#184 How Engineered Log Jams (ELJ) of different designs affect channel morphology and hydraulics in a high energy gravel and sand channel

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The addition of large wood is a common feature of river restoration projects in Western Washington State where wood jams comprised of logs over a meter in width were once a distinguishing characteristic of many rivers. Wood is typically added in a defined jam structure, referred to as an Engineered Log Jam (ELJ). ELJ are incorporated into restoration projects with the goal of influencing local and reach scale channel bathymetry and velocity patterns and, through these effects, improving aquatic habitats.

Logging and land clearing by non-indigenous peoples removed log jams from the rivers and depleted the supply of large logs to the system. Over time, channel morphologies have simplified and the loss of complex channel hydraulics has led to an accompanying loss of aquatic ecosystem habitat. River restoration efforts are often focused on replacing lost habitat structure, particularly through the addition of large wood. Logs and jams that transport easily downstream are unlikely to exert influence over channel morphodynamics. Those jams with long residence times in a channel have the potential to alter channel hydraulics and morphology. ELJ design and construction methods have adjusted over time to increase the likelihood that ELJ will remain in place for 30-50 years, a requirement of many funding agencies. Log jam design includes as variables the number of logs, the number with rootwads, along channel roughness length of ELJ, structure height, structure spacing, and the orientation of the logs. ELJ of different sizes and shapes have been constructed in channels in the western Cascades with the purpose of increasing the amount of wood in the channels and encouraging increases in channel complexity over flood cycles. Stable wood jams may extend into the channel creating shade and over water cover, scour a downstream plunge pool, and enhance groundwater to surface water exchange. Channel morphodynamics adjust to the presence of the wood and the channel planform is stabilized by the wood as the wood decays in place. ELJ design and construction methods have adjusted over time to increase the likelihood that ELJ will remain in place through large floods. Log jam design includes as variables the number of logs, the number with rootwads, along channel roughness length of ELJ, structure height, structure spacing, and the orientation of the logs.

This study focused on the impact of ELJs on channel bed topography, flow complexity, and overall reach complexity in the South Fork Nooksack River, a high energy, gravel and sand bed channel in the Cascades Range in Washington State. Two adjacent reaches were studied over a flood season. The upstream reach has been the focus of multiple restoration efforts since 2006 and numerous ELJ of different sizes and shapes have been constructed. Notably, the ELJ were designed to increase complexity in the channel morphology by maintaining gravel bars and islands, creating self-sustaining side channels with lower flow velocities in winter and spring, and forming deep pools of cooler water at the jams. The downstream reach has remained a single thread channel with leveed banks and few restoration projects. The sizes and designs of the ELJ in the upstream reach vary, enabling a comparison between jam types, ages, and river location. The influence of the ELJ on channel bathymetry and hydraulics was measured over a flood season to quantify the impact of ELJs on channel bed topography, flow complexity, and overall geomorphic unit complexity in a high energy, gravel and sand channel.

Field campaigns were conducted one year apart to measure at before and after geomorphically significant flows. During each campaign, the morphology of the reaches was evaluated by foot and boat, depending on the water depth of the site. An M9 Acoustic Doppler Current Profiler (ADCP) was used to measure channel bathymetry and directional flow velocities. ADCP data were collected as transects, at a detailed level around log jams where it was pushed under and around the logs, and at a census level where the water was deep enough for a boat. All ADCP data were analyzed through VMT Toolbox and GIS. An Acoustic Doppler Velocimeter (ADV) was used to supplement data collection between logs in the larger log jams. The bed surface characteristics were inferred through the gravel bars in the reach. The bars were without any vegetative cover, indicating frequent gravel mobility. The channel bed surface was measured during the field campaigns at three locations: at the middle of one of the large mid-channel bars; on the low portion of an alternate bar where flow would frequently inundate the area; on the bed of one of the side channels. At each location more than 100 grains were measured, and the surface sand content estimated. Gravel clusters and gravel imbrication were documented on the mid-channel gravel bar surface.

The collected data was analyzed along with aerial imagery from the same time frame for the amount of influence over channel hydraulics and whether the amount of increase in hydraulic complexity or pool area could be connected to ELJ size or location. Accurate predictions of ELJ local and reach scale impacts are needed for restoration projects to achieve maximum results. ELJ design and size were not as important as ELJ spacing and location in the channel cross section where the goal is influencing channel flows and morphology. Bedform sequence and reach scale morphologies will adjust over time to the presence of the ELJ depending on how multiple ELJ create feedback between bed sediment and flow velocity patterns.

Photos show ELJ in the study reach. The photo on the left is a ELJ at the head of a gravel bar. Note the people on the bar for scale. The photo on the right is looking upstream at a reach where ELJ were constructed on opposite banks.