“Ground water – climate” relationship revisited

watershed approach

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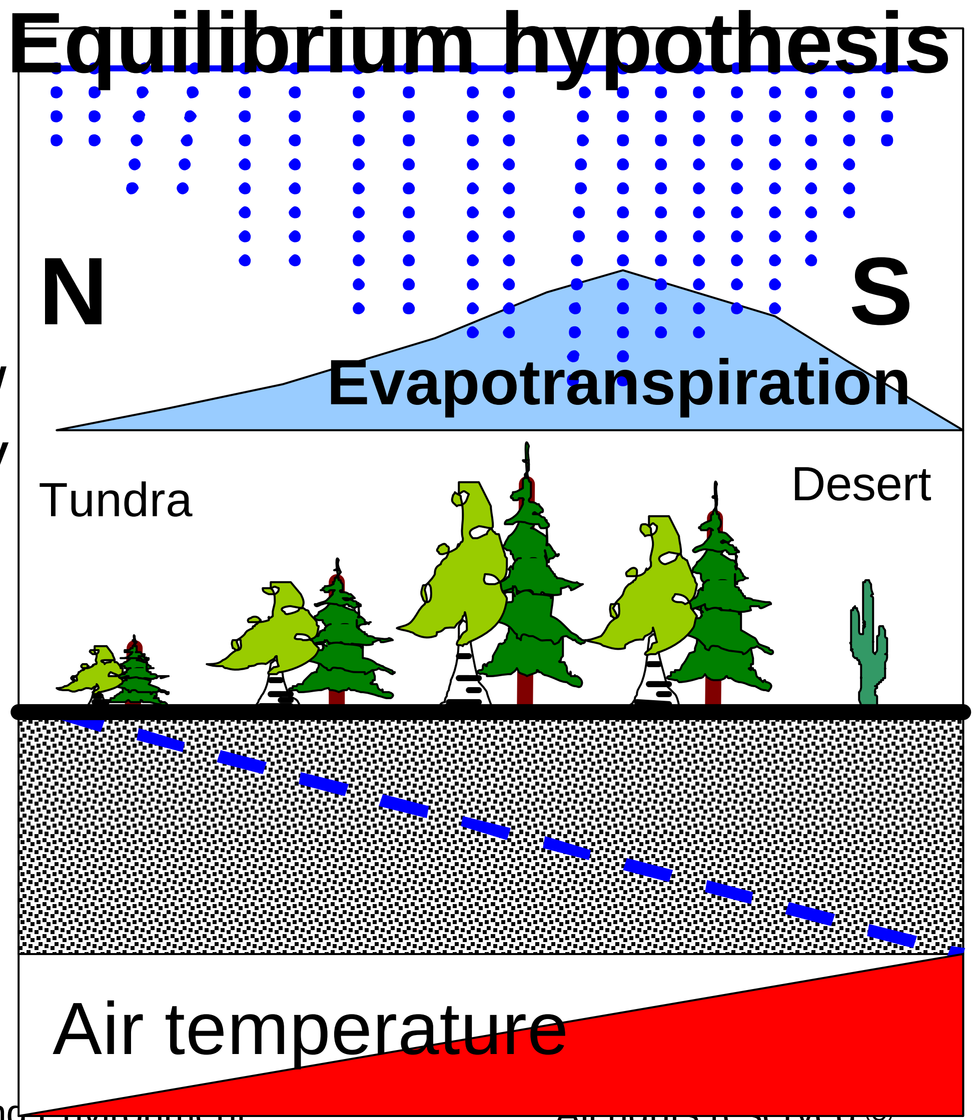
Objectives

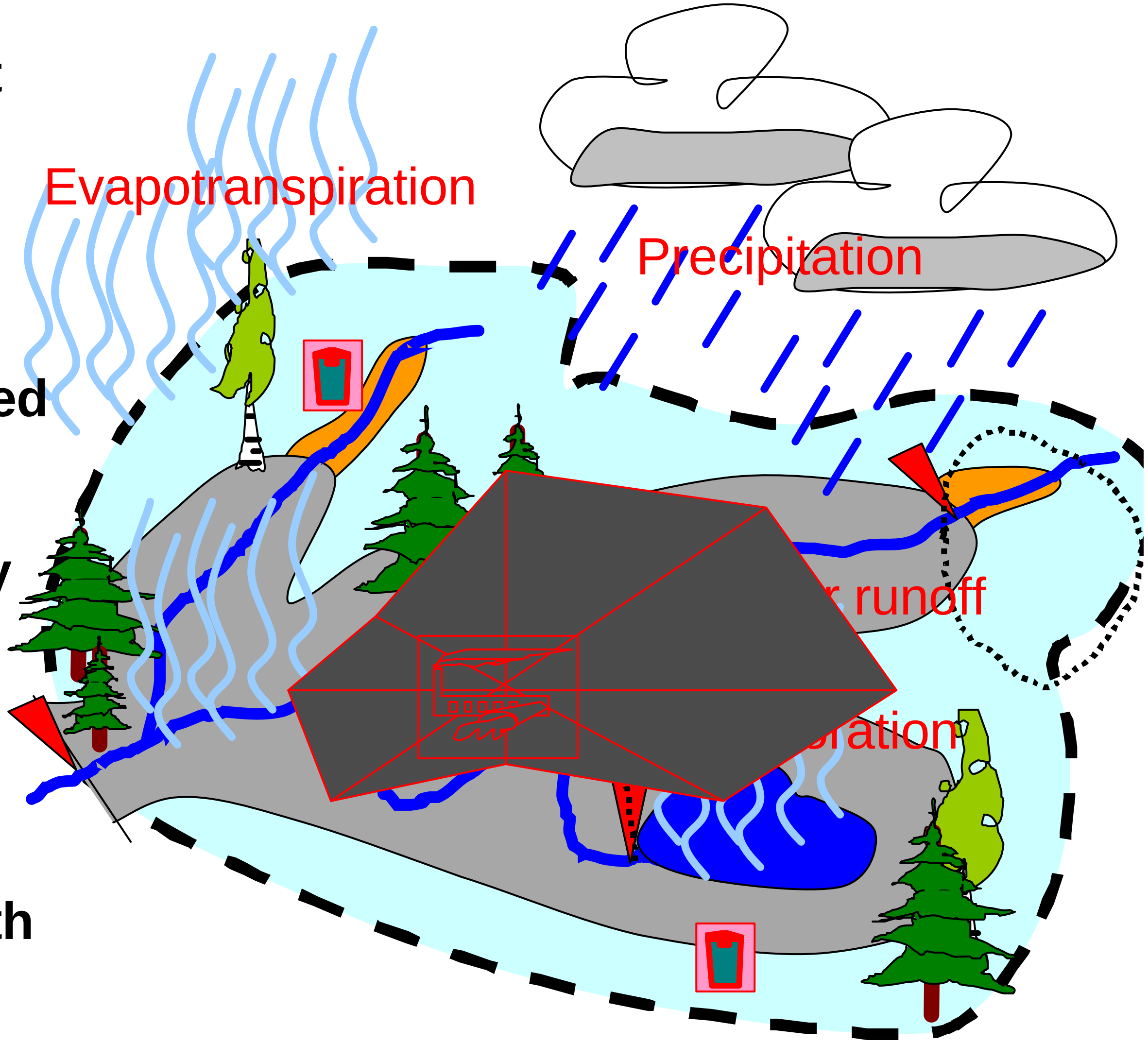
To find:

What role does the interflow component of river flow play in climate – groundwater relationship? Whether does it increase the water table altitude (elevation) or fluctuation (amplitude)?



Why watershed?

- **Watershed is the physio-graphical unit of water cycle, the positive output of which is river flow**
- **River flow is the only parameter that characterizes the whole watershed and is measured in one point – river mouth**
- **Water quality and quantity regime in the specified reach of a river is the identity of the corresponding watershed area health as our blood pressure and content are the indicators of our health**



EWBM

Functions of water:
1. Transport media: physical and bio-chemical (as a solvent)
2. Environment – habitat
3. Resource

Equilibrium Water Balance Model is the tool for:

- Water balance (water cycle) components estimation: E = **P** - S – **R** + dG + dM
- Groundwater – climate relationship assessment
- Reverse hydrological task: to disintegrate river runoff into quantitative components coming from different media

Approximations used in EWBM

1. Weight of each deposit was quantified according to its surface proportion in the watershed area
2. "Uniform area sink" is a river valley with linear H = f(I) relationship
3. Logarithmic H = f(I) relationship above Hlim
4. Watershed as a circle in terms of transmission of hydraulic pressure
5. The water table fluctuations define the fluctuations in vadose zone depths and its capacity (uniformed vadose zone)
6. The residual saturation S depends on the effective saturation

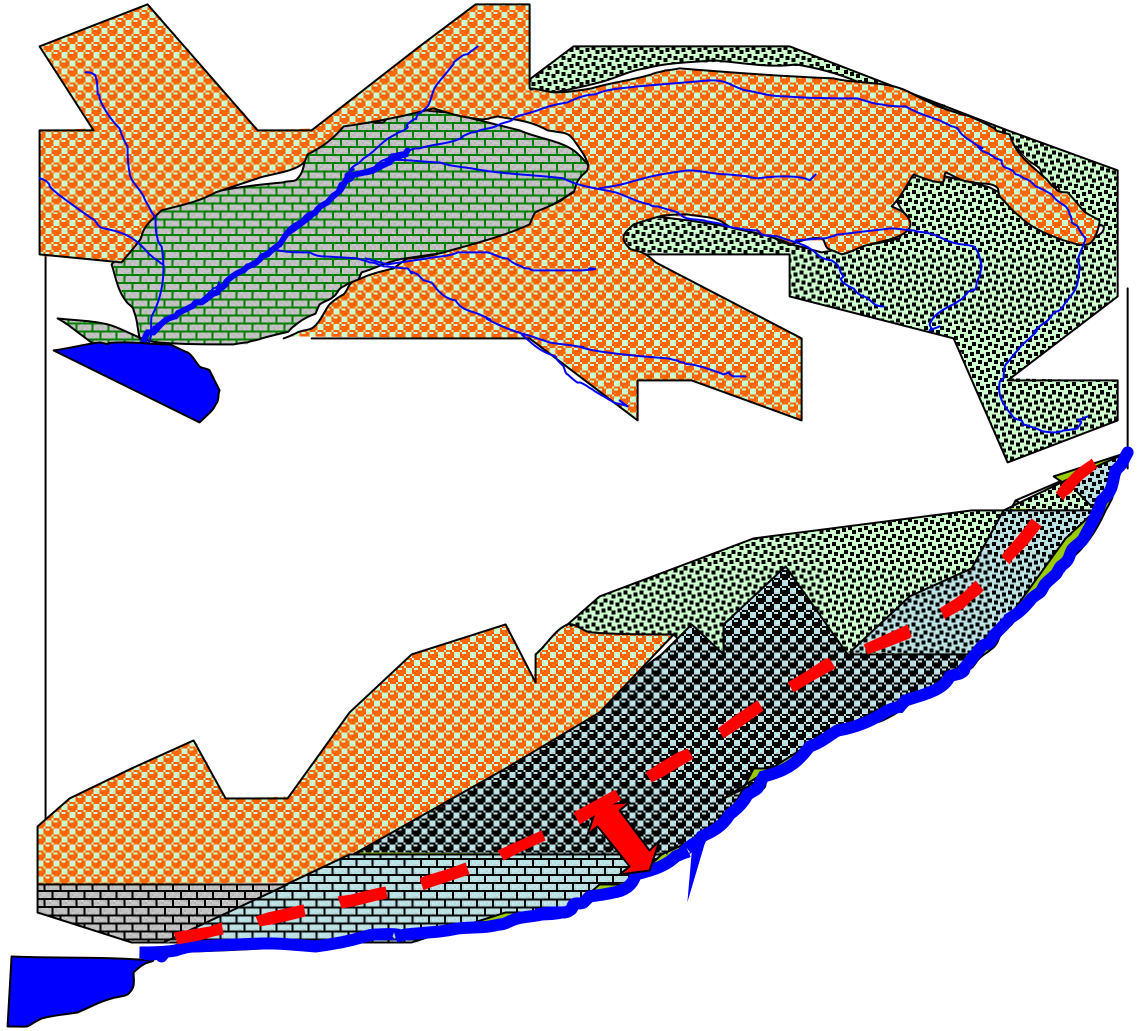
   $$S = 2.5Y/(1 + Y*20)$$

7. Uniformed vadose zone: no seasonal or monthly fluctuations in the vadose zone
8. dQs = 10dQb
9. No wind influence on snow density estimation
10. No anthropogenic impact is taken into account (urbanization, lawn watering, STP, WG, WS)
11. Available meteostation is representative

Approximation 1:

- **dG = dH*Y*1000**

- **In estimation of average storativity, effective porosity or specific yield (Y), weight of each deposit group on a watershed was defined according to its area on the watershed surface**



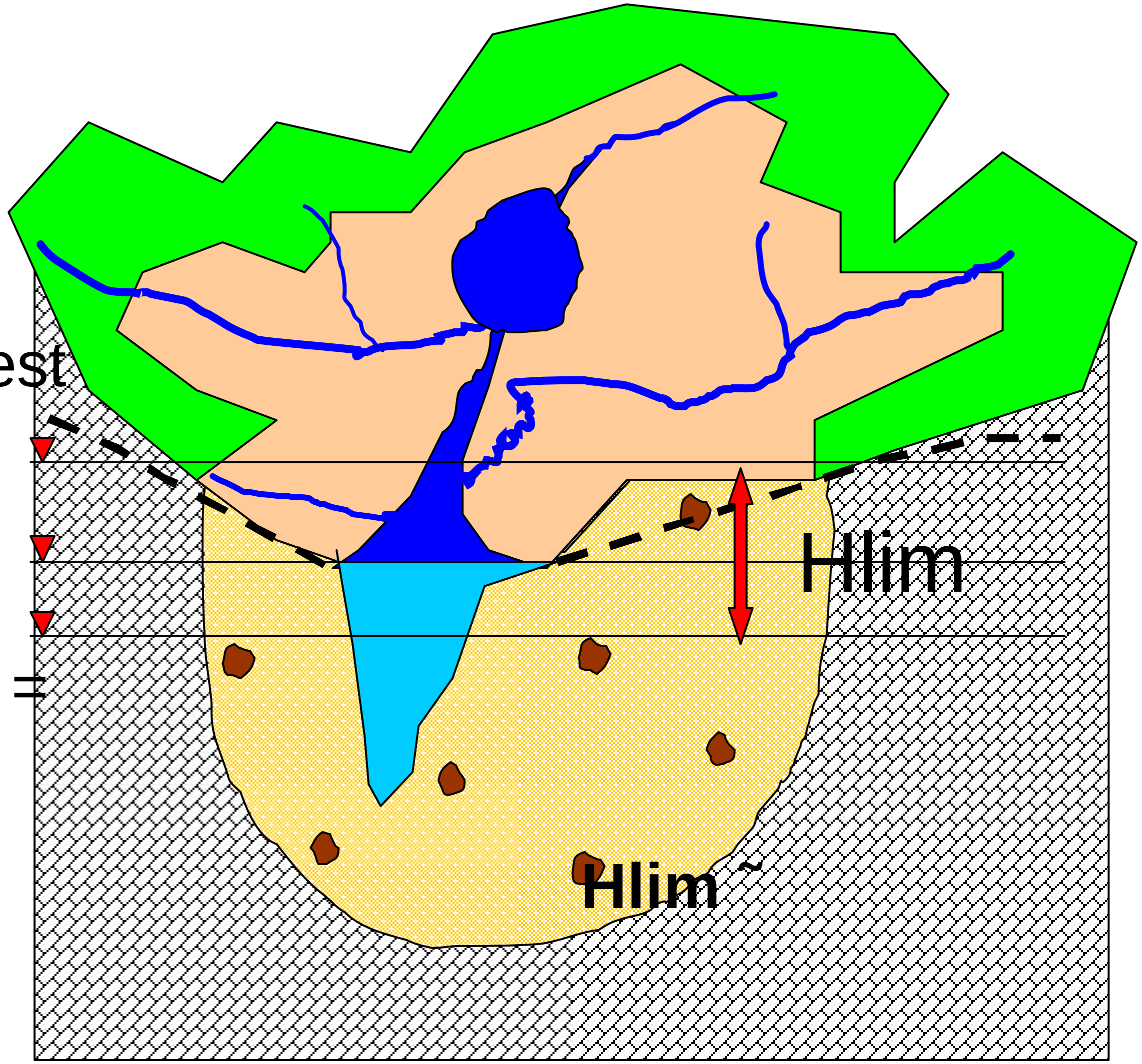
Approximations 2 and 3

2. Whole watershed is divided into two parts characterized by different hydraulic conductivity:

   a river valley (the lowest "Uniform area sink") with linear H = f(I) relationship, and

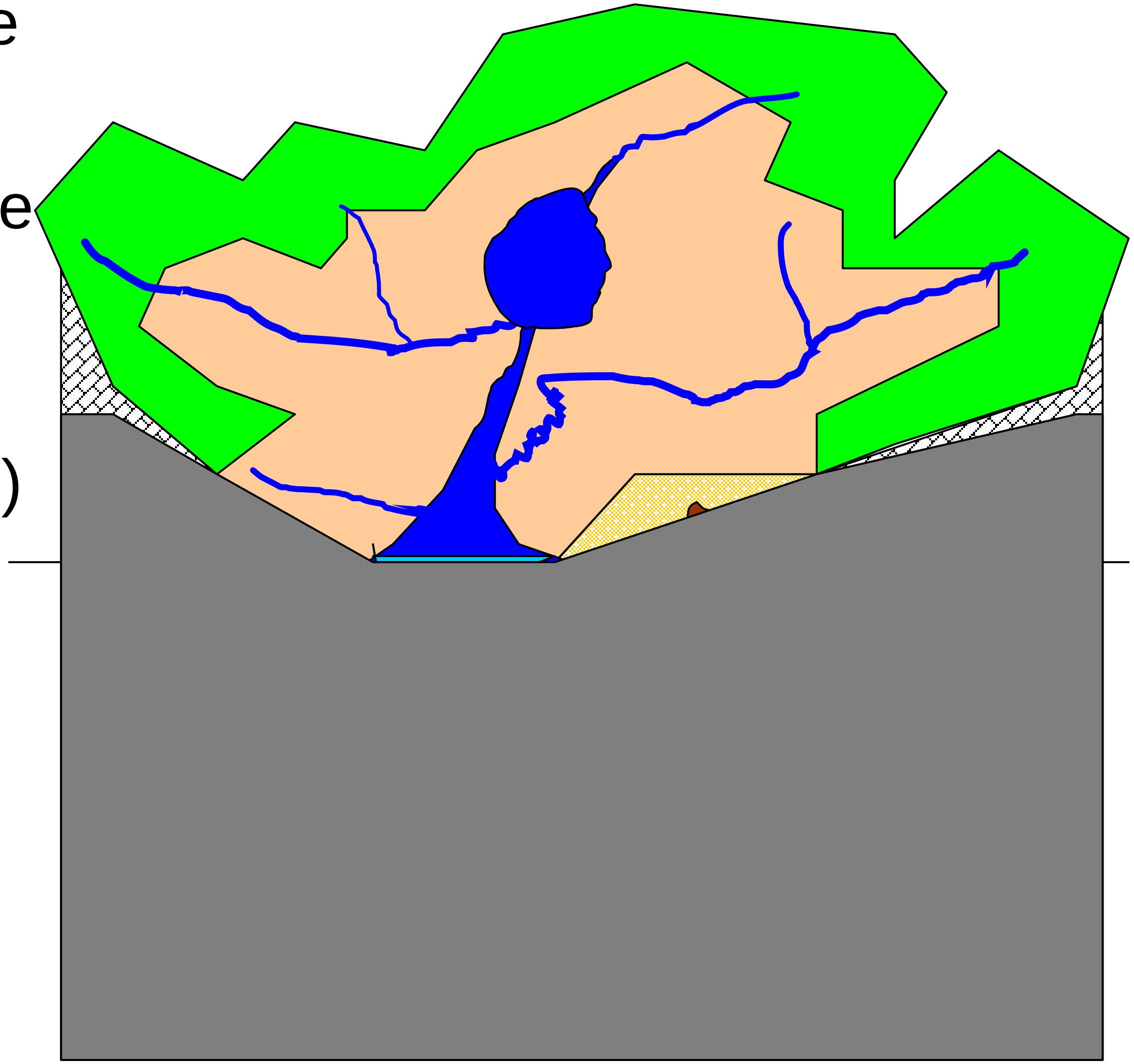
   the rest of watershed with the logarithmic H = f(I) relationship above Hlim

3. The division



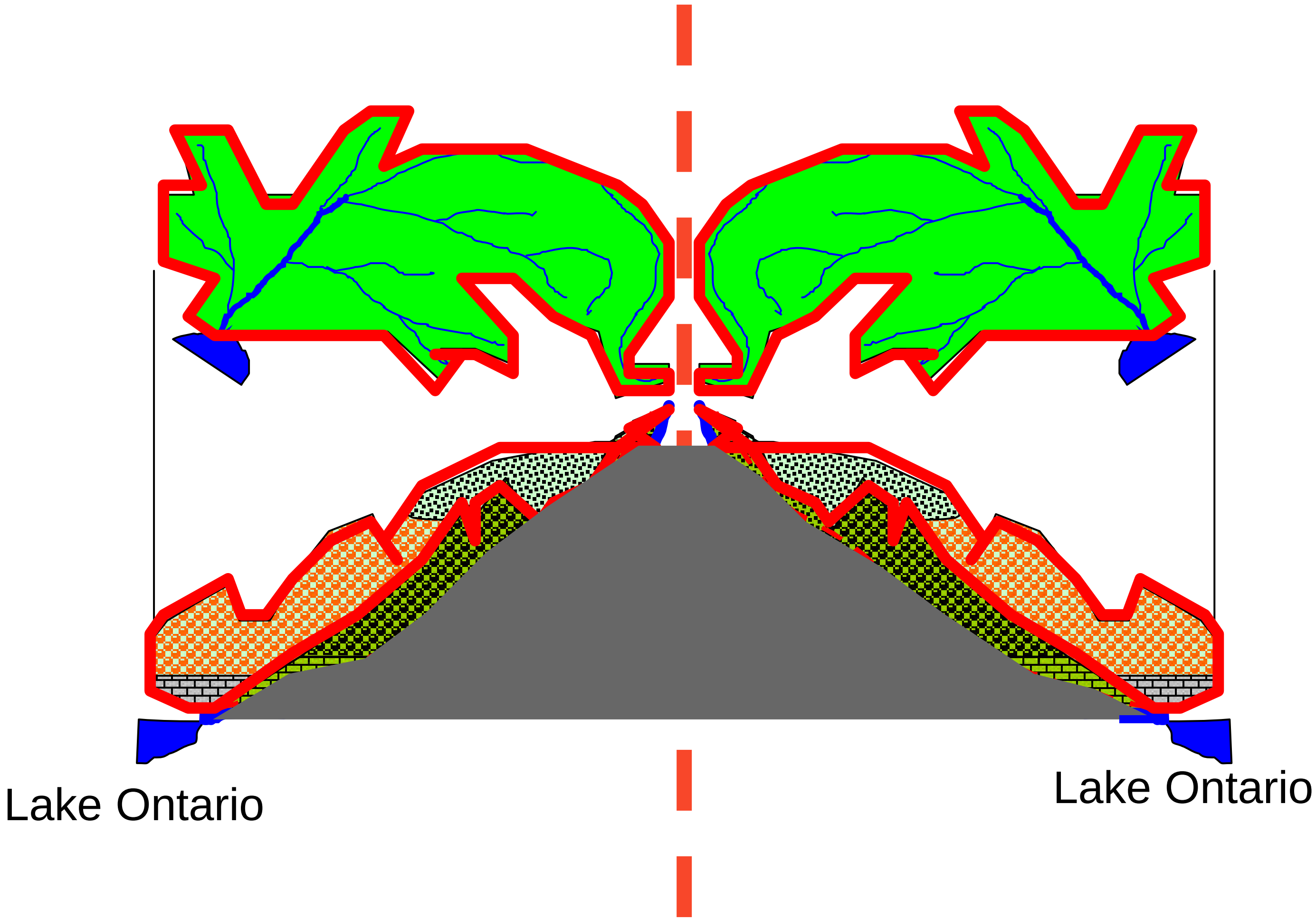
Approximation 4

For estimation of average water table head above the river level the distance between the reach and the watershed boarder is considered as a radius (**r**) of a circle, which area is equal to the drainage area of the watershed



H = Hlim + LN (1 + I***r**/K)

Approximation 4



In terms of hydraulic pressure conductivity it is understandable

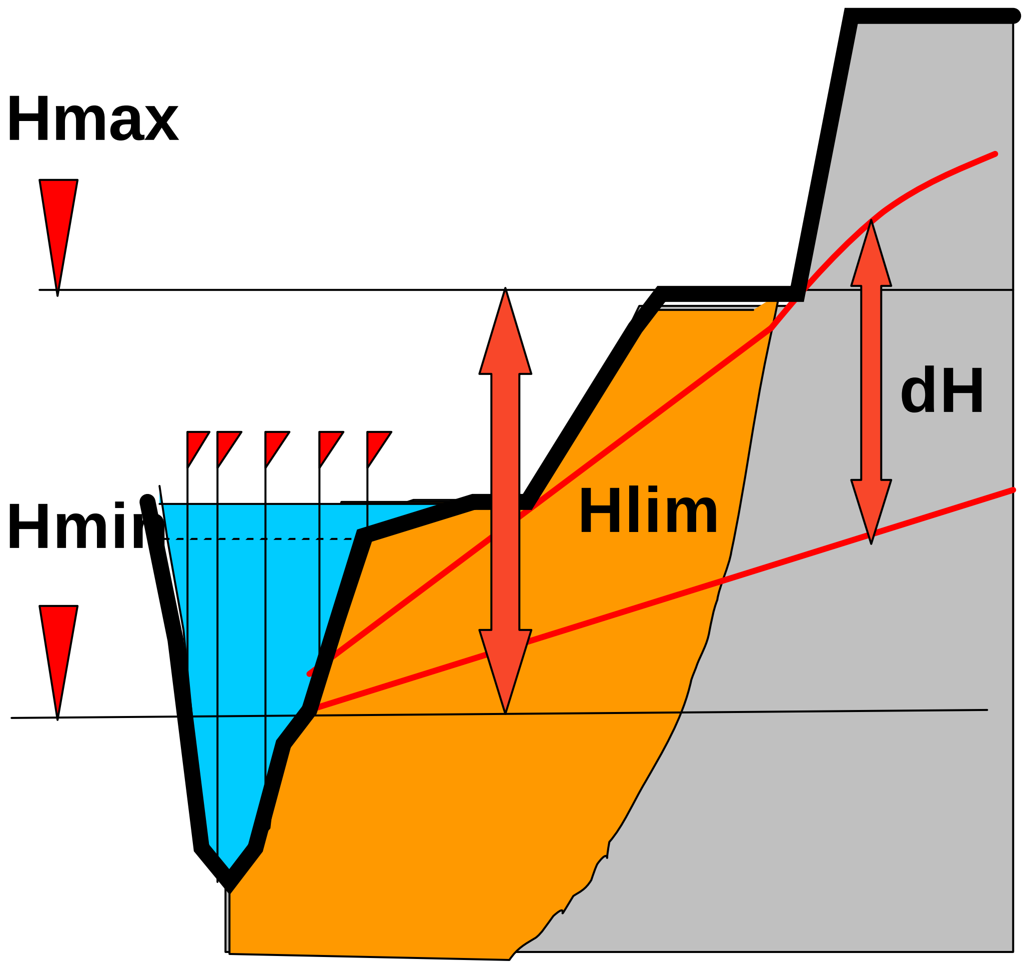
Approximations 5, 6 and 7

5. The water table fluctuations define the fluctuations in vadose zone depths and its capacity

6. The residual saturation S depends on the effective saturation

   $S = 2.5Y/(1 + Y*20)$

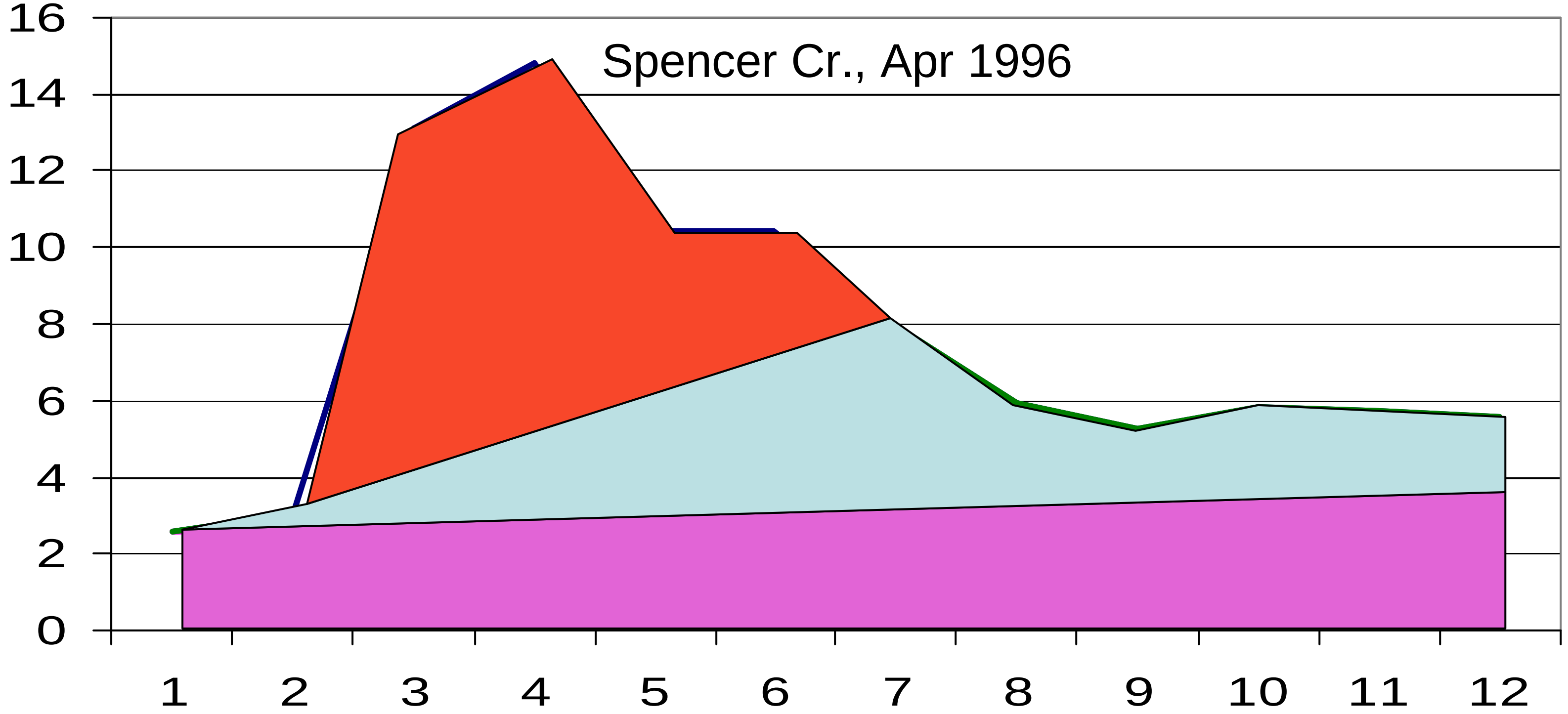
7. Uniformed vadose zone: no seasonal or monthly fluctuations in the vadose zone



Approximation 8

In SimpleBase model $dQ_i = 10dQ_b$

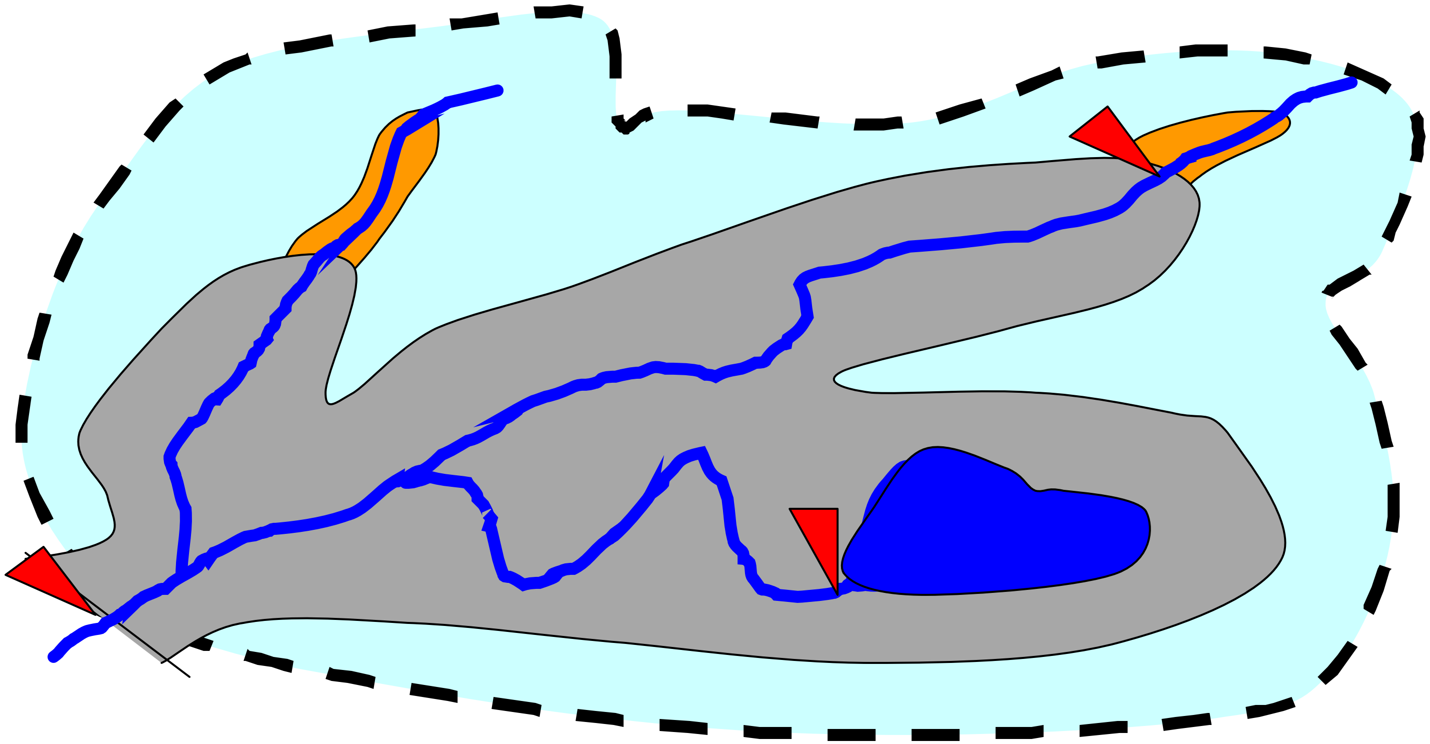
$Q_b = Q_o + dQ_b{*}t$ $\quad$ $Q_i = \Sigma dQ_i$ $\quad$ $Q_s = Q_t - Q_b - Q_i$



Approximation 8

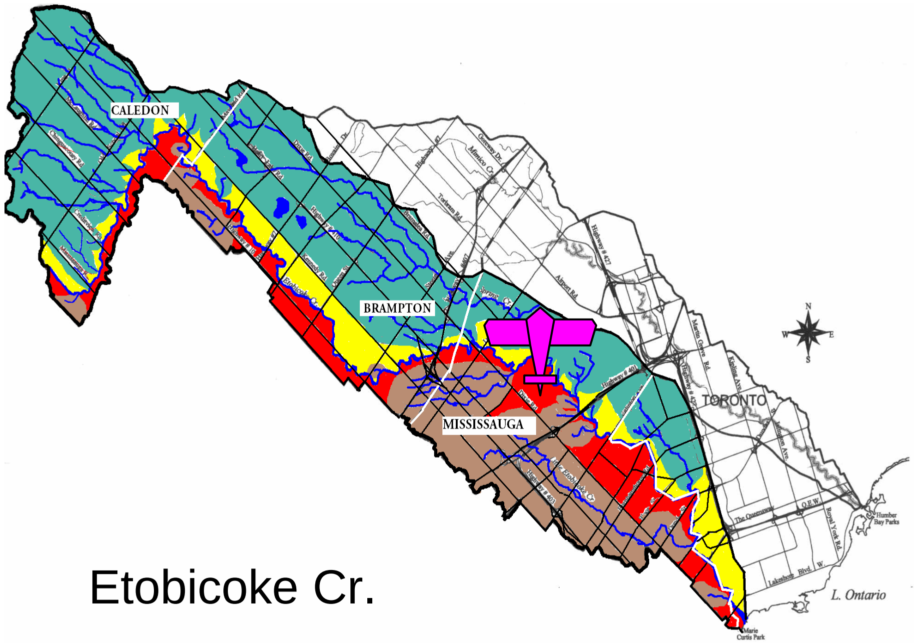
dQi = 10dQb

Whatever geology and size of a watershed is, the filtration capacity of the alluvial deposits of the river valley and flood plain will overcome the background by 10 times

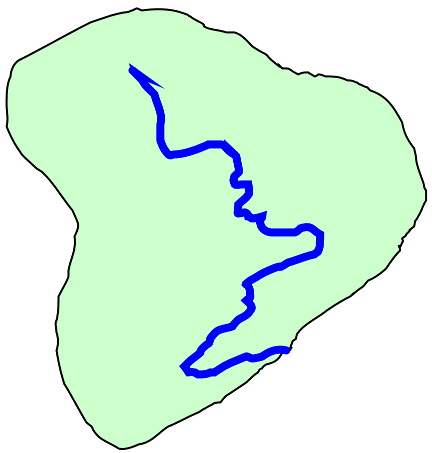


Approximation 11

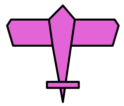
- Representativeness of a single meteostation



Etobicoke Cr.



Spencer Cr.



Parameters	**Etobicoke Creek** (HC030)		**Spencer Creek** (HB023)	
	base	base+inter	base	base+inter
Periods	1990-2000		1990-2000	
F, km^2	204	204	132	132
Y	0.0335	0.0335	0.1570	0.1570
K, m/day	0.080	0.080	0.586	0.586
r	11.40	11.40	9.17	9.17
S	0.050	0.050	0.095	0.095
Meteorological data	1 station: Pierson Airport		1 station: Hamilton Airport	
Precipitation (P)	782	782	883	883
Snow cover (water content), mm	22 (R^2 = 0.9)	22 (R^2 = 0.9)	24 (R^2 = 0.93)	24 (R^2 = 0.93)
Air temperature (T)	8.13	8.13	7.83	7.83
Total runoff, mm	369		391*	
dQ (limit of daily increase), m^3/s	0.27	2.7	0.099	0.99
Baseflow, mm	154		263	
Total groundflow, mm		256		349
Anthropogenic factors affecting geological and hydrological factors accounted	67% of urbanization and 100% of a forest-free, STP, WS, WG, lawn watering: not accounted		Urbanization, agricultural and recreational activities, STP, WS, WG: not accounted	

Results

Parameters	Etobicoke Creek (HC030)		Spencer Creek (HB023)	
	base	base+inter	base	base+inter
Hlim, m above a creek level	2.09	2.71	0	0.01
E, mm	413	413	495	495
Rt (correlation with air temperature)	0.243	0.235	0.276	0.279
Rp (correlation with precipitation)	0.854	0.855	0.777	0.775
Hmin, m	3.04	3.04	0.00	0.00
Hmax, m	4.20	4.20	0.06	0.09
dHd, m (monthly decreasing)	-1.06	-1.06	-0.03	-0.05
dHi, m (monthly increasing)	0.80	0.80	0.03	0.06

Conclusions

- The temporary component of groundwater discharge into a river, interflow, increases the permanent water table altitude. The increase is more pronounced for a watershed with the fine texture of surface deposits. For a watershed with coarse deposits the altitude increase is less pronounced, but amplitude of water table fluctuation is increased as well.
- The model based on minimal data can be pretty sensitive to changes in groundflow discharge to a river in spite of all the approximations done.
- To obtain more reliable evapotranspiration, it is necessary to add the water use data, topographical elements (average watershed height, average river height) and then change the vadose zone profile.