NATIONAL EXAMS DECEMBER 2014

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 *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 give an example showing the use of such a model.

(ii) Consider water flowing through a corrugated steel pipe having length L of 100 m, diameter d of 300 mm and a full flow rate of 100 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); and

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

(6) (iii) Briefly explain two (2) important uses of elevated water reservoirs within a water distribution system.

Problem 2

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

(6) (i) Consider the hydrologic abstraction processes (i.e., hydrologic equation) and briefly explain how precipitation or snow melt are handled differently in the conversion to runoff. In your answer, you may consider a typical watershed as a basis for your explanation.

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

(a) Intensity Duration Frequency (IDF) curves;

(b) Storm sewer; and

(c) Storm infiltration ditch

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

(a) Sanitary forcemain;

(b) Sanitary sewer; and

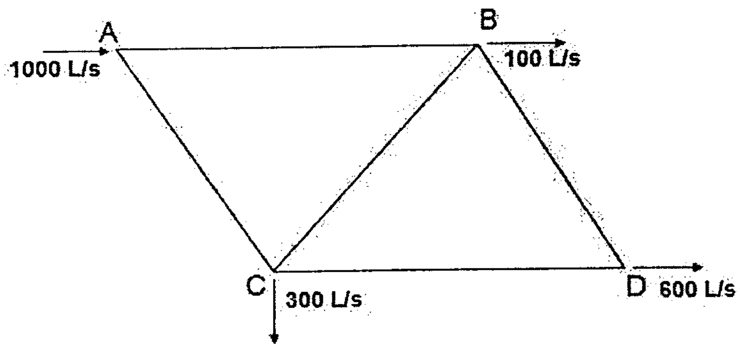
(c) Sewage pumping station overflow

Problem 3

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

(8) (i) Solve for the flows in each pipe of the pipe network below using the Hardy-Cross or similar method, given the following pipe lengths and corresponding diameters:

Pipe	Length (m)	Diameter (mm)
AB	600	250
BC	800	300
CD	600	250
AC	800	300
BD	600	250



(4) (ii) Define and briefly explain under what conditions a pump system may cause a water hammer effect. Explain one (1) way to reduce or eliminate the water hammer effect.

(4) (iii) Provide a schematic of a typical System Head Curve showing the pump curve, the system curve, the operating point and shutoff head.

(iv) Briefly explain a method of using multiple pumps in a cost effective way to:

(2) (a) Increase the discharge head when the flow requirement stays the same; and

(2) (b) Increase the discharge rate when the static head remains the same.

Problem 4

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

(8) (i) You have been asked by the project manager to design a sanitary sewer to convey a peak flow of 5 m^3/s when flowing 80% full with a bedding slope of 5%. 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 0.013 is to be used. Calculate the required diameter in mm for this sewer.

(6) (ii) Briefly describe one (1) on-site and one (1) off-site stormwater runoff control system. For each system, provide one (1) advantage and one (1) disadvantage to their use from the perspective of a municipality that is expected to operate and maintain these systems for a 25-year design life.

(6) (iii) Given the maximum annual instantaneous flows form the Wavy River in Ontario over a 15-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 50 or 100 years .

Water Year	Discharge (m^3/s)	Water Year	Discharge (m^3/s)	Water Year	Discharge (m^3/s)
1930	430	1935	450	1940	730
1931	520	1936	400	1941	630
1932	600	1937	630	1942	500
1933	800	1938	730	1943	490
1934	450	1939	930	1944	330

Problem 5

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

(8) (i) Provide a schematic showing the natural hydrologic cycle identifying the key components and briefly explaining the interactions among three (3) main hydrologic processes.

(6) (ii) Briefly explain two (2) important differences between the major and minor stormwater collection system.

(6) (iii) The Rational method is the most widely used empirical equation for predicting instantaneous peak discharge from a small sub-watershed. Give the basic Rational Formula and two (2) assumptions or simplifications when using the Rational method.

Problem 6

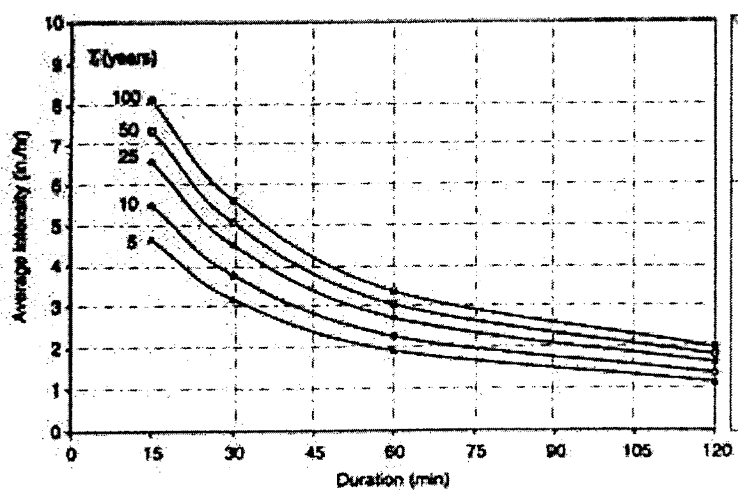
Provide answers to the following questions related to *urban stormwater management* and *intenisty-duration frequency (IDF) analysis curves.*

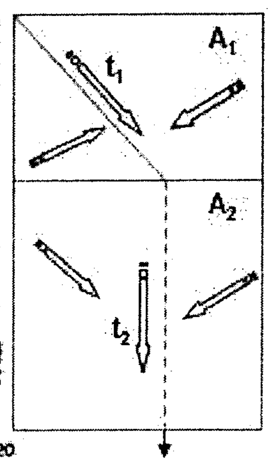
(6) (i) Explain the purpose and key design basis of *stormwater dry ponds* in protecting the downstream receiving water bodies.

(6) (ii) The local regulator requires that a wet pond be designed to protect a downstream fish hatchery zone from suspended solids in the final effluent. Identify and explain two (2) key design features of the pond to ensure that the effluent solids, following 25-year design storm event, are low and will not impact the hatchery zone. State any assumptions you make.

(8) (iii) Use the Rational Formula to determine the 100-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	30	0.6	90
A2	40	0.7	105





Problem 7

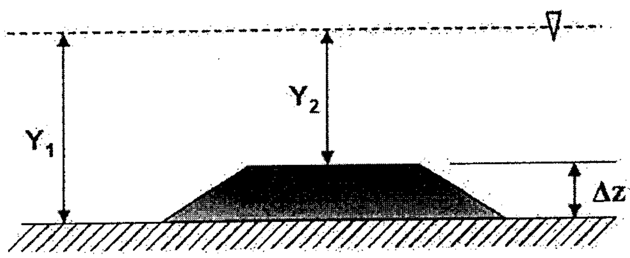
Provide answers to the following questions related to *open channel flows* under *uniform* and *gradually varied flow* conditions and *streamflow.*

(i) A rock lined trapezoidal channel experiences uniform flow at a normal depth of 3 m. The base width is 8 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 4 % calculate the following:

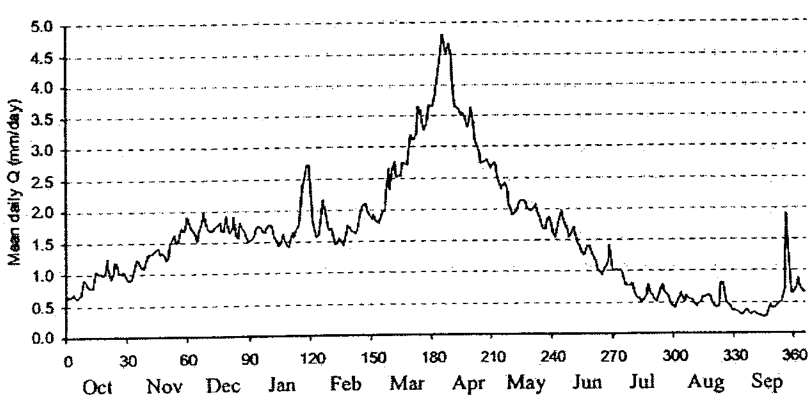
(3) (a) The discharge flow rate Q in m^3/s; and

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

(8) (ii) Assume that the channel has a flowrate of 20 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, 8 m downstream, in which the bed rises Δz equal to 0.6 m. Consider the figure below, assume frictional losses are negligible and you may use the *specific energy* equations at the two locations corresponding to Y_1 and Y_2 in the diagram below.



(6) (iii) Consider the Swift River flow diagram (for the combined past 70-years) showing the mean flow versus time of the year. Briefly explain how this flow data may be used to estimate the probability of occurrence of a major flood and to design reservoir storage capacity to mitigate downstream flooding.



Marking Scheme

1. (i) 8, (ii) (a) 2, (b) 2, (c) 2, (iii) 6, 20 marks total
2. (i) 6, (ii) 6, (iii) 8, 20 marks total
3. (i) 8, (ii) 4, (iii) 4, (iv) (a) 2, (b) 2, 20 marks total
4. (i) 8, (ii) 6, (iii) 6, 20 marks total
5. (i) 8, (ii) 6, (iii) 6, 20 marks total
6. (i) 6, (ii) 6, (iii) 8, 20 marks total
7. (i) (a) 3, (b) 3, (ii) 8, (iii) 6, 20 marks total