NATIONAL EXAMS MAY 2017

04-ENV-A2 HYDROLOGY AND MUNICIPAL HYDRAULICS ENGINEERING

3 hours duration

NOTES

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

2. This is a Closed Book Exam with a candidate prepared $8\frac{1}{2}''$ x $11''$ double sided Aid-Sheet allowed.

3. Candidates may use one of two calculators, the Casio or Sharp approved models. Write the name and model designation of the calculator on the first inside left hand sheet of the exam work book.

4. Any five (5) questions constitute a complete paper. Only the first five (5) answers as they appear in your work book(s), will be marked.

5. Each question is worth a total of 20 marks with the section marks indicated in brackets ( ) at the left margin of the question. The complete Marking Scheme is also provided on the final page. A completed exam consists of five (5) answered questions with a possible maximum score of 100 marks.

Problem 1

Provide answers to the following questions related to *sanitary sewers design*, *runoff control system design* and *probability frequency hydrograph analysis* related to *floods*.

(7) (i) You have been asked by the project manager to design a sanitary sewer to convey a peak flow of 200 m^3/s when flowing 100% full with a bedding slope of 4%. The senior engineer advises that the flow velocity must be greater than 0.8 m/s and less than 7 m/s and that a PVC pipe with a Manning's n of 0.10 is to be used. Calculate the required sewer diameter in m under the stipulated conditions and check that all the conditions are met.

(6) (ii) Briefly describe one (1) on-site and one (1) off-site stormwater runoff control system. For each system compare two (2) key maintenance issues to ensure the systems are functional for a 25-year design life.

(7) (iii) Given the maximum annual instantaneous flows form the Red River in Saskatchewan, Canada over a 12-year period (below), *explain the method* of fitting this data to a curve of best fit to determine the magnitude of the flood equalled or exceeded once in 25, 50 or 100 years .

Year	River (m^3/s)	Year	River (m^3/s)	Year	River (m^3/s)
1950	420	1954	490	1958	760
1951	510	1955	360	1959	610
1952	660	1956	660	1960	560
1953	760	1957	760	1961	510

Problem 2

Provide answers to the following questions related to *stormwater collection system design* and *wastewater collection system design* and *precipitation and snow melt.*

(7) (i) Briefly explain what a stormwater wet pond is, two (2) of its important design considerations and its primary function in a stormwater collection system.

(6) (ii) Briefly explain the function or importance of the following components of a wastewater collection system from a design and operational point of view:

(a) Sanitary pumping station with emergency overflow; and

(b) Sanitary drop structure

(7) (iii) Briefly explain two (2) engineering methods that may be used to manage a sudden surge in flows due to snow melt in the design of a stormwater detention pond to prevent downstream flooding during Spring melt in northern Canada.

Problem 3

Provide answers to the following questions related to *components* and *processes* of the *natural hydrologic cycle.*

(8) (i) Provide a schematic showing the natural hydrologic cycle identifying five (5) key components and briefly explain five (5) main interactions among them.

(6) (ii) Briefly explain the interaction of the intensity-duration frequency analysis and the hydrologic cycle in the design of 'major' components of stormwater collection systems.

(6) (iii) Briefly explain two (2) important linkages between the hydrologic cycle and 'minor' components of stormwater collection systems.

Problem 4

Provide answers to the following questions related to *hydraulics of closed pipe systems*, *water distribution systems* and *conceptual models of runoff*.

(6) (i) Consider water flowing though a Concrete pipe having a length L of 1200 m , diameter d of 400 mm and a full flow velocity of 2.5 m/s. Calculate the following:

(a) The average flow rate Q in m^3/min.

(b) Reynolds number Re and type of flow (i.e., laminar or turbulent).

(c) Pipe head loss H_f in m.

(8) (ii) Within distribution systems, a major source of watermain damage is waterhammer. Identify two (2) potential causes and two (2) potential solutions to prevent waterhammer or its damaging effects.

(6) (iii) Briefly describe how conceptual models of runoff are used and two (2) important differences between conceptual models and analytical models of runoff.

Problem 5

Provide answers to the following questions related to *pipe networks* and *basic pumps or prime movers*.

(6) (i) Analysis of water pipe networks includes determining quantities of flow and head losses in the various pipe lines and the resulting residual pressures. In any pipe network, explain what two (2) important conservation laws must be satisfied and how they are used to assist in the analysis.

(6) (ii) A 150 mm diameter pipe is connected to a 200 mm diameter pipe. If the average velocity in the 200 mm diameter pipe is 10 m/s, what is the average velocity in the 150 mm diameter pipe? Determine the volumetric flow rate in m^3/s and state any assumptions in your calculations.

(8) (iii) Provide a schematic of a typical system pump-head curve and identify the operating point, the net positive suction head (NPSH) and the shutoff head. Briefly explain how a system pump-head curve is used to select the proper pump configurations for a particular application.

Problem 6

Provide answers to the following questions related to *streamflow* and *open channel flows* under *uniform* or *gradually varied flow* conditions.

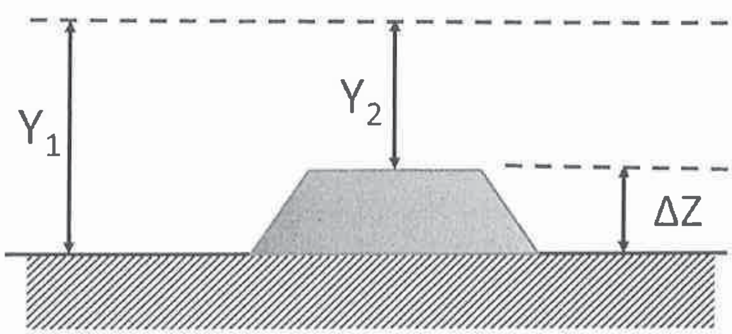
(6) (i) Explain how a stage-discharge curve is generated and used in predicting streamflow. In your explanation, discuss two (2) key assumptions that influence the accuracy of the predicted streamflow.

(6) (ii) A grass lined trapezoidal channel experiences uniform flow at a normal depth of 1.5 m. The base width is 13 m and the side slopes are equal at a H:V of 1:4. Using an appropriate Manning's n and a bed slope S_o of 3 % calculate the following:

(a) The discharge flow rate Q in m^3/min; and

(b) Reynolds number Re and type of flow (i.e., laminar or turbulent).

(8) (iii) Assume that the above mentioned channel has a flowrate of 20 m^3/s at a normal flow depth Y_1 of 1.5 m. Calculate the depth of flow Y_2 in a section of the channel, 30 m downstream, in which the bed rises Δz equal to 0.7 m. Consider the figure below and assume frictional losses are negligible.



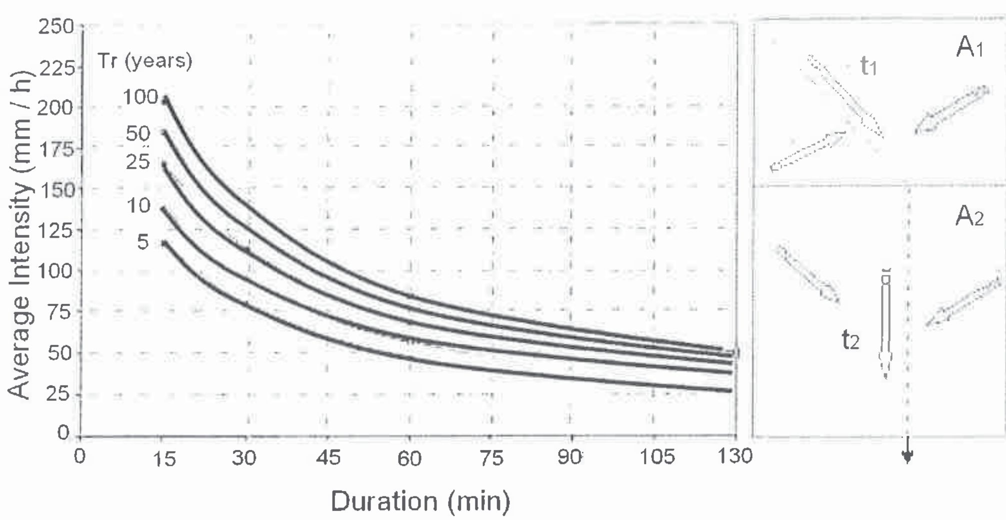
Problem 7

Provide answers to the following questions related to *urban stormwater management* and *intenisty-duration frequency (IDF) analysis curves*.

(10) (i) Explain the basic design approach for a *stormwater dry pond* for the quantity control of surface runoff from an urban watershed. Assume that the primary objective is quantity control (i.e., reduced first flush flow) to reduce downstream erosion.

(10) (ii) Use the Rational Formula to determine the 25-year design peak runoff (m^3/s) for the catchment areas (A1 and A2) shown below. Assume that the intensity duration frequency (IDF) curves given below are applicable for this area. Use the following design information:

Area Label	Area (ha)	Runoff Coefficient (C)	Time of Concentration t (min)
A1	25	0.6	50
A2	35	0.7	75



Marking Scheme

04-Env-A2

Hydrology and Municipal Hydraulics Engineering

1. (i) 7, (ii) 6, (iii) 7 marks, 20 marks total
2. (i) 7, (ii) 6, (iii) 7 marks, 20 marks total
3. (i) 8, (ii) 6, (iii) 6 marks, 20 marks total
4. (i) 6, (ii) 8, (iii) 6 marks, 20 marks total
5. (i) 6, (ii) 6, (iii) 8 marks, 20 marks total
6. (i) 6, (ii) 6, (iii) 8 marks, 20 marks total
7. (i) 10, (ii) 10 marks, 20 marks total