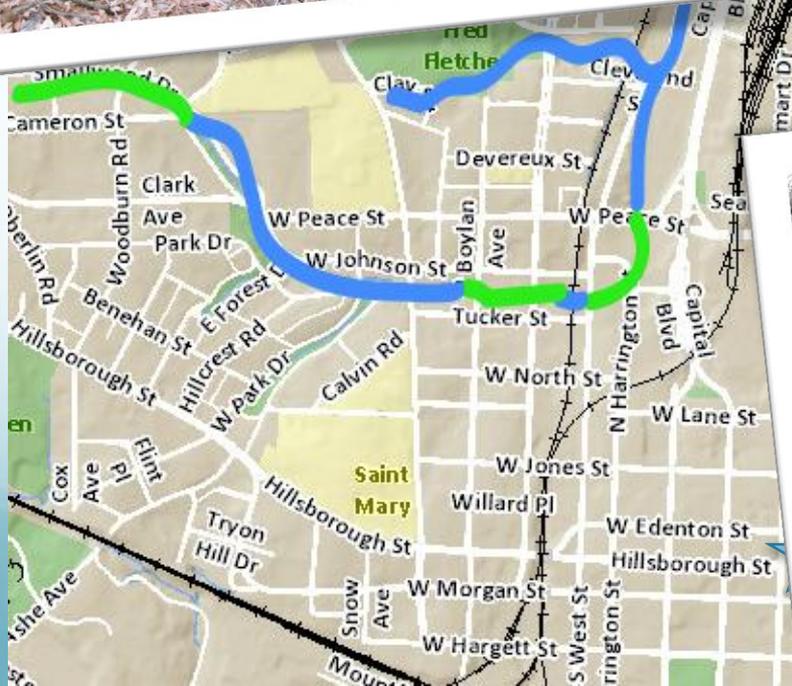
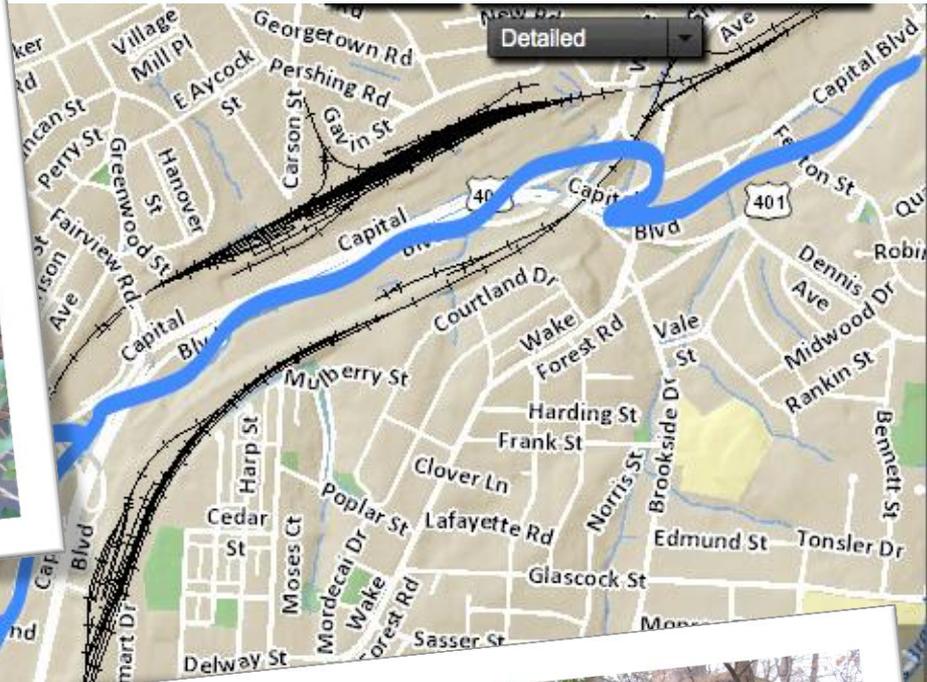
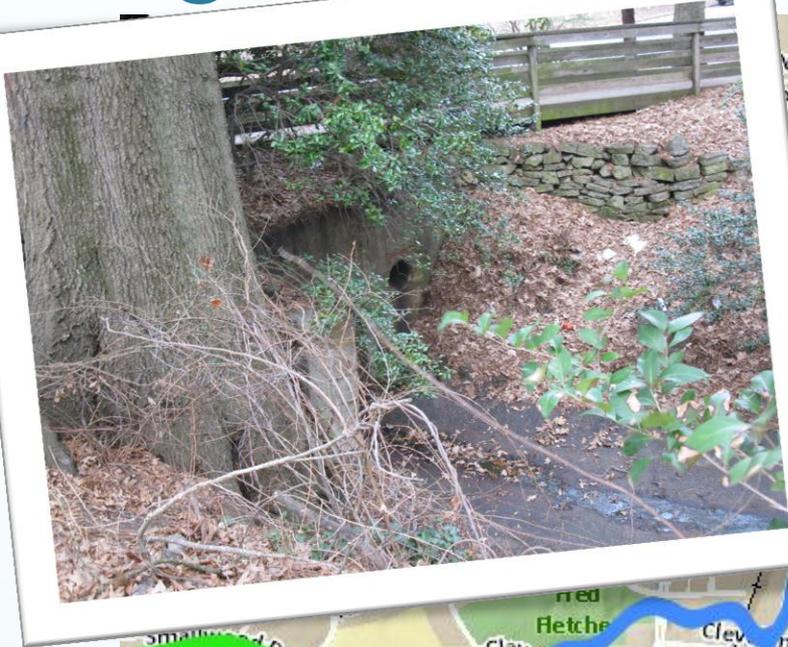


# Effects of Urbanization on Stream Hydrology and Geomorphology

7 February 2013

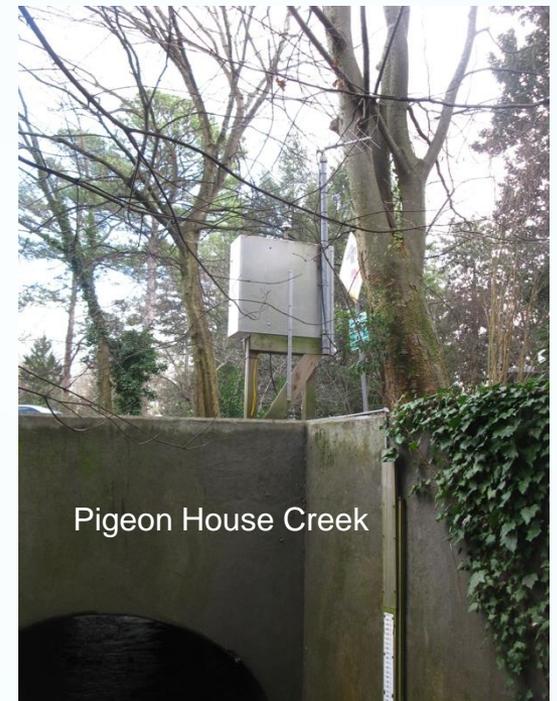
# Pigeon House Creek, Raleigh NC



# USGS Discharge record for Pigeon House Creek

Drainage area = 0.75 km<sup>2</sup>

Contributing Drainage area = 0.70 km<sup>2</sup>

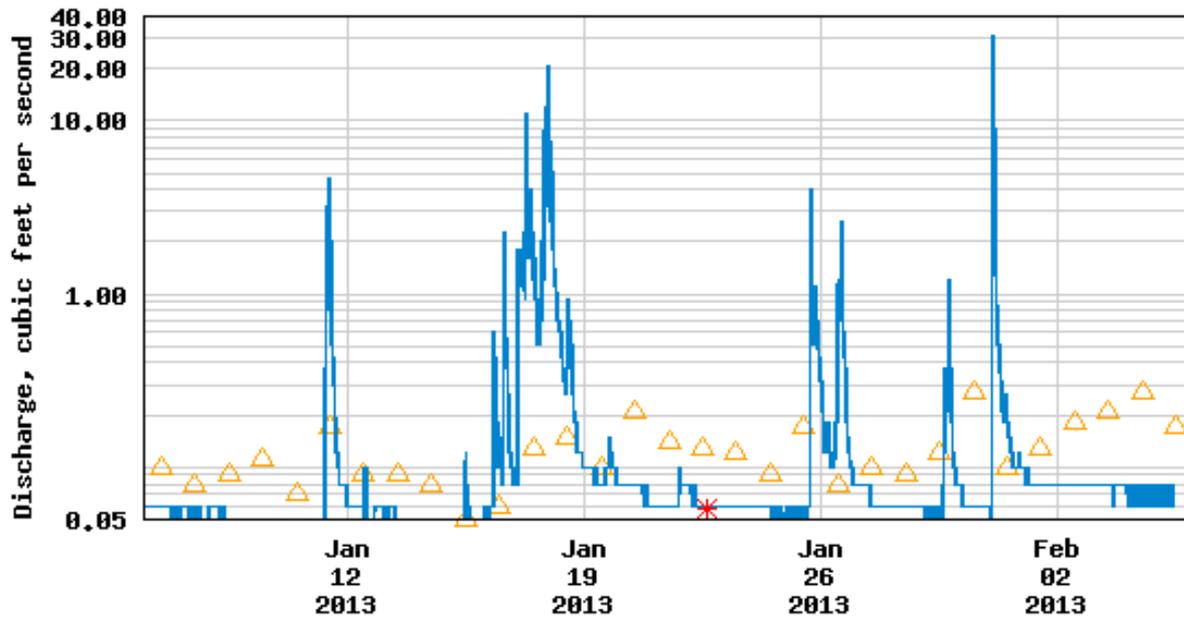


Pigeon House Creek



USGS photo: Baisman Run, Baltimore

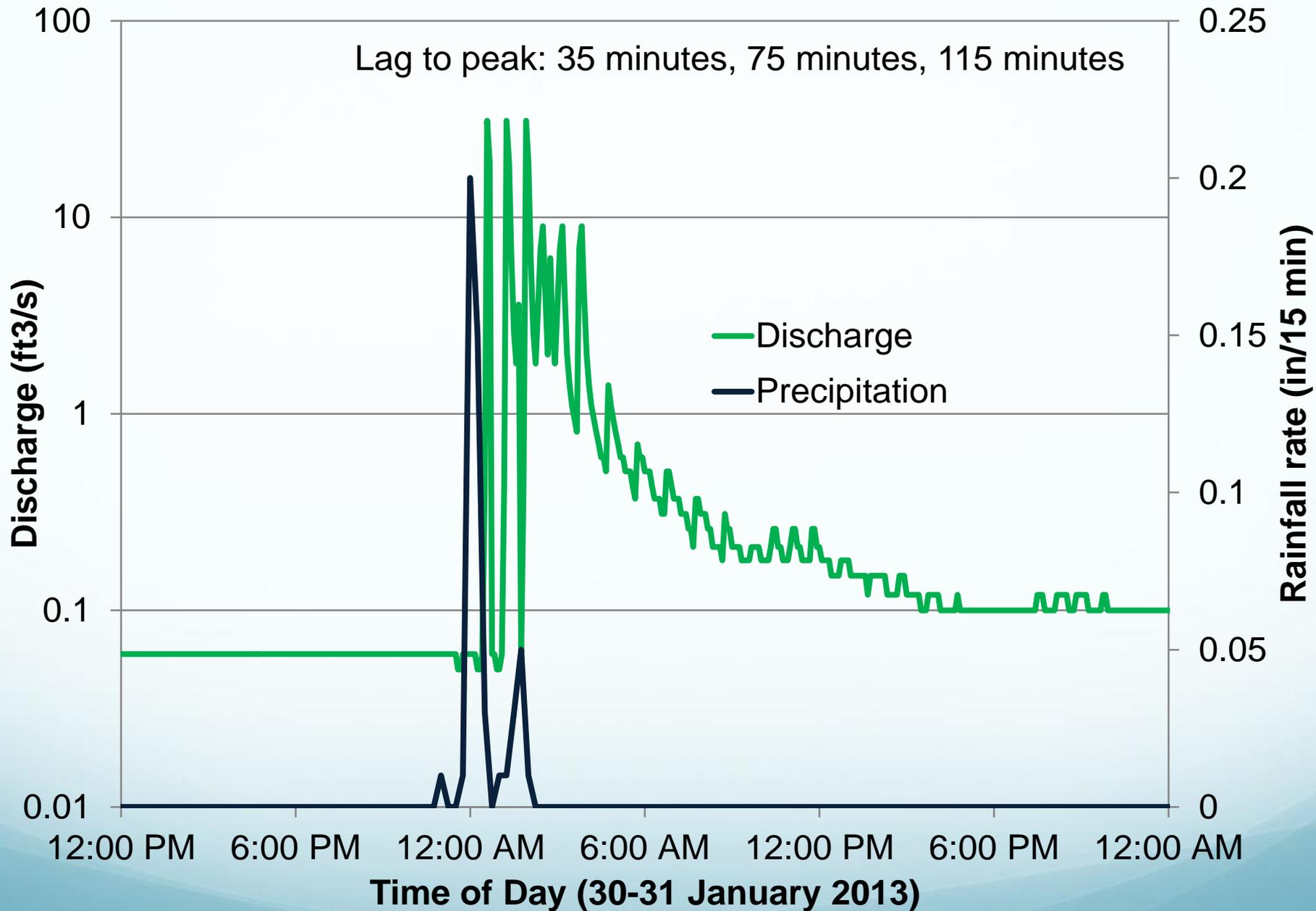
USGS 0208732534 PIGEON HOUSE CR AT CAMERON VILLAGE AT RALEIGH, NC



---- Provisional Data Subject to Revision ----

△ Median daily statistic (16 years) \* Measured discharge  
— Discharge

Graph courtesy of the U.S. Geological Survey



# What controls hydrologic response to urbanization?

## Watershed properties:

- Soils – how fast do they infiltrate water? How quickly do they saturate?
- How big is the watershed?
- How steep is the watershed?
- What is the precipitation regime?
- What is the drainage network like?

## Land cover properties:

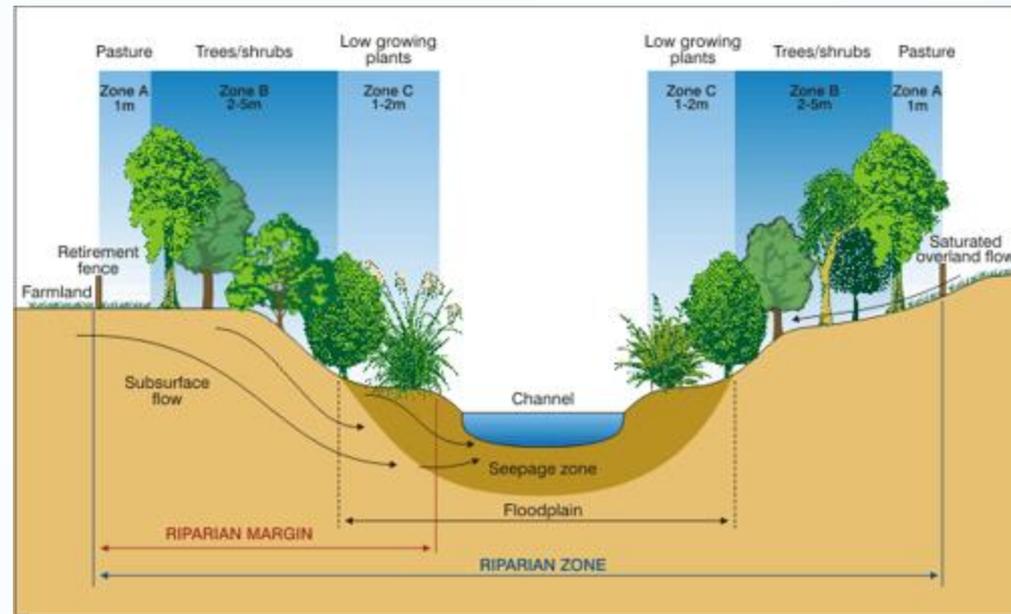
- What is the land cover/use?
  - What is the agricultural management?
  - What is its hydrologic condition?
- How much impervious surface is there?
  - How connected is it?
- What is the variability of watershed land cover and imperviousness?



# Effects of urbanization on stream channels

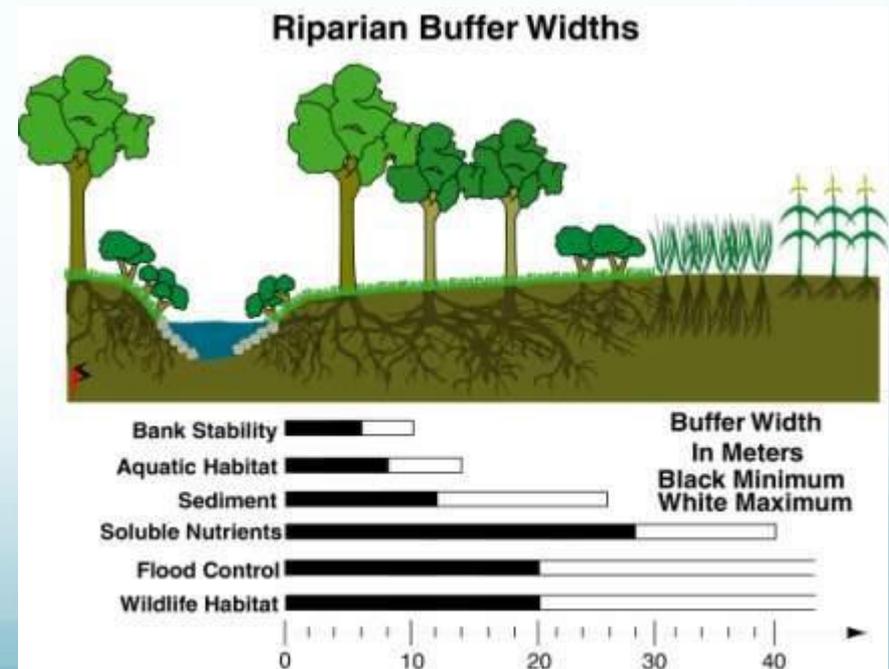
A photograph of a stream channel. The stream flows from the background towards the foreground. The banks are heavily reinforced with large, dark grey stones, forming a stone wall. The water is shallow and reflects the light. The surrounding area is overgrown with trees and shrubs, some of which are bare, suggesting a late autumn or winter setting. The sky is bright and overcast.

# Streams within Riparian Zones



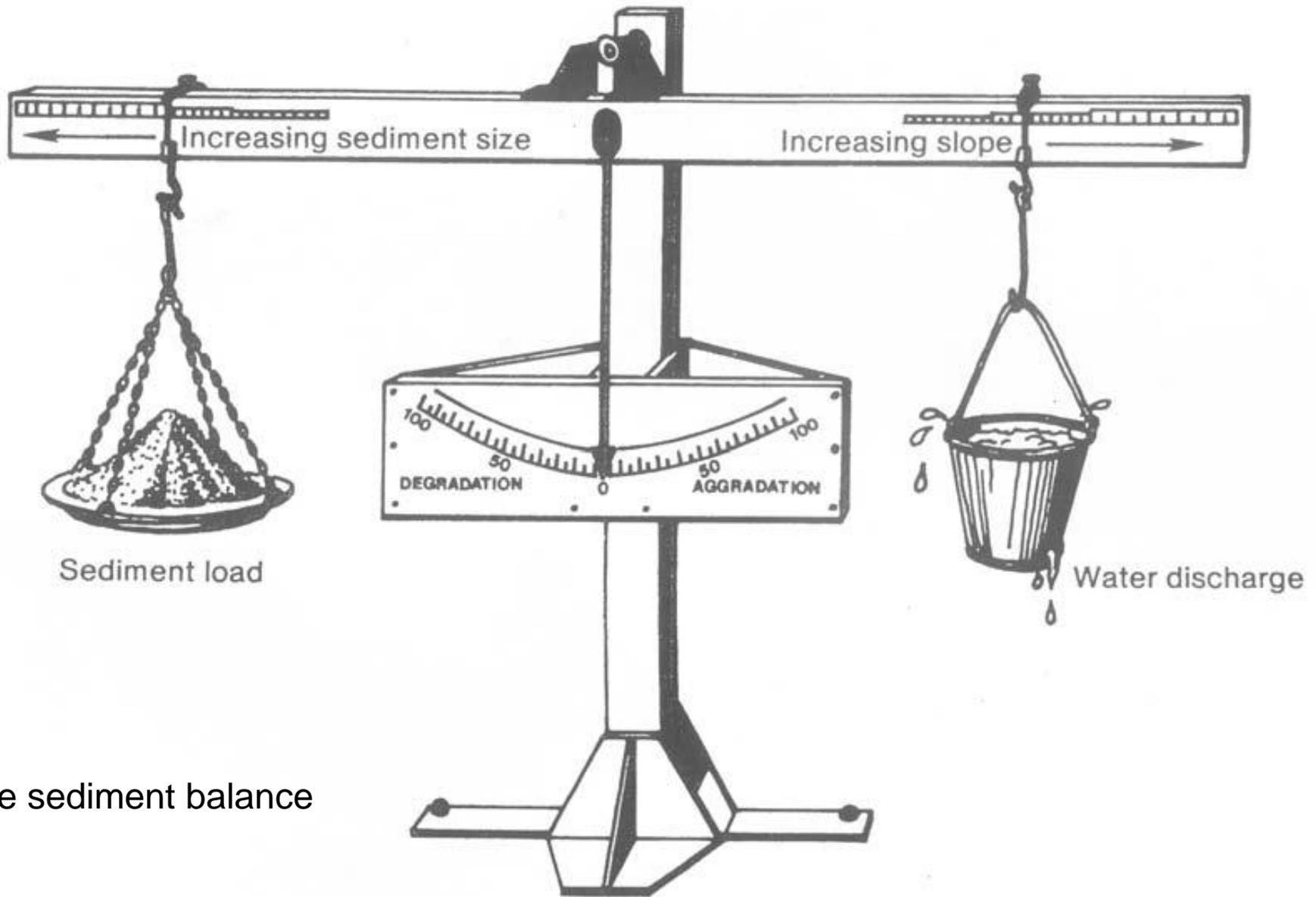
## Benefits of riparian zones:

- Reduced flooding and erosion
- Decreased velocity and increased filtration of water runoff
- Shaded streams
- Increased habitat
- Recreation opportunities
- Increased property values?





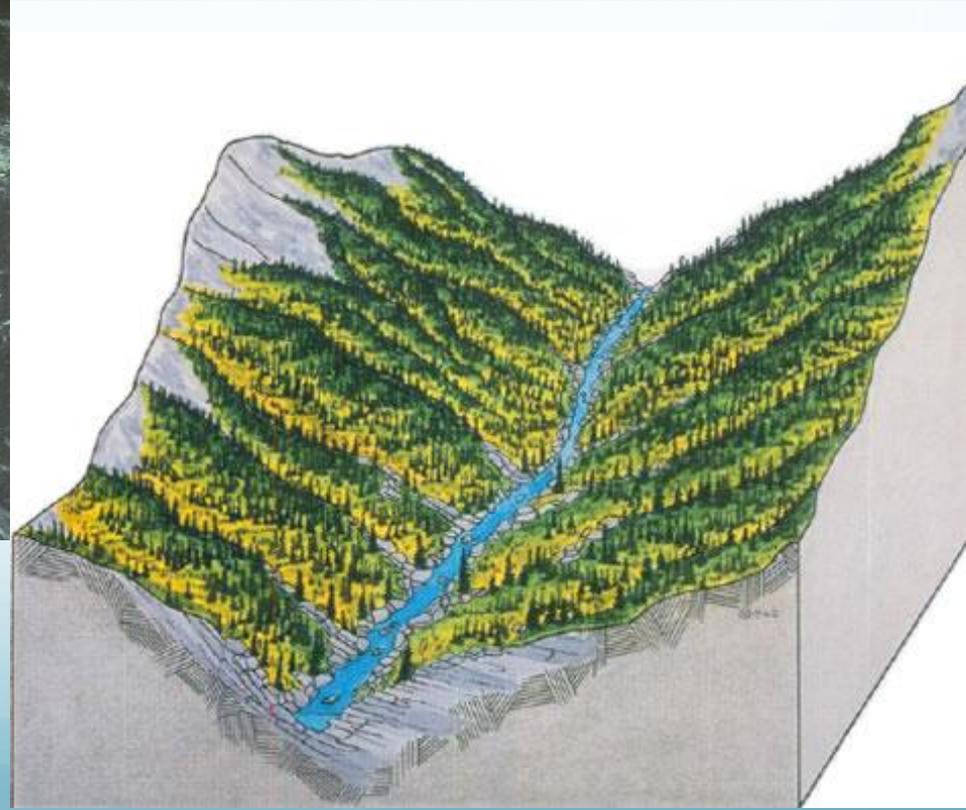
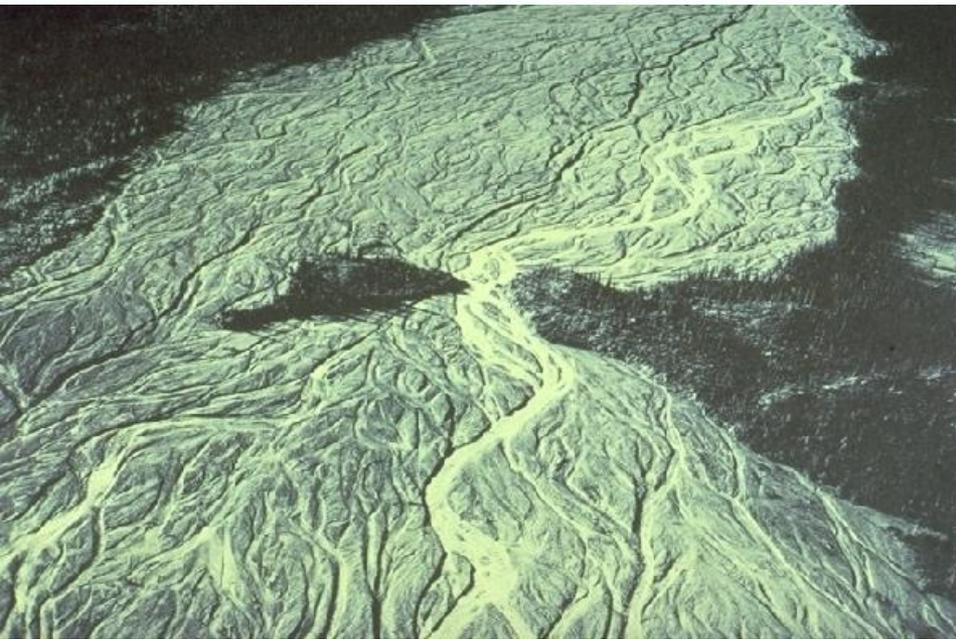
Photos by Jefferson



Lane sediment balance

# Braided, Meandering, or “Straight”

Leopold and Wolman, 1957. “River Channel Patterns: Braided, Meandering, and Straight, USGS Prof. Pap. 282-B.



[http://www.geology.ohio-state.edu/~vonfrese/gs100/lect12/xfig12\\_28.jpg](http://www.geology.ohio-state.edu/~vonfrese/gs100/lect12/xfig12_28.jpg)

[http://www.fgmorph.com/fg\\_4\\_5.php](http://www.fgmorph.com/fg_4_5.php)

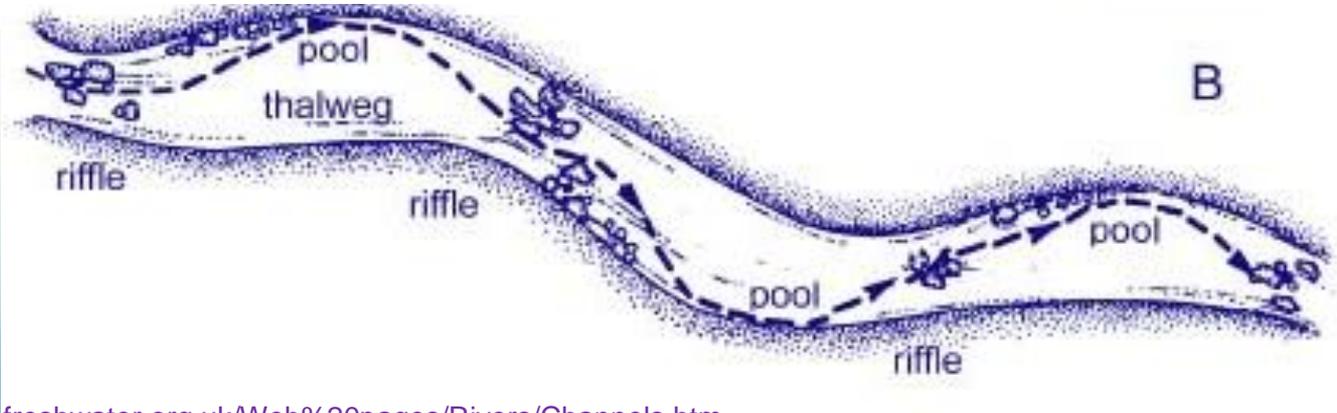
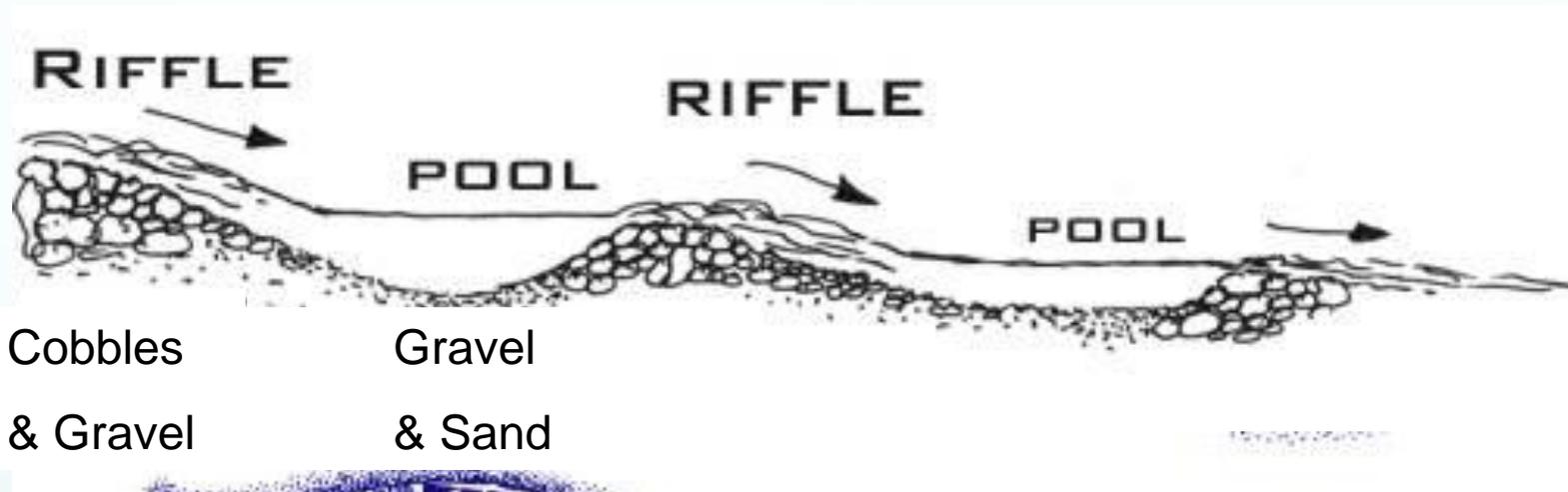
<http://pages.uoregon.edu/millerm/Dep-33.jpeg>

# Pools and Riffles



# Pools and Riffles

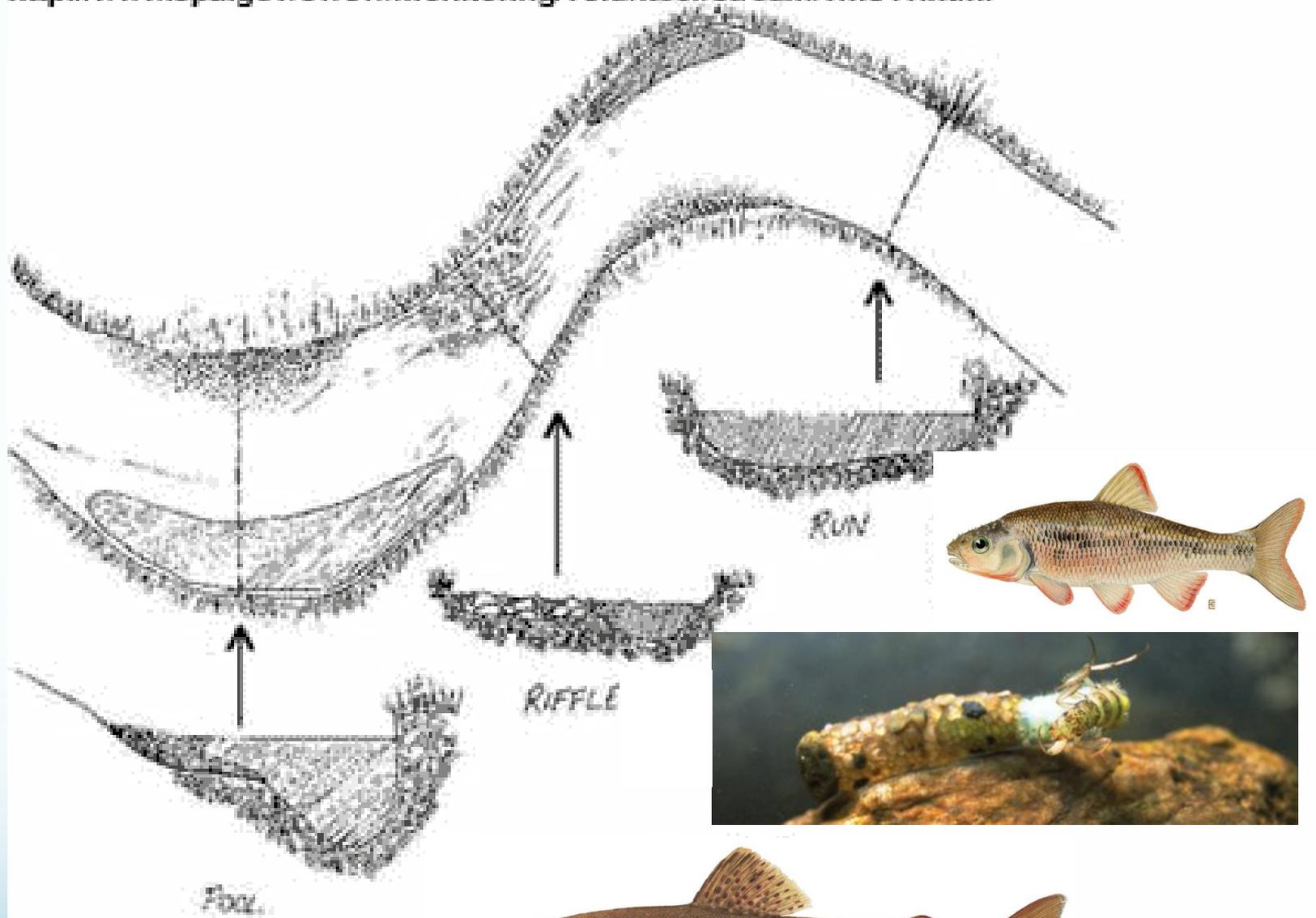
- Alternating deeps and shallows characteristic of gravel-bed streams
- Spacing = ~5-7 widths



# Why pools and riffles are important

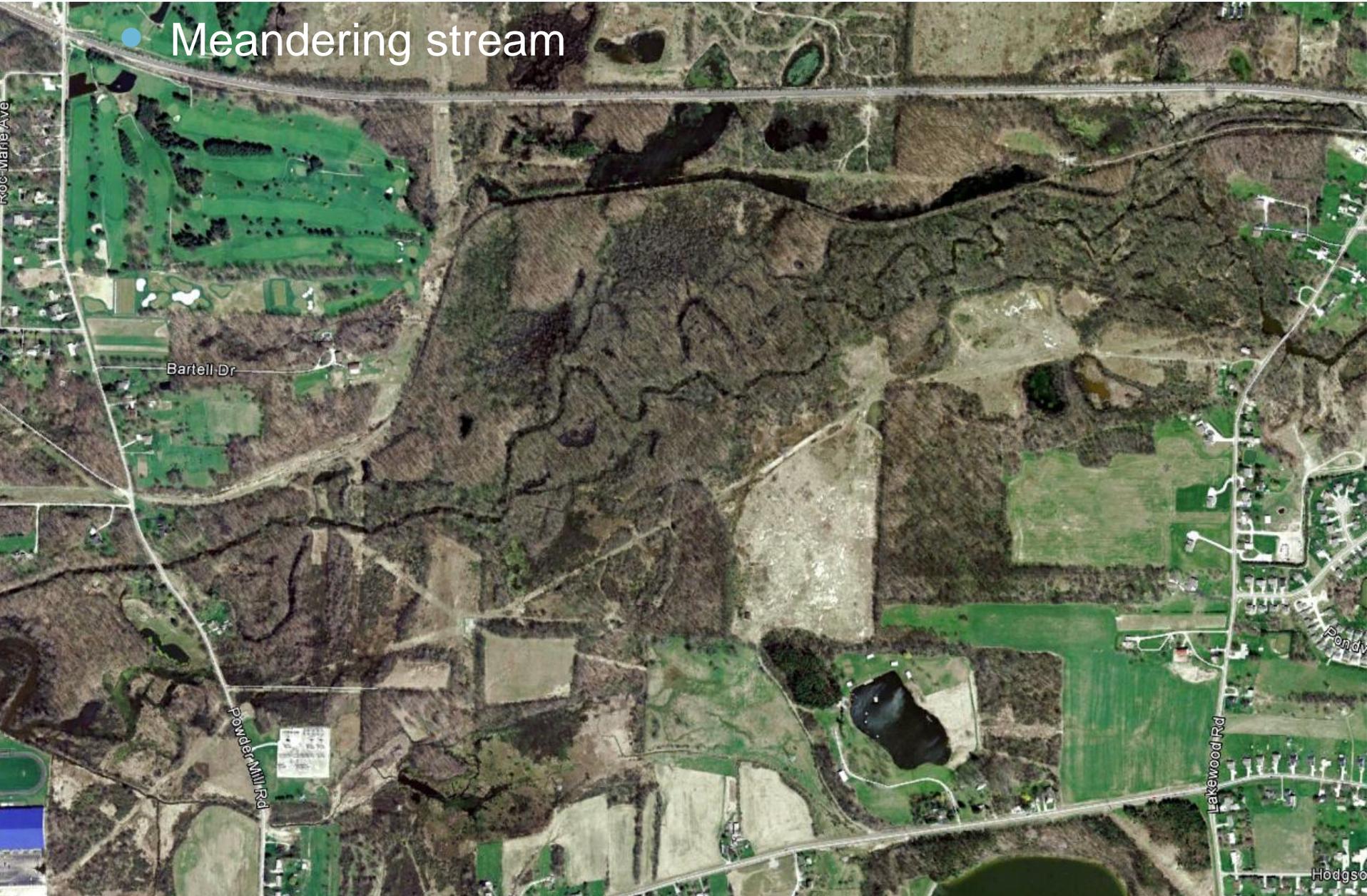


- Stable, equilibrium channel form
  - Particles move downstream, form stays fixed
- Way for stream to adjust to changing  $Q$  and  $Q_b$  & develop meanders
- Primary framework for aquatic habitat
  - Important for macroinvertebrates and fish species
  - Aerate the water



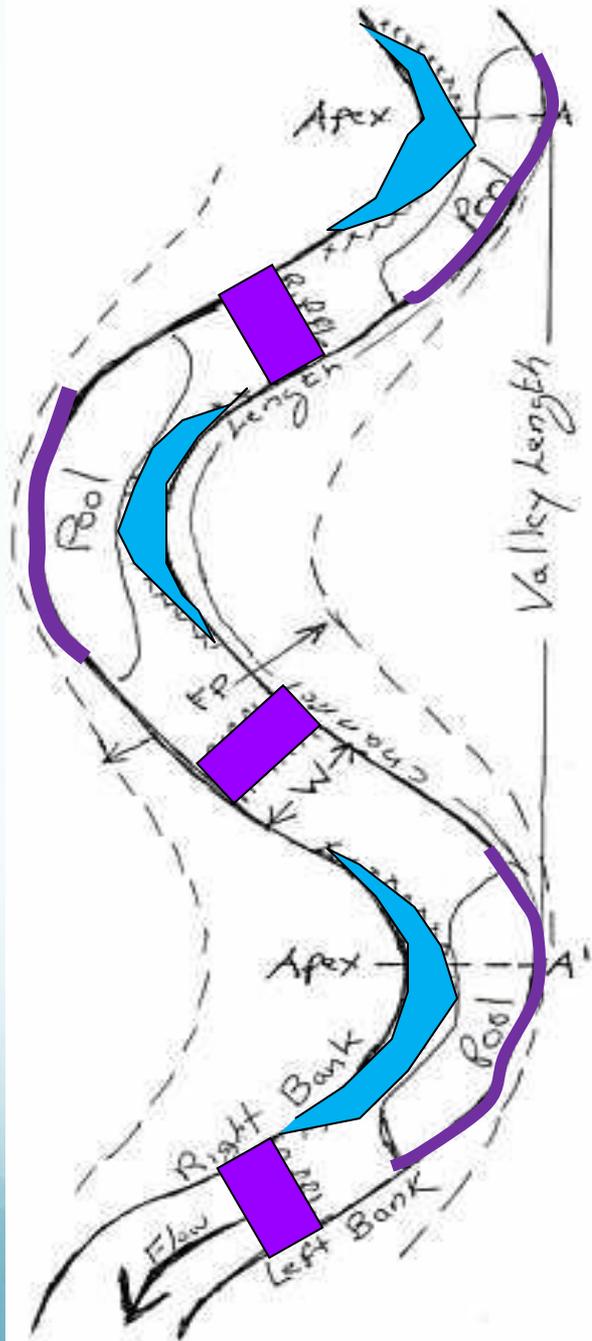
# Breakneck Creek, near Kent

- Meandering stream



# Meander anatomy

- Erosion occurs on the outside of the bend, forming **cut banks**.
- Deposition occurs on the inside of the bend, forming **point bars**.
- **Riffles** form at cross-over points between meanders



# Geomorphologic effects of urbanization

- Sediment yields usually increase during construction, but are low afterwards
  - Why?
  
- Watershed sediment yield: depends on relative decrease in erodibility due to impervious surfaces versus increase in peak flows → so channel is often main point of adjustment

# Geomorphic effects of urbanization

A wide range of changes to geomorphology have been reported:

- **Massive bank erosion during construction**
  - Constriction due to construction sediment
- **Channel enlargement and incision after construction**

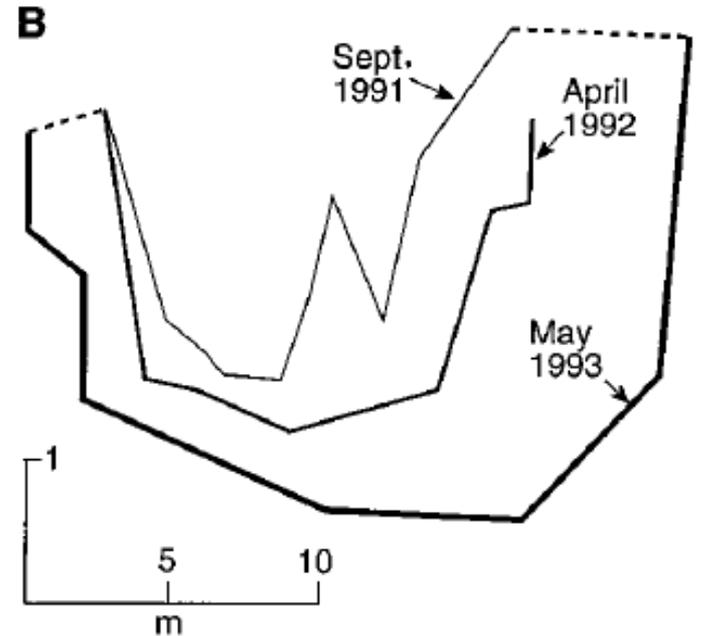
Enlarging upstream channels can supply sediment to downstream reaches
- **Increasing pool depth**
- **Decreasing complexity of channel form**
- **Changes to bed sediment sizes are inconsistent**
  - Coarsening of stream bed sediment, as fine sediments are scoured
  - Increasing percent of sand and silt in stream bed

**B**

1993

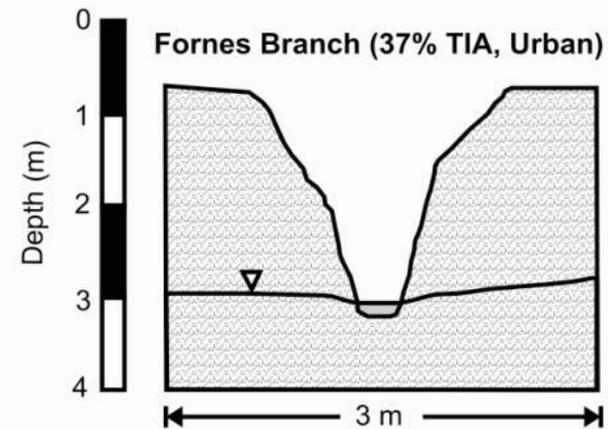
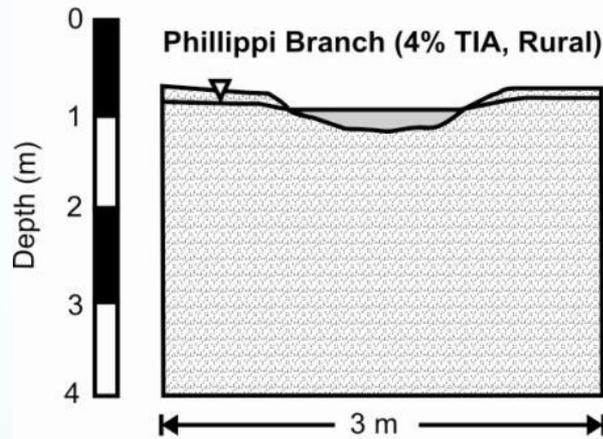
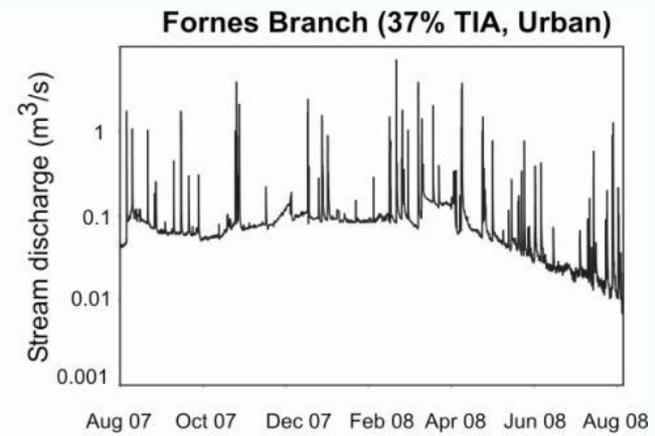
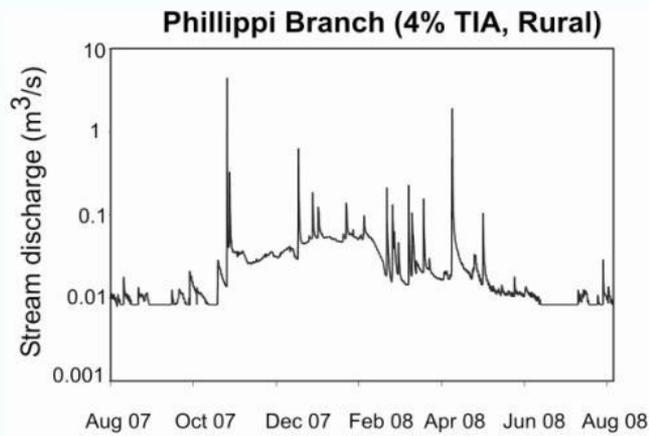


*Person is standing in the same spot*



During active urbanization →  
20 m<sup>3</sup>/m/year bank erosion  
= 2/3 of total sediment yield in  
Orange County watershed

Trimble, S.W. 1997. Contribution of stream channel erosion to sediment yield from an urbanizing watershed. *Science*. 278: 1442-1444.



Phillippi Branch (4% TIA, Rural)

Fornes Branch (37% TIA, Urban)



Simplified



McMillan/Tuttle

Incised



Stable



Aggraded



Top left photo by A. Tuttle, rest by Jefferson