Application and Functional Performance of Engineered LWD

James H. Dooley, PhD, PE   Kenneth R. Chisholm
Justin T. Maschhoff

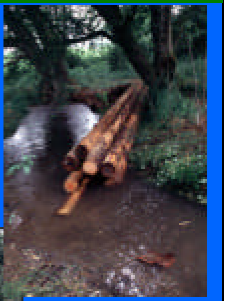
Abstract

An engineered large woody debris structure has been designed and developed for use in habitat and watershed restoration projects. The structure was designed according to the Appreciative Design method to accommodate readily available wood materials, low-tech manufacturing methods, and volunteer-based installation. Technical features include a high organic surface area, structural integrity in an all-wood product, length proportional to channel properties and diameter proportional to flow depth.

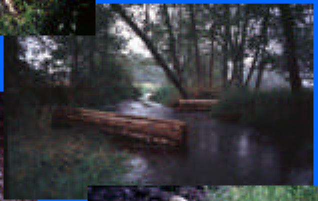
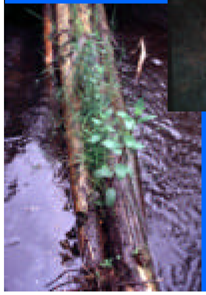
ELWd® structures have been installed to provide a number of different functionalities including: scour pool formation, complex cover features, bank protection, flow routing, sediment storage and high flow refuge. The poster describes the design rationale and critical assumptions that resulted in the present configuration for ELWd® structures, and results of the first three years of in-stream use.

Functions of LWD in Aquatic Systems:

1. Provide shelter and low velocity refuge for fry and juvenile fish (Gregory and Bisson 1997)
2. Facilitate in-channel storage of sediment through creation of dams, bars or islands (Abbe and Montgomery 1996) (Chesney 2000)
3. Modify stream flow to create pool structure (Cherry and Beschta 1989)
4. Direct high-water flow to support hydraulic routing (Gippel 1995; Gregory and Bisson 1997)
5. Trap and hold small organic materials (leaves, needles, carcasses, etc.) (Culp, Scrimgeour, and Townsend 1996)
6. Provide hydraulic roughness to the stream during high flow conditions (Abbe and Montgomery 1996)
7. Provide bank stabilization by reducing erosive action (Donat 1995)
8. Provide visual aesthetics suggesting natural stream conditions (Bisson et al. 1997)
9. Provide habitat and perches for aquatic insects, amphibians, birds and riparian mammals (Borchardt 1993)
10. Provide complex surface and nutrients for microbiological organisms important to the aquatic ecosystem (Bilby and Ward 1989)
11. Feed the "wood budget" to provide a flux of woody organic matter in the stream channel (Chesney 2000)




Design Constraints:

Client Constraints
- Competitive installed cost compared to native LWD
- Low cost for placement (less equipment rental cost is better)
- Lasts long time (lower maintenance cost is better) (lasts until riparian silviculture begins to deliver)
- Applicable to sites with difficult access for large equipment (install with hand crews is better)
- Does not increase risk of damaging downstream resources (lower risk of damage is better)

Fisheries Enhancement Contractor Constraints
- Manufacture from readily available materials (smaller diameter components is better)
- Low tech manufacture (product value does not warrant expensive manufacturing process)
- Easy to train crews to install (lower information content is better)
- Minimize risk liability claim from high water failure (less risk of damage to property & public works)

Volunteer Coordinator Constraints
- Maximum number of structures per grant dollar (lower requirement for rental equipment and operators is better)
- Need to separate volunteers from mechanized equipment operations (install with all hand labor is best)
- Maximize volunteer participation in meaningful part of projects (volunteers putting structures in stream is better than volunteers doing cleanup after machines do the habitat work)
- Easy logistics to prepare for volunteer events and work days (stage kits of lightweight materials is better)

Environmental and Recreational Special Interests
- Materials are all organic and similar to native materials
- Avoid steel, plastics and other unnatural materials
- Structures look like they belong in the natural environment (better aesthetics)
- Debris from failed structures looks natural in the streamside environment

Materials Supplier Constraints
- Utilize non-merchantable or low value raw materials
- Utilize readily available raw materials

Regulator and Public Agency Constraints
- Amenable to meeting the requirements of WAC 220-110
- Natural materials (no car bodies, concrete, tires, asphalt, etc.)
- Does not increase flood height (less flood impact is better)
- Does not increase risk to public works (bridges & culverts) over native LWD risks (lower risk is better)

Design Parameters

- Habitat functionality for target species and life stage (e.g., refugia, shade, current, gravel sorting)
- Physical length, width and height as a function of stream channel and flow conditions
- Mass, specific gravity or other features to keep LWD in place during all but most severe flows
- Hydraulic roughness (Generally higher is better)
- Physical surface roughness to trap sediments, debris, etc. (Generally higher is better)
- Ratio of organic surface area to cross-section area (Generally higher is better)
- Natural appearance after placement to blend with the stream corridor scene
- Natural appearance of components and debris when the structure fails, breaks-up or decays
- Functional life (Life is sufficient to provide bridge from degraded condition to riparian system delivery)
- Debris size when structure fails, to minimize impact on downstream public works
- Materials of construction (Higher percentage of organic content is better. Lower raw materials cost is better. Higher availability is better.)
- Methods of fabrication (Low technology, low information content is better)
- Equipment requirements for installation (Less equipment and tools on-site is better)

Table 1. Functional Performance of Engineered LWD Structures

Project	Bank Full Width (m)	No. of Engr. LWD Installed	Functional Objective(s) Achieved by Installed Structures										
			Provide Bank Protection	Provide Fish Shelter	Store or Sort Sediment	Form Pools	Redirect Current	Store Fine Organic Debris	Increase Channel Roughness	Provide Natural Look to Stream	Perches for Amphib., Birds, Mammals	Organic Substrate for Macro/Micro Organisms	Feed Wood Budget
Griffin 1	10	5	-	X	X	P	X	X	P	X	X	X	P
Mashel	40	4	X	X	P	-	X	-	-	-	X	X	X
Griffin 2	10	5	-	X	P	X	-	-	X	-	X	X	X
Samish	20	2	P	X	-		P	-	X	-	-	-	-
Thornton	5	1	P	X	-	-	-	X	-	X	-	X	-
Newaukum 1	7	13	X	P	P	X	P	X	P	X	X	X	P
Newaukum 2	3	8	X	P	-	X	X	X	P	X	X	X	X
Total		43											

P = Primary Functional Objectives of Project   X = Secondary and Coincidental Functionalities Achieved by LWD Placement

Conclusions

Engineered LWD has proven to be a functionally effective alternative to native solid LWD for habitat enhancement, watershed restoration and bioengineering projects. An evaluation of 43 engineered LWD structures across seven projects suggests that engineered LWD captures organic matter and supports vegetation much more like old remnant LWD than does recently-placed solid LWD. Engineered LWD has proven effective for bank protection and bioengineering stabilization, with a particular benefit as vegetation roots into the structure and binds it to the bank. Ballasting engineered LWD substantially reduces the need for cable anchors. In all other respects, the engineered large woody debris appear to be performing similarly to solid large woody debris.


ELWd Systems
division of *Forest Concepts, LLC*

1911 SW Campus Drive, #655
Federal Way, WA 98023-6441

Ph: (253) 838-4759 Fax: (253) 815-9900
Email: jdooley@seanet.com
Web: www.elwdsystems.com