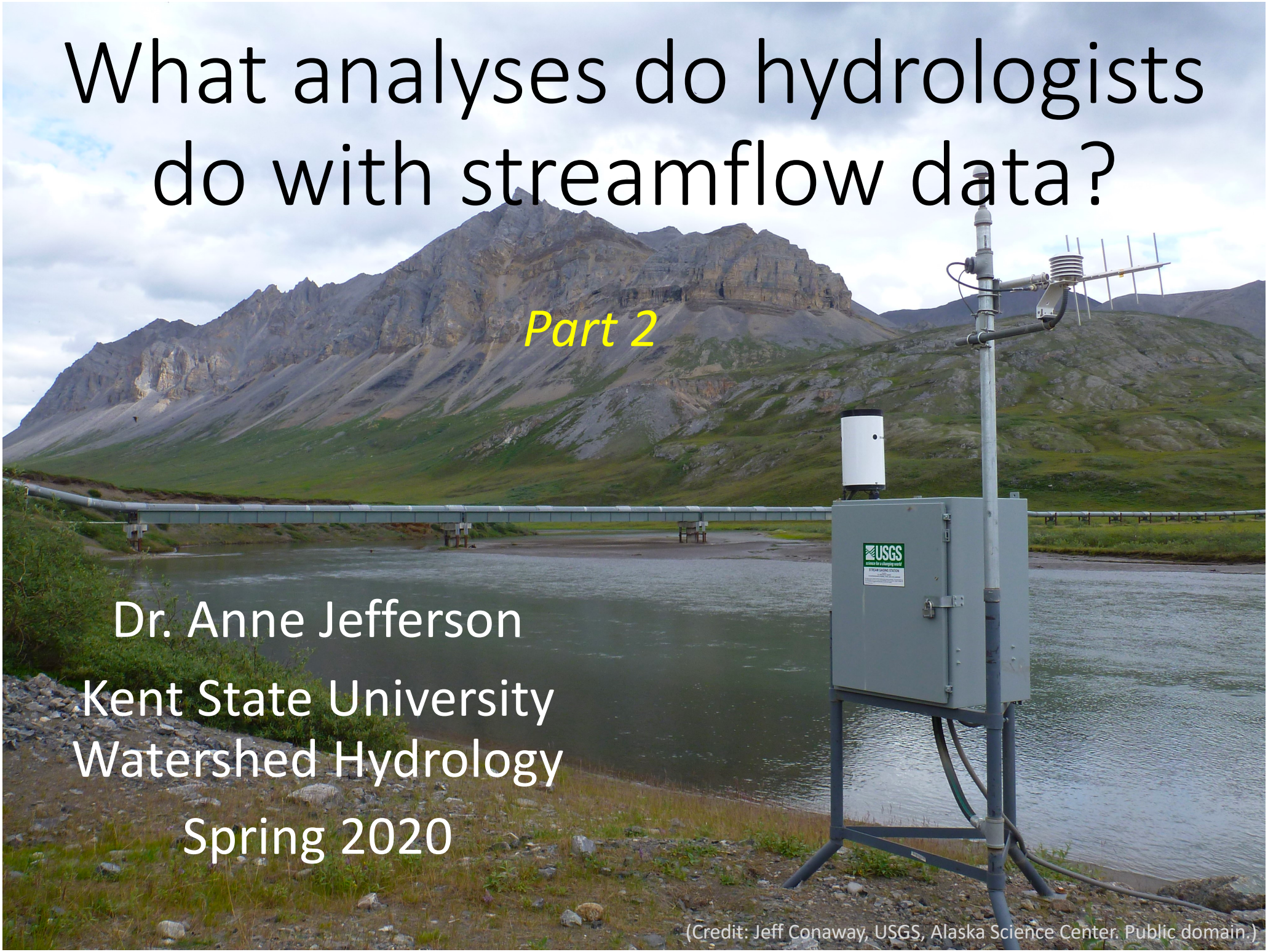
What analyses do hydrologists do with streamflow data?

Part 2



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(Credit: Jeff Conaway, USGS, Alaska Science Center. Public domain.)

What can you do with streamflow data?

Basic analyses (part 1)

1. Create hydrographs
2. Create unit hydrographs
3. Create hydro-hyetographs
4. Analyze flow duration curves
5. Calculate hydrologic response on annual and seasonal timescales

More complicated techniques…

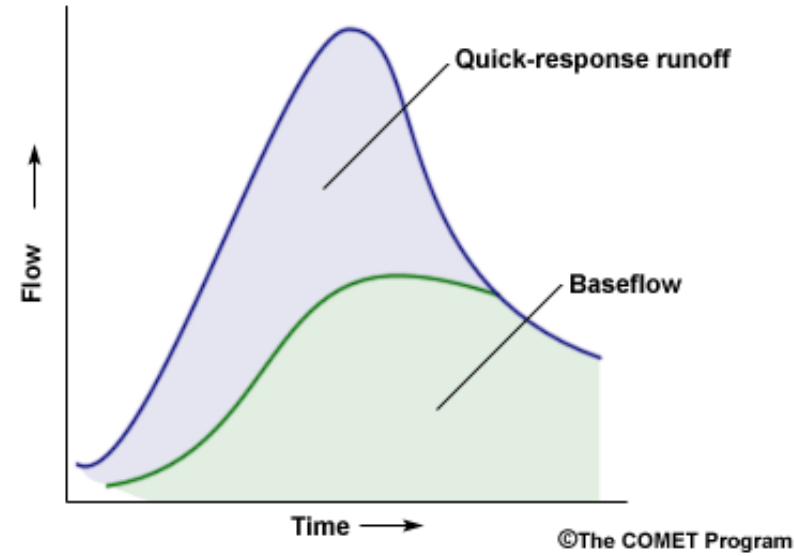
5b. Calculate **hydrologic response** on event timescales

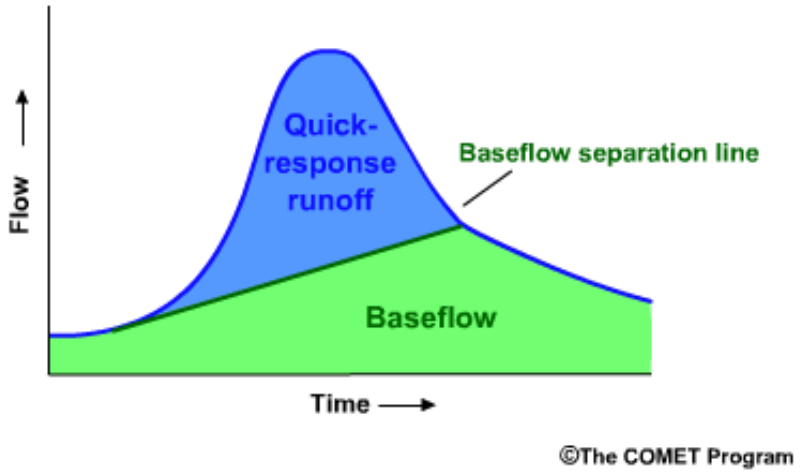
- Hydrologic response function = $\frac{\text{Stormflow (mm)}}{\text{Precipitation (mm)}}$
- Storm-to-storm variability largely depends on antecedent moisture conditions (i.e., soil moisture before storm)

What is stormflow?

…Need to split up the hydrograph into components.

6. Conduct a **Graphical Hydrograph Separation**





- Add a line between stormflow and baseflow
- Calculate volume of stormflow
- Graphical methods prevailed from the 1930s to 1960s

← Simplest method involves a straight line with slope 0.05 $ft^3/sec/mi^2/hour$ (Hewlett and Hibbert, 1967)

Text modified from Doug Burns and Tomas Vitvar: http://www.esf.edu/hss/IsotopeWS/Burns-Vitvar%20presentation/sld001.htm

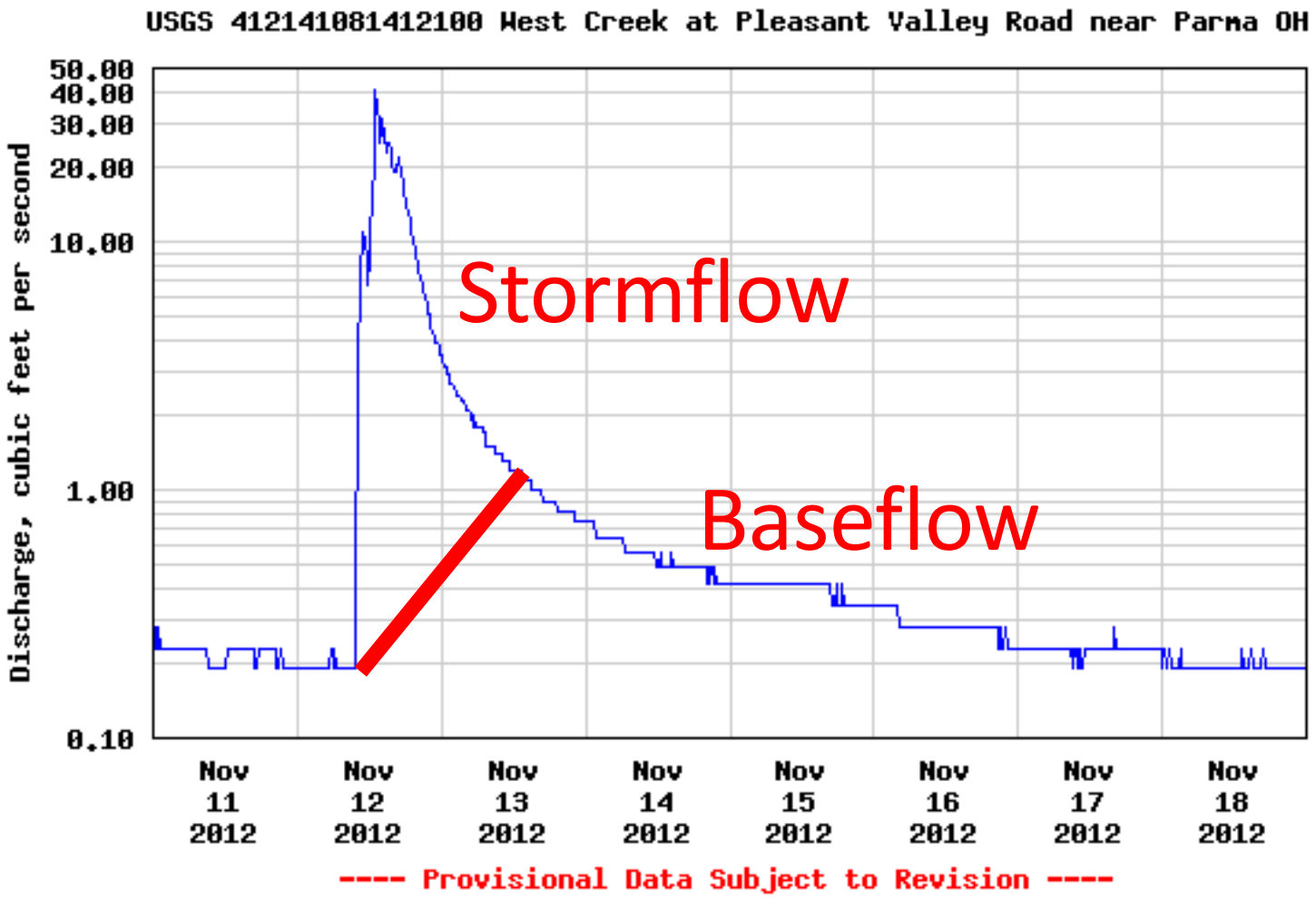
Example graphical hydrograph separation for west Creek at Pleasant Valley Road, November 2012

Start at start of rise, add 0.05 $ft^3/sec/mi^2/$ hour

(1.1 mi^2 → 0.045 $ft^3/sec/mi^2/$ hour or 0.011 $ft^3/sec/mi^2/$ 15 minutes)

Until you intercept the falling limb

Note: this was done with instantaneous data, but most graphical separations use daily data



See also Box 6.2

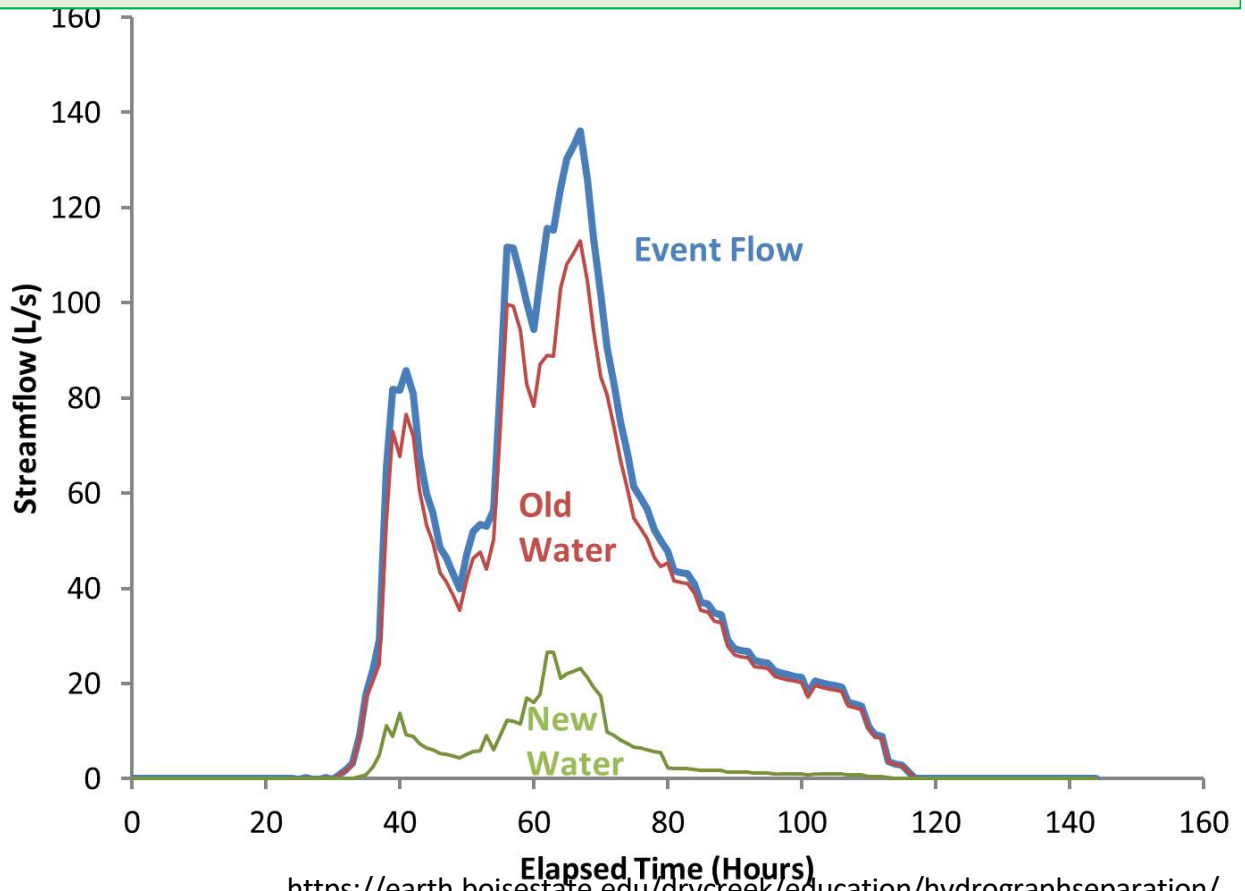
How do hydrologists feel about hydrograph separation?

- "Hydrograph separation is one of the most desperate analysis techniques in use in hydrology." – Hewlett and Hibbert, 1967
- "Hydrograph separation appears to be little more than a convenient fiction." – Freeze, 1972

- Graphical methods are still used by engineers and can be used as a basis for comparing runoff across events or in different watersheds, but they don't reveal much about processes

7. Add tracers for to conduct a better **hydrograph separation**

Studies using **isotopes and other tracers** to separate hydrographs revolutionized ideas about runoff beginning in the late 1970s.



https://earth.boisestate.edu/drycreek/education/hydrographseparation/

Tracer-based separation: New vs. Old Water

- **New water** = water that fell as precipitation in the current storm (i.e., the one we are measuring)
- **Old water** = water stored in the watershed since before the current storm.
  (*Note:* d*oesn't specify how long it has been stored.)*

Important! New vs. old distinction doesn't directly tell us about streamflow generation mechanism. It lets us infer it.

Stormflow is often old water.

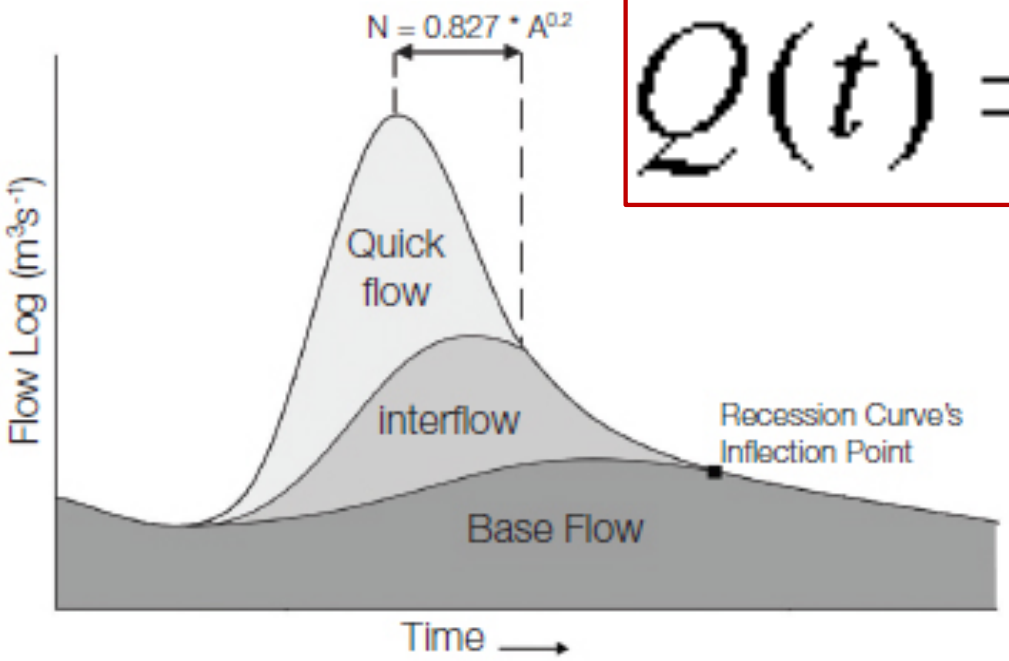
- Old water is typically >50% of peakflow, 60-80% of total storm runoff at most sites (but humid, forested site bias)
- Wetlands and impoundments promote high proportion of old water in stormflow. *Why?*
- Agricultural and urban watersheds are dominated by new water at peak flow. *Why?*

How does old water get quickly to the stream?

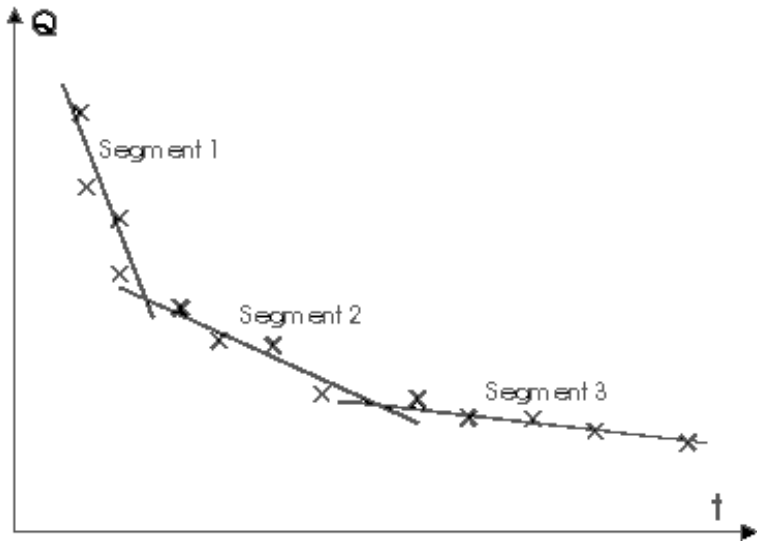
- Saturation overland flow, via return flow
- Subsurface stormflow via macropore flow
- Subsurface stormflow via "transmissivity feedback" (K decreases exponentially with depth, results in perched water table)
- Groundwater ridging/capillary fringe – soils near saturation close to stream, rapid water table rise

For more on streamflow generation and hydrographs vs. transit time, see: http://all-geo.org/highlyallochthonous/2020/04/how-flow-generation-controls-stream-hydrographs/

8. Conduct **recession analysis**



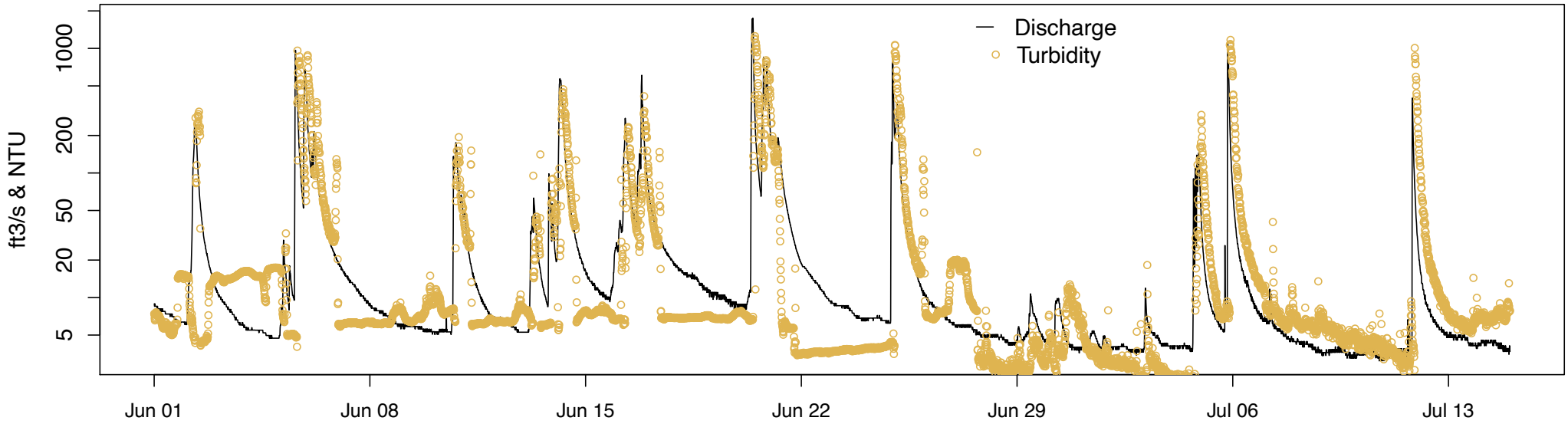
$$Q(t) = Q(t_o)e^{-k(t-t_o)}$$



- Different portions of hydrograph tell about stormflow, soil moisture storage, & groundwater
- Can be used to calculate aquifer parameters + groundwater recharge

What can you do with streamflow data?

9. Explain **water quality patterns**.



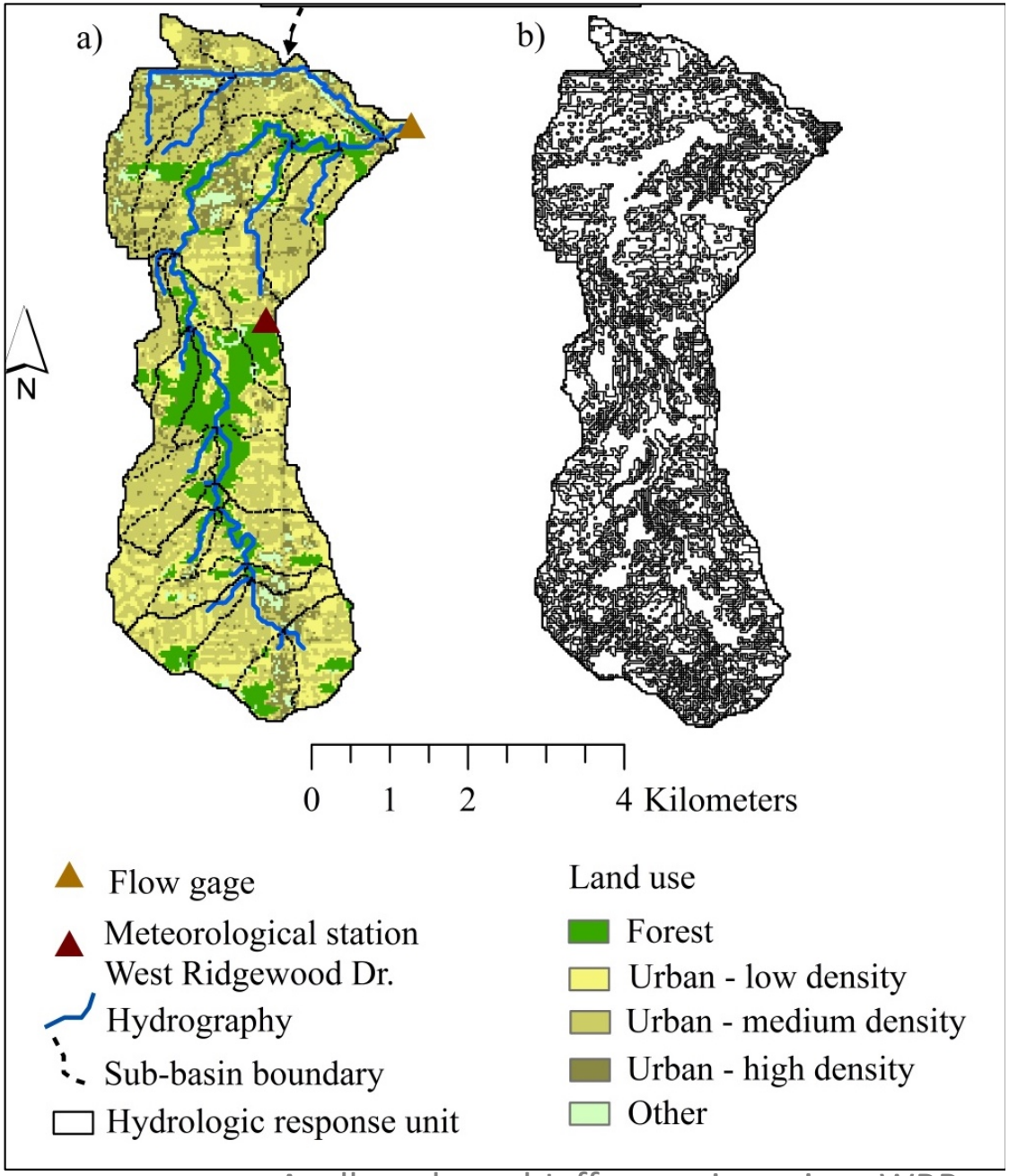
Jefferson et al., unpublished data

10. **Calculate loads** of dissolved or suspended materials.

Load = Concentration x Discharge

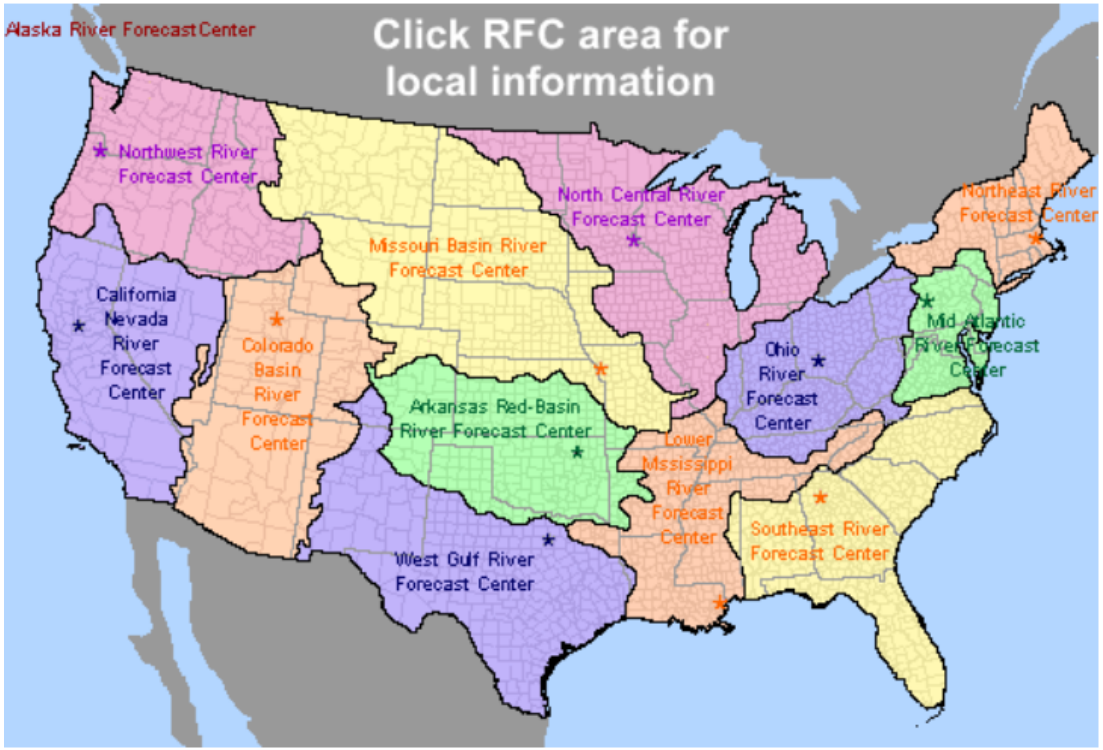
11. Use a **hydrological model** to test scenarios

- Numerical (computer-based) watershed models let us ask “what-if”. How will land use or climate change affect streamflow?
- Models are calibrated to streamflow data



Avellaneda and Jefferson, in review, WRR

12. **Predict future flows and floods** by combining observed streamflow with weather forecasts in a model.



https://water.weather.gov/ahps/rfc/rfc.php

NWS operates 13 River Forecast Centers as part of its Advanced Hydrologic Prediction Services

Use stream gages + satellites + radar + weather stations + weather models + super computers

Generate forecasts for 4000 locations for hours to months.