NATIONAL EXAMS DECEMBER 2013

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*, *ground water flow* and *surface runoff*:

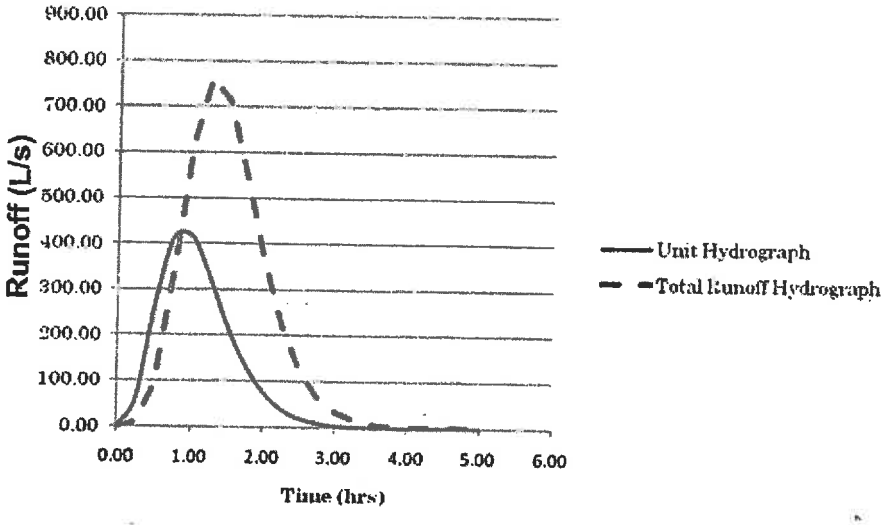
(10) (i) Explain, using a diagram, an example and any necessary equations, three (3) key relationships among precipitation, ground water and surface runoff considering the type of soil or landscape within a large rural watershed.

(10) (ii) Consider the hydrological engineering design principles associated with the construction of a dam to generate electricity. Briefly explain three (3) important hydrological issues that the hydrology engineers of the dam need to design for over a 100-year design life of the dam.

Problem 2

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

(10) (i) With reference to the figure below, explain three (3) significant engineering information that the Unit Hydrograph (UH) and the Total Runoff Hydrograph (TRH) provide to the design engineer of a hydrologic or hydraulic system to control the TRH.



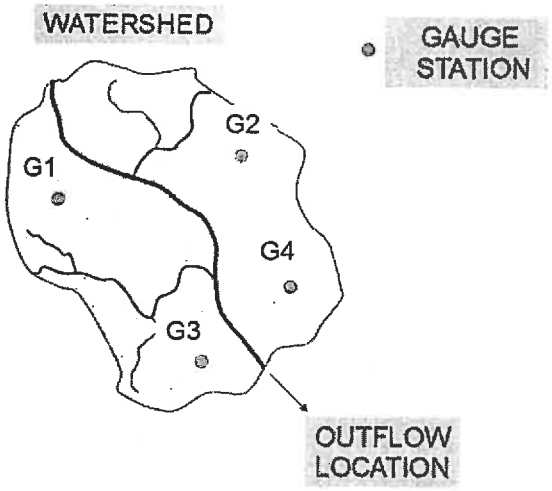
(10) (ii) Define and compare a (1) hydrologic conceptual model with an (2) analytical hydrologic model. First define or explain the essential elements of each type of model and then use a table or matrix layout to identify four (4) key areas for comparison.

Problem 3

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

(10) (i) With reference to the Watershed diagram below, explain how you would use the point and areal methods to estimate the precipitation values, indicating the reliability of your estimates. Your answer may include figures, tables and equations in addition to narrative.

(10) (ii) With reference to the Watershed diagram below, explain how you would determine an accurate stream flow measurement (at the Outflow location) over a 25-year period that could be used to best preserve and harness the water quality and quantity of the watershed.



Problem 4

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

(10) (i) Briefly explain a method useful for channel or river routing and provide a brief example of its use. As part of your answer, provide two (2) limitations of the method.

(10) (iii) As part of the design risk assessment, you are asked to consider a large dam collapse resulting in a flood wave propagating downstream directly towards a nearby town located on the river bank. Describe how you would predict the wave effect downstream along the river (i.e., resulting flow, velocity, wave height) and what measures you would recommend to the town to minimize potential damages.

Problem 5

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

(7) (i) Briefly explain how an intensity-duration frequency (IDF) curve is used in the design of engineered hydrologic systems; and explain how safety factors are used to address the underlying variability in the events used to generate IDF curves.

(8) (ii) Using probability analysis, explain three (3) key sets of information that are necessary for good predictions, of the impacts of intense precipitation or floods in an mixed rural and urban watershed about 100 km^2 in area.

(5) (iii) Briefly explain: (1) what "data outliers (DO)" are and (2) how you would treat low and high DO and why. Consider that the data sets with DO would be used to determine key parameters in your statistical and probability models.

Problem 6

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

(8) (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 40 mm of rain over the year and the river draining the area has an annual flowrate of 200 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

(5) (ii) Provide an example to show how the Energy budget equation (in conjunction with other information) may be used to predict drought conditions associated with minimal precipitation.

(7) (iii) Briefly explain how infiltration may be modelled to predict groundwater recharge of aquifers used as drinking water sources. In your explanation also provide any two (2) assumptions used to simplify the model and which engineers need to consider in ensuring a sustainable yield (i.e., maintain water taking levels so that wells do not go dry).

Problem 7

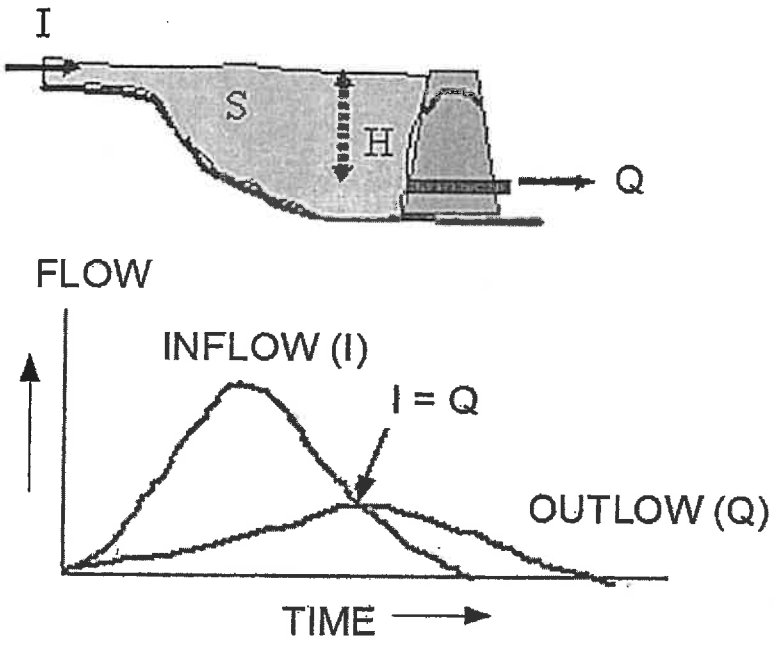
Provide answers to the following questions related to *basics of hydrologic modelling* and *reservoir* and *lake routing*.

(7) (i) A historically important model for estimating runoff rate is the Rational Method. The method formula is provided below. Briefly explain the meaning of the model terms Q, k, C and i; and give three (3) important assumptions when you apply the model.

$$Q = k \cdot C \cdot i \cdot A$$

(7) (ii) Give four (4) important steps in the procedure for hydrologic reservoir routing. Consider providing a specific example with equations, diagrams and/or explanations of each step with reference to the figure provided below.

(6) (iii) Explain the fundamentals of the Muskingum Crest Segment Routing method or similar method that can be used for lake routing.



Marking Scheme

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

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

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

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

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

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

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