NATIONAL EXAMS MAY 2016

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) points for a complete paper.

Problem 1

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

(7) (i) Describe how temperature, precipitation and streamflow are interrelated within the hydrologic processes and briefly explain the importance of each component to the hydrologic cycle. Use a clearly labelled schematic to show the important interrelationships.

(7) (ii) Briefly explain the the importance of recharge areas as related to groundwater flow. In you explanation, consider infiltration, percolation, the water table and discharge area. Use a clearly labelled schematic to show the important interrelationships.

(6) (iii) A new 4 ha suburban development is to be drained by a storm sewer that connects to a municipal drainage system. The time of concentration for the sub-watershed is 50 minutes and the local IDF relationship can be approximated as $i = 6.0 - 0.3t_d$, where t_d is the rainfall duration in hours. Estimate the peak surface runoff using the Rational Method. State clearly your assumptions and the reasons for them.

Problem 2

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

(6) (i) Briefly explain how a runoff hydrograph is generated for a large watershed and give two (2) main properties of a watershed that influence a runoff hydrograph significantly.

(7) (ii) Explain an engineering application of the use of the unit hydrograph in a watershed and briefly explain two (2) major assumptions or limitations of its use.

(7) (iii) A watershed has undergone rapid growth and development recently and a watershed plan, which included a conceptual model for runoff, is to be developed as a way to assist decision makers about surfacewater and groundwater quality and quantity impacts. Describe three (3) major tasks in the development of a conceptual model for the watershed and give two (2) limitations on its use by decision makers. Use a table to organize your answer.

Problem 3

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

(6) (i) Briefly describe two (2) main differences between the Arithmetic Average and Isohyetal Method techniques used to calculate the average watershed precipitation. As part of your description, provide a clearly labelled schematic for each technique showing how each technique is different.

(6) (ii) Briefly explain how real-time hydrographs are generated using a rating curve which relates the stream stage to the stream discharge.

(8) (iii) Briefly explain three (3) key components of the Midsection Method or any other accurate method used to measure the stream flow discharge.

Problem 4

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

(8) (i) Briefly explain two (2) main similarities and two (2) main differences between Distributed Models and Lumped Models and under what conditions each model type would provide the most accurate results.

(6) (ii) Reservoir routing generally combines the elevation-storage relationship with the elevation-discharge curves unique to the reservoir. Briefly explain three (3) important steps in the procedure for hydrologic reservoir routing.

(6) (iii) Define "flood routing" and provide three (3) important assumptions made in routing a flood in a reservoir or lake.

Problem 5

Provide answers to the following questions related to *channel* or *river routing* and *flood wave behavior*:

(7) (i) Briefly explain two (2) main differences between "river routing" and "reservoir flood routing".

(7) (ii) Flood waves are subject to two (2) principal kinds of movements: (1) uniformly progressive wave and (2) reservoir fluctuation. Briefly define each kind of movement and explain the impact on the reservoir storage from a uniformly progressive wave.

(6) (iii) Many different methods are used to route flood waves through river reaches. All these methods are based on the law of continuity. Give the equation form of the law of continuity and briefly explain how it is used to predict the mean outflow during the routing period.

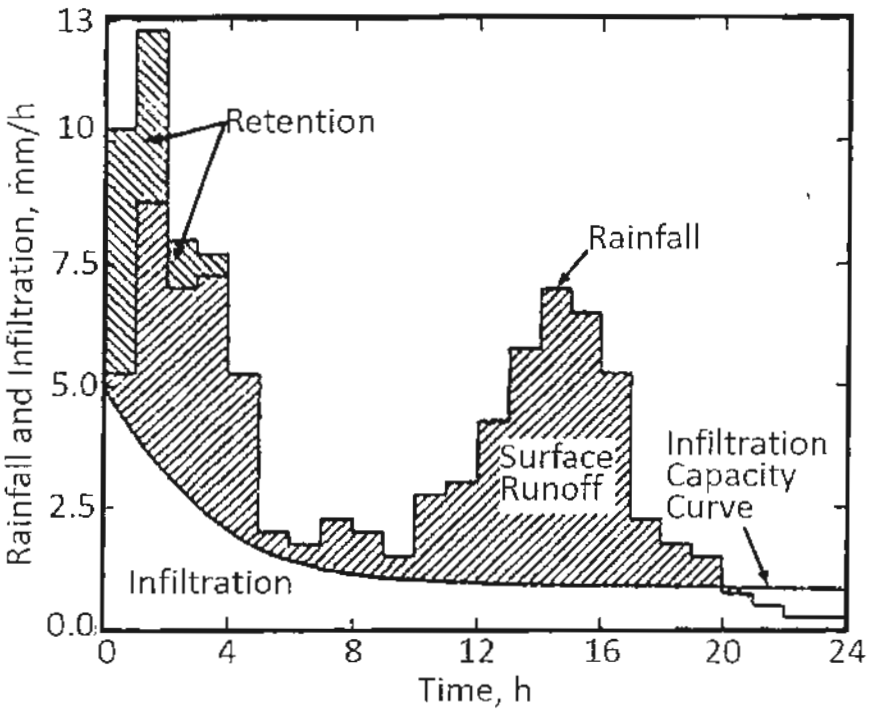
Problem 6

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

(6) (i) Briefly explain how to use the intensity-duration frequency (IDF) curve to predict the peak runoff (Q) of a watershed for a design storm with a 100 year return period. Clearly state your assumptions.

(6) (ii) The local insurance agent is in charge of settling flood claims but is not clear about the concept of "100-year flood". He says, "On the river near me, we have had two 100-year floods in 15 years. I'm really confused about this 100-year flood stuff". Provide a clear explanation about how a 100-year flood can occur twice in the last 15 years.

(8) (iii) With reference to the figure (below) briefly explain how precipitation, retention and infiltration determine the runoff that could result in downstream flooding.



Problem 7

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

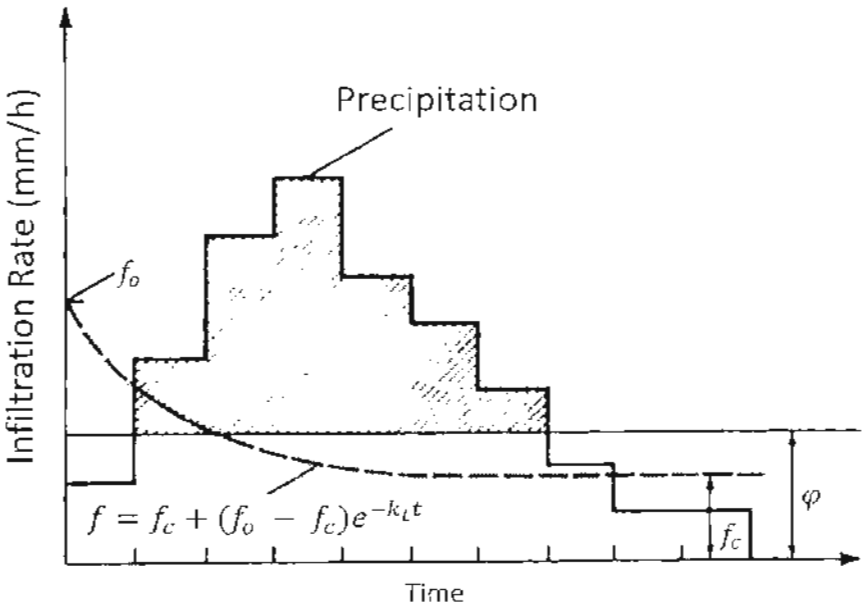
(7) (i) Estimate the amount of evapotranspiration (ET) for the year (mm) from a watershed with a 20,000 km^2 surface area. Consider the drainage area receives 80 mm of rain over the year and the river draining the area has an annual flowrate of 3200 m^3/s. Justify any assumptions you make and use the basic equation of hydrology (BEH). Recall that the BEH may be written as:

$$P - R - G - E - T = \Delta S$$

Where P = Precipitation, R = Surface runoff, G = Groundwater flow
E = Evaporation, T = Transpiration, ΔS = Change in Storage

(7) (ii) Taking into account the energy budget equation, briefly explain the greenhouse effect. Recall that the atmosphere is totally transparent to solar radiation and opaque to infrared radiation.

(6) (iii) Infiltration is a key component of the hydrologic components. Using Horton's infiltration model, explain two (2) key features of the model in predicting the infiltration capacity. The figure (below) provides an illustration of the ϕ index and Horton's equation for infiltration.



Marking Scheme

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

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

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

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

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

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

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