NATIONAL EXAMS DECEMBER 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 *precipitation and snow melt*, *stormwater collection system design* and *wastewater collection system.*

(6) (i) Using the hydrologic abstraction processes, included in the hydrologic equation (HE), briefly explain how you would need to modify the HE to account for snow melt in predicting the peak runoff flowrate. In your answer, you may consider a typical watershed as a basis for your explanation.

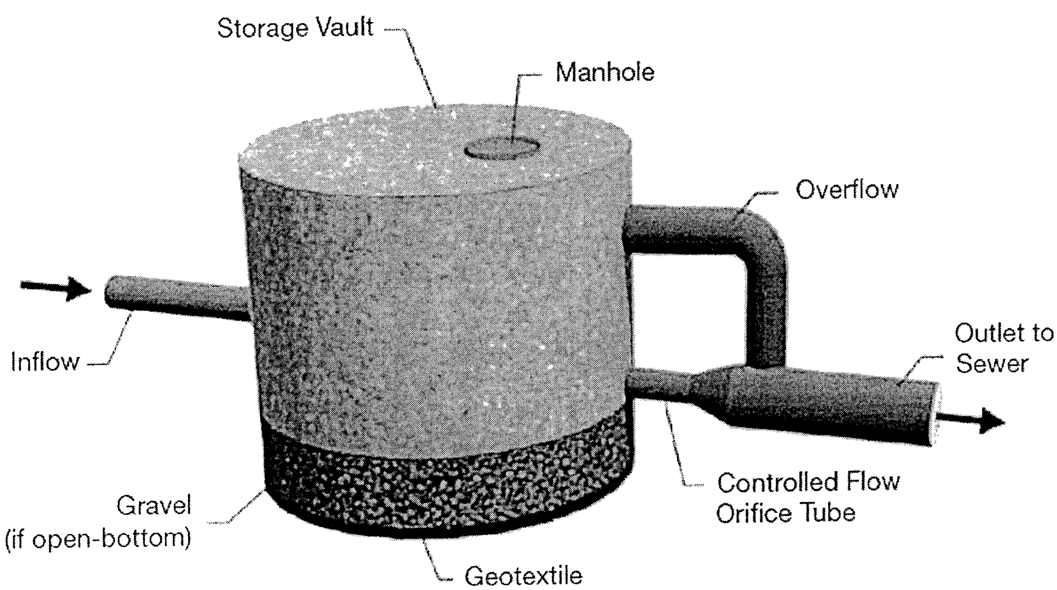
(6) (ii) Briefly explain the function or importance of the following components of a wastewater collection system:

(a) Trunk sewer;

(b) High level water alarm in a pumping station; and

(c) Dry well associated with a pumping station

(8) (iii) Considering the diagram below of a *storage vault system* briefly explain how it functions to promote infiltration and reduce downstream surcharging during high flow storm events.



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) Give one (1) example of a deterministic and a stochastic conceptual model and briefly describe three (3) important differences between these model types that may be used to predict runoff.

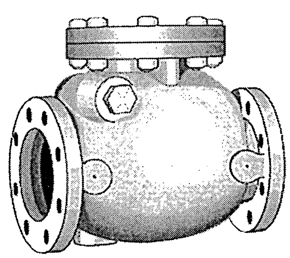
(ii) Consider water flowing though a corrugated steel pipe having Manning n of 0.03, length L of 300 m , diameter d of 500 mm and a full flow rate of 300 L/s. Calculate the following:

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

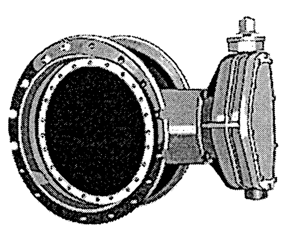
(2) (b) Reynolds number Re and type of flow make a statement about the type of flow expected (i.e., laminar or turbulent).

(2) (c) Estimate of the pipe friction loss H_f in m.

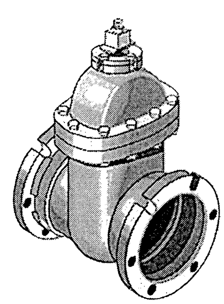
(6) (iii) Briefly explain the function of a swing check valve and a gate valve and when each would be used in a water distribution system with water storage reservoirs. Typical valves commonly used in water distribution systems are shown below.



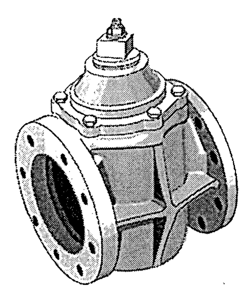
Swing check valve



Butterfly valve



Gate valve



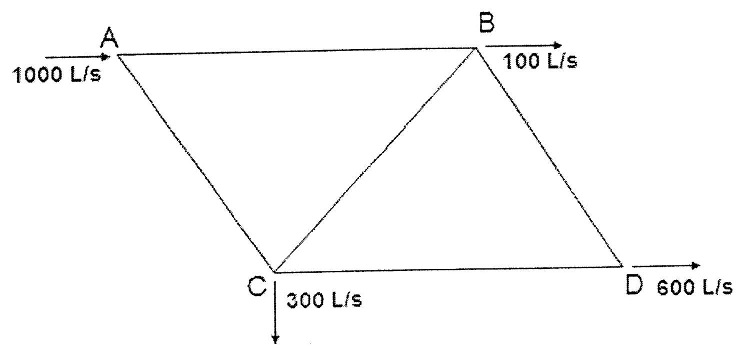
Plug valve

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 shown below using the Hardy-Cross or similar method, given the following pipe lengths (L) and corresponding diameters (d):

Pipe	Length (m)	Diameter (mm)
AB	400	300
BC	600	350
CD	400	300
AC	600	350
BD	400	250



(4) (ii) Describe two (2) main differences between a centrifugal and a positive displacement pump.

(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) Provide an appropriate system pump-head curve to explain when it is recommended to use multiple pumps cost effectively for:

(2) (a) parallel pumping; and

(2) (b) pumping in series

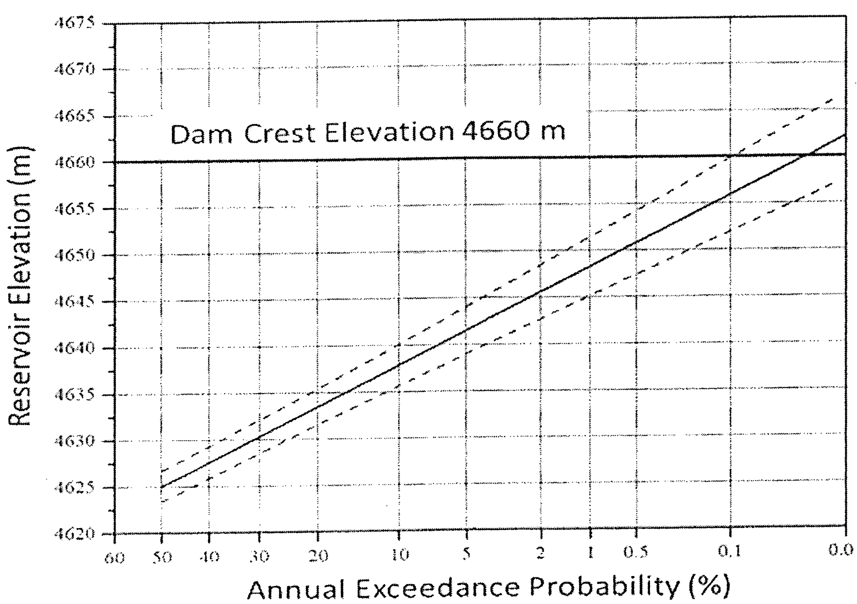
Problem 4

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 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 8 m/s and that a corrugated steel pipe with a Manning's n of 0.025 is to be used. Calculate the required diameter d to the nearest *mm* for this sewer and check that the above conditions can be met.

(6) (ii) Briefly describe one (1) on-site and one (1) off-site stormwater runoff control system and explain an important design or operational feature of the system.

(6) (iii) Function of dams include the control and reduction of risk from large storm events. The figure below provides an example reservoir elevation probability curve for hydrologic risk analysis. The solid line is the median estimate and 95% confidence limits are shown as dashed lines. Briefly explain how this type of figures may be derived for a particular watershed and how they can be used for routing the dam overflow during less frequent events to reduce downstream flooding damage.



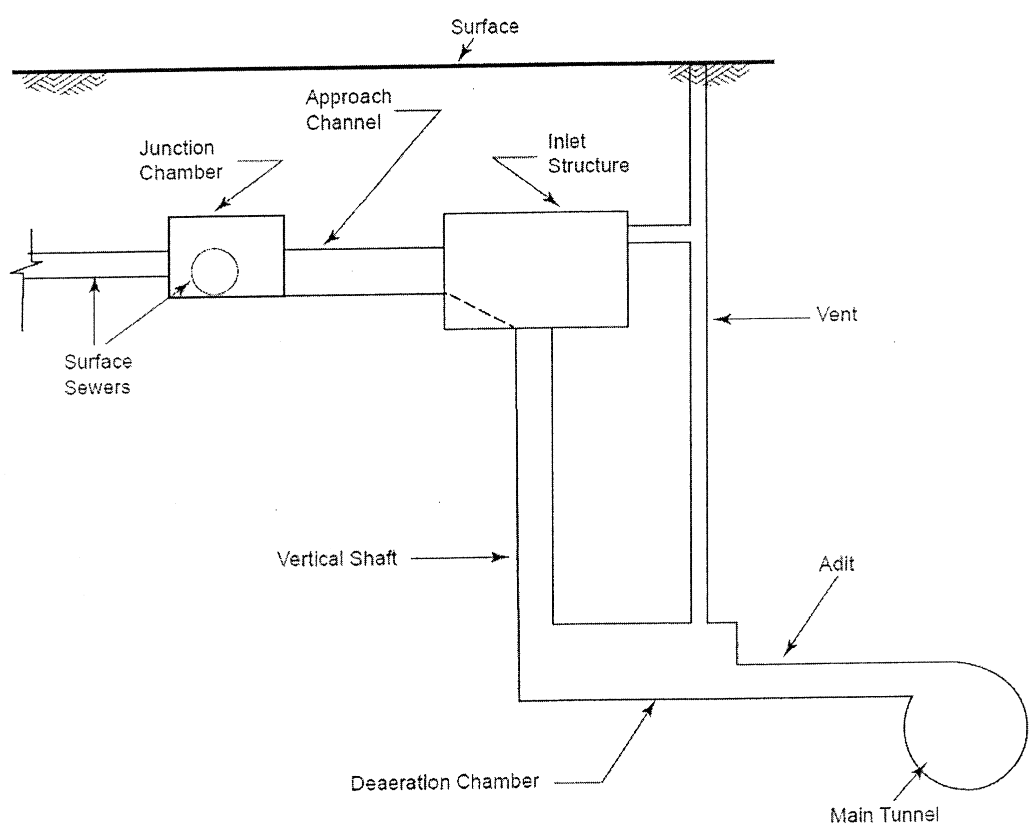
Problem 5

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

(7) (i) Identify three (3) key components or processes of the natural hydrologic cycle that have the most direct impact on the surface runoff from a rural watershed and rank them in priority sequence.

(6) (ii) Briefly explain how the peak storm runoff event may be estimated to design a trunk storm sewer from a large urban watershed that will discharge to a nearby river.

(7) (iii) Explain the function of any three (3) components of the storm sewer drop structure given below as a cross-sectional schematic.



Problem 6

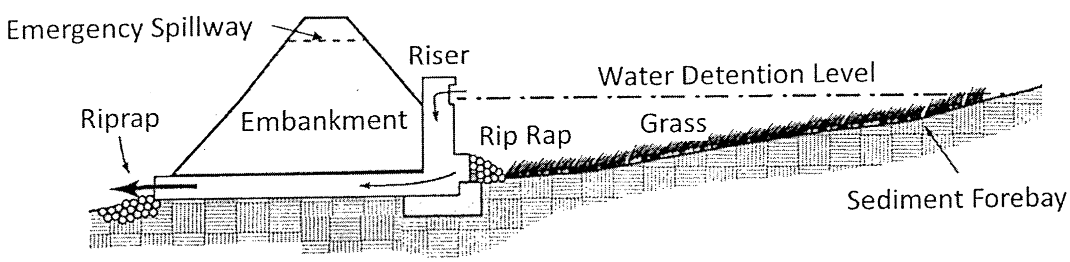
Provide answers to the following questions related to *intenisty duration frequency (IDF) analysis curves* and *urban stormwater management.*

(6) (i) Briefly explain how the IDF curve and Rational formula work together to predict the peak storm flow event and give two (2) assumptions an engineer needs to make when applying the Rational formula.

(6) (ii) Compute the peak flow (Q) from a catchment with an area (A) of 100 ha and a C value of 0.5. Use the IDF equation (below) and assume the time of concentration (t_c) is 60 minutes and the I_{24} is 20 mm/hr.

$$\frac{I_t}{I_{24}} = \frac{1400}{t}^{0.47}$$

(8) (iii) State the main purpose of a dry pond and considering the cross-section of a dry pond (below), explain the importance of three (3) key design features with respect to their primary function.



Problem 7

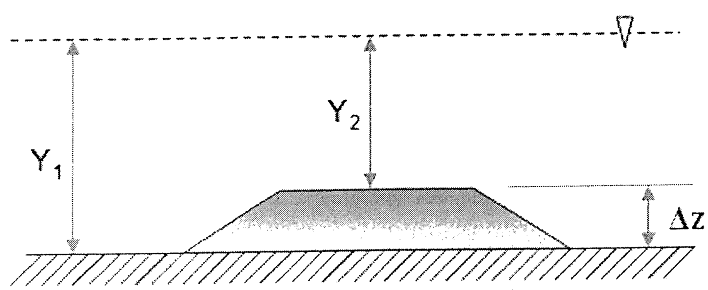
Provide answers to the following questions related to *open channel flows* under *uniform* and *gradually varied flow* conditions and *streamflow*.

(i) A fine sand lined trapezoidal channel experiences uniform flow at a normal depth of 3 *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 2 %, 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 15 m^3/s at a normal flow depth Y_1 of 1.5 *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 0.6 *m*. Consider the figure below, assume frictional losses are negligible and you may use the *specific energy* equations at the two sections.



(6) (iii) Considering Manning's equation (below), explain the meaning of each term and how you would compute the average flow rate (Q) through a triangular cross-sectional stream.

$$V = \frac{R^{\frac{2}{3}}\sqrt{S}}{n}$$

Marking Scheme

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