Use of Wood in Stream Restoration Projects

Rob Sampson, PE

National Water Management Engineer

USDA – NRCS Conservation Engineering Division

and

Jon Fripp, PE

Stream Mechanics Engineer

USDA – NRCS National Design, Construction, & Soil Mechanics Center

Rob Sampson, PE

National Water Management Engineer

USDA – NRCS Conservation Engineering Division

Rob.Sampson@wdc.usda.gov

and

Jon Fripp, PE

Stream Mechanics Engineer

USDA – NRCS National Design, Construction, & Soil Mechanics Center

Jon.fripp@ftw.usda.gov

Planning considerations when using logs or whole trees in NRCS projects include:

- **Context and extent:** how much wood along with other building materials, like rock and living plants, has a high chance of success and are in balance with the upstream reaches and watershed condition, as well as compatibility with stream reaches below?
- Successful use of wood as a **foundation for a bioengineering project** requires one set of planning criteria that is very different from incorporating whole logs at the toe of a riprap slope. A constructed hard point in the stream bank made entirely of trees and other woody material requires an entirely different set of **planning questions.**
- Use and extent of wood is very often a **dual investigation** into the size and **durability of materials** available coupled with an analysis of the **impact wood** will have on hydraulics, sediment transport, resulting additional wood that may collect on the project and the impact of new sediment deposits downstream.

Engineered Log Jams (ELJs)

- Based on stable, naturally occurring log jams
- Stream stability enhancement
- Habitat restoration
- Large, woody material
- Stacked, racked and keyed

- Self healing
- Slows velocity
- Promotes deposition
- Works best in wide, shallow streams with good floodplains
- Safety and backwater?

See design guidance by Tim Abby; especially **"Design of Stable In-Channel Wood Debris Structures for Bank Protection and Habitat Restoration: An Example from the Cowlitz River,** WA" Tim Abbe, David Montgomery, and Catherine Petroff

Rootwads

- Large logs along bank with root mass projecting into the flow
- Often as a continuous line
- Been used in a variety of areas

- Stream bank stability enhancement
- Habitat restoration
- Shade and edge cover
- Terrestrial habitat

Rootwads

- Many different applications
- By themselves or with structural approaches

Rootwads – Design Considerations

Design concerns

- **Stability of the stream system**
- **Forces**
- **Drift load in stream**
- **Anchoring**
- **Materials**

- **Rest of restoration plan?**
- **Backwater affects**
- **Safety**
- **Tolerance for risk**

Redirective Techniques – Vegetated Spurs

•**Deflects erosive flows**
•**Causes sediment to drop out and deposit**
•**Builds up the stream bank and develops substrate for planting**

Redirective Techniques – Vegetated Spurs

Design Criterion
- **Angle**
- **Spacing**
- **Height**
- **Key**
- **Anchoring**
- **Materials**
- **Restoration plan**

Brush or Tree Revetments

A continuous line of dead, woody material placed along the toe of the bank

- **Provides physical protection**
- **Reduces the stream velocity**
- **Causes sediment to drop out and deposit around the branches.**
- **Builds up the stream bank and develops substrate for planting**

Part of a dynamic and living stabilization effort

Soil Bioengineering Project before construction, November 2001

August 2003.

Vertical bundle and brush (juniper) revetment

Brush or Tree Revetments ~ Design Considerations

- What material is going to be used to create the revetment
- Stability of the stream system
- Sediment and debris load in stream.
- How is live material going to be established
    - Volunteer? Plantings?
- Upstream key in
- Bed key in
- Anchoring

Brush or Tree Revetments

Live clumps and flexible wood for toe protection

Brush or Tree Revetments

Hard wood for toe protection

For Every Project Type, There Are Examples Of Problems

- **Inadequate anchoring and/or ballast**
- **Stability of the stream (braided, incised, single thread)**


Photo from Barry Southerland


Photo from Doug Shields

See: Shields, D; “Large wood as a restoration tool: I fought the law and the law won”, STREAMS conf, 2003 and Shields, D; “Large Woody Debris Structures for Sand Bed Channels” J. of Hyd Eng March 2004

RootWads

<u>Problems:</u>
- **Inadequate anchoring and/or ballast**
- **Stability of the stream**

RootWads

Toe Wood

Revetment

<u>Problems:</u>
- **Inadequate anchoring**
- **No material to deposit**

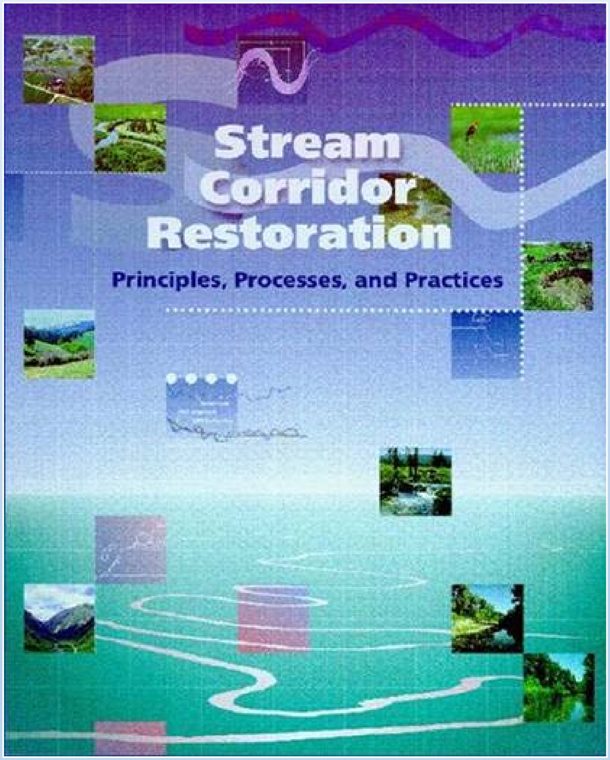
Used well, wood can be a positive tool for many restoration projects

Stream restoration and bank protection

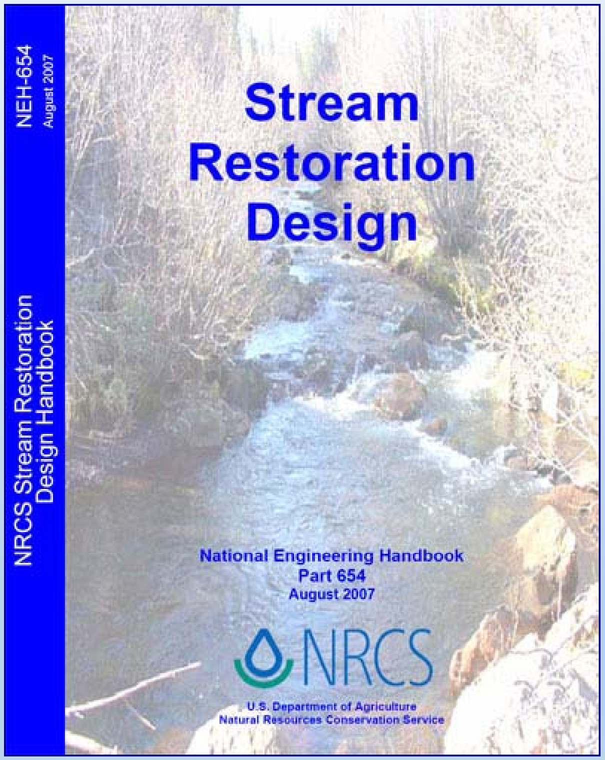
Used well, wood can be a positive tool for many restoration projects

Stream restoration and bank protection

Sources For Planning and Design Information and Guidance



USDA/NRCS NEH-653:
Basic principles, planning.



USDA/NRCS NEH-654:
Design Tools.

Call
1-888-526-3227
LANDCARE to
order

Design Guidance

Technical Supplement 14E

Use and Design of Soil Anchors

17. Integrating Engineered Log Jam Technology into River Rehabilitation

Tim Abbe, George Pess, David R. Montgomery, and Kevin L. Fetherston

Technical Supplement 14J

Use of Large Woody Material for Habitat and Bank Protection

(210–VI–NEH, August 2007)

TECHNICAL NOTES

U.S. DEPARTMENT OF AGRICULTURE NATURAL RESOURCES CONSERVATION SERVICE
Boise, Idaho April 8, 2013

ENGINEERING – NO. 15

INCORPORATION OF LARGE WOOD INTO ENGINEERING STRUCTURES

DESCRIPTION

Large wood (LW) can be incorporated into a structure or used as a structure to (1) disperse flow energy (Buffington and Montgomery, 1999) (2) stabilize channel banks and bed forms (Bilby 1984), (3) increase aquatic habitat, (Bryant and Sedell, 1995) (4) narrow a stream and reduce the width to depth ratio (Sedell and Froggatt 1984), (5) cause localized deposition (Keller et al. 1985), (6) form pools, (Bilby and Ward 1989) (7) route flood water, (Ellis 1999) and (8) decrease costs by using on-site materials (Booth, Montgomery, and Bethel 1996). Also, LW components in engineering structures are often necessary to meet permit guidelines.

Most in-stream work with LW to date has been experiential. Unfortunately, this has resulted in very little documentation of design procedures, stability analyses, or even structure function or success (Frissell and Nawa 1992). The following guidelines provide a procedure for analyzing the stability of LW components in engineering structures. This technical note is not intended to serve as a design template for Engineered Log Jams (ELJ) (Abbe 1999). Guidance on ELJ's from the Watershed Science Institute is forthcoming.

Types of Streams

Not all streams, or locations in a single stream, are appropriate for LW placement. It is necessary to evaluate the hydraulic geometry, floodplain connectivity, channel planform, channel bed and bank material, and the associated riparian plant community of a given stream to determine the appropriateness of large wood placement. Even when a stream system seems to function without the presence of wood, there may actually be a LW component missing that would provide energy dissipation, sediment storage, and aquatic habitat. Since LW was being actively removed from streams before 1900, the perception of "that stream never had any wood in it" may be prevalent, but incorrect.

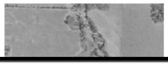
Potentially appropriate stream types are listed below for the Rosgen (1996) and Montgomery and Buffington (1993) stream classification systems and for the Channel Evolution Model (Schumm, Harvey, and Watson 1984).

*Prepared by: Janine Castro, Geomorphologist, Portland, OR and Rob Sampson, Design Engineer, Boise, ID
USDA – NRCS*

Proceedings of the STREAMS Channel Protection and Restoration Conference, October 6-7, 2003, The Ohio State University, Columbus, Ohio

Large wood as a restoration tool: I fought the law, and the law won

STREAMS Channel Protection and Restoration Conference, October 6-7, 2003, Columbus, Ohio



F. Douglas Shields, Jr.
USDA-ARS National Sedimentation Laboratory
Oxford, MS 38655-1157
dshields@ars.usda.gov

Introduction

Traditional incised stream c
combinations of grade contro
protection structures, drop pipes
These methods are effective, bu
range as high as $750 ha^{-1}, and c
as $399 m^{-1}. Previous work h
channels and their stream corrid
effects, particularly when stabili
habitat-limiting factors. The Li
rehabilitation project, a coopera
Corps of Engineers and the U
intended to demonstrate relativel
approaches for stabilizing in
associated habitats. Specificall
planting, placing structures made
hedges in riparian gullies. This
structures (LWDS).

The study reach was located alon
central Mississippi (Figure 1).
Thomas (2002). Contributing dr
characterized by dispersive silt a
material. Sandy deposits were
sinuosity of 2.1, an average widt
materials were primarily medium
occurred as massive outcrops an
mean width had increased by
evaluation performed immediatel
reach was in the aggradational st
evolution, while the middle part
was still degrading (stage III).

CONNECTICUT DEPARTMENT OF ENVIRONMENTAL PROTECTION

Inland Fisheries Division
Habitat Conservation and Enhancement Program

Large Woody Debris Fact Sheet

I. Introduction

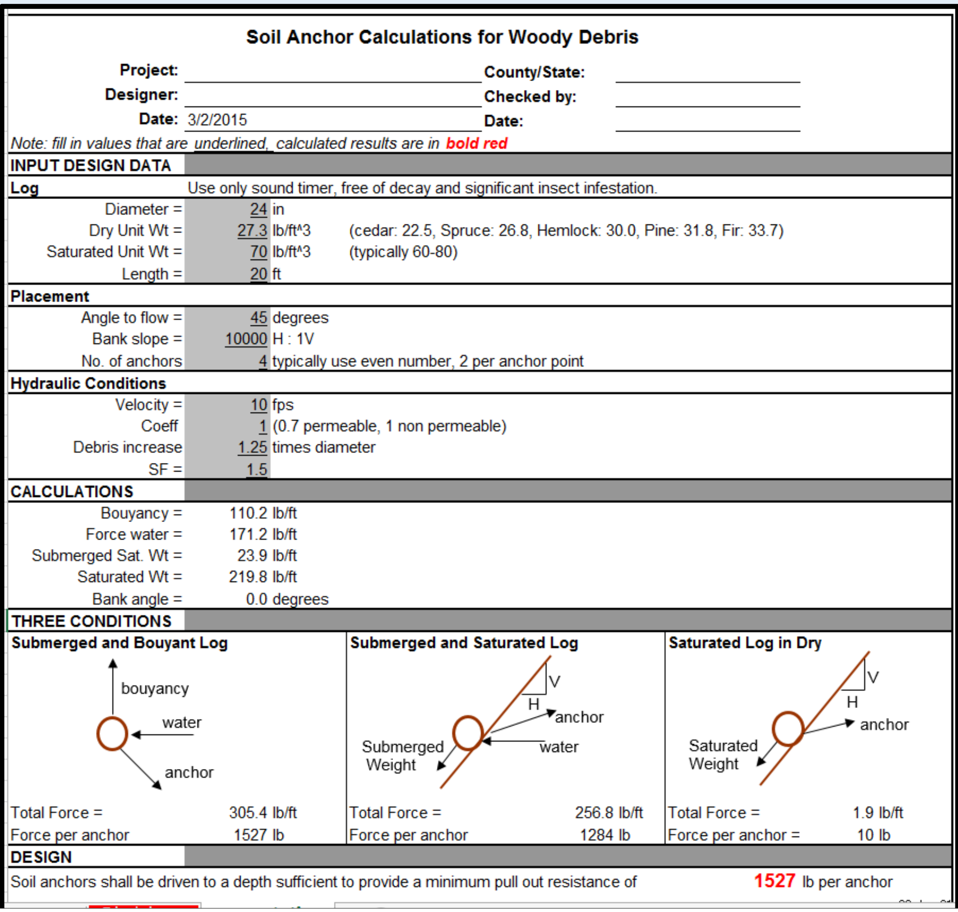
Trees that grow along a streamside can often fall into a watercourse due to floods, erosion, windthrow, disease, beaver activity or natural mortality. These materials, often referred to as Large Woody Debris (LWD) can include whole trees with a rootwad and limbs attached or portions of trees with or without rootwads or limbs. LWD is typically defined by biologists as logs with a minimum diameter of 4 inches and a minimum length of 6 feet that protrude or lay within a stream channel. Environmental and recreational groups have often removed LWD as part of river cleanup or river improvement projects. Although these groups have good intentions, LWD removal can be "very detrimental" to stream health and well being. In fact, during the last decade, the Inland Fisheries Division has been actively adding LWD to river systems as a component of individual stream restoration projects, particularly in streams that are LWD deficient. This fact sheet describes the vital importance of LWD to river ecosystems and provides guidance for its beneficial management.

Example of various types of large woody debris in the Moosup River, Plainfield.

DEP • Inland Fisheries Division • Habitat Conservation and Enhancement Program

1

Design Spreadsheets Are Available



Soil Anchor Calculations for Woody Debris

Project: ____ **County/State:** ____
Designer: ____ **Checked by:** ____
Date: 3/2/2015 **Date:** ____

Note: fill in values that are underlined, calculated results are in ***bold red***

INPUT DESIGN DATA

Log Use only sound timer, free of decay and significant insect infestation.

Diameter =	24	in
Dry Unit Wt =	27.3	lb/ft^3 (cedar: 22.5, Spruce: 26.8, Hemlock: 30.0, Pine: 31.8, Fir: 33.7)
Saturated Unit Wt =	70	lb/ft^3 (typically 60-80)
Length =	20	ft

Placement

Angle to flow =	45	degrees
Bank slope =	10000	H : 1V
No. of anchors	4	typically use even number, 2 per anchor point

Hydraulic Conditions

Velocity =	10	fps
Coeff	1	(0.7 permeable, 1 non permeable)
Debris increase	1.25	times diameter
SF =	1.5	

CALCULATIONS

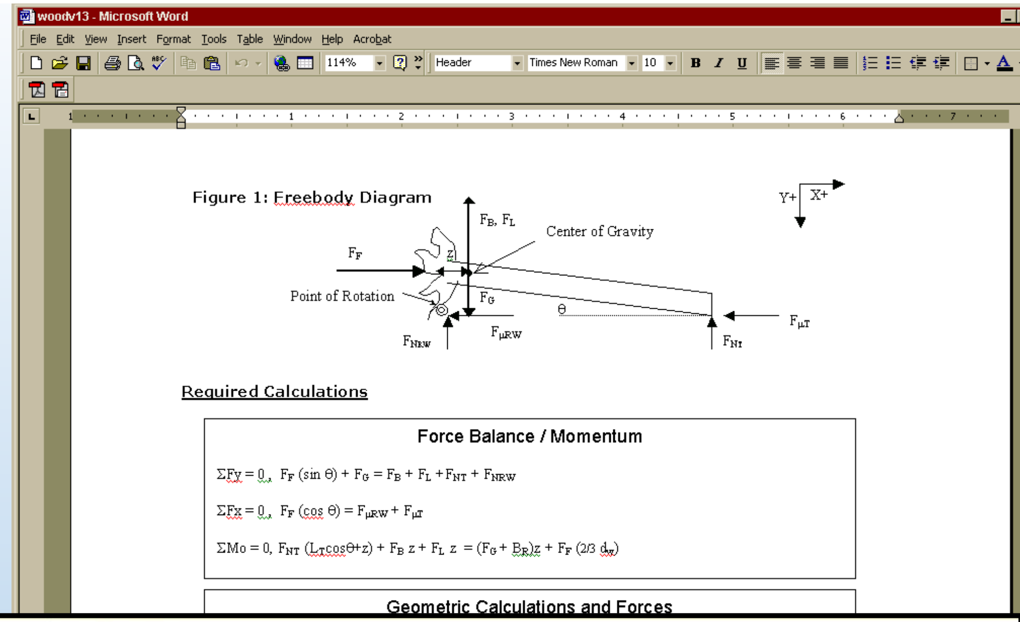
Bouyancy =	110.2	lb/ft
Force water =	171.2	lb/ft
Submerged Sat. Wt =	23.9	lb/ft
Saturated Wt =	219.8	lb/ft
Bank angle =	0.0	degrees

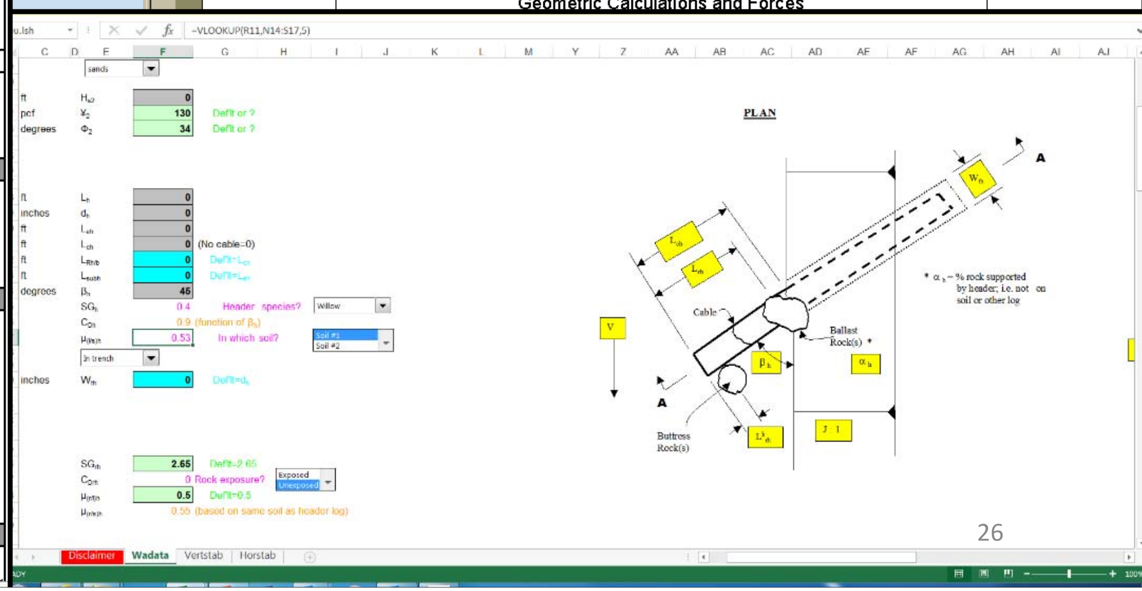
THREE CONDITIONS

Submerged and Bouyant Log		Submerged and Saturated Log		Saturated Log in Dry	
Total Force =	305.4 lb/ft	Total Force =	256.8 lb/ft	Total Force =	1.9 lb/ft
Force per anchor	1527 lb	Force per anchor	1284 lb	Force per anchor =	10 lb

DESIGN

Soil anchors shall be driven to a depth sufficient to provide a minimum pull out resistance of **1527** lb per anchor





Different Ways to Anchor Material

how are you going to keep it from floating away?

Don’t just do something

Stand there!

But we need to avoid the approach of preselecting a technique and then looking for a site to implement it

- ~~Ready~~
- ~~Fire~~
- ~~Aim!~~

We need to talk planning

~

We need to understand the why

Functions of Wood in Streams

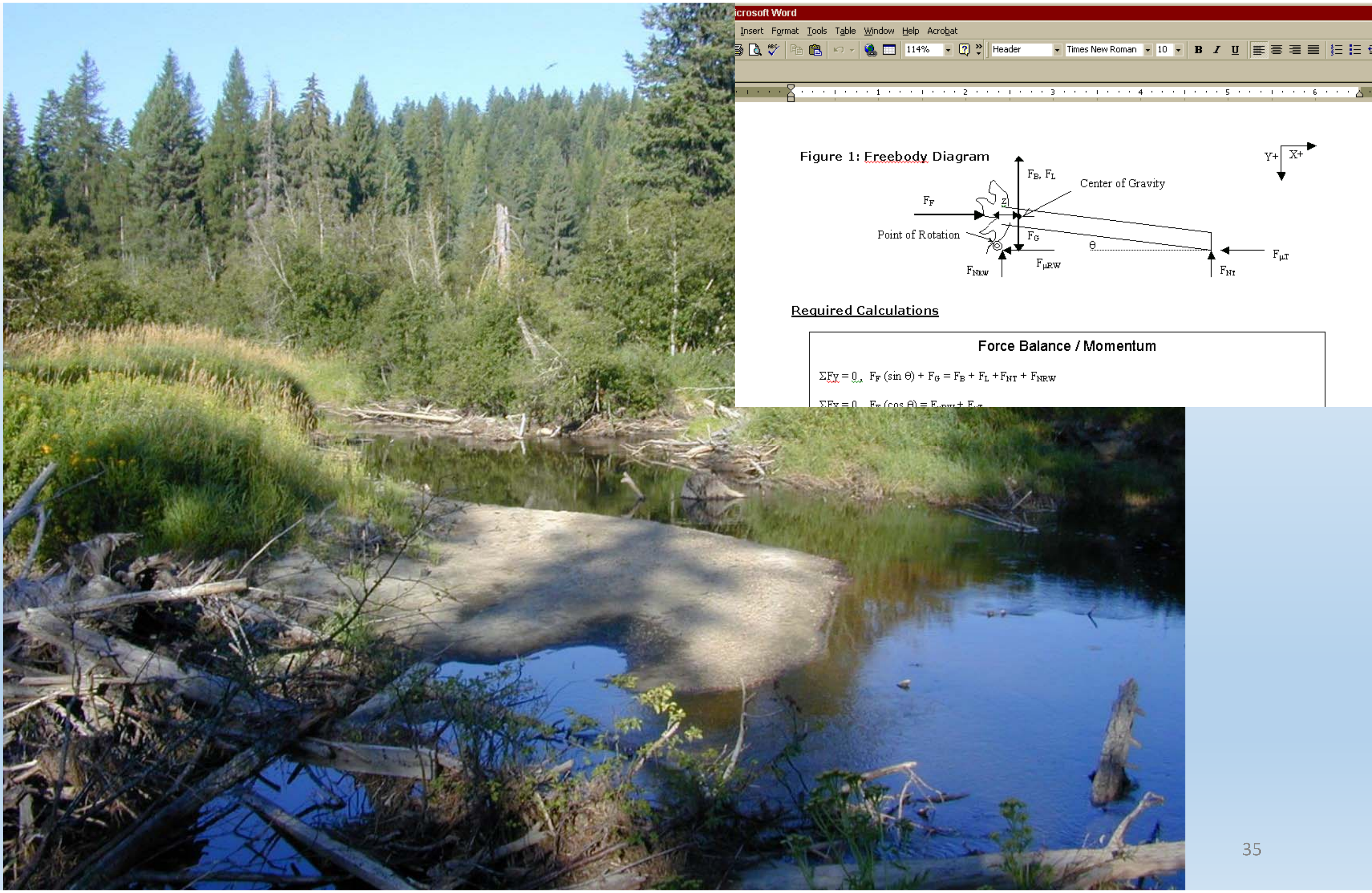
- **Moderate sediment transport**
- **Store sediment and organic matter**
- **Absorb energy (increased boundary roughness)**
- **Reinforce stream form (step-pool, pool riffle)**
- **Provide habitat, shade and substrate for insects, carbon inputs, velocity diversity**

Recent Research

- **Wood loading ↑ Pool spacing ↓**
- **Wood loading ↑ Channel width ↑**
- **Wood loading ↑ Channel type will change ↔**
- **Wood loading ↑ Hyporheic exchange ↑**
- **Wood is hard to maintain in incised channels**
- **Forced wood loading can cause aggradation in incised channels**
- **There must be adequate floodplain in fine grained stream systems before loading with wood**

Do trees attract islands or do islands attract trees?


Rackers and stackers…



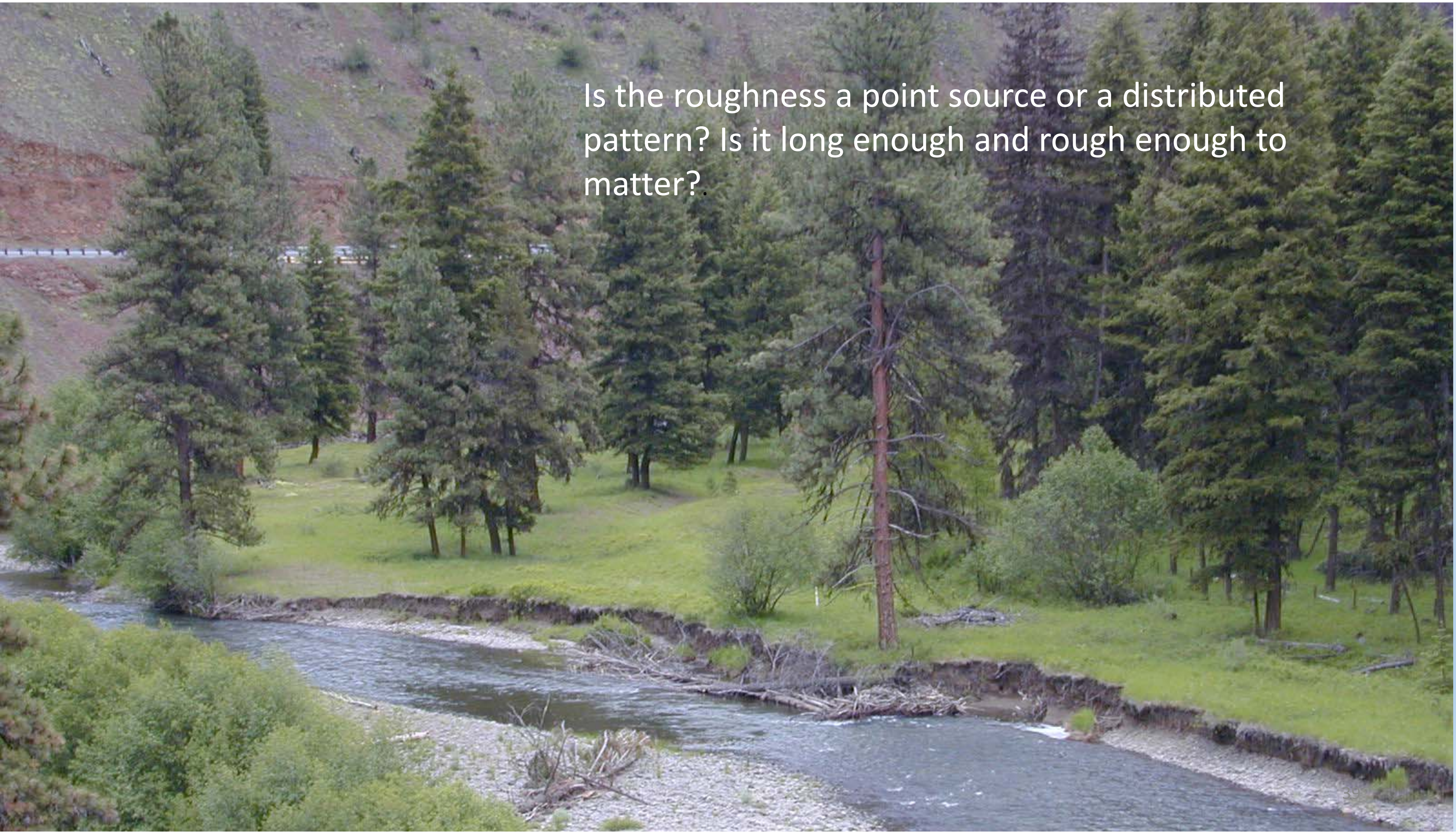
Required Calculations

Force Balance / Momentum

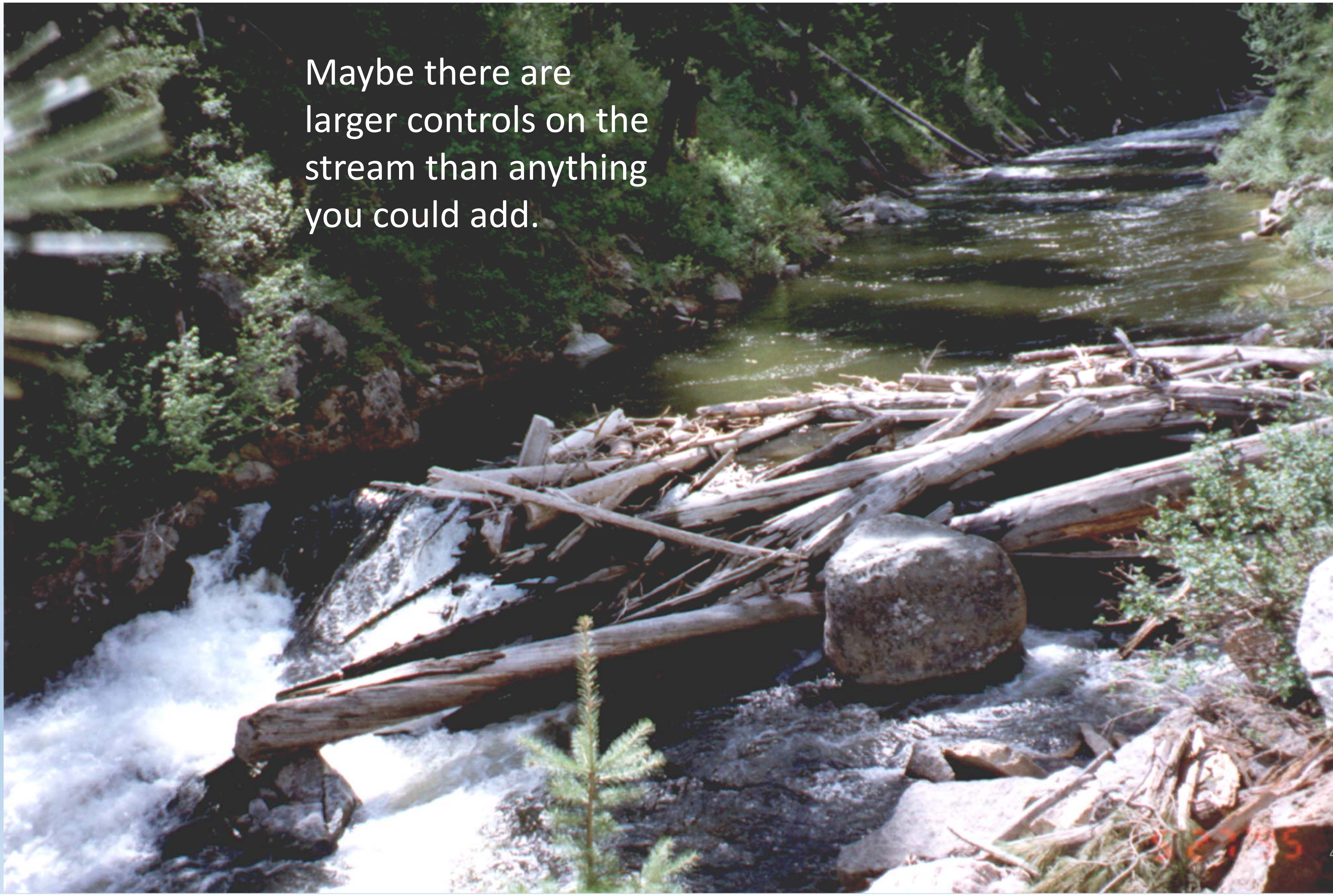
$\Sigma F_y = 0$, $F_F (\sin \theta) + F_G = F_B + F_L + F_{NT} + F_{NRW}$

$\Sigma F_x = 0$, $F_F (\cos \theta) = F_{\mu RW} + F_{\mu T}$


Many of our analogs come from well above CFF. And we try and replicate them below the water.


Is the roughness a point source or a distributed pattern? Is it long enough and rough enough to matter?.

Maybe any roughness you add is washed out by the surroundings…

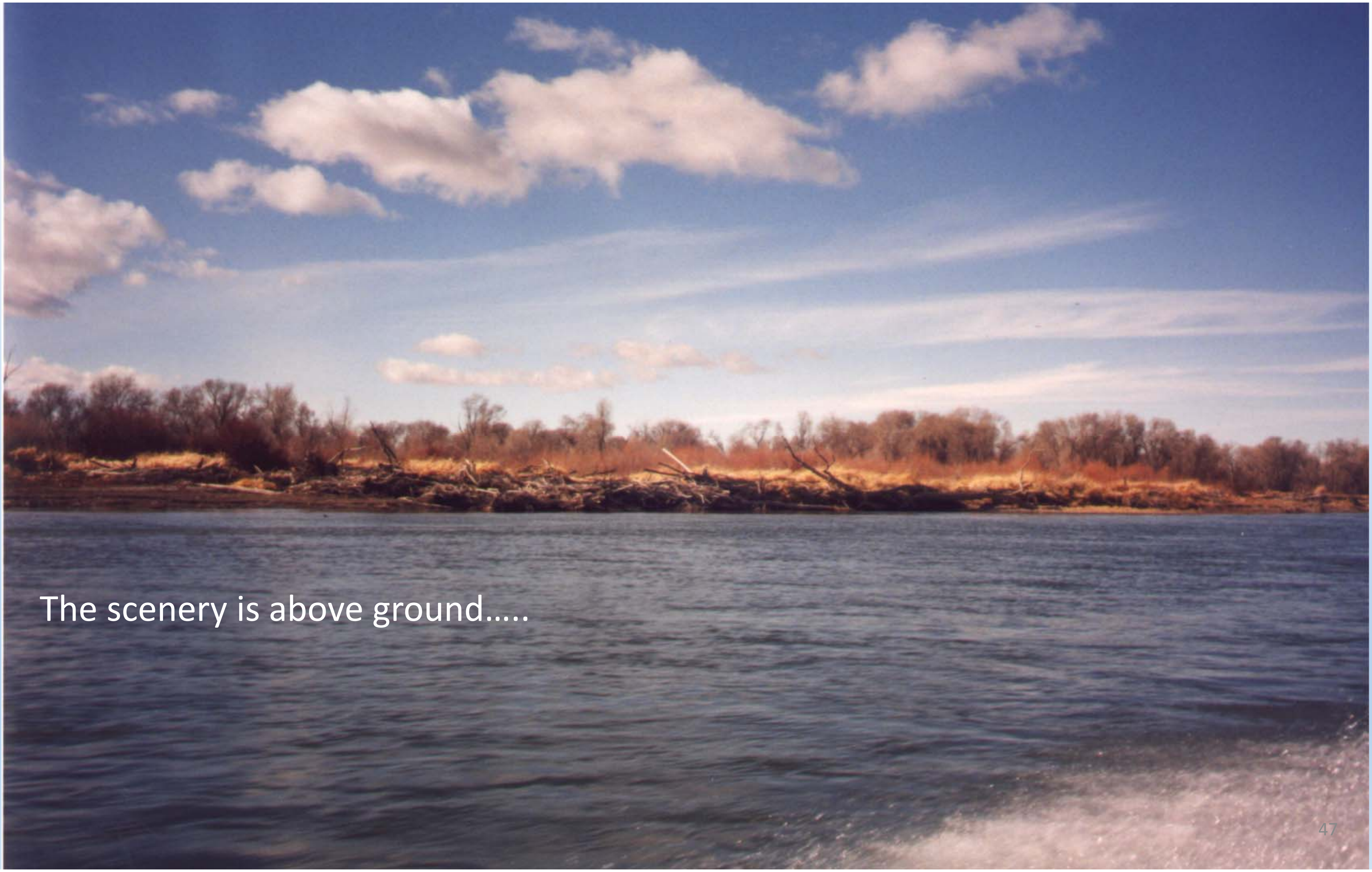

Maybe there are
larger controls on the
stream than anything
you could add.

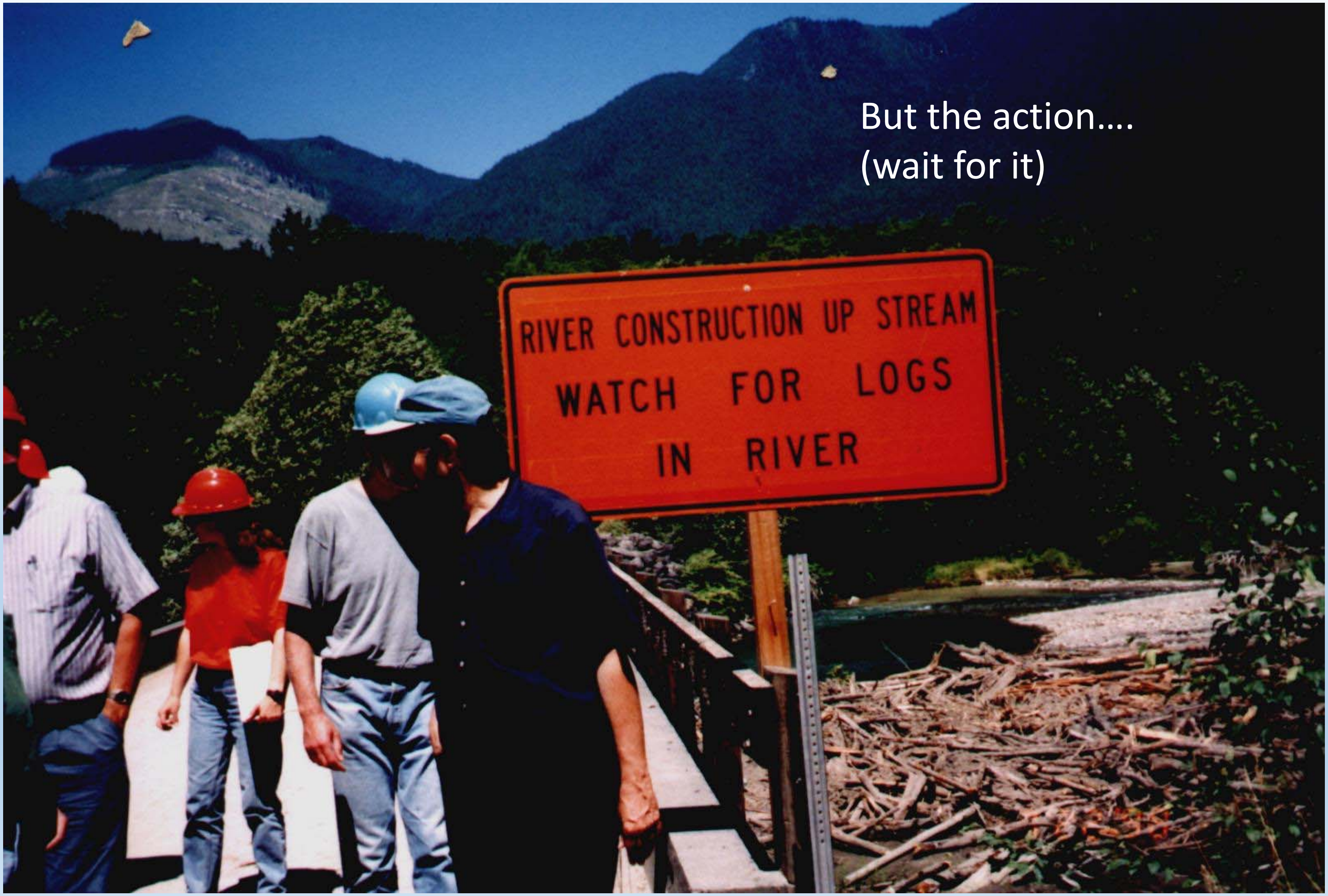

Maybe history and
antecedent conditions are
against your efforts…

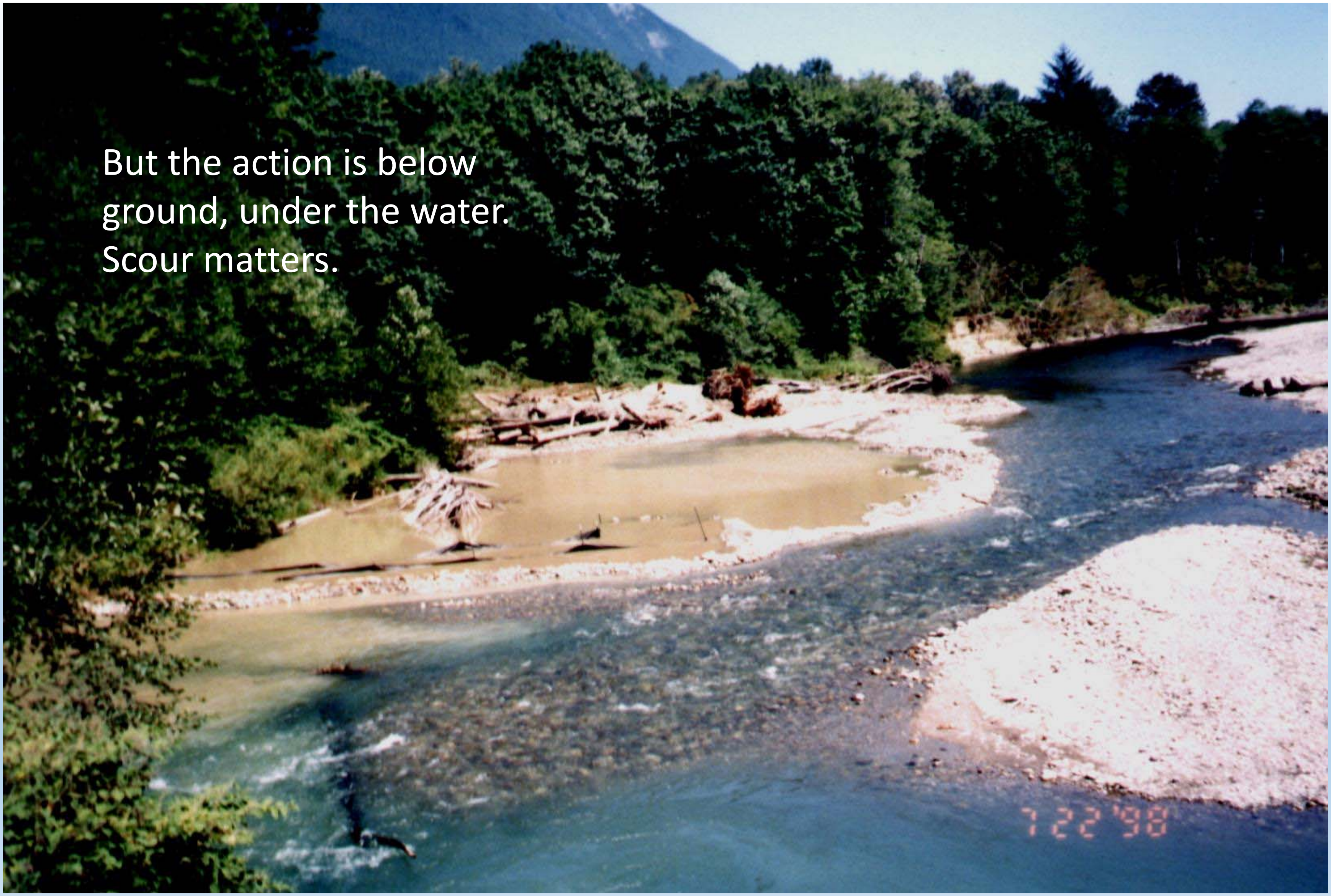

"Go big or go home…" – B. Bair

Material selection is the most important part. If you can't get what you want, Go home.

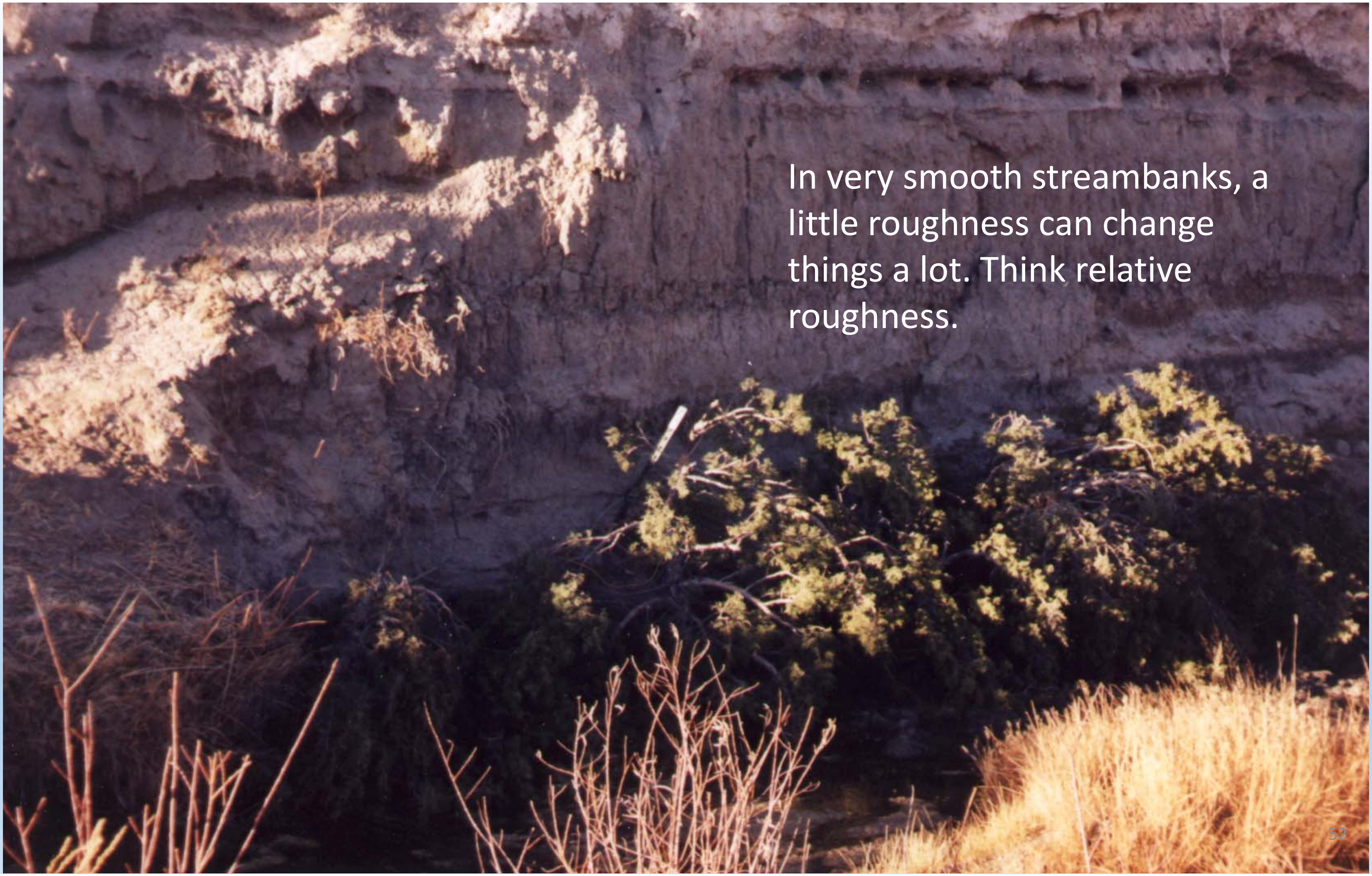

Most ballasting and
anchoring doesn’t
work (perfectly)…


The scenery is above ground…..


But the action….
(wait for it)
RIVER CONSTRUCTION UP STREAM
WATCH FOR LOGS
IN RIVER


But the action is below ground, under the water. Scour matters.
7 22 '98


Do the
simplest things
first…


In very smooth streambanks, a little roughness can change things a lot. Think relative roughness.


JOHN DEERE
650G

SAFETY!

UNDERSTANDING THE LEGAL RISKS ASSOCIATED WITH DESIGN AND CONSTRUCTION OF ENGINEERED LOGJAMS

By
Beth M. Andrus
James L. Gessford, P.E.

Safety hazards to swimmers, rafters, kayakers, canoeist, and fishermen must be considered

News >

Fish and People: Finding a Balance

The best river environment for thriving salmon populations isn't always the best for humans who also use the rivers and streams the fish inhabit. Efforts to enhance habitat with engineered structures such as engineered log jams (ELJs) and large woody debris placements can increase the risk of drowning or injury for fishers, swimmers, kayakers and whitewater rafters that visit the river for relaxation and play.

An engineered log jam

The Lummi Nation faced these safety challenges as they implemented two salmon habitat enhancement projects on the South Fork of the Nooksack River in Whatcom and Skagit County, WA. To address these issues, Lummi Nation Natural Resources engaged GeoEngineers to assess the safety risk for structures placed within the Skookum and Fobes Reaches of the South Fork, and to provide recommendations for how to incorporate public-safety interests into future habitat protection and enhancement projects.

A team at GeoEngineers has been working to address these concerns for a number of years. For the Nooksack ELJ safety assessment project, they reviewed literature, analyzed hydraulic and geomorphic conditions and visited the sites.

The team developed an assessment tool that gives the tribe a process to balance effective habitat

ion

d logjams (ELJs) are a relatively new alternative to traditi

ods. Artificial logjams are bei

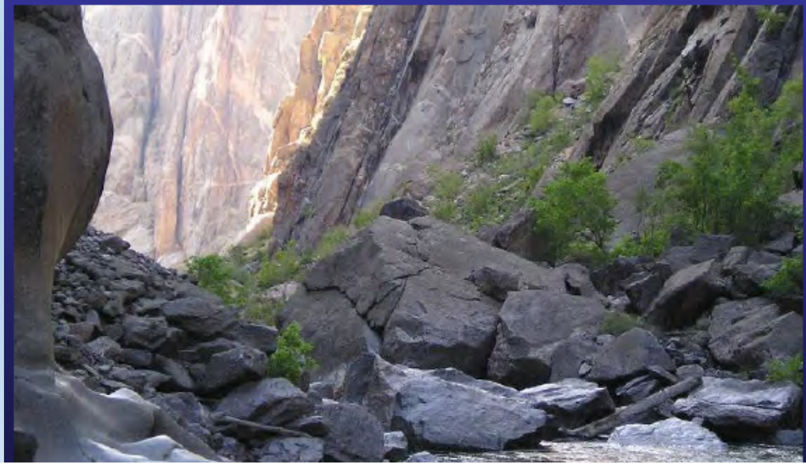
e ecological and hydraulic ben

an habitat; (2) providing erosio

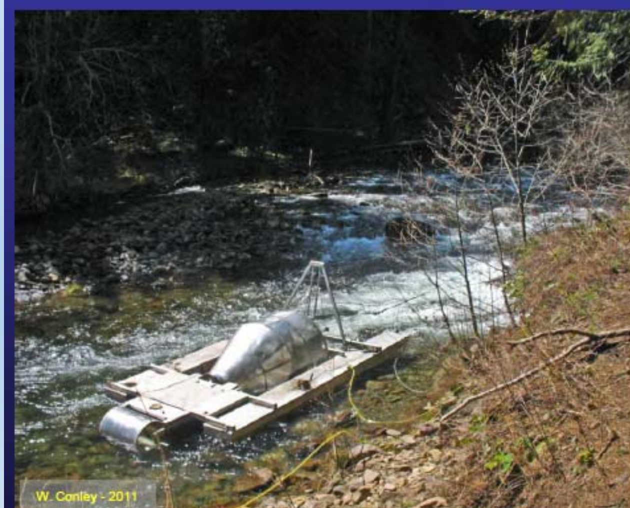
hin a ch

Safety hazards caused by the log jams or the cables that anchor them can be somewhat reduced by placing warning signs upstream from the log jams to alert boaters

Rivers Present a Variety of Hazards: Some Natural…



…Some Not

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Final point for use of tree revetments, ELJs, and root wads: *Loose trees in the stream can do bad things*

Think about what will happen if they break loose

The End

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rob.sampson@wdc.usda.gov

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jon.fripp@ftw.usda.gov

Questions?