Natural Pool-Riffle Formation and Maintenance in a Watershed Impacted by Deforestation and Historic Channel Modifications

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Abstract

Numerous studies have documented channel-maintenance processes in existing pool-riffle couplets formed by natural processes. However, it has been almost impossible to characterize detailed pool-riffle formation mechanisms because of the difficulty of accurately predicting the location where a new pool-riffle couplet will form. The Blackledge River in Connecticut contains a reach within Veterans Fishing Area that had been heavily modified by stream-improvement devices installed by the Civilian Conservation Corps in the 1930s and by the Connecticut Department of Transportation in the 1950s. The area was also impacted by historic deforestation. The combination of these factors has limited large-wood (LW) loading to the channel, with potential impacts on channel morphology. Previous research done at the site in 1999-2001 documented pool-riffle conditions associated with historic stream-improvement devices, including a paired set of triangular deflectors. In 2001, a pool with a residual depth of only 0.27 m was measured just downstream of the deflectors, no riffle was observed and erosion of the left bank was noted with severe undercutting of a large hemlock tree. Years later when the site was revisited, it was noted that the hemlock tree had fallen completely across the channel forming a spanning LW jam. The site provides a unique opportunity to document how pool-riffle couplets form from a relatively flat-bedded channel. Topographic surveys indicate a new residual depth of 1.4 m. Repeat surveys and bed characterization reveal a complex sediment-sorting pattern and sediment-storage system operates in the pool.

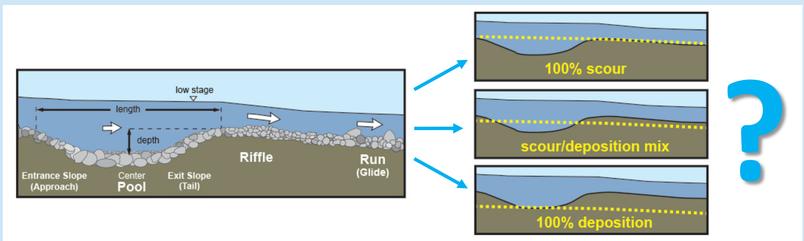

Figure 1. Possible pool-formation patterns.

Methods

- Topographic surveys using a Laser Total Station
- Photographic channel bed pebble characterization

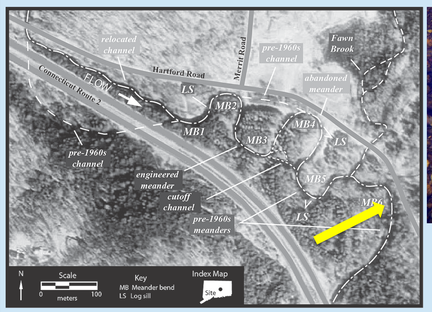

Figure 2. Site map.

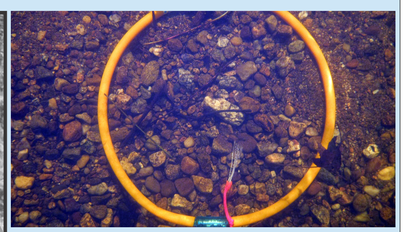

Figure 3. Channel-bed sediments. The orange hoop is used for a consistent measurement area and to scale the particles in the image.

Results

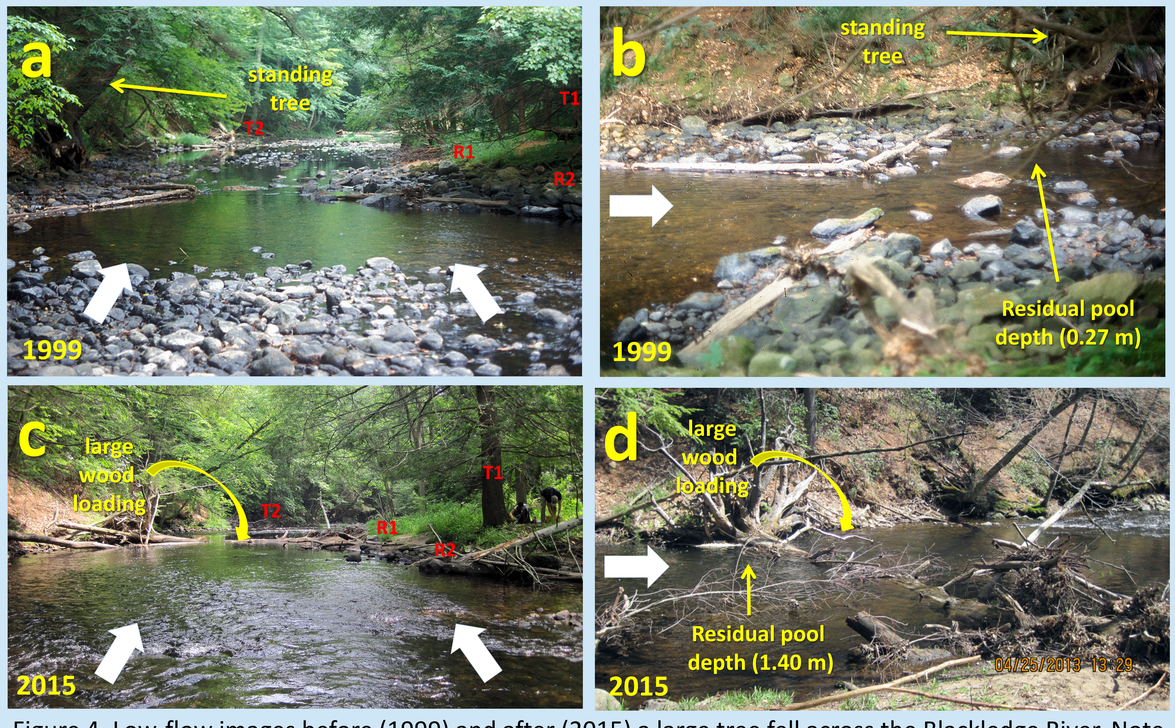

Figure 4. Low-flow images before (1999) and after (2015) a large tree fell across the Blackledge River. Note the standing tree in image 4a and 4b (1999). Also note that water-surface elevations are higher upstream of the large wood at similar low flows in images 4c and 4d (2015).

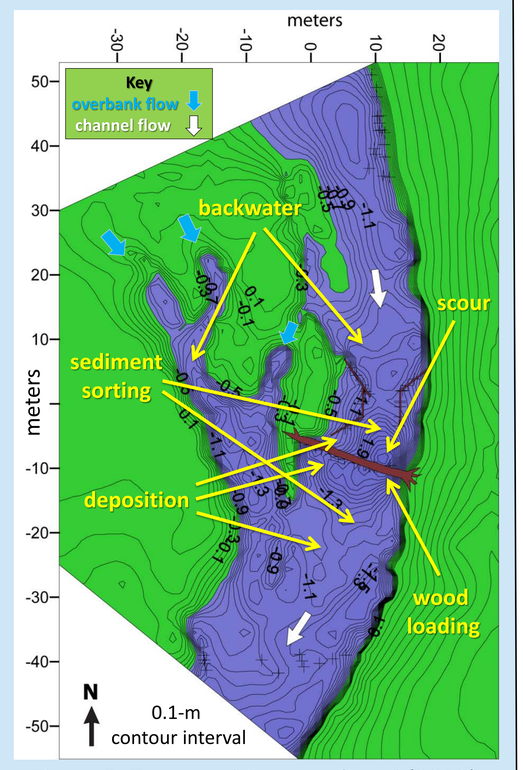

Figure 5. Topographic map of pool (2013).

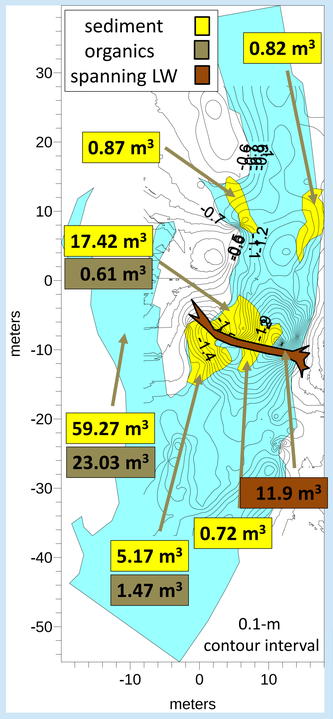

Figure 6. Major deposits (2015 topography and ∀).

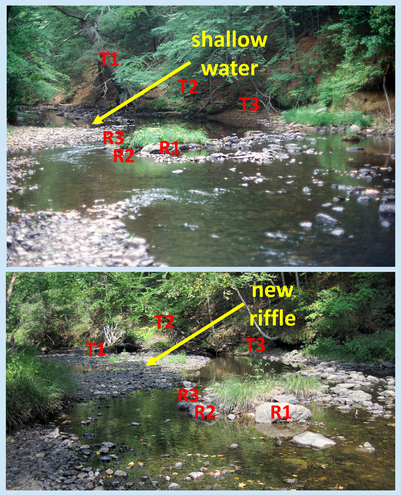

Figure 7. Photographs showing development of riffle deposit. The deposit increased water depth upstream by approximately 0.18 m.

Volume Change	2013-2014	2014-2015
Scour (m3)	12.18	22.98
Deposition (m3)	72.55	12.44
Net change (m3)	-60.37	10.34
Percent filled		

Discussion

Large wood (LW) was introduced to the channel from a riparian tree sometime after 2001 and created a new pool and riffle sequence. Pool spacing along the reach decreased to 3.83 bankfull widths (BFW) from a previous value of 4.47 BFW in 2001. A small existing pool changed from a residual pool depth of 0.27 m to 1.40 m. The change in depth resulted from a combination of approximately 0.96 m of scour (85% of the depth increase) and 0.18 m of downstream deposition (15% of the depth increase), which increased water depths upstream due to backwater formation.

Annual changes in pool volume indicate the pool is capable of maintaining itself under current conditions, and is a major storage area for fine sediments and organic material. Approximately 84.3 m^3 of sand-sized sediment and 25.1 m^3 of organic matter (including LW) is stored in the 40-m long pool and secondary channel. The spanning LW has a volume (∀) of 11.9 m^3. In comparison, LW volumes upstream, downstream, within the secondary channel and in a downstream instream structure total 2.1 m^3, 0.4 m^3, 1.9 m^3 and 0.6 m^3, respectively (29.7% of total ∀). The same 214-m long reach contains 6.4 m^3 of sand-sized sediment storage (7.1% of total ∀).

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