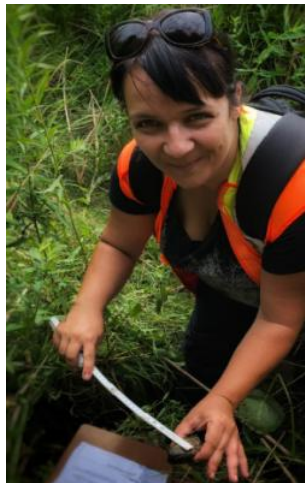


Getting out from under the Rock: Benefits of Site Specific Design

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Getting out from under the Rock: Benefits of site specific design

Latornell

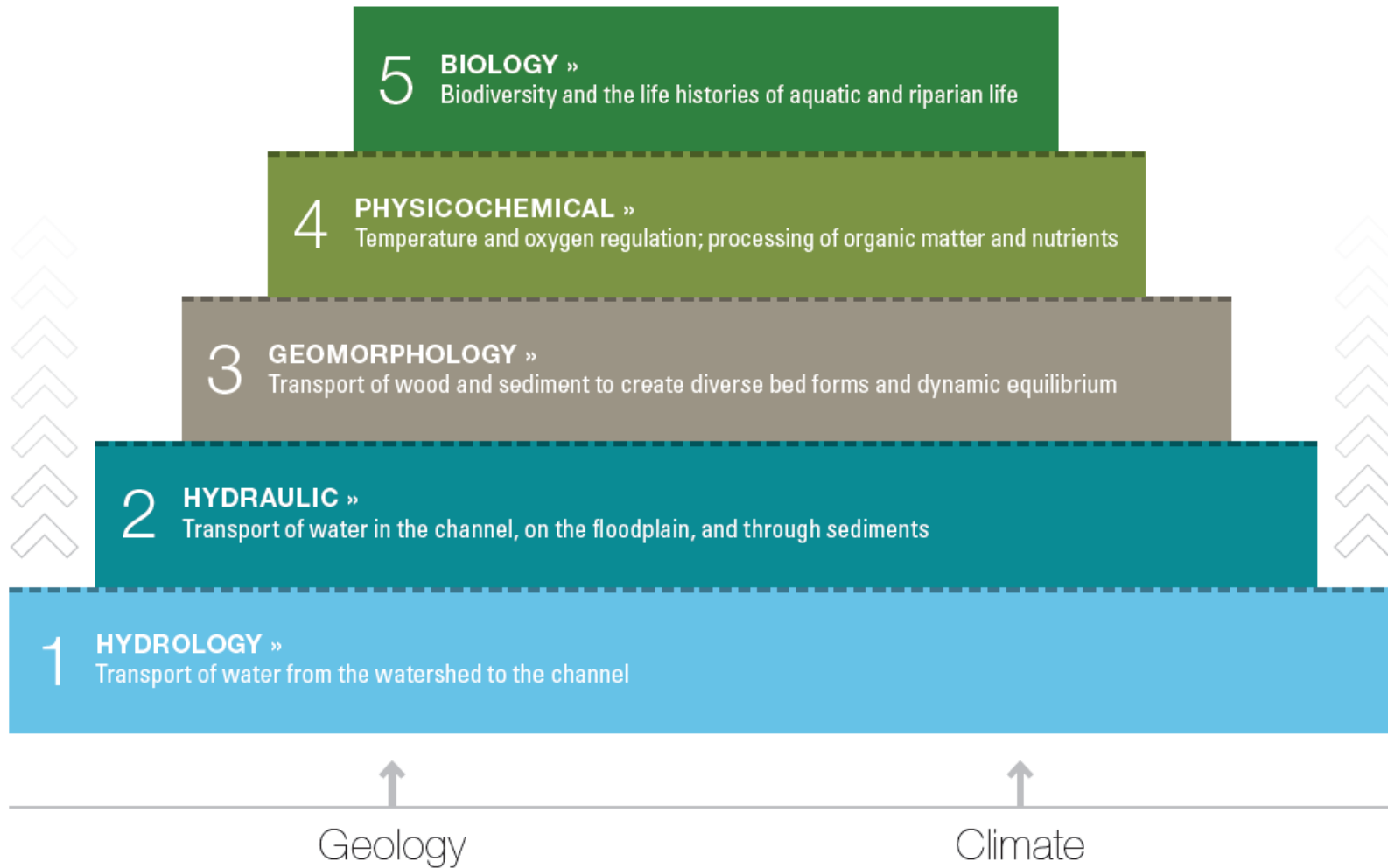
November 21, 2019

Agenda

- Introductions
- Fluvial geomorphology
- Ecology
- Hydraulics
- Conclusions

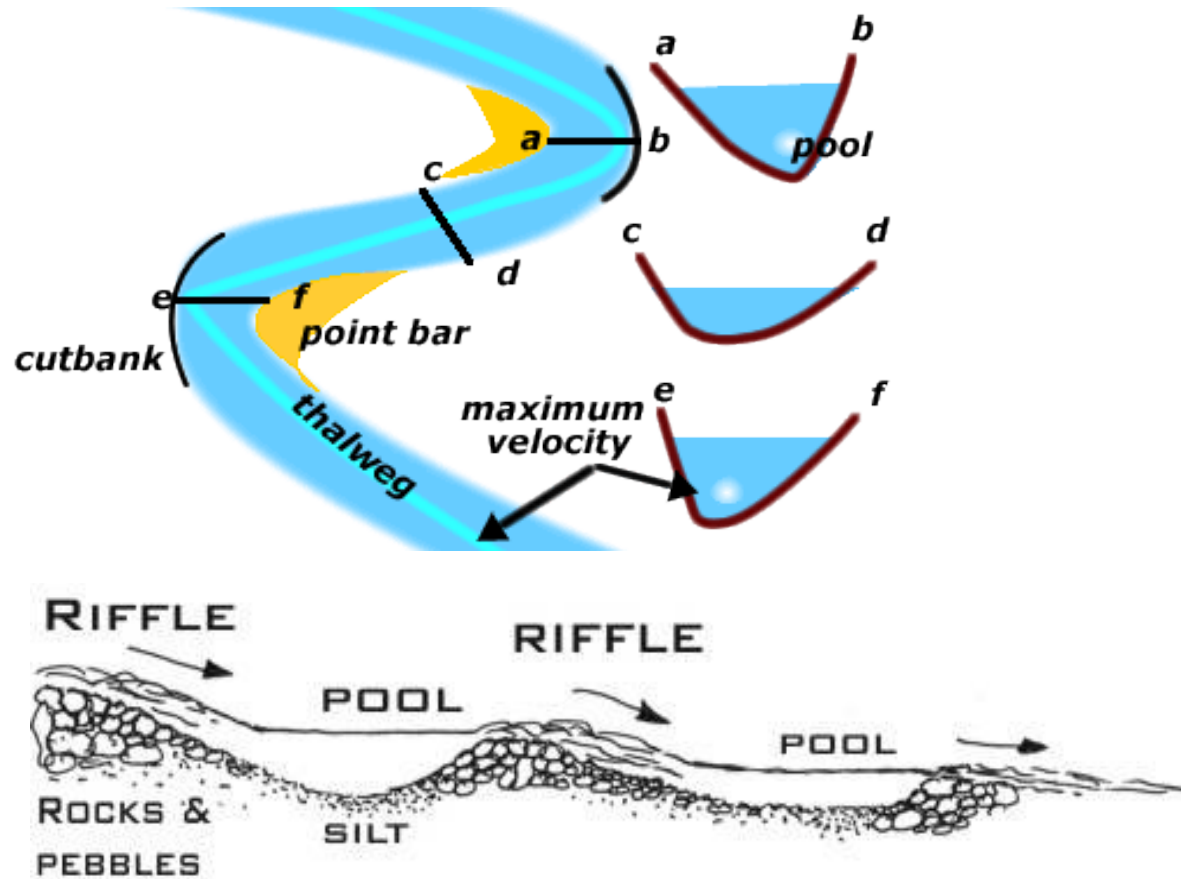


The Stream Function Pyramid

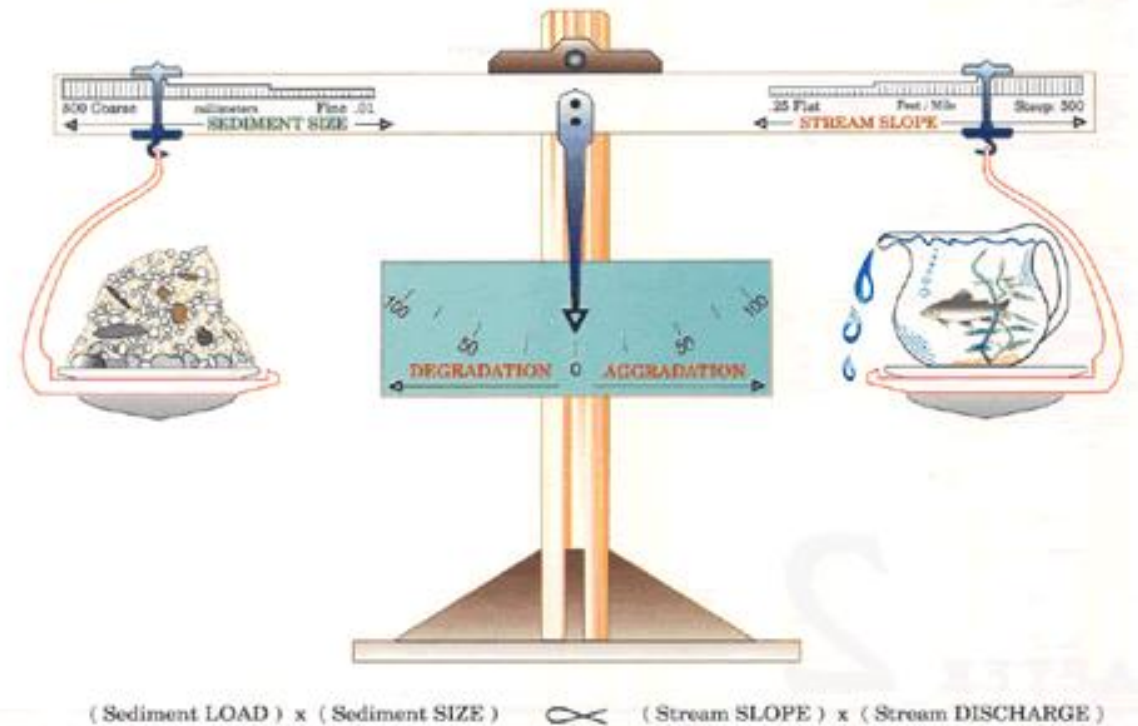


Fluvial Geomorphology – Importance of Sediment

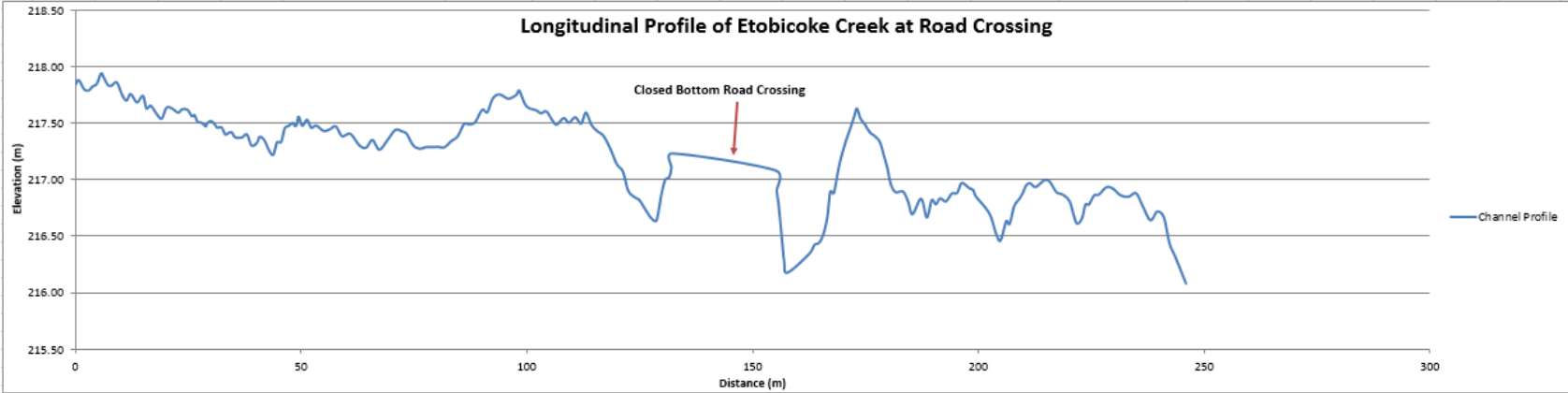
Natural Channel Processes



Alteration of Channel Processes



Fluvial Geomorphology – Importance of Sediment



Fluvial Geomorphology – Sediment Sizing

Pebble Count

Percentile	Cross Section 1	Cross Section 2	Cross Section 3	Cross Section 4	Cross Section 5	Cross Section 6	Cross Section 7	Cross Section 8
D16	0.001	0.003	0.003	0.002	0.001	0.001	0.002	0.002
D50	0.08	0.79	0.67	0.58	0.43	0.09	0.11	0.39
D84	7.45	7.45	7.10	7.45	3.99	3.64	7.09	3.06



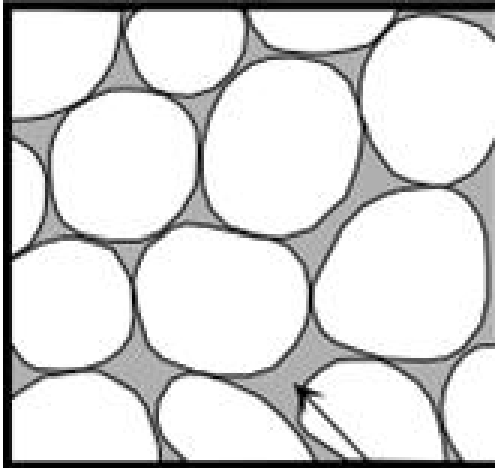
Existing Conditions

Shear Stress and Velocity Equations

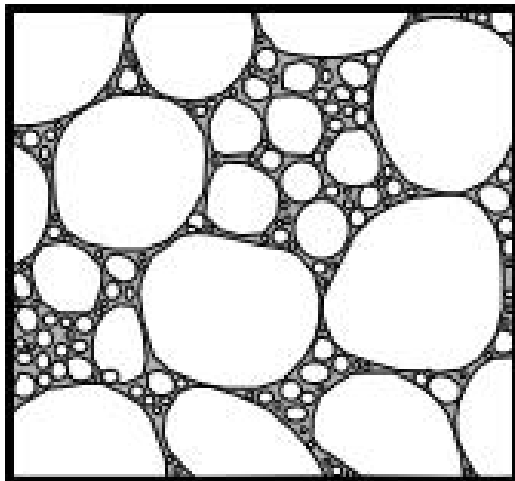
Source	Equation	Input Variables	Recommended D ₅₀ Particle Size
Komar (1988) (modified)	$V = 57D_{50}^{0.46}$	v is velocity (cm/s), and D50 is the median bed material grain size (cm). This value was then converted into m/s.	224 mm
Shield's equation (Knighton, 1998) (modified)	$\tau_c = \tau^* c (\rho_s - \rho_w) g D50$	Where τ_c is the critical shear stress N/m ² , $\tau^* c$ is the dimensionless critical shear stress (0.045), $\rho_s - \rho_w$ is the grain density – the water density Kg/m ³ , g is the gravitational acceleration g (m/s), D50 is the median bed material grain size (m)	76 mm
MTO Highway Drainage Design Standards (January 2008)	Guidance Table	Velocity	200 mm
MTO Drainage Management Manual (MTO, 2008)	$T_{cb} = 0.0642 * D50$	Where T_{cb} is the maximum resistive force and D50 is the median bed material grain size (m)	90 mm
Newbury, R. (2010)	$d = 150v^2 / (\mu g (\rho_r - \rho_w))$	Where d is the grain size, v is velocity, μ is the friction factor, g is gravity, ρ_r is the density of rock, and ρ_w is the density of water.	200 mm
Federal Highway Administration (1989)	$D50 = 0.00594 k_1 V a^3 (d_{avg}^{0.5} k_1^{1.5})$	Where D50 is the median grain size, Va is the average velocity in the channel, d avg is the average depth in the channel centre.	140 mm
U.S Department of Transportation (2005)	Guidance Table	Varies	50 mm to 0.15 m

Fluvial Geomorphology – Substrate Gradation

Gradation is also Important!



- Well sorted soil or sediment indicates that particles are generally all the same size
- Well sorted soil or sediment has higher porosity since there are more voids between particles



- Poorly sorted or unsorted soil or sediment indicates that particles are a wide range of sizes
- Poorly sorted soil or sediment has lower porosity since finer grains will fill the voids between the larger grains



Fluvial Geomorphology

Watercourse surrounded by infrastructure –
watercourse should not move



Watercourse surrounded by open land – let the
creek move



What about Biology?

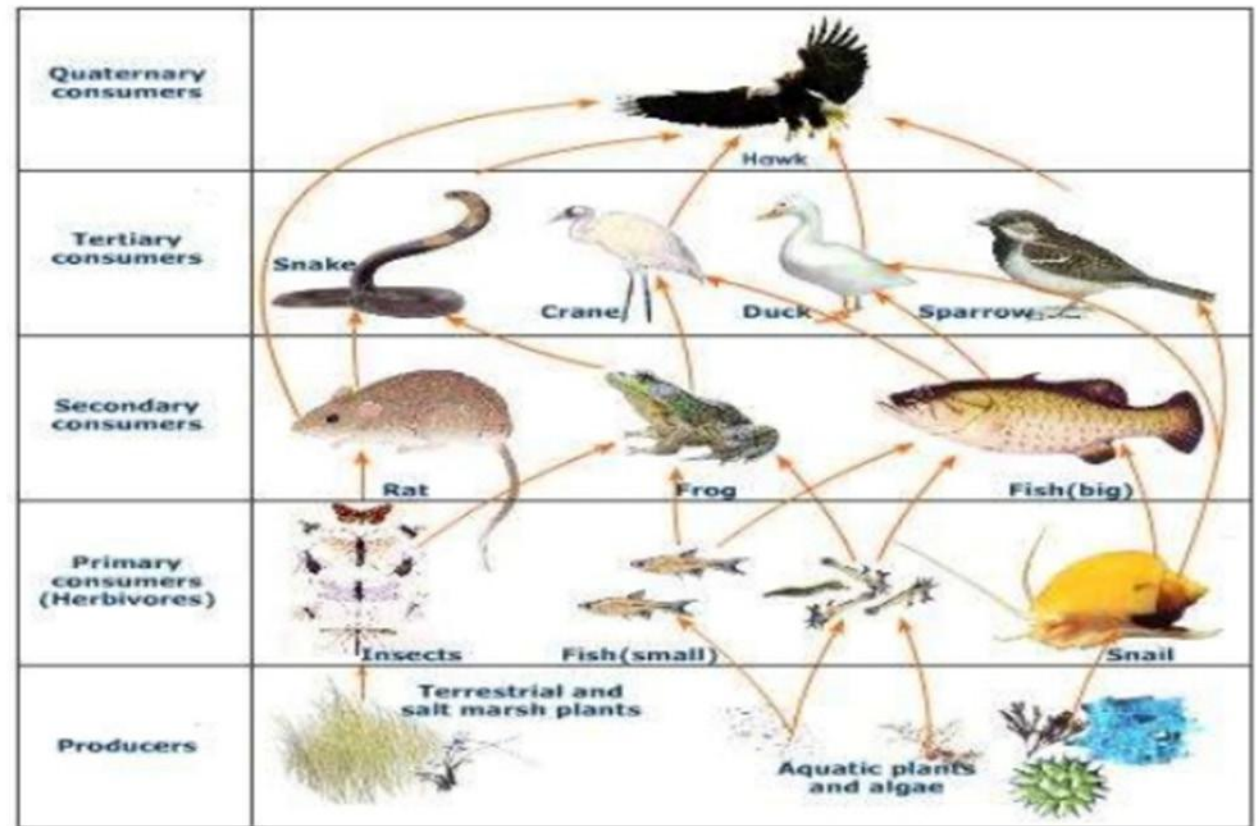
- Ecological Function
- Support native / existing species
- Life processes
- Total biomass
- Back to basics



Back to the Future

- Food, shelter, reproduce, repeat!
- Water quality
- Habitat conditions
- Species specific
- Seasonal changes
- Brusselsprouts

FOOD WEB IN TERRESTRIAL AND AQUATIC ECOSYSTEM

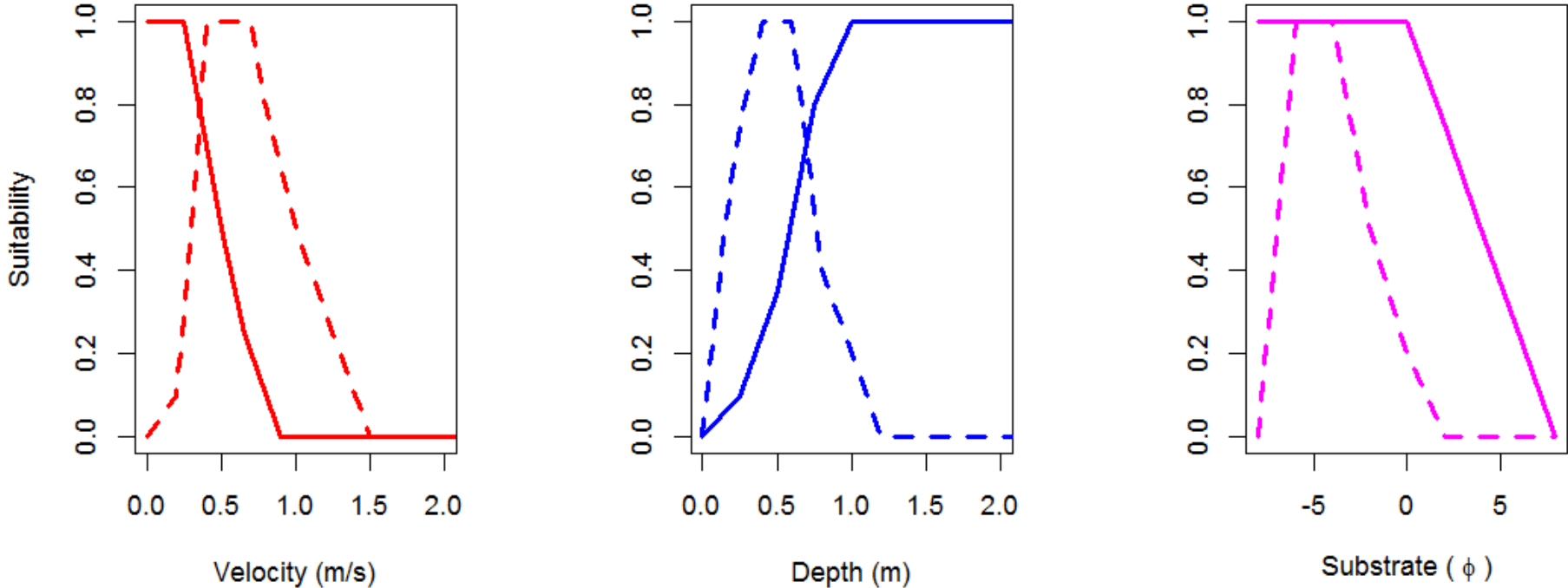


It's all about the ~~Benjami...~~ Balance!

- Variety
- Alternatives
- What if it moves?
- The fluvial way
- Representative reaches
- Back to the drawing board?



Redside Dace HSI



— Adult
- - - Spawning



Bigger Not Always Better

- One question, many problems
- Alterations to flow
- Would you like that Supersized?
- Barrier to fish
- Need for collaboration
- More harm than good



Conventional Use of Riprap Design Overview – Engineering Perspective

- **Riprap** is generally used in drainage channels, bridges, culverts to provide a stable lining to resist erosion by channel flow velocities

“HARD APPROACH”



- The objectives of this part of our presentation are to:
 - Show some of the typical riprap design methods
 - Discuss if the results from these methods support the natural channel functions
 - Compare the “Hard Approach” and the nature oriented design (“Soft Approach”),
 - Discuss the issues and benefits found from the performance of these two approaches

Riprap Design – Methods Overview

- **USACE:** The U.S. Army Corps of Engineers developed this method for flow in man-made or natural channels with low turbulence and slopes $< 2\%$
- **ASCE:** The American Society of Engineers method uses the modified Isbash equation (Isbash 1936) to account for channel bank slope
- **USBR:** The U.S. Bureau of Reclamation developed this method for estimating the riprap size to be used downstream of a stilling basin ($f = \text{average } V$)
- **USGS:** The U.S. Geological Survey method resulted from the analysis of field data taken 4 cities in USA. The survey related the site hydraulic conditions to the performance of the riprap protection ($f = \text{average } V$)
- **ISBASH:** developed for the construction of dams by placing rock into running water (Isbash, 1936)
- **HEC-11:** (FHWA, 1989), developed for the use in rivers or streams with non-uniform flow conditions and discharge $> 1.42 \text{ m}^3/\text{s}$ ($50 \text{ ft}^3/\text{s}$)

Riprap Design – Methods Overview (cont'd)

– Tractive force methods

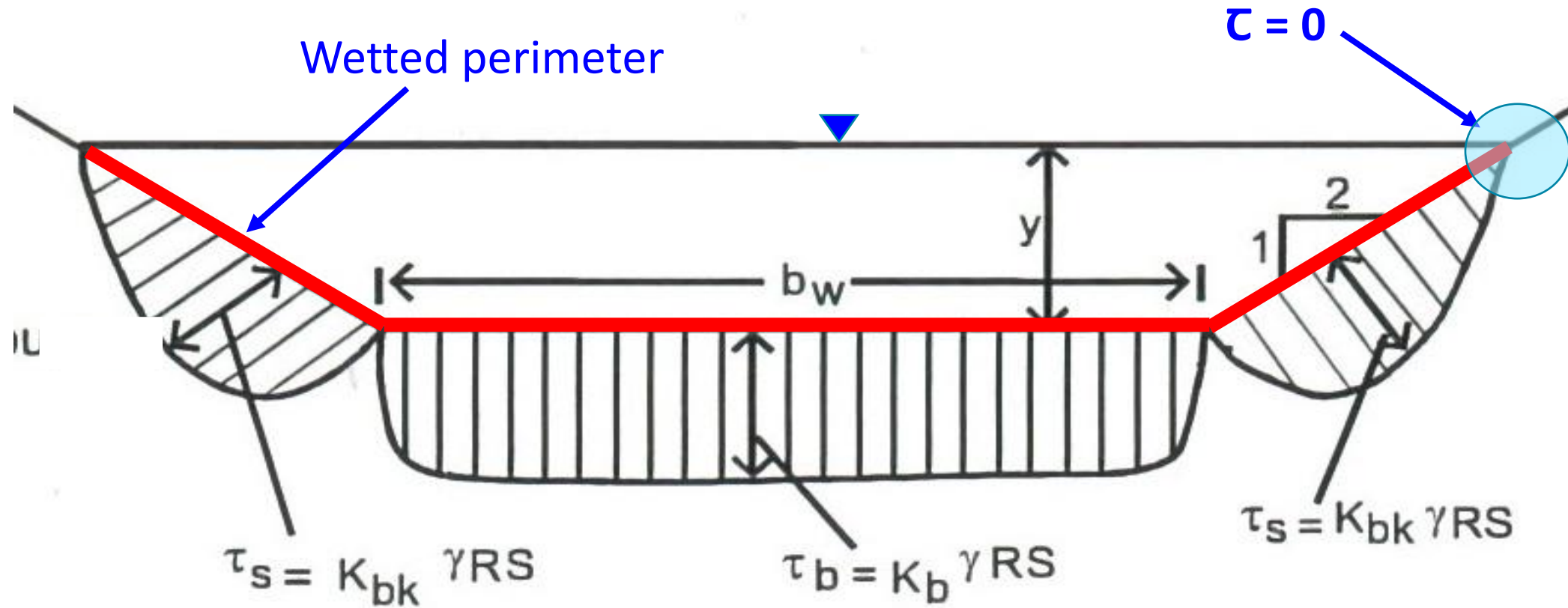
- Tractive force applied by the flow on the wetted perimeter of the channel.
- *If applied tractive force > resistive force of the lining material => erosion occurs*
- *Otherwise, bed and/or bank is stable*

$$\tau = K * \gamma * R * S$$

- Where:
 - τ = Tractive force (wetted perimeter)
 - K = Tractive force coefficient (bottom or sides)
 - γ = Unit weight of water (9810 N/m³)
 - R = Hydraulic radius (m) $\rightarrow A/P$
 - S = Channel slope (m/m)

Riprap Design – Method Overview (cont'd)

Tractive Force Variations in a Trapezoidal Channel



Riprap Design – Method Overview (cont'd)

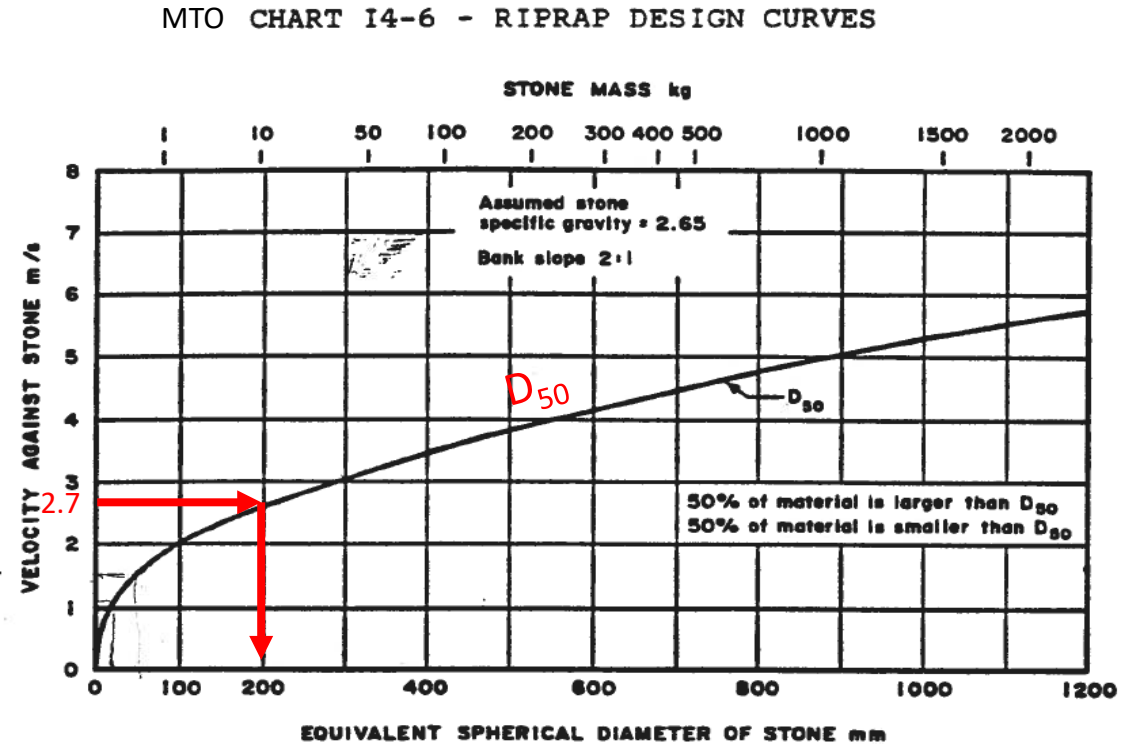
– Avoid the “quick-fix” approach as possible:

– *Example:*

– $V_{100} = 2.7$ m/s

– $D_{50} = 200$ mm

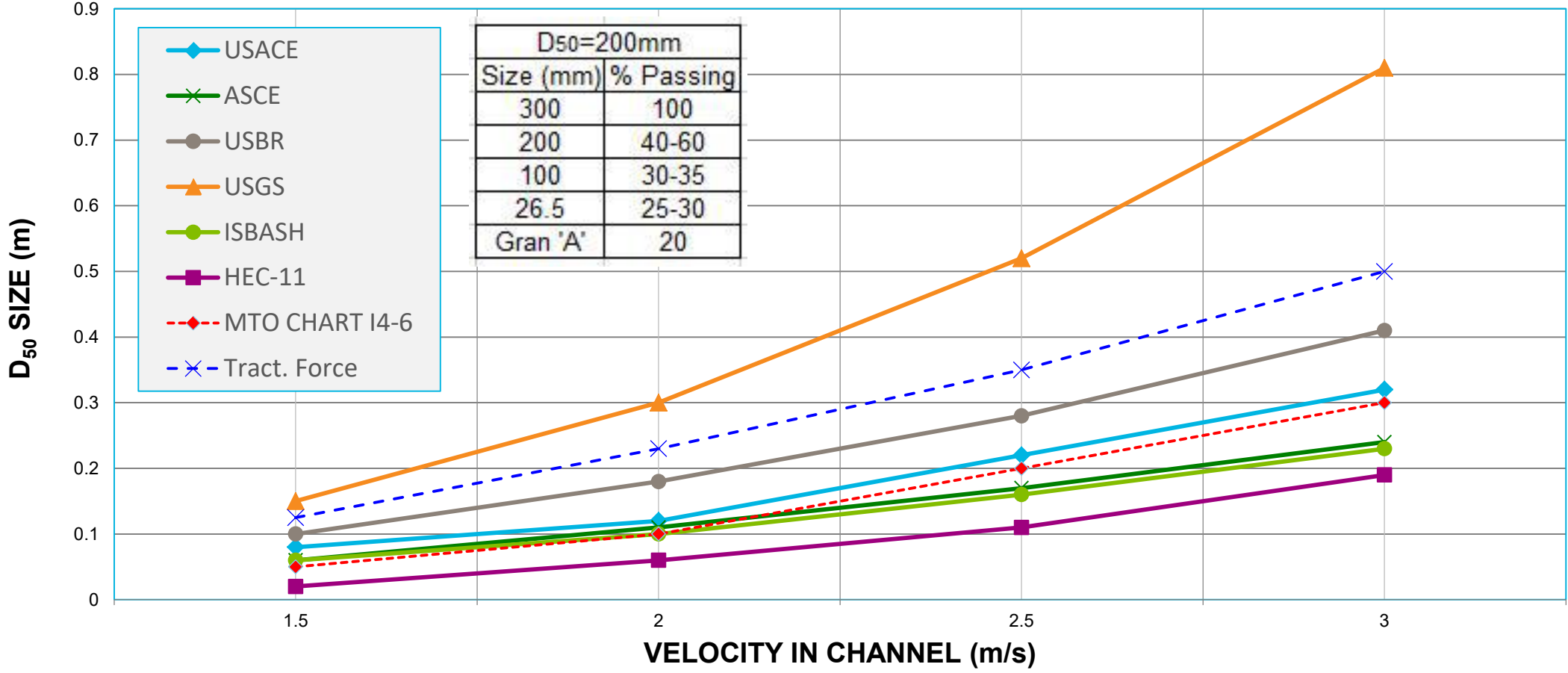
– Is this rock size applicable to banks and bottom?



a. Stone mass and diameter for given local flow velocity.
(Tentative curve based on ref. 11).

Riprap Design Methods – Comparison of Results

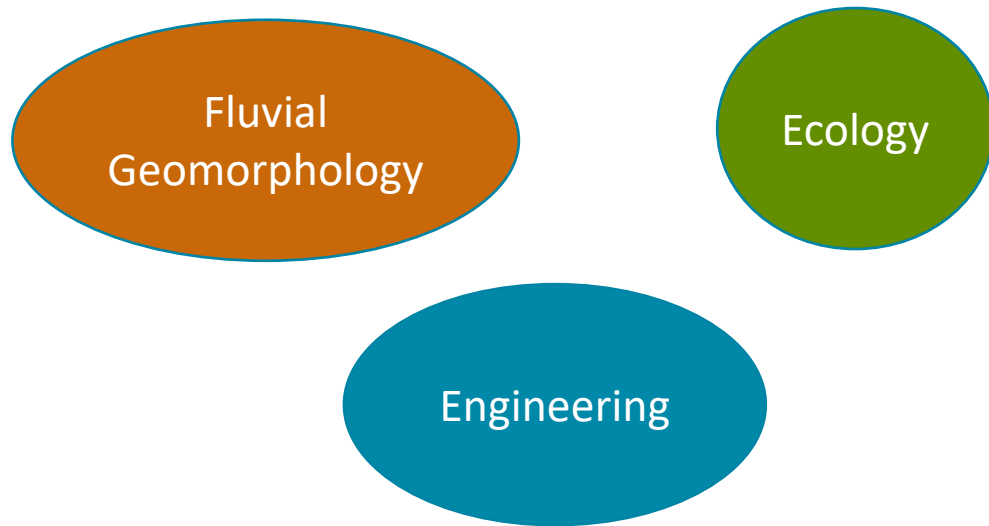
**ESTIMATING THE RIPRAP D_{50} SIZE FOR VARIOUS FLOW VELOCITIES
METHODS COMPARISON**



Standard Practices - “Hard” vs. “Soft” Approaches

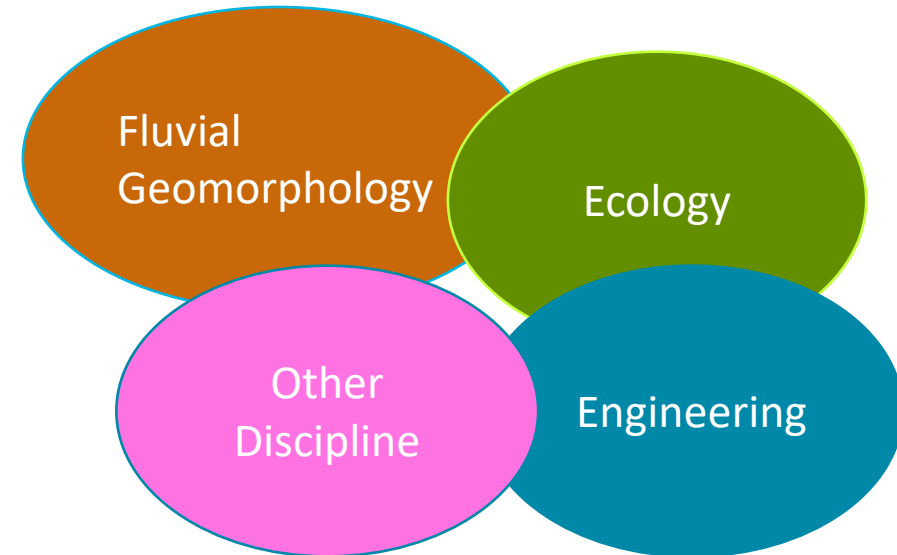
Conventional methods - “Hard Solution”

- It is not an integrated process
- Insufficient communication between disciplines



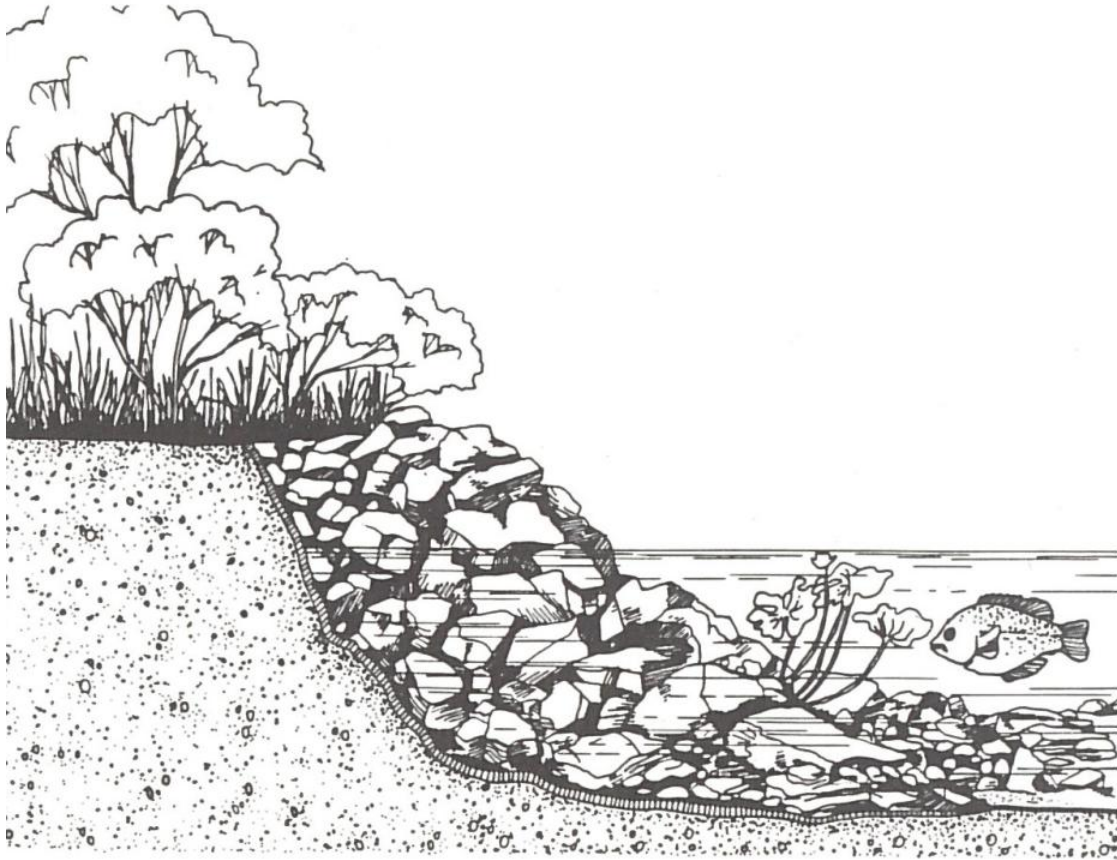
Nature Oriented “Soft Solution”

- More communication between disciplines
- Requirements from other disciplines are included in the design
- Likely more consultation with agencies

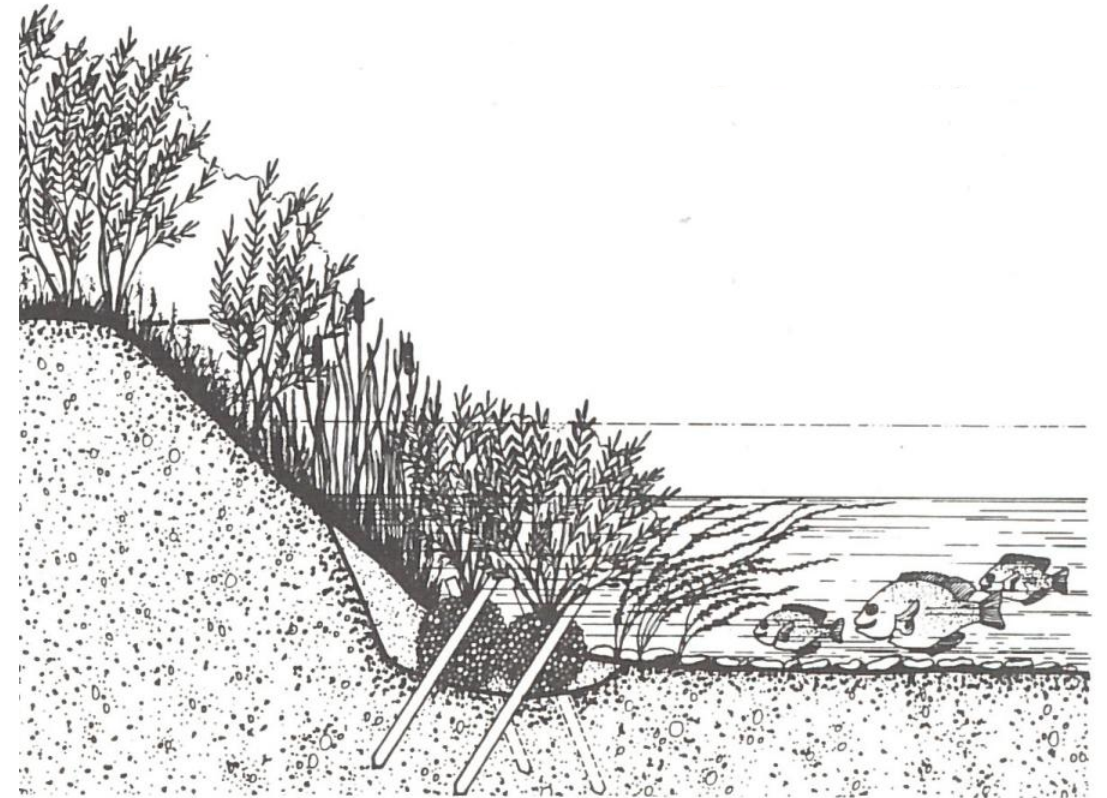


Comparison Between “Hard” and “Soft” Approaches

Conventional “hard” approach



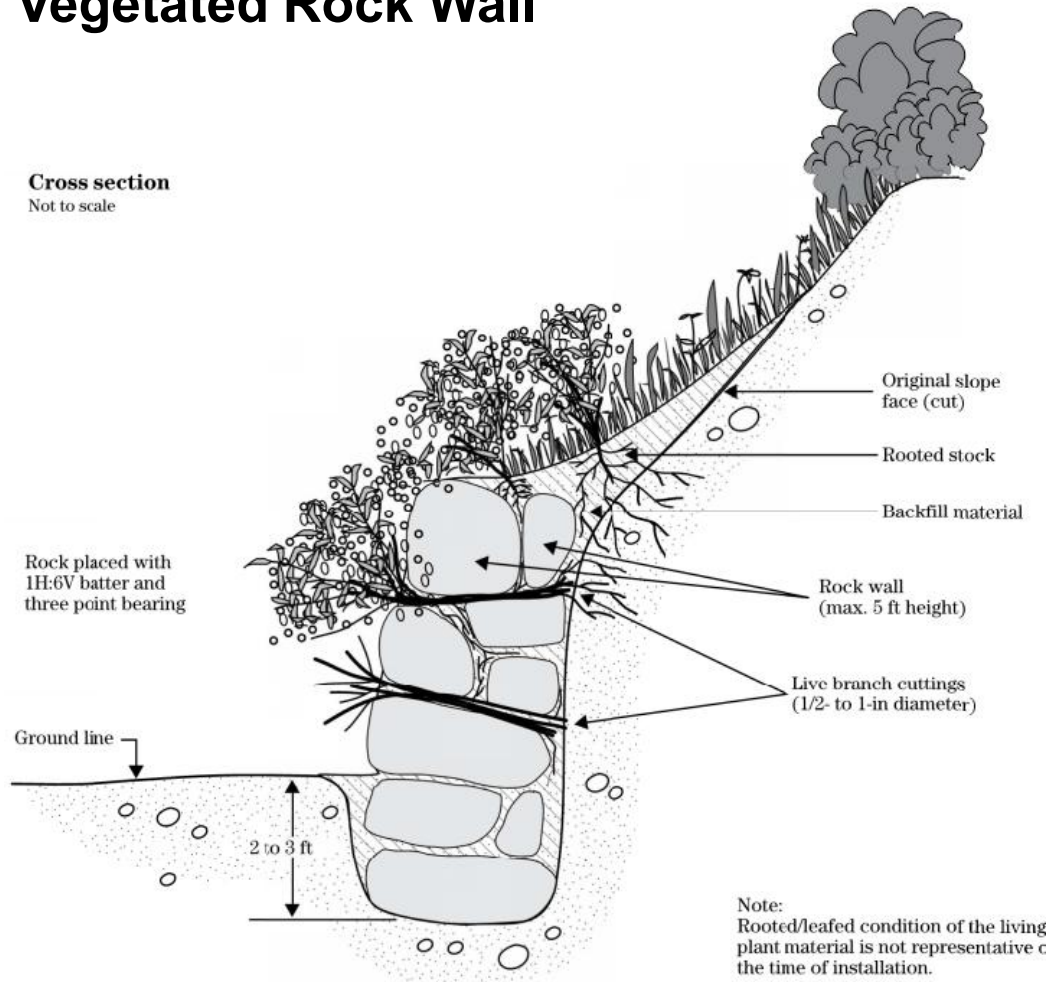
Nature oriented “soft” approach



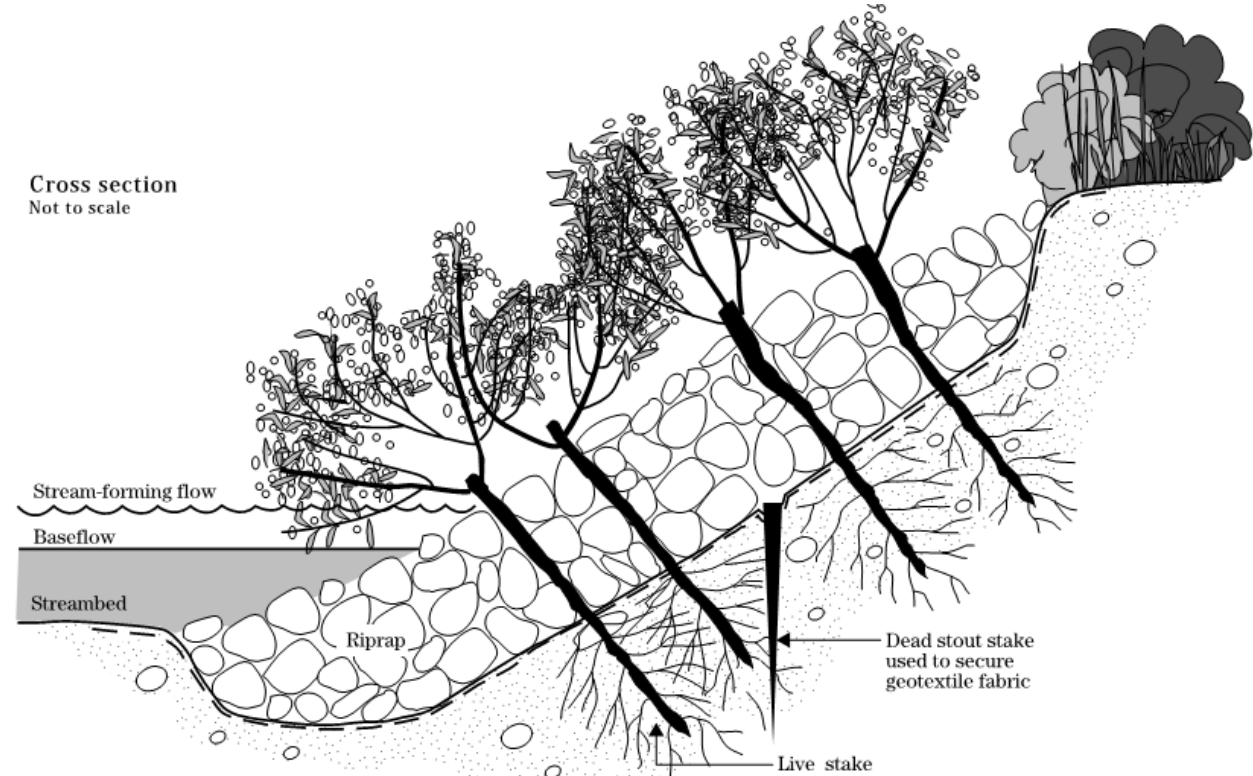
Source: Natural Channel Design (D. Shrubsole, March 1994)

Streambank Bioengineering Methods

Vegetated Rock Wall



Live Stake and Riprap



Streambank Bioengineering Methods – Cont'd



Brush mattress with rock

Live Planting with rock



Source: National Engineering Handbook (NEH) – Part 654

Issues and Benefits - “Hard” vs. “Soft” Approaches

Conventional “hard Approach ” issues

- It does not support riparian flora
- It does not support wild life and aquatic habitats
- May deflects the geomorphic processes to the opposite bank
- It may be ineffective over time
- Maintenance costs are generally higher

Nature oriented “soft Approach” benefits

- Responds better to high flow velocities in the channel banks
- Restore the shape of the channel
- Improve water quality
- Restore lost wild life and fish habitats
- More stable over time
- Compatible with regulatory agencies and requirements
- Cost effective

Challenges

- Timing and cost of project
- Positive attitude - old conventional approach to nature oriented and integrated approach
- Provide the required protection of the channel, at the same time, maintain geomorphic processes (stable stream moves) and ecological requirements
- Quantify numerically the efficiency of the bioengineering technique against high flow velocities
- Urban development within the watershed

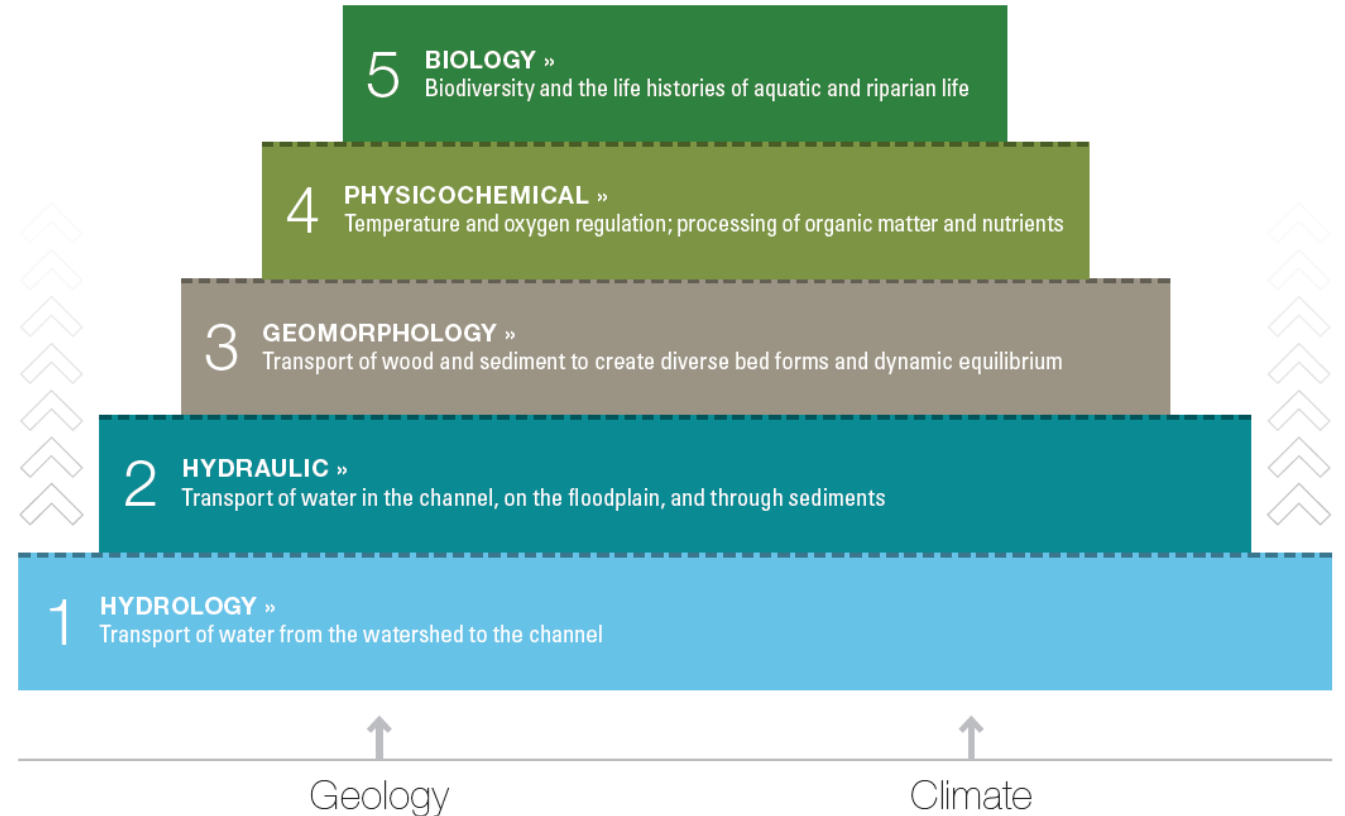
Refining the Process, Defining Success

- What is the objective?
- Site specific considerations
- Rock, paper, scissors
- Understand your constraints
- Engage all disciplines
- Measure of success



Conclusion

- Template for success
- Push your design
- Limitations & constraints
- Larger opportunity?
- Satisfactory solution
- Working together



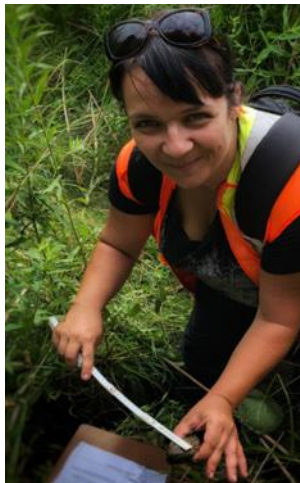
Thank you!

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