Floodplains are Nature-Based Infrastructure

Natural Channels Initiative

Bruce MacVicar

8th Conference on Natural Channels Systems

McMaster University, June 9, 2026

UNIVERSITY OF WATERLOO

>>River Hydraulics Research Group

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A group effort…

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Elli Papangelakis, *MacMaster University*
Colin Rennie, *University of Ottawa*
Thiruni Thirimanne, *University of Waterloo*

Special thanks to…

Peter Ashmore, *Professor Emeritus, Western University*
Jon Slaney, *City of Calgary***
Ivana Vouk, *National Research Council Canada*

Outline

- Nature-Based Infrastructure
- Floodplains
- Key principle – alluvial sediment storage
- Flume experiment example
- Discussion and take-aways

What is Nature-Based Infrastructure?

- Nature-based approaches to working with rivers are process-based, with the central idea that they work by “giving the rivers the **time**, **space**, **energy**, and **materials** to exercise those processes’ (Fryirs & Brierley, 2021).

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- “Natural Infrastructure” managed to allow for dynamic, natural processes is an opportunity to address *increasing climate change stress* and *improve restoration project effectiveness* (Skidmore & Wheaton, 2022)

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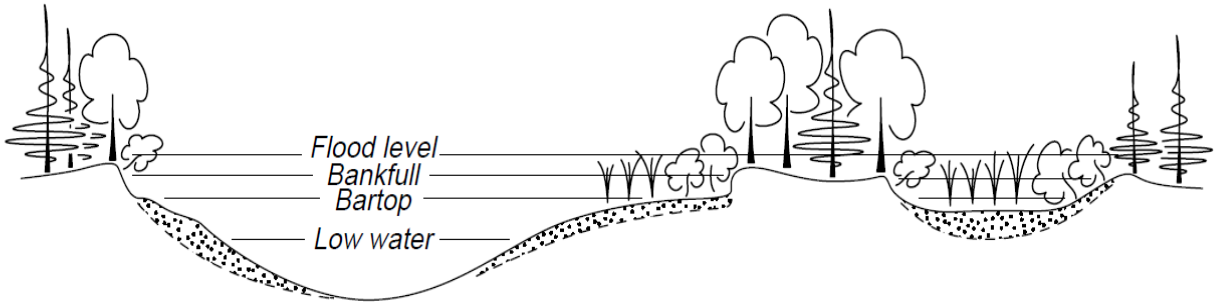
- In NBI, “floods should generate measurable improvements, provide critical feedback, and create opportunities for adaptive management,” which contrasts with conventional approach where post-flood monitoring assesses whether the project was damaged (Ciotti et al., 2021).

What is a floodplain?



Church, 2002

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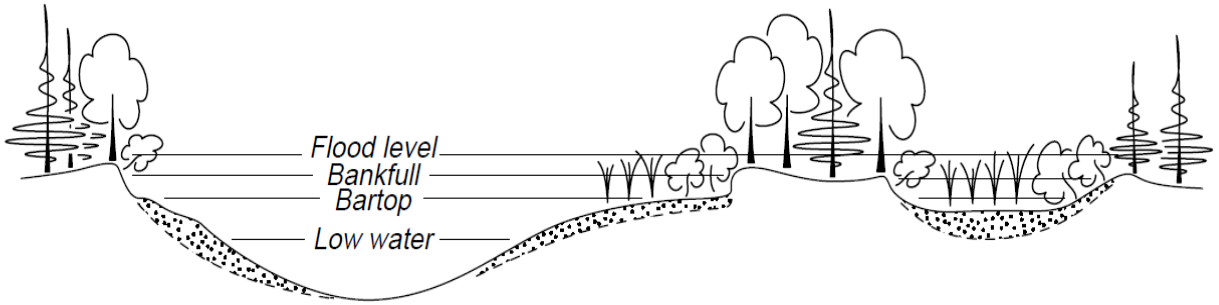

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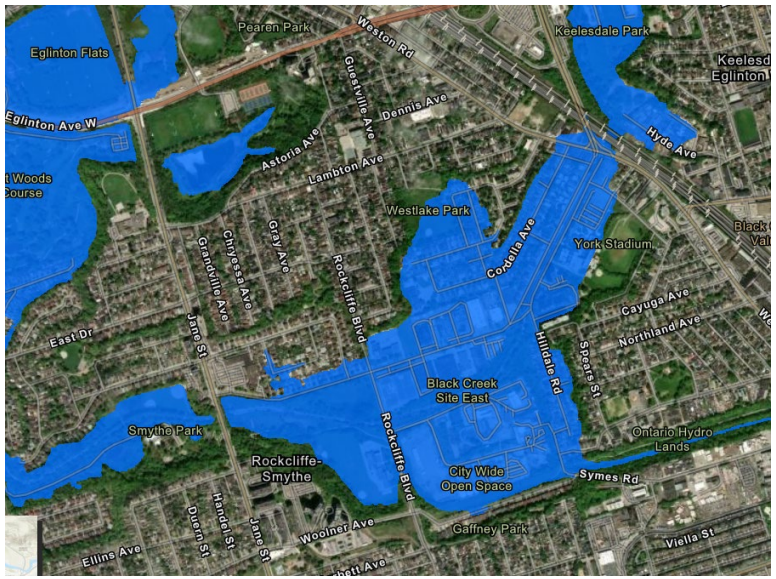
1. A hydrologic floodplain

TRCA Flood Plain Map Viewer



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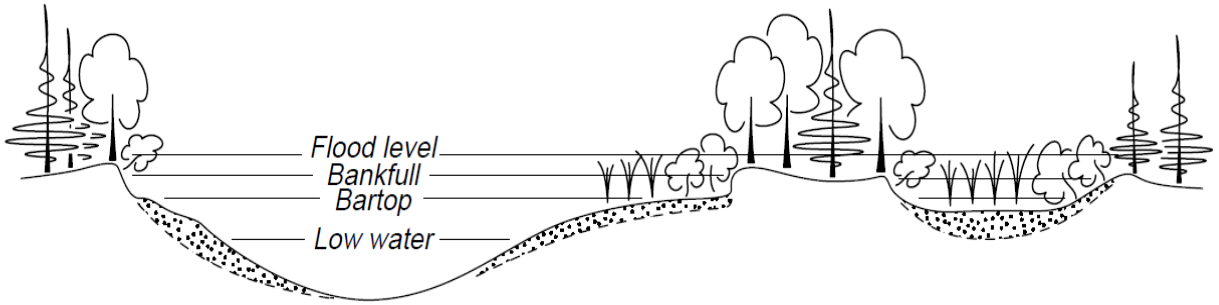

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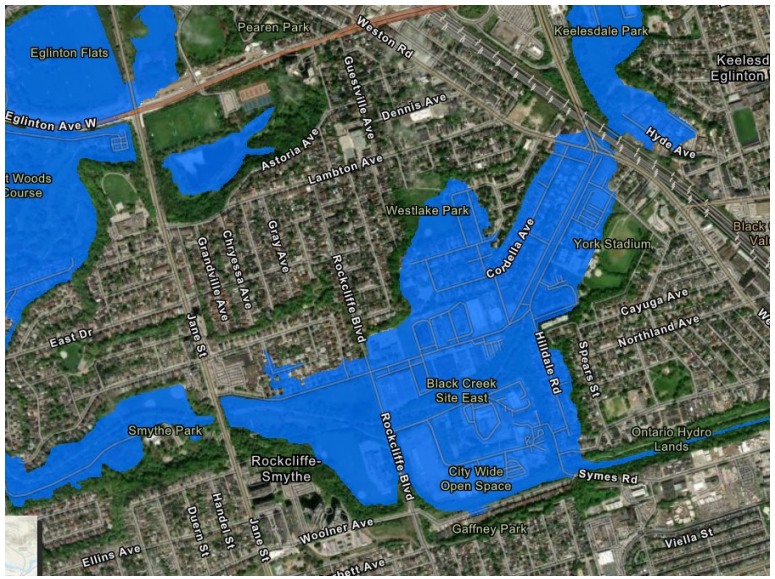
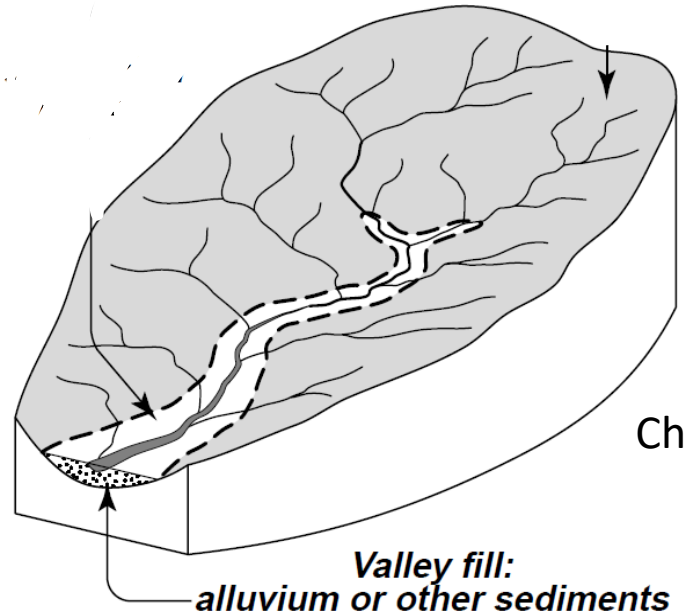


2. A genetic floodplain

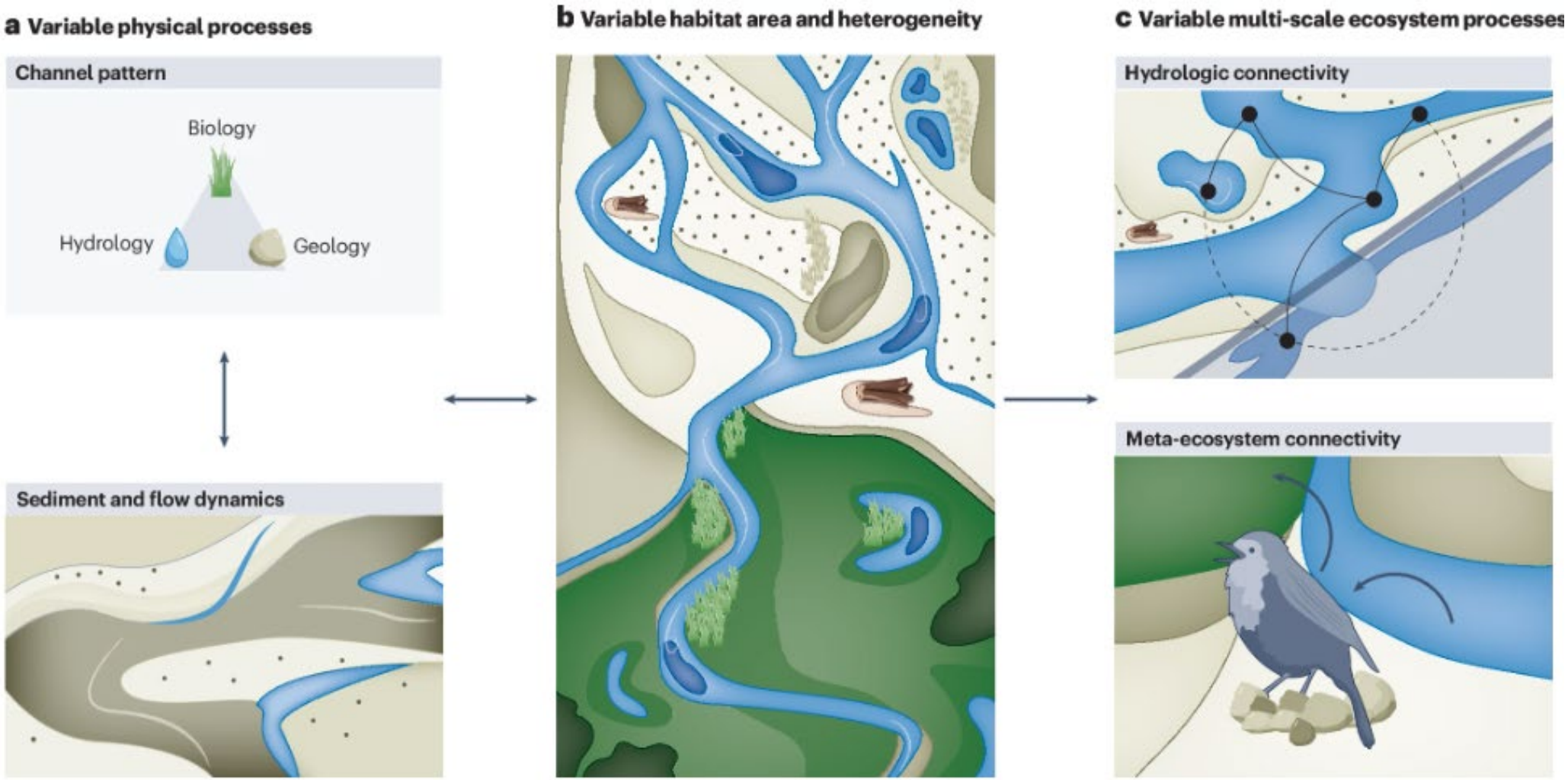


Church, 2002

Other related concepts…

Name	Type				Description
	Hydro	Geo	Bio	Reg.	
Riparian buffer or setback				*	Length measured from the riverbank/centerline to denote zone of special protections or limitations
Active channel		*			Current wet area plus area with recent sediment transport
Meander belt width		*			Active channel plus the area where the active channel is likely to be in a defined future time interval
River corridor	*	*			Active channel, flood inundation limit, plus the underlying hyporheic zone.
Erodible river corridor	*	*		*	An agreed upon delineation of the area within which bank erosion and sediment transport are not impeded
Room for the river	*			*	Dutch programme to reduce the risk of flooding by giving rivers more room to flood
Freedom space	*	*		*	Meander belt width, flood inundation limit, and riparian wetlands
Riverscape		*	*		Valley bottom network of habitats, morphology, processes and flows

Floodplains are ‘disproportionately’ valuable ecosystems

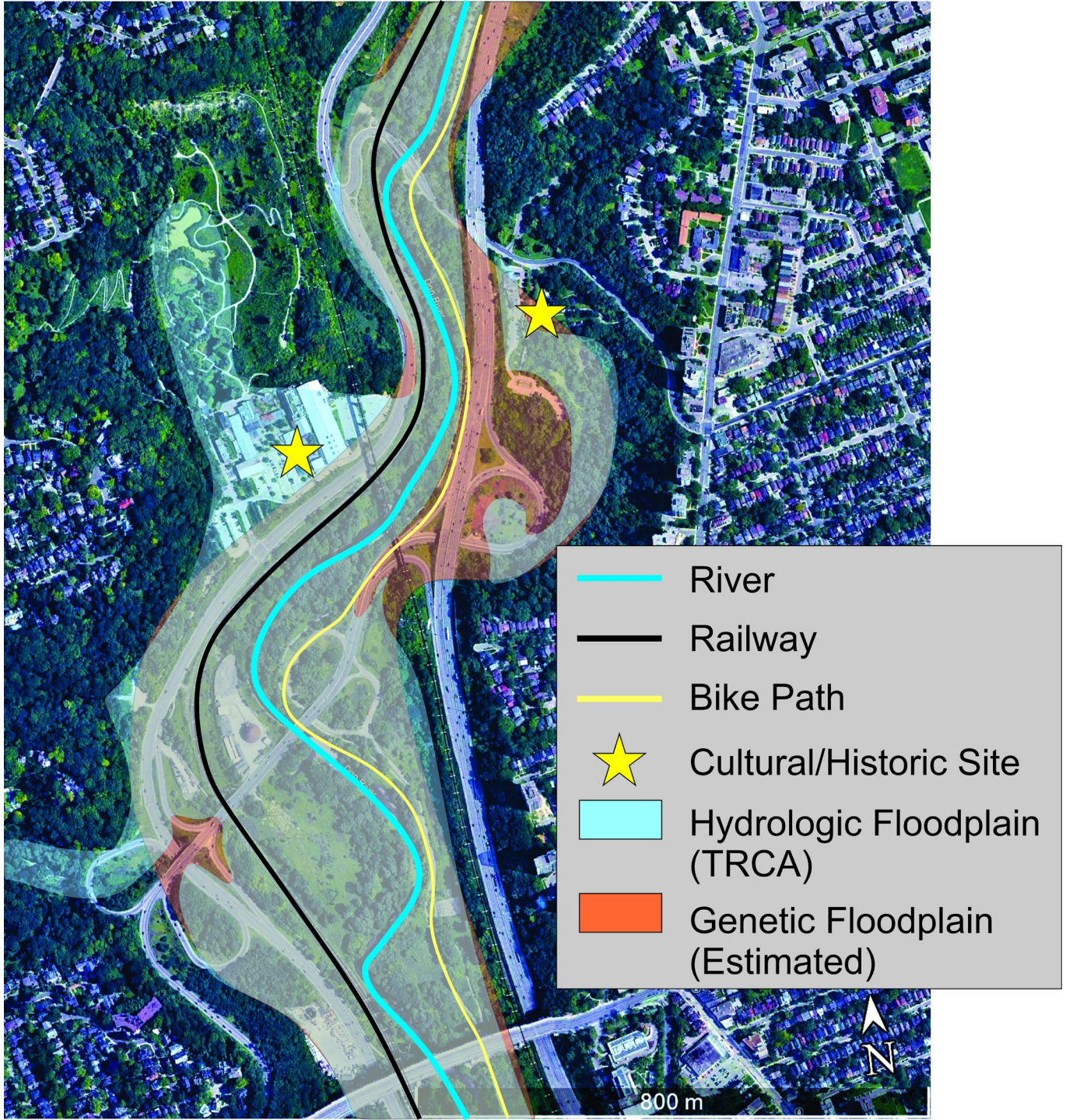


McCabe et al., 2025

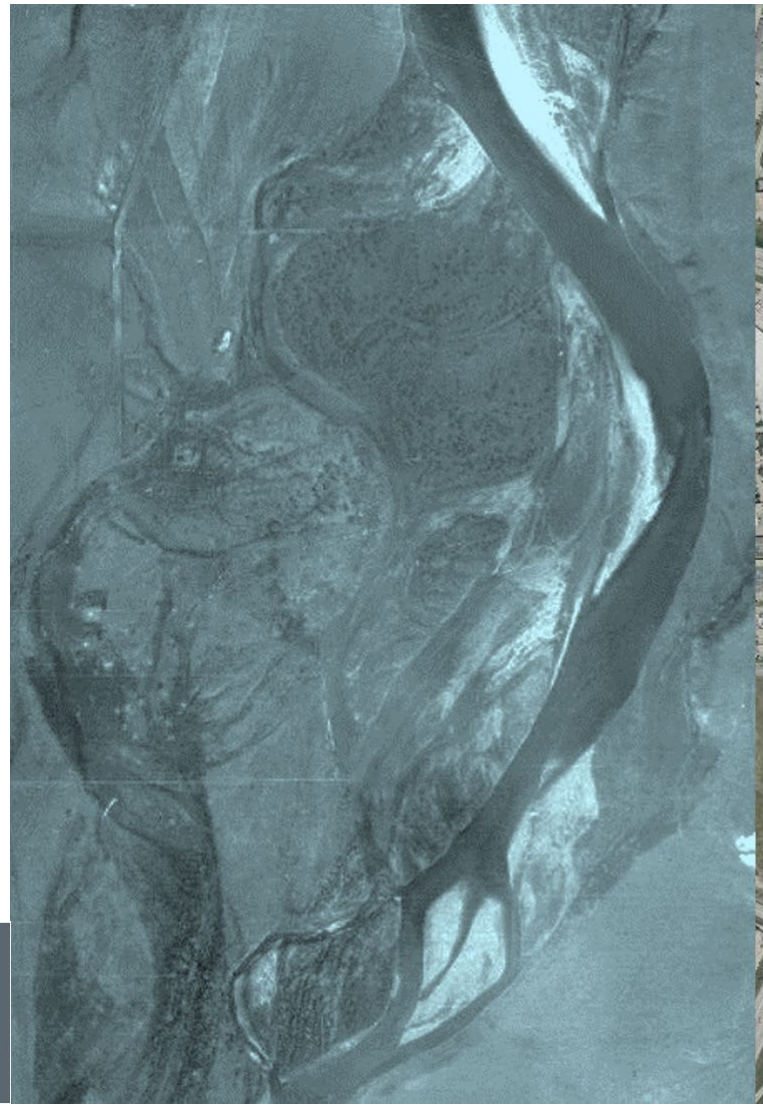
Floodplains are Infrastructure

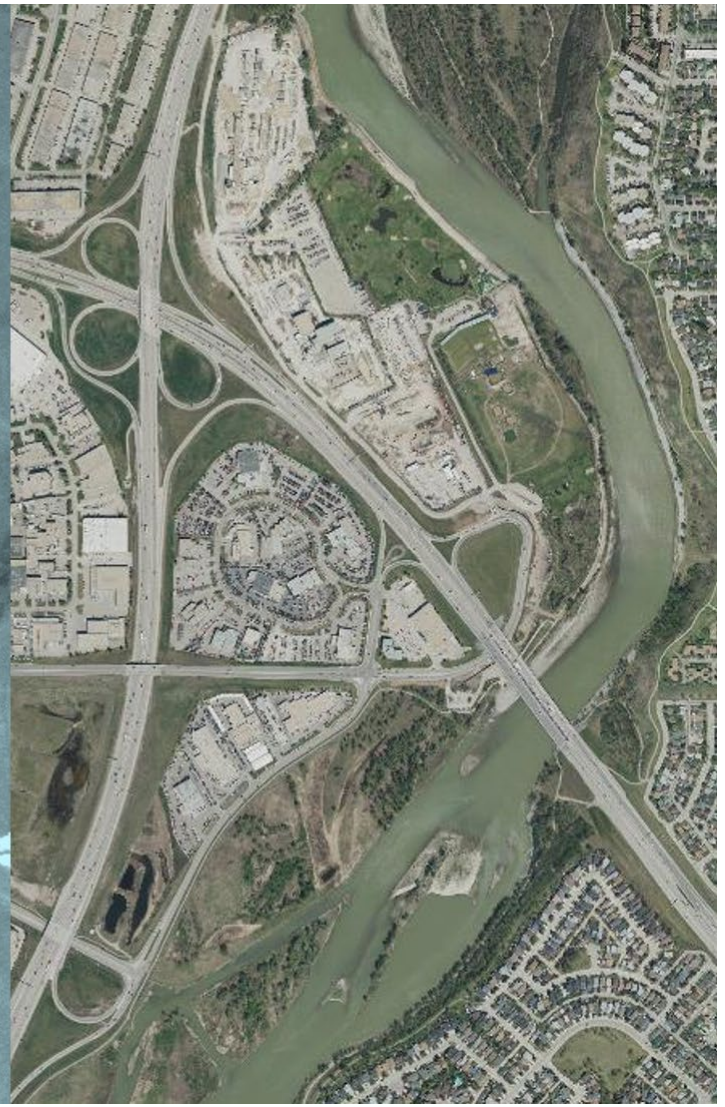
Floodplains are Infrastructure

- Highways and Roads
- Bridges
- Walking paths
- Stormwater outfalls
- Sanitary drainage
- Waste water treatment
- Electrical transmission lines
- Natural gas lines



Bow River example

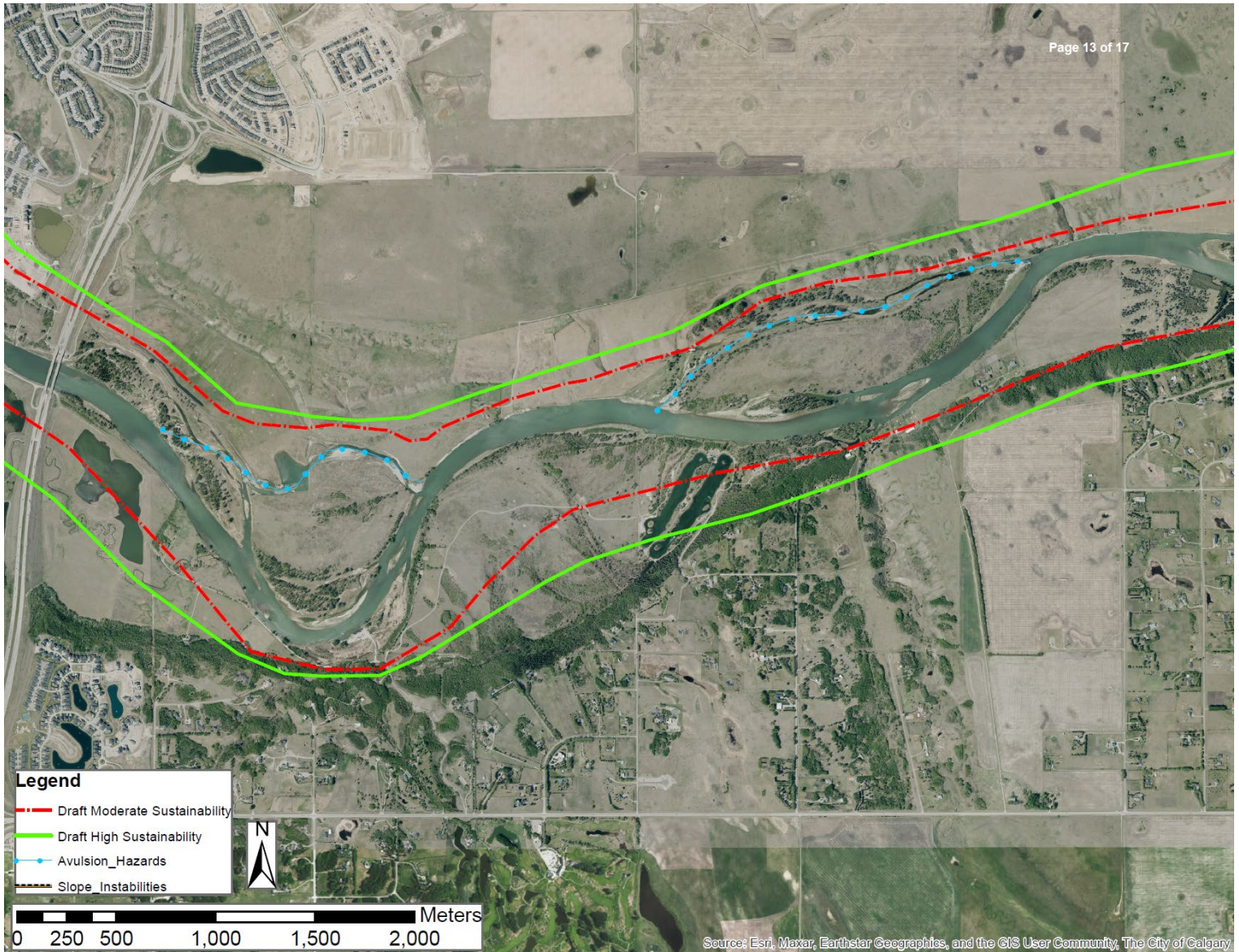




Slaney, City of Calgary 2025

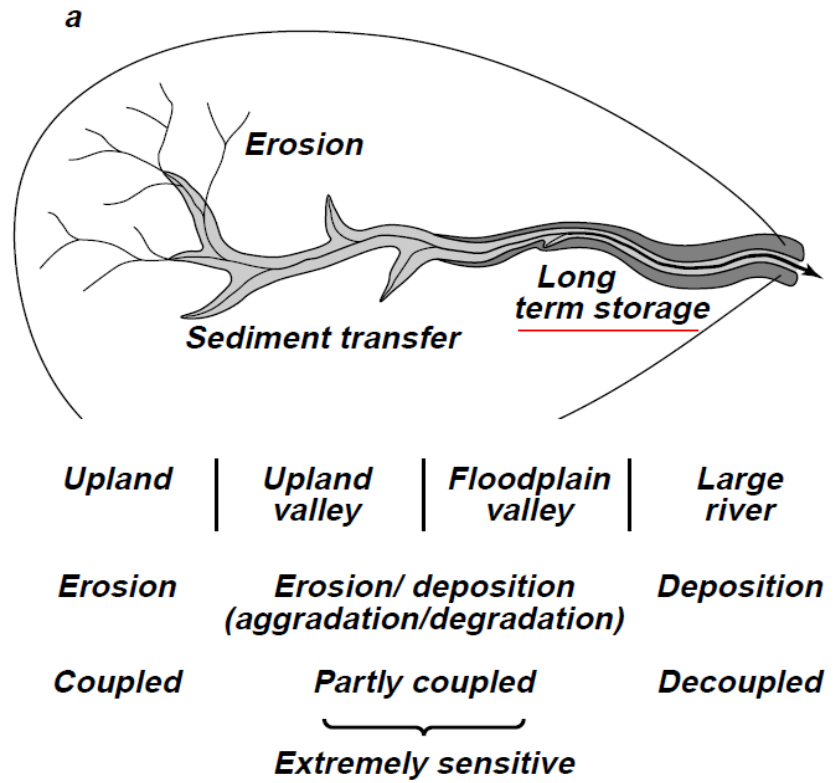
Problem - How do we find a balance?

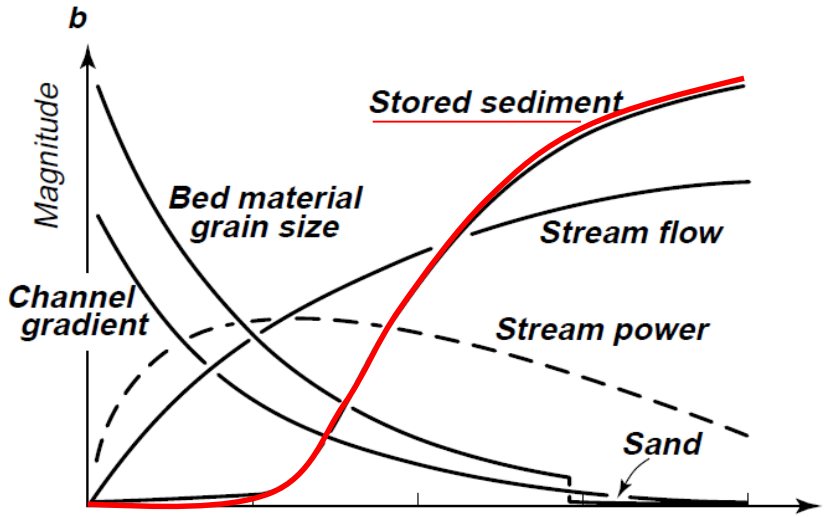
Alternate setback proposals



Slaney, City of Calgary 2025

Key principle- The distribution of floodplains in a watershed is related to sediment storage

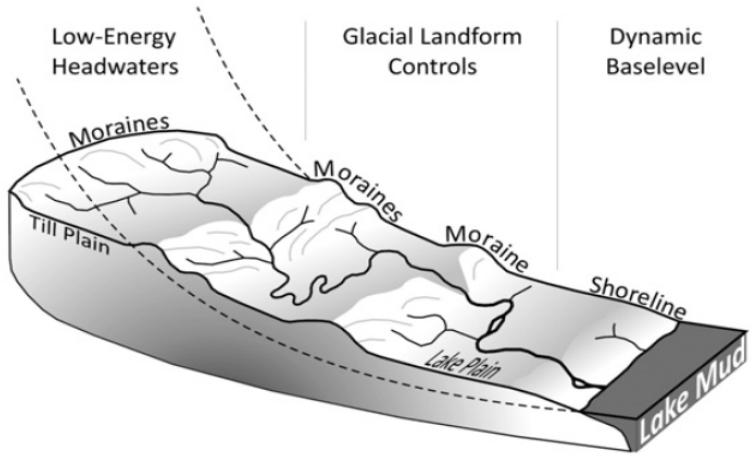


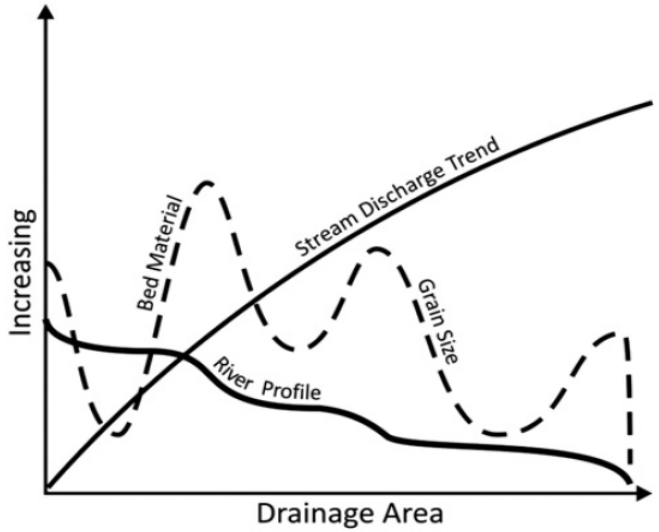


Church, 2002

BUT not all rivers look like the classic diagram

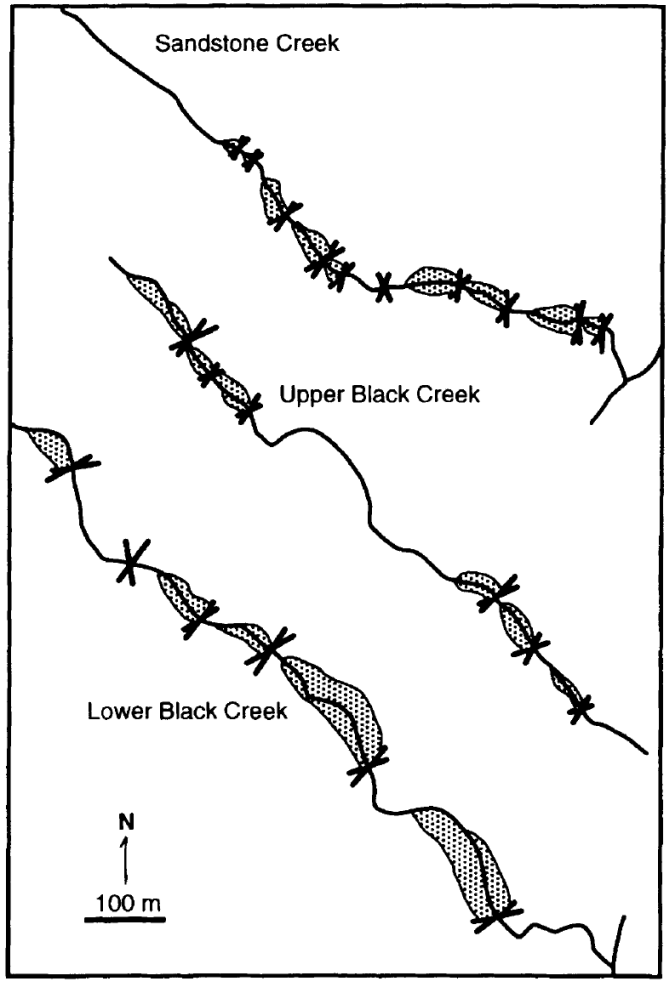
- Glacial legacy





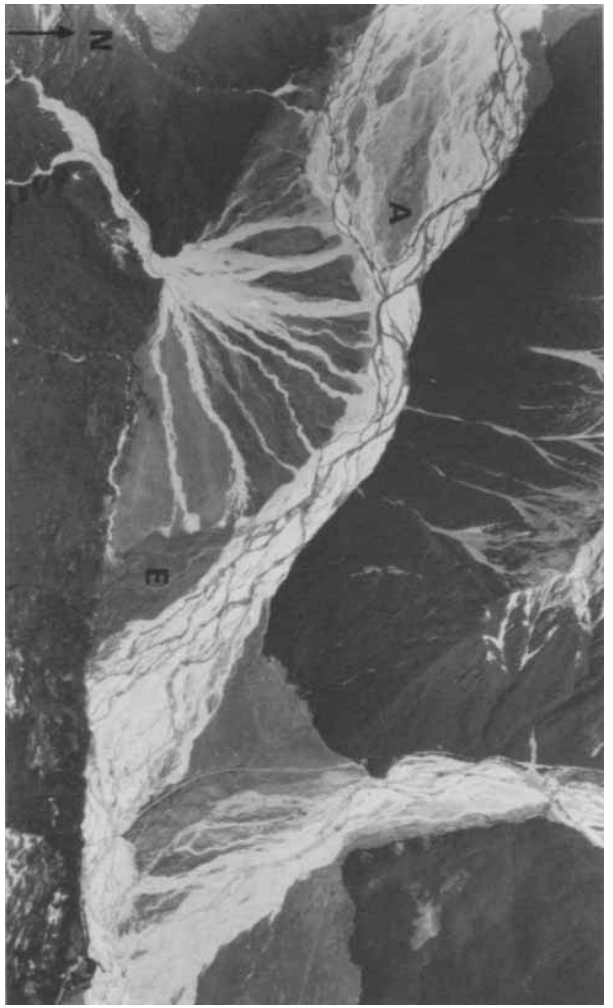
Phillips & Desloges, 2015

- Wood Jams



Montgomery et al., 1995

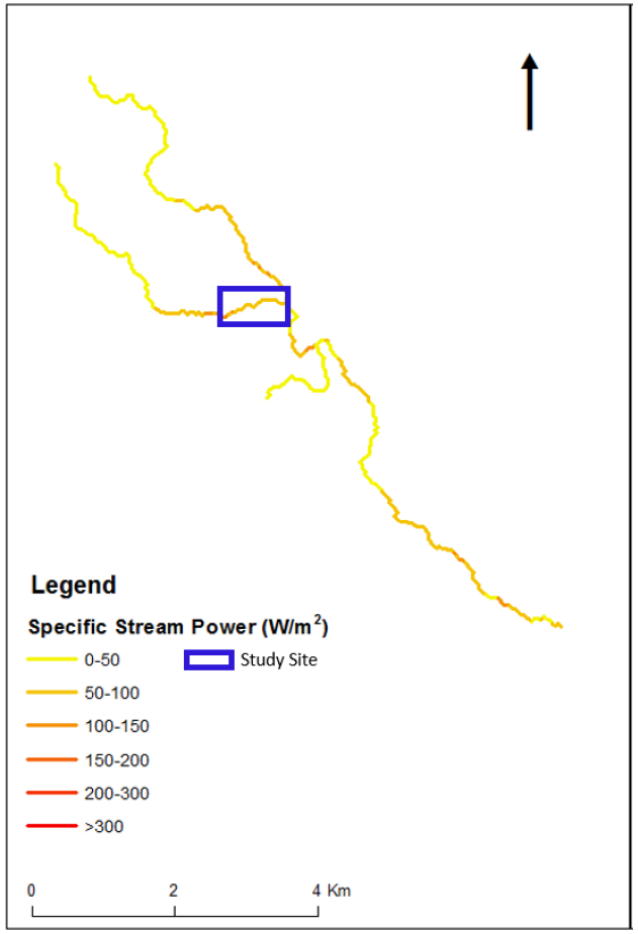
- Tributary inputs



Reinfelds & Nanson, 1993

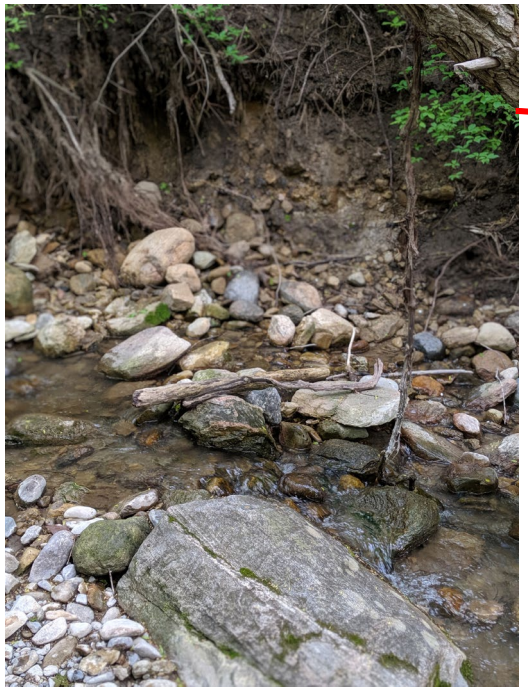
BUT that doesn't mean that they have different physical rules

Aryn Cain MASc. 2019

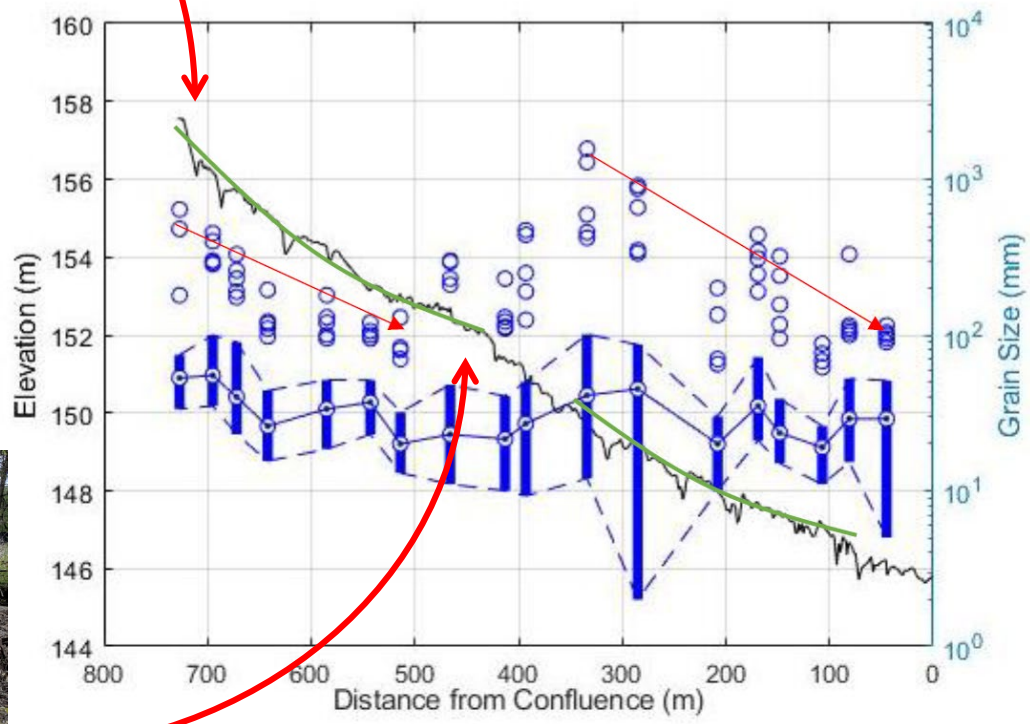


Ganatsekaigon Creek, Pickering

Source

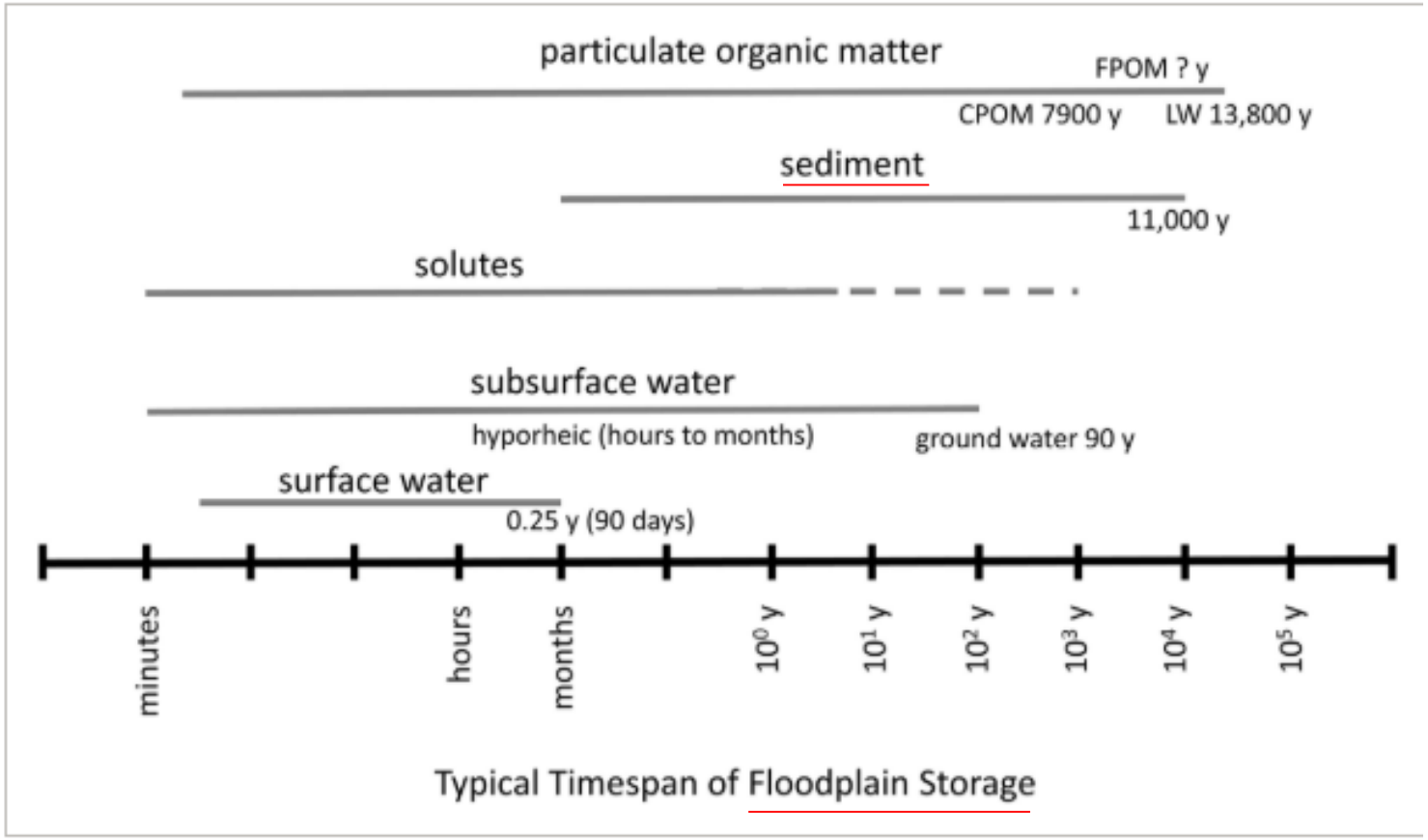


Sink



- these are sediment links (Rice and Church,1998)

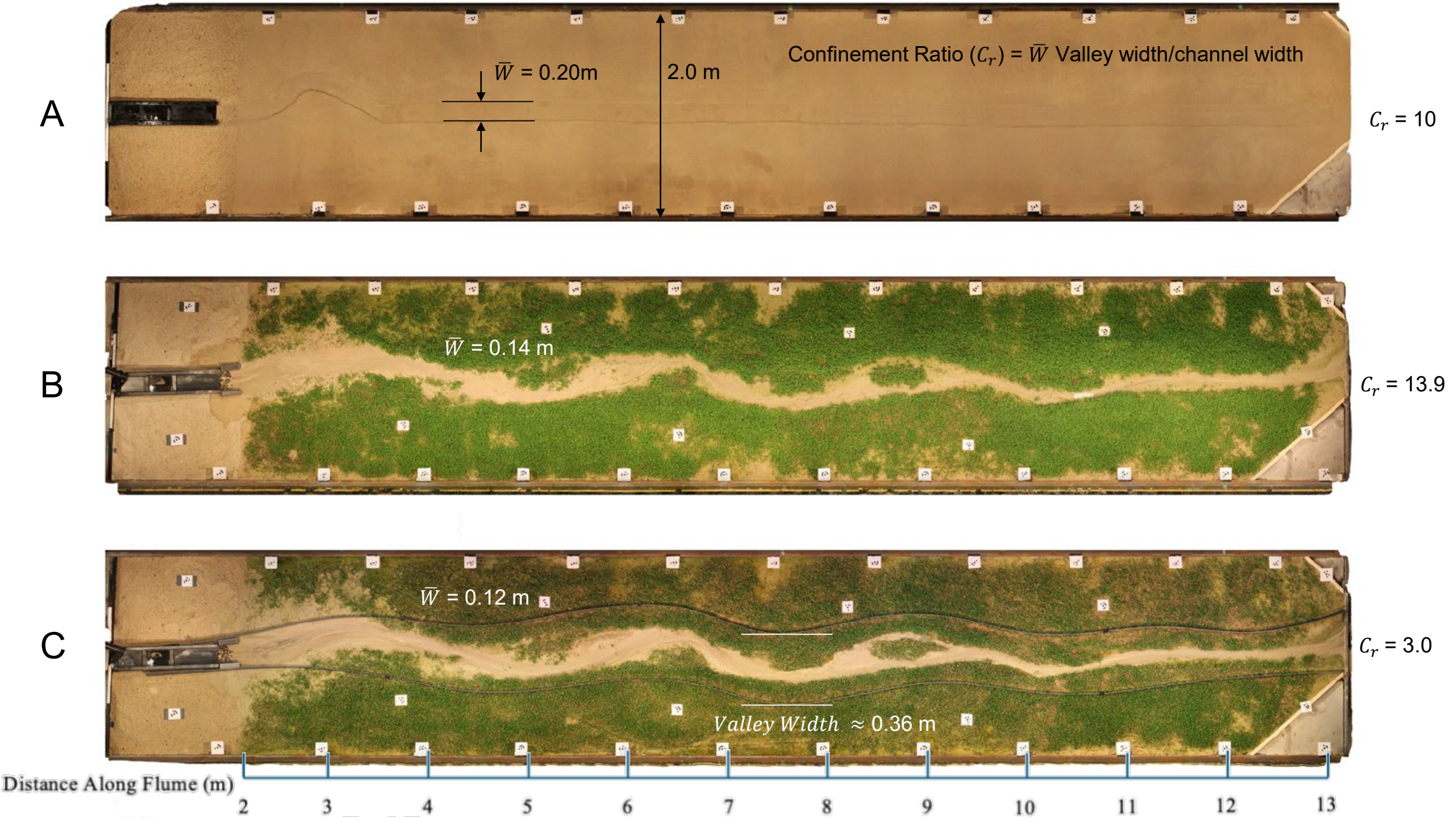
The formation of floodplains takes time, space, energy and materials

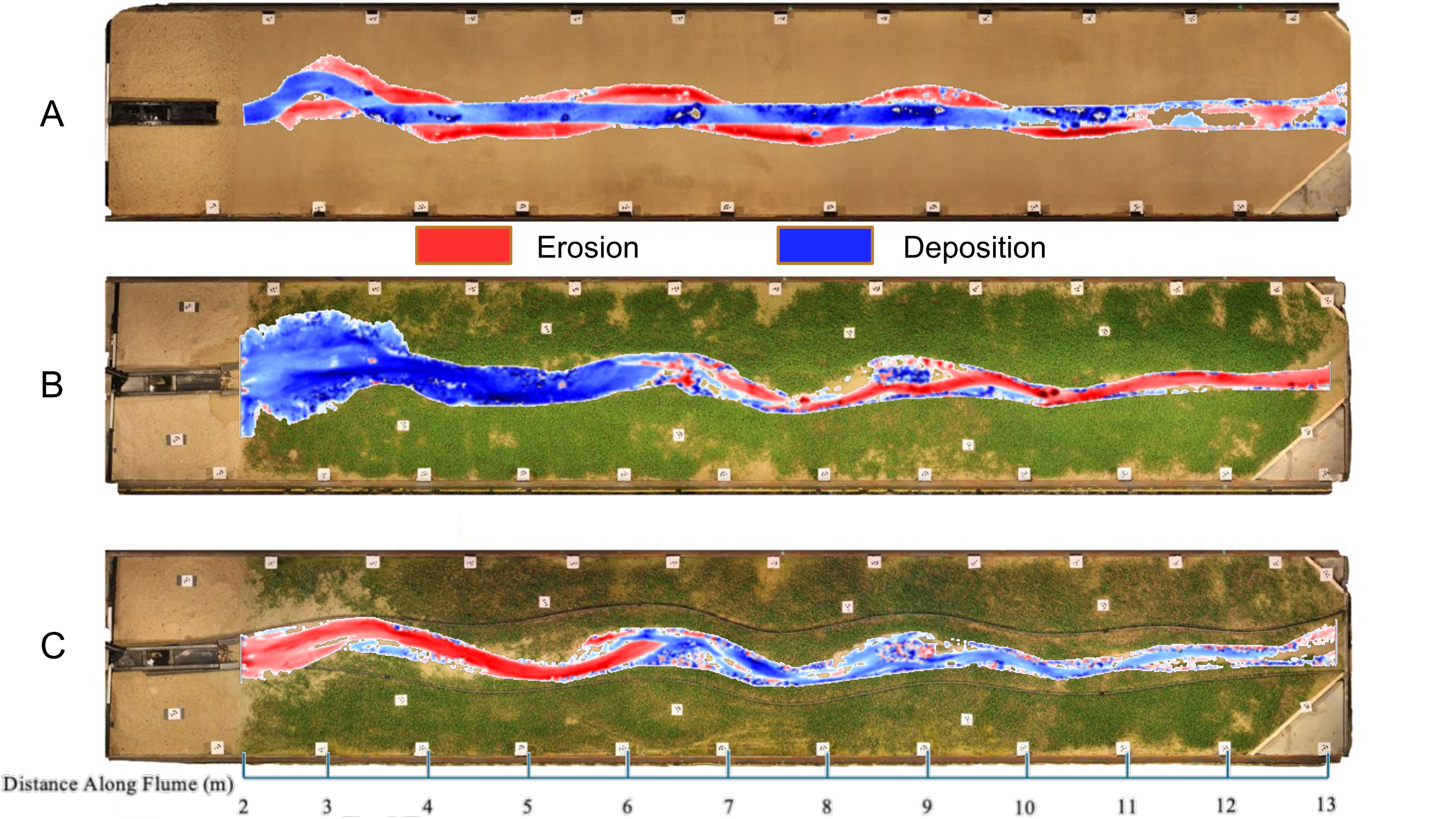


Wohl, 2021

Flume experiment – Floodplain vegetation and sedimentation

Rachael Messenger-Lehmann, MASc, UW


A
$\bar{W}$ = 0.20m
2.0 m
Confinement Ratio (C_r) = $\bar{W}$ Valley width/channel width
C_r = 10
B
$\bar{W}$ = 0.14 m
C_r = 13.9
C
$\bar{W}$ = 0.12 m
$Valley\ Width$ ≈ 0.36 m
C_r = 3.0
Distance Along Flume (m)
2
3
4
5
6
7
8
9
10
11
12
13


A
Erosion
Deposition
B
C
Distance Along Flume (m)
2
3
4
5
6
7
8
9
10
11
12
13

Experiment - Discussion

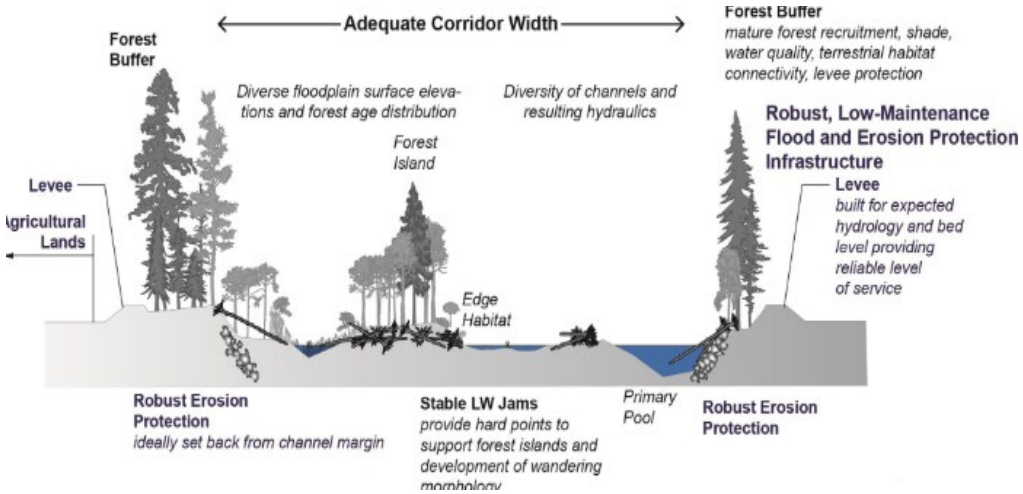
- Floodplains are built during exceptional floods, therefore we should not expect equilibrium during above bankfull events.

Sediment In ≠ Sediment Out

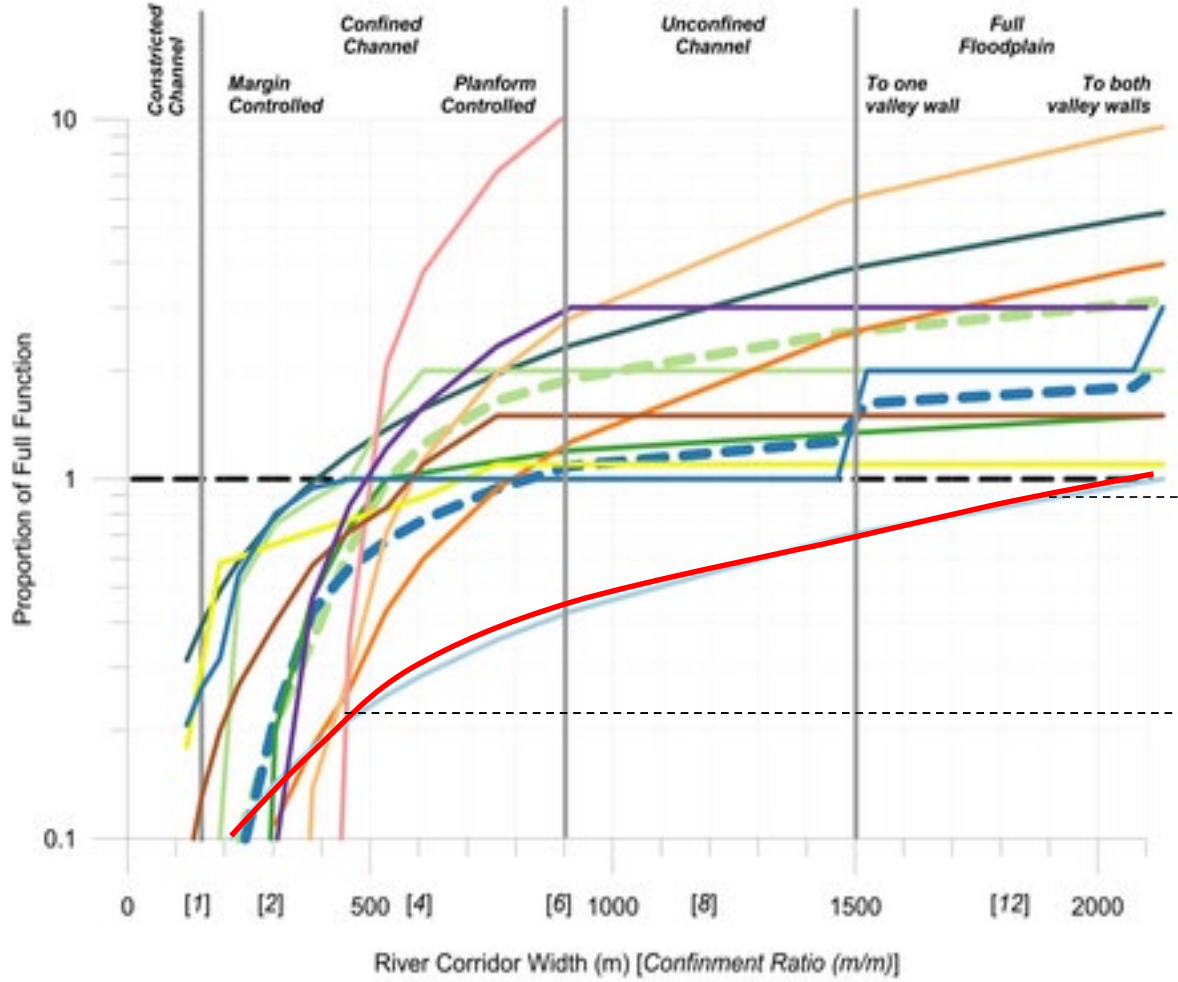
- Confinement decreases sediment storage on floodplains during extreme events, which will lead to more export and potentially increased deposition and dynamism downstream.

“The past history of our globe must be explained by what can be seen to be happening now.” James Hutton

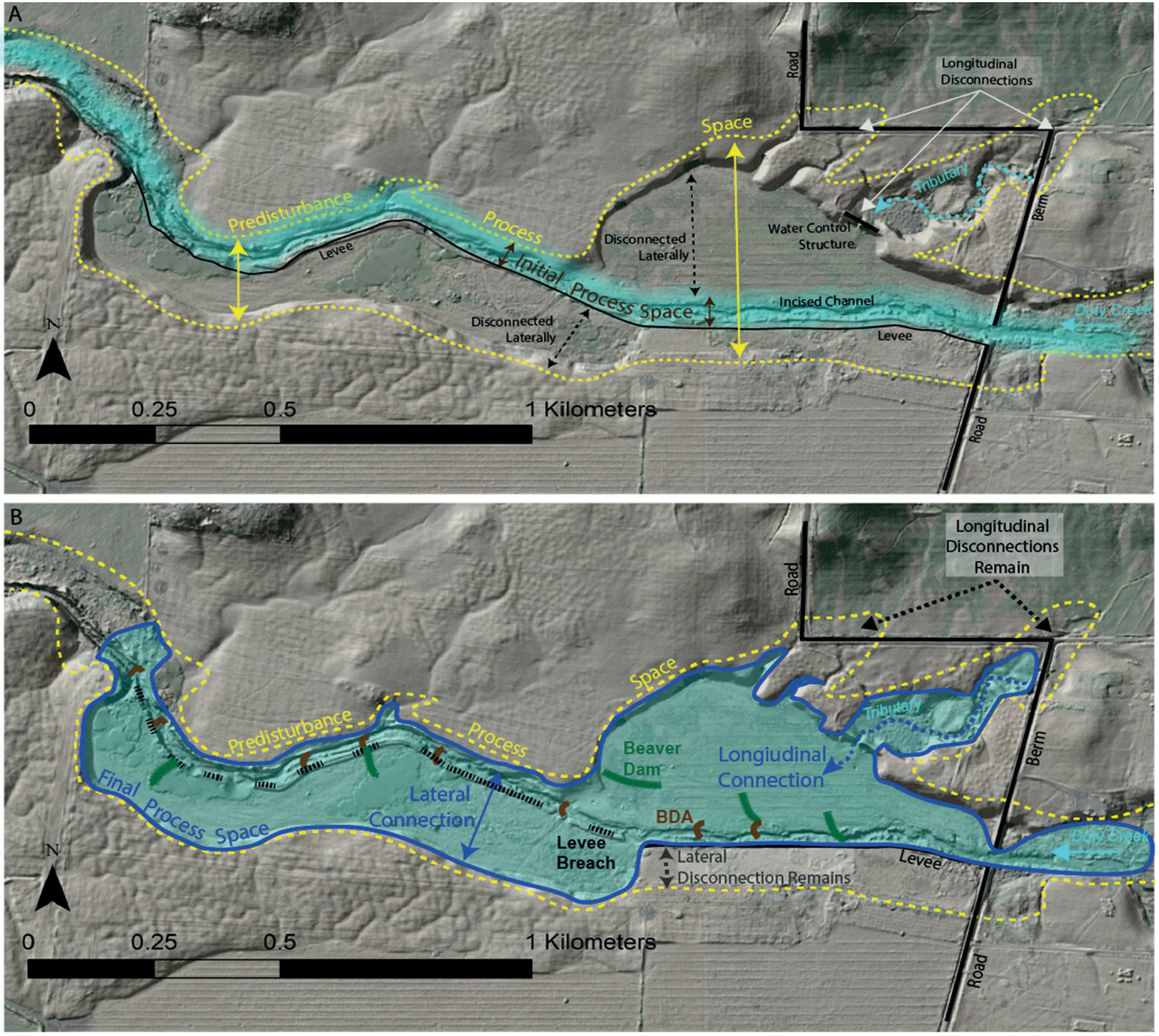
River corridor function as a function of corridor width



Nelson et al., 2024 – Nooksack River (high rates of aggradation)

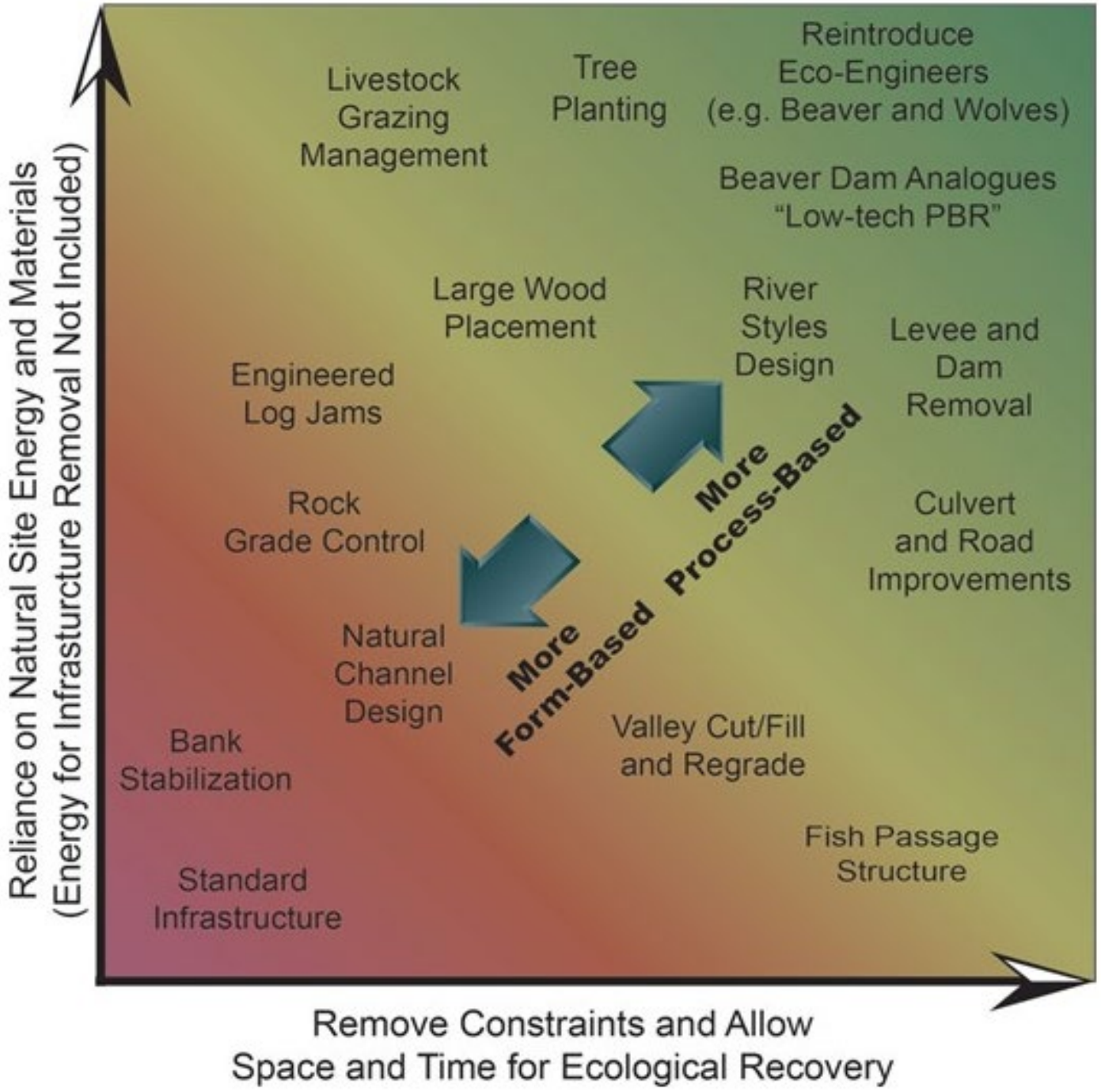


Floodplain restoration can be about expanding the process space



Ciotti et al., (2021) Doty Ravine Creek Project

Most process based restoration actions relate to floodplains



Ciotti et al., 2021

Key messages

- The past decade has seen an explosion of the number and quality of tools for the characterization of floodplains (no time to present).
- Floodplains provide myriad services and benefits for ecosystems and people. In most cases it will be necessary to compromise to find a balance between system integrity and stakeholders.
- Floodplains are the result of erosion and deposition processes over long time and space scales. Nature-based infrastructure should allow these processes to continue in the future.
- Floodplain sedimentation is a benefit that is not obvious until a major flood occurs.

Floodplains are Nature-Based Infrastructure