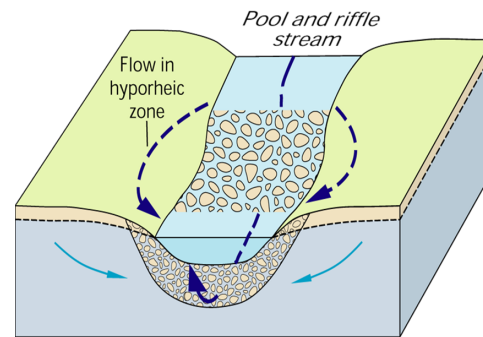
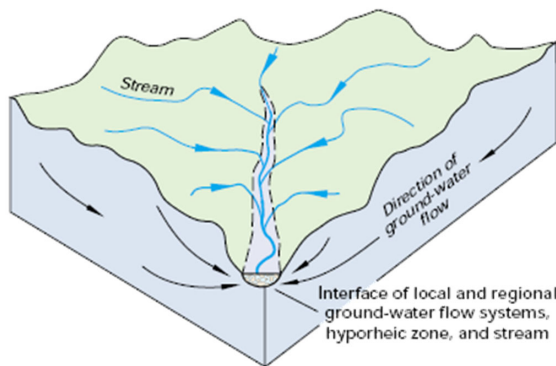


Surface Water - Groundwater Interaction: From Watershed Processes to Hyporheic Exchange



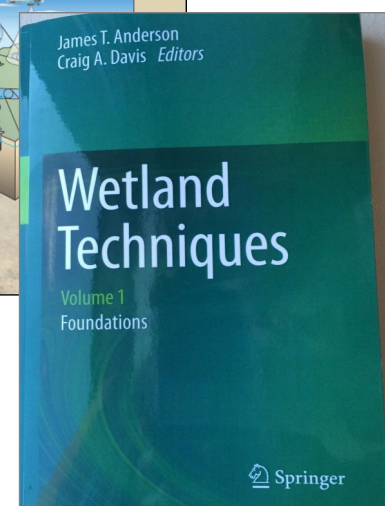
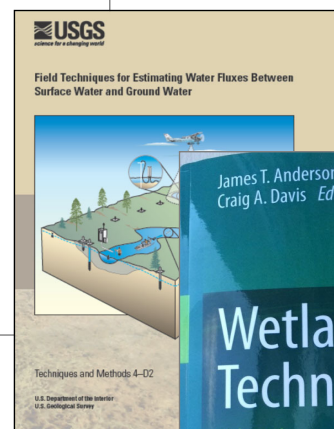
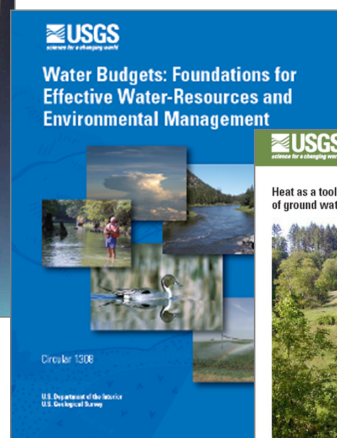
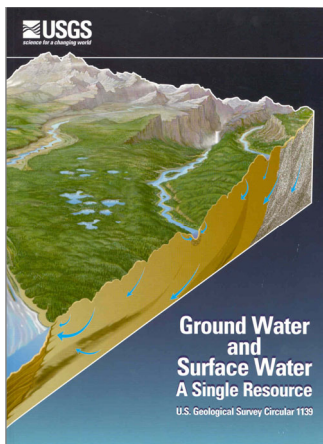
Donald O. Rosenberry, Colorado School of Mines, U.S.A.
Masaki Hayashi, University of Calgary, Canada

Learning objectives:

1. Hydrological processes of SW-GW exchange
2. Field measurement methods at various scales

1

Recommended Reference Books



USGS publications are available
from the course website.

This textbook chapter is
distributed by e-mail.

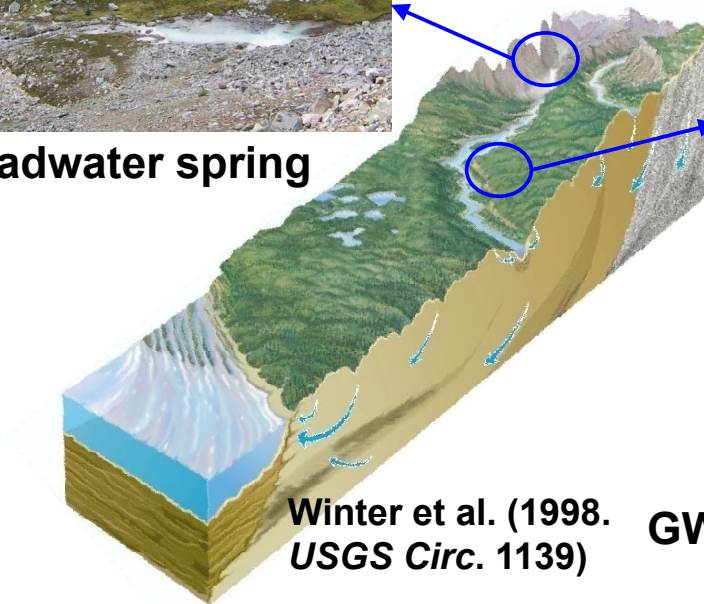
Groundwater Feeding Surface Water



Headwater spring



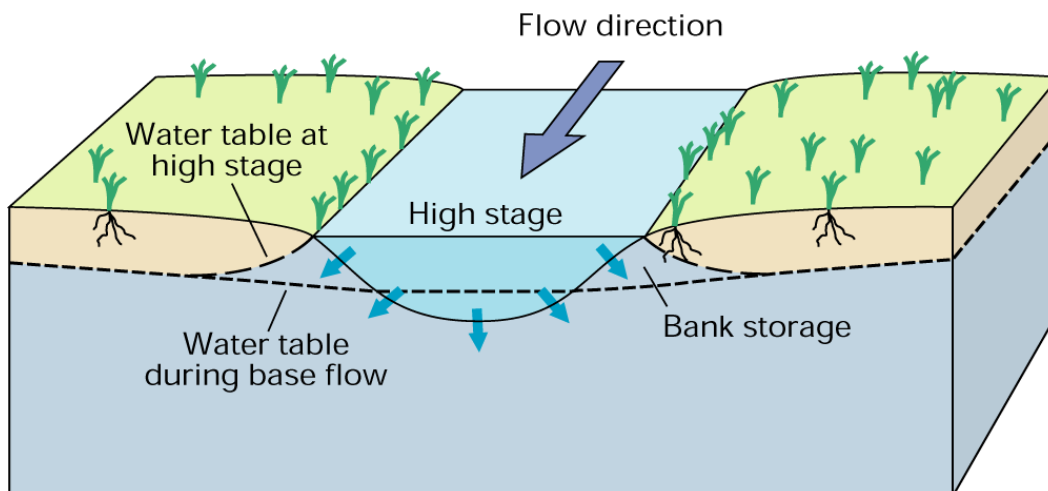
Springs on river bank



GW-dependent ecosystem

3

Groundwater-Surface Water Exchange by Bank Storage



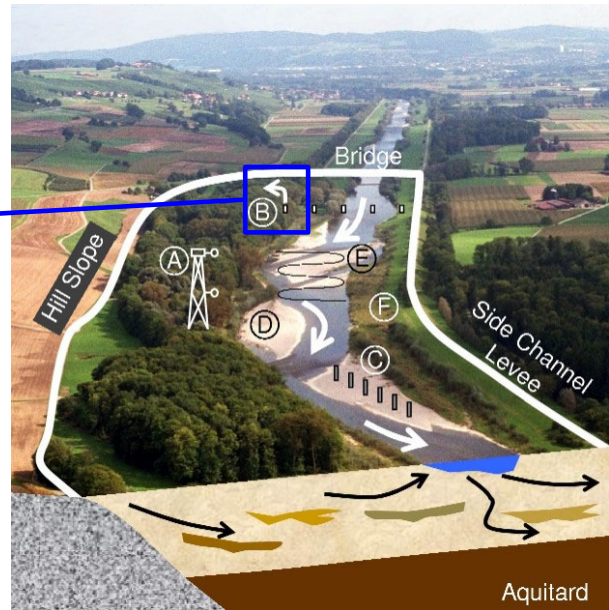
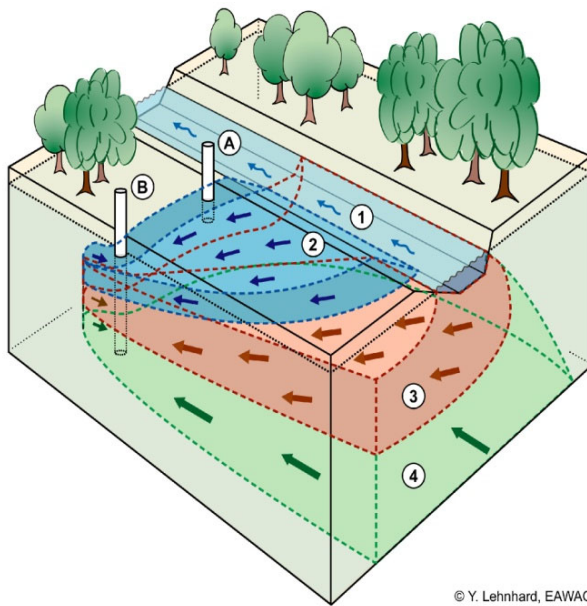
Winter et al. (1998. <http://pubs.usgs.gov/circ/circ1139/>)

4

Bank Filtration Induced by Pumping

Municipal water supplies use bank-filtrated groundwater.

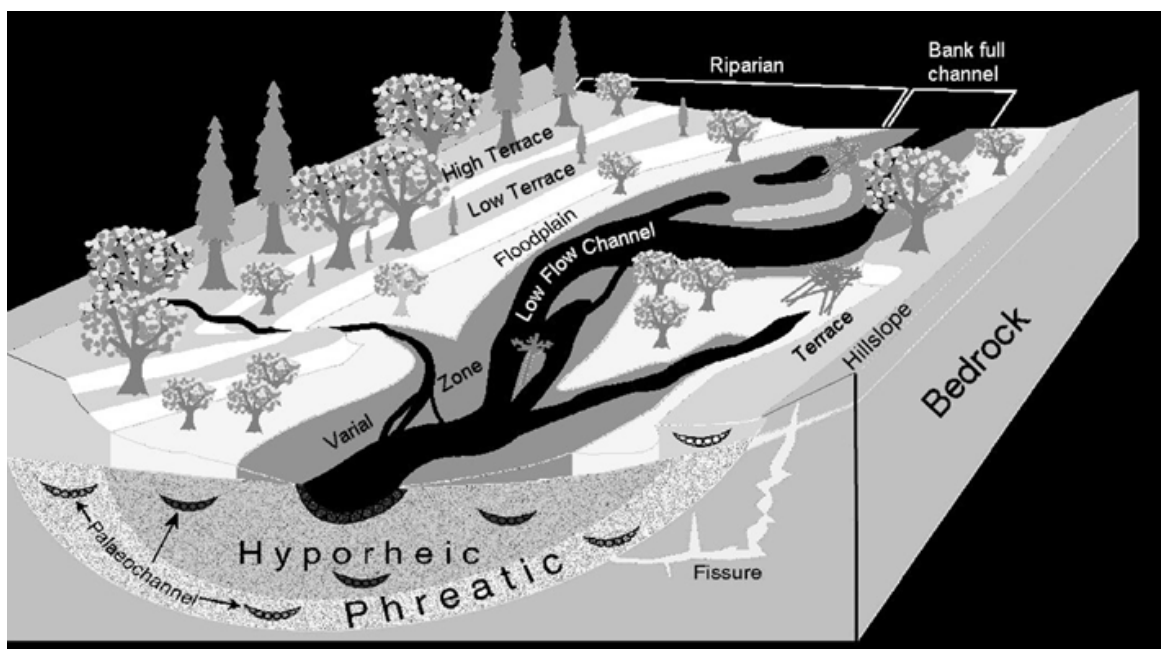
Thur River, Switzerland



<http://www.cces.ethz.ch/projects/nature/Record/sites>

5

“Hyporheic” Zone in the Floodplain Active Two-Way Exchange of Groundwater with River

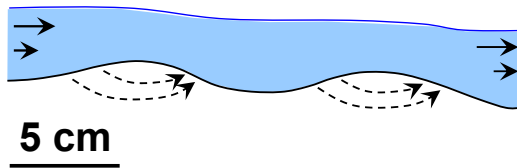


Stanford (1998. *Freshwater Biology*, 40:402)

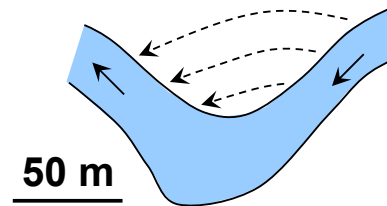
6

Hyporheic Exchange Mechanisms

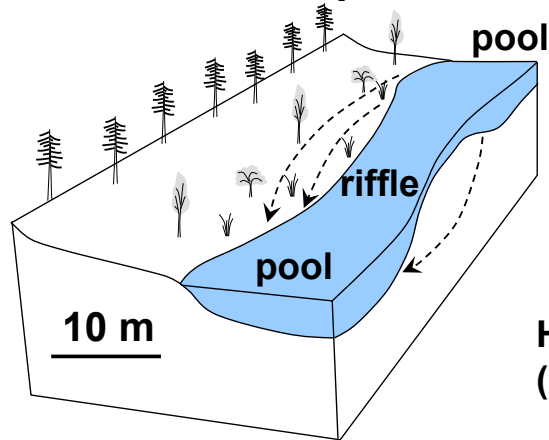
Bedform-induced flow



Meandering channel



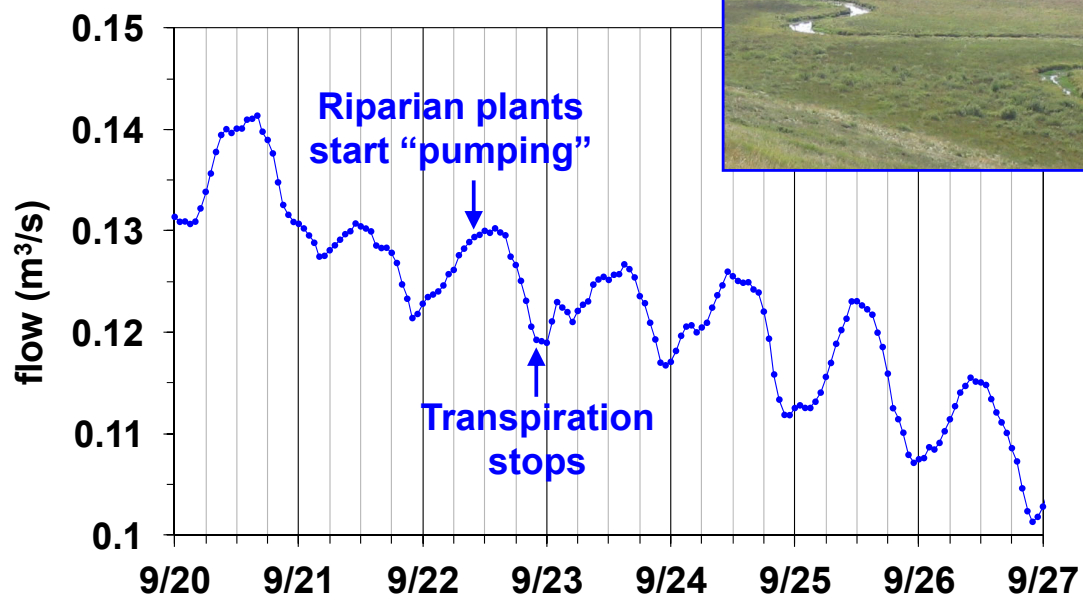
Pool-riffle sequence



Hayashi and Rosenberry
(2002. *Ground Water*, 40: 309)

7

Riparian GW-SW interaction

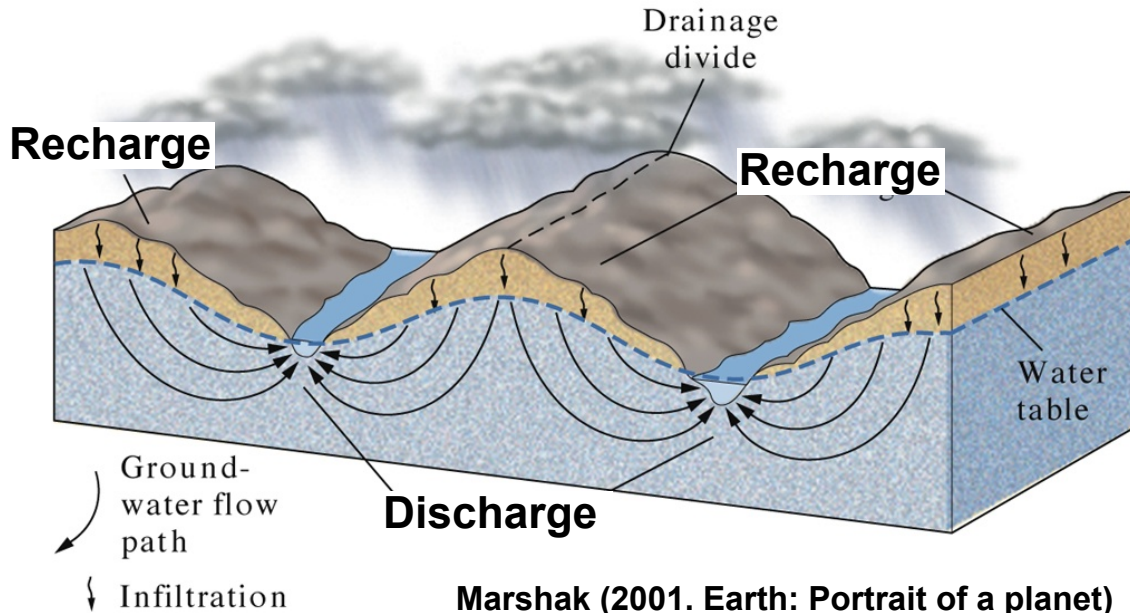


8

Groundwater Flow System

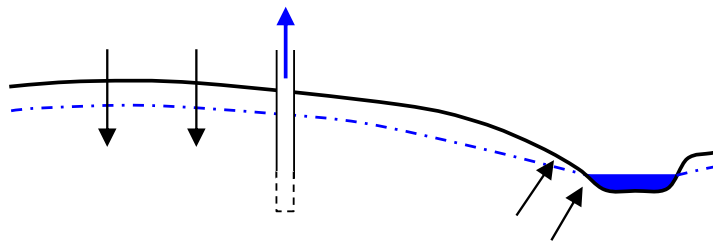
Two fundamental rules that are generally true:

1. Water table is a subdued replica of ground surface.
2. Groundwater flows from high to low.



9

Groundwater is connected to streams
Water balance is key to understand the connection



$$\text{Recharge} - \text{Discharge} - \text{Pumping} = \text{Storage Change} \\ (\text{water level } \uparrow \downarrow)$$

Long-term balance:

$$\text{Recharge} - \text{Pumping} \approx \text{Discharge}$$

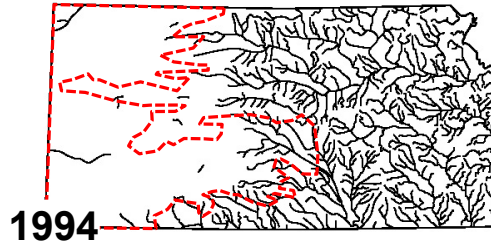
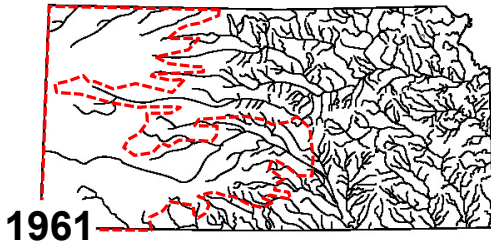
Over pumping may cause:

- Large drawdown of groundwater level
- Reduction of baseflow, or drying of springs

10

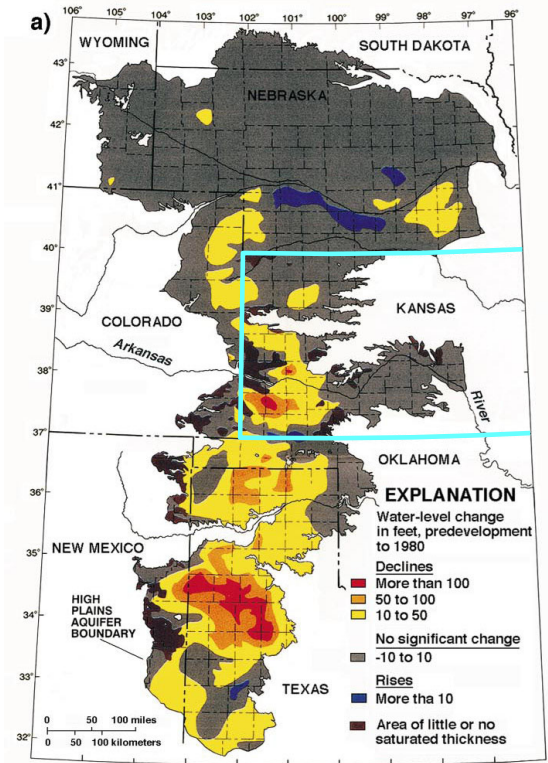
Long-Term Effects of Groundwater Extraction Example from Kansas, U.S.

Ogallala Aquifer



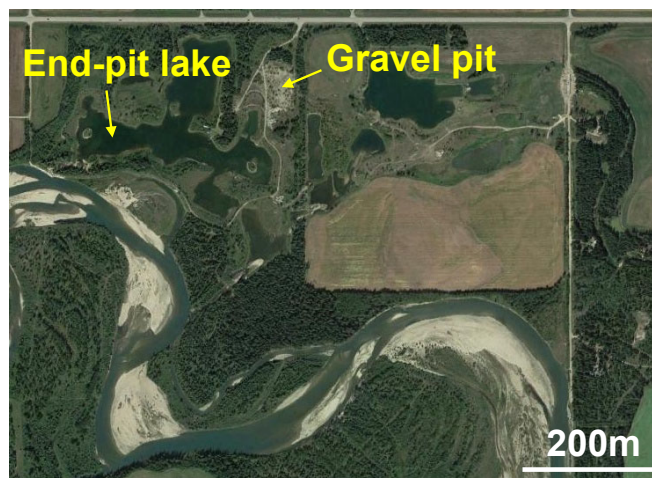
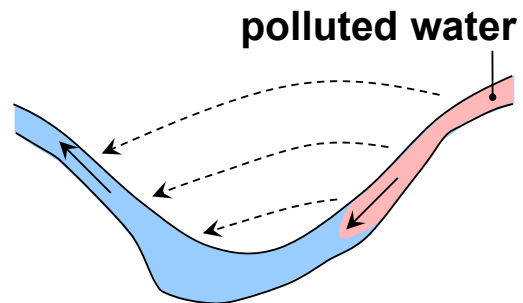
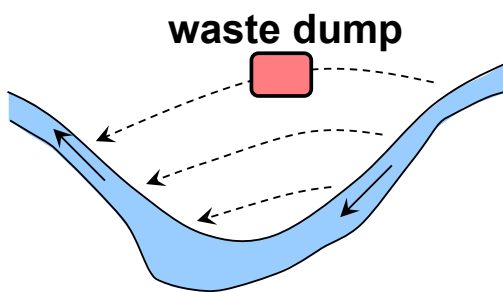
Major perennial streams
in Kansas.

Sophocleous (2000. *J. Hydrol.*, 235: 27)



11

Management Implication of SW-GW interaction



12

Management Implication of SW-GW interaction

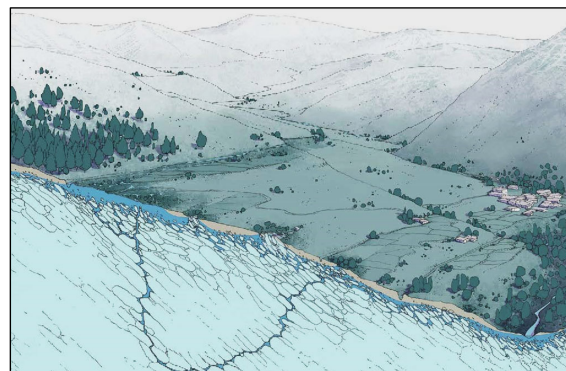
Other examples? Policy framework?

Managed aquifer recharge (MAR) – Esker near Helsinki



13

Local examples from Andalucía



Martos-Rosillo et al. (2019. *J. Hydrol.*, 578, 124047)

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