NATIONAL EXAMS DECEMBER 2009

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 *hydrologic cycle processes*, *ground water flow* and *surface runoff*.

(8) (i) Prepare a simple schematic diagram of the hydrologic cycle identifying the key sources of precipitation (P), evaporation (E), transpiration (T), surface runoff (R), infiltration (I) and groundwater flow (G).

(6) (ii) The ability of an aquifer to store and transmit water is determined by its porosity and permeability. Briefly explain how ground water flow is affected by porosity and permeability.

(6) (iii) Briefly define and explain when surface runoff occurs following or during a precipitation event. Also explain how surface runoff can lead to non-point source pollution.

Problem 2

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

(6) (i) Briefly explain what a *runoff hydrograph* is and how it is influenced, in a quantitative way, by two (2) catchment properties.

(6) (ii) Provide a labeled schematic of a *unit hydrograph*, briefly explain its derivation and use in an engineering application.

(8) (iii) Explain the difference between a *conceptual model* and a *physically-based model* as applied to hydrology. As part of your answer, provide an example where a conceptual model is preferred over a physically-based model.

Problem 3

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

(6) (i) Briefly describe the *Arithmetic Mean* and *Thiessen's Polygon* methods used to calculate areal precipitation. In your answer, provide an advantage and a disadvantage of each method.

(6) (ii) Briefly explain how the *Stream Stage* and *Streamflow* relationships are affected by a changing slope of the stream and roughness of the channel. In your answer, explain how the engineer needs to take these factors into account when designing a structure lasting 20 to 50-years.

(iii) Compare and contrast the following terms:

(4) (a) Section control and Channel control

(4) (b) Stage and Slope of a river channel

Problem 4

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

(6) (i) Briefly explain the process of channel or river routing using the Muskingum Method, provide an example of its use and give an advantage of this method.

(6) (ii) Explain the reasons for changes in the river stage as a flood wave passes through from a dam breach upstream over a 2 hour period. Assume that the full flood wave passes through in 2-hours and provide a sketch showing the river stage versus time at a point on the river.

(8) (iii) Given the continuity equation below, explain the meaning of the 7-terms and how it would be applied for a hydrograph being routed through a reservoir.

$$\left(\frac{I_1+I_2}{2}\right)\Delta t+\left(\frac{Q_1+Q_2}{2}\right)\Delta t=S_1-S_2$$

Problem 5

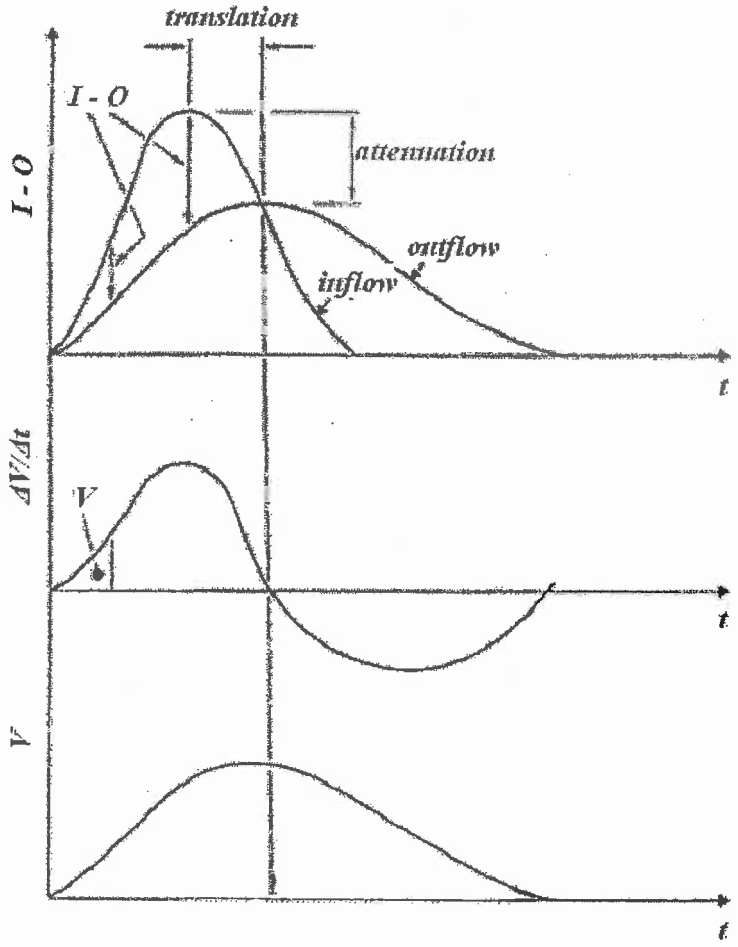
Provide answers to the following questions related to *basics of hydrologic modeling* and *reservoir and lake routing*.

(i) Define and explain the importance of the following terms in engineering applications:

(5) (a) Hydrologic synthesis techniques; and

(5) (b) Subwatershed simulated characterization

(10) (ii) Using the figure below, explain the general principles of routing a flood through a reservoir or lake.



Problem 6

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

(8) (i) Provide a schematic of typical intensity-duration frequency (IDF) curves, describe their derivation and give an example showing how they are used in predicting the peak flows using the Rational or Modified Rational Formula.

(6) (ii) Explain the use of *extreme-value frequency factors* in determining a flood magnitude and recurrence period. Provide an example of their use.

(6) (iii) Explain the justification for using frequency and probability distributions in characterizing and describing hydrologic variables. Identify two (2) hydrologic variables and their commonly applied distributions.

Problem 7

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

(10) (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 100 *mm* of rain over the year and the river draining the area has an annual flowrate of 100 m^3/s. Justify any assumptions you make and use the basic equation of hydrology (below).

$$P - R - G - ET = \Delta S$$

Where

P = Precipitation
R = Surface runoff
G = Groundwater flow
ET = Evapotranspiration
ΔS = Change in Storage

(10) (ii) Explain how Horton's Infiltration Model (given below) can be used to describe the concepts of infiltration rate and infiltration capacity. Explain a limitation, what terms need to be derived and when Horton's Infiltration model generally applies.

$$f(t) = f_c + (f_o - f_c)e^{-kt}$$

Marking Scheme

1. (i) 8 (b) 6 (c) 6 marks, 20 marks total

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

3. (i) 6 (ii) 6 (iii) (a) 4 (b) 4 marks, 20 marks total

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

5. (i) (a) 5 (b) 5 (ii) 10 marks, 20 marks total

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

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