NATIONAL EXAMS MAY 2015

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) key steps in developing a conceptual model to predict the peak runoff from a watershed. As part of your description, explain how such conceptual model is best validated to ensure reliable results.

(ii) Consider water flowing though a PVC pipe having length L of 1000 m, diameter d of 600 mm and a full flow rate of 500 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) Briefly explain three (3) functions of pressure relief valves within a water distribution system which would help reduce water hammer problems and leaks in the 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 the key difference in the modelling of rain versus snow in the prediction of peak runoff from an urban watershed.

(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) Combined storm sewer; and

(c) Storm water pumping station

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

(a) Sanitary sewers;

(b) Sanitary drop structures; and

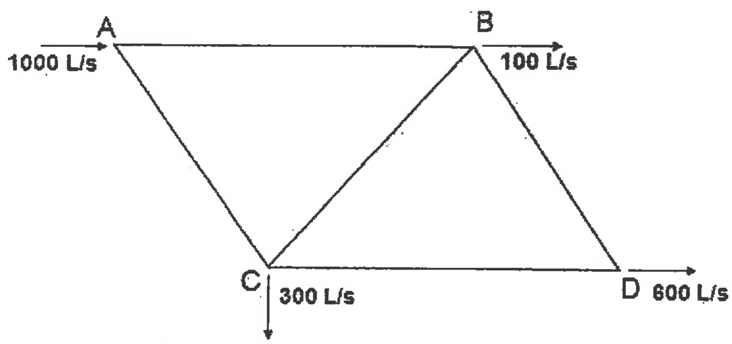
(c) Sewage pumping stations

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 (note the diagram is not to scale):

Pipe	Length (m)	Diameter (mm)
AB	400	250
BC	600	200
CD	400	300
AC	600	200
BD	400	300



(4) (ii) Briefly explain the difference between static and friction head. Use figures or equations to supplement your explanation.

(4) (iii) Provide a schematic of a typical System-Pump Curve for a low static head system. In the schematic, show the pump curve, the system curve, the operating point and static head.

(iv) Using equations or figures provide a clear explanation of how to compute the following for a pump system:

(2) (a) Pump efficiency; and

(2) (b) Hydraulic power.

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 75% full with a bedding slope of 3%. The senior engineer advises that the flow velocity must be greater than 0.8 m/s and less than 5 m/s and that a concrete pipe with a Manning's n of 0.014 is to be used. Calculate the required diameter d in *mm* for this sewer.

(6) (ii) Briefly describe three (3) major differences between the minor and major runoff control system design and give one (1) example of each type.

(6) (iii) Give an example of the use of probability frequency hydrograph analysis to predict the return period (T_R) of a flood.

Problem 5

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 labelled schematic showing the natural hydrologic cycle identifying four (4) key components and processes.

(5) (ii) Briefly explain how a stormwater pumping station may be appropriately located and operated to minimize downstream erosion in a stormwater collection system.

(5) (iii) Give an example of the use of the rational method or the intensity-duration frequency analysis as applied to the design of stormwater collection systems.

(5) (iv) Briefly explain two (2) important differences between the design of on-site and off-site stormwater collection systems.

Problem 6

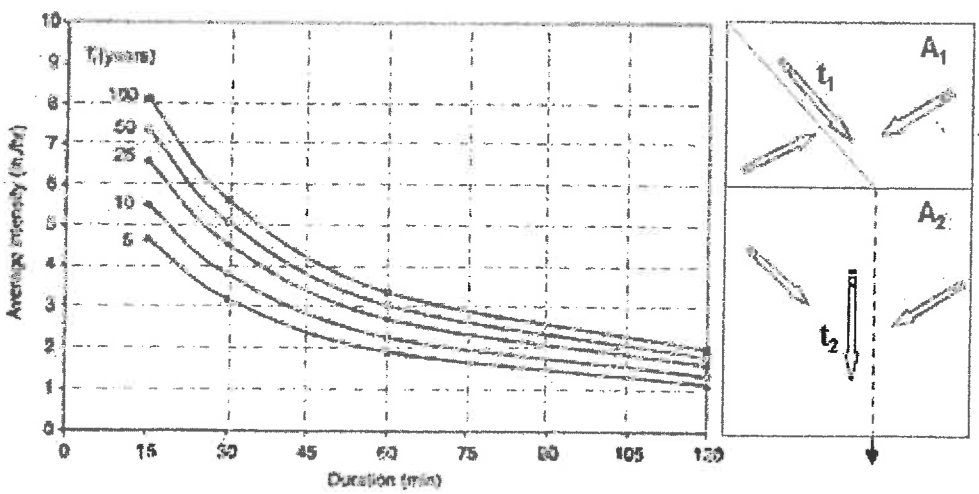
Provide answers to the following questions related to *urban stormwater management* and *intenisty-duration frequency (IDF) analysis curves.*

(6) (i) Explain the purpose and key design basis of *stormwater dry pond* for the control of downstream erosion.

(6) (ii) Give three (3) important maintenance and operational activities for a stormwater wet pond to ensure the the general design objectives of a wet pond (i.e., low effluent TS) are met consistently for the 25-year life of the system.

(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	0.8	70
A2	40	0.6	80



Problem 7

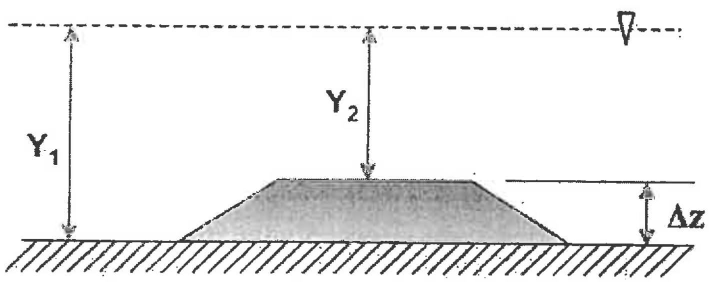
Provide answers to the following questions related to *open channel flows* under *uniform* and *gradually varied flow* conditions and *streamflows*.

(i) A rock 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 4 % calculate the following:

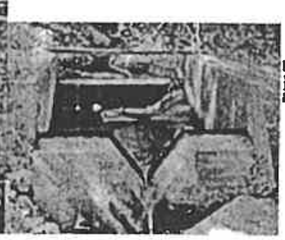
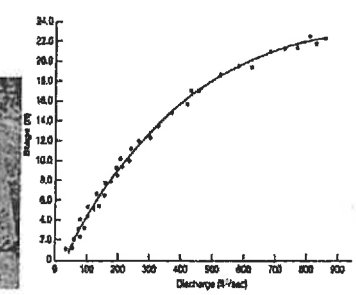
(3) (a) The discharge flow rate Q in m^3/s; and

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

(8) (ii) Assume that the channel (shown below) has a flowrate of 50 m^3/s at a normal flow depth Y_1 of 2.5 m (Section 1). Calculate the depth of flow Y_2 in a section of the channel, 15 m downstream, in which the bed rises ΔZ equal to 0.6 m (Section 2). Assume frictional losses are negligible and you may use the *specific energy* equations at the two sections 1 and 2.



(6) (iii) Explain the use of a plume with a stilling well, a weir and a rating curve to measure streamflows. In your explanation, indicate under what conditions each method is preferred. A plume, weir and rating curve are shown below:

Marking Scheme

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