UNIVERSITY OF SWAZILAND
Faculty of Health Sciences
Department of Environmental Health Science

BSc Environmental Health Science

MAIN EXAMINATION PAPER MAY 2013

TITLE OF PAPER : WATER DRAINAGE AND SEWERAGE

COURSE CODE : EHS:587

DURATION : 2 HOURS

MARKS : 100

INSTRUCTIONS : THERE ARE FIVE QUESTIONS IN THIS EXAM

: ANSWER ANY FOUR OUT OF THE FIVE QUESTIONS

: EACH QUESTION CARRIES A MAXIMUM OF 25 MARKS

: NO PAPER SHOULD BE BROUGHT INTO OR OUT OF THE EXAMINATION ROOM

QUESTION ONE (25 Marks)

A. Describe the following sewer systems:

i. Vacuum sewerage .....[1.5 Marks]

ii. Pressurized sewerage .....[1.5 Marks]

iii. Small bore sewerage. .....[2 Marks]

B. Describe the factors that can lead to

i. Sanitary sewer overflows. .....[1.5 Marks]

ii. Combined sewer overflows. .....[1.5 Marks]

iii. Indicate the steps needed to minimize these overflows. [2 Marks]

C. What are the factors that should be explored in the <u>geotechnical investigation</u> for the design and construction of sewer systems? .....

.....[5 Marks]

D. Match the items in B against the items in A. .....[5 Marks]

Item A	**Item B**
Curved sewers	Consider private ownership of land
Manholes	Maintenance hole provision
Aggressive soil	Economic/practical justification
Design depth of flow	Illegal/inappropriate
Location of pumping stations	Allow for free air ventilation
Width of trench	Cathodic protection
Dead end mains	Provision for venting

E. Describe the factors that should be taken into account in the layout of sewer systems.

.....[5 Marks]

QUESTION TWO (25 Marks)

A. Describe with the help of a sketch inverted siphons showing the necessary appurtenances. State for what condition inverted siphons may be provided and the arrangement for handling the flows in inverted siphons.

.....[5 Marks]

B. If a valley crossing appears too deep for the provision of an inverted siphon, discuss how the sewer should be laid and what kind of sewer pipe would be suitable for such crossing.

.....[5 Marks]

C. List the advantages of backfilling sewers as quickly as possible. Also list the steps (activities) of backfilling

.....[5 Marks]

D. Describe the techniques used for the detection of leakages in manholes

.....[5 Marks]

E. Describe the techniques used for the cleaning of sewer pipes.

.....[5 Marks]

QUESTION THREE (25 Marks)

A multi-family housing project is being developed on 1.4 Km^2 of rolling to flat ground. Zoning regulations establish a population density of 7500 persons per Km^2. The average daily sewage flow is 375 liters per person per day. The peak flow is 160% of the average flow. Infiltration allowance is 460 m^3 per square km per day. Circular concrete pipe with n=0.013 will be used to flow with a minimum velocity of 0.45 m/sec at minimum flow which is 1/3 of the peak flow. The minimum velocity at peak flow is 0.6 m/sec. The maximum spacing between manholes is 150 meters. Using equation 3.1 and the partial flow diagram of Figure Q3.1 provided below:

i. Determine the diameter of the sewer pipe for the final 150 meters between manholes numbers 20 and 21 which serves 0.25 km^2 in addition to the remaining 1.15 km^2. .....[15 Marks]

ii. Check if the minimum velocity of 0.45 m/sec is satisfied at minimum flow and suggest improvements to the design of the sewer. .....[10 marks]

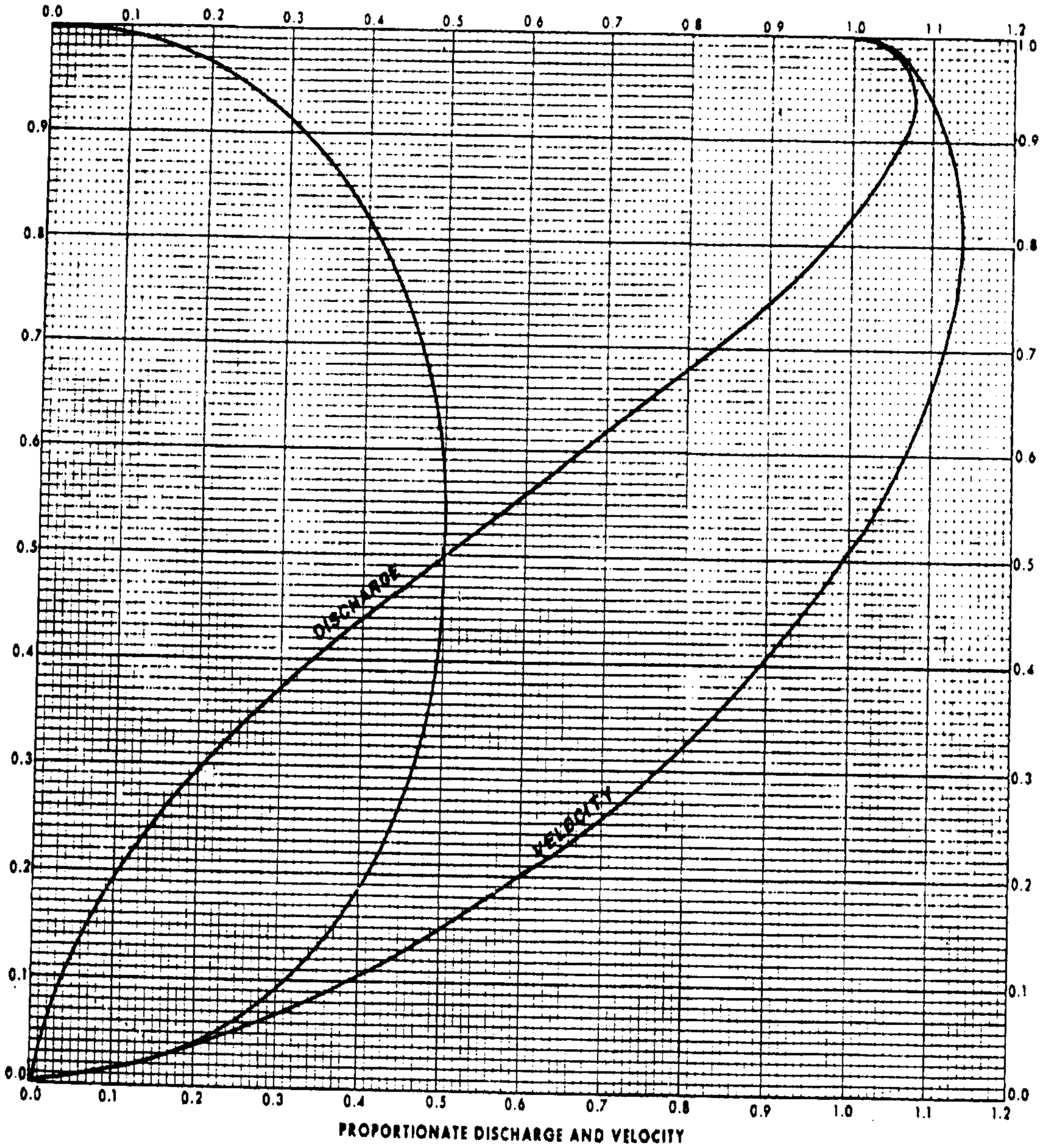
$$Q = \left(\frac{0.312}{n}\right) * D^{\frac{8}{3}} * S^{1/2} \quad \text{.....(Eq. 3-1)}$$

Where Q = sewer flow in m^3/sec

D = Sewer pipe diameter in meters

n = Manning's coefficient = 0.013

S = Slope of sewer pipe (m/m).



PROPORTIONATE FLOW CHART

Figure Q3-1 Partial flow graph for Sewer flow calculation

QUESTION FOUR (25 Marks)

A. Discuss the effects of urbanization on catchment hydrology .....[5 Marks]

B. There are certain factors omitted from the traditional cost-benefit analysis of sewerage systems which will make sewerage system a less favorable alternative. State these factors and indicate how they may be incorporated in the cost benefit analysis.

.....[5 Marks]

C. Discuss the advantages and disadvantages of providing open channel drainage systems. Indicate also how some of the disadvantages of open channel drainage systems may be overcome. .....[5 Marks]

D. List the main contents of a master drainage plan. .....5 Marks]

E. Discuss how the following factors influence the provision urban drainage system;

i. Technical
ii. Socio economic
iii. Financial and institutional factors
iv. Operation and maintenance

.....5 Marks]

QUESTION FIVE (25 Marks)

The rectangular channel shown in Figure Q5.1 below is nearly horizontal, and it carries a discharge per unit width of q = 1.20 m^3/sec-m. The flow depth upstream of the sluice gate is 1.6 m. A hydraulic jump occurs on the downstream side of the sluice gate.

i. Determine the flow depth at Sections B .....[9 Marks]

ii. Determine the flow depth at D .....[8 Marks]

iii. Determine the head loss due to the hydraulic jump. .....[8 Marks]

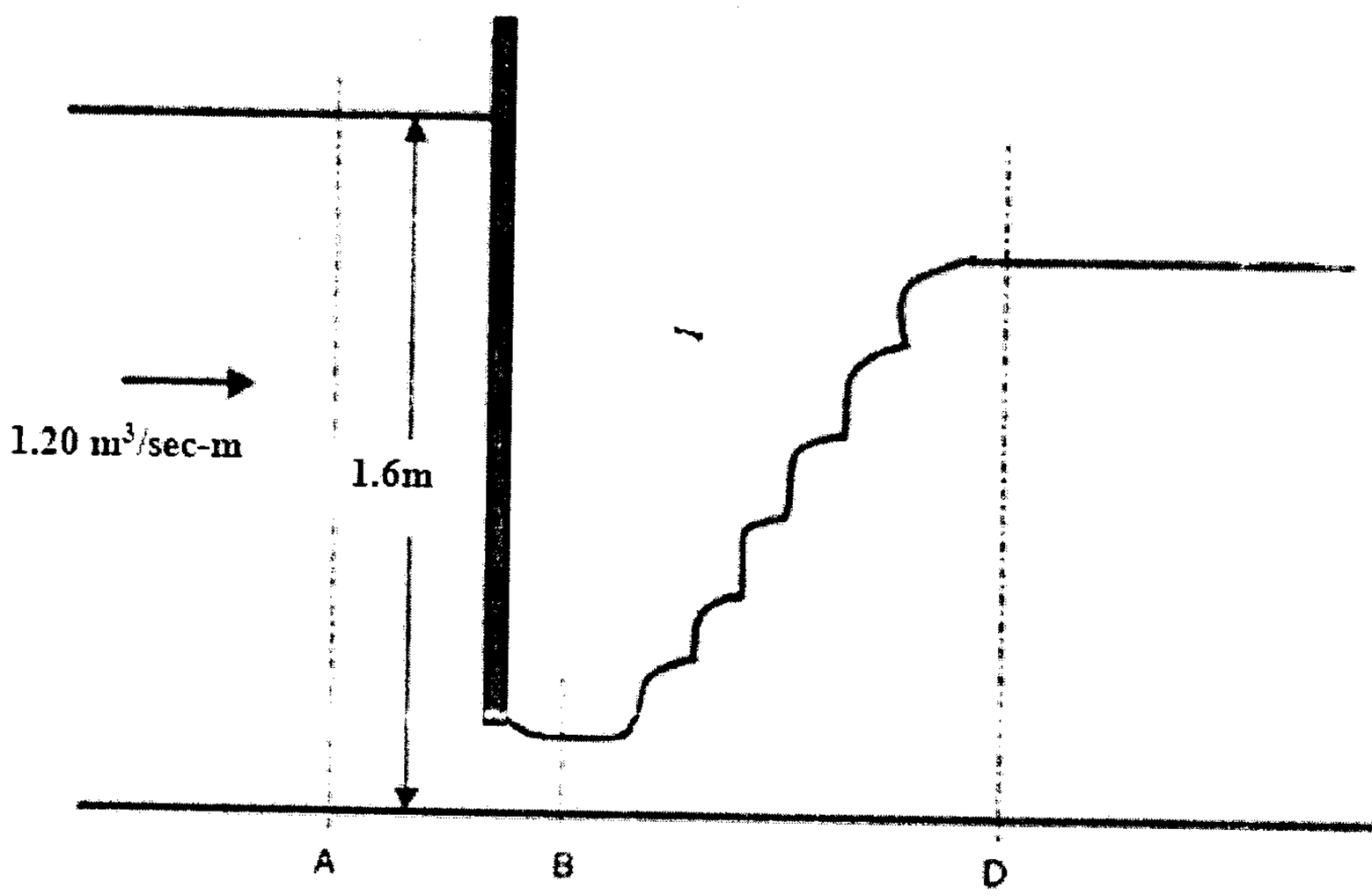


Figure Q5.1. A horizontal open channel of rectangular cross section.

Hydraulic jump equation:

$$Y_2 = \frac{Y_1}{2}\left(\sqrt{1 + 8Fr_1^2} - 1\right) \quad \text{.....Eq. 5.1}$$

Energy loss due to hydraulic jump

$$h_{LJ} = \frac{(Y_3 - Y_2)^3}{4Y_2Y_3} \quad \text{.....Eq. 5.2}$$