Stream Geomorphology

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What Functions do Healthy Streams Provide?

- Flood mitigation
- Water supply
- Water quality
- Sediment storage and transport
- Habitat
- Recreation
- Transportation
- Aesthetic qualities
When streams go wild

In Vermont, most flood damage is caused by fluvial erosion.
History of River Management

- Transportation
- Power
- Agriculture
How DYNAMITE streamlines streams

Practically every farm in the heavy crop-producing areas of the United States needs some ditching, and there is hardly a stream in the entire boundary of the Union that does not need to be corrected to give better service in discharging the large amounts of waste water from heavy rains, and to protect low lands.

FIG. 54. DIAGRAM OF STREAM TROUBLES THAT MAY BE CORRECTED BY BLASTING.

CROOKED STREAMS are a menace to life and crops in the areas bordering on their banks. The twisting and turning of the channel retards the flow and reduces the capacity of the stream to handle large volumes of water. Floods result. Crops are ruined. Lives are lost. Banks are undermined, causing cave-ins that steal valuable acreage.
Traditional River Management

- Goal - contain flow within straight channel
- Stream channels were:
  - dredged
  - bermed
  - armored
to withstand the increased stream power
Disaster Can Result

Energy kept in the channel during flooding can cause catastrophic damages downstream.
Streams are Indicative of Watershed Condition

A change in the watershed will impact the stream network
Disturbance-induced changes in stream structure and function

changes in land or stream corridor use

- changes in geomorphology and hydrology
- changes in stream hydraulics
- changes in function such as habitat, sediment transport, and storage
- changes in population, composition, and distribution, eutrophication, and lower water table elevations
Fluvial Geomorphology

Channel characteristics (e.g., sinuosity, width, depth) are determined by stream discharge and sediment

Influenced by:

- Watershed area
- Land use and land cover
- Soils and geology
- Topography
- Climate
- Human impacts
Streams Adjust to Changing Conditions

1. Lateral
2. Vertical
3. Longitudinal
4. Temporal

Lateral Channel Migration
Vertical Movement of Stream Channel

1992 - 2007
Stream Corridor Longitudinal Profile
(dominated by slope)

Headwaters
Transfer zone
Deposition zone

Miller, 1990
Temporal Changes in Stream Channel

Approximate location of 1900 channel

Channelized reach along toe of valley wall (today)

Lewis Creek
Stream Channel Patterns

- **Straight channels**
  - indicative of strong geologic structure (bedrock) or human control

- **Braided streams**
  - multiple interwoven channels

- **Meandering channels**
  - highly variable, sinuous
Pool and Riffle Sequence
Water is the Driver

Runoff

Horton overland flow

Shallow subsurface flow

Groundwater flow

Litter layer

Water table
Velocity vs. Discharge

\[ Q = v \times A = \text{Discharge (cfs)} \]

\[ v = \text{Velocity (ft/s)} \]

\[ A = \text{Cross-Section Area (ft}^2\text{)} \]
Velocity affects erosion and deposition

Faster flow -> erosion

Slower flow -> deposition
Shaping and Reshaping of Channels

- As gradient (slope) decreases, stream flow meanders -> lateral erosion
- Since flow is faster around the outside of a bend, meanders shift sideways by eroding their outer bank
- Since flow is slower on the inner bank, sediment is deposited
Channel Migration Process
(Planform Change)
Water and Sediment Connection

- Head
- Steeper gradient
- Longitudinal stream profile
- Gentler gradient
- Mouth

Flow velocity
Particle size on stream bottom
Discharge
Longitudinal Summary

High elevation
Steep slopes
V-shaped valleys
Narrow channels
High velocity
Erosion (vertical)

Flat, broad floodplain
Low slopes
Meandering channels
Lateral erosion
High discharge
Deposition dominates

Gentle slopes
Streams merge
Channels begin to meander
Floodplain broadens
Channels widen
Erosion and deposition

Miller, 1990
A stable stream transports the water and sediment produced by its watershed, such that over time it maintains its dimension, pattern, and profile, while neither degrading nor aggrading. However, if any factor changes, the other variables must change to reach a new equilibrium.

The amount of sediment and the size of the sediment particles that can be transported in a stream are directly related to the gradient (slope) of the stream channel and amount of water flowing in the stream channel at a particular time.

Lane (1955)
Storm > ↑ Discharge >>> Degradation
Sediment Supply

Discharge

Waterfall > Slope >>> Degradation
Road Construction
(assume no change in stream power)
Upstream Dam
Out of Balance

• When a stream is unstable, i.e. out of balance, it is either **aggrading** (gaining sediment along its bed and banks) or it is **degrading** (deepening or widening due to the removal of sediment)
What Can Change Streamflow?
(Dynamic equilibrium)

- Vegetative Clearing
- Channelization
- Streambank armoring
- Development
- Bare soil
- Irrigation or drainage
- Overgrazing
- Roads and railroads
- Dams
- Water withdrawal
- Storms
Examples

- Culverts
- Agricultural ditches
- Channel straightening
- Rerouting
Constrictions

Stream crossings
  - roads
  - railroads
  - bridges
Road culverts
Channelization
Dams
Bedrock
What's going on here?

- Bedrock control
- Alluvium

Elevation (m)
- High: 212
- Low: 136
Storm events can trigger catastrophic floods

- **Baseflow** - sustained amount of flow in a stream when no precipitation event has occurred
- **Peak discharge** - stream flow attributed to a precipitation event
Greater runoff and higher in-stream velocities contribute to streambank erosion

Causes of bank erosion
  – Lack of riparian buffers
  – Channelization
  – Dams
  – Overgrazing
  – Commercial dredging
  – Piped discharge
    • (culverts, ditches)
  – Development
    • Impervious surfaces
Sediment in Streams and Rivers

- Leading non-point source of pollution
- Largest source of impairment to streams and rivers worldwide (EPA)
- Decreased water quality
- Negatively impacts habitat health

Tropical storm Irene (02 September 2011)
Bank Protection

- Cedar trees
- Rock rip-rap (armoring)
Armoring moves the problem downstream...
Development increases runoff

- ↑ Impervious surfaces
- ↓ Riparian buffers
- ↑ Stormwater inputs
- ↑ Peak discharge (flooding)
- ↑ Sediment loading

![Before and after development comparison](image)

**Graph:**
- **Y-axis:** Stream Flow (cfs)
- **X-axis:** Time
- **Legend:**
  - Post development
  - Pre development
Google Earth Activity

1. Photointerpret stream features along Browns River
   • Stream features
     • erosion
     • deposition
   • Channel modifications
     • straightening, armoring, ditches, dams
   • Channel adjustments