

The Effects of Hydromodification on River Channels. Why Restoration to Memorable Times May Not be the Most Effective Strategy for a Sustainable Future.

W.K. Annable, PhD, PEng, PE, PGeo
Department of Civil and Environmental Engineering,
University of Waterloo,
Waterloo, Ontario, Canada N2L 5M1

Fluvial responses to changes in watershed topography, hydrology, and sediment supply have been well studied over the past century (Davis, 1899; Leliavsky, 1955; Leopold *et al.*, 1964; Graf, 1984; Schumm *et al.*, 1984; Chang, 1988; Julien, 2002). Observations of such change are also echoed in our social fabric with an all too frequent acceptance that degraded river systems are the inevitable outcome of landuse change (Figure 1). More recent studies have investigated channel responses to landuse change in larger watersheds and have also proffered strategies for mitigating the upland flow regime to minimize or reverse the impacts of channel degradation (MacRae, 1997; Booth, 1990, 1991; MacRae and Rowney, 1992; Henshaw and Booth, 2000; Doll *et al.*, 2002; Bledsoe and Watson, 2001; Konrad *et al.*, 2005; Jordan *et al.*, 2009).



Figure 1. Depiction of channel evolution from landuse change

(Carling Conservation Digest, 1947).

Over the past half century, there have been growing efforts focused on restoring river corridors to pre-impact conditions or their perceived historical (post-colonization) fluvial alignment and function rather than allowing it to evolve to a new state of quasi-equilibrium (Langbein and Leopold, 1964). This approach is reinforced where there is existing infrastructure that may be compromised by new patterns of channel evolution, floodplain encroachment and occupation, and alterations to riparian corridor habitat and management (Brookes, 1988; Hey, 1997). However, restoration to the pre-disturbance conditions may not be achievable or may require long-term maintenance because contemporary land use has imposed a different set of irreversible controlling conditions (Kondolf and Downs, 1996).

Henshaw and Booth (2000) argue that the management of watercourses should not consider only maintaining or restoring a channel to its historical condition but should also explore rehabilitation alternatives that are in balance with a watershed's likely future landuse conditions of hydrology and sediment supply/transport. Consequently, a watercourse rehabilitated to quasi-equilibrium conditions in a watershed where the state variables of hydrology and sediment supply/transport have irreversibly been changed may have a different channel morphology and/or alignment than in its historical (post-colonization) state. However, to determine what the quasi-equilibrium characteristics of such systems are, or will be, has remained elusive because most previous studies have investigated the riverine degradational effects from landuse rather than those of any new conditions of stability.

In the absence of specific information on the quasi-equilibrium characteristics in irreversibly altered landuse, many practitioners rely upon the established quasi-equilibrium characteristics of rural (historical) watercourse conditions being transferable to future settings. Data sets and relationships developed by Leopold and Wolman (1960), Kellerhals *et al.* (1972), Andrews (1980, 1984), Bray (1972), Williams (1986), Hicks and Mason (1991), Annable (1996a), Rosgen (1996), Parker *et al.* (2007), and others are often employed to assist in assessing riverine impacts and used to develop future rehabilitation designs. However, these studies were conducted in rural or wilderness settings. It is by no means apparent how transferable such observations are to the altered flow and sedimentological regimes of altered state variable watersheds.

Some outstanding questions in regards to heavily altered watersheds are: 1) Do quasi-equilibrium river reaches exist within watersheds subjected to significant change? 2) If so, what are their specific characteristics, and how do they compare to rural or wilderness settings in the same hydrophysiographic region? 3) Are there central tendencies common to both altered and rural fluvial processes that can be prescribed to mitigate the adverse effects of irreversible landuse change? These questions are the basis of the workshop with data and restoration projects applied with new trajectories to altered state systems.

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