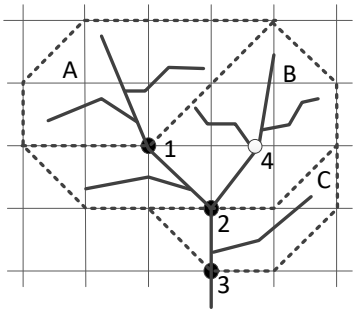
INSTITUTO SUPERIOR TÉCNICO
Master on Environmental Engineering
Joint Master Programme on GroundWater and Global Change, Impacts and Adaptation
Hydrology, Environment and Water Resources
Scholl year 2016/17 – Exam 2 – Duration: 2 horas

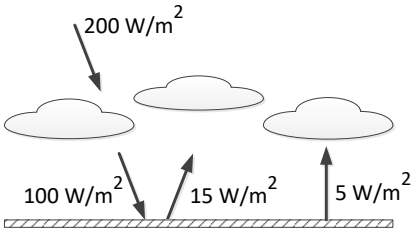
Each question is graded *2/20*

1. Consider a catchment with 1550 km^2 depicted in the image on the right and the mean annual flow values recorded in three sections given in the table. There is also a water uptake in section 4, where 150 l/s are continously withdrawn. Calculate the runoff of subcatchments A, B and C, as well as the runoff of the entire catchment (all in mm).

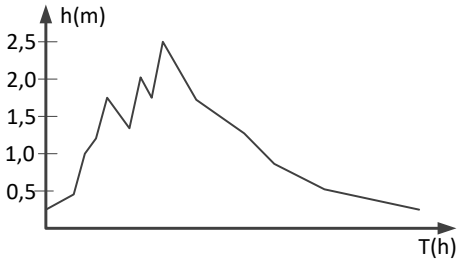
Cross-section	Avg flow (m3/s)
1	4,36
2	13,64
3	16,41



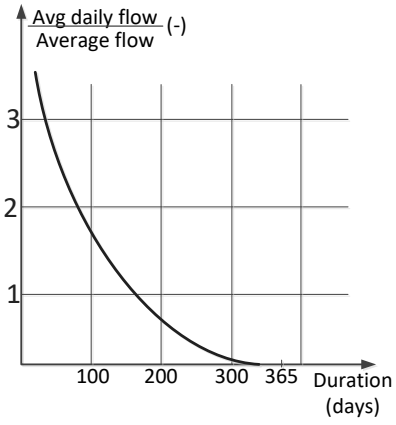
2. The figure shows the energy balance of the atmosphere in a given day. Calculate the radiation available for evaporation and the amount of water that can potentially evaporate on that day, assuming that the capacity to receive water by the atmosphere does not affect this volume. Recall that the latent heat of vaporization is 2.5 MJ/kg.



3. The figure shows the hydrometric level record observed in a hydrometric station following a rainy event. The rating curve of this station is $= 40 \cdot (h - 0{,}2)^{0{,}3}$, with Q in m^3/s and h in m. Knowing that the annual maxima of flow values registered in the station follow a Gumbel distribution with a mean of 20 m^3/s and coefficient of variation of 0.45, calculate the return period of the flood peak shown in the figure.



4. The figure shows the average duration curve of the mean daily flow generated in river basin with an area of 1200 km^2. Knowing that the median flow generated in this basin is 7 m^3/s, calculate the annual flow volume, in hm^3, and the average annual runoff, in mm.



5. Consider a river basin where the soil has a water retention capacity of 100 mm. On a given day the initial moisture content of the soil is 80 mm, the precipitation is 40 mm and the potential evapotranspiration is 15 mm. What are the values of real evapotranspiration and excess precipitation (that generates surface runoff and groundwater flow) on that day?

6. Consider the soil with the characteristics presented in the table, where a crop is cultivated. At a given season, the crop daily potential evapotranspiration equals 5 mm. What is the maximum possible time interval between crop watering? What should be the amount of water to be provide to the crop per day if the farmer wants to control soil salinity by ensuring that 1 mm/day percolates from the root zone downwards. Sketch the time evolution of the water content in the root zone for the two situations, clearly indicating some values of the soil moisture content.

Parameter	Value
Soil depth, h (m)	0,50
Porosity, n (m/m)	0,55
Saturated soil water content, θs (m/m)	0,50
Field capacity, θcc (m/m)	0,30
Wilting point, θe (m/m)	0,15
Hydraulic conductivity when saturated, Ks (mm/h)	5,0

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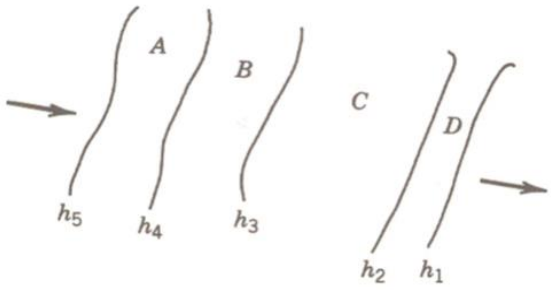
7. Consider the same soil described in the previous question. A precipitation event with a uniform rate equal to 20 mm/h gives rise to surface runoff, which is zero at the beginning of the precipitation and reaches 5 mm/h 10 minutes after precipitation starts. Assuming the Horton model, calculate the parameter of this model.

8. Consider the situation of groundwater flow (a isopiezometric contour map) shown schematically in the next figure If the hydraulic conductivity (K) of area A is 10^{-5} m/s, determine the hydraulic conductivity of the other areas. Assume that the medium has isotropic and heterogeneous characteristics, that the input and output streams of that sector are identical and that Darcy law is valid, calculate the specific discharge (flow per unit area).



9. Consider a basin with the 1 hour unit hydrograph shown in the table. The catchment area lies in an area with the following rainfall depth-frequency curve for a 100 year return period: $P = 10 \cdot D^{0,35}$, with P in mm and D in minutes. Calculate the flood hydrograph resulting from a balanced design hyetograh (with distinct blocks of precipitation) for a 100-year return period, assuming an infiltration rate of 30%.

Time (h)	0	1.0	2.0	3.0	4.0	5.0
Discharge (m3/s)	0	1,5	3,0	2,0	1,0	0

10. Considering the same river basin from the previous exercise, sketch on the same graph the flood hydrographs resulting from rainfall events with constant intensity and with a duraton of 3 hours, 4 hours and 5 hours, clearly indicating the key values of these hydrographs. Justify your answer.

Useful formulas

11.

Standard normal:

p	0.01	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	0.95	0.99
z	-2.33	-1.64	-1.28	-0.84	-0.52	-0.25	0.00	0.25	0.52	0.84	1.28	1.64	2.33

Gumbel distribution probability factor: $K_G = -\frac{\sqrt{6}}{\pi}\{0{,}5772 + ln[-ln(F(x))]\}$

Horton model: $f = f_c + (f_0 - f_c)^{-k \cdot t}$ $F = f_c \cdot t + \frac{f_0 - f_c}{k} \cdot (1 - e^{-k \cdot t})$