National Exams May 2010

04-Agric-B7 Principles of 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 an OPEN BOOK EXAM.

   Any non-communicating calculator is permitted.

3. FIVE (5) questions constitute a complete exam paper.
   The first five questions as they appear in the answer book will be marked.

4. Each question is of equal value.

5. Most questions require an answer involving calculations. Clarity and organization of the answer are important.

1. A watershed in a rural area of some 15 km^2 is made up primarily of agricultural land used for pasturing animals. In midsummer after a 2-week period of no rain it experiences a rainstorm with a constant intensity of approximately 5 mm/hr for 3 hours. The area is drained by a small stream which runs through the middle of the watershed to its outlet. Previous work has suggested the area has a time of concentration of approximately 2.5 hours.
    a. On the graph provided, sketch the rainfall amounts and the runoff hydrograph you would expect to see from this area. Identify on the graphs the areas of maximum infiltration rates, interception amounts and time of peak flows. No calculations are necessary.
    b. Determine quantitatively the peak flow you would expect in the stream as a result of the runoff from this storm.

2. Figure 1 shows the rainfall Intensity-duration curve for a 10-year return period event for an urban area.
    a. Sketch on the graph, showing the relative location to the existing curve, rainfall-intensity curves with 5 and 20-year return periods. Include this graph with your answer booklet.
    b. What is the total depth of precipitation you would use for the design that required the 10-year return period for this area that has a time of concentration equal to 2 hours?
    c. How would you extend this curve for a storm of 300 minutes duration?

3. A double ring infiltrometer has been used to determine the infiltration characteristics of a soil. The inner ring has a diameter of 0.5 m and water is added continuously to the inner ring to keep a depth of no less than 5 mm in it. In the first 5 minutes 0.63 L of water was added, from 45 to 60 minutes 1.03 L was added and from 120 to 135 minutes 0.50 L was added. After 7 hours the amount added every 15 minutes is approximately constant at 0.25 L.
    a. Sketch the infiltration curve (infiltration rate vs time) for this soil on Figure 2.
    b. For any infiltration equation of your choice:
        i. Write out the equation, identifying all variables and parameters with units, and
        ii. Determine the parameters based on the infiltration information given for this soil.

4. Define the following terms with respect to hydrology:
    a. Interception
    b. Probable maximum precipitation
    c. 100-yr flood flow
    d. Watershed
    e. Unit Hydrograph
    f. Flow duration curve
    g. Flood routing
    h. Water Budget

5. Figure 3 shows the discharges measured in a small river that drains a watershed with an area of 2.5 km^2. This hydrograph was recorded during and after a rainfall event of unknown duration and unknown intensity but with a total depth of 3.0 cm.
    a. Determine, using a baseflow separation technique of your choice, the runoff hydrograph.
    b. What is the total runoff volume in m^3?
    c. What is the total runoff depth for this storm in cm?
    What is your best estimate of the time at which precipitation starts?

6. A farm is to be serviced with irrigation requirements from a 30 cm diameter, fully screened, well installed in a local surficial aquifer. At present the water table is approximately 1.0 m below the ground surface and nearly horizontal. The aquifer consists of a sand and gravel material that is 15 m thick and sits on top of an impermeable till layer. Upon pumping the well at a constant rate for some time, the water level in the well reaches a constant level 5 m below the original water level while at the same time water in a monitoring well some 100 m away reaches a constant level some 0.1 m below its original static level.
    a. What is your estimate of the well pumping rate?
    b. What assumptions were required to answer part a?
    c. If the water being pumped is being returned to the land above the aquifer for irrigation purposes, how would you change your approach to part a?

7. Inflow and outflow hydrographs for a reservoir are given in the table below.
   a. Determine the average storage for each one day period assuming the reservoir is initially empty.
   b. What is the maximum storage reached in the reservoir and when is it reached?
   c. How could you determine the time of maximum storage without completing the calculations of part a?

time (days)	Inflow (m^3/s)	Outflow (m^3/s)
0	0	0
1	30	20
2	120	50
3	220	90
4	180	110
5	125	125
6	80	115
7	50	105
8	20	85
9	0	65
10	0	40
11	0	20
12	0	0

Figure 1: Graph for Question 2.

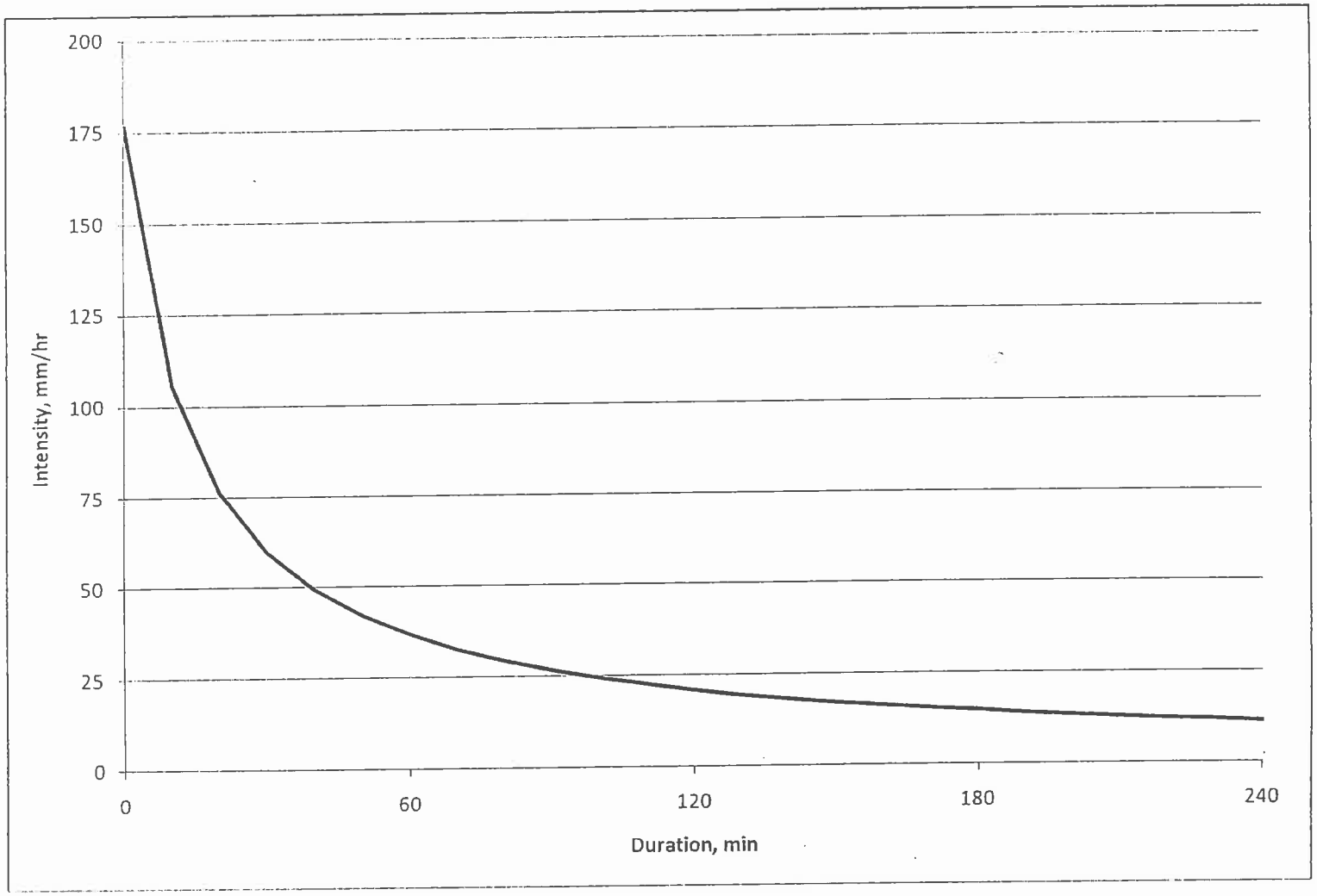

Figure 2: Figure for question 3

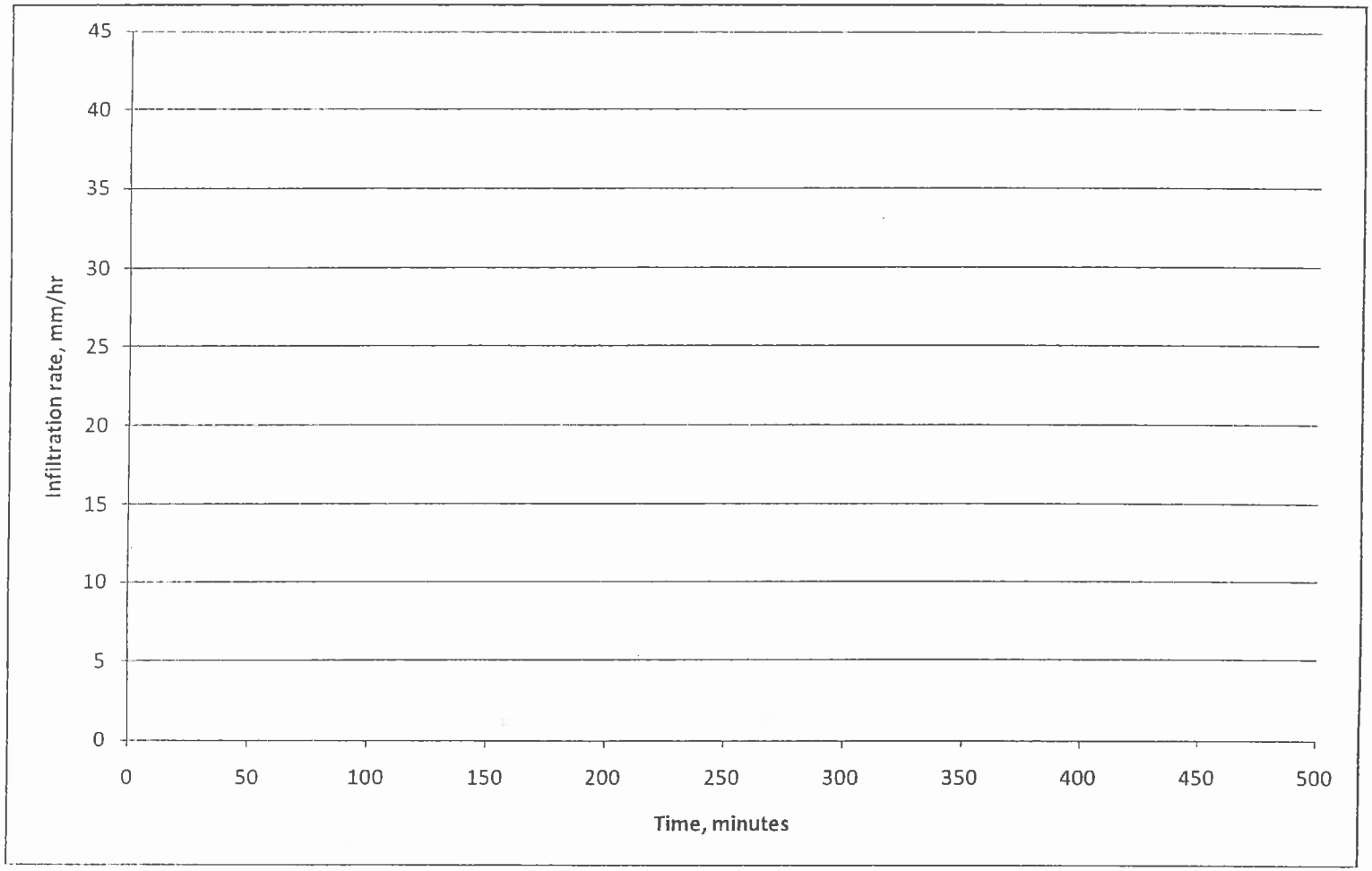

Figure 3: Question 5