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Stream Channel Geometry Used to Assess Land Use Impacts in the Pacific Northwest

Many urban watershed programs fail to fully consider the implications of past, present, or future geometry of the stream system. In many instances, historical data can be used to correlate stream geometry with land use changes and watershed protection efforts. Results from efforts in other watersheds can be extrapolated to predict changes in similar stream systems. As discovered in the Pacific Northwest, the effectiveness of earlier stormwater treatment practices can be assessed by examining current stream channel stability. The observed alterations to stream channel geometry can be linked to changes in land use patterns and, therefore, can provide practical guidelines for predicting and preventing degradation in similar stream systems.

Once a minimum level of watershed imperviousness is exceeded, stream systems begin to exhibit quantifiable impacts to water quality, biological, and physical condition (Schueler, 1994). Booth and Reinelt (1993) found that 10 to 15% effective impervious cover can lead to noticeable changes in channel morphology, biological populations, vegetative succession, and water chemistry in streams and wetlands in western Washington state. Generally, an increase in impervious cover increases the volume of runoff associated with precipitation events of all magnitudes (Hollis, 1975). Consequently, the frequency of occurrence of mid-bankfull flow events also increases with increasing imperviousness. Mid-bankfull flow events have been found to be geomorphically significant in terms of their capacity to transport sediment and form the stream channel (Harvey *et al*., 1979; MacRae and Rowney, 1992). Ultimately, stream geometry, and hence stability, are adversely affected by these events.

The hydrological impacts associated with increased watershed imperviousness may lead to catastrophic channel expansion or channel incision as the stream channel attempts to reestablish equilibrium. The impacts of stream geometry changes can be severe and occur over long periods of time. Eventually, eroding channels destroy habitat diversity and clog downstream systems. Table 1 summarizes the physical characteristics that make stream reaches susceptible to destabilizing erosion, in the Pacific Northwest. One early indicator of a destabilizing channel is when sediment transport changes within the channel itself. Sediment transport is a function of shear stress and the resistance of bottom sediments to movement (Booth, 1990). Sediment transport is directly proportional to slope and inversely proportional to grain size, respectively.

A second indicator of stream erosion susceptibility is the presence of large woody debris (LWD) in the channel, such as trees limbs. LWD adds an external and transitory component of roughness to the stream channel. The increased roughness allows a stable channel to evolve, albeit at a gradient significantly steeper than resistance to sediment transport alone would support (Keller and Swanson, 1979). The channel rapidly incises, lowering the stream bed as the stream attempts to reach equilibrium by reducing the overall channel gradient. The LWD is then stranded above the low flow path. If the bed lowering significantly reduces the overall gradient, the stream incision may potentially be alleviated or halted because much of the total shear stress is dissipated on non-erodible material (i.e., the LWD). However, if the overall gradient is not significantly reduced, incision will be much more difficult to halt (Booth, 1990).

Unfortunately, these generalizations do not specifically reveal how any single stream would respond to land use changes and the timetable over which those responses would occur. This is due to specific physical conditions that differ from stream to stream. Booth (1994) established a protocol for evaluating physical stream channel condition impacts that have resulted from development. The protocol is relatively simple, requires little equipment, and can be implemented using a two-member team. An overview of the protocol is presented Table 2. Specifically designed for regions with steeper slopes, some adaptation is needed to make Booth's protocol applicable to other areas, such as humid coastal zones and the arid Southwest. In addition, all steps may not apply to certain water bodies; for example, bankfull width and depth measurements are not always practical for large rivers.

Table 1: Characteristics of Erosion-Susceptible Stream Reaches

1. Low-order, high gradient streams
2. Fine-grained, noncohesive geologic deposits
3. Low infiltration capacities of upland soils
4. Channel form and gradient controlled by large organic debris