National Exams December 2019

16-Civ-A3, Municipal and Environmental Engineering

3 hours duration

Notes:

1. Each question carries a maximum of 25 marks, for a total of 100. Try to arrange your time according to the value of the question (hence slightly less than 2 minutes per mark).
2. **Candidates MUST answer Question 1, then any 3 out of the four remaining questions.**
   Do not answer five questions. Only the first four questions answered will be graded.
3. If doubt exists as to the interpretation of any question, the candidate is urged to include with their answer a clear statement of any assumptions made.
4. This is an open book exam. You are free to use the tables and figures in the appendix, or your own documentation. State as well as any sources of information used which are not in the examination paper (for example, a table or page number in a textbook).
5. Candidates may use a Casio or Sharp approved calculator.
6. Please take care to give your answers clearly and logically. State any assumptions which you need to make.

Marking Scheme

1. (1) 2.5 marks; (2) 2.5 marks; (3) 2.5 marks; (4) 2.5 marks; (5) 2.5 marks; (6) 2.5 marks; (7) 2.5 marks; (8) 2.5 marks; (9) 2.5 marks; (10) 2.5 marks;
2. (1) 5 marks; (2) 5 marks; (3) 5 marks; (4) 5 marks; (5) 5 marks;
3. (1) 5 marks; (2) 5 marks; (3) 5 marks; (4) 5 marks; (5) 5 marks;
4. (1) 7.5 marks; (2) 7.5 marks; (3) 10 marks;
5. (1) 5 marks; (2) 5 marks; (3) 5 marks; (4) 5 marks; (5) 5 marks;

QUESTION 1 (short answers, 25 marks)

1. What king of population growth equation is more likely appropriate in a downtown area, where available lands are limited and expensive? Why? **[2.5 marks]**
2. Provide the definitions of the major and minor systems in a stormwater collection system. **[2.5 marks]**
3. List four solutions that can be used to limit the impact of urbanization on streamwater quality. **[2.5 marks]**
4. In general, drinking water distribution systems are looped, while stormwater collection systems are not. Why? **[2.5 marks]**
5. How does the presence of storage (in-ground and elevated) in a drinking water distribution system affect the capacity of pumps at the water treatment plant and their energy efficiency? **[2.5 marks]**
6. Water losses in drinking water distribution systems is a major problem in many municipalities. How can they be controlled or eliminated? **[2.5 marks]**
7. Overflows from combined sewer systems are a threat to aquatic life in many urban centers, and their frequency is likely to increase in the future because of global warming. Provide one structural and one non-structural method to reduce them **[2.5 marks]**
8. What is meant by decentralized water and sewer systems, and how are these used **[2.5 marks]**
9. The rational method is the most commonly used formula for peak flow calculation in urban watersheds, despite the fact it relies on multiple simplifying assumptions. Discuss two of these assumptions **[2.5 marks]**
10. How do the maximum and minimum wastewater peak flow factors change with the size of the serviced area? Why? **[2.5 marks]**

QUESTION 2 (pump characteristics)

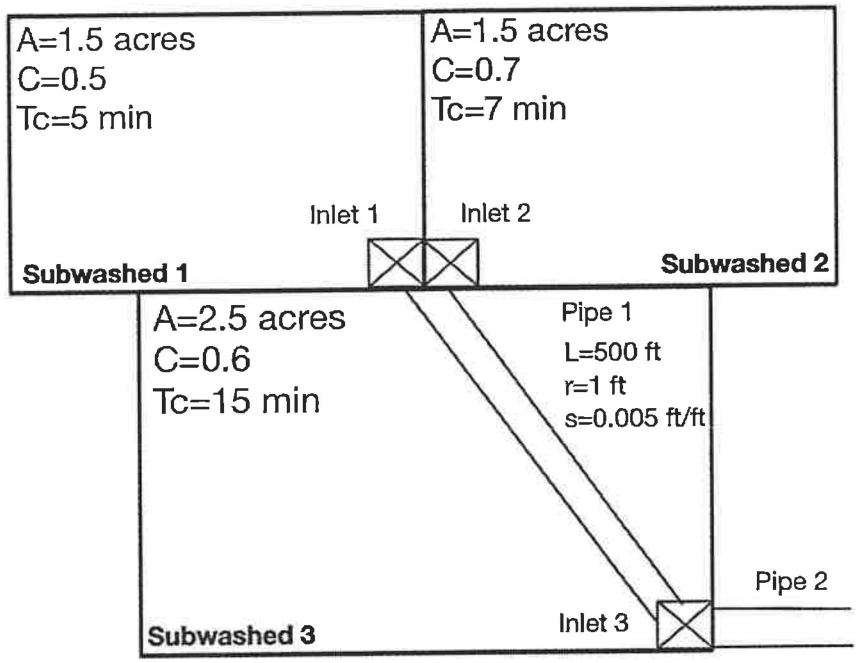
The following table provides the results of a pump performance test.

Discharge (gpm)	0	200	400	600	800	1,000
Dynamic head (ft)	150	145	135	120	90	50

1. Plot the pump characteristic (performance) curve. **[5 Marks]**
2. Plot the characteristic curve for two pumps in series. **[5 Marks]**
3. Plot the characteristic curve for two pumps in parallel. **[5 Marks]**
4. What pump configuration would work for a flow of 1,700 gpm, which must overcome a head of 80 ft? **[5 Marks]**
5. What pump configuration would work for a flow of 1,700 gpm, which must overcome a head of 160 ft? **[5 Marks]**

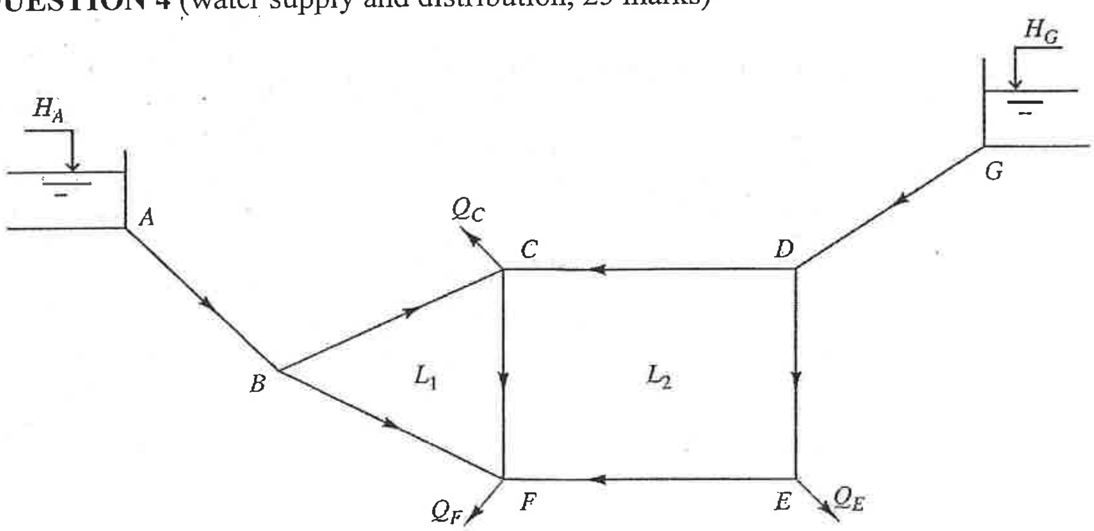
QUESTION 3 (Peak discharge calculation in urban areas, 25 marks)

The objective of this problem is to calculate the peak discharge in various elements of the stormwater collection system shown below. Use a 50-yr return period and the IDF curves in figure 1 at the end of the exam. Pipes 1 and 2 is a circular concrete pipe (n=0.011) with a radius of 1ft. Assume the wetted perimeter is 80% of the pipe circumference.



1. Estimate the peak flow in inlet 1. **[5 Marks]**
2. Estimate the peak flow in inlet 2. **[5 Marks]**
3. Estimate the peak flow in inlet 3. **[5 Marks]**
4. Estimate the peak flow and velocity in pipe 1. **[5 Marks]**
5. Estimate the peak flow and velocity in pipe 2. **[5 Marks]**

QUESTION 4 (water supply and distribution, 25 marks)



Consider the pipe network on the above figure, which contains two reservoir sources. Suppose $H_A = 85m$, $H_G = 102m$, $Q_C = 0.10m^3/s$, $Q_F = 0.25m^3/s$, $Q_E = 0.10m^3/s$. The pipes and junction characteristics are tabulated below, along with the initial flow rates in the pipes.

Pipe	Length (m)	Diameter (m)	e/D	f	K (sec^2/m^5)	Q (m^3/sec)	Junction	Elev. (m)
AB	300	0.30	0.00087	0.019	194	0.200	A	48
BC	350	0.20	0.00130	0.021	1,900	0.100	B	46
BF	350	0.20	0.00130	0.021	1,900	0.100	C	43
CF	125	0.20	0.00130	0.021	678	0.050	D	48
DC	300	0.20	0.00130	0.021	1,630	0.050	E	44
EF	300	0.20	0.00130	0.021	1,630	0.100	F	48
DE	125	0.20	0.00130	0.021	678	0.200	G	60
GD	250	0.25	0.00104	0.020	423	0.250		

1. Describe the method you would use to estimate the discharge in each pipe. **[7.5 Marks]**
2. Provide a set of equations to use to calculate flow adjustments in the system (tip: sketch the loops and direction of flow correction in the system; write the equation of the flow correction in each loop). **[7.5 Marks]**
3. Perform **one iteration** and present new values of flowrate in the system. **[10 Marks]**

QUESTION 5 (sanitary sewer systems, 25 marks)

A city of 5000 inhabitants is planning a new sanitary sewer system to service its population for the next 20 years. The growth rate of the population is 5% per year. Assume a sanitary water production of 450 litres/(capita.d), as well as 50 llitres/(capita.d) for inflow and infiltration.

1. Calculate the population at the end of the design period. **[5 Marks]**
2. Calculate the average domestic flowrate in m^3/d. **[5 Marks]**
3. Calculate the minimum and maximum flowrate for which the trunk should be designed, in m^3/d. **[5 Marks]**
4. Assuming the slope of the trunk is 2%, and that it is made of concrete (n=0.011), calculate the diameter required to carry the maximum flow. **[5 Marks]**
5. Calculate the water velocity using the previously calculated maximum and minimum flowrates. Are these velocities acceptable? **[5 Marks]**

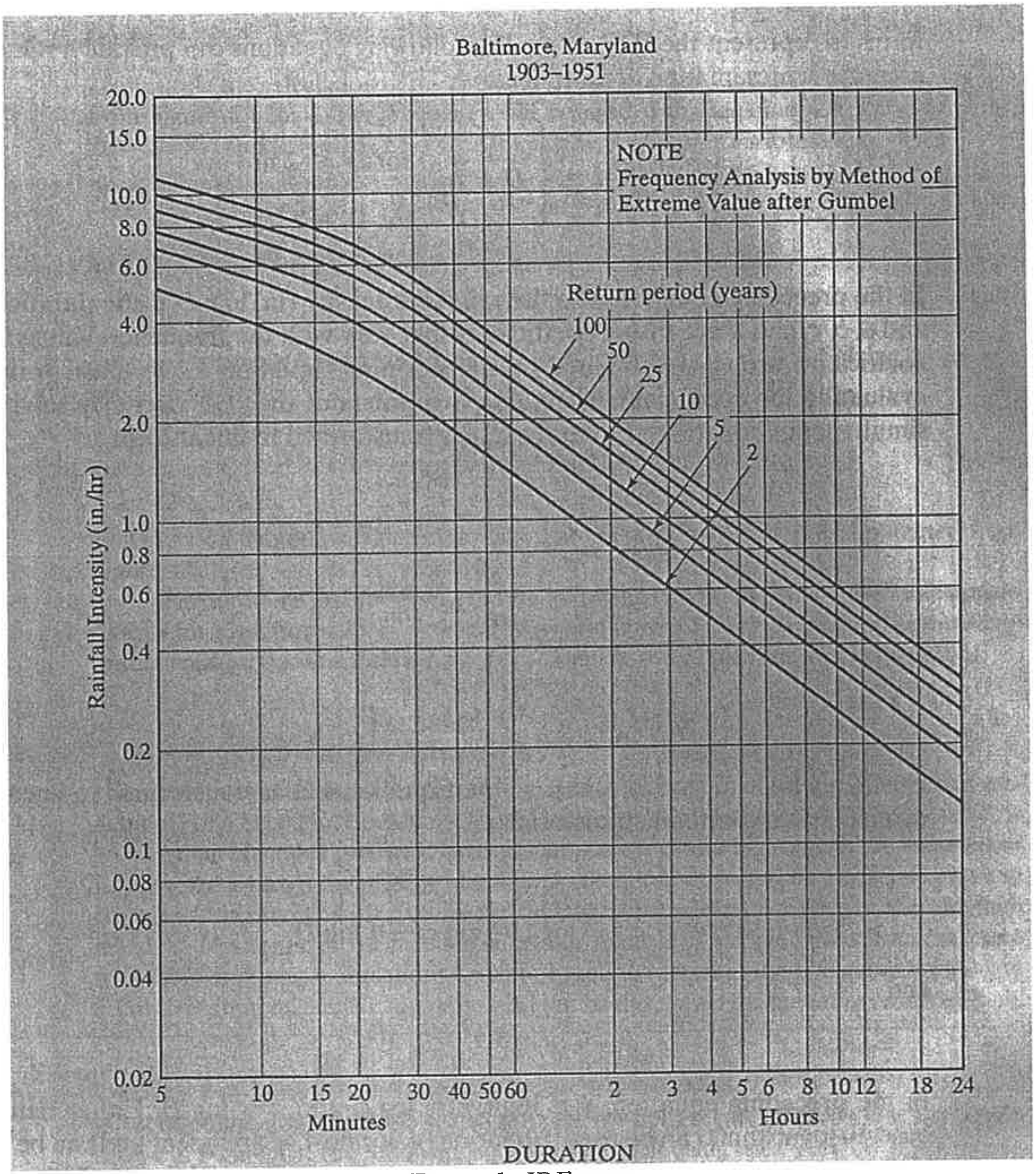


Figure 1: IDF curve