NATIONAL EXAMS DECEMBER 2012

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 *components* and *processes* of the *natural hydrologic cycle* and *stormwater collection system design*.

(5) (i) Provide a schematic showing the natural hydrologic cycle identifying the key components and processes.

(5) (ii) Briefly explain how combined sewer overflows (CSOs) occur in a combined sewer system and how the impacts of the CSOs on the environment may be minimized.

(5) (iii) Briefly explain the use of the rational method or the intensity-duration frequency analysis design basis as applied to the design of stormwater collection systems.

(5) (iv) Briefly explain two (2) important differences between sanitary and stormwater collection systems.

Problem 2

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

(8) (i) Briefly describe three (3) important properties of conceptual models of runoff and how they differ (in the three (3) important properties that you mention) from analytical or physical models of runoff.

(ii) Consider water flowing though a concrete pipe having length L of 500 m , diameter d of 600 mm and a full flow rate of 600 L/s. Calculate the following:

(2) (a) The average fluid velocity V in m/s.

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

(2) (c) Pipe friction loss H_f in m.

(6) (iii) Calculate or explain the process to calculate the flowrate (Q) and volume (V) of water required to provide adequate fire protection to a 10-story non-combustible building with an effective floor area of 8,000 m^2. In your explanation, discuss three (3) important factors needed or assumed to adequately calculate the Q and V.

Problem 3

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

(6) (i) Discuss briefly the effects of snow melt and precipitation on the engineering controls of runoff quality and quantity in an urban and rural environment. Use a matrix similar to the one below to provide short explanations about each of the four conditions.

"Considerations of Engineering Runoff Controls"	Snow Melt	Precipitation
Urban		
Rural		

(6) (ii) Briefly explain the function or importance of the following components/concepts of a stormwater collection system design:

(a) The Rational Formula;

(b) Swales or ditches; and

(c) Storm sewers

(8) (iii) Briefly explain the function or importance of the following components of a wastewater collection system:

(a) Sanitary sewers;

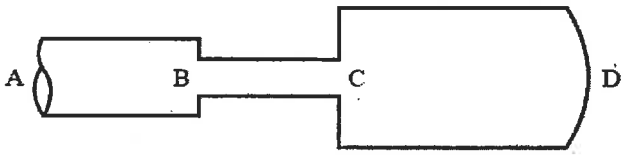
(b) Sanitary manholes or stormwater catchbasins; and

(c) Sewage pumping stations

Problem 4

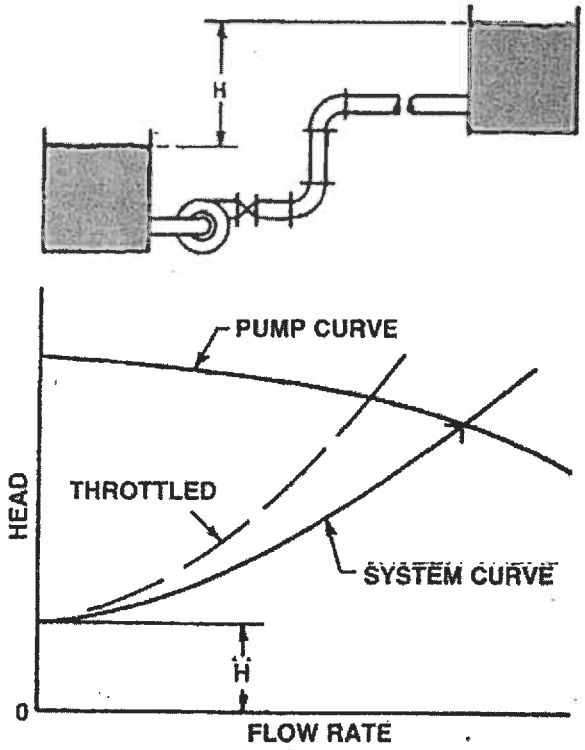
Provide answers to the following questions related to *pipe networks* and *basic pumps or prime movers*.

(10) (i) For a flowrate of 50 L/s, determine the pressure head at points B and D in the series of pipes shown below. Assume fully turbulent flow in all cases and pressure head at point A is 30 m. If any justified simplifying assumptions are made, please state them for full marks.



$D_1 = 30$ cm $\quad D_2 = 20$ cm $\quad D_3 = 40$ cm
$L_1 = 2000$ m $\quad L_2 = 1000$ m $\quad L_3 = 2000$ m
$f_1 = 0.022 \quad f_2 = 0.025 \quad f_3 = 0.021$
$z_A = 20$ m, $z_B = 25$ m, $z_C = 32.5$ m, $z_D = 37.5$ m

(10) (ii) In the schematic below, explain the system-pump curve in relation to the schematic of the system. In your explanation, discuss the importance of each curve (including the curve labeled "Throttled") for the design and operation of the water distribution between two (2) reservoirs.



Problem 5

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 10 m^3/s when flowing 100% full with a bedding slope of 5%. The senior engineer advises that the flow velocity must be greater than 0.6 m/s and less than 8 m/s and that a PVC pipe with a Manning's n of 0.015 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. Compare the design, operation and maintenance issues from the perspective of a municipality that is expected to operate and maintain these systems for a 20-year design life. Provide a recommendation as to a strategy that the municipality should consider based on your analysis.

(7) (iii) Given the maximum annual instantaneous flows form the Mighty River in British Columbia 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 equaled or exceeded once in 20, 40 or 90 years .

River Discharge		River Discharge		River Discharge	
Year	(m^3/s)	Year	(m^3/s)	Year	(m^3/s)
1930	330	1934	380	1938	650
1931	400	1935	250	1939	500
1932	550	1936	550	1940	450
1933	650	1937	650	1941	400

Problem 6

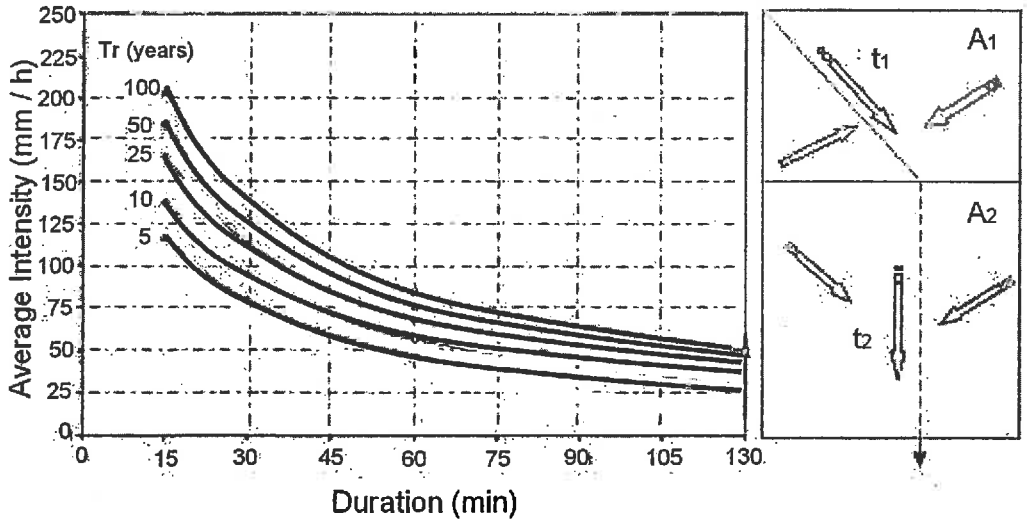
Provide answers to the following questions related to *urban stormwater management* and *intenisty-duration frequency (IDF) analysis curves*.

(6) (i) Explain the basic design approach for a *stormwater dry pond* for the detention and attenuation of surface runoff from an urban watershed. Assume that the primary objective is erosion control to the downstream receiving water body.

(6) (ii) Assume that a stormwater management pond is discharging to a receiver with a cold-water fishery and sediment mitigating measures have been requested by the local regulator. Explain two (2) sediment control design measures to reduce solids discharges to the cold-water fishery receiver from the pond effluent.

(8) (iii) Use the Rational Formula to determine the 25-year design peak runoff (m^3/min) 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	0.8	65
A2	35	0.6	80



Problem 7

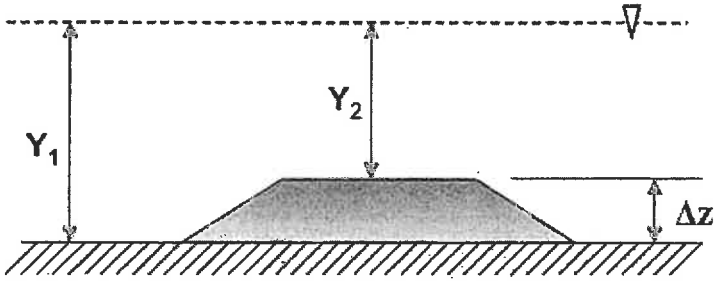
Provide answers to the following questions related to *open channel flows* under *uniform* and *gradually varied flow* conditions and *streamflow*.

(i) A concrete lined trapezoidal channel experiences uniform flow at a normal depth of 5 m. The base width is 12 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 5 % calculate the following:

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

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

(8) (ii) Assume that the above mentioned channel has a flowrate of 15 m^3/s at a normal flow depth Y_1 of 3 m. Calculate the depth of flow Y_2 in a section of the channel, 15 m downstream, in which the bed rises Δz equal to 0.8 m. Consider the figure below, assume frictional losses are negligible and you may use the *specific energy* .



(6) (iii) With respect to streamflow, explain the importance of base flow, lag time and lateral erosion. In your explanation, briefly explain how these three (3) factors influence the quantity and quality of the streamflow.

Marking Scheme

1. (i) 5, (ii) 5, (iii) 5, (iv) 5 marks, 20 marks total

2. (i) 8, (ii) (a) 2, (b) 2, (c) 2, (iii) 6 marks, 20 marks total

3. (i) 6, (ii) 6, (iii) 8 marks, 20 marks total

4. (i) 10, (ii) 10 marks, 20 marks total

5. (i) 7, (ii) 6, (iii) 7 marks, 20 marks total

6. (i) 6, (ii) 6, (iii) 8 marks, 20 marks total

7. (i) (a) 3, (b) 3, (ii) 8, (iii) 6 marks, 20 marks total