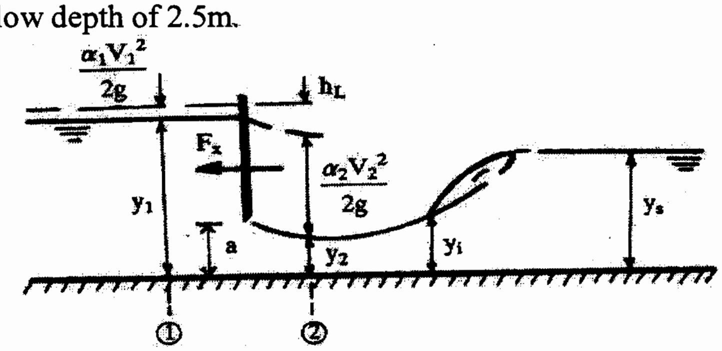


Fig. 1

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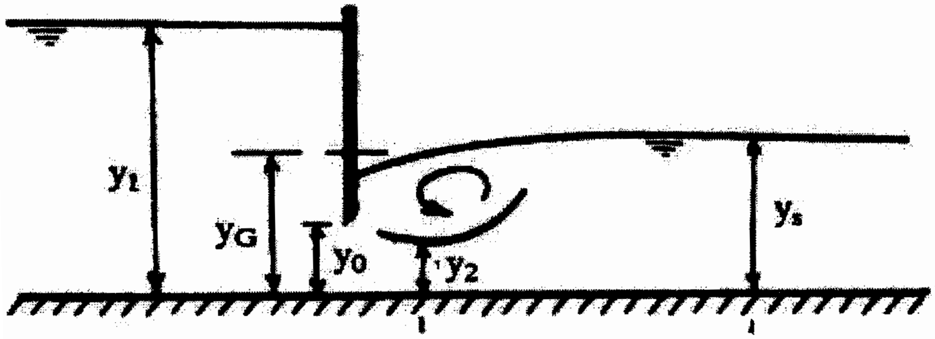

Fig. 2

a) Verity that that a hydraulic jump occurs. Assume $\alpha = \beta = 1.0$ (See fig.1)

(5 marks)

b) Calculate the head loss in the jump.

(3 marks)

c) If the head loss through the gate is $0.05\ V_j^2/2g$, calculate the depth upstream of the gate and the force on the gate.

(9 marks)

d) If the down stream depth is increased to 3.0 m analyze the flow conditions at the gate. (See fig.2)

(8 marks)

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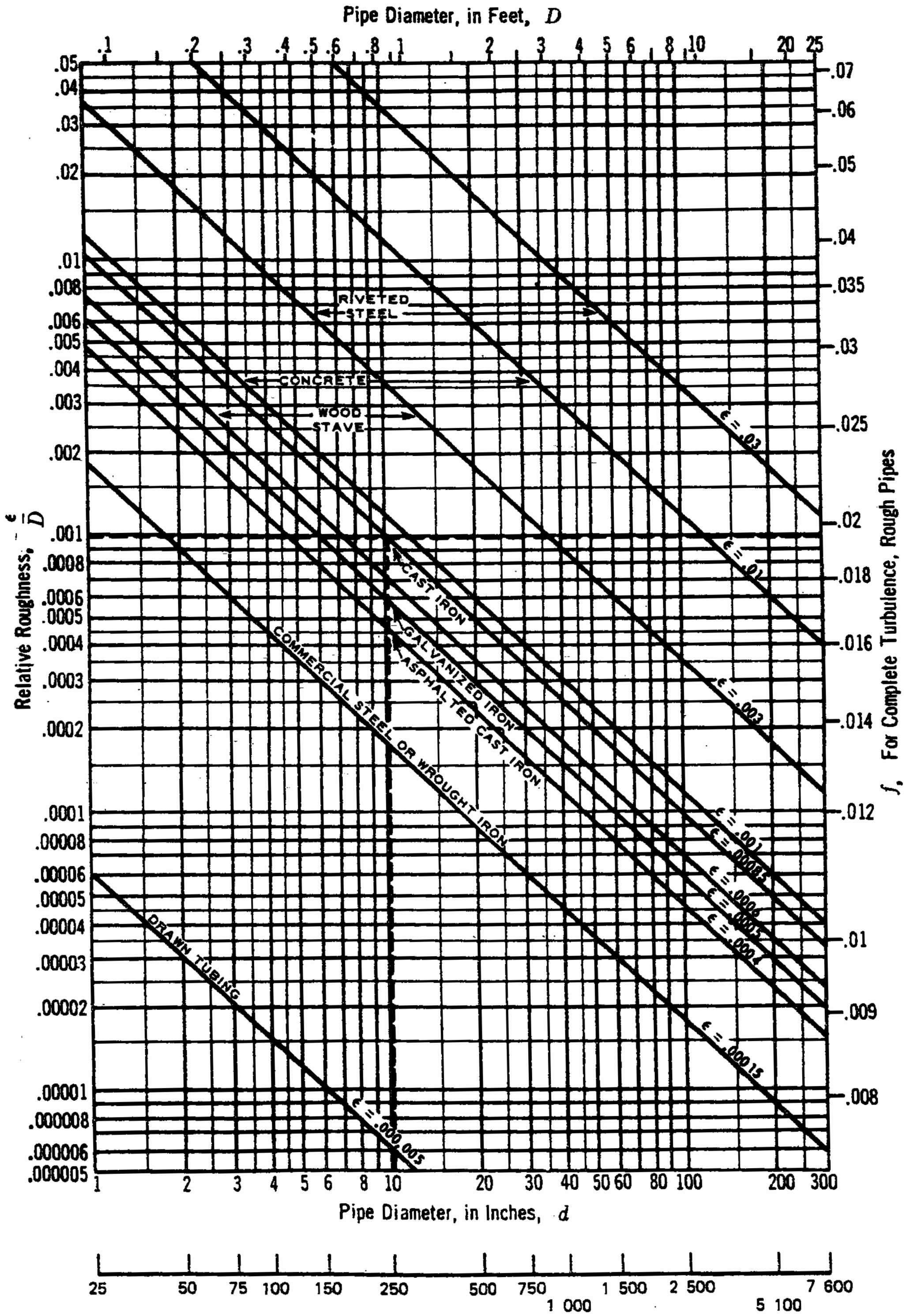

Pipe Diameter, in Feet, D
.1 .2 .3 .4 .5 .6 .8 1 2 3 4 5 6 8 10 20 25
Relative Roughness, ε/D
.05 .04 .03 .02 .01 .008 .006 .005 .004 .003 .002 .001 .0008 .0006 .0005 .0004 .0003 .0002 .0001 .00008 .00006 .00005 .00004 .00003 .00002 .00001 .000008 .000006 .000005
f, For Complete Turbulence, Rough Pipes
.07 .06 .05 .04 .035 .03 .025 .02 .018 .016 .014 .012 .01 .009 .008
RIVETED STEEL
CONCRETE
WOOD STAVE
CAST IRON
GALVANIZED IRON
ASPHALTED CAST IRON
COMMERCIAL STEEL OR WROUGHT IRON
DRAWN TUBING
ε = .03
ε = .01
ε = .003
ε = .001
ε = .00085
ε = .0006
ε = .0005
ε = .0004
ε = .00015
ε = .000 005
Pipe Diameter, in Inches, d
1 2 3 4 5 6 8 10 20 30 40 50 60 80 100 200 300
25 50 75 100 150 250 500 750 1 000 1 500 2 500 5 100 7 600

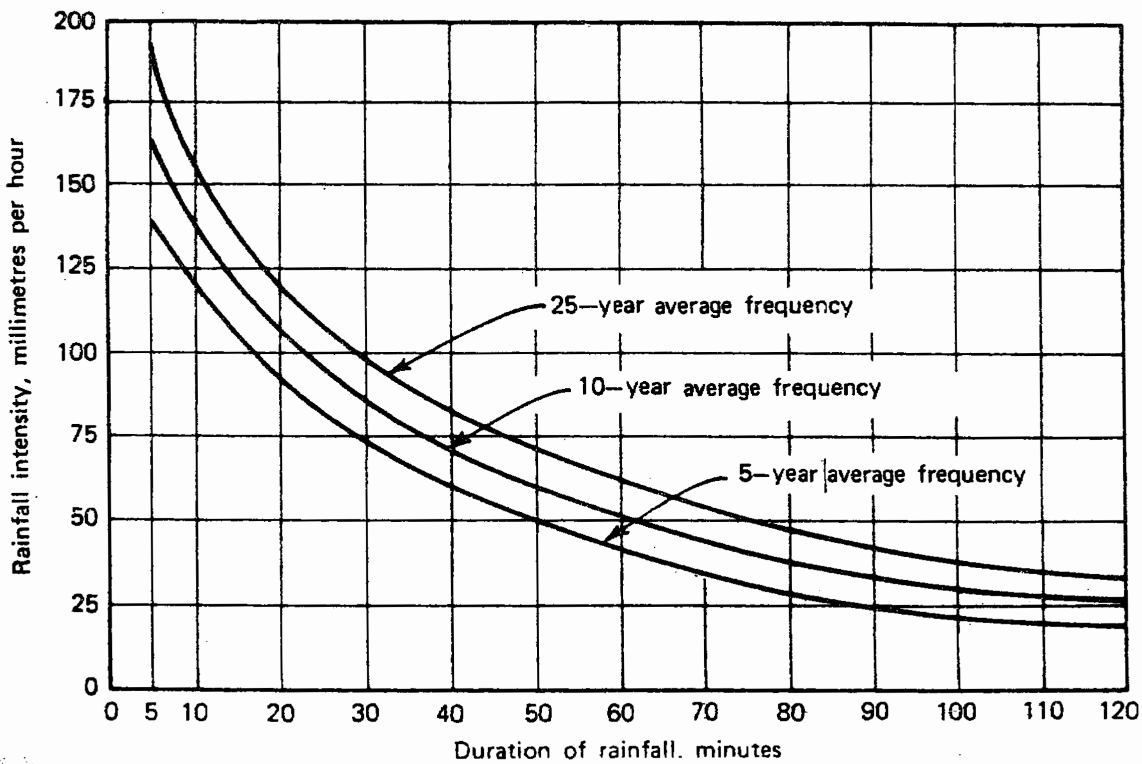


FIGURE 4

Hydraulics and Hydrology

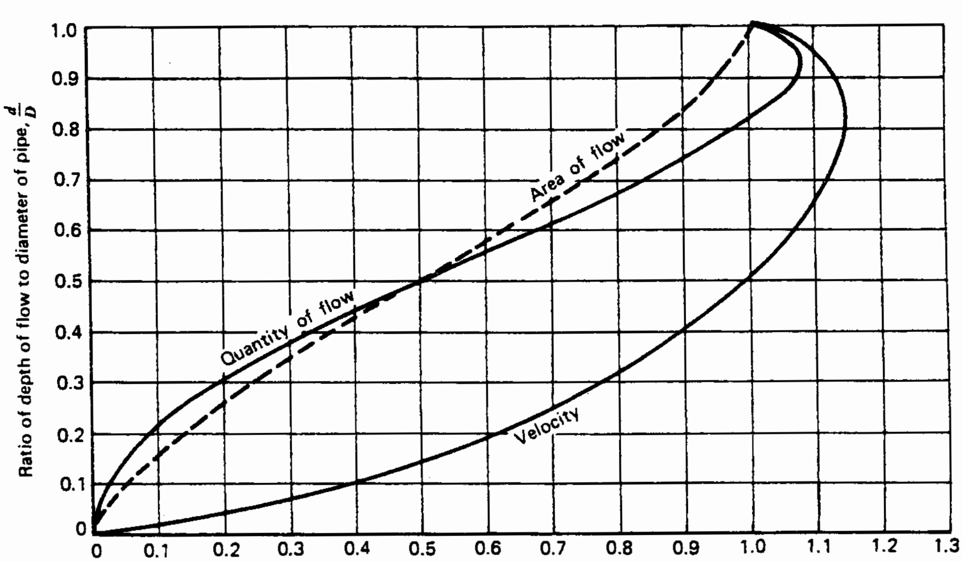


FIGURE 7

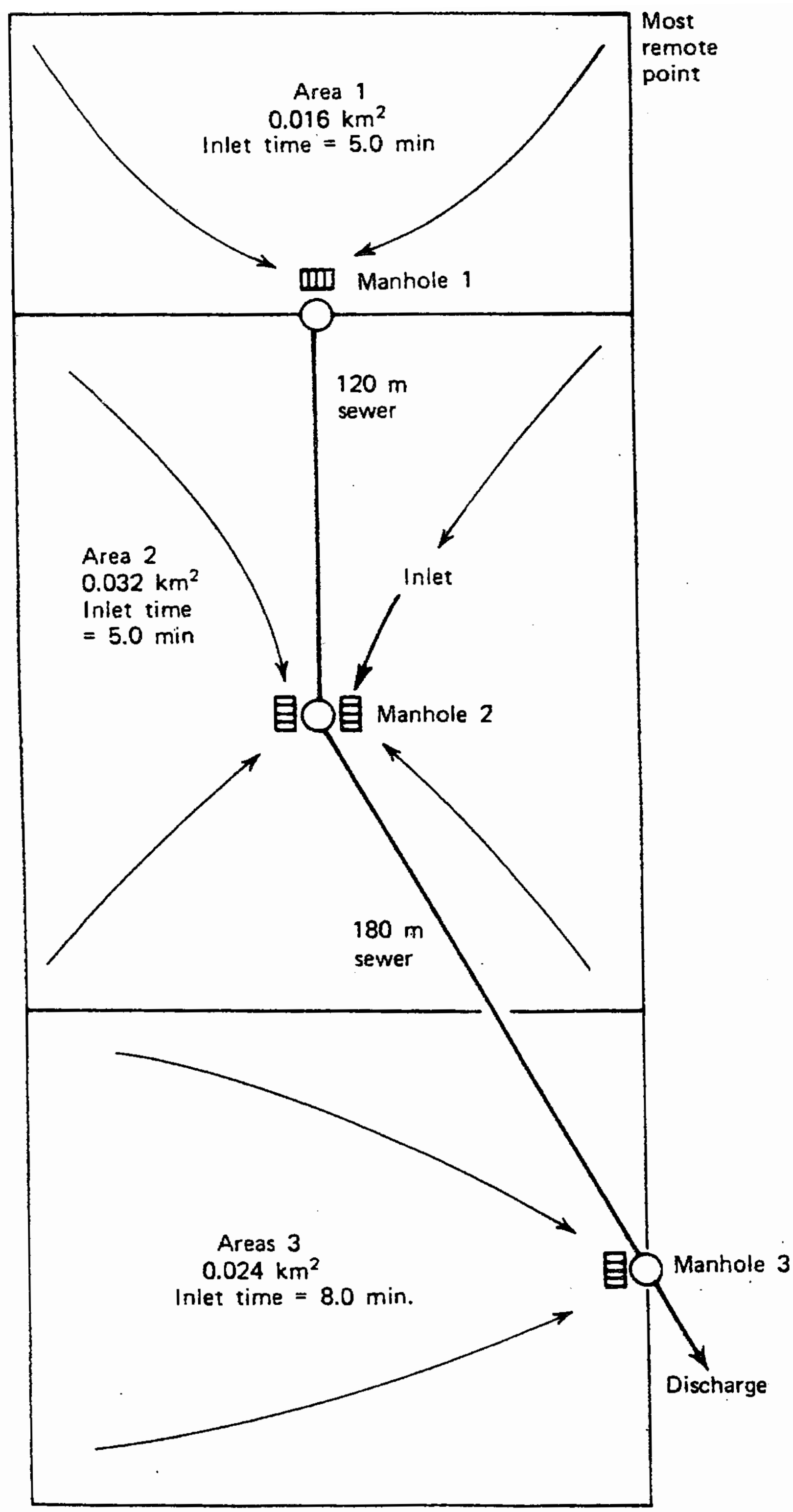
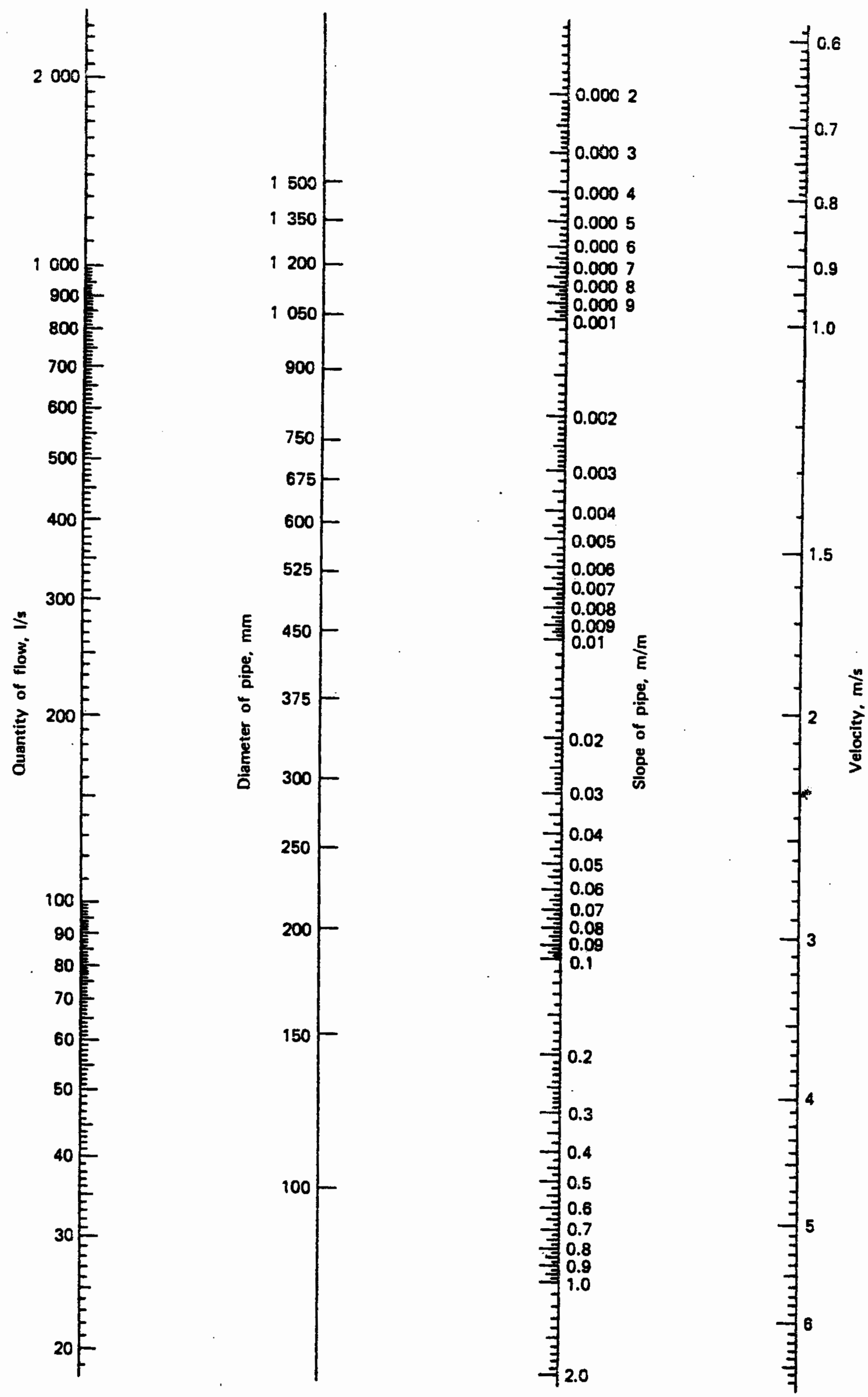

Most
remote
point
Area 1
0.016 km²
Inlet time = 5.0 min
Manhole 1
120 m
sewer
Area 2
0.032 km²
Inlet time
= 5.0 min
Inlet
Manhole 2
180 m
sewer
Areas 3
0.024 km²
Inlet time = 8.0 min.
Manhole 3
Discharge

FIGURE 3



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

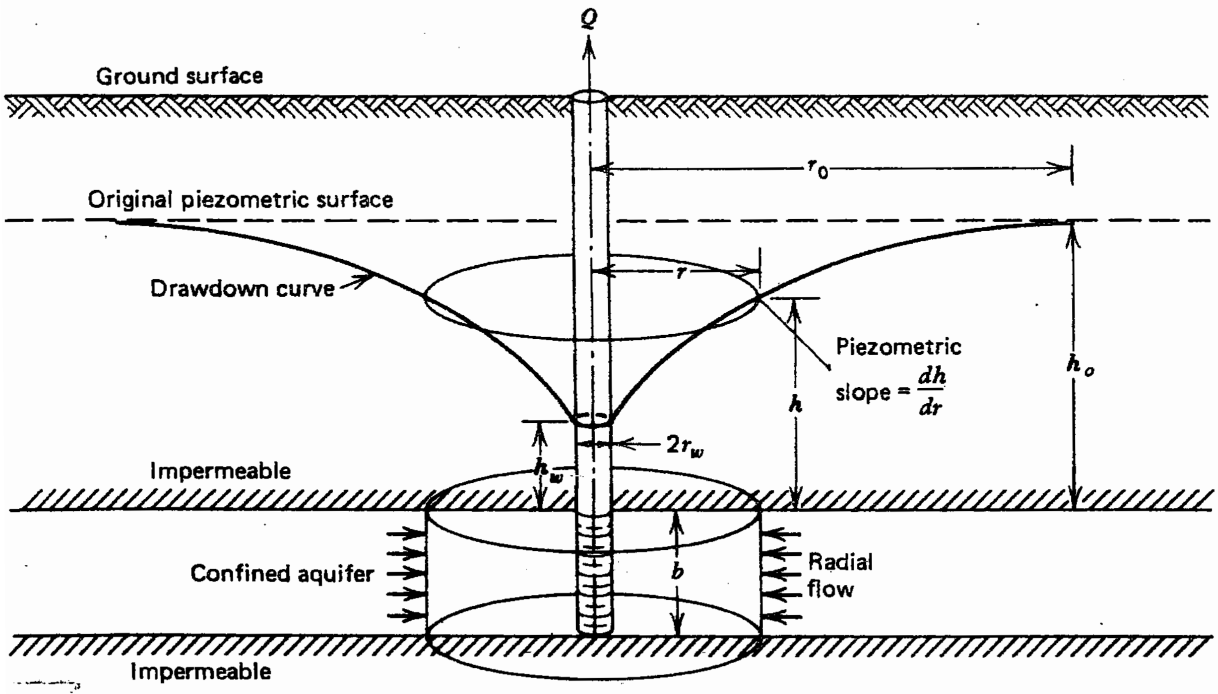

Q
Ground surface
r_0
Original piezometric surface
Drawdown curve
r
Piezometric
slope = $\frac{dh}{dr}$
h_o
h
$2r_w$
Impermeable
h_w
Confined aquifer
b
Radial
flow
Impermeable

Figure 1.