McMaster University

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Fluvial Geomorphology at McMaster

What does channel-scale nature-based infrastructure aim to do?

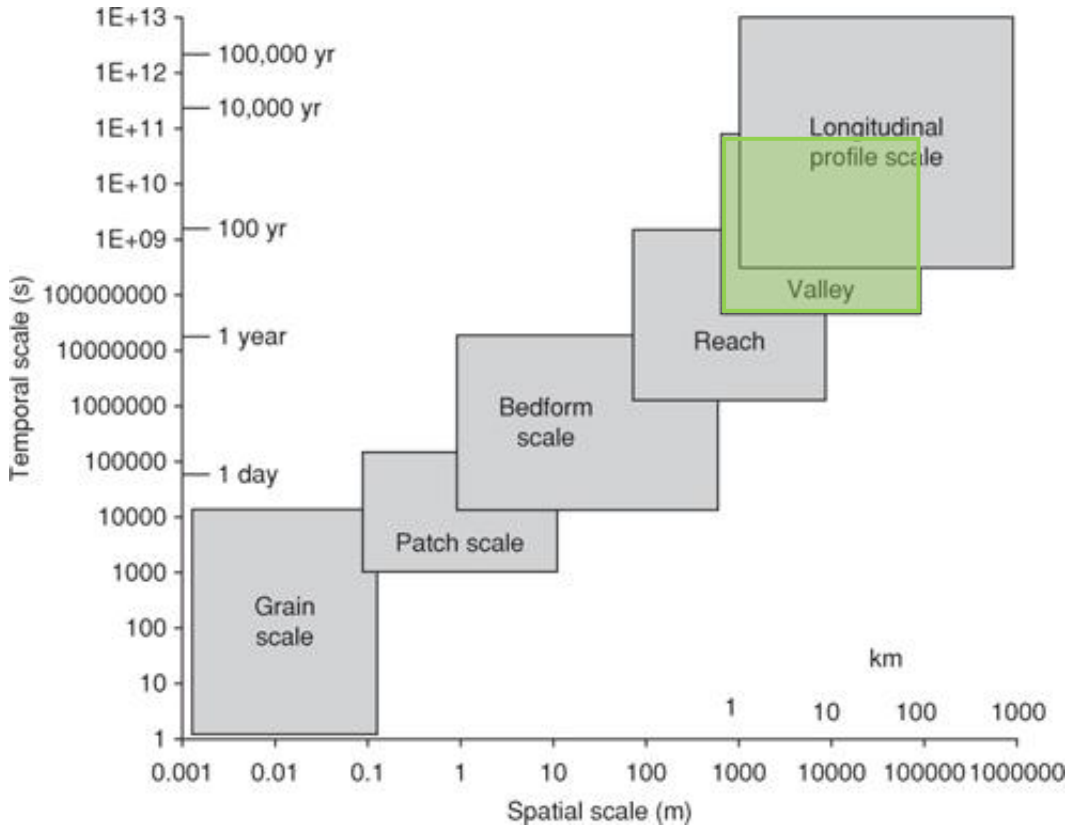
Elli Papangelakis

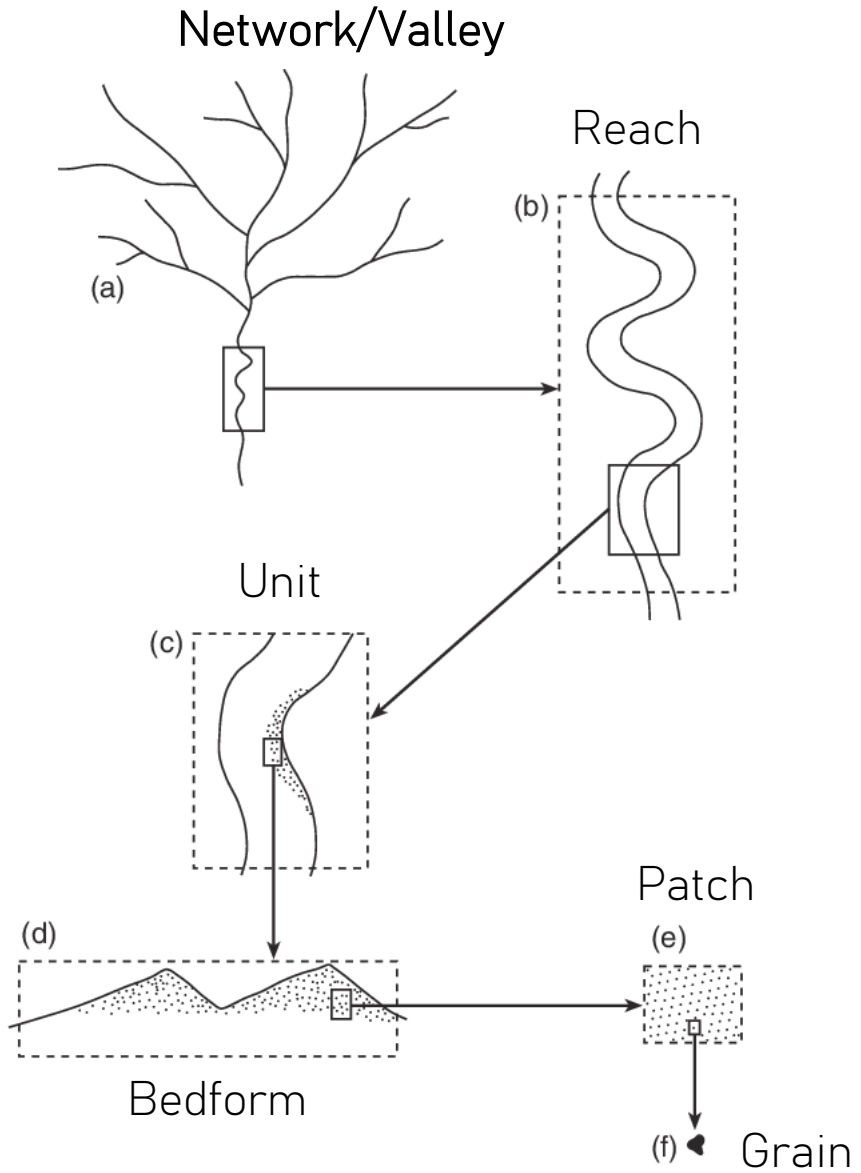
8th Natural Channels Conference

June 9, 2026

McMaster University, Hamilton, Ontario

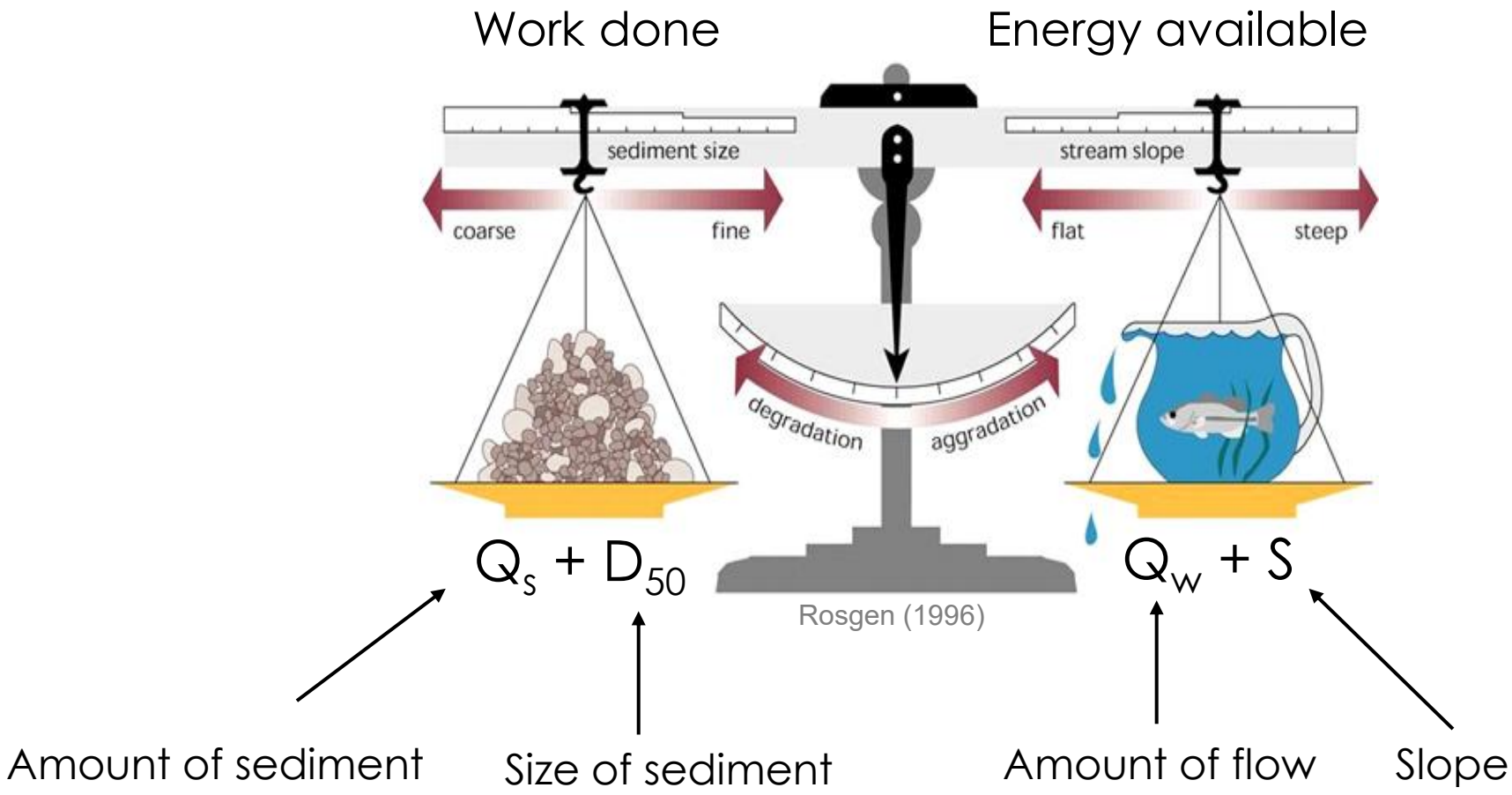
Nature-based Infrastructure Scales





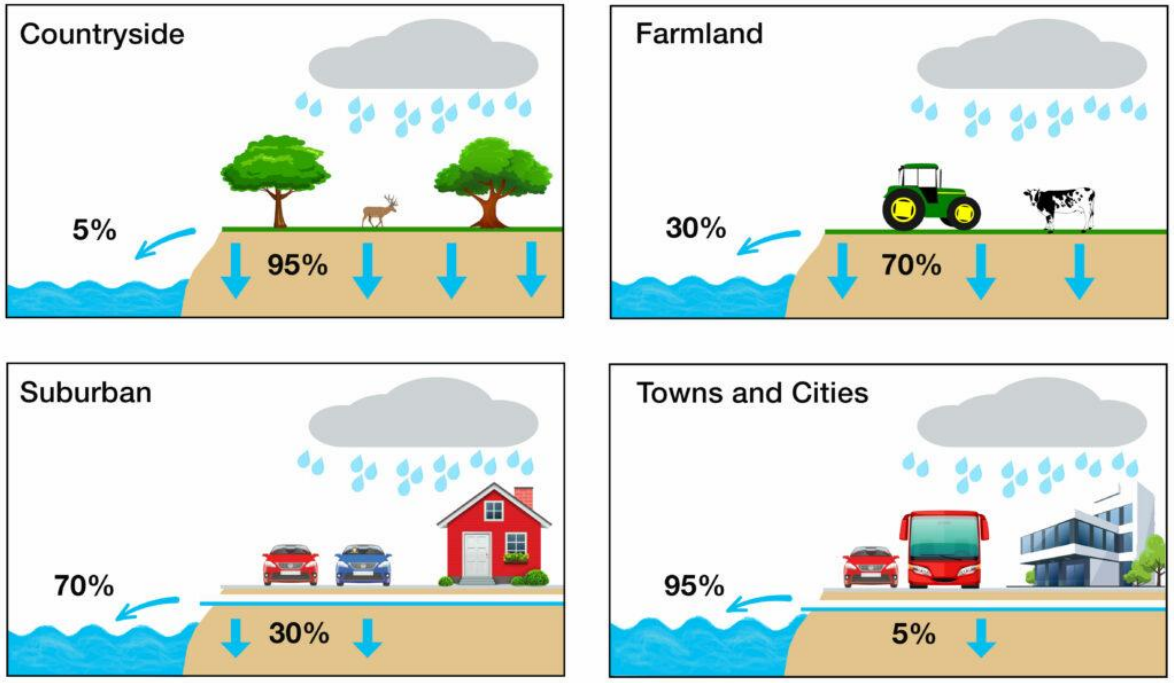
Rivers in Balance

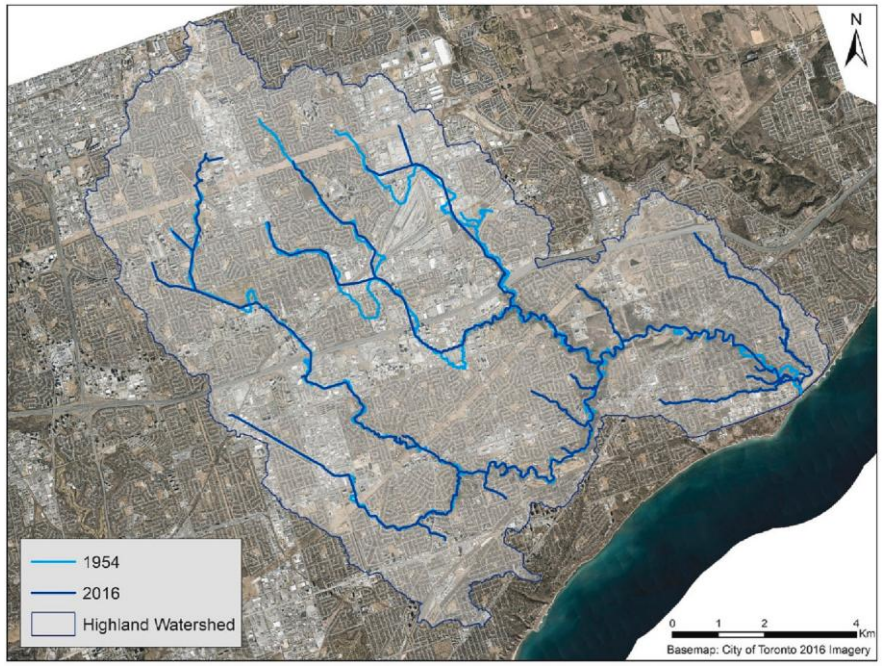
Lane's Balance:



Example: Urban Rivers

- Increased runoff from paved surfaces
- Efficient storm stewer systems
- Decrease in sediment delivery
- Straightening (= steepening)

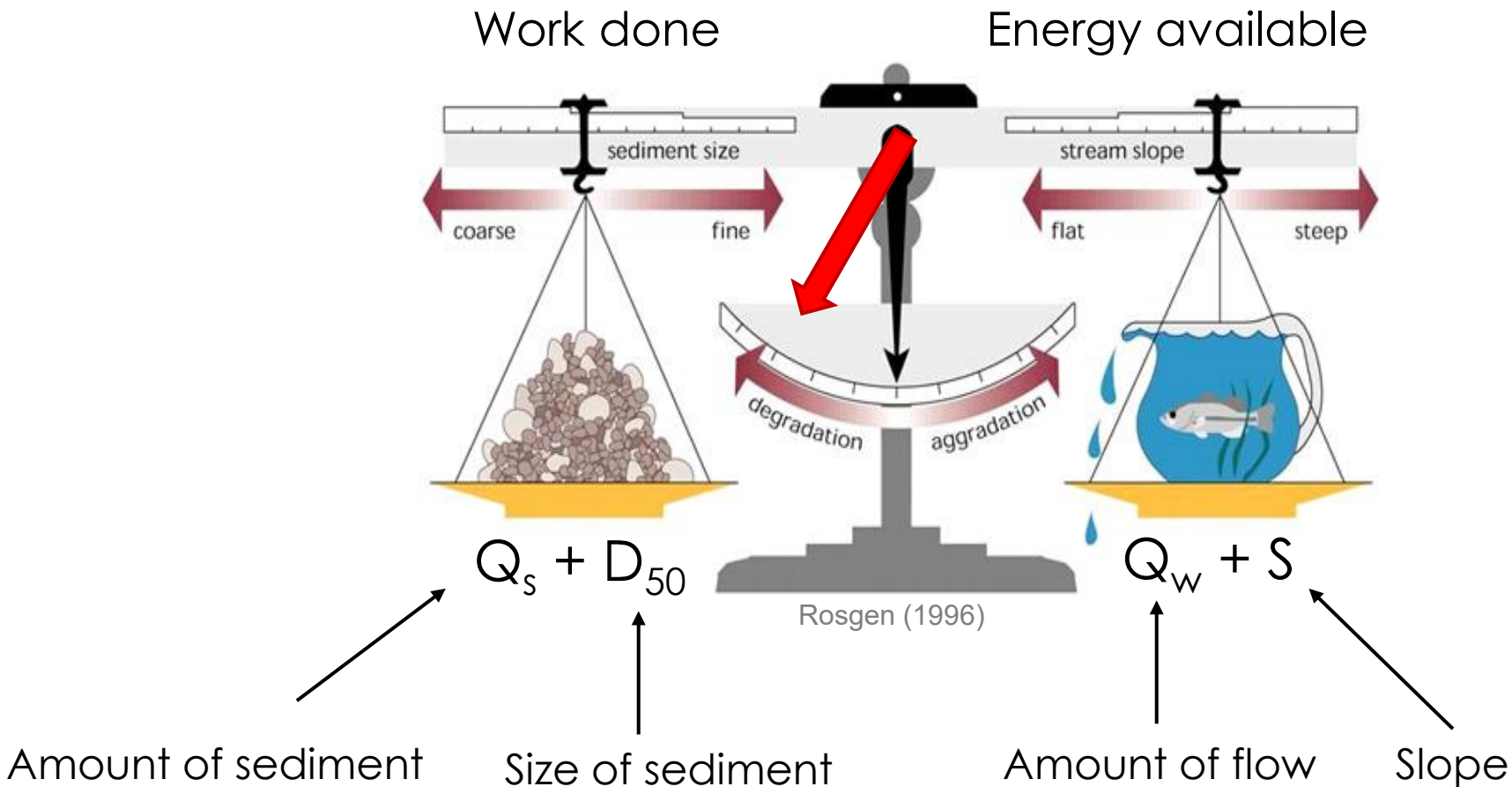




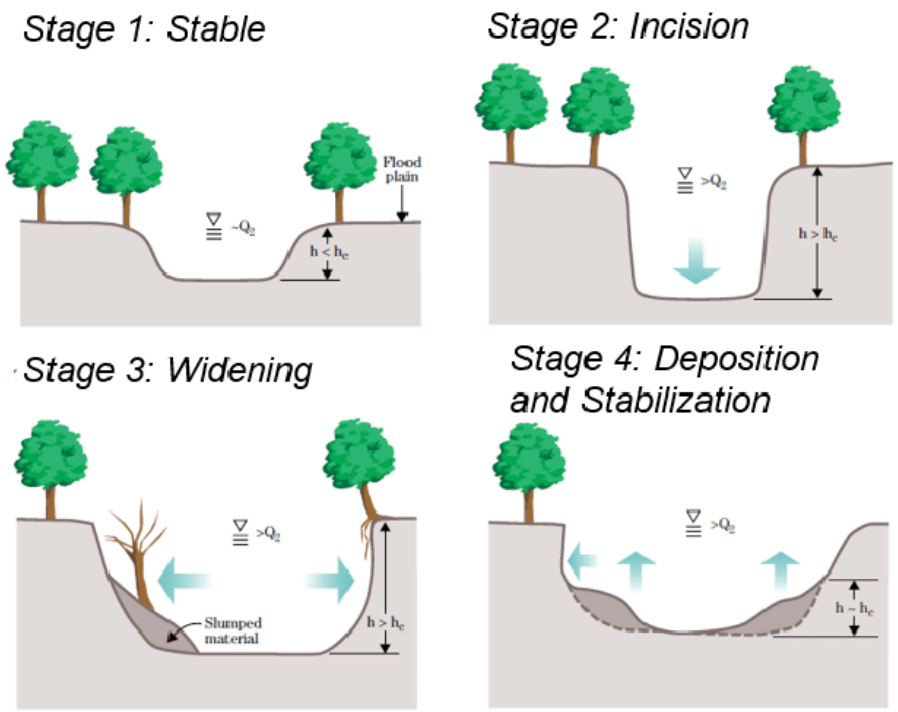
Ashmore et al. (2023)

Rivers in Balance

Lane's Balance:



What does “river degradation” look like?



Yochum & Reynolds (2020)

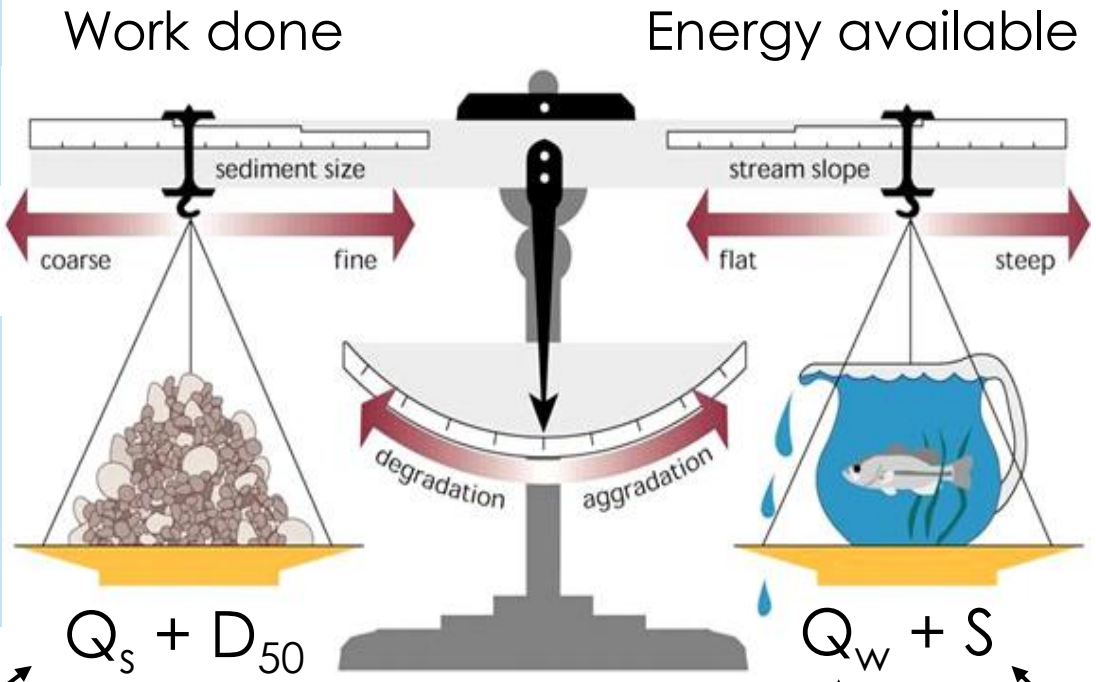
Other river stressors work in a similar way

Forest fires:
- Increase in sediment supply
- Increase in Q

= DISEQUILIBIRUM

Dams:
- Decrease in sediment supply downstream
- Disruption of Q regime

= DISEQUILIBIRUM



Climate change:
- Increase in Q

= DISEQUILIBIRUM

Irrigation Use:
- Decrease in Q
- Increase in S

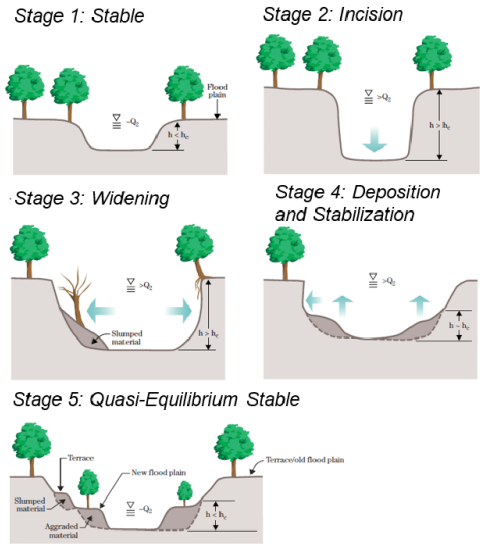
= DISEQUILIBIRUM

How can nature-based infrastructure help?

Broadly, in three ways:

1

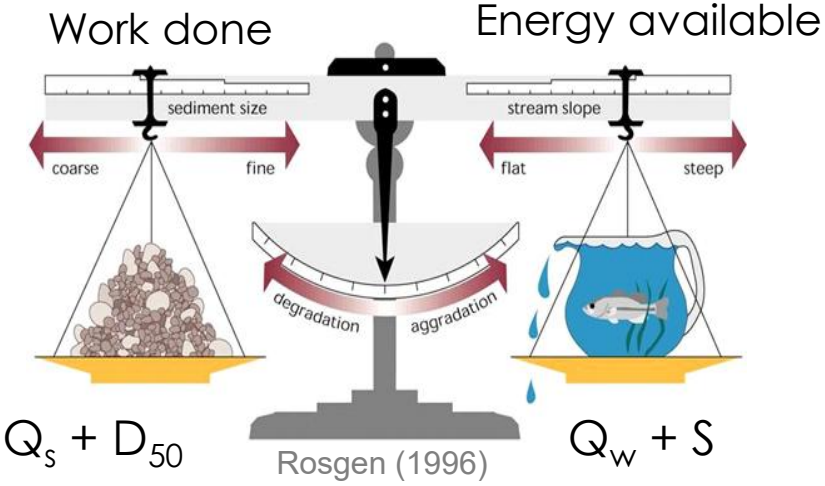
Design channels to accommodate new flow and sediment regime



Yochum & Reynolds (2020)

2

Try to rebalance the scale by changing the variables on either side

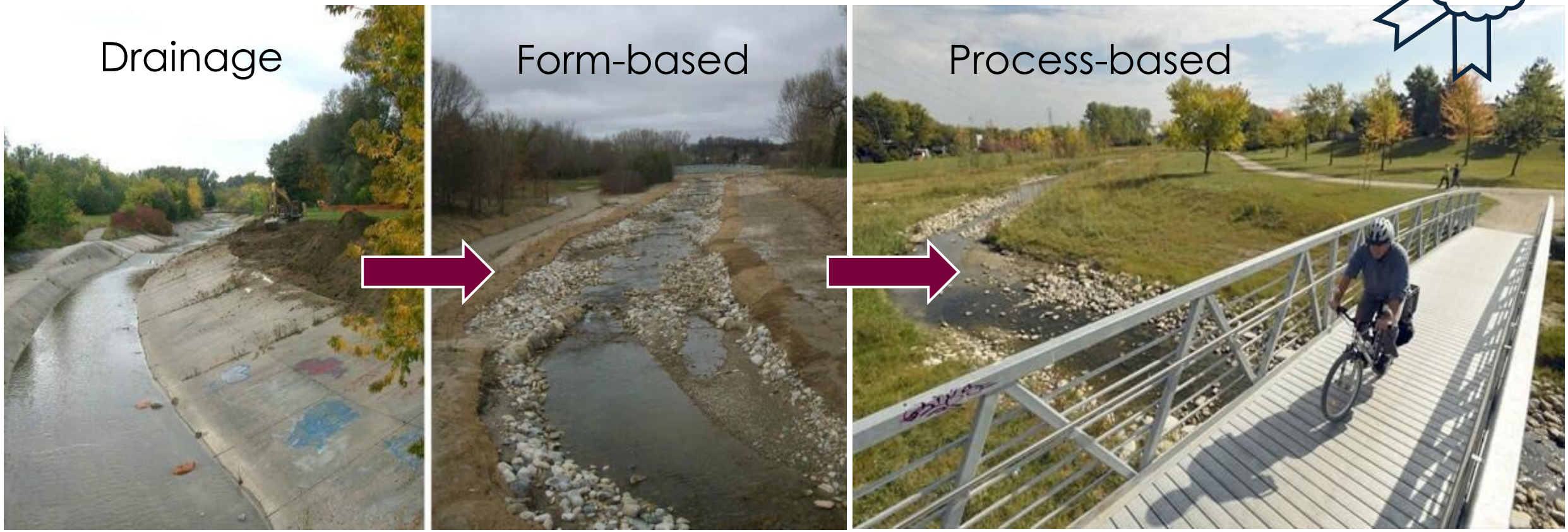


Rosgen (1996)

3

Treat areas of concern directly

Option 1: Natural Channel Designs



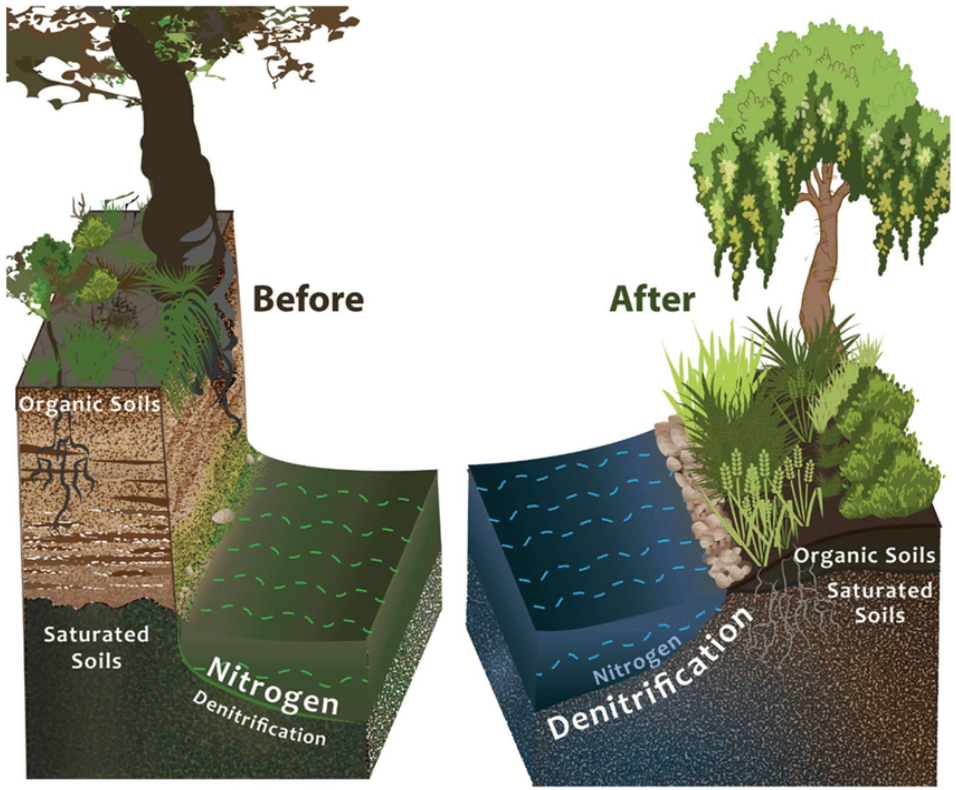
"The intent is to work *with* natural processes to improve geomorphic condition and enhance river recovery, rather than simply treating the visible symptoms."

– Fryirs., 2015

Images of Henry Strum Creek, Kitchener, Ontario. From CBC (2015) and The Record (2015)

Natural Channel Design

Reconnecting floodplains and wetlands



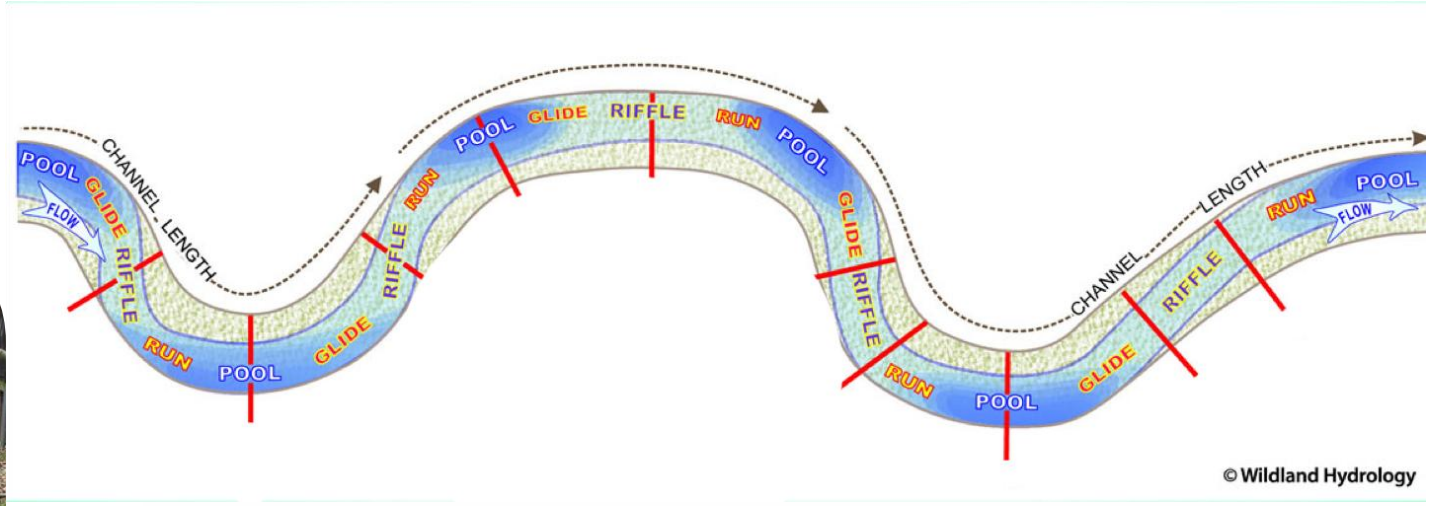
Mayer et al. (2022)

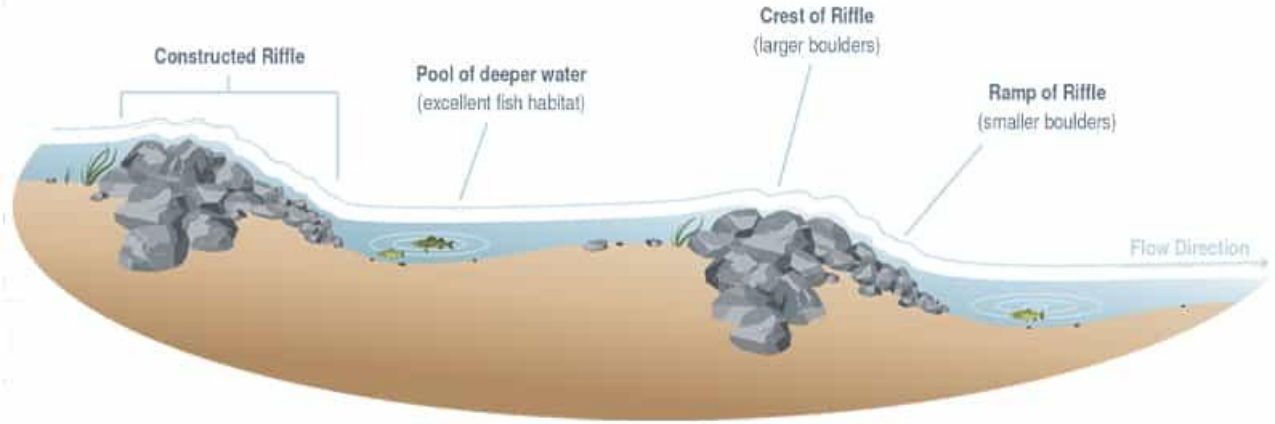
Milwaukee Metropolitan Sewerage District

Natural Channel Design

- Building meanders
- Pools and Riffles

Illinois State Water Suevey

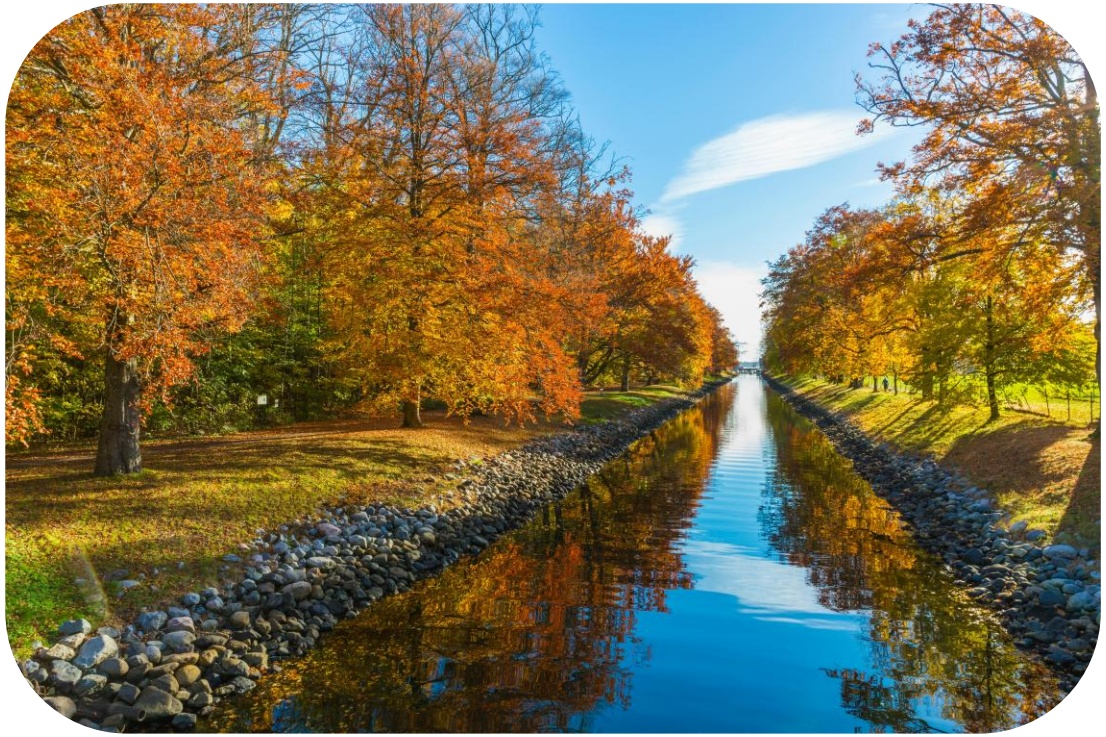




Streamhandbook.com

Natural Channel Design

If you google “beautiful river”:



Natural Channel Design

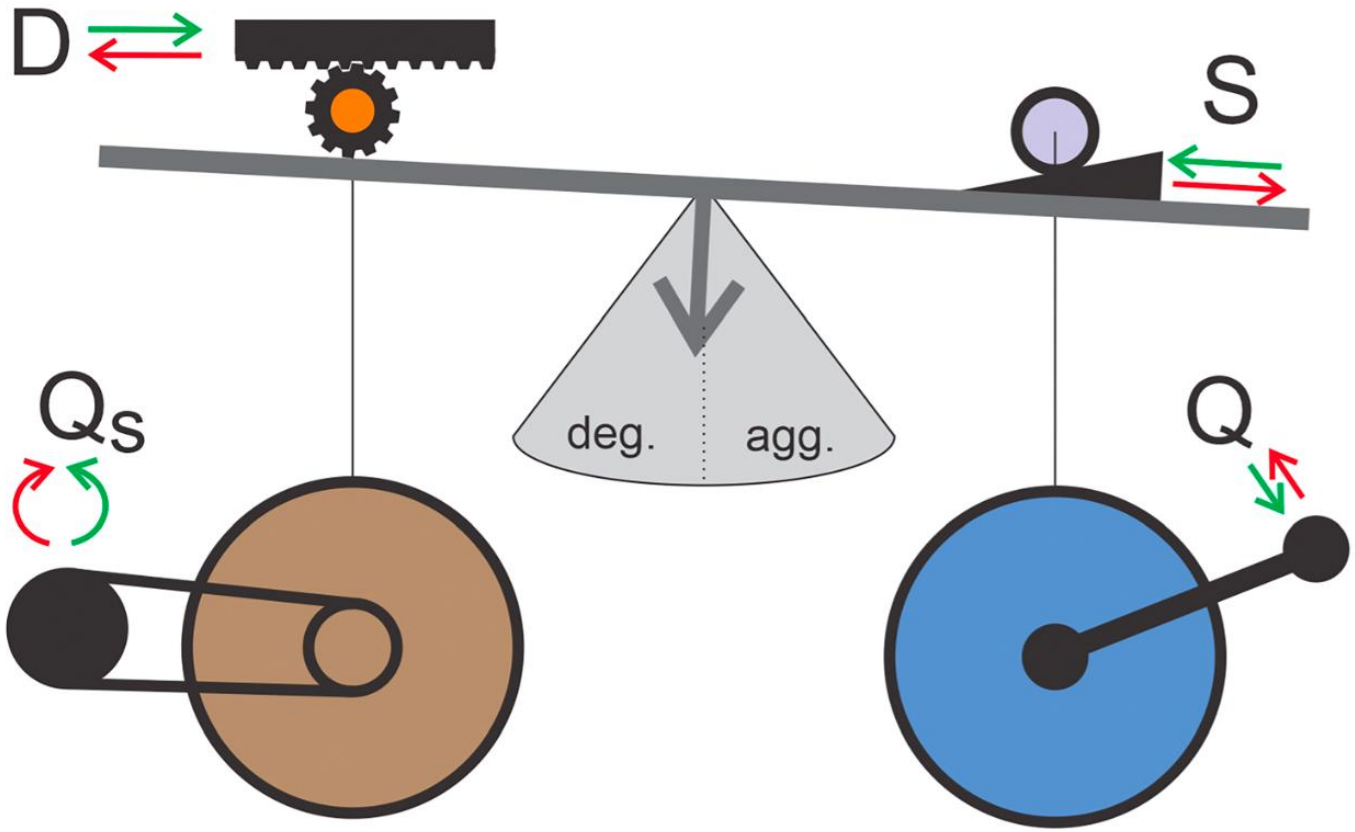
'Messy rivers are healthy rivers'

Bob & Diana McElroy

Brenkman (2008)

Option 2: Restore Balance

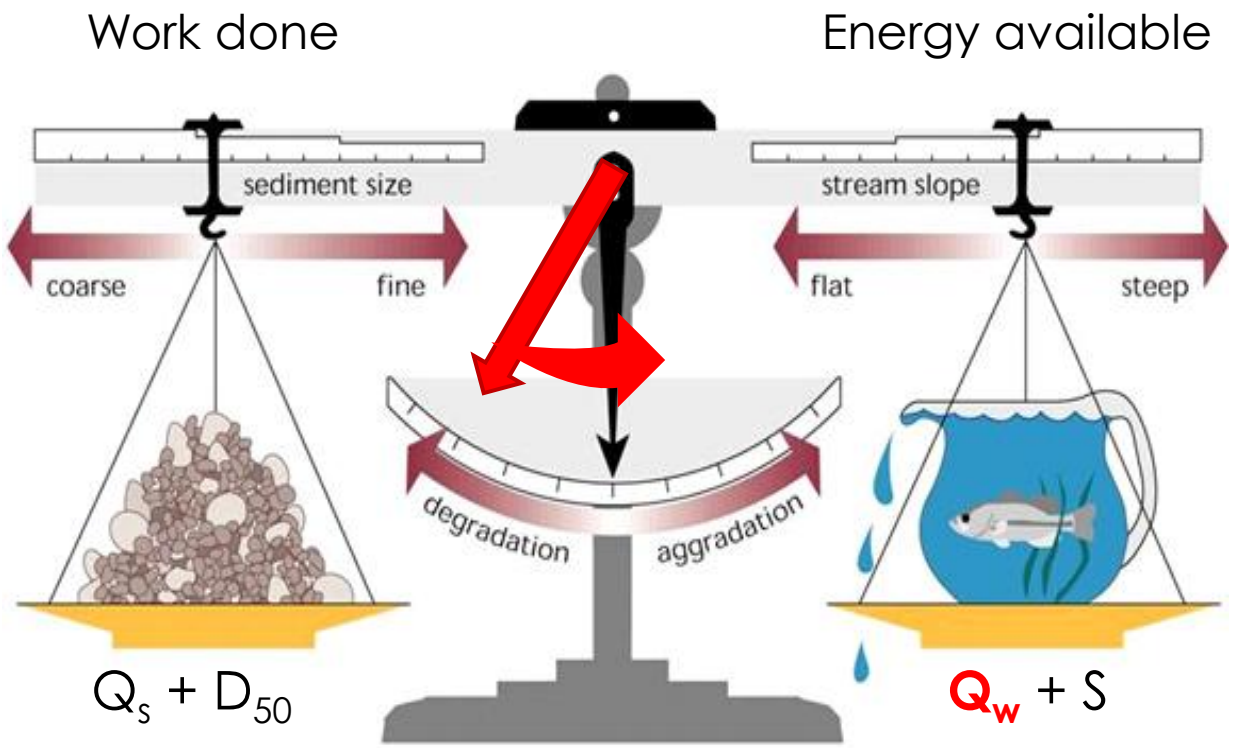
We can implement different strategies to change any of the four variables in Lane's Balance.



Papangelakis et al. (2025)

Option 2a: Stormwater Management

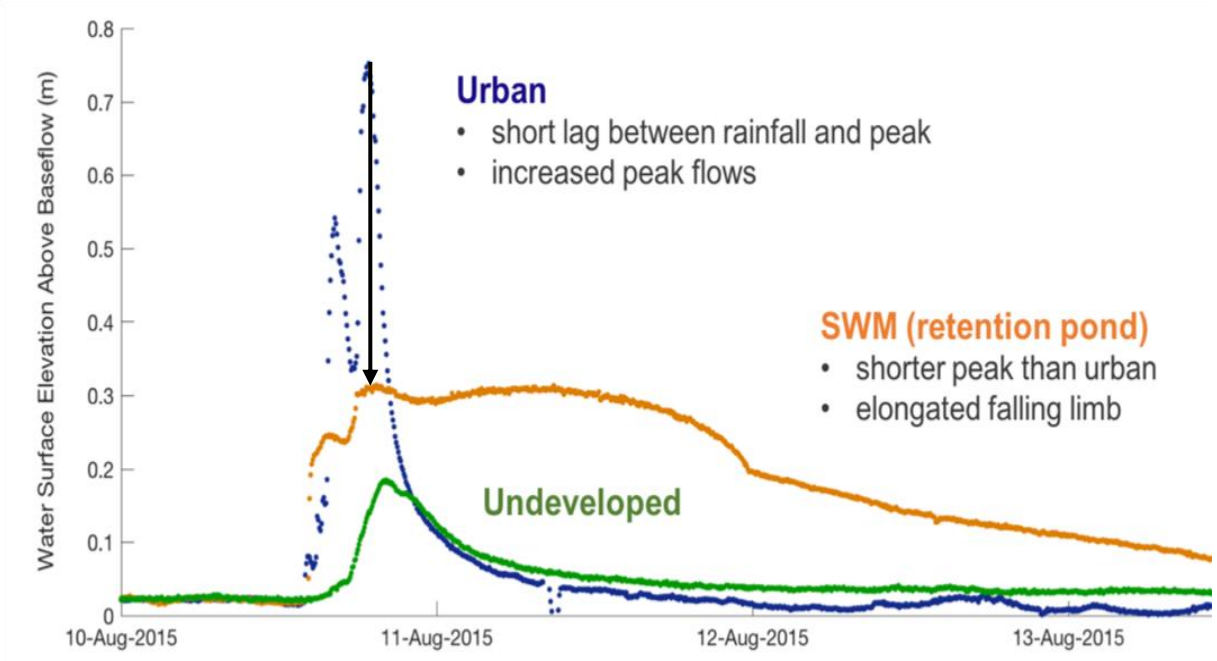
- Address the problem by reducing the excess runoff caused by urbanization
- Standard practice since 1990s
- Early focus was only on flood control



Rosgen (1996)

Option 2a: Stormwater Management

- Traditional ‘peak-shaving’ approaches
- Poor water quality and habitat outcomes



Option 2a: Stormwater Management

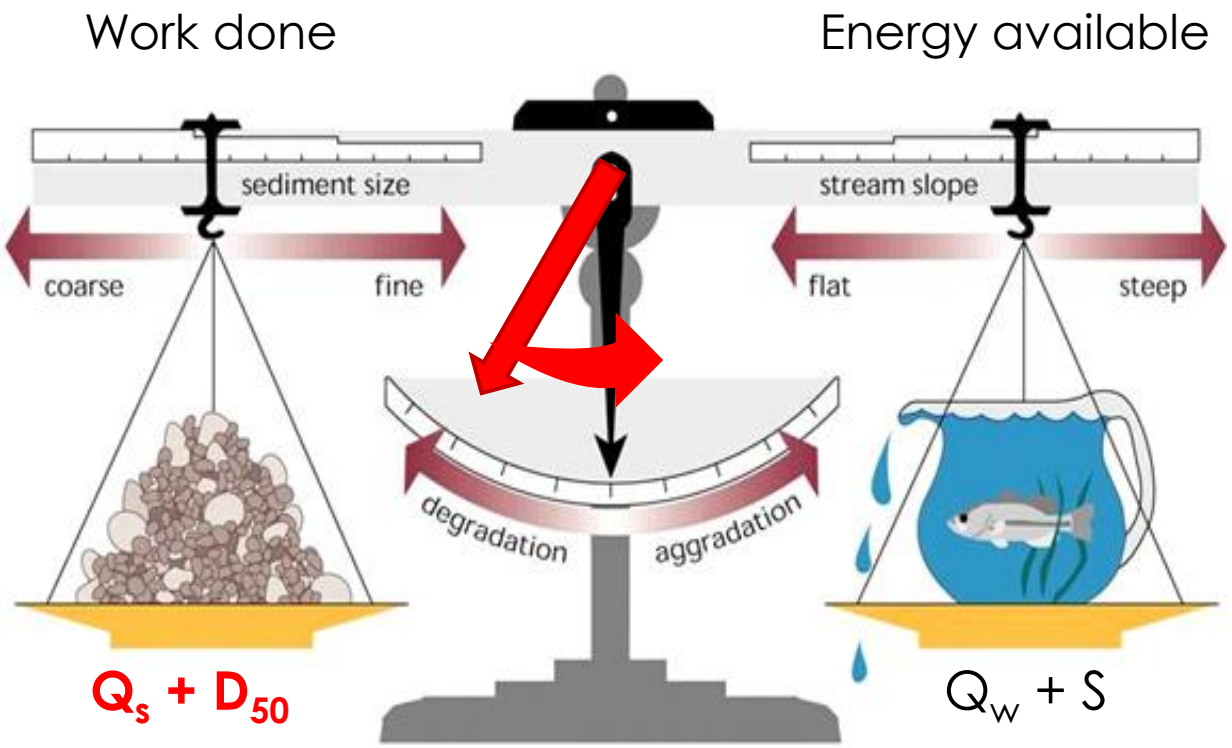
- Low Impact Development (LID) tried to build in more infiltration in the watershed
- Restored or artificial wetlands
- Rain gardens, bioswales, infiltration trenches, permeable pavement, rainwater harvesting
- Mimic natural hydrologic regime

TRCA (2022)

Option 2b: Sediment Augmentation

- Replenish low sediment supply and let the river 'fix' itself
- Used downstream of dams
- Can we use this strategy in urban channels?

Arnaud et al. (2017)



Rosgen (1996)

Sediment Augmentation Questions

- Where would sediment cover form and what would it look like?
- How much sediment do we need to feed (i.e. supply rate)?
- Does channel geometry have an effect?

Option 3: Direct Erosion Protection

Rock structures Wood structures Hybrid approaches Bioengineering

“traditional”
“hard”
“engineered”

Nature-based Infrastructure

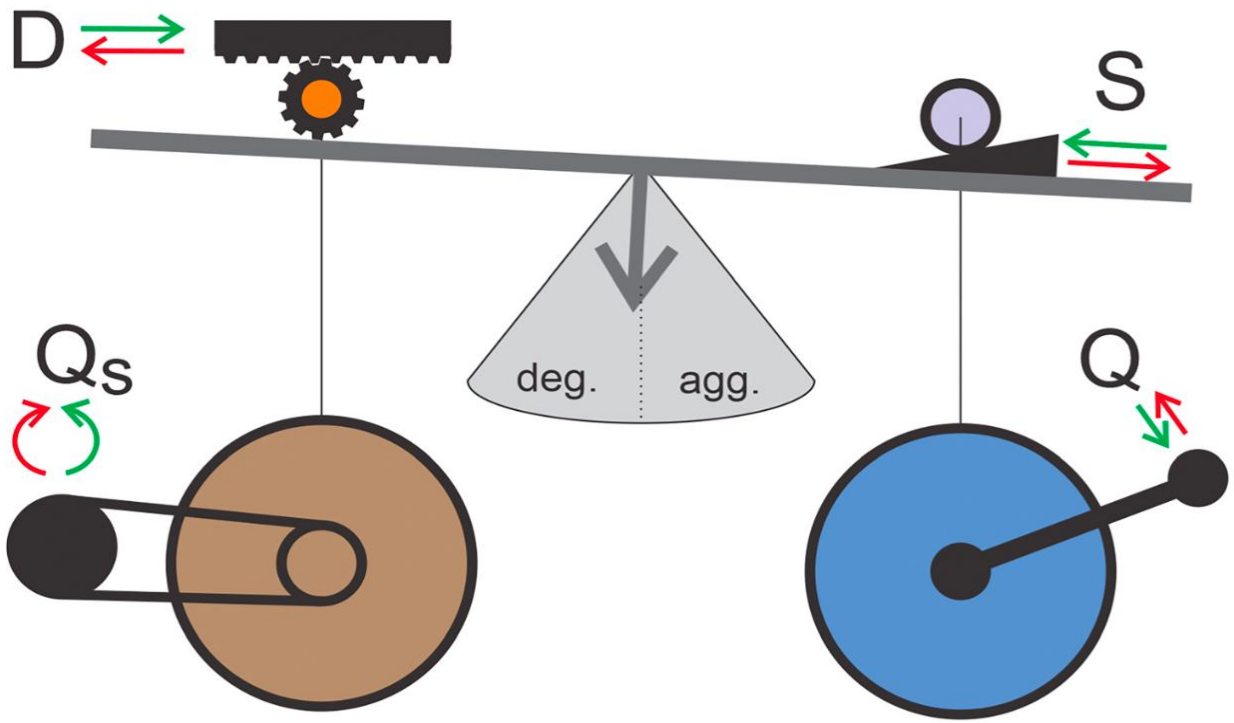
Terra Erosion Control

Ausable River Association

So…how do you choose?

Depends on:

- Project goals
- Local conditions
- Available materials
- Budget
- Stakeholder priorities
- Maintenance needs…etc.



Papangelakis et al. (2025)

So…how do you choose?

Different strategies target different processes

- Altering flow and/or sediment regime
- Grade control
- Flow velocity reduction
- Flow redirection
- Direct erosion protection
- Increased bank strength

	Restore Balance	Increase capacity	Grade control	Direct protection	Velocity reduction	Velocity redirection
Process Management						
Flow management	X				X	
Sediment management	X			X		
Wood management	X				X	
Channel re-alignment						
Natural Channel Design	X	X	X	X	X	X
In-Channel Works						
Rock structures						
Ex. 1: Gabion baskets				X		
Ex. 2: Rock weirs			X		X	
Wood structures						
Ex.: Toe wood				X	X	X
Ex.: Beaver dam analog			X		X	
Bioengineering & Hybrid Structures						
Ex. 1: Vegetated rip rap				X	X	
Ex. 2: Riparian planting				X	X	

Summary

- Channel-scale NBI has many different functions
- Seemingly disparate strategies can be places within a unified framework centered on **processes** driving riverine flooding and erosion
- Choice of channel-scale NBI should be thoughtfully made based on goals, local environment, and logistical considerations

Thank you!

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Fluvial Geomorphology at McMaster

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