UNIVERSITY OF SWAZILAND
Faculty of Health Sciences

DEGREE IN ENVIRONMENTAL HEALTH SCIENCES
FINAL EXAMINATION PAPER 2005

TITLE OF PAPER	: WATER DISTRIBUTION AND SEWERAGE
COURSE CODE	: EHS 544
DURATION	: 3 HOURS
MARKS	: 100
INSTRUCTIONS	: READ THE QUESTIONS & INSTRUCTIONS CAREFULLY
	: ANSWER ONLY **FIVE** QUESTIONS
	: EACH QUESTION CARRIES 20 MARKS.
	: WRITE NEATLY & CLEARLY
	: NO PAPER SHOULD BE BROUGHT INTO OR OUT OF THE EXAMINATION ROOM.
	: BEGIN EACH QUESTION ON A SEPARATE SHEET OF PAPER.

DO NOT OPEN THIS QUESTION PAPER UNTIL PERMISSION IS GRANTE BY THE INVIGILATOR.

202

WATER DISTRIBUTION AND SEWERAGE FINAL EXAMINATION FOR THE FIFTH YEARS

QUESTION 1:

Using the information provided in figure 1 and attached tables design the distribution network. Calculate the design population for the next 10 years; the mean daily demand; the peak flow, peak flow per standpipe and the sizes of the reservoir and pipeline.

Given information:

- There are 10 people per homestead
- Design population = present population $(1+r)^{10}$
- Population annual growth rate, r = 3%
- Per capita consumption per day = 30 litres
- Peak flow factor = 4
- Standard reservoir sizes are $30m^3$, $45m^3$, $60m^3$, $75m^3$, $90m^3$ and $120m^3$
- Standard flow per standpipe = 0.25 l/s
- Velocity = 0.4 to 0.99m/s

[20 marks]

QUESTION 2

a) A pipeline diameter of 300mm and 80 m long contains two 90° elbows and one gate valve. Allowing for sharp pipe entry and exit losses, calculate the equivalent pipe length and the total head loss when the flow rate is 0.1 m^3s^{-1} and the valve is fully open. Take the friction factor f = 0.003.

[16 marks]

b) Write short notes on shallow sewerage

[4 marks]

QUESTION 3

a) Estimate the energy (head) loss along a short length of pipe suddenly enlarging from a diameter of 350mm to 700mm and conveying 300 litres per second of water. If the pressure at the entrance of the flow is 10^5 N/m^2 find the pressure at the exit of the pipe. What would be the energy loss if the flow were to be reversed with a contraction coefficient of 0.62?

[15 marks]

b) A rectangular orifice 300mm wide and 500mm deep placed with the upper edge in a horizontal position 0.90m vertically below the water surface in a vertical sidewall of a tank, is discharging to the atmosphere. Calculate the rate of flow through the orifice if its discharge coefficient is 0.62.

[5 marks]

QUESTION 4

Multiple choice: Write true or false against each letter corresponding to the following statement as they apply to water distribution and sewerage

a) For steady conditions, total inflow to a junction is equal to total outflow from it.

b) In any fluid under gravitational attraction, pressure increases with increase of height.

c) For steady flow at any junction the algebraic sum of all the mass flows must not necessarily be zero.

d) In a fluid at rest there cannot be shear forces.

e) In a fluid at rest pressure in all directions at a point is not equal.

f) Absolute pressure is equal to gauge pressure minus atmospheric pressure.

g) When pressures are expressed as head, it is essential that the mass density is given or the fluid named.

h) Energy losses in sudden transitions are due to the formation of eddies and pressure loss dissipating in the form of heat energy.

i) The maximum gauge pressure of water that can be measured by means of a piezometer tube 2m high is 19.62×10^3 Nm $^{-2}$.

j) A fluid moving through a pipeline is not subjected to energy losses from various sources such as continuous resistance exerted by the pipe walls.

[20 marks]

QUESTION 5

Multiple choice: Write true or false against each letter corresponding to the following statement as they apply to water distribution and sewerage

a) The hydraulic grade line shows the elevation of the velocity head along the pipe.

b) For the flow of a real fluid through a pipe or other conduit, the velocity will not vary from wall to wall.

c) Except in nuclear processes, matter is neither created nor destroyed.

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

e) Pressures measured below atmospheric pressure are known as gauge pressures.

f) For a common block shallow sewer the self cleansing velocity should be 0.2m/s and minimum diameter should be 50m and the minimum gradient 1 in 150.

g) Pipe network analysis involves the determination of the pipe flow rates and pressure heads which satisfy the continuity and energy conversation equations.

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

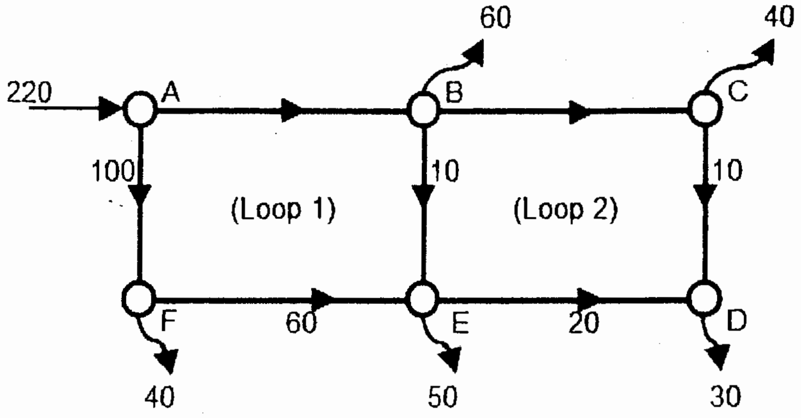
i) For the design of shallow sewers, the minimum peak flow should be 2.2 litres/second.

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

[20 marks]

QUESTION 6

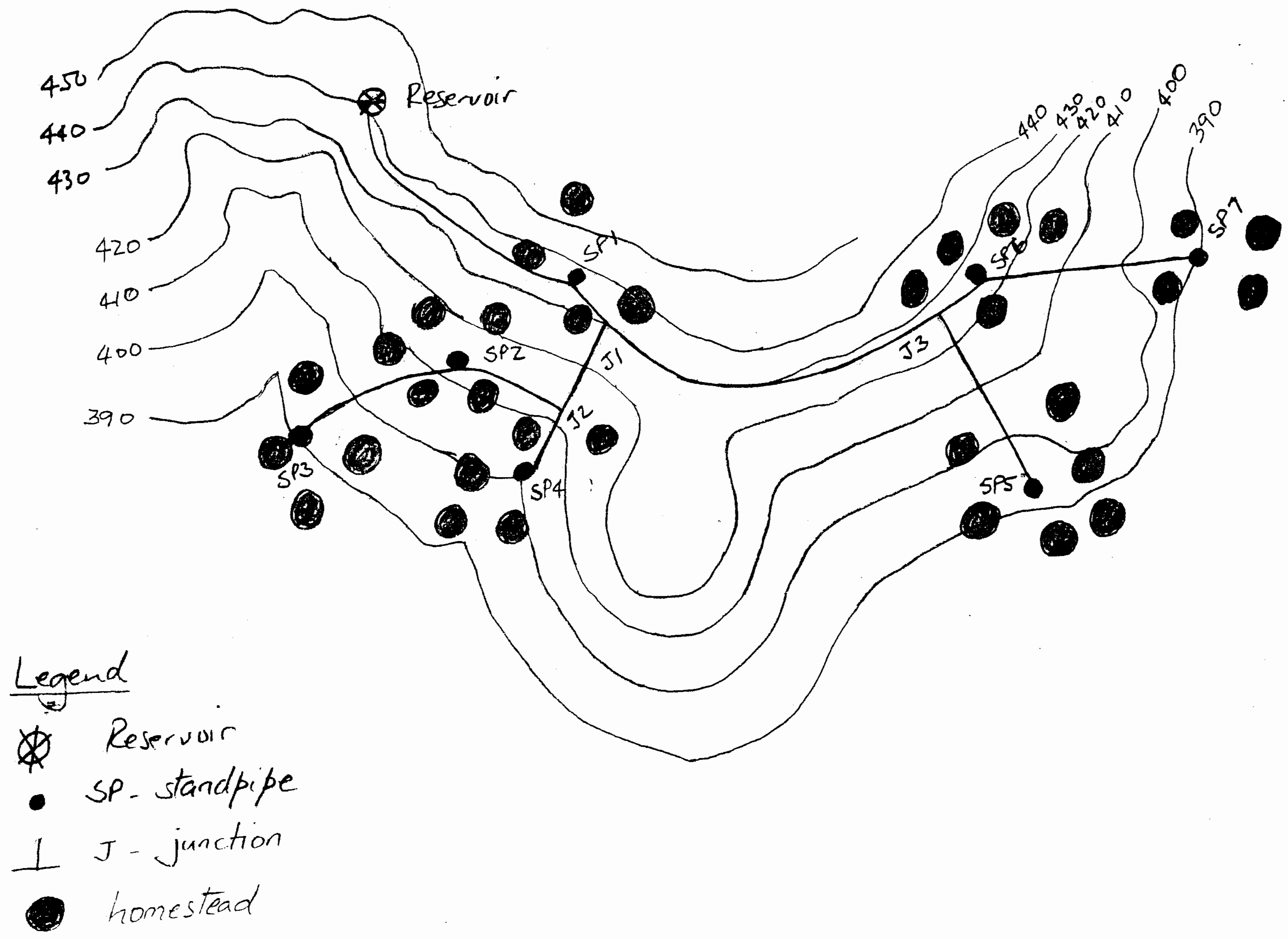
Use the information provided and calculate the valves of ΔQ, adjusted Q for both loops 1 and 2.



Loop	Pipe	Q (l/s)	k	h_L (m)	h_L/Q	Q
1	AB	120.00	797.0	11.48	?	?
	BE	10.00	33877.0	3.39	?	?
	EF	-60.00	11229.1	-40.42	?	?
	FA	-100.00	836.6	-8.36	?	?
				$\sum =$	?	?
2	BC	50.00	11359.7	28.40	?	?
	CD	10.00	33877.0	3.39	?	?
	DE	-20	12338.9	-4.94	?	?
	EB	-24.23	31232.9	-18.34	?	?
				$\sum =$	?	= ?

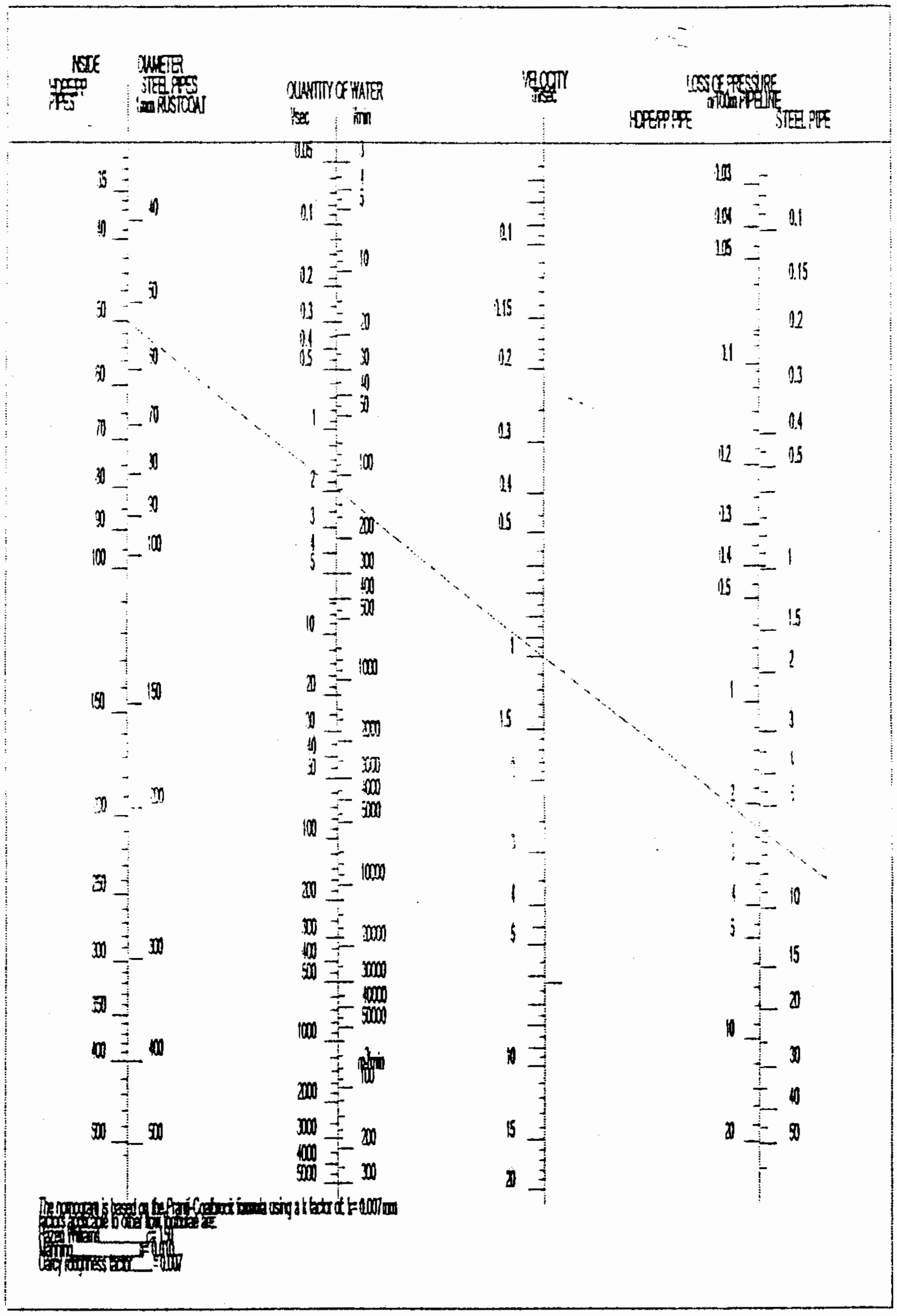
[20 Marks]

Figure 1


450
440
430
420
410
400
390
Reservoir
SP1
SP2
SP3
SP4
SP5
SP6
SP7
J1
J2
J3
440
430
420
410
400
390
Legend
Reservoir
SP - standpipe
J - junction
homestead

Calculation sheet for Figure 1

Pipe No.	Reach		Elevation	Length	Friction loss 1m/100m		Static head	Hydraulic	Residual	Flow	Velocity	Pipe diameter (mm)		Pipe material + class
	Node	Node	(m)	(m)	Calculated	Opted	(m)	head (m)	head (m)	l/s	m/s	Caculated	Standard	
	Reservoir													
1	Res	SP1												
	SP1													
2	SP1	J1												
	J1													
3	J1	J2												
	J2													
4	J2	SP2												
	SP2													
5	SP2	SP3												
	SP3													
6	J2	SP4												
	SP4													
7	J1	J3												
	J3													
8	J3	SP5												
	SP5													
9	J3	SP6												
	SP6													
10	SP6	SP7												
	SP7													

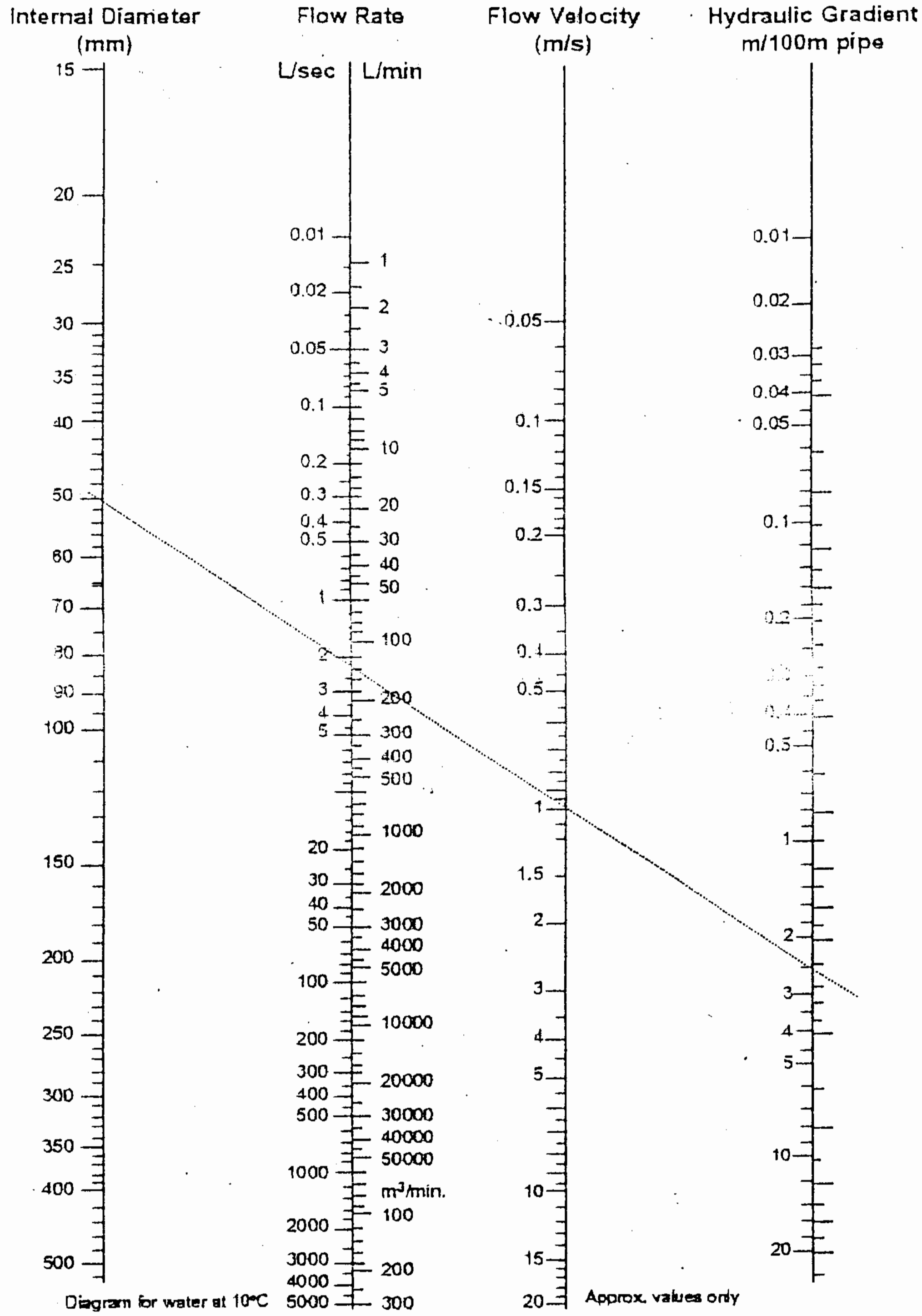


Source Megapipe

Figure 8.6: Nomograph for HDPE and steel.

The nomogram is based on the Pranti-Coalbrook formula using a k factor of: k=0.007mm
Factors applicable to other formulae are:
Hazen Williams................................c=150
Manning..n=0.010
Darcy roughness factor...................... =0.007

Flow Nomogram



Source Dura pipe

Figure 8.7: Nomograph for uPVC pipes

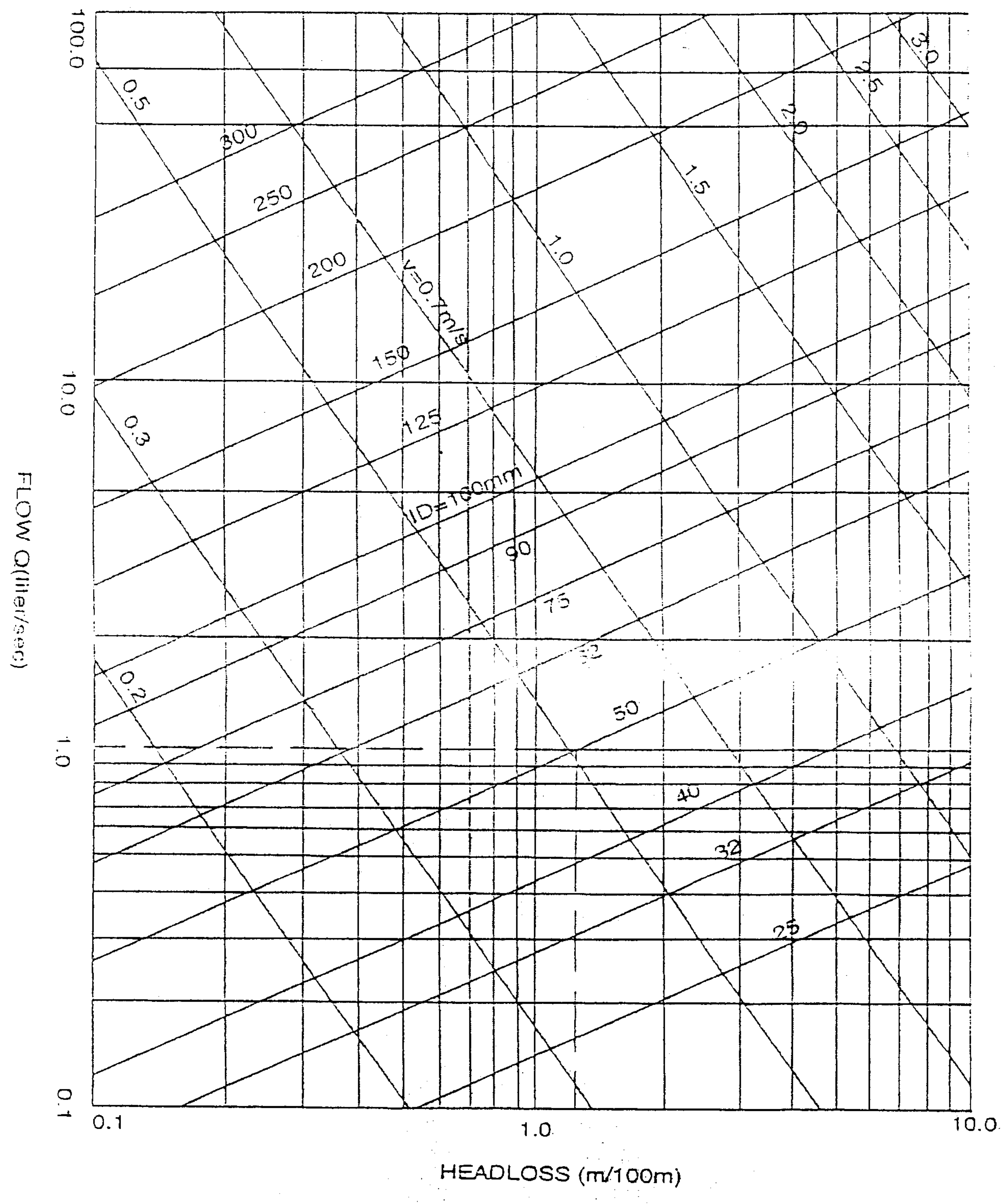


Figure 8.5: Hazen Williams chart C = 120

EQUATIONS AND TABLES

1. The Manning equation:

$$Q = \frac{A}{n} R^{2/3} S_o^{1/2}$$,where A = area of flow

P = wetted perimeter
R = A/P
S = bed slope
n = Manning roughness coefficient

2. Head loss (h_L) = $(v^2 - v^2)/ 2g$

3. Energy equation:

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + h_L$$

4. Continuity of flow: $Q = A_1V_1 = A_1V_2$

5. $h_L = \left(\frac{1}{C_c} - 1\right)^2 \frac{V^2}{2g}$

6. $Q = 2/3\, C_d \sqrt{[2g}\, B\, (H_1^{3/2} - H_2^{3/2})$

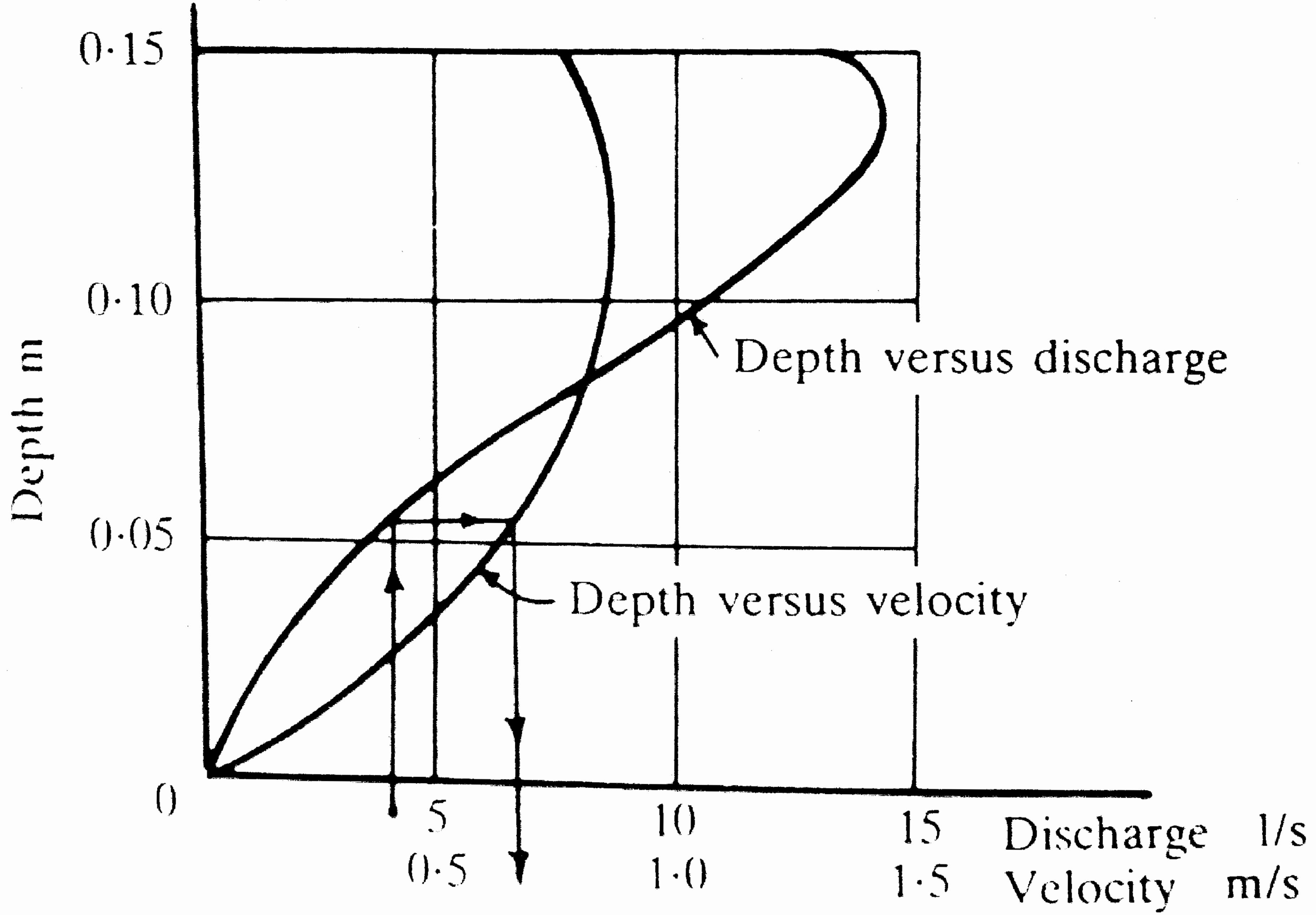
7. $Q = \left\{\frac{a_1}{(m^2 - 1)^{1/2}}\right\} \sqrt{\left[2gh\left(\frac{\rho_{man}}{\rho} - 1\right)\right]}$

8. $l_e = Kd/4f$

9. $h_f = 4f(l + l_e)\frac{V^2}{2dg}$

Fitting	Loss coefficient, K
Gate valve (open to 75% shut)	0.25→ 25
90° elbow	0.9
Sharp pipe entry	0.5
Sharp pipe exit	0.5
Pipe exit	1.0
45° elbow	0.4
Large radius 90° bend	0.6

Table 1 Head loss coefficients for a range of pipe fittings.


0·15
0·10
0·05
0
Depth m
Depth versus discharge
Depth versus velocity
5
0·5
10
1·0
15
1·5
Discharge l/s
Velocity m/s

213