NATIONAL EXAMS DECEMBER 2014

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 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.

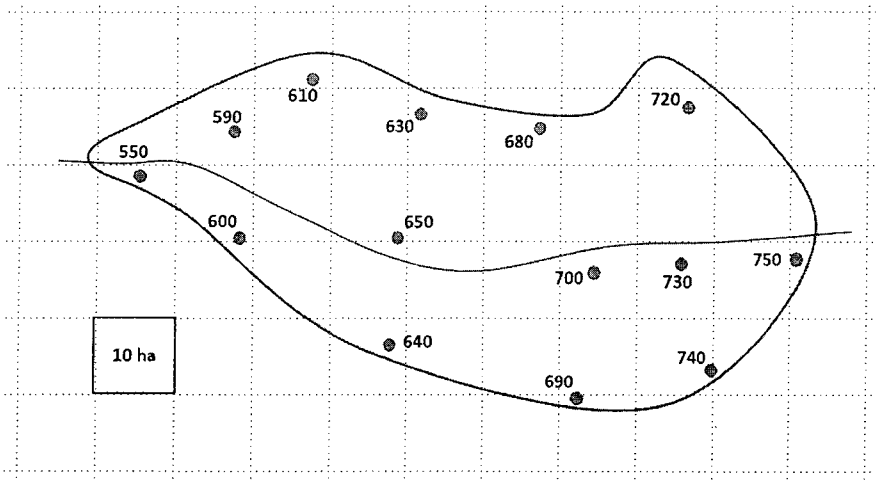
4. Any five (5) questions constitute a complete paper. Only the first five (5) answers as they appear in your work book(s), will be marked.

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 *point and areal estimates of precipitation* and *stream flow measurements*.

(10) (i) Using the figure of a watershed below and the Isohyetal Method or the Thiessen Polygons method, compute a good estimate of the average precipitation for the whole watershed. Assume that the shaded circles are rain gauges with the precipitation given in mm and each grid square represents 10 ha. State clearly any assumption you make.



(10) (ii) Briefly explain how a stream *Rating Curve* is developed, how it is used and how you would calibrate the curve that is 20-years old for a given stream length of 100 km. State clearly any assumptions you make.

Problem 2

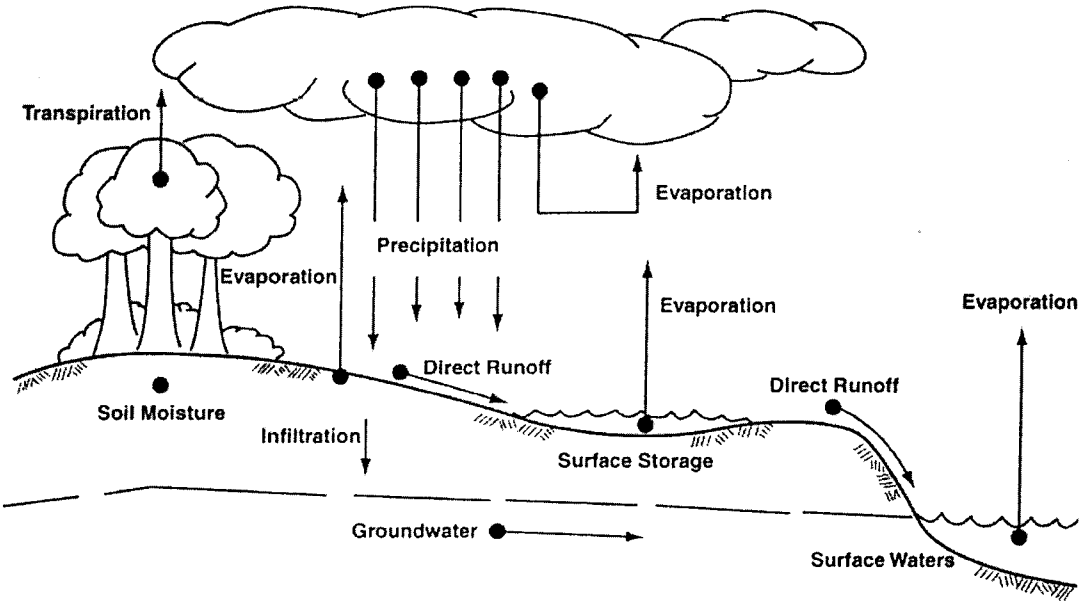
Provide answers to the following questions related to *hydrologic cycle processes*, *surface runoff* and *groundwater flow*.

(i) Using the figure below as a simplified reference to the hydrologic cycle processes, answer the following questions:

(7) (a) Identify and briefly explain the three most important processes for the engineering design of a dam to generate hydro-electric power.

(7) (b) Conceptually explain how to predict the amount of surface runoff from a 100 km^2 watershed. Clearly state what information you need to make a good estimate.

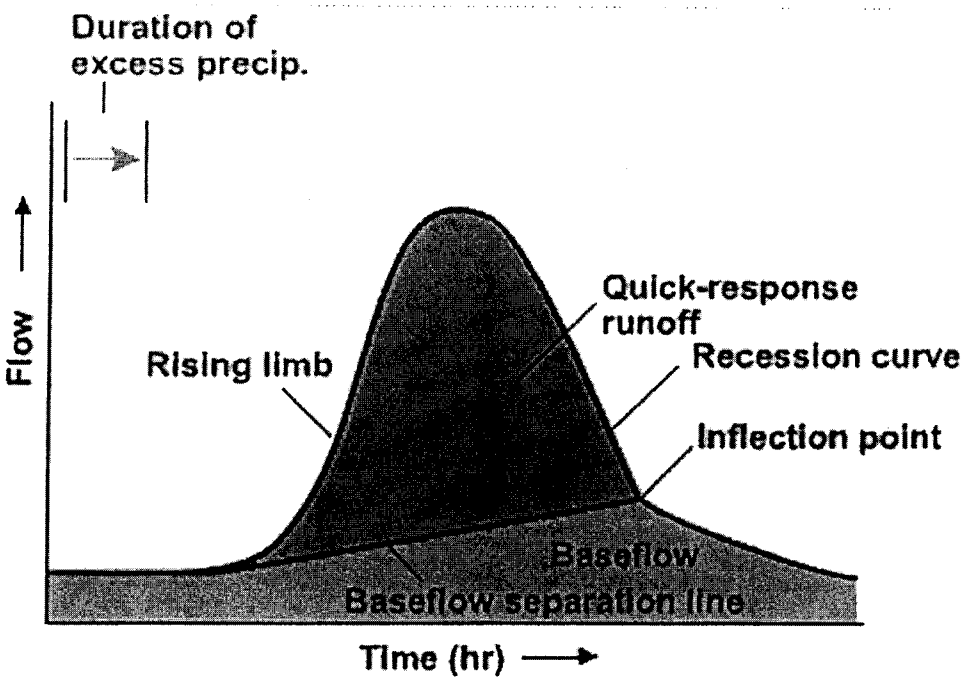
(6) (c) Groundwater flow is particularly important for aquifer recharge. Identify and explain the key processes one needs to know to predict the recharge potential of a watershed. Consider that the aquifer is an essential drinking water source for a small municipality and you are the engineer responsidble to ensure a continuous water supply.



Problem 3

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

(7) (i) The figure below identifies important aspects of a unit hydrograph. Explain the significance of any three terms with reference to engineering system design such as flood prediction.



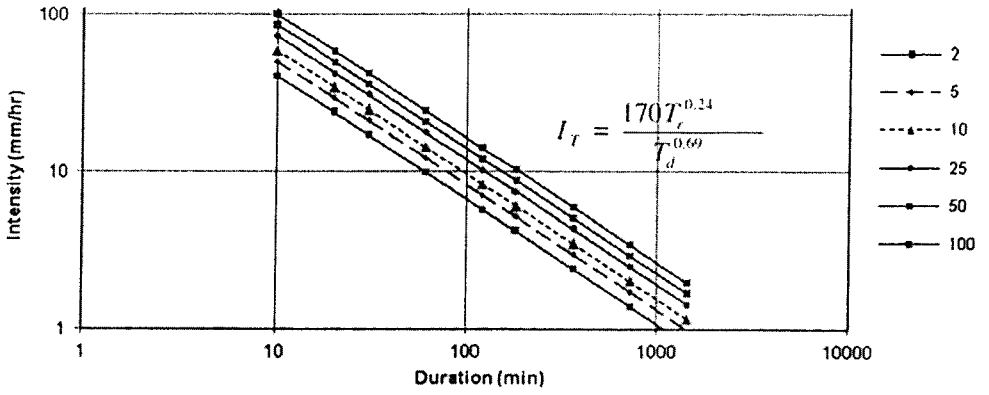
(8) (ii) Consider a large urban watershed with four large subwatersheds interconnected by ditches towards a stormwater outfall to the nearby stream. Briefly explain how the runoff hydrograph can be generated to predict the flow at the outfall. Use any equations and figures necessary to clearly provide an engineering explanation.

(5) (iii) Briefly describe three important differences between a conceptual model and an empirical model of stormwater runoff prediction.

Problem 4

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

(8) (i) Explain four main differences between the intensity-duration frequency (IDF) curve method and the Rational Method for predicting peak flows from rainfall events. A sample set of IDF curves are provided below.



(4) (ii) Provide an example to show the determination of the recurrence interval of a flood event in a river valley. Consider the data and statistical methods most appropriate and necessary in predicting flood events.

(4) (iii) Explain the justification for using probability distributions in characterizing and describing hydrologic events. Give an example that shows why such probability methods are appropriate.

(4) (iv) Can two "100-year floods" occur within several years or even within the same year? What is commonly meant when people speak of a "100-year flood"? What is the percent change of recurrence of a "100-year flood" in the next 25-years?

Problem 5

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

(8) (i) Briefly explain three (3) important differences in *lumped* and *distributed* routing methods applied to a reservoir or lake. Briefly explain the relative accuracy from each type of routing methods and how they can be improved.

(ii) Briefly discuss the importance of the following steps in predicting flood events using hydrologic modelling of a large watershed:

(4) (a) The adequate delineation of the watershed boundaries.

(4) (b) Obtaining appropriate and sufficient hydrologic and geographical data.

(4) (c) Spatial and temporal scaling of model parameters for the appropriate model selection.

Problem 6

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

(7) (i) Estimate the amount of evapotranspiration (ET) for the year (*mm*) from a watershed with a 10,000 km^2 surface area. Consider the drainage area receives 150 *mm* of rain over the year and the river draining the area has an annual flowrate of 300 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

(8) (ii) Select a model used to predict infiltration in soil and briefly explain three (3) important assumptions of the model that engineers need to consider when applying the model.

(5) (iii) The Energy balance in a region influences the water budget which is heavily affected by precipitation. Using basic energy and mass balance concepts, diagrams or equations, explain this phenomenon with respect to a watershed adjacent to an ocean.

Problem 7

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

(7) (i) Briefly itemize the key steps in a common process of channel or river routing and explain two advantages and two issues associated with the process that engineers need to take into account.

(8) (ii) Floodwater moves downstream along a channel. Provide a methodology to predict a flood event and give two methods commonly used to calibrate and verify the flood event predictions.

(5) (iii) A spillway overflow design is commonly designed using the following discharge equation (below). Briefly explain the significance of the terms Q, C, L and H with consistent dimensions.

$$Q = C \cdot L \cdot H^{\frac{3}{2}}$$

Marking Scheme

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

2. (i) (a) 7, (b) 7, (c) 6 marks, 20 marks total

3. (i) 7, (ii) 8, (iii) 5 marks, 20 marks total

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

5. (i) 8, (ii) (a) 4, (b) 4, (c) 4 marks, 20 marks total

6. (i) 7, (ii) 8, (iii) 5 marks, 20 marks total

7. (i) 7, (ii) 8, (iii) 5 marks, 20 marks total