The Role of Eco-Hydraulics in the Restoration of a Degraded Urban Stream

Ian D. Smith, B.Math., M.Sc., OLS/OLIP, EP[1],
[1]*Fluvial Geomorphologist, Urban & Environmental Management Inc., Niagara Falls, Ontario, Canada*

The urbanization of small watersheds has had a marked impact upon the stability of riverine systems (Maddock, Harby, Kemp, & Wood, 2013). The increase of impermeable areas in urban catchments has typically led to increased bank forming flood flow magnitudes of decreased duration (Doyle, Harbor, Rich, & Spacie, 2013). The resultant increase in the energy of water flowing through an urbanized stream channel is manifested as an increase in the tractive forces. Unfortunately, pre-urbanization flow regimes that had given rise to the stream's stable morphology are impacted greatly by the change in stream flow energy post-urbanization (Newbury & Gaboury, 1994). This increase in tractive force, particularly during the bank-forming flood event, is the driving factor for stream degradation, leading to bank erosion and stream widening and/or entrenchment (Lane, 1955, Ontario Ministry of Environment, 2003).

Beverley Hills Creek (a Tributary of the Lower Twelve Mile Creek) is a small urbanized stream that drains approximately 92.75 hectares (less than 1.0 km^2) in the City of St. Catharines. Peak post-urbanization bank-forming flow was estimated to be approximately 2.8 m^3/s, and had led to degradation of the stream channel, primarily in the form of bed erosion and entrenchment. Of particular concern was the loss of material supporting footings of a box culvert serving as a stream crossing for a major arterial road.

Stream modelling (HEC-RAS) and in-situ measurements were made to understand the ecohydraulics and thus quantify the forces acting upon a 100 metre reach of the stream in the immediate vicinity of the Lakeshore Road culvert. The primary mechanisms for stream degradation were identified and a restoration plan was derived. A need to dissipate energy in the study reach was clearly evident.

It was decided to create several energy dissipation structures, using natural/bio-engineering techniques such that the stream would regain ecological value for aquatic and riparian species while mitigating the instable flow regime. The crossing was re-configured as an embedded culvert, to reduce velocity and thus tractive force via increased stream bed friction. An energy reducing plunge pool was created at the culvert outlet, and rocky ramps (Newbury Weirs) were created at the terminus of the culvert outlet pool as well as at regular intervals along the 100 metre reach. The entire reach was designed to force critical flow at regular intervals such that the energy status of the channel was fully balanced over the study reach. This was achieved entirely with bio-engineered and Natural Channel Design (NCD) structures that also created high quality aquatic and riparian habitat features.

References

Doyle, M. W., Harbor, J. M., Rich, C. F., & Spacie, A. (2013, May 15). Examining the Effects of Urbanization on Streams Using Indicators of Geomorphic Stability. *Physical Geography - Special Issue: Human Impacts in Geomorphology*, 155-181.

Lane, E. W. (1955, July). The importance of fluvial morphology in hydraulic engineering. *Proceedings, American Society of Civil Engineers, 81*(745).

Maddock, I., Harby, A., Kemp, P., & Wood, P. (2013). *Ecohydraulics: An Integrated Approach (First Edition).* West Sussex: John Wiley & Sons, Ltd.

Newbury, R. W., & Gaboury, M. N. (1994). *Stream Analysis and Fish Habitat Design, A Field Manual* (Second ed.). Winnipeg, Manitoba, Canada: Manitoba Natural Resources.

Ontario Ministry of Environment. (2003). *Stormwater Management and Planning Manual; Appendix C - Rapid Geomorphic Assessment.* Toronto: Queen`s Printer.