

2009 California Water Conference:
Changing Tides in the Inland Sea – A Confluence of Challenges and Opportunities

Incorporating hardened vegetated buffers along levees

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1-11-08

Lower Puyallup River

River
Road

North
Levee

Puyallup River

Silt Bench



Channel and floodplain confinement in the early 1900s



**Problem:
Bank erosion threatening
critical levee**



Project Site 2004 (Figure 3, CHE 2005)

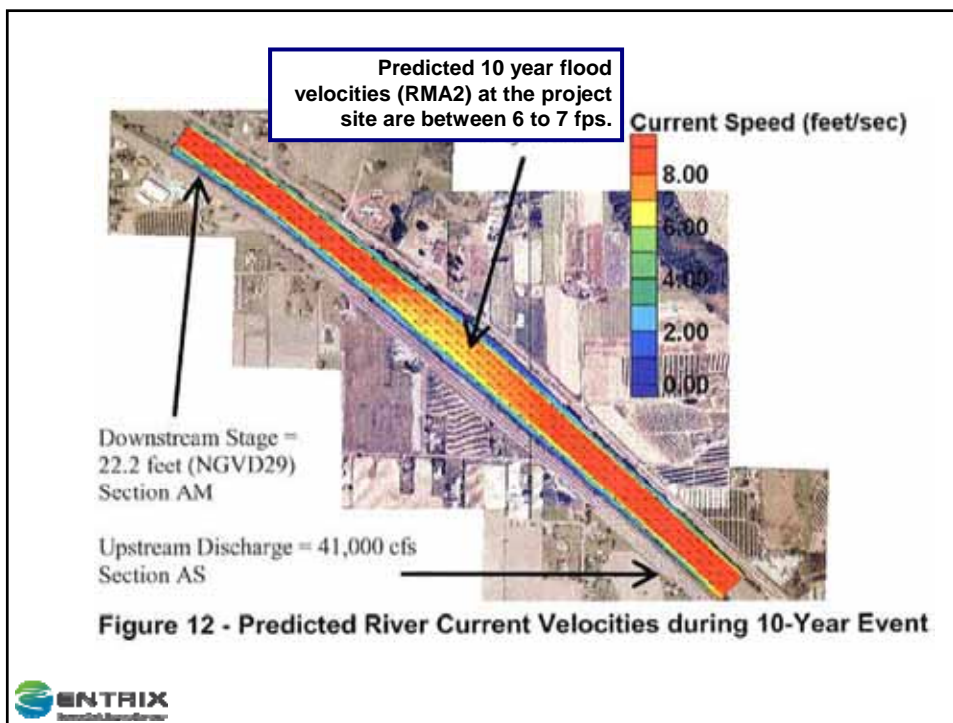
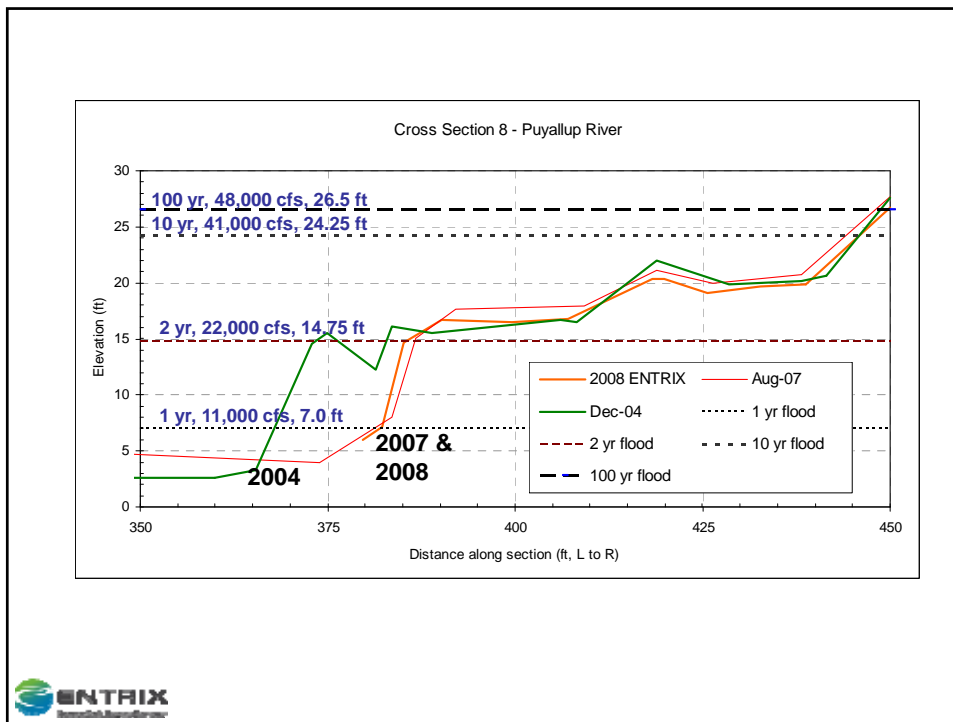


Project Site 9/27/07



River up to ordinary high water owned by Puyallup Tribe.

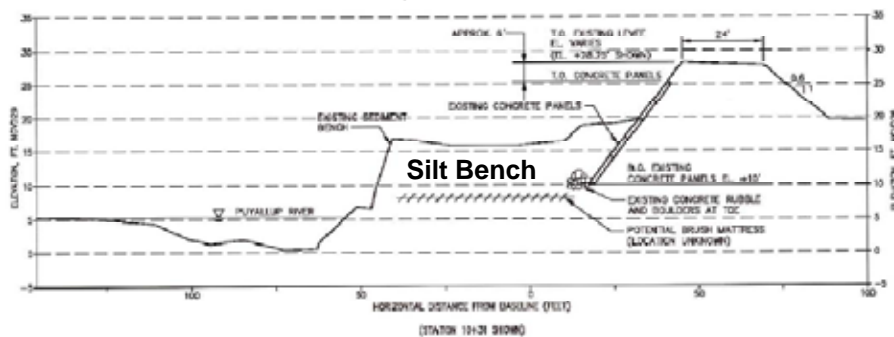




Historic North Levee Structure



Construction of a “silt bench” along inboard side of historic levee was critical element in protecting toe of levee



Problem: Erosion of Silt Bench
Goal: Protect Silt Bench



Historic elements: concrete slope



**Historic elements: Cedar brush matting
underlying silt bench**



**It is unclear regarding the extent of this work –
there is no direct evidence from corings or bank
stratigraphy it was done at site.**



Eroding bank into historic concrete armoring
Right Bank of Puyallup River 01/11/08:

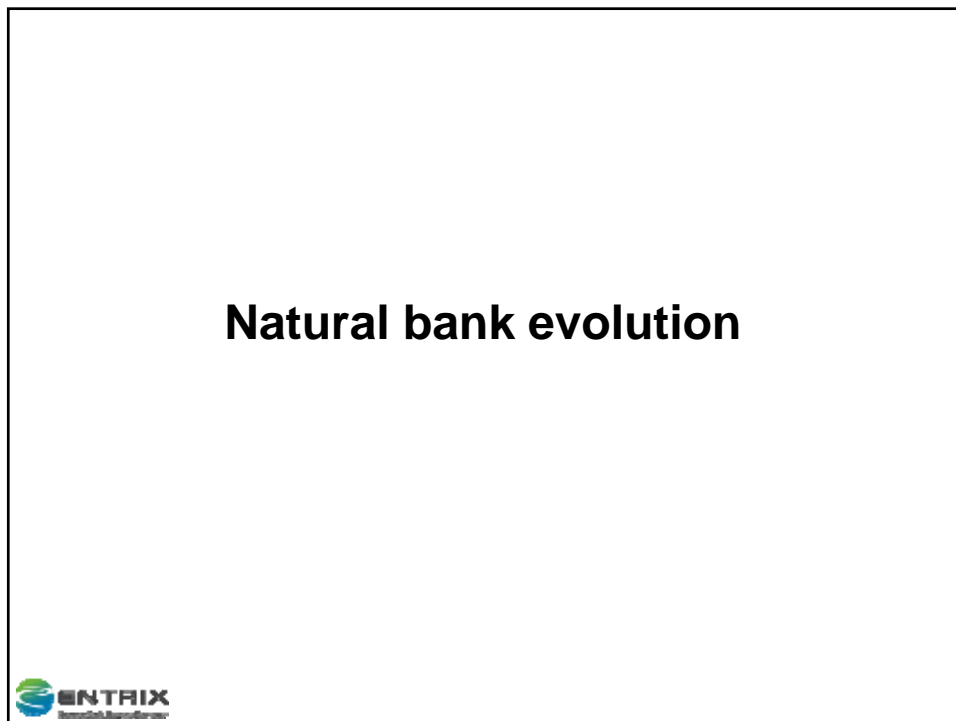
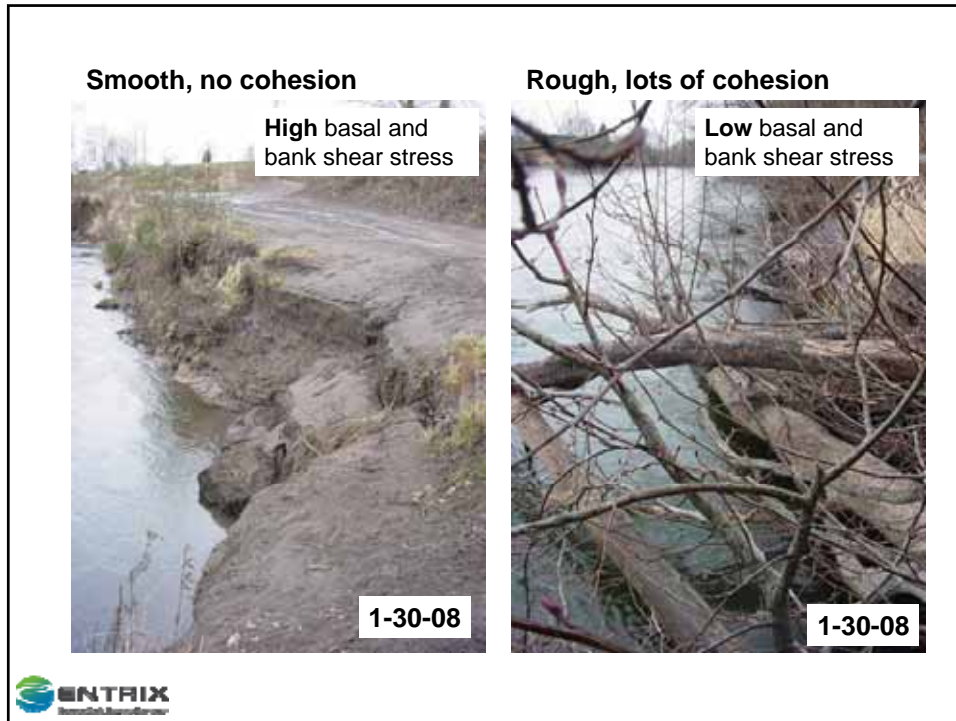


GOAL – Prevent this from occurring at project site.



**Existing Bank Conditions
along Lower Puyallup River**







Bank Erosion, slumping

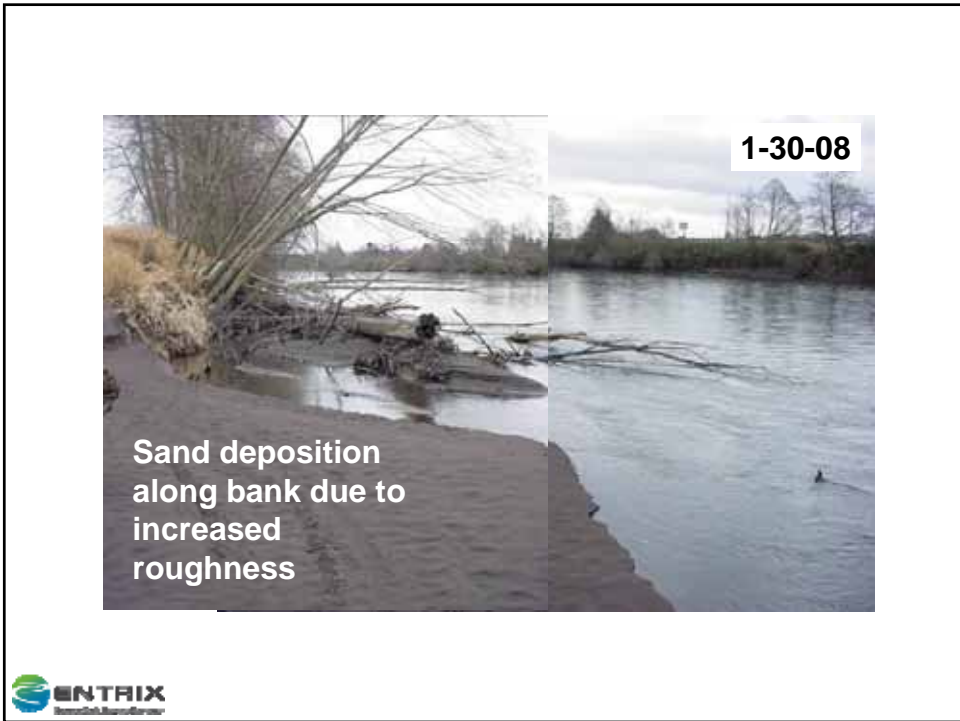
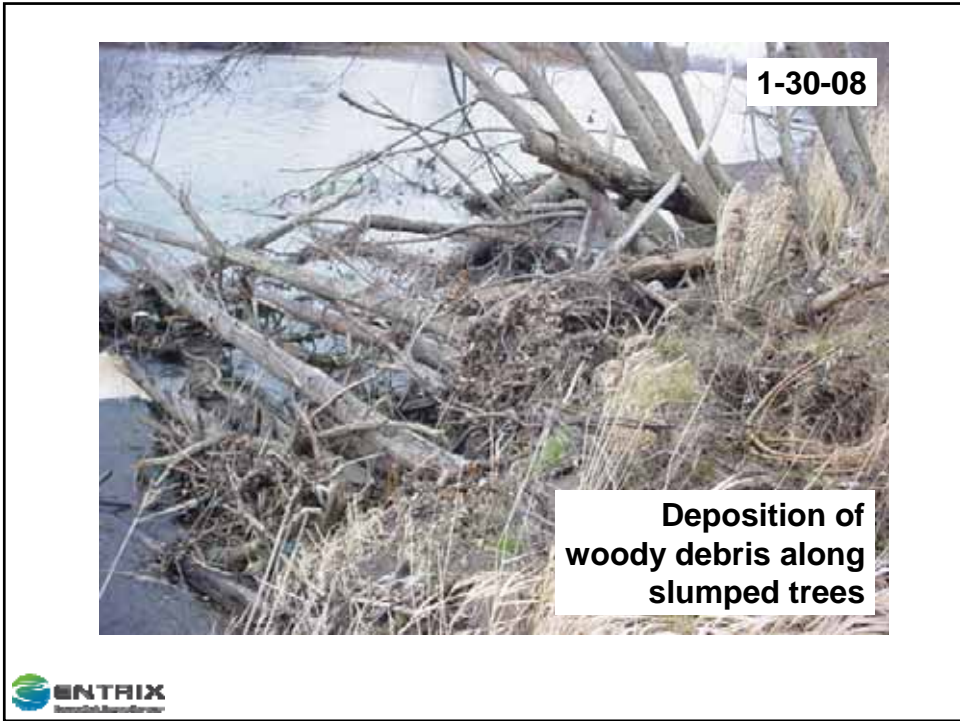


Project Site 01/11/08: looking upstream at bank slump



Submerged trees increase bank roughness





**Right Bank of Puyallup River 01/11/08:
Naturally re-constructed silt bench shoreline**



**Naturally reconstructed shoreline,
note buried trees along bank**



Key factors not considered in previous engineering investigations that developed expensive heavily engineered bank protection options:

- 1. Vegetation cohesion**
- 2. Boundary roughness attributed to vegetation and snags**
- 3. Self-anchoring characteristics of snags**
- 4. Natural shoreline development & regime theory**



**Conceptual Model Illustrating the
Geomorphic Evolution of Silt Bench
or the 'natural' evolution of an inset
floodplain in an oversized channel**



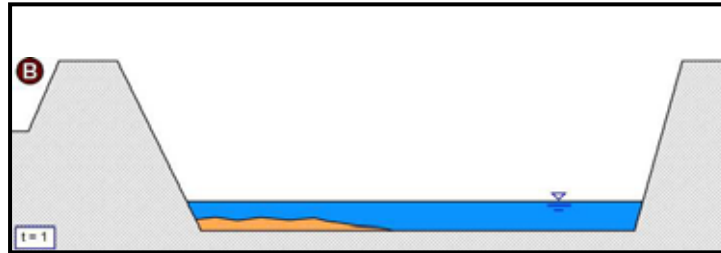
Geomorphic Evolution of Puyallup Silt Bench



Flood conveyance channel oversized relative to dominant flows



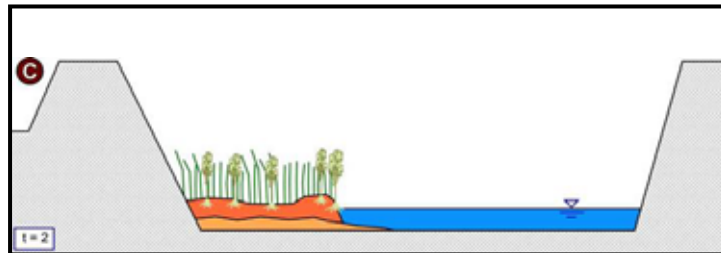
Geomorphic Evolution of Puyallup Silt Bench



Sedimentation and bar formation resulting from over-sized channel



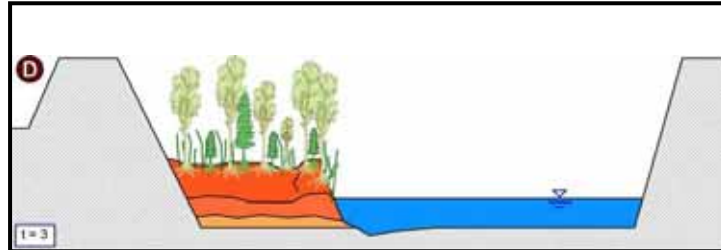
Geomorphic Evolution of Puyallup Silt Bench



Plant colonization and sedimentation



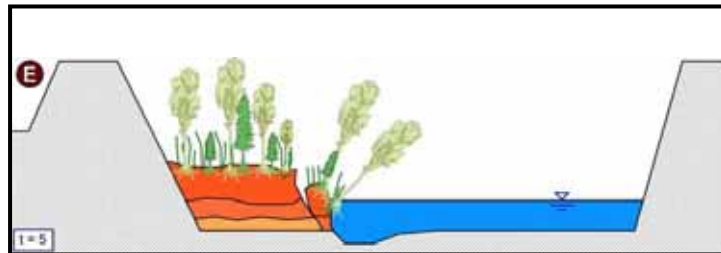
Geomorphic Evolution of Puyallup Silt Bench



Plant growth, accelerated sedimentation, and first signs of toe erosion



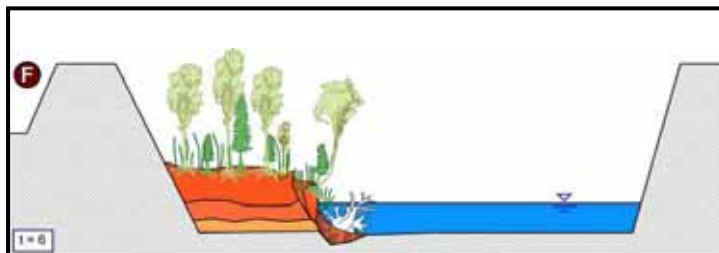
Geomorphic Evolution of Puyallup Silt Bench



Toe erosion under-cuts bank, tension cracking and slumping



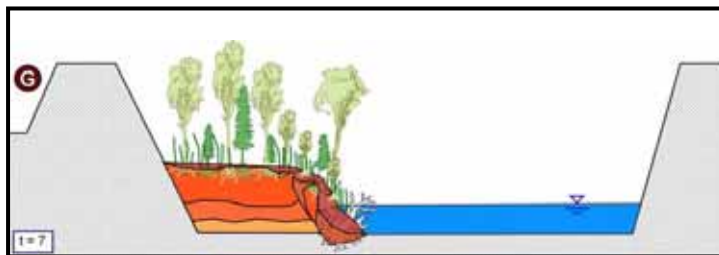
Geomorphic Evolution of Puyallup Silt Bench



Tree falls into channel forming snag that adds toe roughness. Fallen tree straightens out getting “pistol butt trunk”, snag and vegetation reverses erosion



Geomorphic Evolution of Puyallup Silt Bench

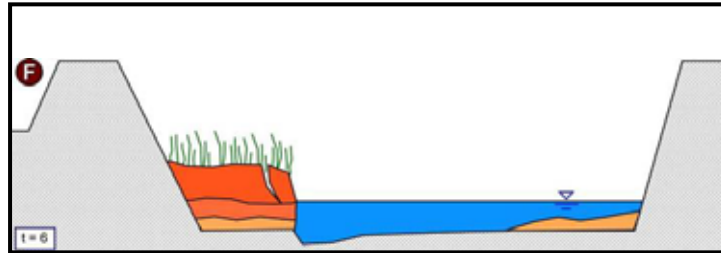


Colonizing vegetation further roughens bank, adds root cohesion and accelerates bank re-construction



Geomorphic Evolution of Puyallup Silt Bench

With no riparian trees, bench is at elevated risk of erosion



Without cohesion and roughness provided by trees bank erosion continues - channel shifting occurs similar to historic changes in location of point bar

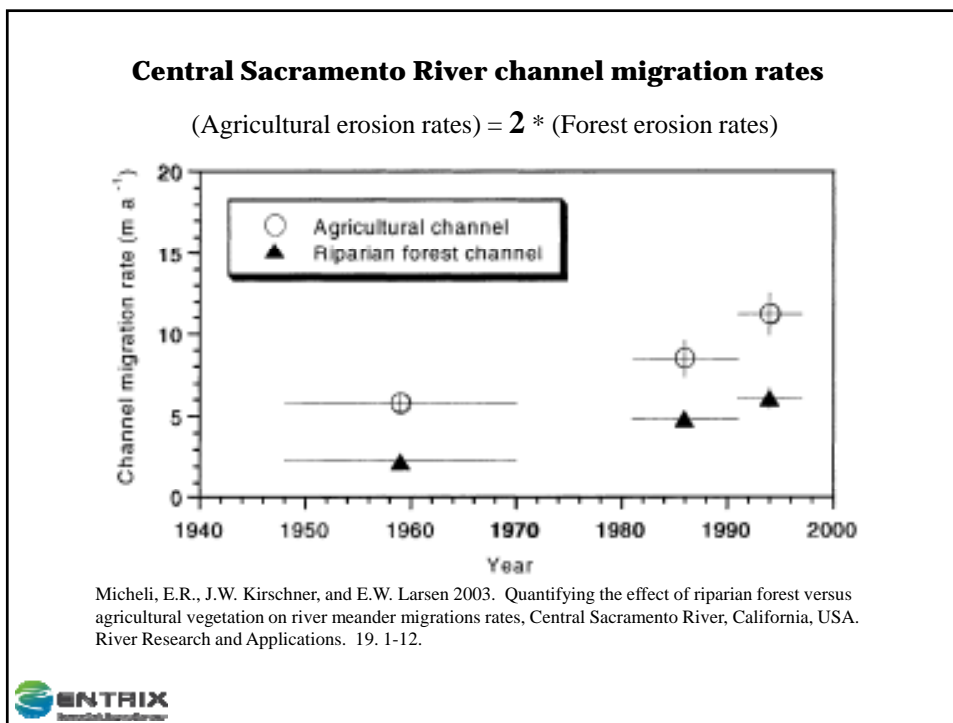
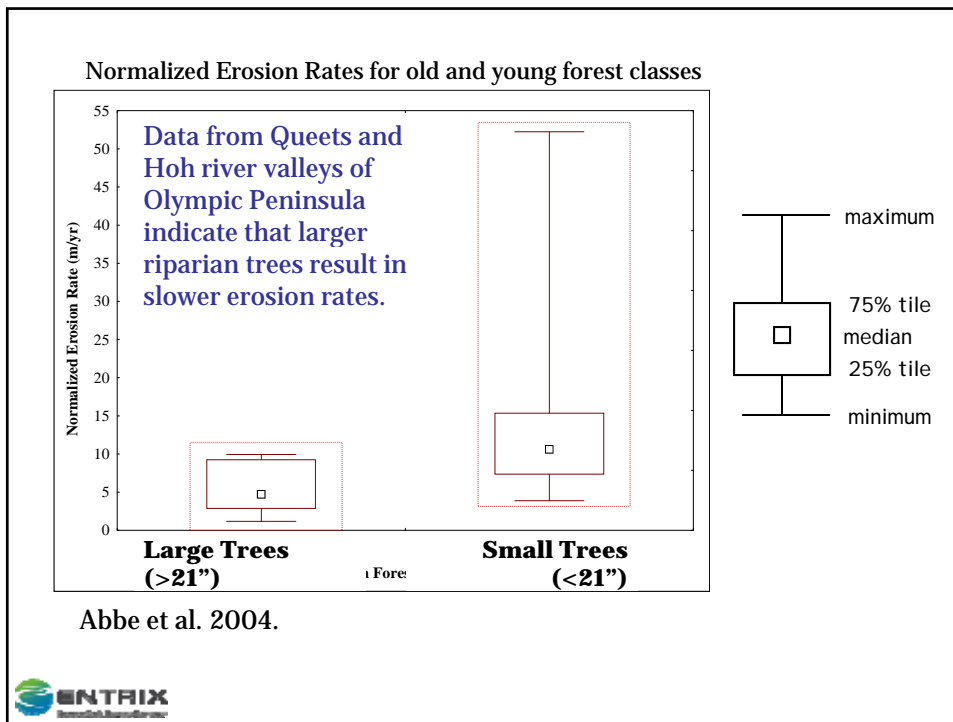


Evidence is mounting that riparian vegetation is effective in slowing erosion

The presence of woody corridors played a significant role in preventing damage to levees and reduced failure lengths by half along a 353-mile segment of the lower Missouri River during the flood of 1993.

Allen, Stephen B., John P. Dwyer, Douglas C. Wallace, and Elizabeth A. Cook, 2003. Missouri River Flood of 1993: Role of Woody Corridor Width in Levee Protection. J. of the American Water Resources Association (JAWRA) 39(4):923-933.

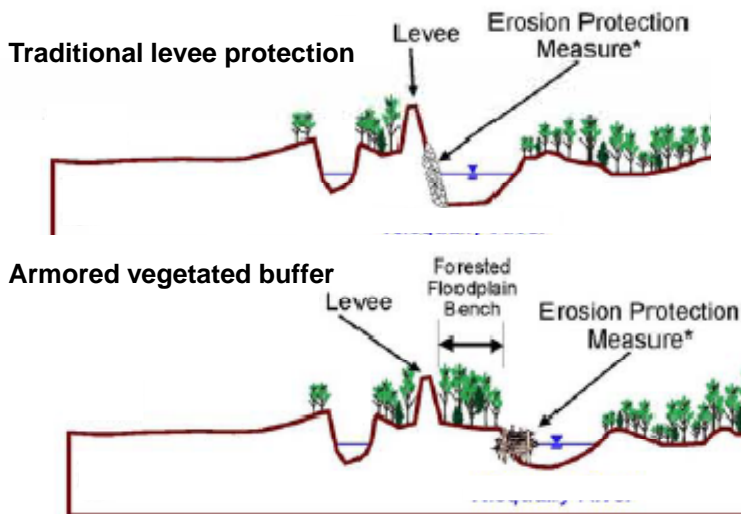




Developing levee protection alternatives that work emulate natural processes in the Lower Puyallup



Vegetated buffers offer additional protection and environmental benefit



* Erosion Protection Measure: complex dynamic revetments, engineered logjams



Design Issues

- How do we reinforce the silt bench?
- How do we do it without raising 100 yr flood wsel?
- How can we design for scour?
- How can we reduce cost of structure?
- Can we ultimately design a 'self-mitigating' design to satisfy stakeholders while providing the desired flood protection confidence?

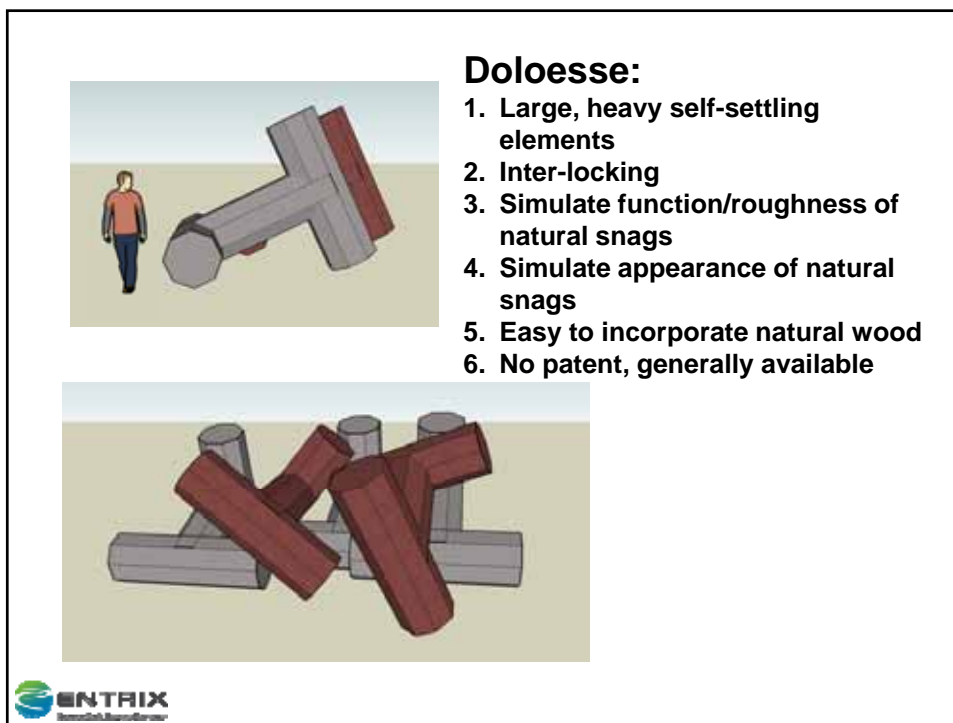
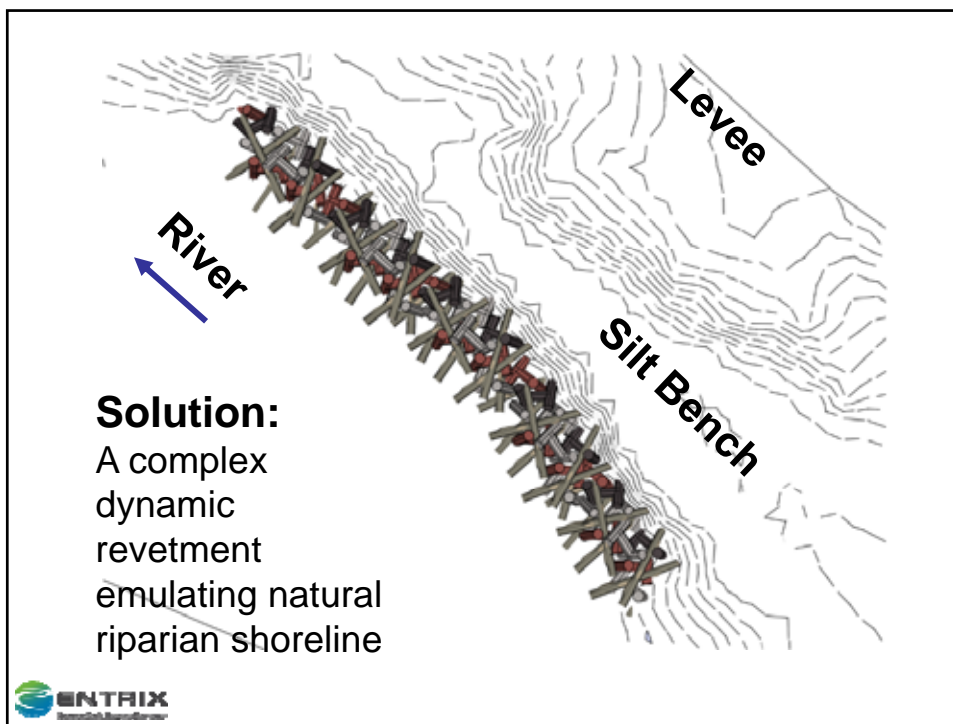
The key was seeking a “biomimicry” solution by simulating the natural anchoring and interlocking characteristics of trees and snags.



The Answer

- A self-settling, interlocking “dynamic” revetment
- A complex revetment to reduce near bank shear stress and create edge habitat
- Incorporation of natural materials into revetment: woody debris and vegetation
- Design that would allow in-water construction.
- Simple construction.
- Structure designed to “evolve” with natural processes of the site.





Relatively easy to incorporate wood debris

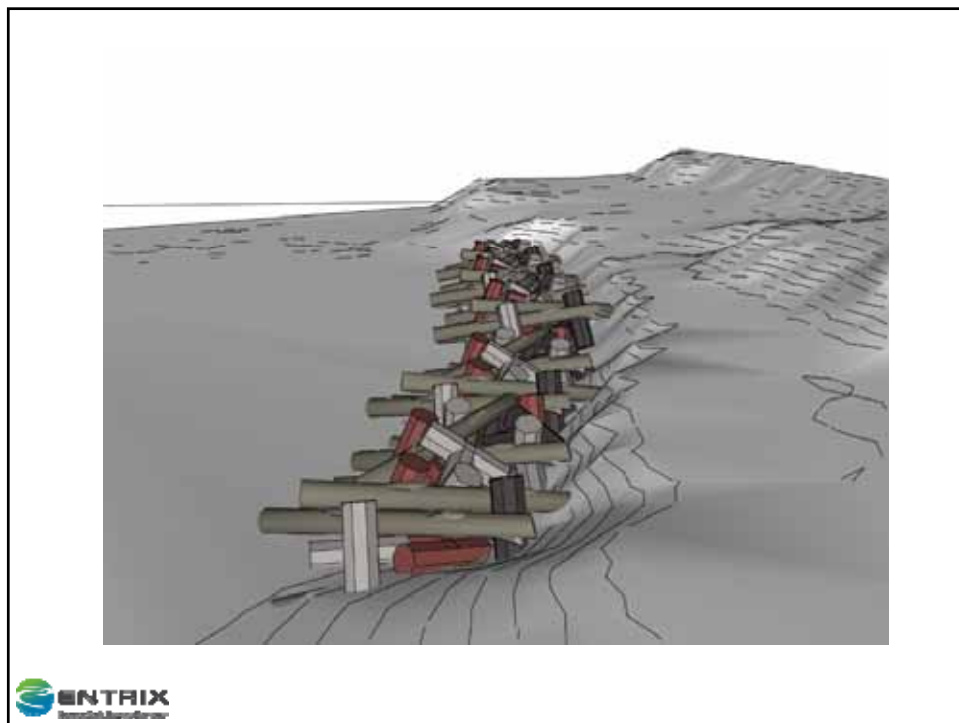
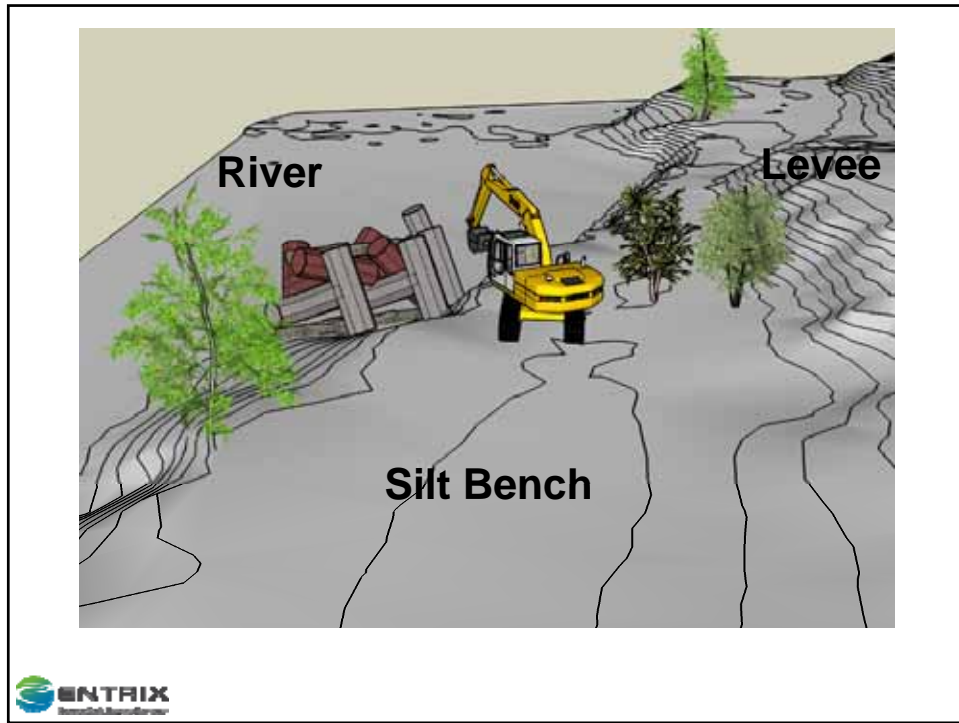


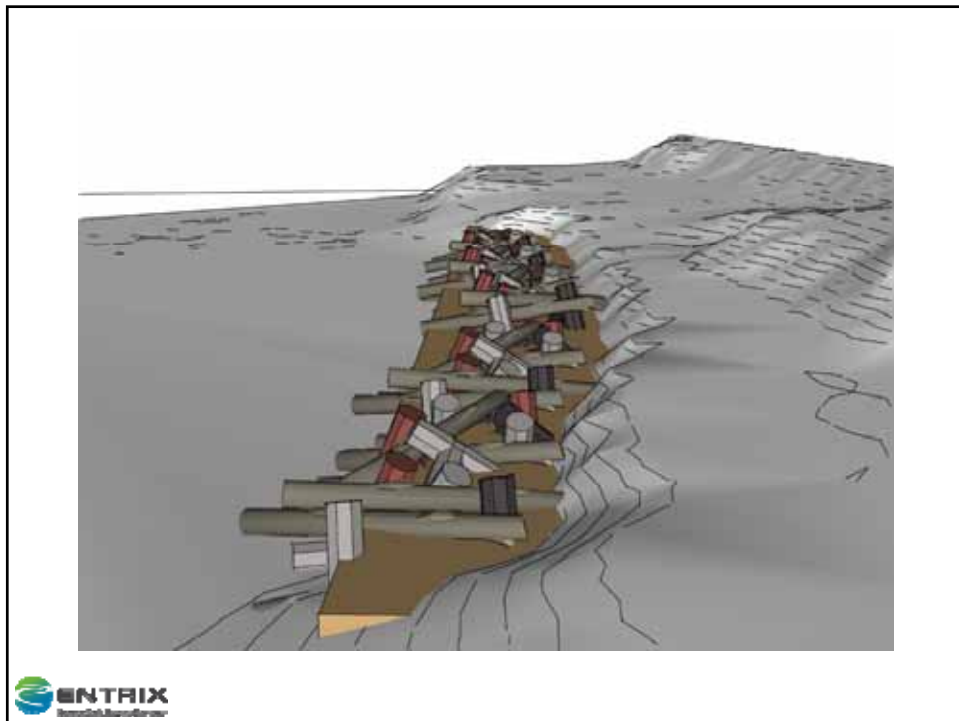
Construction visualization

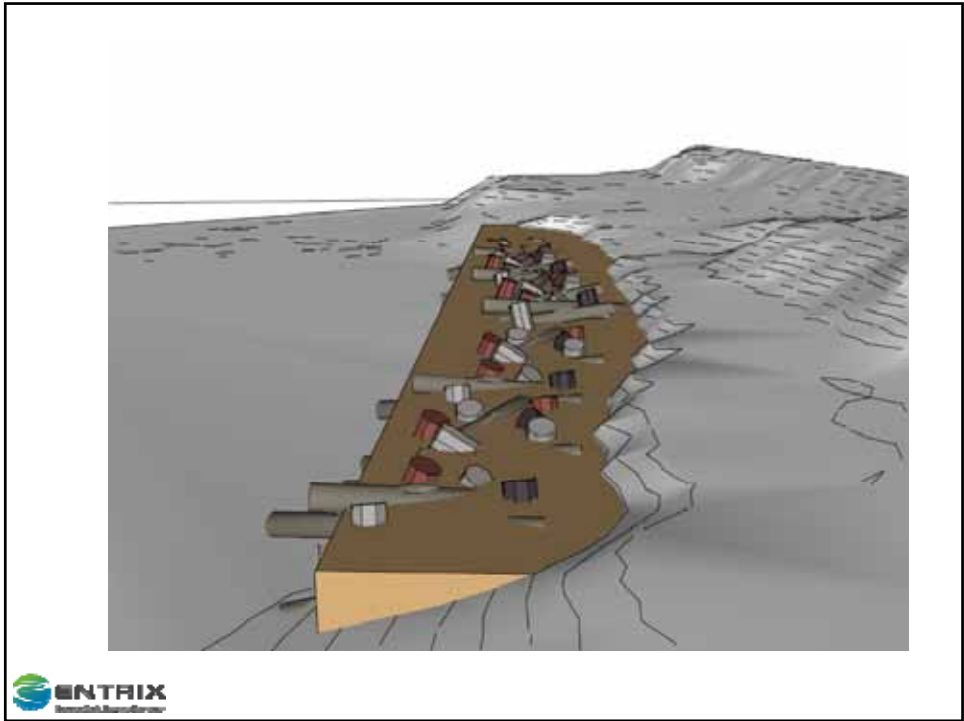


**Construction can be accomplished all with
single large excavator**









Construction



**Ground delivery
Crew of 2
1 450 Excavator**



Pile placement



Dolo and timber placement



Dolo and timber placement



Dolo layer one



Dolo layers two and three



Dolo layer four



Completed revetment



Completed revetment



Project completed on time and on budget, saving over \$1M compared to other alternatives.

Questions?

