Examination Land Surface Hydrology
Tuesday November 6, 2007
Duration: 13.00 to 16.00

The use of pocket calculators is allowed. The last page of this examination is the sheet with formulas.

At the end of the examination hand in your answer sheet, the mm-paper and this examination. Write your student number on all the sheets you eventually hand in.

This examination consists of large number of questions. Do not loose too much time on a specific question but continue with the next. If you skip a question or answer it later on, please indicate this.

Motivate your answers but be as concise as possible. You are allowed to answer in English or in Dutch.

If you think you need to know an answer to a previous question to answer the next, assume a value yourself and state this clearly in your answer and continue.

Good luck!

Rens van Beek

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Question 1: Background (15 points in total, equally divided)

a) Explain the meaning of the variables in the following equation. What are the units of v, L en ν?

$$\mathrm{Re} = \frac{v \cdot L}{\nu}$$

b) What is the difference between total energy head and specific energy head?

c) Given here is the momentum equation for 1-D flow without lateral inflow, the so-called St.Venant equation:

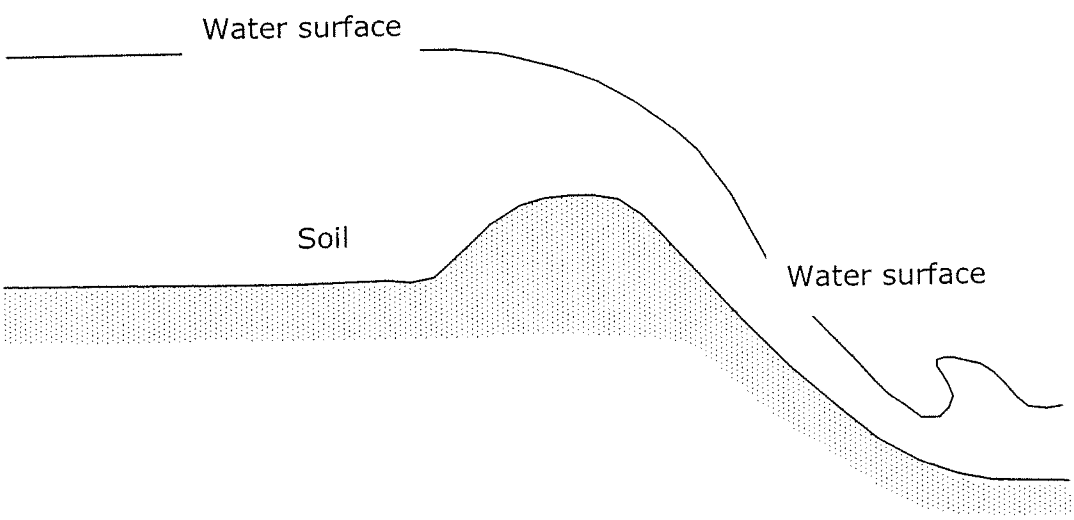
$$S_f = S - \frac{\partial y}{\partial x} - \frac{v}{g}\frac{\partial v}{\partial x} - \frac{1}{g}\frac{\partial v}{\partial t}$$

Provide a physical interpretation of the following four terms of the equation: S_f, S, dy/dx and [(v/g)(dv/dx) – (1/g)(dv/dt)].

d) Give three methods to obtain rainfall excess besides infiltration curves and CN.

Question 2: Derivation of discharge formula for weirs (20 points, 2a= 15, 2b= 5)

a) Here you see a natural weir consisting of a submerged but raised threshold above the downstream bed; derive the general discharge formula using the Equation of Bernoulli. Copy the figure and clearly indicate the symbols used and list the assumptions made.



b) What is the modular limit of a discharge measuring structure?

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Question 3: Literature (Total 20 points, 3a= 4, 3b= 8, 3c= 8)

Please be short and to the point in your answers.

a) What is a Geomorphological Instantaneous Unit Hydrograph? What is the basic concept of it? How could hydrochemical information be of use to define the GIUH model.

b) Uhlenbrook and Hoeg (2003) name five sources of uncertainty that have to be considered in the quantification of runoff components using isotopic tracers. What are these five sources and what is their relative order of importance in the light of the dominant hydrological processes?

c) Drawing from the articles of Jones et al. (2006) and Uhlenbrook and Hoeg (2003) devise a sampling strategy to separate base flow and direct runoff in a catchment *that is not instrumented yet.* Motivate your choices for instrumentation in terms of needs and resources available by prioritizing them.

Question 4: Linear reservoir (Total 25 points, 4a= 10, 4b= 5, 4c= 10)

Given are the measured discharge and effective precipitation for a 3.2 km^2 large catchment.

Time [day]	**P(eff)** [mm]	**Discharge** [l/s]
1		68
2	35	64
3		147
4		280
5		229
6		191
7		156
8		131
9		116
10		105
11		98
12		89
13		86
14		80
15		75
16		71
17		65
18		61
19		58
20		54

a) Determine the Unit Hydrograph in terms of *excess precipitation* for the35 mm effective precipitation on day 2.

b) What is the increase in storage (in m^3) on day 9 relative to day 2 assuming that the linear reservoir model applies for the groundwater reservoir?

c) Given that on days 21 and 22 respectively 10 and 25 mm precipitation fall over the catchment and assuming an equal conversion of effective precipitation into excess precipitation, calculate the total discharge for the next 10 days (day 21-30).

Question 5: (Total 20 points, 5a= 2, 5b= 3, 5c= 5, 5d= 7, 5e= 3)

Given are 15 years of maximum daily discharge for the Rhine at Lobith.

Year	Discharge
1992	4917
1993	10940
1994	8100
1995	11885
1996	4353
1997	6926
1998	9413
1999	7920
2000	6224
2001	8664
2002	7958
2003	9372
2004	6632
2005	5464
2006	5675

a) What are the units of the daily discharge?

b) What kind of flood frequency analysis is being used here?

c) Describe how you can derive the empirical frequency distribution and how one could use this distribution to calculate the exceedence probability for a given design discharge. Mention the shortcomings that could affect your results.

d) Calculate the exceedance probability $P(X \geq x)$ for the Weibull distribution $(m/(n+1))$. Plot the discharge against the probability $F(x)= 1-P(x)$ where the latter are transformed logarithmically ($\log^{10}(F(x))$ or *reduced variate*).Does this graph fit your expectations (please explain)?

e) Say a discharge of 9500 is a critical limit for some management purpose, what is then the expected recurrence period?

Equations LSH examination:

Reynolds number $$Re = \frac{v \cdot L}{\nu}$$

Froude number $$Fr = \frac{v}{\sqrt{gD}}$$

Bernoulli's equation: $$\frac{\overline{v^2}}{2g} + \frac{P}{\rho g} + z = \text{constant}$$

Manning: $$Q = A \cdot V_{avg} = \frac{A \cdot R^{2/3} \cdot S^{0.5}}{n}$$

Chezy: $$Q = A \cdot V_{avg} = A \cdot C \cdot (R \cdot S)^{0.5}$$

Muskingum

$$O_2 = c_0 I_2 + c_1 I_1 + c_2 O_1$$

$$c_0 = (-KX + 0.5*\Delta T) / (K - KX + 0.5*\Delta T)$$

$$c1 = (KX + 0.5*\Delta T) / (K - KX + 0.5*\Delta T)$$

$$c2 = (K - KX - 0.5*\Delta T) / (K - KX + 0.5*\Delta T)$$

\+ Cunge

$$c = m*v$$

$$K = \Delta x / c$$

$$X = 0.5 * [1 - q_o / (S_0 * c * \Delta x)]$$

St. Venant $$S_f = S - \frac{\partial y}{\partial x} - \frac{v}{g}\frac{\partial v}{\partial x} - \frac{1}{g}\frac{\partial v}{\partial t}$$

Linear reservoir $$Q_t = Q_{t-1} \cdot e^{-dt/k} + I_t \cdot \left(1 - e^{-dt/k}\right)$$

$$Q_t = \frac{k - \frac{1}{2}\Delta t}{k + \frac{1}{2}\Delta t} Q_{t-1} + \frac{\Delta t}{k + \frac{1}{2}\Delta t} I_t$$