NATIONAL EXAMS MAY 2011

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 2-sided ($8\frac{1}{2}'' \times 11''$) AID SHEET prepared by the candidate allowed.

3. The candidate may use one of two calculators, the Casio or Sharp approved models. Note that you must indicate the type of calculator being used. 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 equally weighted at twenty (20) points for a total of a possible one-hundred (100) points for a complete paper.

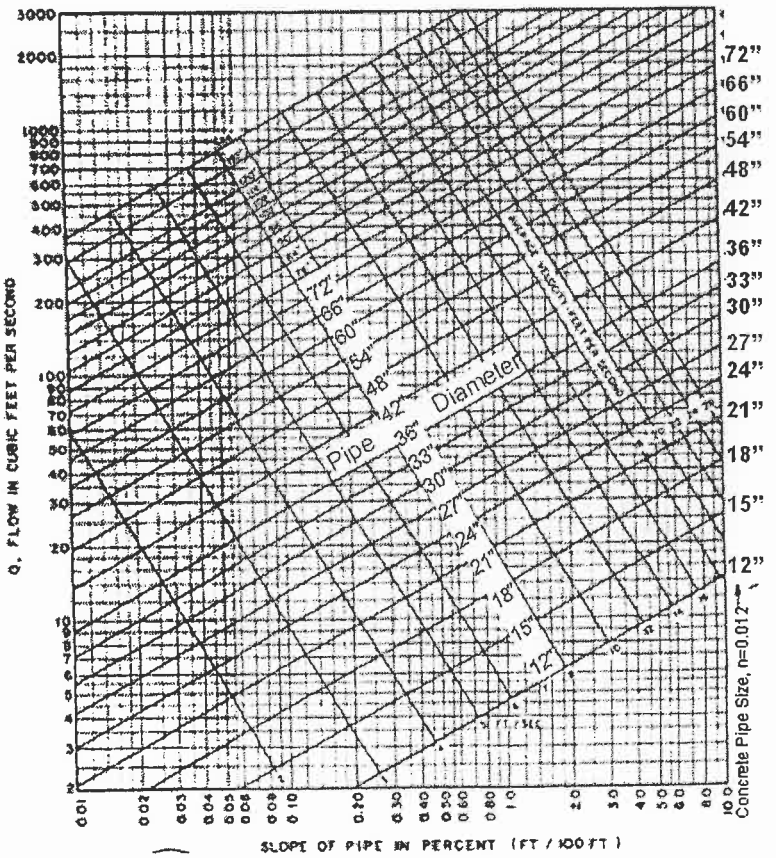
Problem 1

Provide answers to the following questions related to *hydraulics of closed pipe systems*, *design of sanitary sewers* and *stormwater collection system design.*

(7) (i) Determine Reynolds number (**R**) and the head loss (h_f) for a flow of 140 L/s of oil, $\nu = 0.00001$ m^2/s, through a 400 m long cast-iron pipe with a 200 mm diameter. Assume that the friction factor from the Moody diagram $f = 0.023$. Is the flow turbulent or laminar?

(7) (ii) Explain why a 250 mm diameter sanitary sewer has a minimum recommended slope of 0.30% and a maximum recommended slope of 12%. In case where a sanitary sewer cannot be placed at a slope of < 12% what can be done to build the sanitary sewer system? You may support your answers by short calculations and/or diagrams.

(6) (iii) Select the diameter in inches of a circular concrete pipe required for a storm sewer installed on a 0.1% slope with a required flow of 40 cubic feet per second. The n value is 0.012 and the minimum velocity is 3 feet per second.



Problem 2

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

(i) A concrete lined trapezoidal channel experiences uniform flow at a depth of 2 m. The base width is 7 m and the side slopes are equal at a H:V of 1:3. Using an appropriate Manning's n and a bed slope S_o of 2%, calculate the following:

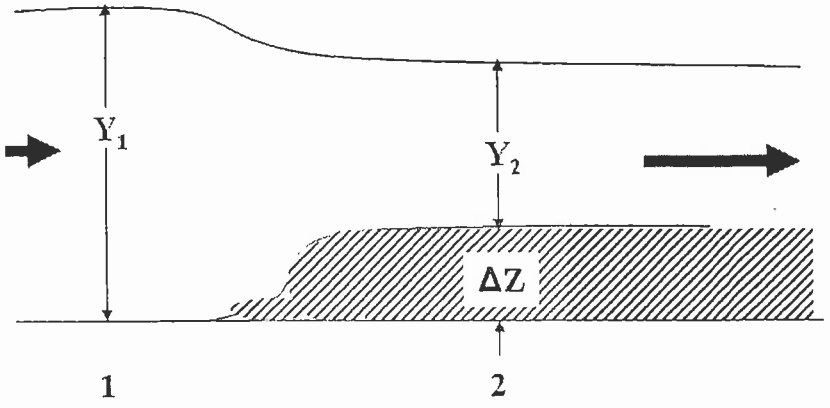
(4) (a) The average discharge velocity V, in m/s.

(4) (b) The Froude number F associated with this flow and hydraulic significance.

(5) (iii) Briefly explain the steps necessary to determine the flow profile in a channel reach experiencing gradually varied flow (GVF). Recall that a general expression for GVF is given by:

$$\frac{dy}{dx} = \frac{S_o - S_f}{1 + Fr^2}$$

(7) (iii) Assume that the channel has a flowrate of 20 m^3/s at a flow depth Y_1 of 3 m. Calculate the depth of flow Y_2 in a section of the channel in which the bed rises ΔZ equal to 0.7 m. See figure below, assume frictional losses are negligible and consider the *specific energy* at the two sections 1 and 2.



Problem 3

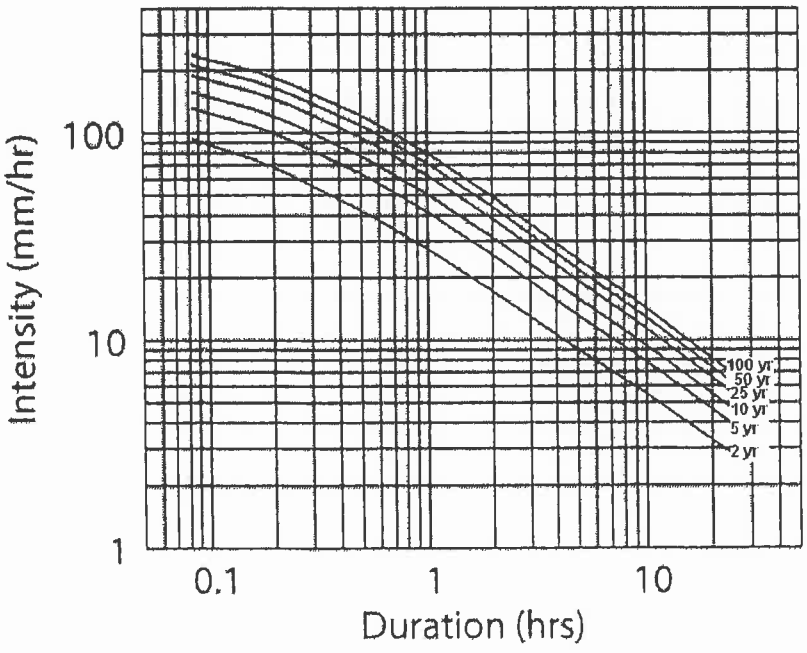
Provide answers to the following questions related to *components* and *processes* of the *natural hydrologic cycle*, *storm frequency* and *duration analysis*.

(5) (i) Briefly explain the link between two (2) hydrologic processes and ground water flow in a rural enviornment. In your explanation, use equations and/or figures as necessary.

(5) (ii) Briefly explain two (2) assumptions of the rational formula ($Q = C \cdot i \cdot A$) and explain how these assumptions limit the applicabilty of the rational formula.

(4) (iii) Describe a probalistic or frequency distribution method used to analyze storm duration (t_R) for the purpose of relating it to rainfall intensity.

(6) (iv) Briefly explain how the intensity duration frequency (IDF) curves for a large municipal subdivision are generated and used to design a stormwater collection system for a 100-year return design storm. Consider the sample IDF curves below to assist in your explanation.

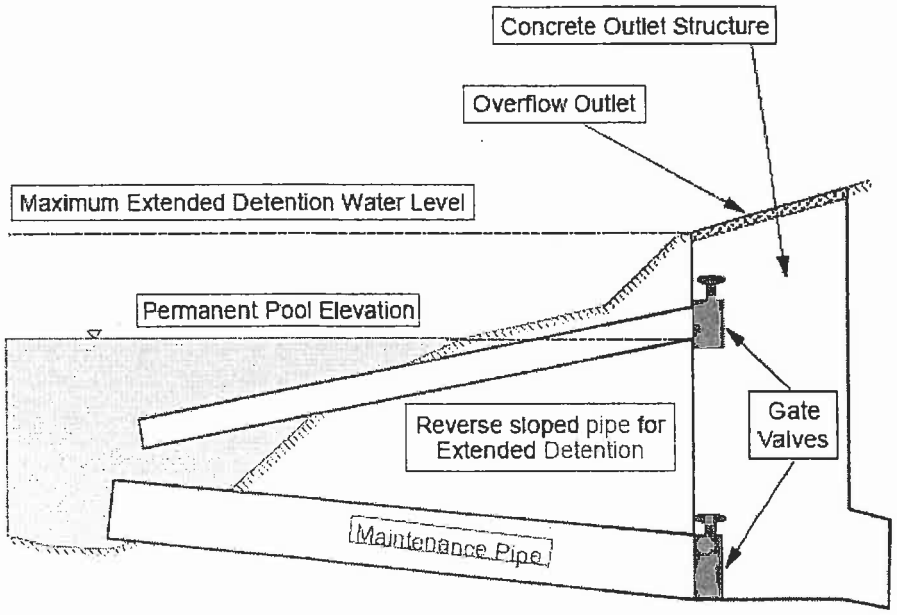


Problem 4

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

(10) (i) Compare and contrast the "minor system" and the "major system" by identifying two (2) key features of each and give an example of each system that may be used to address runoff issues from a new large urban subdivision. In your answer, consider that the regulators require that the post-development peak runoff flow rates stay within the pre-development levels.

(10) (ii) Using the diagram below of a cross section of an extended wet pond outlet structure, briefly explain the primary design function of the permanent pool, overflow outlet, reverse sloped outlet pipe, gate valves and maintenance pipe.



Problem 5

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

(8) (i) In the absence of representative runoff data, conceptual models are necessary for flood predictions. Describe the fundamentals of a conceptual model and how it can be used to predict runoff from a rural watershed. Discuss two (2) main assumptions and data needs for the model to make reasonable predictions about the peak runoff from the area.

(6) (ii) Briefly explain how to measure streamflow and how the measured value will vary over time. Briefly explain two (2) environmental factors that change the streamflow from year to year.

(6) (iii) Describe a statistical technique for fitting frequency distribution data to predict the design flood for a river at some location. Briefly explain the use of this technique in predicting flooding events and give two (2) important factors needed for good predictions.

Problem 6

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

(6) (i) Explain four (4) key features of the Hardy-Cross method used in for water distribution system analysis.

(4) (ii) Explain three (3) important reasons why water storage reservoirs are used in water distribution systems.

(5) (iii) Explain three (3) important hydraulic design principles used to design sewage pumping stations within wastewater collection systems that serve a community with a population of 10,000 people.

(5) (iv) Identify and briefly discuss three (3) important design issues for water or wastewater systems to ensure adequate redundancy and reliability of the systems.

Problem 7

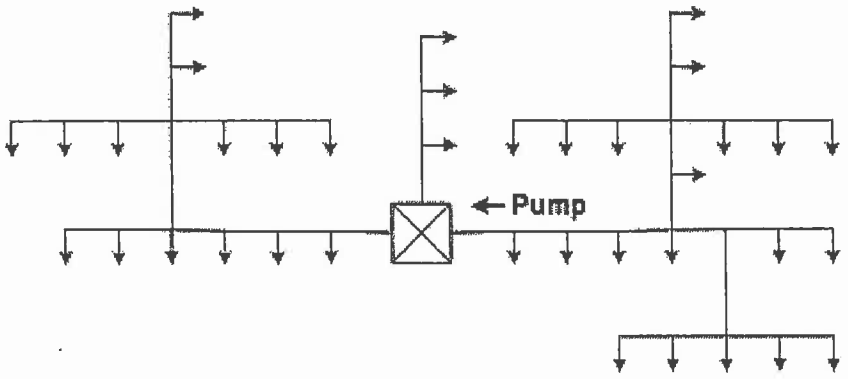
Provide answers to the following questions related to *open channel flow*, *basic pumps or prime movers* and *network design*.

(5) (i) Briefly explain the significance and difference between subcritical and supercritical flow in open channel hydraulics.

(5) (ii) Provide a sketch of a pump-system curve with two pumps operating in parallel. Identify the pump operating envelope, with one pump and then two pumps operating. Clearly label the axes.

(5) (iii) Explain the different types of losses and efficiencies of a centrifugal pump or a diaphragm pump.

(5) (iv) Consider the water pipe network below and discuss how the total water demand for the system can be accurately computed so that the high-lift pump size and power demand may be adequately determined.



Marking Scheme

1. (i) 7, (ii) 7, (iii) 6 marks, 20 marks total

2. (i) (a) 4, (b) 4 (ii) 5, (iii) 7 marks, 20 marks total

3. (i) 5, (ii) 5, (iii) 4, (iv) 6 marks, 20 marks total

4. (i) 10, (ii) 10 marks, 20 marks total

5. (i) 8, (ii) 6, (iii) 6 marks, 20 marks total

6. (i) 6, (ii) 4, (iii) 5, (iv) 5 marks, 20 marks total

7. (i) 5, (ii) 5, (iii) 5, (iv) 5 marks, 20 marks total