NATIONAL EXAMS DECEMBER 2013

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 two (2) examples where conceptual models of runoff are used to assist with engineering design of hydraulic structures.

(ii) Consider water flowing though a concrete pipe having length L of 500 m , diameter d of 250 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).

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

(6) (iii) Briefly explain three (3) functions of elevated water reservoirs located within a water distribution system which would help reduce the need for pumping.

Problem 2

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

(6) (i) Provide a simple schematic showing the natural hydrologic cycle identifying three (3) key processes and briefly explain how each process may affect the resulting runoff in a rural watershed.

(4) (ii) Briefly explain how to use the Babbitt formula (below) or similar equation to calculate the dry weather peaking factor (PF) in the sizing of storm sewers.

$$PF = \frac{5}{EP^{0.2}}$$

(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 the hydraulic design of combined sewers and storm sewers.

Problem 3

Provide answers to the following questions related to *precipitation and snow melt, stormwater collection system design, wastewater collection system* and *intenisty-duration frequency (IDF) analysis curves.*

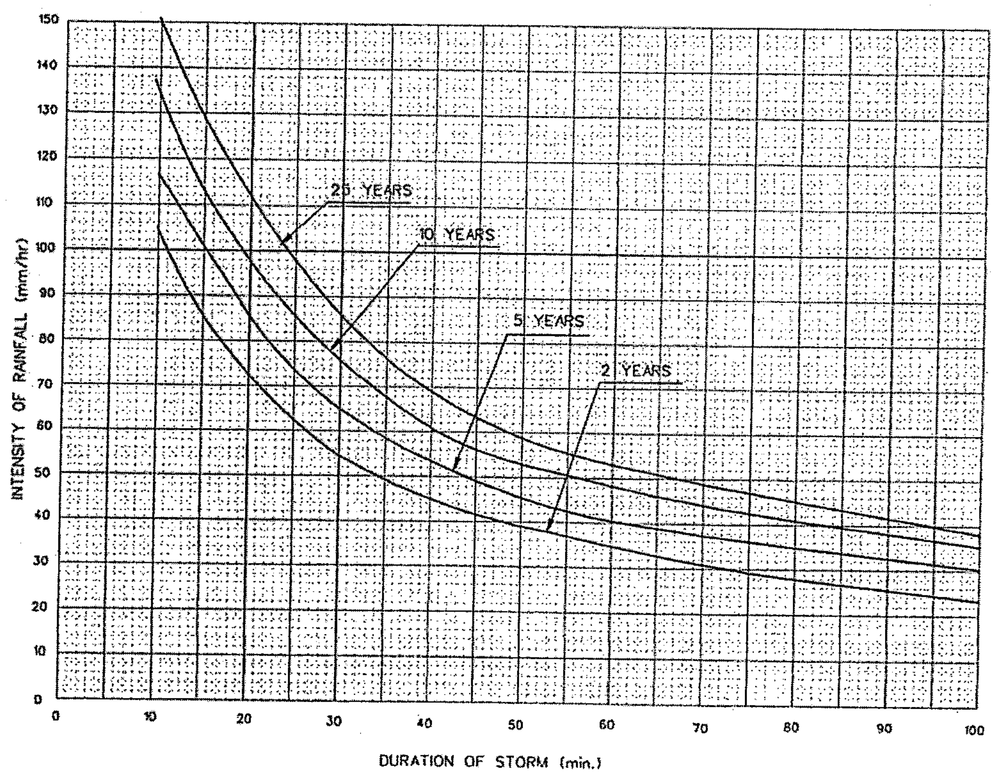
(6) (i) Consider the hydrologic abstraction processes (i.e., hydrologic equation) and briefly explain how only a fraction of precipitation or snow melt is converted to runoff. In your answer you may consider a typical watershed as a basis for your explanation.

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

(a) Sanitary forcemains; and

(b) Stormwater culvert;

(8) (iii) Give an example of the use of the Intensity Duration Frequency (IDF) curves (below) in the design of stormwater collection system design for a design storm having a 5-year return period in an urban watershed.



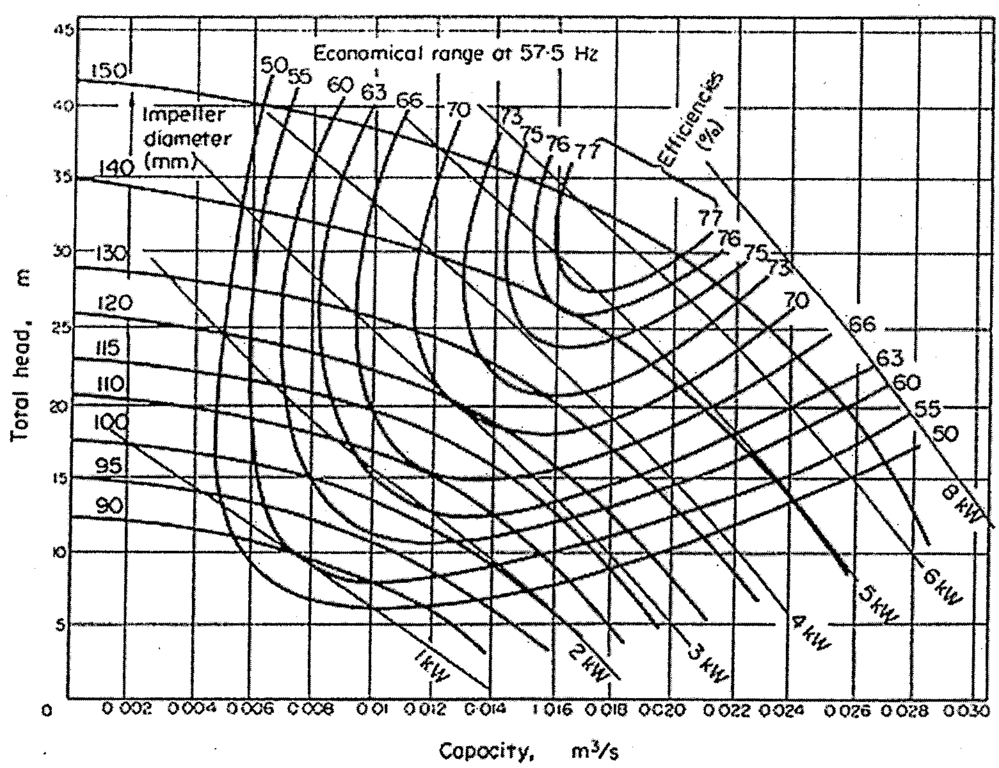
Problem 4

Provide answers to the following questions related to *urban stormwater management* and *basic pumps or prime movers*.

(6) (i) Explain the purpose and key design basis of *stormwater dry pond* for the detention and treatment of surface runoff from an urban watershed.

(6) (ii) Assume that a stormwater management pond is discharging to a cold-water fishery and temperature mitigating measures have been requested by the local regulator. Suggest three (3) temperature mitigating measures to reduce temperature impacts on the cold-water fishery from the pond effluent.

(8) (iii) Assume an impeller diameter change from 110 mm to 140 mm. With reference to the pump characteristic curve (below) determine the new optimum capacity (m^3/s), the head (m), the brake horse power (kW), pump efficiency expected and the percent pump capacity improvement (%).

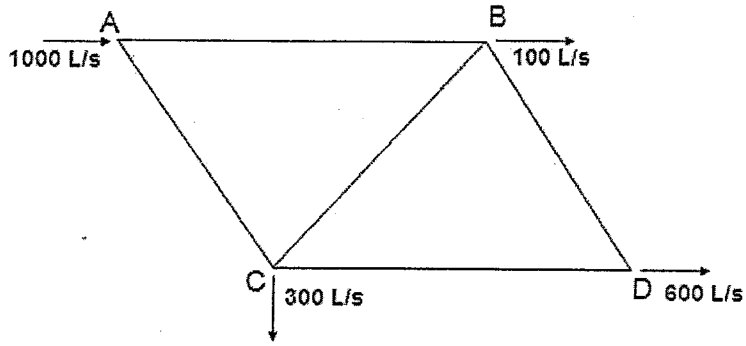


Problem 5

Provide answers to the following questions related to *pipe networks* and *sanitary sewers design.*

(10) (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 (L) and corresponding diameters (d):

Pipe	Length (m)	Diameter (mm)
AB	600	300
BC	800	350
CD	600	300
AC	800	350
BD	600	300



(5) (ii) Explain the use of the Manning Formula (below) to design a sanitary sewer to maintain a minimum cleansing velocity of 0.6 m/s at full flow.

$$Q = \frac{A}{n} \cdot R^{2/3} \cdot S^{1/2}$$

(5) (iii) Explain the use of the Harmon Formula (below) to account for peak flow events when designing sanitary sewers.

$$M = 1 + \frac{14}{4 + p^{1/2}}$$

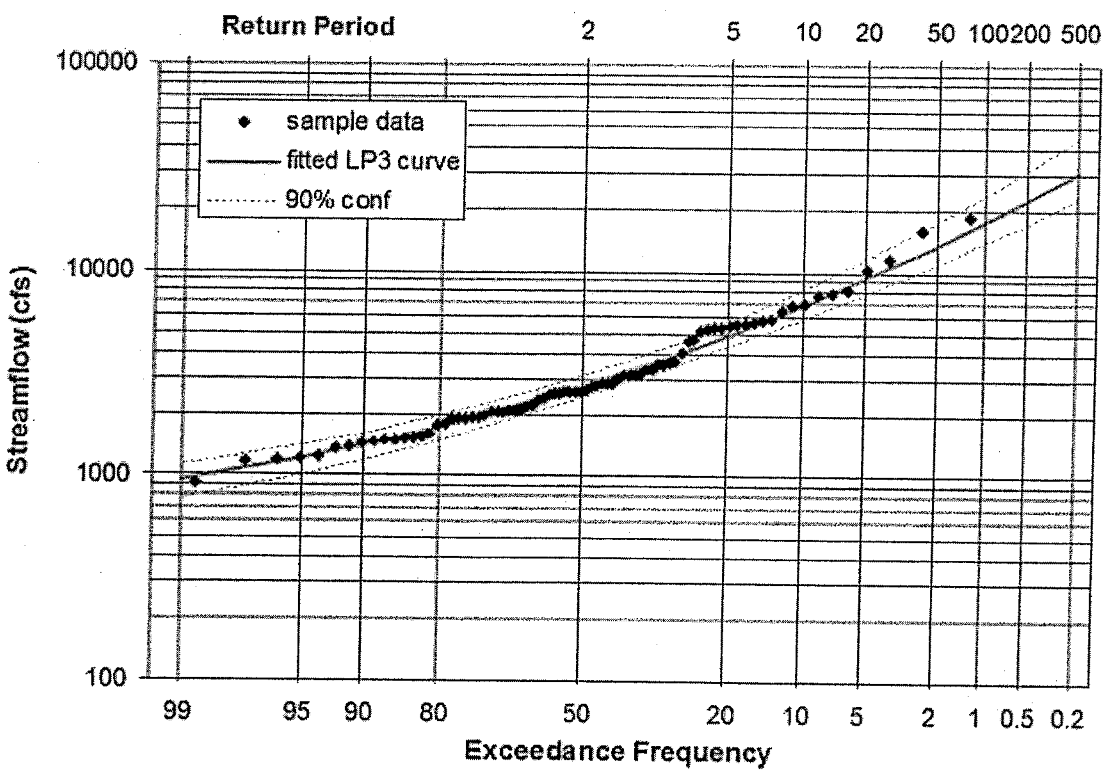
Problem 6

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

(6) (i) Most structural urban runoff best management practices (BMPs) function on the principle that it is best to hold runoff for a period of time. Provide three (3) reasons why the use of stormwater management ponds as BMPs serve this principle well.

(6) (ii) Select an on-site and an off-site runoff control system and briefly explain two (2) necessary routine maintenance measures (for each control system) required to ensure the long term performance of these systems.

(8) (iii) Flooding occurs when streams overtop their banks and downstream areas are flooded. These historical events are recorded and flood frequency historical curves (similar the one below) are generated for engineering designs. Briefly explain how these curves are generated, give an example of the use of the flood frequency distribution curve and explain two (2) underlying assumptions about the use of such curves which the designer needs to consider.



Problem 7

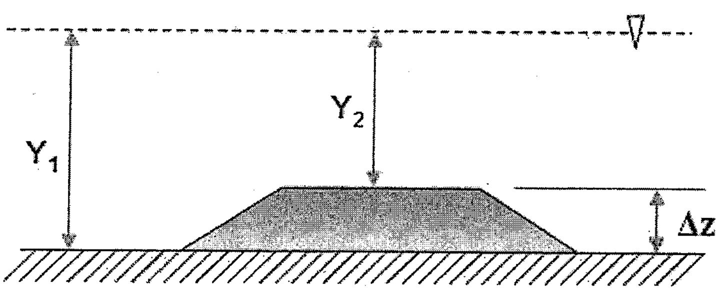
Provide answers to the following questions related to *open channel flows* under *uniform* and *gradually varied flow* conditions and *streamflow.*

(i) A concrete lined trapezoidal channel experiences uniform flow at a normal depth of 6 *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:

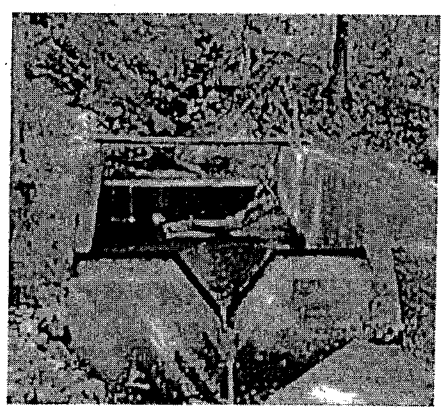
(3) (a) The discharge flow rate Q in m^3/s; and

(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 1 *m*. Consider the figure below, assume frictional losses are negligible and you may use the *specific energy* equations at the two sections 1 and 2.



(6) (iii) Calibration structures (e.g., picture of V-notch weir below) are commonly used to verify stream stage-discharge curves. Explain the use, using an equation, of the V-notch weir in calibrating stage-storage curves and any assumptions made in using such in-stream devices.



Marking Scheme

1. (i) 8, (ii) (a) 2, (b) 2, (c) 2, (iii) 6 marks, 20 marks total
2. (i) 6, (ii) 4, (iii) 5, (iv) 5 marks, 20 marks total
3. (i) 6, (ii) 6, (iii) 8 marks, 20 marks total
4. (i) 6, (ii) 6, (iii) 8 marks, 20 marks total
5. (i) 10, (ii) 5, (iii) 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