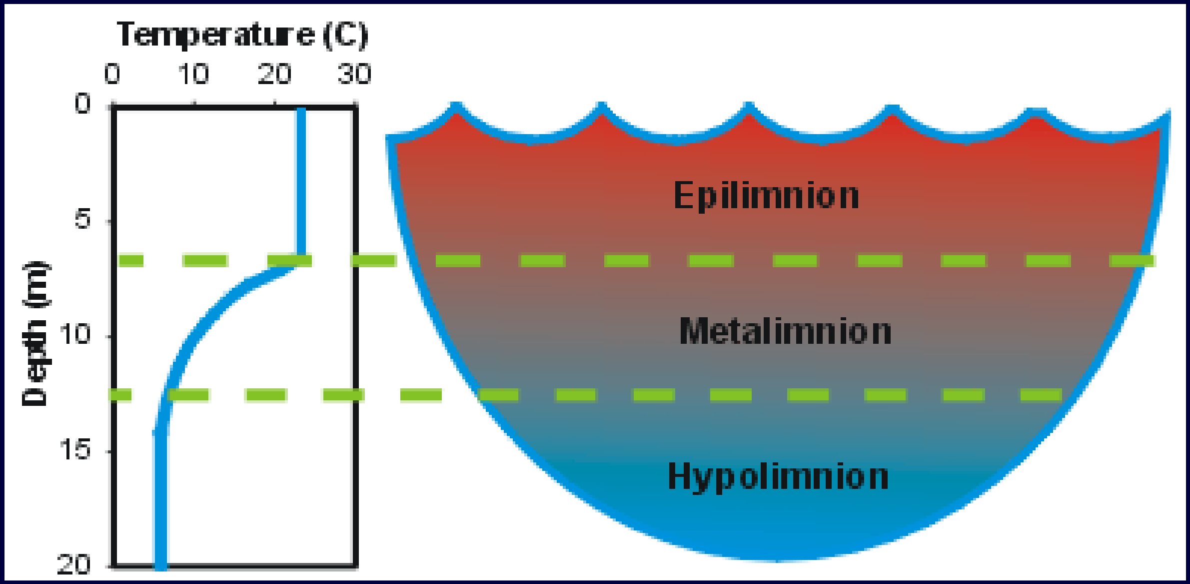
Stream environments

Limnology

Lecture 16

Depth/Stratification



weeks

months

years

Permanence

1000s of years

25,000,000 years

Nutrients

Flow requires radically different adaptations

Limnology

- Lentic
  - Still waters
  - Lakes, ponds, fens, marshes

- Lotic
  - Moving waters

Major environmental gradients in limnology

Lakes/ponds/wetlands

Permanence

Depth/stratification

Nutrients

Geology

Streams

Permanence

Flow

Nutrients

Geology

Names of streams

Stream
branch
brook
beck
burn
creek
kill
lick

Rill
bayou
rivulet
run
fork
prong
arroyo

River – waterway
Stream smaller
Creek
Brook

Stream water sources

Overland flow

Subsurface flow

Groundwater recharging

Base flow -- relatively constant groundwater input to streams

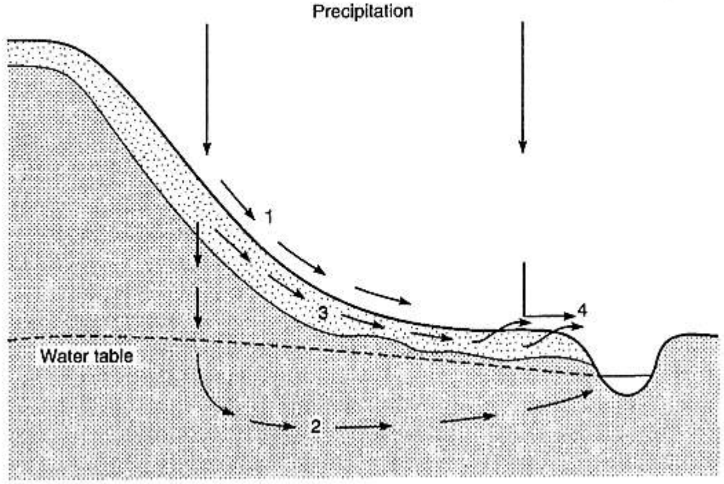


FIGURE 1.2 Pathways of water moving downhill. Overland flow (1) occurs when precipitation exceeds the infiltration capacity of the soil. Water that enters the soil adds to groundwater flow (2) and usually reaches streams, lakes, or the oceans. A relatively impermeable layer will cause water to move laterally through the soil (3) as shallow sub-surface stormflow. Saturation of the soil can force sub-surface water to rise to the surface where, along with direct precipitation, it forms saturation overland flow (4). The stippled area is relatively permeable topsoil. (Redrawn from Dunne and Leopold, 1978.)

Stream Order

Stream order – increases by one downstream with every confluence

1's beget 2's
2's beget 3's, . . .

Stream order only increases when 2 streams of = rank meet

What is the highest rank of a river?

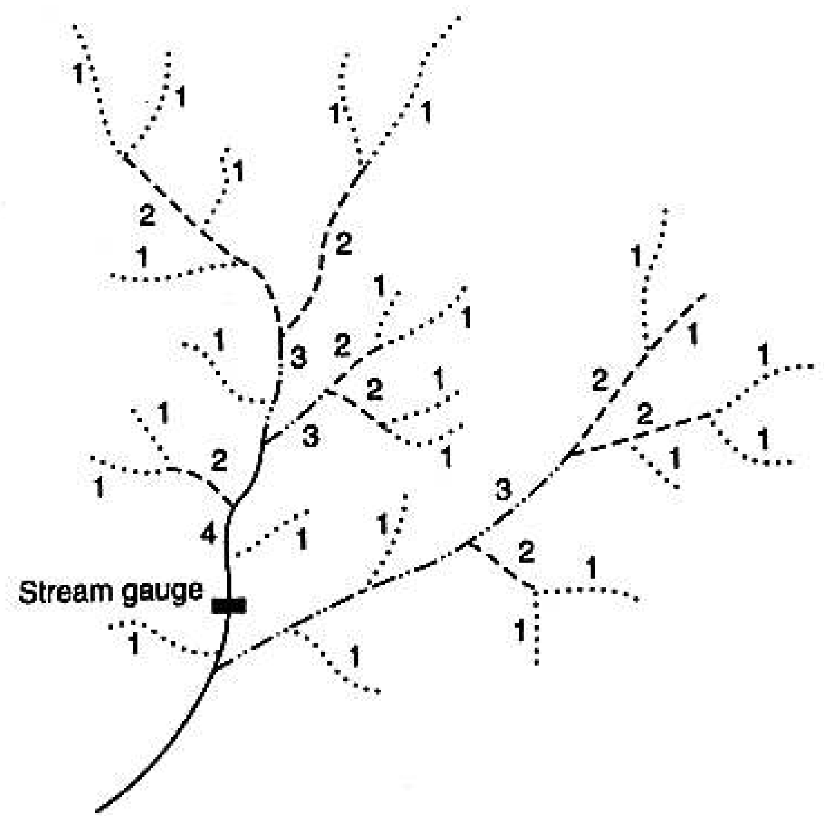


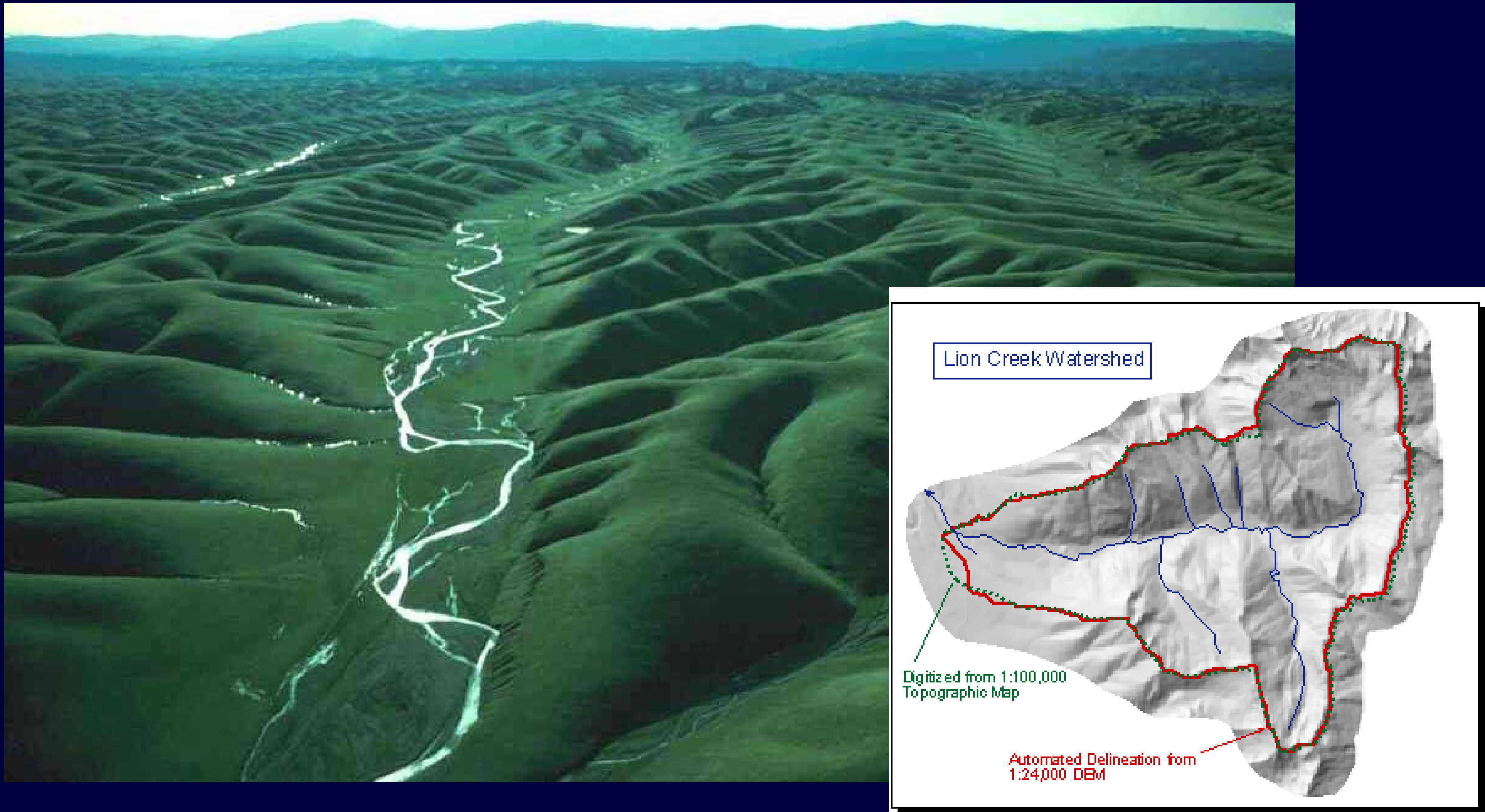
FIGURE 1.13 A drainage network illustrating stream order classification for a fourth-order watershed.

Amazon = 12, Nile, Mississippi = 10

Catchment or drainage basin

Sometimes called watershed

Area of land drained by river and its tributaries



“The valley rules the stream”

Stream affected by catchment

- energy sources (allochthonous)
- soil
- chemistry
- vegetation
- development

Scale is really important

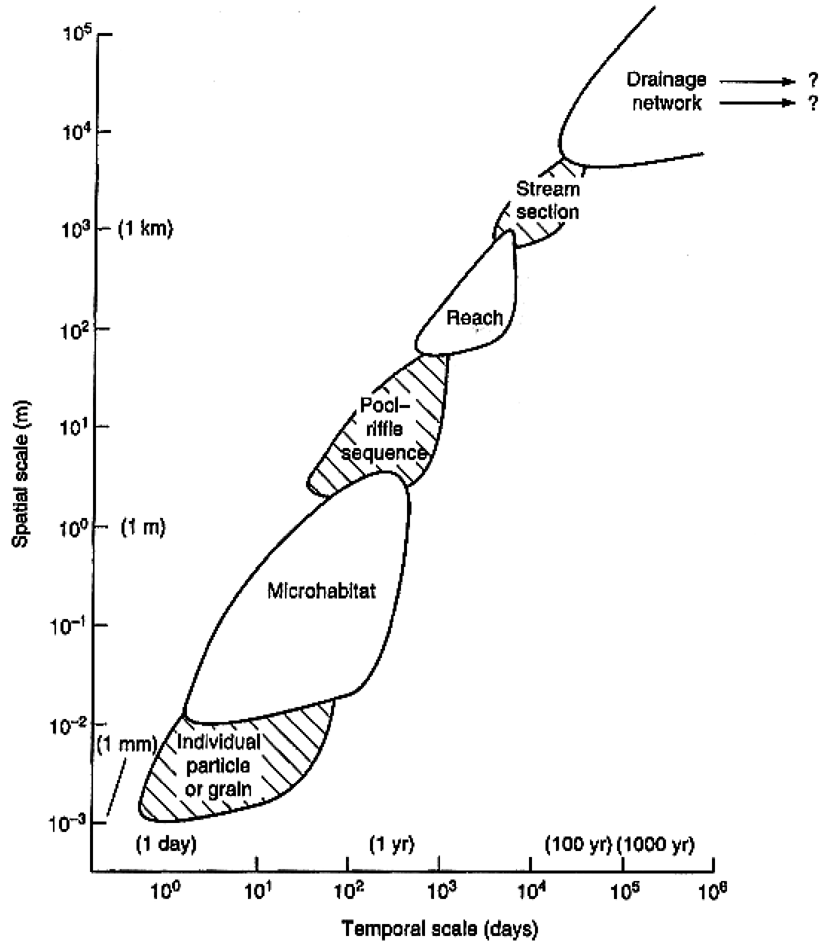


FIGURE 1.9 An approximate spatial and temporal scale over which physical change takes place in rivers. (From Frissell *et al.*, 1986.)

Hierarchical Organization

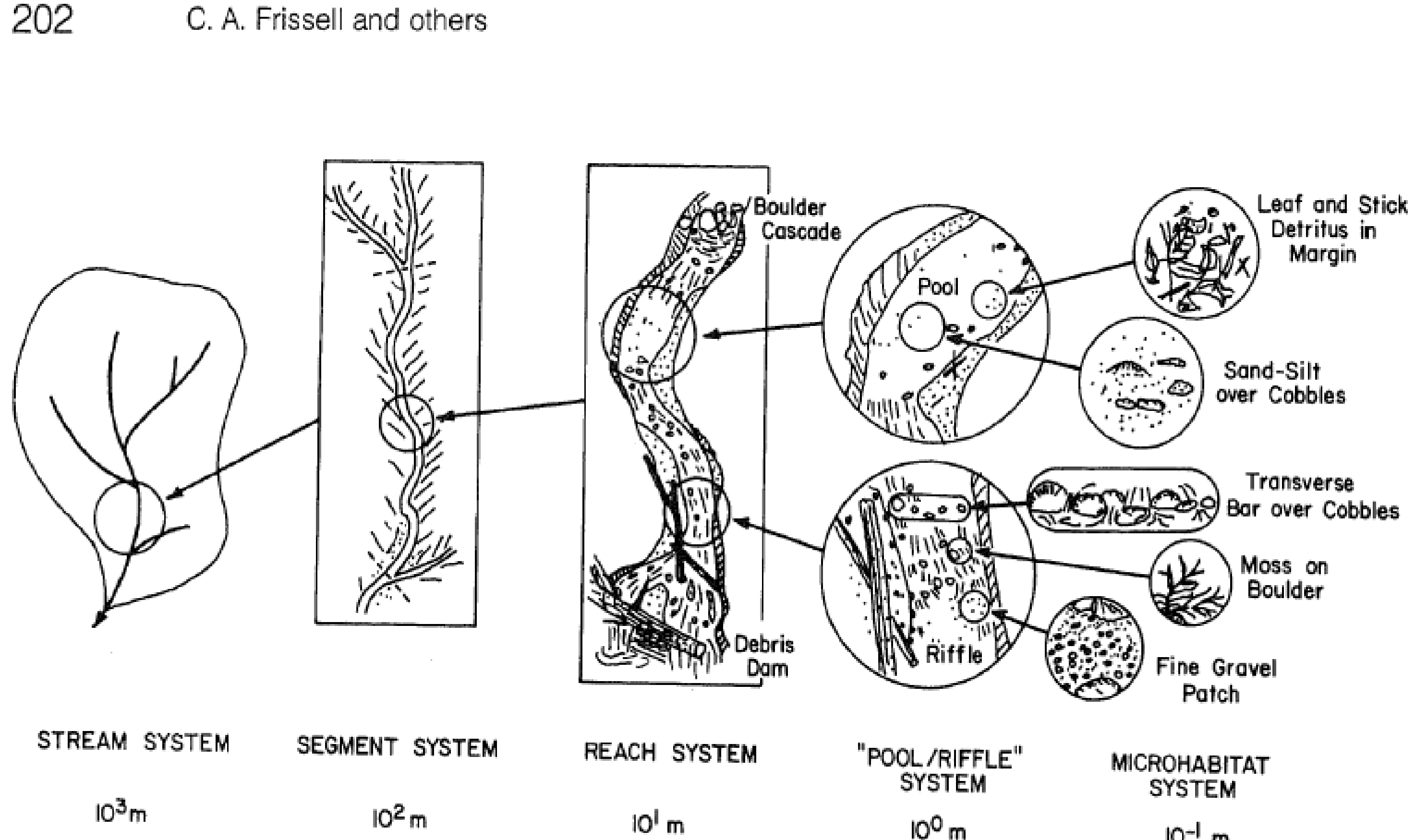


Figure 2. Hierarchical organization of a stream system and its habitat subsystems. Approximate linear spatial scale, appropriate to second- or third-order mountain stream, is indicated.

Higher level processes constrain lower level processes

Discharge

$Q = WDU$

Q = Discharge
(m^3/s or CFS)
W = Width
D = Mean Depth
U = Velocity

Why v-notch weir used?

Hydrograph

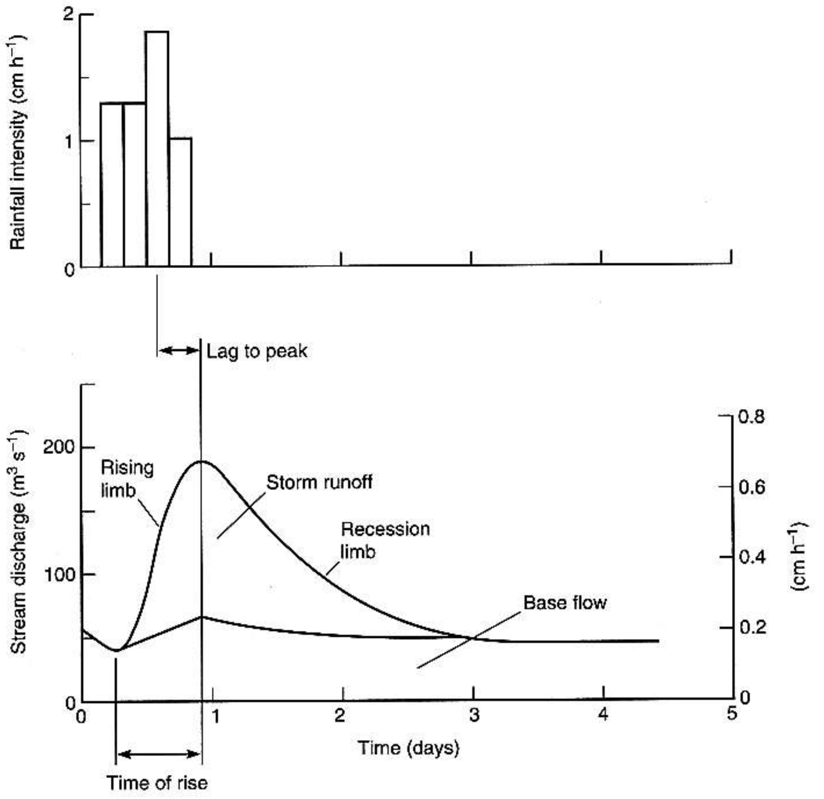


FIGURE 1.5 Streamflow hydrograph resulting from a rainstorm. (Redrawn from Dunne and Leopold, 1978.)

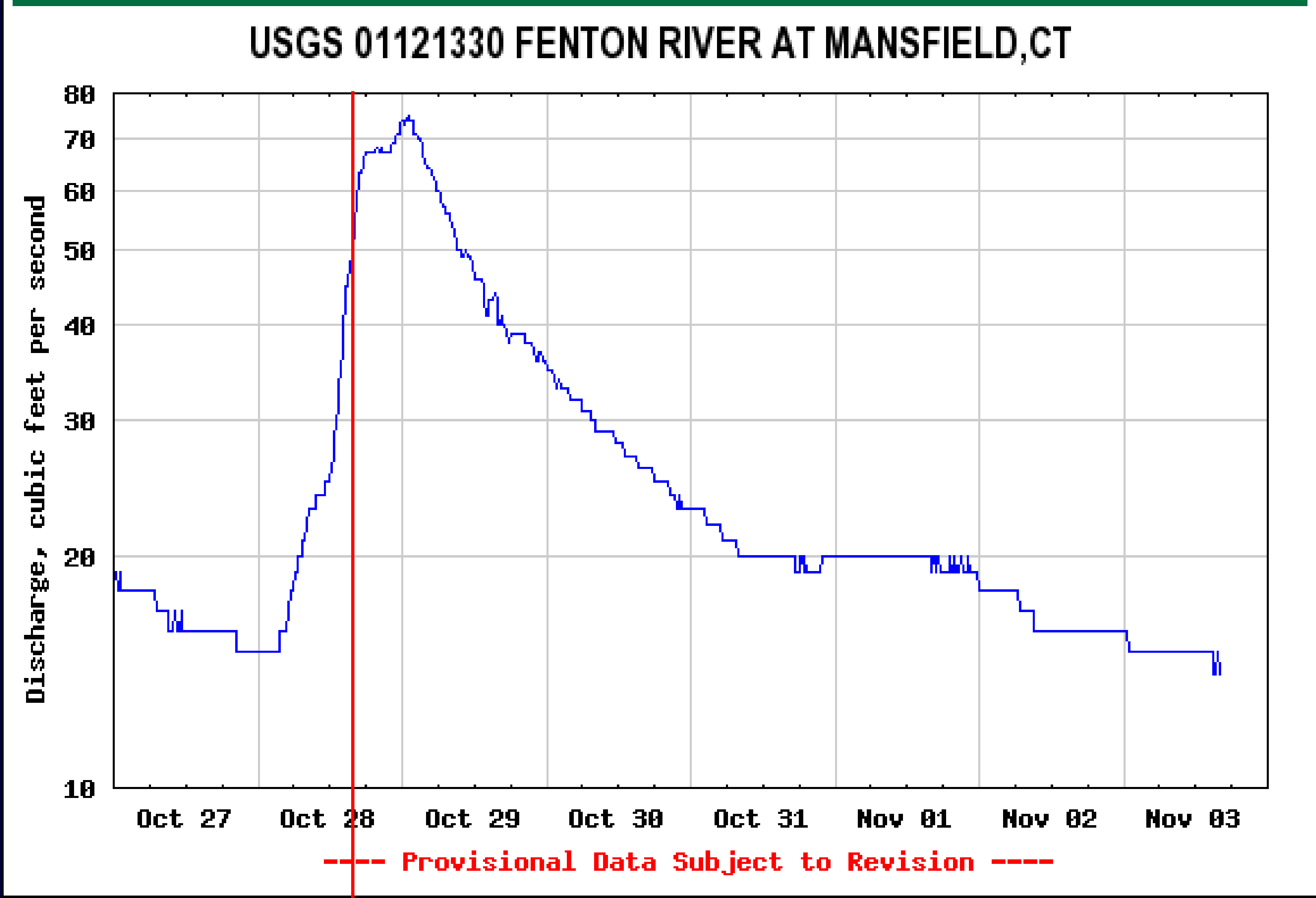
Discharge over time

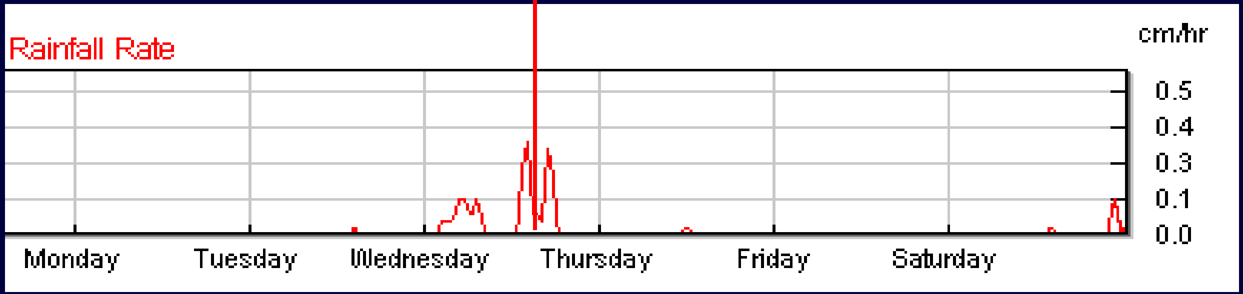
Rising limb

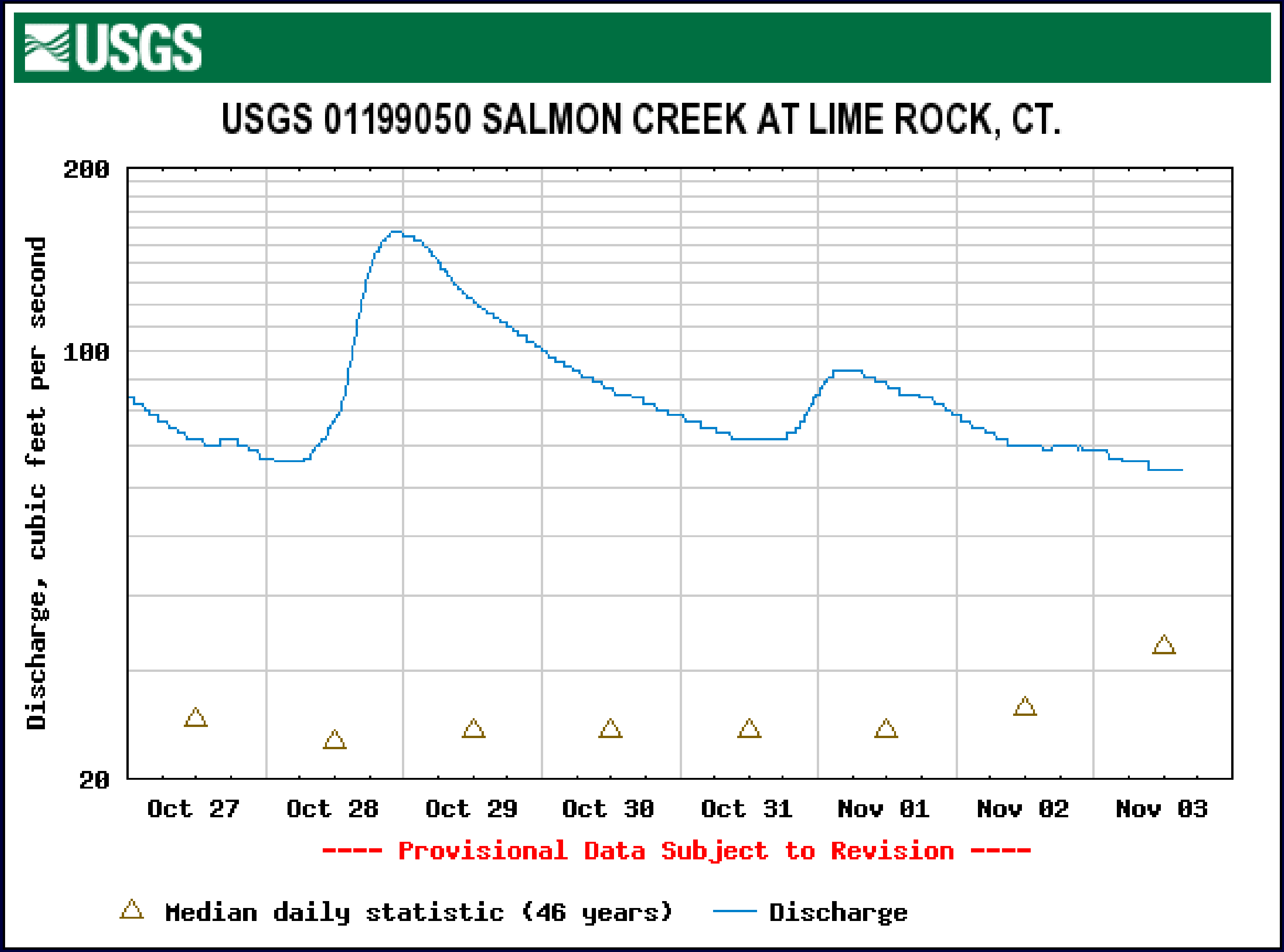
Lag to peak – difference between rainfall timing and peak flow

Recession limb

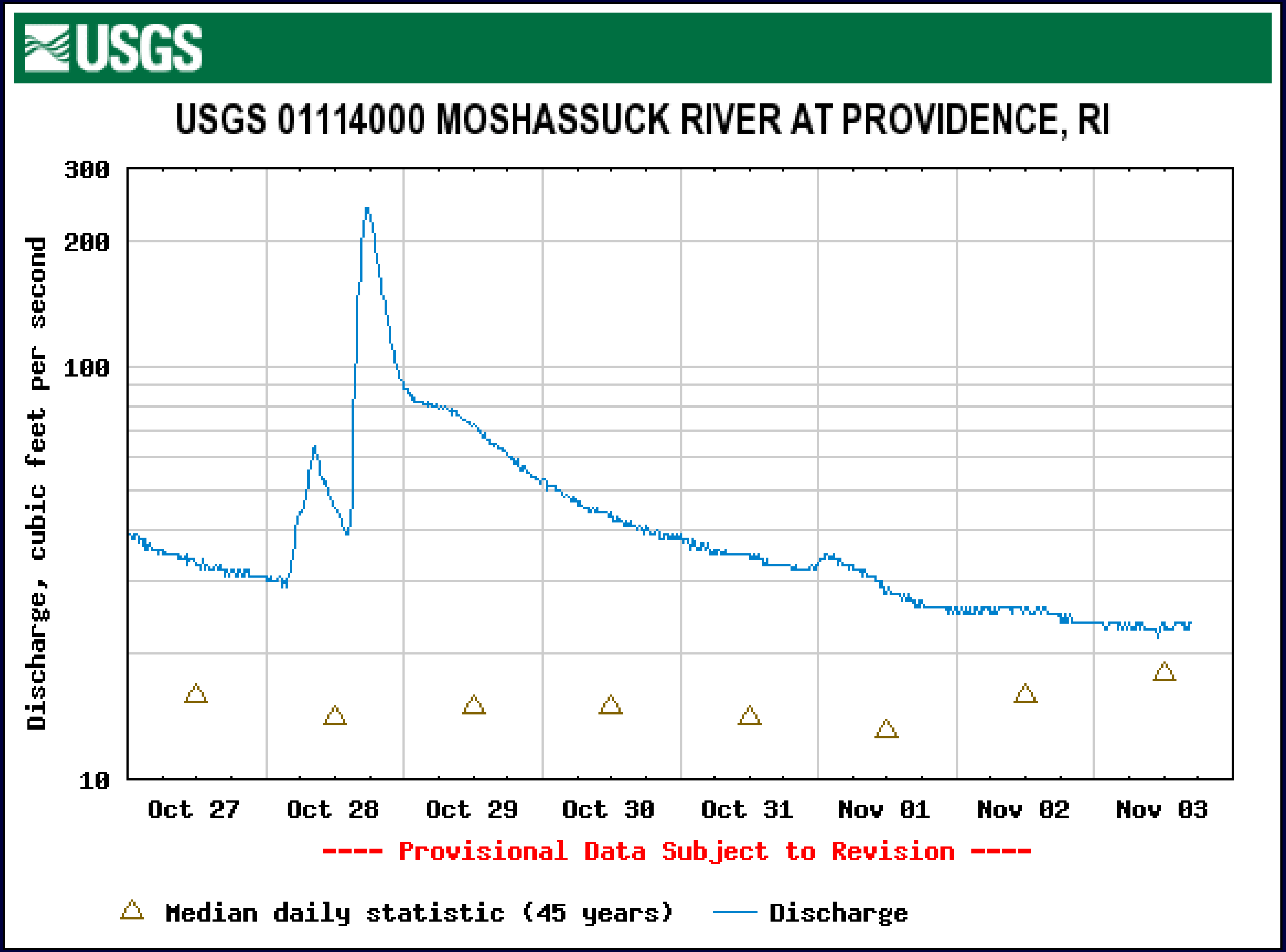
Base flow


USGS 01121330 FENTON RIVER AT MANSFIELD,CT
Discharge, cubic feet per second
80
70
60
50
40
30
20
10
Oct 27
Oct 28
Oct 29
Oct 30
Oct 31
Nov 01
Nov 02
Nov 03
---- Provisional Data Subject to Revision ----

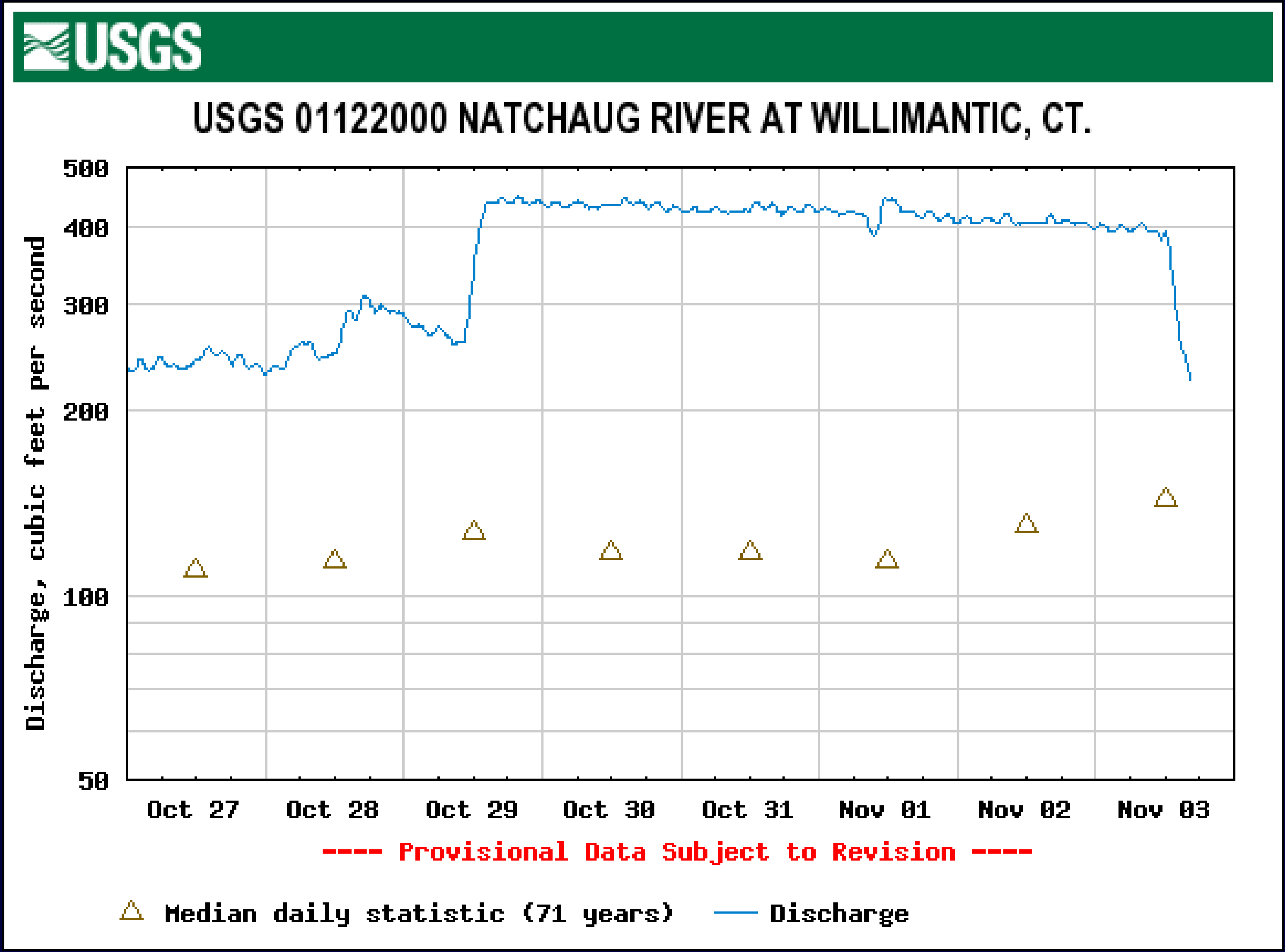

Rainfall Rate
cm/hr
0.5
0.4
0.3
0.1
0.0
Monday
Tuesday
Wednesday
Thursday
Friday
Saturday



Non-flashy stream



Flashy stream

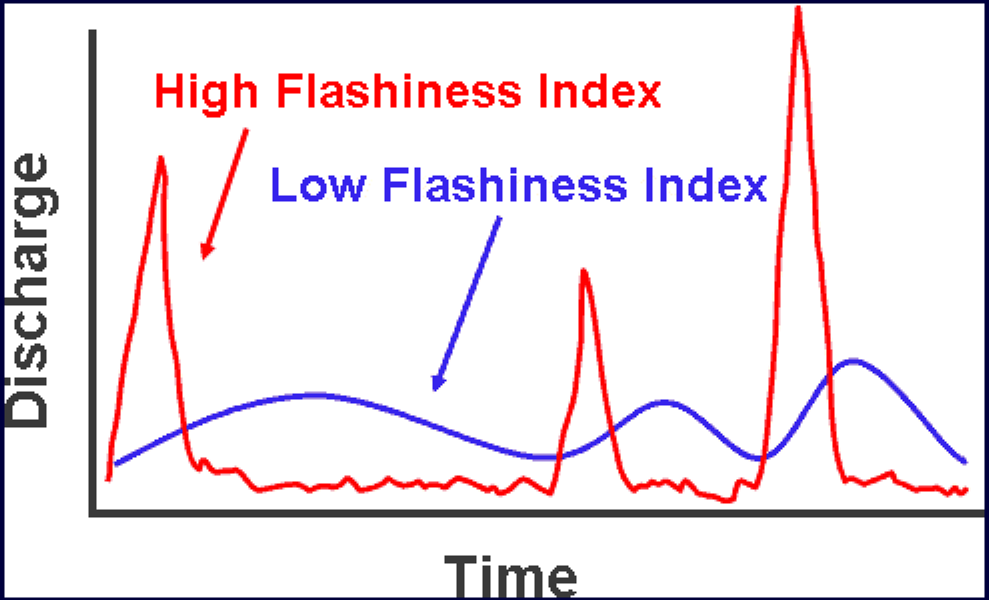

USGS
USGS 01122000 NATCHAUG RIVER AT WILLIMANTIC, CT.
Discharge, cubic feet per second
500
400
300
200
100
50
Oct 27
Oct 28
Oct 29
Oct 30
Oct 31
Nov 01
Nov 02
Nov 03
---- Provisional Data Subject to Revision ----
Median daily statistic (71 years)
Discharge

Flashiness

Frequent and rapid changes in stream flow

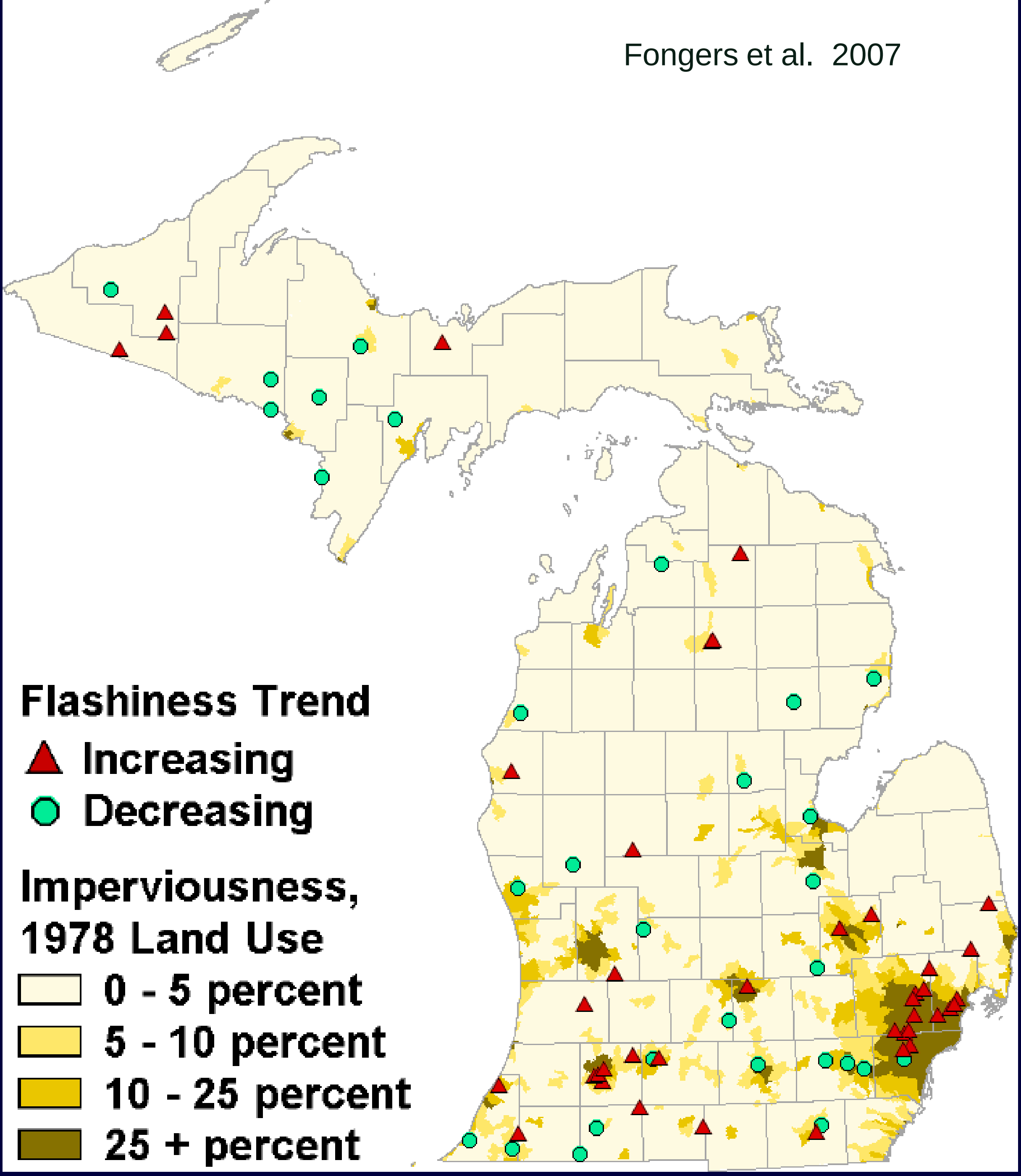
Reasons

1. Impermeable surface
2. Geology (poor drainage)
3. Low biological activity (roots)



Richards-Baker Flashiness
index = sum(daily flow differences)/ sum daily flows

Fongers et al. 2007



Flood Frequency

$$P = \frac{1}{T} = \frac{m}{n+1}$$

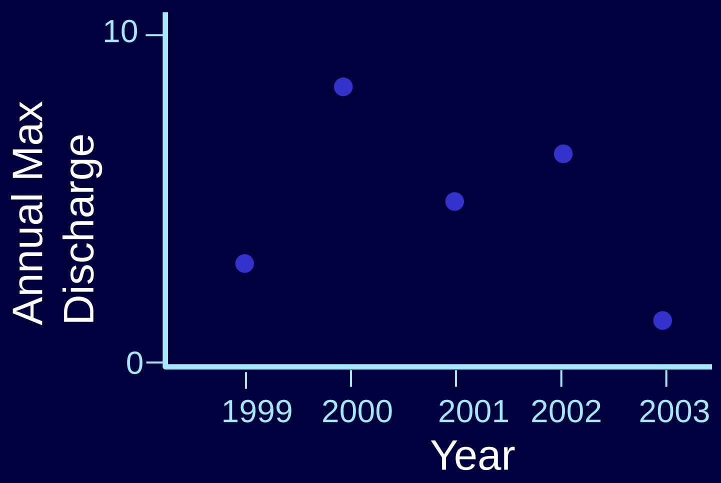
$$T = \frac{n+1}{m}$$

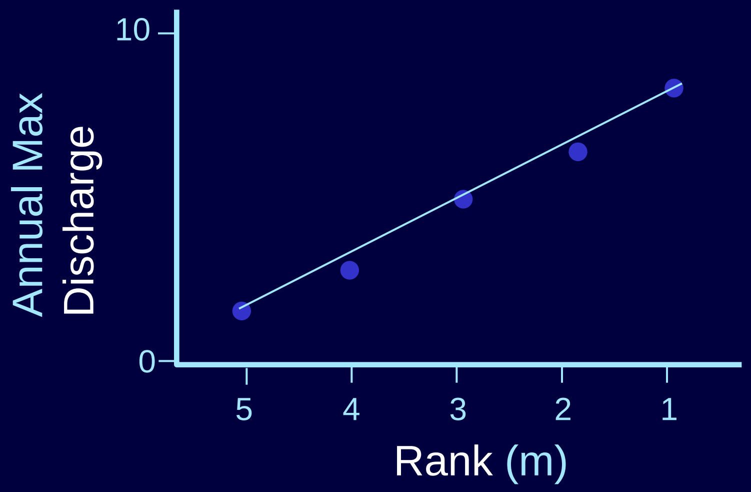
P = Probability of equalling or exceeding this value

T = Average recurrence interval

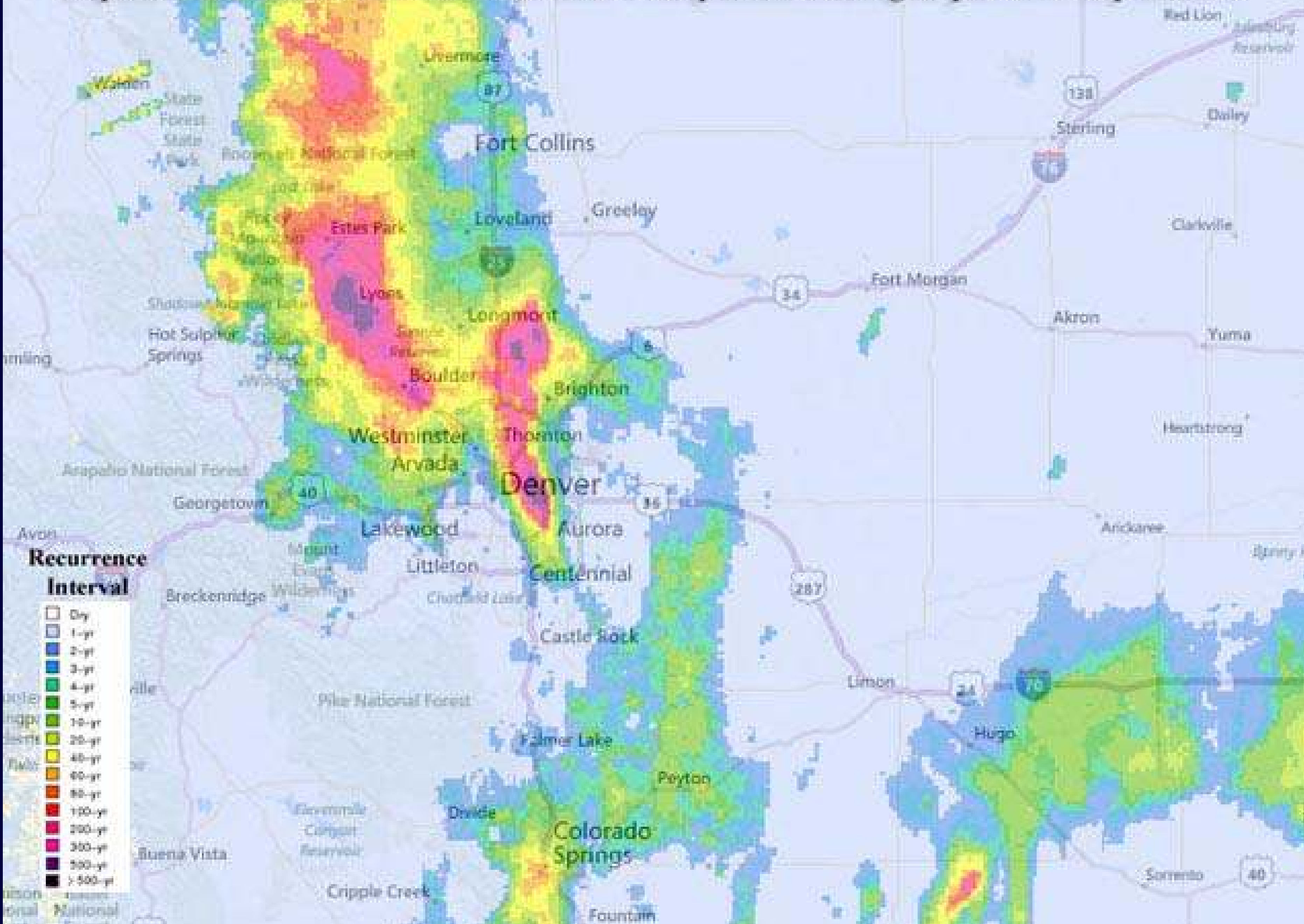
n = years of record

m = rank





Expected Recurrence Interval for 24-hour Precipitation Ending 12 pm MDT Sep 13, 2013



"100-year flood"

Flood water expected >= every 100 years, on average

Probability of occurring in a year?

Should be called "1 in 100 chance" flood

What is the chance that a 100-year flood occurs in a 100-year period?

$$\text{Prob. n-yr flood in n yrs} = 1 - (1 - Pf)^n$$

Pf = Prob. of flood in a year

n = no. of years

Flow

Approximate mean velocity = velocity at 0.6 depth or 0.8 surface velocity

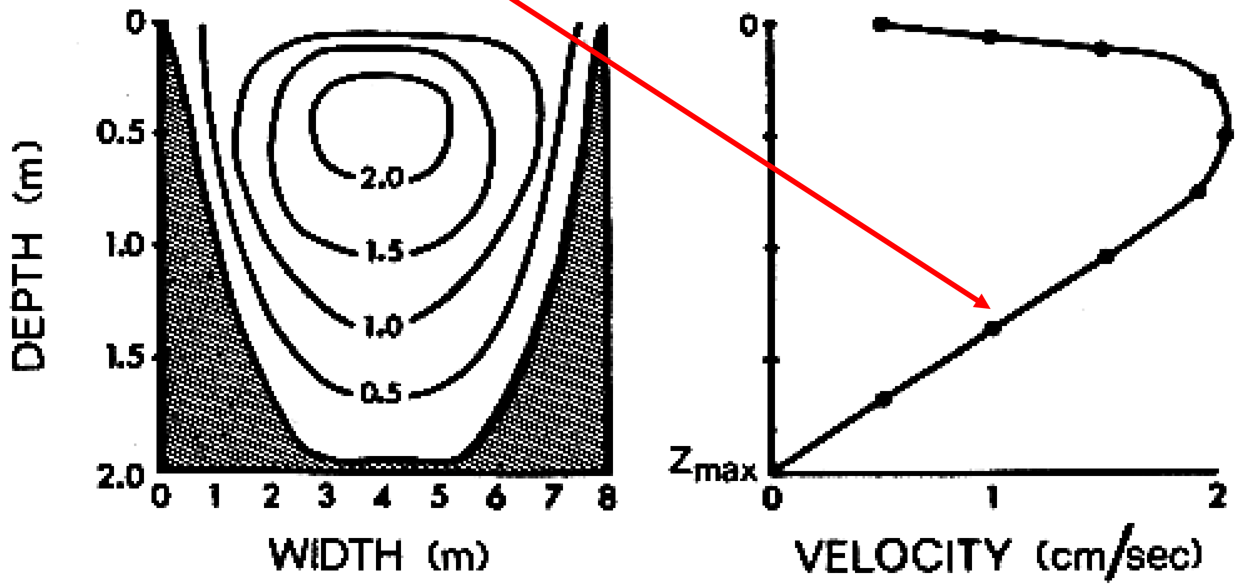
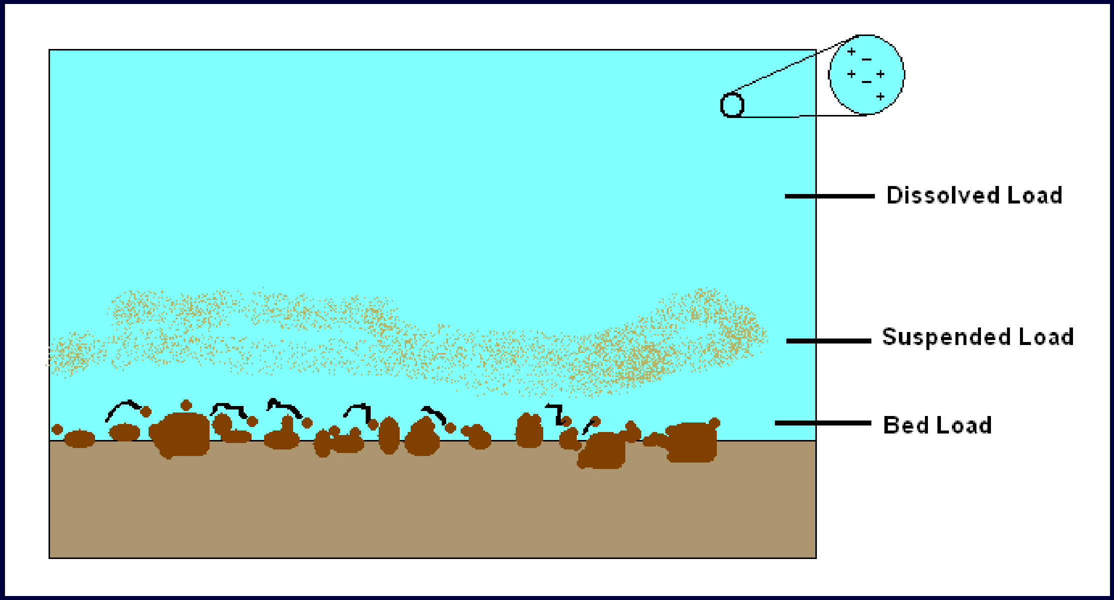


FIGURE 7-4 Idealized current velocity in cm sec^{-1} in a channel cross section (*left*) and in profile at the midpoint of the cross section (*right*). (From Wetzel and Likens, 1991.)

Material Transport

- Stream Load
  - Solid load
    - Bed load
    - Suspended load
  - Dissolved load



Sediment Transport

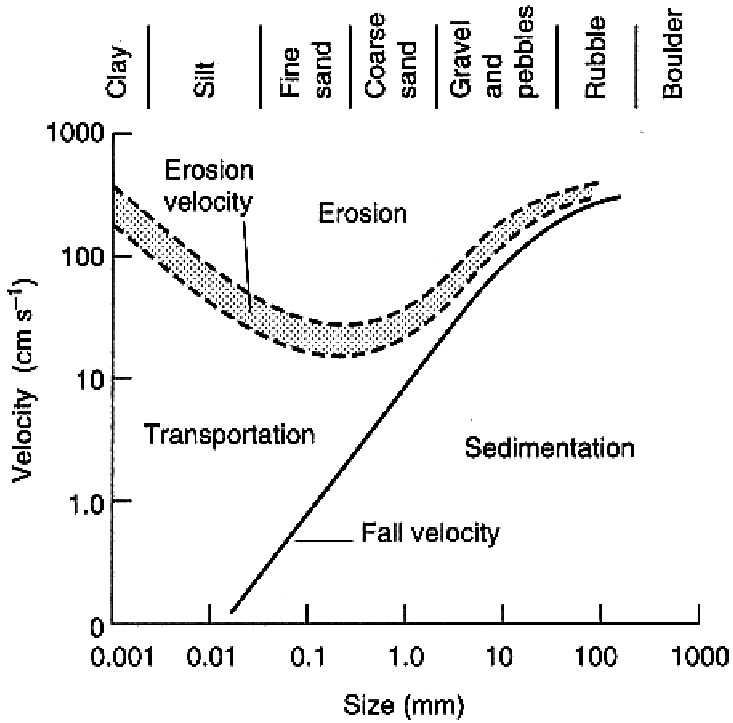


FIGURE 1.7 Relation of mean current velocity in water at least 1 m deep to the size of mineral grains that can be eroded from a bed of material of similar size. Below the velocity sufficient for erosion of grains of a given size (shown as a band), grains can continue to be transported. Deposition occurs at lower velocities than required for erosion of a particle of a given size. (Redrawn from Morisawa, 1968.)

Competence

- largest particle in bedload

Critical erosion velocity

- lowest velocity at which a particle will move

Gradual vs. Catastrophic Processes

Scablands

Grand Canyon

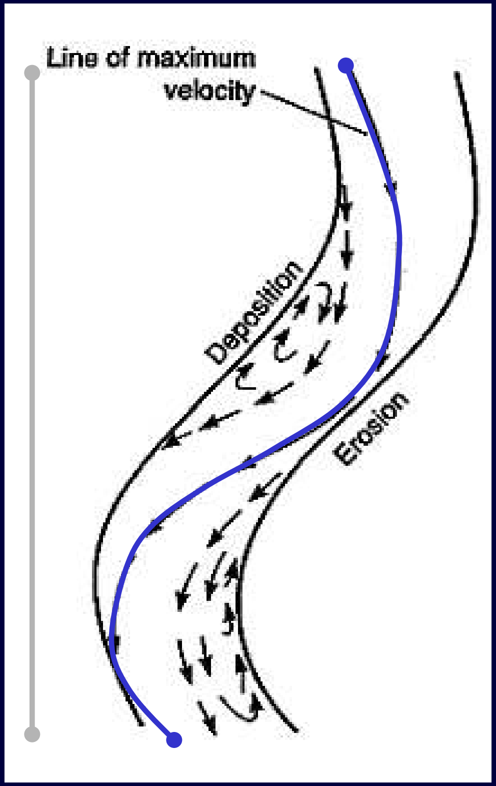
Sinuosity

$$SI = \frac{\text{Channel (thalweg) distance}}{\text{Downvalley distance}}$$

Sinuousity
Index

Thalweg = “valley line”

Continuous deep
channel



Erosion and Deposition

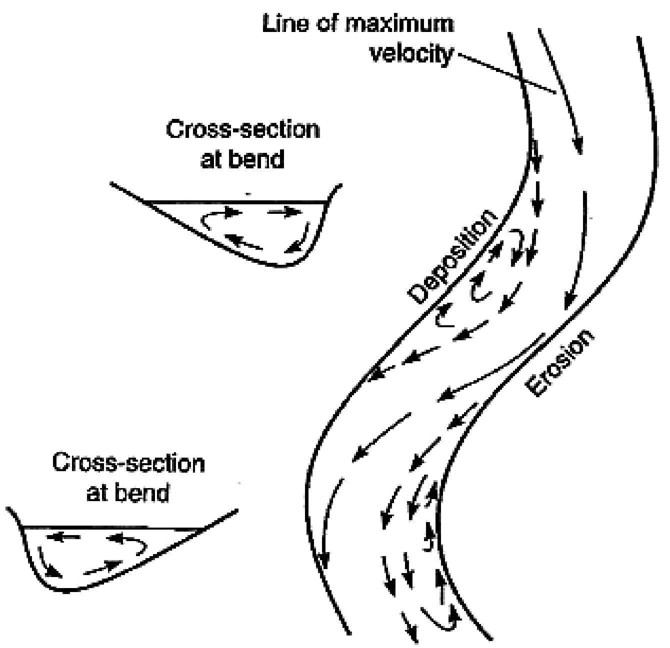


FIGURE 1.10 A meandering reach, showing the line of maximum velocity and the separation of flow that produces areas of deposition and erosion. Cross-sections show the lateral movements of water at the bends. (Redrawn from Morisawa, 1968.)

Human Impacts on Sediment Transport

Yellow River
(China)

Colorado River below Glen
Canyon Dam

Perennial vs. permanent