NATIONAL EXAMS DECEMBER 2018

18-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.

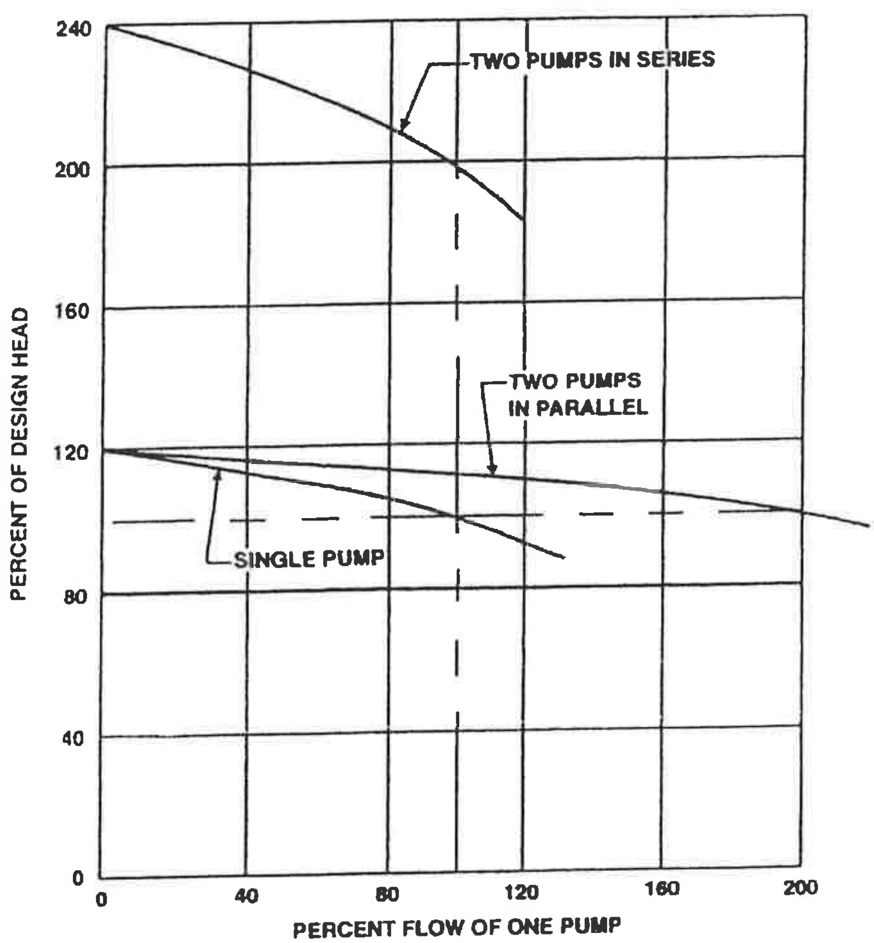
Problem 1

Provide answers to the following questions related to *stormwater collection system design* and *basic pumps or prime movers.*

(8) (i) For each system, explain two (2) critical functions of a minor and major stormwater collection system. In your explanation, discuss how the minor system integrates into the major system during large storm events.

(7) (ii) With reference to pumped systems, briefly explain what water hammer is, under what conditions it occurs and one (1) way to eliminate or reduce its undesirable effects.

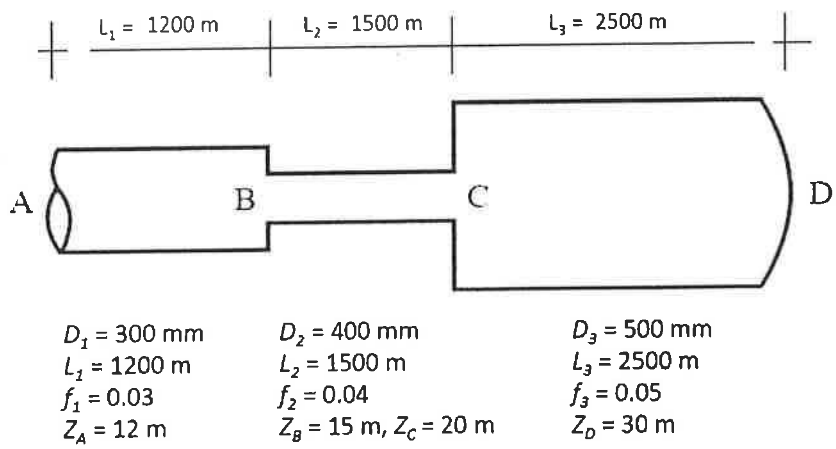
(5) (iii) With reference to the schematic below, briefly explain under what conditions an engineer would design multiple pumps in series or in parallel. As part of your explanation, provide one (1) advantage and one (1) challenge associated with each different design approach.



Problem 2

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

(8) (i) For a flowrate of 200 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 60 m. Clearly state any assumptions made.



(6) (ii) Briefly explain the Hardy Cross or similar method used in network designs and as part of your explanation, discuss two (2) key assumptions that each method makes and designers need to be aware of.

(6) (iii) You have been asked to design a sanitary sewer to convey a peak flow of 6 m^3/s when flowing full with a bedding slope of 4%. The senior engineer advises that the flow velocity must be greater than 0.7 m/s and less than 8 m/s and that a concrete pipe with a Manning's n of 0.04 must be used due to soil loads. Calculate the required diameter d in mm for this sanitary sewer.

Problem 3

Provide answers to the following questions related to *hydraulics of closed pipe systems*, *open channel flows* under *uniform* and *gradually varied flow* conditions.

(i) Consider water flowing through a plastic pipe having length L of 1000 m, diameter d of 500 mm and a full flow velocity of 4 m/s. State any assumptions clearly and calculate the following:

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

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

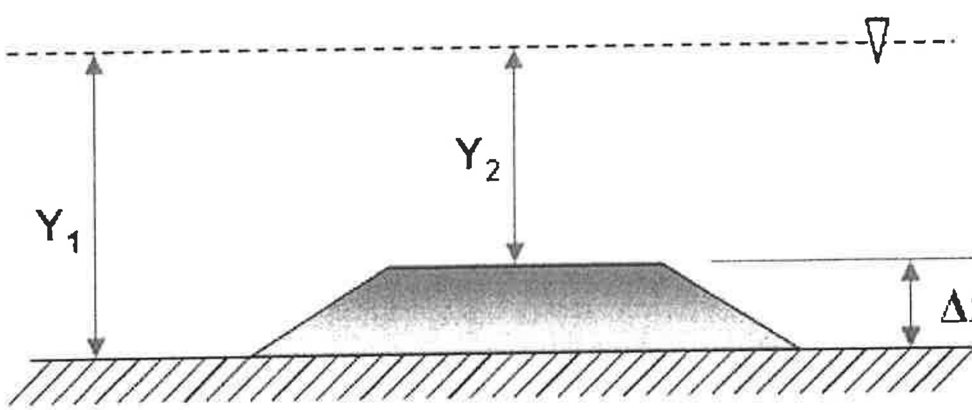
(2) (c) Pipe head loss H_f in m.

(ii) A grass lined trapezoidal channel experiences uniform flow at a normal depth of 5 m. The base width is 4 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:

(4) (a) The discharge flow rate Q in m^3/s.

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

(7) (iii) Assume that the channel has a flowrate of 10 m^3/s at a normal flow depth Y_1 of 2.5 m. Calculate the depth of flow Y_2 in a section of the channel in which the bed rises Δz equal to 0.5 m. See figure below, assume frictional losses are negligible and consider the *specific energy* at the two sections 1 and 2.



Problem 4

Provide answers to the following questions related to *water distribution systems*, *wastewater collection systems* and *storage reservoirs*.

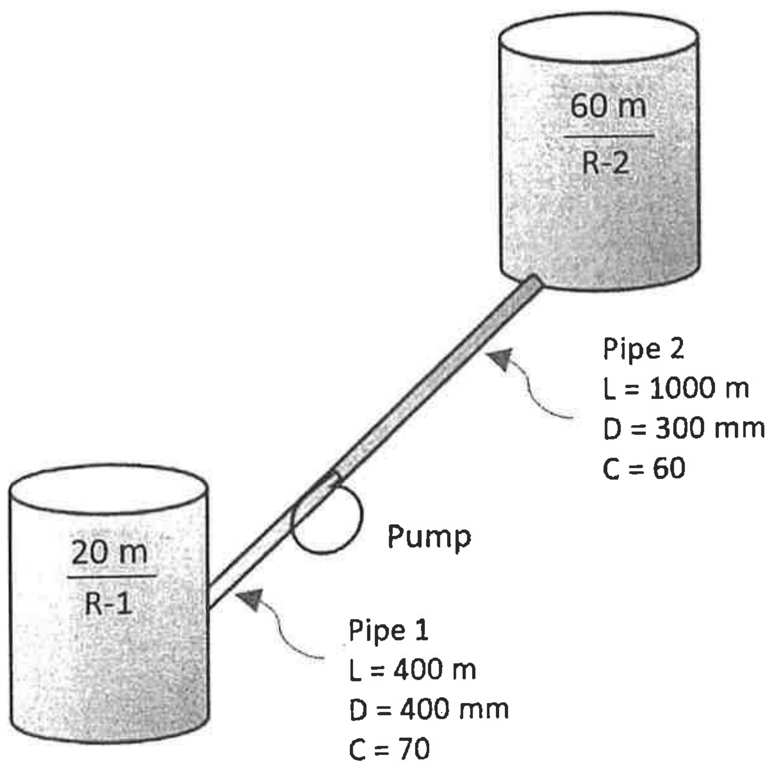
(i) Briefly explain how a butterfly and globe valve work and under what conditions each is used within a water distribution system.

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

(6) (a) Sanitary forcemain; and

(6) (b) Sanitary pumping station;

(8) (iii) Determine the approximate pump head in m needed to deliver water from reservoir R-1 to reservoir R-2 shown (see figure below) at a rate of 100 L/s. Compute the friction head losses using the Hazen-Williams equation and pipe characteristics (L, D and C) provided in the figure. Clearly state any assumptions.



Problem 5

Provide answers to the following questions related to *conceptual models of runoff, streamflow* and *probability frequency hydrograph analysis* related to *floods.*

(7) (i) Briefly explain three (3) important properties of a conceptual model of runoff and give two (2) important assumptions that these models generally make to reduce the data burden to implement more complicated models.

(7) (ii) Explain two (2) important ways to use the stage-discharge approach in predicting streamflow. In your explanation, discuss two (2) key parameters that affect the confidence level of the predicted streamflow which need to be considered to reduce liability.

(6) (iii) Given the maximum annual instantaneous flows from the Muddy River in Northern Quebec 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 100 years.

Water Year	Discharge (m^3/s)	Water Year	Discharge (m^3/s)	Water Year	Discharge (m^3/s)
1950	400	1954	570	1958	840
1951	500	1955	560	1959	750
1952	670	1956	550	1960	620
1953	830	1957	650	1961	700

Problem 6

Provide answers to the following questions related to *urban drainage* and *runoff control system design.*

(10) (i) Briefly explain how on-site and end-of-pipe urban stormwater management (STWM) systems are used to control downstream flooding and protect downstream water quality. As part of your explanation, provide two (2) key design principles and two (2) operational measures for a wet-pond or a wet-pond with integrated wetland.

(10) (ii) Describe three (3) methods of runoff control system design indicating one (1) advantage and one (1) limitation for each method. Use a table to organize your answer.

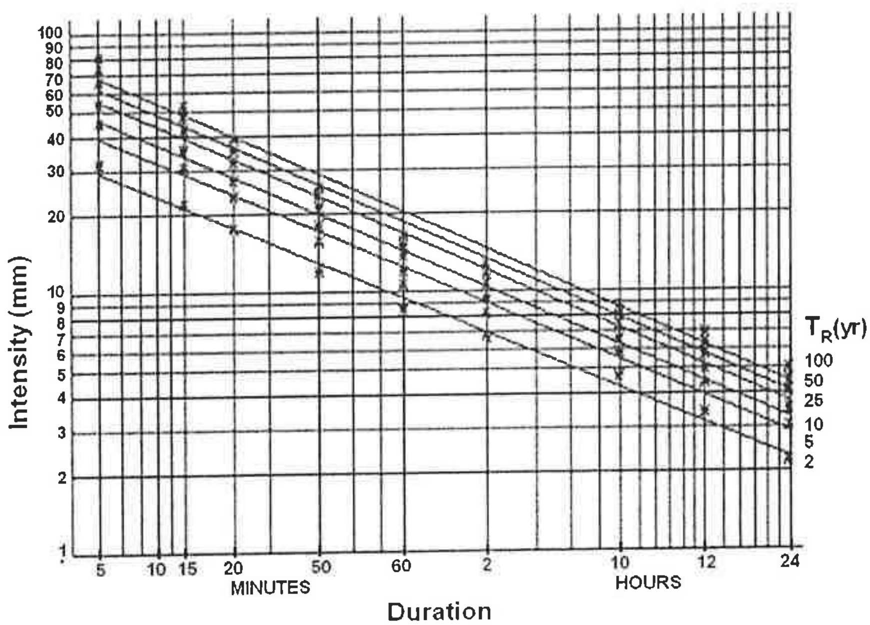
Problem 7

Provide answers to the following questions related to *components* and *processes* of the *natural hydrologic cycle*, *precipitation*, *runoff*, *storm frequency* and *duration analysis*.

(8) (i) Provide a schematic showing the natural hydrologic cycle identifying four (4) key processes and briefly explain three (3) important relationships among the processes that affect the runoff from a large watershed.

(7) (ii) Use the Rational Formula to determine the 50-year design peak runoff (m^3/min) for the catchment areas (A1 and A2) referred to 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	120



(5) (iii) Briefly explain the rational method, two (2) important assumptions and how these assumptions need to be taken into account during the engineering design of the major stormwater conveyance system.

Marking Scheme

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