NATIONAL EXAMS DECEMBER 2015

98-Civ-B4, Engineering Hydrology

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) marks for a complete paper.

Problem 1

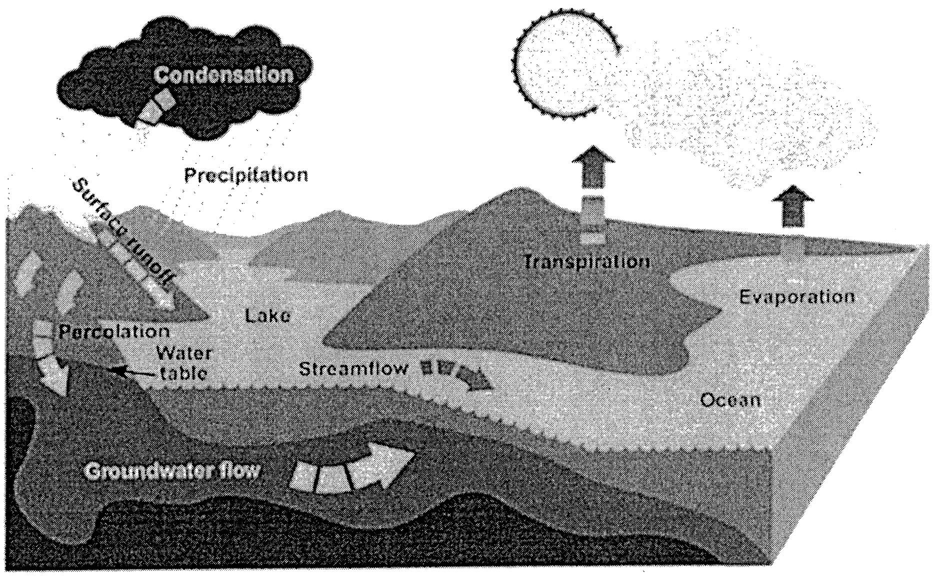
Provide answers to the following questions related to *hydrologic cycle processes, groundwater flow* and *surface runoff*:

(10) (i) Flow in groundwater may be explained using Darcy's Law given below:

$$Q = A \cdot K \left(\frac{\Delta h}{\Delta x} \right)$$

Explain all the terms of the equation, give a system of consistent dimensions for each term and briefly explain how to use this equation to compute the flow of water through an aquifer.

(10) (ii) Consider the hydrologic cycle diagram below and provide an equation that explains the inter-relationship between precipitation (P), surface runoff (R) and groundwater flow (G) by taking into account surface soil storage (ΔS). Use the parameters provided and include a consistent system of dimensions for each parameter used. You may include other parameters as necessary.

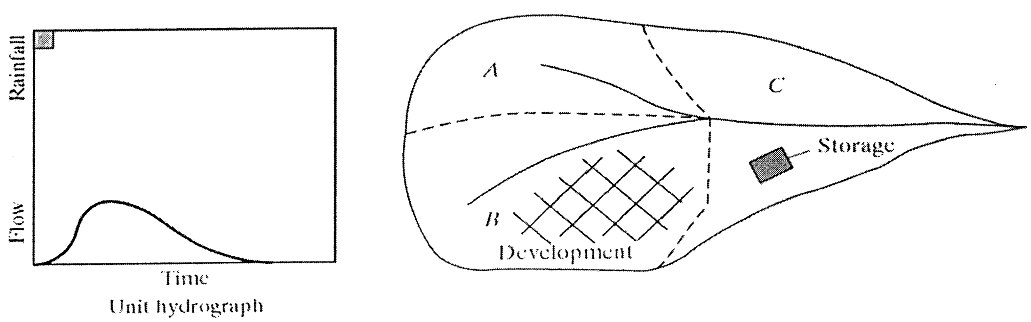


Problem 2

Provide answers to the following questions related to *conceptual models of runoff, unit hydrographs* and *runoff hydrographs.*

(10) (i) Explain two (2) main differences between a conceptual model and a physical model as applied to an engineered hydraulic or hydrology system. As part of your comparison, provide an example where a conceptual model is preferred over a physical model.

(10) (ii) Consider the figure below of a unit hydrograph and watershed and briefly explain **how** a unit hydrograph is derived and **how** a design storm hydrograph (runoff hydrograph) for the whole watershed shown may be developed. For the watershed shown assume that area A and C are not developed and B is developed with a large stormwater management storage pond. Note that **how** to solve the problem only is being asked. State clearly any realistic assumptions you make.



Problem 3

Provide answers to the following questions related to *basics of hydrologic modelling, reservoir* and *lake routing.*

(10) (i) Give the equation and briefly explain the assumptions, limitations and data requirements of the: (1) Hydrologic transport model and (2) Non-linear outflow-storage equation. A matrix may be useful to organize your answer.

(5) (ii) Explain three key steps in the field verification of a rainfall-runoff model.

(5) (iii) Explain the fundamentals of the Muskingum Routing method or similar method used for reservoir or lake routing.

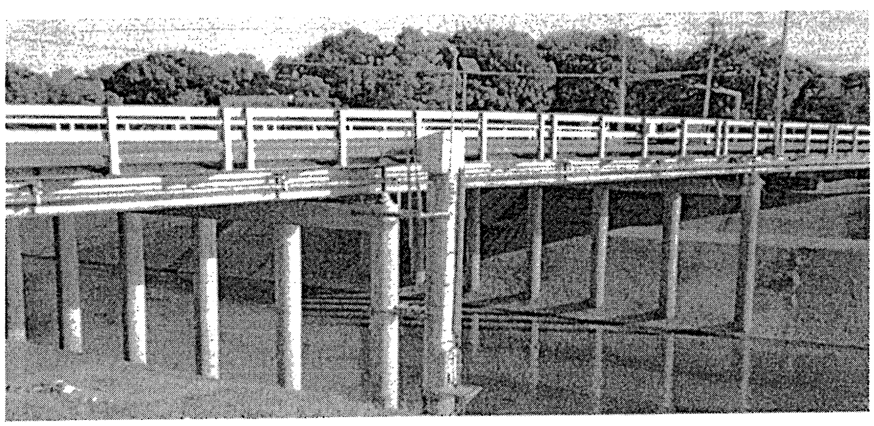
Problem 4

Provide answers to the following questions related to *point* and *areal estimates of precipitation* and *stream flow measurements*.

(7) (i) Briefly describe the Isohyetal Contour and Thiessen Polygon techniques used to calculate the average areal precipitation.

(7) (ii) Briefly define Stream Stage and Rating Curve. In your answer, explain how a stream rating curve is derived and how it may be used to develop a flood alert system.

(6) (iii) Explain how a peak flow frequency analysis from the available historical rating curve data can be used to determine the 100-year return period peak flow event. Use appropriate equations and state any assumptions in your explanation.



Problem 5

Provide answers to the following questions related to *channel*, *river routing* and *flood wave behavior*.

(6) (i) Briefly explain the Convolution method or similar method useful for channel or river routing and provide two (2) underlying assumptions of the method.

(7) (ii) Briefly explain how **river reaches** and **river rating curves** are used in channel or river routing. You may find the use of equations and clearly labeled diagrams helpful in answering this question.

(7) (iii) Consider a flood wave propagating in a river due to a sudden large rainfall event. Describe **how** you would solve this problem in principle to predict the wave effect downstream along the river including the peak flow rate, the maximum wave height and time to crest.

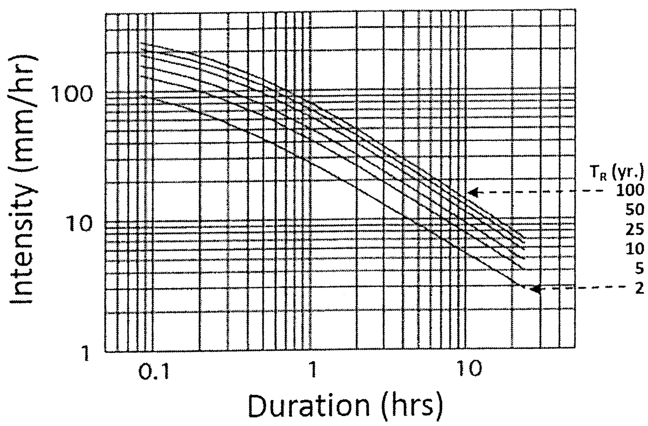
Problem 6

Provide answers to the following questions related to *statistical methods of frequency, probability analysis applied to precipitation* and *floods*:

(7) (i) Explain how flood-frequency analysis is used to predict the magnitude and timing of future floods.

(7) (ii) Explain why frequency and probability distributions are used to characterize hydrologic variables. Identify one (1) frequency and one (1) distribution commonly used in engineering applications.

(6) (iii) Briefly explain how an intensity-duration frequency (IDF) curve (example below) may be derived and give two (2) underlying assumptions to be considered or made when used in urban applications.



Problem 7

Provide answers to the following questions related to the *hydrologic equation, energy budget equation* and *infiltration simulation*:

(10) (i) From the energy budget equation (EBE) given below, explain the meaning of any three (3). For each of the three (3) terms of the EBE, you selected, briefly explain how they correspond to the hydrologic cycle.

$$E_s = (E_a + R_t) - (R_r + E_e + H_n + R_1)$$

(5) (ii) Provide an example to show how the EBE (in conjunction with any other assumed information) may be used to estimate the peak runoff associated with snow melt.

(5) (iii) Give a representation of Horton Infiltration Model and briefly explain its assumptions and limitations when used in an engineering application.

Marking Scheme

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